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Technical note

Estimation of genetic and phenotypic trends for body weight traits of sheep in Guilan province of Iran

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Abstract The main objective of the present study was to estimate genetic and phenotypic trends for body weight traits in Guilan province sheep. Traits included were birth weight (BW, n=14,549), 3-month weight (3MW, n=13,109) and 6-month weight (6MW, n=10,141). Data and pedigree information used in this study were collected during 1994 to 2011 by the Agricultural Organization of Guilan province in Iran. Animal breeding values were predicted using univariate analysis based on animal model. The GLM procedure of SAS was used for determining the fixed effects which had significant influence on the traits under study. The Wombat software was employed to estimate the breeding values. The Best Liner Unbiased Predictions (BLUP) of breeding values were obtained, and genetic and phenotypic trends were estimated as the regression of the average predicted breeding and phenotypic values on birth year, respectively. Environmental trends were calculated as the difference between phenotypic and genetic trends. Direct genetic trends were positive and significant ($P<0.0001$) for BW, 3MW and 6MW and being 0.51±0.101, 5.56±1.21 and 18.46±2.24 g/year, respectively. Maternal genetic trends for BW, 3MW and 6MW were negative and significant ($P<0.0001$); these were -0.14±0.04, -1.42±0.31 and -5.48±0.67 g/year, respectively. Phenotypic trends for above mentioned traits were -40.21±1.02 ($P<0.0001$), -206.54±7.01 ($P<0.0001$) and 23.38±9.08 ($P<0.05$) g/year, respectively, with their environmental trends estimated to be -40.72±0.919, -212.1±5.8 and 4.92±6.84 g/year, respectively. The results showed increases in the average breeding values for body weight in Guilan province sheep during the years under study; therefore, improvement in body weight of Guilan province sheep seems feasible in selection programs.tract

Keywords: genetic trend, phenotypic trend, body weight, Guilan province sheep

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Introduction

Sheep in Guilan province are fat-tailed numbering some 400,000 in the north of the country, and distributed in the northern and western parts of Guilan province in the mountains between Assalem, Khalkhal, Oshkourat, and Deilaman. Guilan's sheep can also be found in some areas of Guilan-Zanjan border. The detailed specifications of Guilan's sheep were reported in previous study (Eteqadi et al., 2014).

Evaluation of genetic progress for economic traits is an essential part of successful planning of future breeding schemes, and allows documentation of progress from past selection. Such an evaluation requires separation of the genetic and environmental portions of total phenotypic trend. The phenotypic trend could be estimated more accurately by regressing actual performance records on time. However, unbiased estimates of genetic or environmental trends are difficult to obtain because of potential confounding of changes in environment with changes in genotype. Available procedures for appraising these components vary depending on the experimental situations (i.e., controlled laboratory experiments *vs.* field experiments), but in all approaches, regression procedures assume a central role (Nadarajah et al., 1987).

Accurate prediction of breeding value of animals is one of the best tools available to maximize response to selection programs. Success of any breeding program can be assessed by actual change in the breeding value expressed as a proportion of expected theoretical change of the mean breeding value of the trait under selection (Jurado et al., 1994). Estimates of genetic and phenotypic trends for body weight of different sheep breeds have been reported by several authors (Shrestha et al., 1996; Shaat et al., 2004; Hanford et al., 2005; Gizaw et al., 2007; Bosso et al., 2007; Mokhtari and Rashidi, 2010; Caro Petrović et al., 2012).

Selection of livestock is usually based on a combination of economically important traits that may be phenotypically and genetically correlated. Estimates of genetic and phenotypic trends are important to test the efficiency of applied breeding schemes and to provide breeders with information to develop more efficient selection programs in the future. Birth weight (BW) and 3-month weight (3MW) are important in productivity and are the major selection traits in sheep breeds known to be influenced by genetic and environmental factors (Mandal et al., 2003; Behzadi et al., 2007, Dass et al., 2008). Information on the performance of indigenous sheep breeds can vary from year to year. It is, therefore, important to investigate the effects of various factors on the variation among animals in order to find efficient breeding plans to improve production. Information on the genetic and phenotypic trends of body weight traits of Guilan province sheep is not available. Therefore, the objective of this study was to evaluate the phenotypic and genetic trends for body weight traits in Guilan province sheep from 1994 to 2011.

Materials and methods

Data and management

Data and pedigree information of Guilan province sheep used in this study were collected by the Agricultural Organization of Guilan province (Rasht, Iran) from 1994 to 2011. The traits included were: birth weight (BW), 3-month weight (3MW) and 6-month weight (6MW). Data included 14,549 lamb records born from 389 sires and 4,708 dams for BW, 13,109 lamb records born from 365 sires and 4,428 dams for 3MW and 10,141 lamb records born from 319 sires and 3,395 dams for 6MW. The number of records, mean, standard deviation, coefficient of variation, number of sires and dams for the traits studied are presented in Table 1. On the basis of individual inbreeding coefficient, the animals were grouped in three classes, including the non-inbred animals (F=0), and two classes of inbred animals ($0<F\leq 5\%$ and $F > 5\%$, respectively).

Statistical and genetic analyses

Initially, the GLM (SAS, 2003) was used to determine the fixed factors having significant effect on the traits. The data were screened several times and defective and doubtful records were deleted (e.g., lambs without weight records or with incomplete records of parentage or with registration numbers lower than the numbers of their parents were omitted from calculations). The significance level for the inclusion of fixed effects into the final models of analysis was set at $P < 0.05$. The models included the fixed effects of flock-year-season of lambing, lamb's sex (in 2 classes: male and female), type of birth (in 3 classes: single, twin and triplet), parity (in 3 classes: 1 through 3), dam's age at lambing (in 6 classes: from 2 to 7 years of age) and inbreeding class. All interactions were included in the models. Lamb's sex, type of birth, dam's age at lambing, flock-year-season of lambing and inbreeding class were fixed effects which significantly affected the traits. Interactions between the lamb's sex and inbreeding class were fixed effects which significantly affected on 3MW and 6MW. Interactions between the lamb's sex and type of birth, type of birth and dam's age at lambing were fixed effects which significantly affected on BW. Parity and interactions between type of birth and inbreeding class were fixed effects which significantly affected on 3MW. Also, age of animal at weighing was covariate effect which significantly affected on 6MW and 3MW.

Variance components and corresponding genetic parameters were estimated for each trait using the Average Information Restricted Maximum Likelihood (AIREML) algorithm of the Wombat program (Meyer, 2006) by fitting six single trait animal models which ignore or include additive direct and maternal genetic and permanent environmental effects. The models used were:

Model 1: $\mathbf{y}=\mathbf{Xb}+\mathbf{Z_a a}+\mathbf{e}$

Model 2: $\mathbf{y}=\mathbf{Xb}+\mathbf{Z_a a}+\mathbf{Z_C c}+\mathbf{e}$

Model 3: $\mathbf{y}=\mathbf{Xb}+\mathbf{Z_a a}+\mathbf{Z_m m}+\mathbf{e}$ Cov(a,m)=0

Model 4: $\mathbf{y}=\mathbf{Xb}+\mathbf{Z_a a}+\mathbf{Z_m m}+\mathbf{e}$ Cov(a,m)=$A\sigma_{am}$

Model 5: $\mathbf{y}=\mathbf{Xb}+\mathbf{Z_a a}+\mathbf{Z_m m}+\mathbf{Z_C c}+\mathbf{e}$ Cov(a,m)=0

Model 6: $\mathbf{y}=\mathbf{Xb}+\mathbf{Z_a a}+\mathbf{Z_m m}+\mathbf{Z_C c}+\mathbf{e}$ Cov(a,m)=$A\sigma_{am}$

where, **y** is vector of observations, **b** is vector of fixed effects with incidence matrix **X**, $\mathbf{a}$~N(0, $A\sigma^2_a$) and $\mathbf{m}$~N(0, $A\sigma^2_a$) are vectors of direct and maternal genetic effects with incidence matrices Z_a and Z_m, respectively; $\mathbf{c}$~N(0, $I_c\sigma^2_c$) is vector of random maternal permanent

Table 1. Characteristics of data set for Guilan province sheep

Trait	No. of records	No. of sires	No. of dams	Mean (kg)	SD (kg)	CV (%)
BW	14549	389	4708	3.12	0.61	19.55
3MW	13109	365	4428	15.39	3.85	25.02
6MW	10141	319	3395	20.69	4.53	21.89

BW: Birth weight, 3MW: 3-month weight, 6MW: 6-month weight, SD: Standard deviation, CV: Coefficient of variation.

environmental effects with incidence matrix Z_c, and $\mathbf{e}$~N(0, $I_n\sigma^2_e$) is vector of random residual effects. Also, $\sigma^2_a$is the direct genetic variance, σ^2_m is the maternal genetic variance, σ^2_c is the maternal permanent environmental variance, σ^2_e is the residual variance, **A** is the additive genetic relationship matrix, and I_c and I_n are the identity matrices of order equal to the number of maternal permanent environmental effects and the number of records, respectively.

The most suitable model amongst all six models was determined based on Akaike's Information Criterion (AIC) (Alkaike, 1974):

$$AIC_i = -2\log L_i + 2p_i$$

where logL_i is the maximized log likelihood of model i at convergence and p_i is the number of parameters obtained from each model. The model with the lowest AIC is considered as the best model for each trait.

Genetic and phenotypic trends of the traits studied were estimated by regressing breeding values and phenotypic values on birth year, respectively. Genetic trend analyses were performed using the regression procedure (Proc Reg) of SAS program (SAS 2003; SAS Institute Inc., Cary, NC). Environmental trends of the traits studied were calculated by subtracting the genotypic trend from the phenotypic one.

Results and discussion

The number of records decreased with age. The coefficient of variation for birth weight (Table 1) was much lower than that for the other traits. Phenotypic means of the studied traits by the year of birth varied from 2.82 to 3.49, 9.86 to 17.73 and 19.04 to 22.23 for BW, 3MW and 6MW, respectively, over all years of this study.

The results showed that model 4 was the best model for genetic analysis of body weight traits in Guilan province sheep. Therefore, this model was selected to estimate the breeding values. Means of direct and maternal breeding values by year of birth are shown in Figures 1 and 2, respectively. The estimates of genetic, phenotypic and environmental trends (g/year) for investigated traits are reported in Table 2. As illustrated in Figures 1 and 2, average direct and maternal breeding values of Guilan lambs generally indicated an increase and a decrease over time for all studied traits between 1994 and 2011, respectively. The average yearly direct and maternal genetic trends were positive and negative with irregular variation over the years, respectively. There were significant direct and maternal genetic changes for BW, 3MW and 6MW ($P<0.0001$ and $P<0.05$, respectively) over the years (Table 2). Generally, genetic trends for birth weights (both direct and maternal) were very different than those of the other body weight traits. Based on Figures 1 and 2, genetic change of birth weight appears to be flat. For the other weight traits, plots of the mean predicted breeding values on year of birth followed similar patterns (Figures 1 and 2). Estimates of direct genetic trends indicated that there was significant positive genetic improvement in all studied traits and in

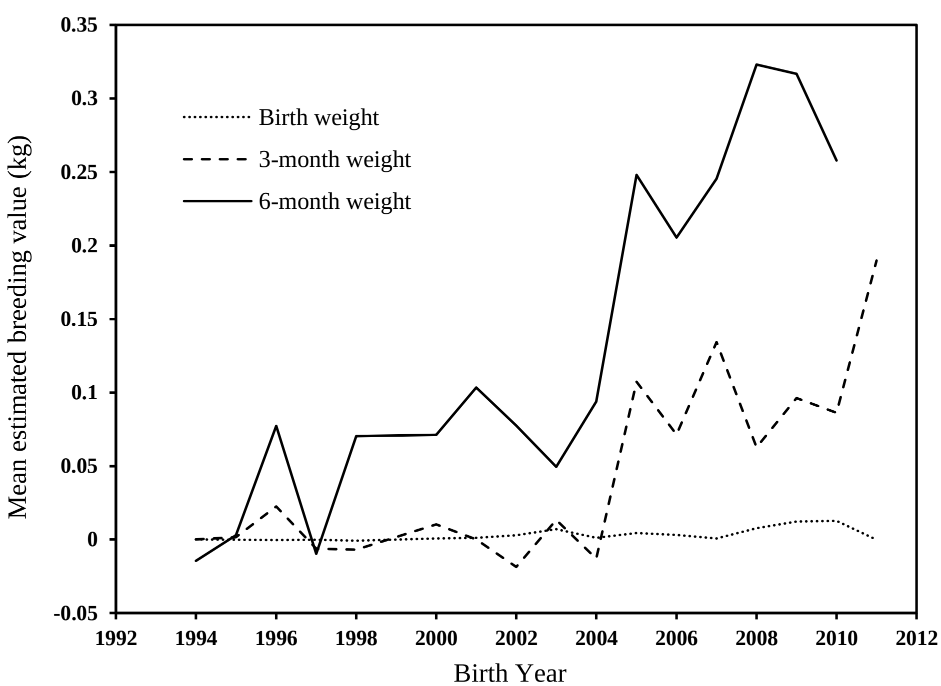

Figure 1. Average estimated direct breeding values by year of birth observed for BW, 3MW and 6MW in Guilan province sheep

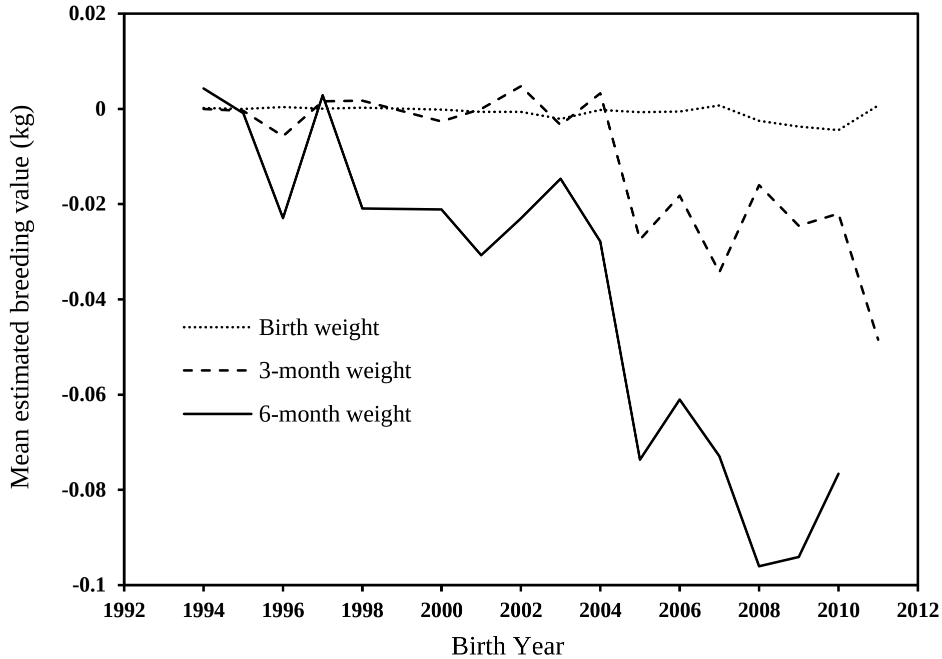

Figure 2. Average estimated maternal breeding values by year of birth for BW, 3MW and 6MW in Guilan province sheep

Table 2. Estimates of genetic, phenotypic and environmental trends (g/year) for body weight traits in Guilan province sheep

Trait	DGT ± SE	MGT ± SE	PHT ± SE	ET ± SE
BW	0.51**±0.101	-0.14**±0.04	-40.21**±1.02	-40.72±0.919
3MW	5.56**±1.21	-1.42**±0.31	-206.54**±7.01	-212.1±5.8
6MW	18.46**±2.24	-5.48**±0.67	23.38*±9.08	4.92±6.84

BW: Birth weight, 3MW: 3-month weight, 6MW: 6-month weight, DGT: Direct genetic trend, MGT: Maternal genetic trend, PHT:Phenotypic trend, ET: Environmental trend, SE: Standard error.
**significant at P<0.0001, *significant at P<0.05.

dicated that selection would be effective for improvement of body weight traits in Guilan province sheep. Although, there were more irregular fluctuations in the annual mean of predicted direct and maternal breeding values for 3MW and 6MW (Figures 1 and 2). Also, there were abrupt increases (Figure 1) and abrupt decreases (Figure 2) in yearly mean predicted breeding values of animals for 3MW and 6MW especially in 2005, respectively.

The decrease in the mean predicted breeding values of animals in 2005 was probably due to selection of sires with low breeding values. This low selection response could indicate that introduction of external sires was based solely on phenotypic characteristics (Mokhtari and Rashidi, 2010).

The evaluation of genetic trend gives an indication of breed direction as well as the rate of genetic improvement due to the application of breeding program (Bosso et al., 2007). In this study, direct genetic trend estimates showed that there was a significant and positive genetic improvement in all studied traits and indicated that selection would be effective.

Estimate of direct genetic trend for BW in the current study (0.51 g/year) was low and lower than the reports of Ghavi Hossein-Zadeh (2012) in Moghani sheep (1.63 g/year). Estimate of maternal trend for BW (-0.14 g/year) was lower than direct trend and this may be related to the smaller maternal effects on BW than direct genetic effects in Guilan province sheep. Higher estimates of genetic trends for BW in other sheep breeds were reported by several authors (Mokhtari and Rashidi, 2010; Rashidi and Akhshi, 2007; Gizaw et al., 2007; Bosso et al., 2007). Results of the current study were inconsistent with the result of Ghavi Hossein-Zadeh (2012) who reported maternal genetic effects on BW were generally important in Moghani sheep.

Estimate of direct genetic trend for 3MW obtained in the present research (5.56 g/year). Also, estimate of direct genetic trend for 3MW was lower than the estimates of 92, 128, 125, and 69.2 g/year reported by Shaat et al.,

(2004) in Rahmani breed, Rashidi and Akhshi (2007) in Kurdi sheep, Mokhtari and Rashidi (2010) in Kermani sheep, and Ghavi Hossein-Zadeh (2012) in Moghani sheep, respectively. Zishiri et al. (2010) reported predicted direct breeding values for pre-weaning weights increased at an annual rate of 0.23% and that of weaning weight by 1.21% per annum in South African terminal sire sheep breeds. Hanford et al. (2005) reported that the average predicted breeding values for weaning weight increased about 9.0 kg in Rambouillet sheep during a 49-year period.

The direct genetic trend estimate of 6MW (18.46 g/year) was in agreement with that of 21 g/year which was reported by Shaat et al. (2004) in Ossimi sheep. Lower estimates of direct genetic trend were reported by Mohammadi et al. (2012) in Makooei sheep (38.7 g/year), Mokhtari and Rashidi (2010) in Kermani sheep (91 g/year) and Ghavi Hossein-Zadeh (2012) in Moghani sheep (79.4 g/year).

Conclusions

The current study provided useful estimates which would be applied for designing breeding schemes in Guilan province sheep. Due to the existence of positive direct genetic trends for body weight traits, it can be concluded that genetic selection for improvement in body weight of Guilan province sheep seems feasible. Also, this study indicated that an effective breeding program would result in greater progress in genetic gains of body weight in this breed.

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برآورد روند ژنتیکی و فنوتیپی صفات وزن بدن در گوسفندان استان گیلان

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چکیده هدف از این پژوهش برآورد روند ژنتیکی و فنوتیپی صفات وزن بدن گوسفندان گیلان بود. صفات مورد مطالعه شامل وزن تولد (۱۴۵۴۹)، وزن سه‌ماهگی (۱۳۱۰۹) و وزن شش‌ماهگی (۱۰۱۴۱) بود. داده‌ها و اطلاعات شجره در طی سال‌های ۱۳۷۳ تا ۱۳۹۰ توسط سازمان کشاورزی استان گیلان جمع‌آوری شده بود. ارزش اصلاحی حیوانات با استفاده از آنالیز تک متغیره بر اساس مدل حیوان پیش بینی شد. آزمون معنی‌داری اثرات ثابت مؤثر بر صفات مورد مطالعه با استفاده از رویه GLM نرم افزار SAS انجام گرفت. از نرم افزار Wombat برای برآورد ارزش های اصلاحی استفاده شد.BLUP ارزش های اصلاحی بدست آمد و به منظور برآورد روند ژنتیکی و فنوتیپی صفات، به ترتیب از تابعیت میانگین ارزش‌های ا صلاحی دام‌ها و تابعیت میانگین عملکرد صفات مختلف بر سال تولد ا ستفاده گردید. روند محیطی نیز از طریق تفاوت روند فنوتیپی از روند ژنتیکی محاسبه گردید. روند ژنتیکی مستقیم برای صفات وزن تولد، وزن سه‌ماهگی و وزن شش‌ماهگی مثبت و معنی دار (P<۰/۰۰۰۱) بود و به ترتیب ۰/۱۰۱ ± ۰/۵۱، ۱/۲۱ ± ۵/۵۶ و ۲/۲۴ ± ۱۸/۴۶ گرم در سال برآورد گردید. روند ژنتیکی مادری برای صفات وزن تولد، وزن سه‌ماهگی و وزن شش‌ماهگی منفی و معنی دار (P<۰/۰۰۰۱) بود و به ترتیب ۰/۰۴ ± ۰/۱۴–، ۰/۳۱ ± ۱/۴۲– و ۰/۶۷ ± ۵/۴۸– گرم در سال برآورد گردید. روند فنوتیپی صفات ذکر شده به ترتیب (P<۰/۰۰۰۱) ۱/۰۲ ± ۴۰/۲۱–، (P<۰/۰۰۰۱) ۷/۰۱ ± ۲۰۶/۵۴– و (P<۰/۰۵) ۹/۰۸ ± ۲۳/۳۸ گرم در سال و روند محیطی آنها به ترتیب ۰/۹۱۹ ± ۴۰/۷۲–، ۵/۸ ± ۲۱۲/۱– و ۶/۸۴ ± ۴/۹۲ گرم در سال برآورد گردید. نتایج این مطالعه نشان می‌دهد که میانگین ارزش های اصلاحی صفات وزن بدن گوسفندان استان گیلان در طی سال های مورد مطالعه افزایش یافته است و همچنین در گوسفند گیلانی پیشرفت ژنتیکی برای صفات وزن بدن به وسیله برنامه های انتخاب امکان‌پذیر است.