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Short Communication

Genetic parameters and trends for litter size in Markhoz goats¤

Parámetros genéticos y tendencias para el tamaño de la camada en cabras Markhoz

Parâmetros genéticos e tendências para o tamanho da ninhada em cabras Markhoz

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Abstract

Background: Prolificacy has a high economic value and is one of the most important reproduction traits in small ruminants such as Markhoz goats, which is an endangered breed.

Objective: To estimate genetic, environmental and phenotypic trends, and genetic parameters for litter size (LS), as a prolificacy trait of Markhoz goat does.

Methods: The study was conducted using kidding records of 3,064 Markhoz does from 1992 to 2015. Genetic parameters were estimated with a logit link function using ASReml software, fitting a repeatability animal model, with birth year, kidding year, and kidding age as fixed effects, and direct additive genetic and permanent environmental effects as random effects. Genetic, phenotypic and environmental trends were estimated by using regression of breeding value, phenotypic value and environmental deviation averages on birth year, respectively.

Results: Low and negligible heritability (0.002), repeatability (0.054) and coefficient of permanent environment (0.052) were estimated for LS, which indicates low possibility to achieve rapid genetic progress through phenotypic selection. A non-significant -actually, zero- genetic trend (0.00004 heads/kidding/year), and significant negative phenotypic and environmental trends (-0.01097 and -0.01100 heads/kidding/year, respectively) were estimated in this study.

Conclusion: Optimizing environmental conditions and application of high-throughput technologies in selection programs could help reducing the extinction risk of Markhoz breed.

Keywords: *extinction risk, genetic trend, heritability, phenotypic selection, prolificacy*.

Resumen

Antecedentes: La prolificidad tiene un alto valor económico y es uno de los rasgos reproductivos más importantes en pequeños rumiantes, tales como la raza caprina Markhoz. que está en peligro de extinción. **Objetivo:** Estimar las tendencias genéticas, ambientales y fenotípicas, y los parámetros genéticos para el tamaño de la camada (LS), como rasgo de prolificidad de las hembras de cabras Markhoz.

Métodos: Se utilizaron registros de partos de 3.064 hembras Markhoz, de 1992 a 2015. Los parámetros genéticos se estimaron con una función de enlace logit utilizando el software ASReml, ajustando un modelo animal de repetibilidad, con el año de nacimiento, el año del parto y la edad al parto como efectos fijos, y genéticos aditivos directos y efectos ambientales permanentes como efectos aleatorios. Las tendencias genéticas, fenotípicas y ambientales se estimaron mediante la regresión del valor de la cría, el valor fenotípico y los promedios de desviación ambiental en el año de nacimiento, respectivamente.

Resultados: Se estimó la heredabilidad -baja e insignificante- (0,002), repetibilidad (0,054) y coeficiente de ambiente permanente (0,052) para LS, lo que indica una baja posibilidad de lograr un progreso genético rápido a través de selección fenotípica. Se estimó una tendencia genética no significativa -de hecho, cero- (0,00004 cabezas/parto/año) y se estimaron tendencias fenotípicas y ambientales negativas significativas (-0,01097 y -0,01100 cabezas/parto/año, respectivamente) en el período estudiado.

Conclusión: La optimización de las condiciones ambientales y la aplicación de tecnologías de alto rendimiento en los programas de selección podrían reducir el riesgo de extinción de la raza Markhoz.

Palabras clave: *heredabilidad, prolificidad, riesgo de extinción, selección fenotípica, tendencia genética.*

Resumo

Antecedentes: A prolificidade tem um elevado valor económico e é uma das mais importantes características de reprodução nos pequenos ruminantes, como a raça de caprinos Markhoz, que está em perigo de extinção. **Objetivo:** Estimar tendências genéticas, ambientais e fenotípicas, e parâmetros genéticos para o tamanho da serapilheira (LS), como um traço de proliferação de cabras Markhoz.

Métodos: Este estudo foi realizado usando registros de parto de 3.064 Markhoz entre 1992 e 2015. Os parâmetros genéticos foram estimados com uma função logit link utilizando o software ASReml, ajustando um modelo animal de repetibilidade, com o ano de nascimento, o ano de parto ea idade de caçoar como efeitos fixos e efeitos ambientais diretos e genéticos diretos como efeitos aleatórios. As tendências genéticas, fenotípicas e ambientais foram estimadas pela regressão do valor de criação, valor fenotípico e médias de desvio ambiental no ano de nascimento, respectivamente.

Resultados: Herdabilidade baixa e negligenciável (0,002), repetibilidade (0,054) e coeficiente de ambiente permanente (0,052) foram estimadas para LS, o que indica baixa possibilidade de alcançar um progresso genético rápido através da seleção fenotípica. Foi estimada uma tendência genética não-significativa e realmente zero (0,00004 cabeças/parto/ano) e tendências fenotípicas e ambientais negativas significativas (-0,01097 e -0,01100 cabeças/parto/ano, respectivamente) no período estudado.

Conclusão: Parece que a otimização das condições ambientais ea aplicação de tecnologias de alto rendimento em programas de seleção poderiam reduzir o risco de extinção para a raça Markhoz.

Palavras-chave: *heritabilidade, prolificidade, risco de extinção, seleção fenotípica, tendência genética.*

Introduction

Markhoz goat is one of the most important native breeds in Iran, mainly raised in Kurdistan province, in west Iran (Rashidi *et al*., 2015). Markhoz goat is well known for mohair and meat production (Farshad *et al*., 2008), which is obviously different from other Iranian goat breeds, such as Mahabadi and Lori (Simaei-Soltani et al., 2016). Twinning rate in this breed is approximately 26%, and triplet births also occur (Rashidi *et al*., 2011). The Markhoz goat is an endangered breed and needs more attention for conservation. According to Bahmani *et al*. (2011), total and effective population sizes, and number of breeding Markhoz females and males in 2009 were 2,456, 266, 1,332 and 70 heads, respectively. That study revealed that the Markhoz goat is facing demographic and geographical risks, decreasing variation, and imminent danger of extinction. Breeding for productivity and profitability could stimulate farmers to keep a breed and, thus, could be considered as an efficient way to prevent breed extinction. A non-intensive breeding program has been planned for the whole Markhoz population, but irregular tandem selection programs including periodical phenotypic selections on different important traits -including mohair properties, body weight and reproduction efficiency- have been conducted at the Markhoz Goat Research Center for several generations during past years.

Litter size is one of the most important reproduction traits, especially in small ruminants with a high economic merit and a noticeable impact on profitability (Abdoli et al., 2016); hence a primary objective of breeding programs for sheep and goat should be maximizing genetic progress of litter size.

Estimation of genetic, phenotypic and environmental trends provides an evaluation perspective for previous selection strategies and facilitates designing a more suitable breeding program for the future. Therefore, the aim of this study was to estimate genetic parameters and trends for litter size as a prolificacy trait in Markhoz goats.

Materials and methods

Animal and data collection

Data and pedigree information were collected from 1992 to 2015 at the Markhoz Goat Research Center in Kurdistan province, west Iran (35°16’37.7”N 47°01’11.3”E). The goats were kept under semi- intensive management conditions with a controlled mating system. The mating season was from October to November and kidding was from February to March. The does were first exposed to the bucks at about 18 months of age and each buck was randomly mated with 10 to 15 does for two to three mating seasons. Newborn kids were weighed and ear-tagged at birth (Rashidi *et al*., 2011; Khani *et al*., 2017). Litter size (LS) was defined as the number of kids born alive per kidding and considered as a prolificacy trait of dams. The dataset included 3,064 LS records from 1,171 does. Minimum, maximum and average of LS records were 1, 3 and 1.3, respectively. The pedigree was traced back to all available ancestral information, consisting of 12 generations. The pedigree file included 5,137 animals, with 235 sires, 1,481 dams and 343 founders.

Statistical analysis

The fixed factors in the following model with significant effects on LS were determined based on a preliminary general linear model analysis using the GLM procedure of SAS® software, version 9.4 (SAS Institute Inc., Cary, NC, USA) (2013). Variance components and breeding values were estimated using a repeatability animal model as follow:

$$y = Xb + Zu + Wpe + e$$

Where:

y: is vector of observations.

b: is vector of fixed effects, determined from the general linear model analysis, including birth year (1992–2012), kidding age (2–7 years) and kidding year (1995-2015).

u, pe and e: are vectors of random direct additive genetic, permanent environmental and residual effects, respectively.

X, Z and W: are incidence matrices relating observations to the corresponding effects. This model was fitted with a logit link function using ASReml (Analysis of mixed models for S language environments, using Restricted Maximum Likelihood), version 2 (Gilmour *et al*., 2006). In this model, the LS was analyzed as a threshold trait (Mrode, 2014).

Environmental deviations (E) were estimated:

$$E= P - \mu - BV$$

Where:

P: is the phenotypic value.

µ: is the overall mean. BV: are breeding values.

Genetic, phenotypic, and environmental trends were estimated by regression of breeding value, phenotypic value and environmental deviation averages on doe birth year, respectively, using REG procedure of SAS 9.4 (SAS Institute Inc., 2013).

Results

Fixed effects, variance components and genetic parameters

Birth year, kidding year and dam age at kidding had significant associations with LS ($p<0.01$) and, thus, were included as fixed effects in the animal mixed model used to estimate the variance components and breeding values. Estimates of variance components, heritability (h^2), repeatability (r), and coefficient of permanent environmental effects (pe^2), defined as the ratio of permanent environmental to total phenotypic variances, are presented in the Table 1. A very low and non-significant heritability (0.0016 ± 0.0068) was estimated for LS in the studied population. Low estimates were also obtained for r and pe^2 (0.0536 ± 0.0111 and 0.0520 ± 0.0129, respectively).

Genetic, phenotypic and environmental trends

Estimates of genetic, environmental and phenotypic trends and their significance level (p values) are presented in Table 2. General trends of breeding values, phenotypes and environmental deviations are also illustrated in Figure 1. A non-significant, and actually zero, genetic trend (0.00004 ± 0.00002 heads/kidding/year) was estimated for LS in the study. Despite a relatively stable situation of the breeding values, negative and significant phenotypic and environmental trends (-0.01097 ± 0.00336 and -0.01100 ± 0.00337 heads/kidding/year, respectively) were estimated for LS in the studied period (Table 2). Phenotypic and environmental trends had similar patterns in different years (Figure 1).

Table 1. Variance components and genetic parameter estimates for litter size of Markhoz goats.

σ^2_a	σ^2_{pe}	σ^2_e	σ^2_p	$h^2 \pm$ SE	$pe^2 \pm$ SE	$r \pm$ SE
0.0003	0.0086	0.1564	0.1650	0.0016 ± 0.0068	0.0520 ± 0.0129	0.0536 ± 0.0111

σ^2_a: additive genetic variance; σ^2_{pe}: permanent environmental variance; σ^2_e: residual variance; σ^2_p: phenotypic variance; h^2: heritability; pe^2: ratio of permanent environmental variance on phenotypic variance; r: repeatability; SE: standard error.

Table 2. Estimates of genetic, environmental and phenotypic trends (heads/kidding/year) for litter size (LS) of Markhoz goats.

Genetic trend ± SE	Phenotypic trend ± SE	Environmental trend ± SE
0.00004 ± 0.00002 (p= 0.1017)	-0.01097 ± 0.00336 (p= 0.0040)	-0.01100 ± 0.00337 (p= 0.0040)

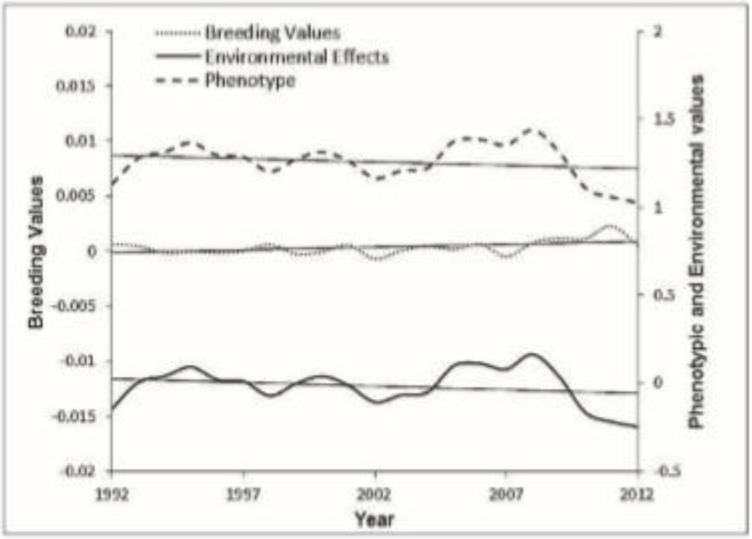

Figure 1. Genetic, environmental and phenotypic trends for litter size (LS) of Markhoz goats from 1992 to 2012.

Discussion

Most reproduction traits, including litter size, have low heritability estimates. In other words, additive genetic effects have little effects on reproduction traits, while environmental and non-additive genetic effects considerably affect these traits. A low heritability indicates low possibility to achieve rapid genetic progress through phenotypic selection. Low -and close to zero- estimate of heritability for LS in the present study agrees with previous estimations in different goat breeds (Maghsoudi *et al*., 2009; Rashidi *et al*., 2011). In a previous study on genetic parameters of pre-weaning performance and reproduction traits in Markhoz goats, the LS was considered as a continuous trait and its h^2 estimate was also low and close to 0.01 (Rashidi *et al*., 2011). This negligible difference with results of the present study is likely due to different considerations of the trait in the models (continuous vs. categorical), and inclusion of more data in the present study. Moreover, the LS phenotypic and environmental averages had considerable decreases in recent years (Figure 1), which could decrease the estimate of h^2, as the result of an increase in phenotypic and environmental variances. Low heritability of LS in the present study supports previous concepts about the need of more studies on major genes, and finding genetic background of LS trait in different goat breeds (Simaei-Soltani *et al*., 2016). Low estimates were also obtained for repeatability and permanent environment coefficient; thus the LS repeatability is entirely due to permanent environmental effects. Low r and pe^2 indicate considerable effect of temporary environment on LS, at least in the studied population.

Results of the current study show that genetic progress of LS in Markhoz goats was actually zero during the past two decades. Similar estimate of genetic trend has been reported in Saanen goats in Croatia (Kasap *et al*., 2013). This observation is due to low heritability of LS and thus, unfeasibility of genetic progress by common phenotypic selection methods. Negligible genetic trend along with significant and similar estimates of phenotypic and environmental trends (-0.01097 and -0.01100 heads/ year, respectively) emphasize the noticeable effects of environmental factors on LS. Based on negative estimates of phenotypic and environmental trends, it could be concluded that the environmental factors and as a result, phenotypic situation of LS in Markhoz goats is worsening every year. A main source of the observed negative phenotypic and environmental trends was dramatic decline of litter size after 2009, which indicated poor management and feeding strategies of Markhoz goats in recent years. This situation considerably increases the extinction risk of this breed. Hence, preservation of this breed needs more precise strategies for breeding and management.

This study shows that the programs used have not been efficient to improve the reproduction ability of this breed. A way to protect the Markhoz breed from extinction risk is improving its reproduction efficiency to stimulate farmers to keep this breed. Low heritability of litter size means that traditional breeding methods based on phenotypic data, would be time consuming and an inefficient process, because they need several generations for a slight genetic progress. Improvement of environmental factors such as nutrition, management and health care strategies would be more efficient methods to enhance the reproduction ability traits. In addition to optimize environmental conditions, more attempts to find genetic background of LS trait in Markhoz breed, and application of molecular genetics and high-throughput technologies, such as single nucleotide polymorphism (SNP) chips, whole genome sequencing, and whole transcriptome analysis for marker assisted selection (MAS) or prediction of genomic breeding values could improve the genetic situation of reproduction traits and reduce the extinction risk for this breed.

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Conflicts of interest

The authors declare they have no conflicts of interest with regard to the work presented in this report.

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