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# Estimates of genetic parameters for lifetime reproductive performance traits in Makuie ewes

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ABSTRACT

The objective of this study was to estimate genetic parameters for lifetime (over 2–5 years of age) reproductive performance traits in Makuie ewes. The data were extracted from Makuie Sheep Breeding and Raising Station dataset between 1989 and 2015. The studied traits were average of lifetime fertility, fecundity, survival, stay-ability, and total of lifetime female lambs born per ewe joined, female lambs weaned per ewe joined, weight of lambs born, weight of lambs weaned, and pregnancy days. Each trait was fitted by four different animal models, which were differentiated by including or excluding maternal effects. The Akaike information criterion was used to select the most appropriate model for each trait. In addition, series of bivariate animal models were implemented to estimate genetic and phenotypic correlations between traits. Estimates of direct heritability for traits were ranged from 0.00 to 0.15, which indicated that some traits (average fertility, average fecundity, and total weight of lambs born) had low additive genetic basis but others had no or very lower genetic basis. Maternal effects (both genetic and permanent environment) had very little or no effect on the studied traits. Genetic and phenotypic correlations between traits ranged from −0.92 to 0.99 and −0.01 to 0.97, respectively. The results indicated that fertility, fecundity, and total weight of lambs born could be improved by inclusion in the selection index due to their heritability estimation of greater than 0.12. For other traits genetic gain through conventional genetic selection method may be useless in Makuie sheep due to their low heritability estimates. However, these traits could be improved by providing better environment and management techniques.



## 1. Introduction

Reproduction efficiency is one of the most important factors affecting profitability of livestock industries. Therefore, improving reproductive traits could potentially reduce the operational costs (Notter, 2000). Performance of reproductive traits is the product of many other complex traits such as puberty, ovulation, estrus, fertilization, individual body fat deposition management, etc. (Snowder, 2008; Lee et al., 2009b; Gowane et al., 2014). These component traits have low to moderate genetics basis (Safari et al., 2005), and their genetic expression is highly affected by environmental factors such as climatic conditions and management techniques. It is concluded that knowledge on genetic parameters of economically important traits, particularly those related to reproduction, is necessary for genetic improvement programs (Safari et al., 2005). From seed stock producers' perspective, it is also recommended to analysis the reproductive traits over a lifetime cycle because the reproductive traits are highly influenced by environmental factors over the years (Lee et al., 2009a) and may have different performance over the years compared with single year. Reproductive performance overlife time cycle can be investigated using two approaches considering their genetic basis and environment factors that the animals were exposed (Lee et al., 2009a): between-ewes within years that is called lifetime analysis, and within-ewe between years that is called single-year analysis. Lifetime analysis covers more variation in reproductive performance, and it could improve accuracy of estimations and ultimately improve the genetic gain compared with single-year analysis (Lee et al., 2009a). Lifetime reproductive traits can be considered as the average performance of the ewes at first three or four years of their reproductive life after maturity such as fertility, fecundity, survival and stay-ability, or it could be considered as accumulated traits over three or four years performance for the traits such as total female lambs born per ewe joined, total female lambs weaned per

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the ewe joined, total weight of lambs born, total weight of lambs weaned and total pregnancy days (Duguma et al., 2002; Van Wyk et al., 2003; Zishiri et al., 2013).

Sheep breeds are categorized mainly into three groups of tailed, semi-tailed, and fat-tailed based on their tail shape. Fat-tail breeds account for 25% of global sheep population, mainly distributed in middle-east and some of African countries. Fat-tailed sheep are adapted to harsh environment, and when there is plenty of food, sheep accumulate fat in baggy deposit in hind parts on both sides of their tail. Depending on the breed and feast season, size of fat-tail could be up to 30 kg (Kashan et al., 2005). This fat is subsequently used for maintenance and support production performance during dry season/or in the winter. Fat-tail could be a good source also to support reproductive performance, but some believed that it could also prevent rams from having a successful mating with ewes, and consequently affecting reproductive outcomes. There are published results on genetic parameters of some lifetime traits in tailed sheep breeds. Although, it is believed that fat deposition could have substantial effect on reproductive performance and fat-tail could affect reproductive outcomes, to the best of our knowledge, there is no report on genetic parameters of lifetime reproductive traits in fat-tailed sheep breeds. Moreover, lifetime reproductive traits can also be influenced by maternal effects which are overlooked by most of the available reports, so study of these effects on the variation of lifetime reproductive traits deserve further investigation (Duguma et al., 2002; Van Wyk et al., 2003; Gowane et al., 2014). Ultimately, considering maternal and permanent environmental random effects in the mixed model may provide unbiased parameter estimations (Hoque et al., 2008).

Number of reports have been published studying genetic basis of production traits in Makuie breed (Jafari et al., 2012; Jafari et al., 2014; Jafari and Hashemi, 2014a,b). However, based on literature review on lifetime reproductive performance, it is concluded that there is a lack of report, to the best of our knowledge, on genetic parameters of reproductive traits using fat-tail breed data and most of the available reports on tailed breed did not considered maternal and permanent environmental effects in the estimations. Therefore, objectives of the present study were to estimate genetic parameters for lifetime reproductive performance in Makuie sheep breed, a fat-tailed breed, applying different mixed models and to reveal any associations between the traits by using bivariate analysis.

## 2. Materials and methods

### 2.1. Animals and herd management

A total of 6060 animals, progeny of 172 sires and 1600 dams was used in this study. Of the 6060 animals, 4288 were without records either because they did not meet imposed selection criteria or were males sold for market. Base animals were animals without identifiable parents bought from local producers at the time of establishing MSBRS station in 1986. Only 1215 ewes had useable records for this study. Since including relatives of individuals increases the power of genetic analyses, all animals (6060) were included in the pedigree analysis and genetic estimations.

Makuie sheep is a native breed to West-Azerbaijan province of Iran, and their population is estimated at approximately 2.7 million (Abbasi and Ghafouri-Kesbi, 2011). This sheep is fat-tailed medium-sized breed with white color body and black rings around eyes, noses, and feet. Makui sheep breed has been well adapted to cold and highland environments. In order to improve production and reproduction performance of this breed, Makuie Sheep Breeding and Raising Station (MSBRS) was established in 1986 at Maku city, Iran, and since then data on their production and reproduction traits have been recorded.

The records were acquired from MSBRS database from 1989 to 2015. The details of herd management were presented by Jafari et al. (2014). In short, the base animals were purchased at 1989 from local producers. The minimum and maximum of lambing age were 18 and 72 months, respectively. The ewes were selected based on their growth, fleece records, and body measurement traits at their first breeding year. Besides, fertility, fitness, mothering ability, and the records of offspring played main role in the culling of the ewes. The ewes and rams were kept in the herd for a maximum of 6 parity and 4 breeding seasons, respectively.

### 2.2. Traits definition

Nine lifetime reproductive traits (over 2–5 years) were considered in this study. They were: average fertility (FER) = number of successful lambing by the ewe in the first four lambing opportunities divided by 4. The FER trait was calculated for all ewes joined. Practically, most of the fat-tailed sheep breeds including Makuie breed have seasonal breeding, starting late summer (August) and ending early fall (October) within which all ewes are exposed to rams. If an ewe had successful lambing at all of her first four lambing season, her average fertility score was 1 (4 lambing/4 years) whereas an ewe with 3 successful lambings got the score of 0.75 (3 lambing/4 years) etc. Average fecundity (FEC) = number of lambs born alive per ewe lambing in the first four lambing opportunities divided by 4, and this trait was calculated for ewes lambing. Survival (SUR) = average number of lambs weaned in the first four lambing opportunities divided by the number of lambs born. The number of lamb born ranged from 4 to 8 (Lee et al., 2009b). Average stay-ability (STA) = number of lifetime breeding opportunities of the ewe joined divided by 4. The STA determines a ewe chance being in the herd depending on her other merits such as disease resistance along with her reproductive performance since producer may decide to keep a ewe in the herd though she did not have a successful lambing.

The other traits were total female lambs born (TFB), and weaned per the ewe joined (TFW), total weight of lambs born (TWB), and weaned (TWW), and total number of days a ewe was pregnant (TPD). Both TFB and TFW determine an ewe's ability to produce female replacements in the flock which are the main part of the herd.

### 2.3. Statistical analysis

The GLM procedure of SAS (2005) software was used to test significance ($P < 0.05$) of the fixed effects that required to be considered in the animal models. The fixed effects were birth year and birth type of the ewe, and her dam's age with 20, 3, and 6 levels, respectively. Variance and covariance components were estimated based on animal model with restricted maximum likelihood (REML) approach using a derivate-free (DF) algorithm (Meyer, 1989) in WOMBAT package (Meyer 2007). Four different univariate models were fitted for each trait, and they differed in accounting for various random effects. The basic model (I) included individual additive genetic effect; in Models II, III, and IV the random effects of maternal permanent environment, maternal genetic, or both effects were added to the basic model (Meyer, 1992).

The linear forms of the four fitted models were:

$$\text{Model I}: \ Y_{ijklm} = \mu + YR_i + BT_j + AD_k + AN_l + e_{ijklm}$$

$$\text{Model II}: \ Y_{ijklmn} = \mu + YR_i + BT_j + AD_k + AN_l + PE_m + e_{ijklmn}$$

$$\text{Model III}: \ Y_{ijklmn} = \mu + YR_i + BT_j + AD_k + AN_l + M_m + e_{ijklmn}$$