

Analysis of Genetic Relationship between Reproductive vs. Lamb Growth Traits in Makooei Ewes

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ABSTRACT

A selection program is being implemented to improve meat production in Makooei sheep. Increasing litter size per ewe is the main objective, but possible repercussions on weight traits of lambs should be considered. The aim of this study was to estimate heritability along with genetic and phenotypic correlations between ewe's reproductive vs. weight traits in Makooei ewes. Data were comprised of 5,364 records of body weight of lambs from 289 sires and 1,726 dams, plus 3,418 records of reproductive traits from 1,429 ewes collected from 1996 to 2009 from a Makooei flock at Makoo Station in West-Azerbaijan Province. The ewe reproductive traits investigated were Conception Rate (CR), Litter Size at Birth (LSB), Litter Size at Weaning (LSW), Litter Weight at Birth (LWB) and Litter Weight at Weaning (LWW). The lamb traits investigated were Weights at Birth (BW) and at Weaning (WW). Genetic parameters were estimated through REML procedure using ASReml program. The estimates of direct heritability for lamb body weights were 0.15 ± 0.04 at birth and 0.16 ± 0.03 at weaning. The estimates of heritability for reproductive traits varied from 0.05 ± 0.02 for CR to 0.17 ± 0.03 for LWB. Additive genetic correlations between BW and ewe's reproductive traits varied from small to moderate, ranging between -0.14 and 0.22 . Additive genetic correlations between WW and ewe reproduction traits varied from moderate to high, positively ranging between 0.21 and 0.67 . In conclusion, WW could be considered as a selection criterion in indirectly improving the ewe's reproductive traits in Makooei sheep.

Keywords: Birth weight, Ewe reproductive traits, Genetic correlation, Weaning weight.

INTRODUCTION

The efficiency of meat production in sheep is dependent upon reproduction, mothering care, milk production of the ewe, as well as growth rate and survival of the lamb (Rao and Notter, 2000). Several traits have been employed as indicators of ewe reproductivity. Litter size at birth is directly related to ovulation rate, but selection for only this trait would not be enough for an increase in lamb production, since it doesn't include the survival rate and weight of the individual lambs at weaning (Rosati *et al.*, 2002). Litter size at weaning includes survival of lambs at weaning but not the

weight. On the other hand, litter weight of lambs weaned per ewe lambing combines ewe's fertility, survival rate and growth performance of lambs from birth to weaning. Therefore this trait is considered as the most important factor in determining an ewe's reproductivity and therefore economic efficiency in a lamb enterprise. Genetic improvement of ewe reproductive efficiency could be achieved either by direct selection for these traits or by indirect selection for correlated traits which exhibit high and positive genetic correlation with ewe reproductive traits. Direct selection for ewe reproductive traits may be beneficial provided that these traits are of high

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heritability. Estimate records of heritability for ewe reproductive traits generally reported low in literature; ranging from 0.02 to 0.16 for litter size at birth (LSB), between 0.02 to 0.11 for litter size at weaning (LSW), from 0.046 to 0.107 for litter weight at birth (LWB) and between 0.02 and 0.11 for litter weight at weaning (LWW), (Rao and Notter, 2000; Hanford *et al.*, 2003; Van Wyk *et al.*, 2003). Another challenge in direct selection for ewe reproductive traits is the assessment of these traits which can be carried out only at a relatively late stage in life, and therefore early selection for these traits based on an individual's performance is not possible. On the other hand, while direct selection for ewe reproductive traits is planned, genetic correlations between these traits and other economically important traits should be taken into account. If there exist genetic antagonisms among ewe reproductive traits and other economically important traits, direct selection for increased ewe reproductive efficiency may lead to correlated decrease in these traits. Hence, a knowledge of genotypic as well as phenotypic correlations is important for multiple trait evaluation and for predicting correlated responses to selection (Olivier *et al.*, 2001). This study was conducted to estimate the genetic and phenotypic correlations among ewe reproductive traits vs. birth and weaning weights in Iranian Makooei sheep.

MATERIALS AND METHODS

Data and Management

The data set employed in this study consisted of 5,364 records of birth weight, 4,261 records of weaning weight of lambs born to 289 sires and 1,726 dams, along with 3,418 records of reproductive traits from 1,429 ewes collected from 1996 to 2009 inclusive, from a Makooei research flock at the Makoo Research Station in West-Azerbaijan Province of Iran. The flock was managed under a semi-migratory system.

The breeding period extended from late August to late October (20-25 ewes randomly assigned randomly to every one ram) and consequently, lambing being started in late January. Young ewes are mated to lamb for the first time at approximately 1.5 years of age. Ewes are supplemented, depending upon the ewes' requirements, for a few days after lambing. The lambs are identified at birth day with birth weights, as well as sex, birth type and pedigree information recorded. During the suckling period, lambs are fed with their mothers' milk while being allowed dry alfalfa after 3 weeks of age. Lambs are weaned at approximately 100 days of age. Animals are kept on natural pasture during spring, summer and autumn seasons. Since environmental conditions are adverse during the winter, therefore the animals are kept indoors during the three winter months.

Experimental Traits

The ewe reproductive traits investigated were Conception Rate (CR, denoted as 1 or 0, for an ewe mated to a ram that did or did not become conceived), Litter Size at Birth per each ewe lambing (LSB, 1, 2 or 3), Litter Size at Weaning per ewe lambing (LSW, 0, 1, 2 or 3), Litter Weight at Birth (LWB) and Litter Weight at Weaning (LWW). Throughout the study, the relationships between ewe reproductive traits and own Birth Weight (BW) as well as Weaning Weight (WW) were also analysed. The data utilized in the analyses are presented in Table 1.

In the calculation of *LWB* and *LWW* for each ewe within a specific lambing year, the contrast values for sex of lambs for birth and weaning weights of lambs were initially determined by least squares procedures. Individual birth and weaning weights of the lambs were then corrected according to these values. Finally, these adjusted birth and weaning weights were used to calculate the *LWB* and *LWW* for each ewe within a specific lambing year.

Table 1. Number of records of Mean, Standard Deviation (SD) and Coefficient of Variation (CV) for reproductive traits in Makooei ewes.

Trait	No. of records	No. of ewes	No. of sires of the ewes	Mean	SD ^h	CV ⁱ (%)
BW ^a (kg)	5364	1726	289	4.16	0.57	13.70
WW ^b (kg)	4261	1280	227	21.73	4.81	22.13
CR ^c	3418	1429	206	0.93	0.26	27.95
LSB ^d	2836	1304	197	1.16	0.39	33.62
LSW ^e	2836	1304	197	0.98	0.47	47.95
LWB ^f	2746	1387	188	4.29	1.68	39.16
LWW ^g	2647	1387	188	26.44	8.43	31.88

^a Birth Weight; ^b Weaning Weight; ^c Conception Rate; ^d Litter Size at Birth; ^e Litter Size at Weaning; ^f Litter Weight at Birth; ^g Litter Weight at Weaning; ^h Standard Deviation; ⁱ Coefficient of Variation.

Statistical Analysis

The GLM procedure of SAS (2003) was applied to identify important fixed effects to be considered in the final model. The statistical model included: year of lambing; age of dam (2-6 and ≥ 7); sex of lamb (male or female); type of birth (single or multiple) as well as age (in days) as covariates regarding lamb weights at weaning. For reproductive traits the factors included were: year of ewe lambing and age of ewe (age of lamb was included as a covariate in the models used in analyzing LWW). All the effects were significant ($P < 0.05$) and hence included in the animal model. (Co)Variance components and correlations were estimated from an animal model in a bivariate analysis, using the restricted maximum likelihood method (ASReml program of Gilmour *et al.*, 2006). Two different animal models were employed. Tests of significance of each random effect were performed using log likelihood ratio tests after including each random effect (excluding residual) to the fixed effects' model. An effect was considered significant when its inclusion in the model caused a significant increase in the log likelihood. A Chi-square distribution for $\alpha = 0.05$ and appropriate degrees of freedom (1) were utilized as the critical test statistics. When double the difference between log likelihood was greater than the critical value the

inclusion of the effect was considered significant. When differences between log likelihoods were not significant the model with the fewest random effects was chosen. The following bivariate animal models constituted fitted ones:

$$y_i = X_i b_i + Z_i a_i + M_i m_i + e_i$$

$$y_i = X_i b_i + Z_i a_i + W_i pe_i + e_i$$

Where, y_i , b_i , a_i , pe_i , m_i and e_i are the vectors of observations, fixed effects, direct additive genetic effects, permanent environmental effects due to repeated records for reproductive traits, maternal additive genetic effects for lamb traits, and residual random effects for the i th trait, respectively. Incidence matrices X_i , Z_i , W_i and M_i are related to the observations of the i th trait as regards the respective fixed effects, additive genetic effects, permanent environmental effects, and maternal genetic effects, respectively. The Average Information (AI) REML algorithm was used to maximize the likelihood (convergence criterion being 10^{-8}) and additional restarts were performed until no further improvement in log likelihood occurred.

RESULTS AND DISCUSSION

Results of variance analyses indicated that the age of dam, year of birth, type of birth and sex exerted significant effects on growth traits ($P < 0.01$). Also, the effects of year and age of ewe were significant ($P < 0.01$) for CR, LSB and LSW and as well the effect of



production years were significant on *LWB* and *LWW* ($P < 0.05$).

The least square means of lamb traits increased with the age of dam, the highest means occurring in the 6-year old dam group. Single-born male lambs were heavier than multiple-born female ones for all ages. The least square means of reproductive traits increased with the age of the ewe, the highest occurring in four to six year old ewes. Male lambs benefitted from a higher litter weight at birth and at weaning than the female ones. Due to variations in climatic conditions, the effects of the year of lamb birth and ewe lambing were highly significant on all lamb characteristics, including reproductive traits.

Estimates of direct heritability, maternal heritability, permanent environmental variance as proportion of phenotypic variance as well as repeatability for lamb body weight and reproductive traits are presented in Table 2. Estimates of direct heritability for *BW* (0.15) were in agreement with those reported by other researchers (Hanford *et al.*, 2006; Mohammadi *et al.*, 2011). Higher estimates for direct heritability of *BW* (Gowane *et al.*, 2011) and lower corresponding values (Mohammadi *et al.*, 2010) have also been reported. Obtained values for maternal heritability regarding *BW* (0.08) were in match with estimates of Kushwaha *et al.* (2009) and Mohammadi *et al.* (2010). The importance of maternal

effects at birth reflects differences in the uterine circumstances, including the quality and capacity of the uterine space, for growth of the fetus. In the present study the *BW* was only significantly influenced by maternal genetic effects. The obtained value (0.16) for direct heritability of *WW* was in agreement with several reports for various tropical sheep breeds, fitting models that accounted for maternal effects (Mohammadi *et al.*, 2010; Kariuki *et al.*, 2010). Higher (Eskandarinasab *et al.*, 2010) and lower values (Jafaroghli *et al.*, 2010) have also been published in the literature.

Heritability estimate for *CR* was recorded as 0.05 ± 0.02 in the study. Coefficients of heritability of this trait in Australian Merino sheep was 0.04 (Safari *et al.*, 2007), which is consistent with the results of this study. Conception rate is of great economic importance. However, because the estimate of its heritability is quite low, the genetic progress through the method of "within flock selection" would be low.

Estimate of heritability for *LSB* was 0.11 ± 0.01 . In two separate studies the heritability for weighted means of *LSB* were reported as 0.13 and 0.10 (Fogarty, 1995; Safari *et al.*, 2005), that were in agreement with the results in this study. The heritability estimates for *LSW* (0.06 ± 0.01) was higher than those recorded in literature (Fogarty, 1995; Safari *et al.*, 2005). Therefore, improving multiple births in Makooei sheep

Table 2. Variance component and genetic parameter estimates for traits studied fitting the most appropriate model.

Trait ^a	σ_a^2 ^b	σ_m^2 ^c	σ_{pe}^2 ^d	σ_e^2 ^e	σ_p^2 ^f	$h_a^2 \pm SE$	$h_m^2 \pm SE$	$pe^2 \pm SE$ ^g	r^j
<i>BW</i>	0.54	0.31	-	2.62	3.47	0.15 ± 0.04	0.08 ± 0.02	-	-
<i>WW</i>	2.39	-	1.03	11.10	14.52	0.16 ± 0.03	-	-	-
<i>CR</i>	0.92	-	0.63	14.57	16.13	0.05 ± 0.02	-	0.03 ± 0.02	0.10
<i>LSB</i>	0.60	-	0.26	4.66	5.33	0.11 ± 0.01	-	0.04 ± 0.01	0.16
<i>LSW</i>	1.65	-	3.17	22.36	26.19	0.06 ± 0.01	-	0.12 ± 0.01	0.21
<i>LWB</i>	4.73	-	2.43	18.52	27.13	0.17 ± 0.03	-	0.08 ± 0.02	0.38
<i>LWW</i>	5.88	-	1.94	38.44	47.36	0.12 ± 0.02	-	0.04 ± 0.01	0.20

σ_a^2 : direct genetic variance; σ_m^2 : maternal additive genetic variance; σ_{pe}^2 : maternal permanent environmental variance; σ_e^2 : residual variance; σ_p^2 : phenotypic variance; h_a^2 : direct heritability; h_m^2 : maternal heritability; pe^2 : ratio of maternal permanent environmental effects to phenotypic variance; r : repeatability; S.E.: standard error.

^aFor trait abbreviations see footnote of Table 1.

through genetic means would be expected as slow.

The estimate of heritability for *LWB* was 0.17 ± 0.03 , consistent with average, reported by Fogarty (1995) and weighted means by Safari *et al.* (2005). The estimate of heritability for *LWW* (0.12 ± 0.02) is similar to that reported by Vanimisetti *et al.* (2007) in Katahdin breed (0.12) and to that reported by Lôbo *et al.* (2009) in multi-breed meat sheep population (0.11). *LWW*, compared to the other reproductive traits could be considered as the most suitable criterion for selection because it is indicative of the overall reproductive potential traits in ewes in terms of weights of lambs produced per parity, even though it does not take into account *CR*.

The trait exhibits a low heritability estimate, possibly due to such environmental effects as creep feeding from 30 days of age until weaning.

Repeatability estimates for reproductive traits obtained in the current study ranged from 0.10 for *CR* to 0.38 for *LWB*. They were similar to previously reported estimates (Fogarty, 1995).

Heritability estimates for lamb body weight and reproductive traits obtained throughout the study indicated that, lamb

body weight traits gave higher responses to selection, in comparison with reproductive ones, because of their higher heritabilities. Also, selection based upon lamb body weight leads to faster genetic progress due to the fact that the body weight of lambs can be assessed at earlier stages in life, thus reducing generation intervals.

The estimates of correlations between lamb body weight and reproductive traits are exhibited in Table 3. Estimates of genetic correlation between pairs of ewe reproductive traits were found to be pronounced and positive. Among pairs of ewe reproductive traits, estimate of additive genetic correlation between *LSB* and *LWB* was recorded the highest (0.92).

Estimate of genetic correlation between *LSB* and *LSW* obtained in the study (0.91) was in agreement with the estimate of 0.96 reported for Dormer sheep (Van Wyk *et al.*, 2003), and an estimate of 1.00 reported for Columbia sheep (Bromley *et al.*, 2000). The current estimate was also equal to the average estimate of 0.91 reported by Fogarty (1995), who summarized the genetic parameter estimates reported by various authors. Hanford *et al.* (2003) for Targhee ewes and Bromley *et al.* (2000) for Polypay, Rambouillet and Targhee ewes reported high

Table 3. Estimates of genetic correlations (above diagonal), phenotypic correlations (below diagonal) and standard errors of estimates (brackets) between lamb body weight and reproductive traits.

Trait ^a	BW ^b	WW ^c	CR ^d	LSB ^e	LSW ^f	LWB ^g	LWW ^h
BW	-	0.63 (0.02)	0.20 (0.08)	-0.07 (0.01)	-0.14 (0.05)	0.22 (0.08)	-0.03 (0.09)
WW	0.63 (0.02)	-	0.21 (0.09)	0.36 (0.08)	0.43 (0.05)	0.37 (0.06)	0.67 (0.03)
CR	0.09 (0.02)	0.05 (0.02)	-	-0.04 (0.02)	-0.02 (-0.01)	-0.13 (0.03)	-0.09 (0.05)
LSB	-0.08 (0.02)	0.03 (0.03)	0.05 (0.02)	-	0.91 (0.06)	0.92 (0.07)	0.71 (0.07)
LSW	-0.02 (0.02)	0.025 (0.02)	0.11 (0.03)	0.34 (0.04)	-	0.79 (0.05)	0.89 (0.05)
LWB	0.02 (0.03)	0.04 (0.03)	0.10 (0.03)	0.33 (0.03)	0.47 (0.03)	-	0.84 (0.02)
LWW	0.02 (0.01)	0.04 (0.02)	0.04 (0.02)	0.30 (0.03)	0.42 (0.04)	0.30 (0.03)	-

^a For trait abbreviations see footnote, Table 1. ^b Birth Weight; ^c Weaning Weight, ^d Conception Rate; ^e Litter Size at Birth; ^f Litter Size at Weaning; ^g Litter Weight at Birth; ^h Litter Weight at Weaning.



and positive estimates, ranging between 0.58 and 0.77 with these estimates being lower than the current ones.

The evaluation of the genetic correlation between *LSB* and *LWB* throughout the current study was pronounced and positive (0.92), and as well comparable to the estimate of 0.78 by El Fadili and Leroy (2001), who also reported a high record.

Estimates of genetic correlation between *LSB* and *LWW* in literature are recorded as high and positive. The reports of other authors (Olivier *et al.*, 2001; Van Wyk *et al.*, 2003) ranged between 0.51 and 0.91. An estimate of 0.71 repeatedly found in the current study was within the range found in literature.

Genetic correlation between *LSW* and *LWB* in the current study, being high and positive (0.79), was in agreement with the reports of El Fadili and Leroy (2001). However, the figure was higher than the values of 0.12 and 0.31 reported for crossbred ewes (Rosati *et al.*, 2002).

The genetic correlation between *LSW* and *LWW* in the study (0.89) was in agreement with the estimates of van Wyk *et al.* (2003) for Dormer sheep, El Fadili and Leroy (2001) for D'man×Timahdite crosses and of Bromley *et al.* (2001) for Columbia, Polypay, Rambouillet, and Targhee sheep, who reported the figures between 0.85 and 0.99.

As observed in other pairs of ewe reproductive traits, the genetic correlation between *LWB* and *LWW* was high and positive (0.84), similar to literature estimates (El Fadili and Leroy, 2001). Genetic and phenotypic correlations for CR and other traits were in general either negative or very low, in agreement with other reports (Vatankhah *et al.*, 2008) but much lower than the weighted means in the literature (Safari *et al.*, 2005). The low genetic correlation observed is partly due to the measurement method of the traits. Also ewes either not able to lamb by 2 years of age or undergo possible successive lambing times which were culled from the experiment could influence the assessment of

heritability and genetic correlations. The low estimation of genetic variances for CR and other reproductive traits could account for an important factor for the low heritability and genetic correlation among traits.

The positive and high estimates of the genetic correlation between pairs of ewe reproductive traits found in the current study indicate that a selection programme aiming at an improvement of either one of these traits may increase the genetic merit of other ewe's reproductive traits.

Estimates of phenotypic correlation between pairs of ewe reproductive traits found in the current study ranged between 0.04 and 0.47, which were within the range reported (between 0.46 and 0.96) in literature (El Fadili and Leroy, 2001; Olivier *et al.*, 2001; Van Wyk *et al.*, 2003). Such positive and high phenotypic correlations between pairs of ewe reproductive traits could be expected as all of these traits were composite ones comprising various combinations of ewe reproductivity, lamb growth or survival rates. The high and positive phenotypic correlation among ewe reproductive traits indicates the environmental effects that could promote one of these traits could also exert positive effects on the other traits.

BW in Makoei sheep proved a negative genetic correlation with *LSB*, *LSW* and *LWW* (-0.07, -0.14 and -0.03, respectively). Similar to current estimates, Bromley *et al.* (2000) reported low to moderate the genetic correlation between *BW* and *LSB* (-0.01 to 0.26) and as well between *BW* and *LSW* (-0.37 to 0.01) for Columbia, Polypay, Rambouillet and Targhee sheep breeds. However, estimate of genetic correlation between *BW* and *LWB* in the current study was moderate and positive (0.22). The results in the present study indicate that selection for an improvement of *BW* would have little influence on genetic response in litter weight at birth.

The genetic relationships were, in general, more pronounced for growth traits at weaning weight and for the ewe's reproductive traits.

Estimates of genetic correlation between *WW* and ewe's reproductive traits in literature were very varied. These estimates ranged from 0.07 to 0.40 for genetic correlation between *WW* and *LSB* (Ap-Dewi *et al.*, 2002; Hanford *et al.*, 2003; Van Wyk *et al.*, 2003) from 0.15 to 0.43 for genetic correlation between *WW* and *LSW* (Rao and Notter, 2000; Hanford *et al.*, 2003), and from 0.10 to 0.67 for genetic correlation between *WW* and *LWW* (Rao and Notter, 2000; Olivier *et al.*, 2001; Ap-Dewi *et al.*, 2002). Estimates of genetic correlation between *WW* and *LSB* or *LSW* obtained in the current study stood at the high side of the range of literature estimates. However, the positive and high estimate of genetic correlation between *WW* and *LWW* (0.68) in the current study was more pronounced than those reported in literature.

Among pairs of weight and ewe's reproductive traits, the greatest genetic correlation was observed between *WW* and *LWW* (0.68). *LWW* is a composite trait of litter size and average weaning weight of lambs in the litter. The high genetic correlation between *LWW* and *WW* indicates that the main component of *LWW* is *WW*. Therefore, selection on *WW* would have highly positive correlated response in *LWW*. Furthermore, in a study carried out in the same flock as that in the current study, Ozcan *et al.* (2005) reported that *WW* exhibited high and positive genetic correlation with *BW* (0.79), yearling weight (0.58) and average daily gain from birth to weaning (0.98), and if *WW* was used as a selection criterion, all these traits could be indirectly improved. Hence, *WW* could be considered as the selection criterion to improve both lamb growth and ewe's reproductive traits in Makooei sheep.

CONCLUSIONS

The heritability estimates obtained for lamb growth and ewe's reproductive traits in the present investigation indicated that responses to selection for traits of lamb

growth were more highly pronounced than the responses to selection for the reproductive traits. Birth weight did not exhibit a high genetic correlation with ewe's reproductive traits; moreover it was in negative genetic correlation with *LSB* and *LSW*. The estimates of genetic correlations between weaning weight and various reproductive traits were positive, ranging from moderate to high. Estimates of genetic correlations between weaning weight and reproductive traits, especially litter weight at weaning as net reproductive (ewe productivity), were high and positive, suggesting that selection based upon increasing weaning weight may increase genetic merit in ewe reproductive traits. Therefore, weaning weight could be considered as a selection criterion to indirectly improve the reproductive traits (ewe's reproductivity) in such breeds of sheep as Makooei that are of low twinning rates.

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آنالیز رابطه ژنتیکی بین صفات تولیدمثلی و صفات رشد در میش‌های نژاد ماکویی

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چکیده

برنامه انتخاب برای بهبود افزایش تولید گوشت در گوسفند نژاد ماکویی در حال اجرا است. افزایش تعداد بچه به ازای هر میش از اهداف اصلی این برنامه می‌باشد، اما باید عواقب احتمالی آن بر صفات وزن بدن بچه‌ها در نظر گرفته شود. هدف از مطالعه حاضر برآورد وراثت‌پذیری و همبستگی‌های ژنتیکی و فنوتیپی بین صفات تولیدمثلی میش با صفات وزن بدن در گوسفند ماکویی می‌باشد. در این مطالعه از ۵۳۶۴ رکورد وزن بدن حاصل از ۲۸۹ رأس قوچ و ۱۷۲۶ رأس میش و ۳۴۱۸ رکورد صفات تولید مثلی حاصل از ۱۴۲۹ رأس میش گله ماکویی ایستگاه پرورش و اصلاح نژاد گوسفند ماکویی واقع در ایستگاه ماکو در استان آذربایجان غربی طی سال‌های ۱۳۷۵ تا ۱۳۸۸ جمع‌آوری شده بود، استفاده گردید. صفات تولیدمثلی میش مورد مطالعه در این تحقیق شامل میزان آبستنی، تعداد بچه متولد شده به ازای هر میش مورد آمیزش، تعداد بچه شیرگیری شده به ازای هر میش مورد آمیزش، کل وزن تولد به ازای هر میش مورد آمیزش و کل وزن شیرگیری به ازای هر میش مورد آمیزش بودند. صفات وزن بدن در این مطالعه شامل وزن تولد و وزن شیرگیری بودند. پارامترهای ژنتیکی با استفاده از روش حداکثر درست‌نمایی محدود شده و برنامه ASReml برآورد گردید. وراثت‌پذیری مستقیم برای صفات وزن تولد 0.15 ± 0.04 و وزن شیرگیری 0.16 ± 0.03 برآورد گردید. وراثت‌پذیری صفات تولید مثلی از 0.05 ± 0.02 برای میزان آبستنی تا 0.17 ± 0.03 برای کل وزن تولد به ازای هر میش مورد آمیزش متغیر بود. میزان همبستگی ژنتیکی افزایشی بین وزن تولد با صفات تولیدمثلی کم تا متوسط و دامنه آن بین $0.145 - 0.224$ بود. میزان همبستگی ژنتیکی افزایشی بین وزن شیرگیری با صفات بهره‌وری میش متوسط تا بالا و دامنه آن بین 0.210 تا 0.679 بود. در نتیجه، وزن شیرگیری می‌تواند به عنوان معیار انتخاب غیر مستقیم برای بهبود صفات تولید مثلی میش در گوسفند ماکویی در نظر گرفته شود.