J. Agr. Sci. Tech. (2012) Vol. 14: 549-556

Inbreeding and Inbreeding Depression in Iranian Moghani Sheep Breed

M. Dorostkar[1], H. Faraji Arough[2*], J. Shodja[1], S. A. Rafat[1], M. Rokouei[3], and H. Esfandyari[2]

ABSTRACT

The objective of this study was to determine the inbreeding depression on growth traits in Moghani sheep. Pedigree information of 8836 animals collected during the years of 1987 to 2006 by Moghani Breed Center in Jafar Abad Moghan, were used for analysis. The base population year was 1988. Analysis of the records was performed by ASReml software. Inbreeding depression was estimated as the regression of performance on the individual inbreeding coefficients via fitting an animal model. The mean inbreeding for all animals, females and males, were 0.500, 0.515 and 0.484 %, respectively. Totally, 24.22 % of all the animals were inbred. The mean of inbreeding for inbreed animals was 2.062 %. The rate of increased inbreeding per year for all animals was 0.05%. The inbreeding depression for body weight traits at birth, 3, 6, 9 and 12 months of age was , respectively, -0.007, - 0.291, - 0.026, -0.018 and -0.041 kg, per 1% increase in individual coefficient.

Keywords: Inbreeding, Inbreeding depression, Moghani sheep, Growth traits.

INTRODUCTION

Inbreeding is defined as the probability that two alleles at any locus are identical by descent and occur when related individuals are mated to each other (Falconer and Mackay, 1996). The initial consequence of inbreeding is inbreeding depression, which reduces the performance of growth, production, health, fertility and survival traits. This concern has become more serious in present day animal breeding, in which selection responses are maximized by the use of animal model best linear unbiased predictors (BLUP) of breeding value. The use of these breeding values alone may result in more closely related selection candidates preferred for selection, with increased levels of inbreeding since they share most of their familial information (Fernandez and Toro, 1999).

The rates of inbreeding must be limited to maintain diversity at an acceptable level so that genetic variation will ensure that future animals can respond to changes in environment (Van Wyk *et al*., 2009).

Estimates of inbreeding depression on birth weight and weaning weight reported in several literature (Alsheikh, 2005; Van wyk *et al*., 2009; Swanepoel *et al*., 2007; Norberg and Sorenson, 2007; Barkzak *et al*., 2009). There have been limited studies on the effect of inbreeding on body weight traits at 180, 270, and 365 days of age (Akhtar *et al*., 2000; Mandal *et al* 2002). The Moghani breed is a meat breed. This breed is mainly raised in Ardebil Province in Iran. For this sheep, early growth weight has an important role in profitability of the farms. In recent years, selection of superior animals in Jafar Abad station for this breed has caused increasing possibility of close mating among

[1] Department of Animal Science, Faculty of Agriculture, University of Tabriz, Tabriz, Islamic Republic of Iran.
[2] Department of Animal Science, Faculty of Agriculture, Ferdowsi University of Mashhad, Mashhad, Islamic Republic of Iran.
[*] Corresponding author; e- mail: hadifaraji.um@gmail.com
[3] Department of Animal Science, Faculty of Agriculture, University of Zabol, Zabol, Islamic Republic of Iran.

the animals. Thus, the mating of animals more closely related in this breed has resulted in higher inbreeding coefficient.

The aims of this study were: (i) to quantify the increase of inbreeding during the years of study, and (ii) to estimate the effect of inbreeding depression on body weight at the ages of birth(BW), 3 (BW3), 6 (BW6), 9 (BW9) and 12 months (YBW) in Moghani sheep breed in Jafar Abad Station.

MATERIALS AND METHODS

Computation of Inbreeding Coefficients

Pedigree of 8836 animals from 402 sires and 2665 dams, collected in Moghani Breed Station in Jafar Abad Moghan, during years of 1987 to 2006, were used to compute inbreeding coefficients. In the pedigree 22.50 % of the animals had unknown sire, 11.60 % of animals had unknown dam and for 11.50 % both parents were unknown. 1015 animals (Table 1) were foundation animals. These animals had unknown parents and inbreeding coefficients for these animals were zero. Animals with unknown parents were also included in the number with unknown sires and in the number of unknown dams.

Computation of Pedigree Completeness Index

As the quality of pedigree information is of great importance in assessing inbreeding level and trends in inbreeding, a coefficient of pedigree completeness (PEC) was computed and the degree of completeness of pedigree was detected using the index proposed by MacCluer *et al*., (1983):

$$PCI_{animal} = \frac{2C_{sire}C_{dam}}{C_{sire} + C_{dam}}$$

Where, C_{sire} and C_{dam} are contributions from the paternal and maternal lines, respectively. The contributions are computed as:

$$C = \frac{1}{d}\sum_{i=1}^{d} g_i ,$$

Where, g_i is the proportion of ancestors present in generation i and d is the total number of generations taken into account. In this study, 5 ancestor generations were considered (d = 5). The average pedigree completeness index for the 5 generations was calculated according to the birth year. The EVA software (Berg *et al*., 2007) was used for computation of PCI. The modified algorithm of Colleau was used to estimate individuals inbreeding coefficient (CFC software, Sargolzaei *et al*., 2006). Description of pedigree is presented in Table 1.

Estimation of Inbreeding Depression

Details of data used for estimation of inbreeding depression are given in Table 2, where the number of records is shown after editing i.e. animals with unknown sex and liter size = 0 and animals with weight > weight at the same month ± 3SD are deleted. The mean inbreeding for the animals with records is higher than the mean inbreeding for all the animals. The low CV for all traits shows that the traits are not variable. Maximal body

Table 1. Data description of the studied Moghani sheep flock.

	n	% of total	Mean of inbreeding (%)
Total number of animals	8836	100	0.500
Non inbreed	6696	75.78	0.000
Inbreed	2140	24.22	2.062
Number of animals with unknown sires	1988	22.50	-
Number of animals with unknown dam	1025	11.60	-
Number of animals with both parents unknown (foundation animals)	1015	11.50	-

Table 2: Number of observations, mean, standard deviation and mean of inbreeding coefficient of traits.

	BW	BW3	BW6	BW9	YBW
No. records	5329	5071	4252	2235	1843
Mean(kg)	4.58	22.46	34.63	37.53	38.86
SD(kg)	0.78	5.05	6.31	5.6	6.09
CV (%)	17.03	22.48	18.22	14.92	15.67
Min(kg)	1.8	9.5	13	18	21.7
Max(kg)	7.5	42	56	55.7	71
Mean F (%)	0.694	0.683	0.691	0.702	0.755

weight at 9 months was lower than that at 6 months (Table 3). There are fewer records at 9 months than at 6 months, possibly because the heavier animals at 8 or 9 months of age were sent to the market. Based on the distribution of inbreeding coefficients, the animals were divided into 6 classes of inbreeding (F=0, 0<F<6.25, 6.25≤F <12.50, 12.50≤F <18.75, 18.75≤F<25.00 and F≥25.00) (Table 4). The following model was used for analysis of inbreeding depression effects on body weight traits in all animals:

$Y_{ijklmnopq} = \mu + YS_i + S_j + T_k + b_1 (DW_m) + b_2 (DD_n) + b_3 (AF_o) + a_p + e_{ijklmnopq}$

Where,

$Y_{ijklmnopq}$ is body weight record of animal p, YS_i = the effect of year- season of birth (24 levels), S_j = effect of sex, T_k = type of birth (4 levels), DW_m = days of weighting at various traits (except of birth weight) in animal p, DD_n = age at lambing (in days) of dam n, AF_o = inbreeding of animal o, a= additive genetic effect, and e = residual effect. Also b_1, b_2, and b_3 were regression coefficient traits of age of weighting, dam age at lambing and inbreeding of the animal, respectively. In this model, fixed effects were lamb's sex, litter size, and year- season of birth. DW_m, DD_n and AF_o were fitted as covariates in the model. ASREML software (Gilmour *et al*., 2000) was used for the analysis.

Breeding system in Moghani breed is winter and summer system. In this station, all animals used pasture in summer. In winter, handy feeding was used. In the late summer, male and female animals were maintained together. This breed is out of season lambing but lambing in the middle of winter is more frequent than in other seasons. All the lambs were weaned around 90-110 days. In current years, synchronization was used in this breed. The animals were vaccinated against Enterotoxaemia, Foot and Mouth disease, Sheep Pox, Pleuro-Pneumonia and Haemorrhagic Septicaemia. Mating system in this breed is random mating.

RESULT AND DISCUSSION

The completeness of pedigree was low for this breed (Figure 1). The PCI value for 5 generations was approximately 0.31.

Average of PCI for 2002- 2006 was 0.53. The trend of PCI for 2000- 2006 was increasing. Arnason and Jonmundsson (2008) reported 0.4 for PCI in Iceland sheep. Norberg and Sorenson (2007) and Li *et al*., (2009) used animals with PCI values greater than or equal to 0.9 and 0.6, respectively, for estimation of inbreeding depression. Low estimates of inbreeding coefficient for this breed could be due to low PCI value.

Descriptive statistics for inbreeding coefficients for the whole population and the inbred population are shown in Table 5. The mean of inbreeding coefficient in females and males was 0.515 and 0.484 %, respectively. Totally, 24.21% of the animals were inbred with mean inbreeding coefficient of 2.062%. This illustrated that some matings of close relatives occurred, but, the number of these matings was low. Coefficient of inbreeding in this study is lower than in other published results (Rzewuska *et al*, 2005; Swanepoel *et al*, 2007; Norberg and Sorenson, 2007). The estimates were higher than in Baluchi sheep, another Iranian sheep breed (Mehmannavaz *et al*, 2002). This low estimate was due to

Table 3. Distribution of animals in different classes of inbreeding for various weight traits.

	BW		BW3		BW6		BW9		YBW	
Classes of F	% animal	Mean	% animal	Mean	% animal	Mean	% animal	Mean	% animal	Mean
F=0	62.34	4.56[a]	67.47	22.17[ab]	65.59	34.57[b]	71.50	37.66[a]	64.95	39.46[a]
0<F<6.250	34.17	4.61[a]	28.83	23.21[ab]	30.74	34.72[b]	24.34	37.09[a]	30.76	37.66[a]
6.25≤F <12.50	1.95	4.50[a]	2.04	21.10[b]	1.99	33.27[b]	2.37	36.51[a]	2.50	37.12[a]
12.50≤F <18.75	1.33	4.56[a]	1.47	22.94[ab]	1.52	35.60[b]	1.52	39.50[a]	1.63	39.91[a]
18.75≤F<25.00 <,<<18.75	-	-	-	-	-	-	-	-	-	-
F≥25.00	0.21	4.32[a]	0.19	24.89[a]	0.16	40.87[a]	0.27	39.85[a]	0.16	40.67[a]

Difference between two levels of the same factor with different letters are significant at $p<0.01$.

Table 4. inbreeding depression for studied traits per 1 percent increase of inbreeding.

Trait	Regression coefficient(kg) (all animals)	Regression coefficient(kg) (Animals with PCI > 35%)
Birth weight	-0.007± 0.004[ns]	-0.005± 0.004 [ns]
Body weight in 3 month	-0.291± 0.003[*]	-0.006± 0.003 [ns]
Body weight in 6 month	-0.026± 0.044[ns]	- 0.007± 0.004 [ns]
Body weight in 9 month	-0.019± 0.035[ns]	-0.032± 0.040 [ns]
Body weight in 12 month	-0.042± 0.050[ns]	-0.067±0.050 [ns]

* Significantly different from zero at $p<0.05$. ns = No significantly different from zero.

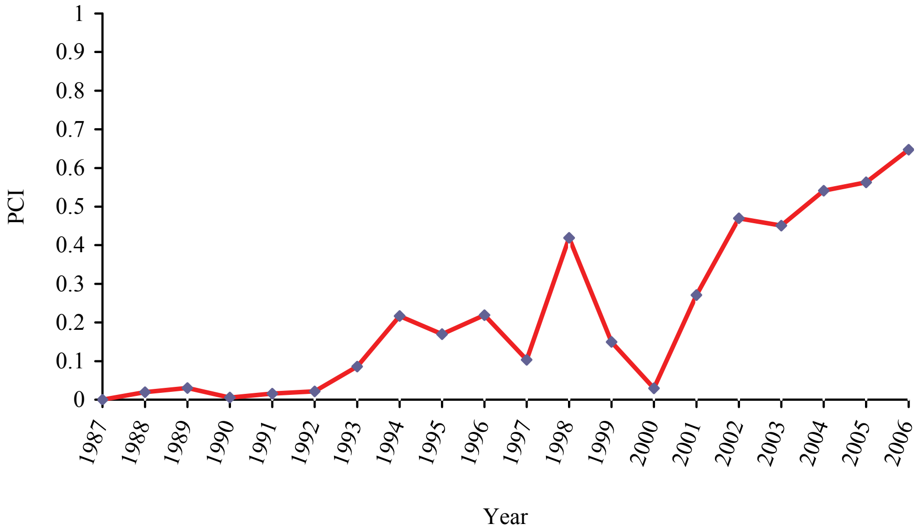

Figure 1. Average pedigree completeness indices (PCI) for each birth year of Moghani Sheep.

Table 5. Descriptive statistics for inbreeding coefficients for the studied population of Moghani sheep.

	all population			Inbred population		
	Female+ male	female	male	Female+ male	female	Male
Animal, no	8836	4367	4469	2140	1091	1049
Mean (%)	0.500	0.515	0.484	2.062	2.062	2.062
SD (%)	1.950	1.960	1.940	3.540	3.490	3.580
Minimum (%)	0.000	0.000	0.000	0.001	0.003	0.001
Maximum (%)	28.00	27.00	28.00	28.130	26.610	28.130

low accuracy of the data recording in the station that caused low pedigree completeness.

Figure 2 shows an increasing trend of the mean inbreeding for all animals, females and males. The maximum inbreeding was observed in 1998 for male animals. Mean inbreeding for males was 0 until 1992. The increasing trend was not regular until 2000, but, afterwards, inbreeding means showed regular increase. The mean level of inbreeding decreased in the year 2000. The reason for this decrease was the prevention of closed mating in sheep by the breeder. In that year, the station began to perform synchronization of ovulation and some female and male animals were imported in the station. This decrease was observed in all females and males and one could say that breeders selected non-related animals for mating. Besides, pedigree completeness went down to almost zero, therefore, even if the animals were related, inbreeding could not be detected. In 2006, the mean inbreeding level for all animals was 0.852 %. This percentage was very low, but it illustrated that the mean of inbreeding had increased compared to the base year of 1988. Annual inbreeding rate for all animals was 0.05 % per year during the 18 years of the study. This estimate of inbreeding rate was less than 0.40, 1.00 and 1.53 % reported by Huby *et al*., (2003), Norberg and Sorenson, (2007) and Van Wyk *et al.*, (2009), respectively.

Inbreeding Depression

Table 3 illustrates the distribution of animals in classes of inbreeding. The maximum number of animals were in the

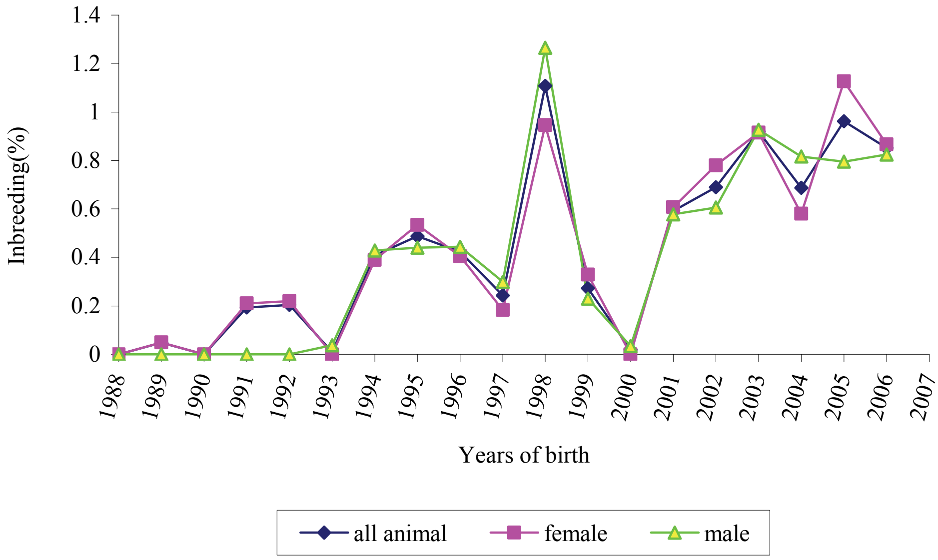

Figure 2. Annual mean of inbreeding for all, female, and male animals.

first class of inbreeding (F=0) and the minimum number of animals was in the sixth class, for all the studied weights. There were no animals in the fifth class i.e 18.75≤F<25.00.

The percent of animals in other classes of inbreeding were between the first and later classes. Mean of BW, BW3 and BW6 traits decreased irregularly by increasing inbreeding coefficient, but, in the cases of BW9 and BW12 traits, decreasing trend was observed from the first to the third class. In the latter classes of inbreeding (F≥25.00), the mean of weight was more than that of the other classes. This could be due to fewer records in these groups (except for the first group).

Regression coefficients per 1 % increase of inbreeding for birth weight, BW in the 3rd , 6th , 9th and in the 12th month were -0.007, -0.291, -0.026, -.019 and -0.042 kg, respectively (Table 4). These regression coefficients show negligible (or insignificant) inbreeding depression.

These estimates were higher than -0.0005 and - 0.006 kg estimated for Baluchi and dormer sheep (Mehmannavz *et al,* 2002; Van Wyk *et al*., 2009), but, lower than those in some other reports (Lamberson and Thomas, 1984; Analla *et al*., 1999; Norberg and Sorensen, 2007; Barkzak *et al*., 2009). Reduction of BW3 by 0.291 kg found in this study was lower than that reported by Awemu *et al*., 1999. The estimate for BW3 was larger than that published by other authors: Lamberson and Thomas reported inbreeding effect of -0.111 kg and Ercanbrack and Knight (1991) reported -0.114, -0.116 and -0.087 kg for Ramboilet, Targhee, and Colombia breed, respectively.

Inbreeding depression for BW6, BW9 and BW12 were -0.026, -0.019 and -0.042 kg per 1% increase in inbreeding coefficient, respectively. Inbreeding depression for body weight at these ages was much less studied and fewer studies reported significant effect of inbreeding (Mandal *et al*., 2002). Akhtar *et al*. (2000) reported that inbreeding depression was 0.093, -0.013 and -0.019 kg for BW6, BW9 and BW12, respectively. Regression coefficients per 1 % increase of inbreeding for animals with PCI> 35% are shown in Table 4. Regression coefficients for BW in the 3rd and 6th month are less than those for all the studied animals. Estimates of inbreeding depression for birth weight and BW in the 3rd and 6th month are low; nevertheless these coefficients are for animals with higher data quality (PCI> 35 %). Thus, low inbreeding depression does not originate from missing pedigree recording, rather, it is due to real lack of effect of these traits in this breed. Regression coefficients for BW in the 9th and 12th month are more than that for all the studied animals. Estimates of -0.032 and -0.067 kg per 1% increase in inbreeding coefficient for BW in 9th month and BW in 12th month are more than the values reported in other studies; but, these effects are not significant effect of inbreeding and it could be said that inbreeding depression for the two traits is true. In the present study, the estimated inbreeding depression was very different from the other studies. The difference could be due to low level of inbreeding or low pedigree completeness.

ACKNOWLEDGEMENTS

The authors thank the Moghani Breed Center in Jafar Abad Moghan for providing the pedigree data and records of weight traits.

REFERENCES

1. Akhtar, P., Ahmad, Z., Mohiuddin, G. and Abdullah, M. 2000. Effect of Inbreeding on Different Performance Traits of Hissardale Sheep in Pakistan. *Pakistan Vet. J.* **20(4)**:169-172.
2. Alsheikh, S. 2005. Effect of Inbreeding on Birth and Weaning Weights and Lamb Mortality in Flock of Egyptain Sheep. Department of Animal Breeding, Desert Research Center. Cario, Egypt. ISAH-Warsaw, Poland. **1**: 187-191.
3. Analla, M., Montilla, J. M. and Serradilla, J. M. 1999. Study of the Variability of the Response to Inbreeding for Meat Production in Merino Sheep. J. Anim. Breed. Genet. **116 (6)**:481- 488.
4. Arnason, T., and Jonmundsson. 2008. Multiple Trait Genetic Evaluation of Ewe Traits in Icelandic Sheep. *J. Anim. Breed. Genet.* **125**: 390-396.
5. Awemu, E. M., Nwakalor, L. N., Abubakar, B. V., and Nsukka, N. 1999. Environmental Effects on Litter Size and Mortality Rate in Yankasa Sheep in the Sub- Humid Zone of Nigeria. *J. Sustainable Agric Environment*. **1(1)**:44- 50.
6. Barczak, E., Wolc, A., Wojtowski, J., and Slosarz, P. 2009. Inbreeding and Inbreeding Depression on Body Weight in Sheep. *J. Anim. Feed. Sci.* **18**:42-50.
7. Berg, P., Sørensen, M. K., and Nielsen, J. 2007. Eva Interface User Manual . 40 pp., http://eva.agrsci.dk/index.html.
8. Ercanbrack, S. K. and Knight, A. D. 1991. Effects of Inbreeding on Reproduction and Wool Production of Rambouilet, Targhee and Columbia Ewes. *J. Anim. Sci.* **69(12)**:4734 – 4744.
9. Falconer, D. S. and Mackay, T.F.C. 1996 .Introduction to Quantitative Genetics. Fourth Edition. Addison Wesley Longman, Harlow, Essex, UK. 464.
10. Fernandez, J . and Toro, M. A. 1999. The Use of Mathematical Programming to Control Inbreeding in Selection Schemes. J. Anim. Breed. Genet. **116**:447-466.
11. Gilmour, A. R., Cullis, B. R., Welham, S. J. and Thompson, R. 2000. ASREML Reference Manual. ftp.res.bbsrc.ac.uk in pub/aar.
12. Huby, M., L. Griffon, S. Moureaux, H. De Rochambeau, C. Danchin Burge, and E. Verrier. 2003. Genetic Variability of Six French Meat Sheep Breeds in Relation to Their Genetic Management. *Genet. Sel. Evol.* **35**:637–655
13. Lamberson, W. R. and Thomas, D. L. 1984. Effects of Inbreeding in Sheep: A Review. Anim. Breed.
14. Li, M. H., Stranden, I., and Kantanen, J. 2009. Genetic Diversity and Pedigree Analysis of the Finnsheep Breed. *J. Anim. Sci.* **87**:1598-1605
15. MacCluer, J. W., Boyce, A. J., Dyke, B., Weitkamp, L. R., Pfennig, D. W., and Parsons, C. J. 1983. Inbreeding and Pedigree Structure in Standardbred Horses. *J. Hered.* **74**, 394–399.
16. Mandal, A., Pant, K.P., Rout, P. K., Singh, S. K., and Roy, R. 2002. Influence of Inbreeding on Growth Traits of Muzaffarangari Sheep. *Indian J. Anim. Sci*.**72**:988-990.
17. Mehmannavaz, Y., Vaez Torshizi, R., Salehi, A., and Shorideh, A. 2002.

Inbreeding and its Effect on Production Traits in Iranian Baluchi Sheep. The first Iranian seminar on genetics and breeding applied to livestock, poultry and aquatics.Agriculture faculty. Tehran University. 263-268.
18. Norberg, E., and Sorensen, A. C. 2007. Inbreeding Trend and Inbreeding Depression in the Danish Populations of Texel, Shropshire, and Oxford Down. *J. Anim. Sci*. **85**: 299-304.
19. Rzewuska K., Klewiec J., Martyniuk E. 2005. Inbred Effect on Reproduction and Body Weight in. a Closed Flock of Booroola Sheep. *Anim. Sci. Pap. Rep.* **23(4)**:237-247.
20. Sargolzaei, M., Iwaisaki, H. and Colleau, J. J. 2006 .A Tool for Monitoring Genetic Diversity. comm. 27-28 in proceeding of the 8th World Conger. Genet Appl. Livest. Pro Belo Horizonte, Brazil.
21. Swanepoel, J. W., Van Wyk, J. B., Cloete, S. W. P., and Delport, G. J. 2007. Inbreeding in the Dohne Merino Breed in South Africa. *South African. J. Anim. Sci.* **37(3)**:176-179.
22. Van Wyk , J. B., Fair, M. D., and Cloete , S. W. P. 2009. Case Study: The Effect of Inbreeding on the Production and Reproduction Traits in the Elsenburg Dormer Sheep stud. *Livest. Sci.* **120(3)**: 218-224.

هم‌خونی و افت هم‌خونی در نژاد گوسفند مغانی ایران

م. درستکار، ه. فرجی آروق، ج. شجاع، س. ع. رفعت، م. رکوعی، ه. اسفندیاری

چکیده

هدف از این تحقیق تعیین افت هم‌خونی بر روی صفات رشد در نژاد مغانی است. اطلاعات شجره ای ۸۸۳۶ حیوان که در طول سالهای ۱۳۶۶ تا ۱۳۸۵ توسط مرکز اصلاح نژاد جعفر آباد مغان جمع آوری شده بود برای آنالیز استفاده شد. سال پایه برای این تحقیق ۱۳۶۷ بود. آنالیز رکورد ها توسط نرم افزار ASReml انجام شد. افت هم‌خونی به صورت تابعیت عملکرد حیوان از ضریب هم‌خونی از طریق برازش در مدل حیوانی بدست آمد. متوسط هم‌خونی برای کل حیوانات، ماده ها و نر به ترتیب ۰/۵۰۰، ۰/۵۱۵ و ۰/۴۸۴ درصد بود. رویهمرفته ۲۴/۲۲ درصد از حیوانات هم‌خون بودند. متوسط هم‌خونی برای حیوانات هم‌خون ۲/۰۶۲ درصد برآورد شد. سرعت افزایش هم‌خونی برای همه حیوانات ۰/۰۵ درصد به ازای هر سال بود. افت هم‌خونی برای افزایش ۱ درصد هم‌خونی حیوان برای وزن تولد، ۳، ۶، ۹ و ۱۲ ماهگی به ترتیب ۰/۰۰۷-، ۰/۲۹۱-، ۰/۰۲۶-، ۰/۰۱۸- و ۰/۰۴۱- کیلوگرم برآورد شد.