Research Article

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THE EFFECT OF INBREEDING ON BIRTH AND WEANING WEIGHTS OF GOKCEADA SHEEP

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ABSTRACT

The objective of this study was to estimate the level of inbreeding and investigate the effect of inbreeding on birth weight (BWT), weaning weight at 90-d (WWT90), and weight gain (PWWG) of pre-weaning period in the conservation programme of flock of indigenous Gökçeada sheep as genetic resources. The pedigree database was based on 557 heads of Gökçeada male and female lambs. The rate of inbreeding was approximately 1.13% per year. Fixed factor on weight traits, together with estimated inbreeding depression was estimated**.** Analysis of variance technique and regression method were used for estimating the effects on weight traits. No significant inbreeding depression was observed in either birth or weaning weights. On contrary, it has been observed that inbreeding had significant impacts on all traits examined. The obtained results might be attributed to improved management and selection manipulations which compensated to any adverse effect of inbreeding. The similar data were obtained for contribution of relatives of dams. Tests of the effect of maternal inbreeding were estimated as similar magnitude to that of above examined traits. Effect of rate of inbreeding depression and weight traits for this breed needs to be recorded and monitored, and the flock size should be increased in the future in Marmara Livestock Research Institute.

Keywords: Inbreeding, Gökçeada sheep, birth weight, weaning weight

GÖKÇEADA KOYUNUNDA AKRABALI YETİŞTİRMENİN DOĞUM VE SÜTTEN KESİM AĞIRLIKLARI ÜZERİNE ETKİSİ

ÖZET

Bu çalışmanın amacı, gen kaynaklarını koruma projesi kapsamında koruma altında tutulan Gökçeada koyun sürüsünde akrabalı yetiştirmenin seviyesinin belirlenmesi ve akrabalı yetiştirmenin doğum (DA), sütten kesim ağırlıklarına (SKA) ve sütten kesim öncesi canlı ağırlık artışı (CCA) üzerine etkilerini araştırmaktır. Çalışmada erkek ve dişi olmak üzere toplam 557 kuzuya ait kayıtlar kullanılmıştır. Akrabalı yetiştirme katsayısının yıl başına yaklaşık artış %1.13 olarak bulunmuştur. Bu çalışmada üzerinde durulan ağırlıklarda akrabalığın etkisinin yanı sıra akrabalı yetiştirme dejenerasyonu da tahmin edilmiştirdi. Bu verilerin değerlendirilebilmesi için varyans analizi ve regresyon metotları kullanılmıştır. Deneme sonunda, DA ve SKA üzerine akrabalı yetiştirmenin olumsuz bir etkisinin olmadığı saptanmıştır. Bunun aksine bu sürüdeki akrabalık düzeyinin DA ve SKA üzerinde olumlu etkilerinin olduğu ortaya konulmuştur. Bu bulguların ışığında, seleksiyon ve yetiştirme koşullarının iyileştirilmesi sonucunda akrabalılı yetiştirmeden dolayı meydana gelmiş olabilecek olumsuzlukların önüne geçilebildiği düşünülmektedir. Analaın akrabalı yetiştirme için de benzer durum ortaya çıkmıştır. Sonuç olarak korumaya alınan bu ırkta, akrabalı yetiştirme sürekli hesaplanmalı ve gözlemlenmeli ve Marmara Hayvancılık Araştırma Enstitüsü'nde bulundurulan hayvanlarda akrabalı yetiştirmenin ileride meydana gelebilecek olumsuz etkisinden kaçınabilmek için sürü büyüklüğü artırılmalıdır.

Anahtar kelimeler: Akrabalı yetiştirme, Gökçeada koyunu, doğum ağırlığı, sütten kesim ağırlığı

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INTRODUCTION

There has been a 47% decrease in sheep population in Turkey during to the last two decades and this decline continues (Anonymous, 2007). White Karaman, Red Karaman, Cine Caparı, Daglic, Karakul, Awassi, Herik, Kivircik, Tuj, Karayaka, Gökçada (Imroz), Hemsin sheep breeds are under risk. Gökçeada breed has been dominant sheep breed in Gökçeada Island (northwest region of Aegean sea) in Turkey (Konyali et al., 2004; Yılmaz et al., 2003). Total size of the population of Gökçeada is about 70.000 heads (Kaymakçı, 2006).

Because of this a genetic resource conservation flock of Gökçeada sheep was started at Marmara Livestock Research Institute (MLRI) in Bandirma/Balikesir, Turkey, for the purpose of genetic conservation, and of study and determination of its characteristics. This flock was transferred from Kumkale State Farm in 1997, and has been maintained in MLRI since then, about 65 heads of ewes and rams, excluding the ewe and rams lambs. Although not frequent, rams or ewes were added to the flock to avoid inbreeding. However, during the past nine years, no new introductions were made and the flock thus became closed. In a breeding program, the inbreeding coefficient (F) and the rate of annual inbreeding (ΔF) should be monitored because of their impact on production (Falconer and Mackay, 1996). Moreover, the ΔF is an indicator of how many years a flock can be kept before reaching a critical level of inbreeding (Pante *et al*., 1998). Konyali *et al*. (2004) stated that inbreeding depression would occur in the flock kept in MLRI due to size of the flock. They also recommended in order for Gökçeada sheep to be used as native genetic resource that the current system should be maintained and supported, where Gökçeada sheep lives in a semi-human controlled environment in Gokçeada Island in Turkey. Indigenous Gökçeada sheep breed is among the smallest sheep breeds in Turkey. Animals are predominantly white, with black marker around the mouth, nose and eyes, on the ears and rarely on the tip of legs. The tail is thin and long, ram has strong spiral horns, ewes are generally polled, but up to 30% of the ewes have small horn. This breed has been raised for milk and lamb production. As a result of crossbreeding and shrinking breeding areas, the number of purebred Gökçeada sheep decreased during the last decade. Because of this, the Gökçeada sheep has been included in the genetic resources project for the conservation of the indigenous breed of Turkey (Yilmaz *et al*., 2003).

Inbreeding has long been considered an important tool to be used in the development of breeding stock with high prepotency and reveal and thus make possible the elimination of hidden genetic defects and to increase the frequency of desirable genes in the population. Unfortunately, the process increases homozygosity for whatever genes are present, including the less desirable ones, with the result that merit typically declines in some traits (Ercanbrack and Knight, 1991). The breeding programs applied today are effective in generating genetic gain; however, they also contribute to an increase in the rate of inbreeding (ΔF). The population size and the ratio of males to females are two important factors that have an effect on ΔF (Falconer and Mackay, 1996; Norberg and Sørensen, 2006). Inbreeding is the mating of related individuals, and results in some loci bearing alleles that are identical-by-descent. The unavoidable mating of related animals in a closed population leads to accumulation of inbreeding and decreased genetic diversity (Falconer and MacKay, 1996; Kathryn and Noter, 2003). Most programs involving domestic animals may try to minimize accumulation of inbreeding and quantify the increase by calculating the change in inbreeding per generation (ΔF) (Boichard *et al*., 1997).

Therefore, the aim of this study was to estimate the levels of inbreeding and to investigate the occurrence of inbreeding depression, if any, in birth, weaning weights, and preweaning weight gain in the genetic resource conservation flock of Gökçeada sheep breed kept in MLRI.

MATERIALS AND METHODS

Data included the performance of 557 Gökçeada ewes and ram lambs born during 11 lambing seasons from 1998 to 2008. Data were collected from a flock of Gökçeada sheep raised at MLRI, which belongs to the Turkish Ministry of Agriculture since 1997. The flock has been maintained for the purpose of genetic resource conservation of the indigenous breed of Turkey since 1997. All ewes were mated to rams for the first time at average age of 18 months. Controlled (hand) mating was applied

once a year between June 15th and August 15th in different years and continued for 45 to 60 days in individual years. All lambs were weighed and ear tagged within 12 h of birth, and kept together with their dam in individual cages for first three days after birth. Then a flock composed of suckling lambs and their dams was formed. All lambs were weaned on the same day within each year, when lambs averaged 90th days of age approximately. Animals were housed in semi-open sheds. Feeds consisted mainly of concentrate feed mixture (16% crude protein, 2600 ME/Kcal/kg) plus alfalfa when available. The rams were selected according to individual performance, and parent-offspring and brothers-sister mating were avoided in order to reduce the inbreeding. Lambing starts in December and completed in two months.

The traits analyzed for inbreeding depression were birth weight (BWT), weaning weight at 90-d (WWT90), and pre-weaning weight gain (PWWG). Birth weight was defined as the live weight of a lamb, in kilograms, measured within 12 h of birth with device sensitive to 100 g. The lambs were weaned around 90th day after birth, live weight was measured and standardized for 90-d for all lambs. Then, WWT90 was defined as the live weight of a lamb, in kilograms. PWWG was defined as the difference between the WWT90 and BWT. All animals with BWT and with/without WWT90 and PWWG were included in the estimation of inbreeding depression.

The algorithm of Boldman *et al*. (1995) was used to calculate the coefficients of inbreeding utilizing pedigree data of all individuals. General Linear Models (GLM) procedure (SAS, 1990) was used to calculate the regression of BWT, WWT90, and PWWG on inbreeding coefficient of animals in order to investigate any association between the performance values and inbreeding coefficients. Assumptions were made that all lambs in the first year (1998) had an inbreeding coefficient of zero. The annual rate of inbreeding was calculated as the regression of average inbreeding coefficient of individuals born in year y on year y.

RESULTS AND DISCUSSION

Table 1 shows that the average inbreeding coefficient (F) was zero until the year 2001, afterwards it increased with the years. The overall inbreeding coefficient of the lambs was 0.0113.

This value was less than the values reported in previous studies 0.0142 by Elshennawy and Raheem (2000), 0.0121 by Fikse et al. (1997), and 0.0072 by Alsheikh (2005), but it was greater than the values reported in other studies 0.009 by Casanova et al. (1992), and 0.008 by Stal et al. (2003)

Table 1. Number of lambs, inbred animals percentage (IA%), average of inbreeding coefficient and standard error (F±SEM), and birth weight and standard error (BWT±SEM), weaning weight at 90-d and standard error (WWT90±SEM), and pre-weaning weight gain and standard error (PWWG±SEM) during the years from 1998 to 2008 of Gökçeada sheep flock at Marmara Livestock Research Institute

Birth years	n	IA%	F±SEM	BWT±SEM	WWT90±SEM	PWWG±SEM
1998	63	0.0	0.000±0.0000	2.53±0.098	28.00±0.7960	25.47±0.805
1999	53	0.0	0.000±0.0000	2.85±0.083	25.23±0.7547	22.39±0.719
2000	68	0.0	0.000±0.0000	2.72±0.068	20.45±0.5673	17.70±0.571
2001	47	0.0	0.000±0.0000	2.99±0.097	22.51±0.6561	19.51±0.637
2002	67	1.0	0.004±0.0037	2.68±0.085	26.24±0.7582	23.54±0.740
2003	57	5.0	0.009±0.0053	2.90±0.095	29.74±0.5731	26.81±0.567
2004	27	11.0	0.009±0.0055	2.99±0.150	21.50±0.9140	18.41±0.907
2005	38	8.0	0.013±0.0079	3.17±0.111	22.37±0.7726	19.15±0.730
2006	34	29.0	0.027±0.0079	3.67±0.120	29.87±0.8371	26.20±0.837
2007	33	64.0	0.044±0.0079	3.63±0.139	29.46±3.2551	25.77±3.276
2008	70	59.0	0.035±0.0050	3.65±0.085	22.48±0.5517	18.80±0.544
Overall	**557**	**15.0**	**0.0113±0.0014**	**2.98±0.034**	**24.89±0.2884**	**21.92±0.287**

Table 2. Sign of regression coefficients of birth weight (BWT), weaning weight at 90-d (WWT90), and pre-weaning weight gain (PWWG) on coefficient of inbreeding of lamb and of dam of the flock of Gökçeada sheep breed from year 2001 to 2008

Traits	Sex	N	F_lamb	F_dam
BWT	Male	130	+ **	-
	Female	146	+ **	+*
	Overall	276	+ **	+
WWT90	Male	114	-	-
	Femle	136	-	+*
	Overall	250	-	+*
PWWG	Male	114	-	-
	Female	136	-	+*
	Overall	250	-	+*

*P<0.05, **P<0.001, F_lamb: inbreeding coefficient of lamb, F_dam: inbreeding coefficient of dam

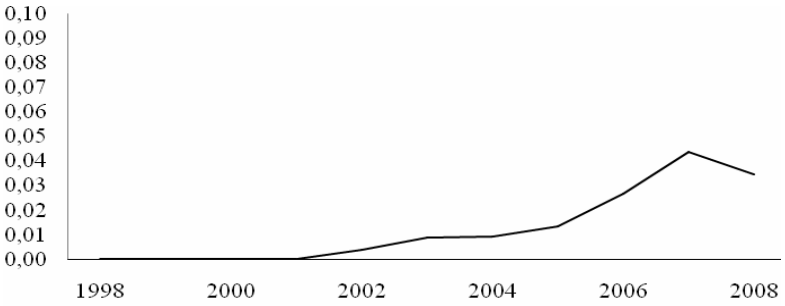

Figure 1. Average inbreeding coefficient during the period from 1998 to 2008 in the flock of Gokceada sheep

Figure 1 illustrates average inbreeding coefficient (F) of animals during the period from 1998 to 2008. The estimates of average inbreeding coefficient of the lambs during the period from 1998 to 2001 were zero. Lamb's inbreeding coefficient increased from 2001 to 2008 (last 8 years).

This result could be attributed to the fact that the flock was newly established and some rams used were selected inside the flock, but the other rams were purchased from outside the flock. In addition, mating plan was applied in order to avoid mating of close relatives. However, during the latter period (2001-2008), the flock was closed and mating plan was held using the animals inside the flock. Thus, the inbred animals were started to emerge even though the mating was planed so as to avoid parent-offspring and brothers-sister relationship to reduce the inbreeding. These were probably resulted from mating of full sibs, with some additional relationship of the parents due to common ancestors further back in the pedigree. It is expected that the level of inbreeding coefficient of the lamb in the coming years will increase (Konyali et al., 2004) with increased relationship between rams and ewes in mating groups unless the size of the flock was increased and avoid mating of relatives.

The effect of inbreeding on BWT, WWT90, and PWWG was investigated only using data obtained from 2001 to 2008 due to the reason that there was no inbreeding until the year 2001. Effect of inbreeding was expressed as linear regression coefficient of

performance values on inbreeding coefficient of the lambs and dams. Thus, in order to avoid underestimating the regression of the performance values on the inbreeding coefficient, it was preferred to use part of the data. The effect of inbreeding on BWT, WWT90, and PWWG is shown in Table 2. The sign of regression of BWT on inbreeding coefficient of lambs was positive and significant ($P<0.001$) for both sexes, but negative and insignificant regression was observed on WWT90 and PWWG. The sign of regression of BWT, WWT90, and PWWG on inbreeding coefficient of dam of the ewe lambs was positive and significant ($P<0.05$), but negative and insignificant regression was observed on ram lambs for BWT, WWT90, and PWWG. The linear regressions indicated that each increase of inbreeding coefficient of the ewe and ram lambs was associated with a significantly higher BWT. In addition, each increase of inbreeding coefficient of dam was associated with a significantly higher WWT90 and PWWG only for ewe lambs. These results are in a conflict with general expectation that the inbreeding has a negative effect on fitness (Falconer and Mackay, 1996; DeRose and Roff, 1996) and performance values in closed populations. Norberg and Sorensen (2007) investigated inbreeding depression in Danish population of Texel, Shropshire and Oxford Down sheep breeds, and found that inbreeding had adverse effect on the mean of all traits investigated for all breeds. Lamberson and Thomas (1984) in a review paper stated that each 1% increase in inbreeding coefficient was associated with -13 g of BWT. The results obtained in this study could be explained by that in closed populations homozygosity increased, the chance of undesired alleles acting together in a certain locus is increased, at the same time it can conveniently be assumed that the chance of desired alleles being in same locus is also increased. In addition, the positive effects of selection and improved management on BWT, WWT90, and PWWG were larger than the negative effect of inbreeding. Since the genetic resource conservation flock of Gökçeada sheep has been established, increased selection for BWT and WWT90 has been applied, and the management has been improved. Consequently, as seen in Table 1, mean value of BWT has been increased from 2.53±0.0975 in 1998 to 3.65±0.0845 in 2008. This result indicated that the selection and improved management had positive effect on BWT which compensated any negative effect of inbreeding (Hussain *et al*., 2006). The same statement could be made about the results reported by Prod'Homme and Lauvergne (1993). They found no inbreeding depression for prolificacy in an inbred population of Merino Rambouillet probably due to same reasons. William *et al*. (1982) reported regression coefficients that have positive effect of dam's inbreeding on birth weight, supporting the findings in this study. In addition, Michelle (2003) reported significant effects of lamb inbreeding on birth, 60 day, and weaning weights while the dam inbreeding had no significant effects on such traits. On the other hand, Kaygisiz et al. (1993) were reported negative effect of inbreeding for the birth weight.

CONCLUSION

Some level of inbreeding might have a positive significant effect on BWT, WWT, and PWWG. In Gökçeada sheep some degree of inbreeding might be required in order to increase birth weight of lamb, and the dams with some degree of inbreeding might have better mothering ability than those with non inbred or highly inbred dams. On the other hand, if no new blood is introduced from outside the flock, the level of inbreeding will continue to increase and its negative effect on these traits is expected to occur in the future. Also, the general policy in the flock should be continue to avoid the mating of closely related rams and ewes, while calculation of inbreeding coefficient in the flock should be carried out annually and the flock size should be increased.

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