

Estimation of inbreeding coefficient and its effects on birth weight and kid survival in Markhoz goats



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Abstract:

Pedigree data of 4186 Markhoz goats which collected from 1993-2012 by Markhoz goat Performance Testing Station in Sanandaj, Kurdistan province of Iran, were analyzed for estimation of inbreeding coefficient and its effects on birth weight (BW) and kid survival (KS). The results showed 58.07% of animals were inbred. The means of inbreeding coefficient for whole and inbred populations were 3.03 and 5.21%, respectively. The trend of inbreeding coefficient was 0.236 ± 0.044 and significant ($P < 0.05$). Maximum of inbreeding coefficient was 31.25%. Effects of inbreeding on BW and KS were estimated by restricted maximum likelihood (REML) method under 12 animal models. The most appropriate model for each trait was determined by Akaike's Information Criterion (AIC) test. The regression coefficients of BW and KS on inbreeding coefficient were -0.50 ± 1.57 gm and -0.17 ± 0.10 percent, respectively. The results obtained in the present study showed inbreeding had not significant effects on BW and KS ($P > 0.05$).

Keywords: inbreeding coefficient; birth weight; kid survival

I. Introduction:

Goats have an important role in agriculture of developing countries where over 90% of the world goat populations are raised. The total number of goats in the world has increased by about 66% in the last two decades and is expected to continue to rise, especially in dry or harsh conditions [1]. The beginning of Markhoz goat raising in Kurdistan dates back to 10,000 years ago. The bones of a goat (*Capra hircus*) found at

Ganj Dareh in Kermanshah Province, shows the earliest secure evidence of goat domestication in Kurdistan [2]. Markhoz goat is a multipurpose breed. Mohair and kids sale are main sources of income for producer whereas milk production is of secondary importance. These goats are raised in a wide range of forest mountain habitats in harsh region of Kurdistan and produce in the low output system.

Predominant feed of animals during

winter is tree foliage, which collected from Oak trees (*Quercus* spp.) during summer by producers [3]. Historically, the mohair obtained from these animals has an important cultural role in manufacturing local clothes in Kurdistan [4]. Although, goats have been traditionally one of the major sources of red meat in Iran, there are limited published researches on the effects of inbreeding coefficient on birth weight and kid survival in Markhoz goats. The most notable consequence of inbreeding is the reduction of the mean phenotypic value (inbreeding depression). The objective of the present study was to estimate inbreeding coefficient and its effects on birth weight and kids survival in Markhoz goats by determining the most appropriate animal models.

kids at birth (BW) and kid survival from birth to weaning (KS) collected from 1993-2012 by Markhoz goats Performance Testing Station in Sanandaj, Kurdistan province of Iran. Does were first exposed to the bucks at about 18 months of age. Annually 20–30 bucks were randomly allocated to mate with about 10 or 15 does each, with sire identification recorded. Sires were typically used for two or three mating seasons. Does were kept for a maximum of 7 parities (8 years of age). The annual replacement rate of does was 25-30%. The inbreeding coefficient was estimated using CFC software program [5]. Analysis of data for investigation of inbreeding coefficient effects was conducted with restricted maximum likelihood method (REML) using ASReml 3.0 computer program under 12 different animal models [6]. Coefficient of inbreeding for each kid added to models as a covariate. The models are shown as below:

II. Material and Methods:

The data set and pedigree information used in this study were body weight of 4186

$y = Xb + Z_a a + e$		<i>Model 1</i>
$y = Xb + Z_a a + Z_c c + e$		<i>Model 2</i>
$y = Xb + Z_a a + Z_m m + e$	$Cov(a, m) = 0$	<i>Model 3</i>
$y = Xb + Z_a a + Z_m m + e$	$Cov(a, m) = A\sigma_{am}$	<i>Model 4</i>
$y = Xb + Z_a a + Z_m m + Z_c c + e$	$Cov(a, m) = 0$	<i>Model 5</i>
$y = Xb + Z_a a + Z_m m + Z_c c + e$	$Cov(a, m) = A\sigma_{am}$	<i>Model 6</i>
$y = Xb + Z_a a + Z_{il} l + e$		<i>Model 7</i>
$y = Xb + Z_a a + Z_c c + Z_{il} l + e$		<i>Model 8</i>
$y = Xb + Z_a a + Z_m m + Z_{il} l + e$	$Cov(a, m) = 0$	<i>Model 9</i>
$y = Xb + Z_a a + Z_m m + Z_{il} l + e$	$Cov(a, m) = A\sigma_{am}$	<i>Model 10</i>
$y = Xb + Z_a a + Z_m m + Z_c c + Z_{il} l + e$	$Cov(a, m) = 0$	<i>Model 11</i>
$y = Xb + Z_a a + Z_m m + Z_c c + Z_{il} l + e$	$Cov(a, m) = A\sigma_{am}$	<i>Model 12</i>

where y is a vector of observations in the studied traits; b , a , m , c , l and e are vectors of fixed (year, sex, type of birth, age of dam and coefficient of inbreeding as a covariate), direct additive genetic, maternal additive genetic, maternal permanent environmental, common litter and residual effects, respectively. Also, X , Z_a , Z_m , Z_c and Z_l are corresponding design matrices relating observation to the fixed effects, direct additive genetic effects, maternal additive genetic effects, maternal permanent environmental effects and common litter effects, respectively. It is assumed that direct additive genetic effects, maternal additive genetic effects, maternal permanent environmental effects, common litter effects and residual effects are normally and independently distributed with mean 0 and variance $A\sigma_a^2$, $A\sigma_m^2$, $I\sigma_c^2$, $I\sigma_l^2$, and $I\sigma_e^2$, respectively, where σ_a^2 , σ_m^2 , σ_c^2 , σ_l^2 , and σ_e^2 are direct additive genetic variance, maternal additive genetic variance, maternal permanent environmental variance, common litter variance and residual variance, respectively, A is the additive numerator

relationship matrix, I_d , I_l and I_n are identity matrices that have order equal to the number of dams, litters and records, respectively, and $\sigma_{a,m}$ denotes the covariance between direct additive genetic and maternal additive genetic effects. In order to determine the most appropriate model for estimating the inbreeding coefficient effects on each traits, Akaike's information criterion (AIC) was used as follow [7].

$AIC_i = -2 \log L_i + 2p_i$, where $\log L_i$ is the maximized log likelihood of model i at convergence and p_i is the number of parameters obtained from each model. Model with the lowest AIC was chosen as the most appropriate model.

III. Results and Discussion:

The results obtained from this study showed the number of inbred animals was 2431 heads out of the total number of 4186 animals under investigation. The mean of inbreeding coefficients estimate were 3.03% for whole population and 5.21% for inbred population (Table I).

Table.I: Means of inbreeding coefficient, birth weight and kid survival.

Year	No. of animal	No. of Inbred	Means ^a					
			ICW	ICI	BWW	BWI	KSW	KSI
1993	137	0	-	-	2.52	-	91.24	-
1994	288	0	-	-	2.62	-	93.75	-
1995	269	5	0.42	22.5	2.53	2.50	96.65	100.00
1996	186	13	0.87	12.5	2.60	2.61	89.25	92.31
1997	200	25	1.78	14.25	2.73	2.60	97.50	96.00
1998	261	58	2.00	9.00	2.80	2.85	95.02	87.93
1999	244	103	2.94	6.97	2.65	2.62	90.16	92.23
2000	191	106	3.12	5.63	2.74	2.71	95.81	95.28
2001	224	149	4.69	7.05	2.74	2.46	95.09	93.29
2002	194	161	5.31	6.40	2.55	2.54	97.94	98.14
2003	175	152	4.21	4.84	2.34	2.32	-	-
2004	197	126	2.74	4.29	2.46	2.45	91.88	92.86
2005	210	201	5.56	5.82	2.46	2.46	88.57	88.56
2006	224	211	3.32	3.53	2.76	2.75	90.18	90.52
2007	164	149	2.75	3.03	2.51	2.51	-	-
2008	175	164	3.95	4.22	2.34	2.35	-	-
2009	187	167	3.35	3.75	1.89	1.89	89.84	89.82
2010	237	230	3.92	4.04	2.56	2.56	-	-
2011	227	220	5.00	5.15	2.11	2.11	91.19	90.91
2012	196	191	5.59	5.74	2.66	2.67	93.37	93.19
Total	4186	2431	3.03	5.21	2.53	2.46	93.07	92.11

^a: Inbreeding coefficient mean in whole population (ICW), inbreeding coefficient mean in inbred population (ICI), birth weight mean in whole population (BWW), birth weight mean in inbred population (BWI), kid survival mean in whole population (KSW), kid survival mean in inbred population (KSI).

The means of the whole and inbred population were 2.53 and 2.46 kg for BW and 93.07 and 92.11% for KS, respectively. Therefore, the means of BW and KS in the whole population were greater than that of inbred population. The average of inbreeding coefficient estimate (3.03%) in the whole population indicated that close

relative mating during experimental period was not used too much. However, the highest individual inbreeding coefficient was 31.25%. Hence, it can be said that a very close relative mating such as repeated mating of sire to daughter and granddaughter has been occurred at least a few times in this population. Frequency of

inbreeding classes was showed in Table II. As can be seen, 41.92% of the population had zero inbreeding coefficients. Also, 40.20% of animals had to inbreeding coefficients class 0-6.25%. Increasing of inbreeding coefficient rate had negative effects on mean of KS and BW. As inbreeding coefficient increased from zero to 0.25, means of KS and BW reduced from 94.06 to 87.24 and 2.62 to 2.52, respectively. However, the rate of reduction for KS was regular, but for BW was not regular, probably record collection for BW was not accurate compared to KS. The mean of inbreeding coefficient was increased from the 1993 to 2012. The positive inbreeding trend for kids over the last 20 years was presented in Figure 1. Average increasing of inbreeding coefficient (%) of kids by the year of birth was 0.24 ± 0.04 . Inbreeding coefficient of the animals during 1993 and 1994 was zero, but mating of relative resulted in gradually increasing of average inbreeding coefficient.

Table.II: Number of kids and means of KS and BW across inbreeding classes

Inbreeding classes (%)	No. Anima l	Means of traits	
		KS (%)	BW (kg)
F=0	1755	94.06	2.62
0<F≤6.25	1683	93.38	2.45
6.25<F≤12.5	357	91.64	2.54
12.5<F≤18.75	304	90.84	2.44
18.75<F≤25	47	88.00	2.44
F<25	40	87.24	2.52

The mean of inbreeding coefficient had fallen sharply in 2004 and 2007, which could be due to the prevention of close relationship mating in these years and sire imported from outside of flock.

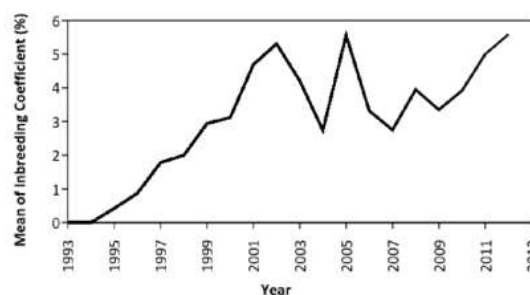


Fig.1. Mean of inbreeding coefficient by year of birth.

The results obtained from analysis of variance for traits studied are presented in Table III. The fixed effects included year of birth, sex, birth type and dam age had significant influences on BW ($P < 0.01$), whereas only year of birth and type of birth had significant effects on KS ($P < 0.01$). Model selection was determined using the AIC ratio test with the most appropriate model is shown in bold face in Table IV. The most suitable model for BW included direct additive genetic, maternal additive genetic, maternal permanent environmental, and common litter effects, as well as covariance between direct and maternal additive genetic effects (Model 12), whereas the model including direct additive genetic and maternal permanent environmental effects (Model 2) was the most appropriate for KS.

Table.III: Summary of analysis of variance for the traits studied.

SOV	DF	MS	DF	MS
Year	19	10.8 ^{**}	15	0.19 ^{**}
Sex	1	43.2 ^{**}	1	0.01 ^{ns}
Birth type	2	10.2 ^{**}	2	0.33 ^{**}
Dam age	5	4.1 ^{**}	5	0.04 ^{ns}
Error	4158	0.2	3411	0.06

** : P<0.01, ns: P>0.05

The regression coefficients of birth weight and kid survival on inbreeding coefficient were -0.50 ± 0.57 (gm) and -0.17 ± 0.10 (%), respectively. These results indicated that for every one percent increase in inbreeding coefficient, BW decreases by 0.50 gm and KS decreases by 0.17%. However, these reductions were not statistically significant ($P > 0.05$). Unfortunately there is no published literature on the effects of inbreeding in goats; however, different results have been reported on the effects of inbreeding on BW and KS in sheep. The regression coefficient of BW on inbreeding coefficient reported for Rambouillet, Targhee and Columbia sheep breeds were -0.8, -14 and -2 gm, respectively [8].

Table.IV: AIC values for traits studied

Mode	Traits	
1	BW	KS
1	-3625.94	-5908.64
2	-3680.84	-5911.06
3	-3665.24	-5906.74
4	-3668.72	-5906.90
5	-3680.82	-5909.06
6	-3684.38	-5905.24
7	-3868.94	-5908.64
8	-3884.74	-5909.58
9	-3881.28	-5906.64
10	-3882.50	-5907.00
11	-3884.42	-5907.58
12	-3885.56	-5903.94

Also, results reported for Elsenburg Dormer sheep showed the rate of decrease for BW per 1% increase in inbreeding coefficient was 8 gm [9]. The regression coefficient of BW on inbreeding coefficient reported for Baluchi sheep was -0.52 gm [10]. Results obtained for effects of inbreeding on BW and KS in a flock of Egyptian Barki sheep showed 6 gm decreasing of BW and 0.06 % increasing of mortality per 1 percent increasing of inbreeding coefficient [11]. The investigation of inbreeding effects on pre-weaning growth traits in Thalli sheep showed, per 1 percent increasing of inbreeding coefficient, BW was decreased by 6 gm [12]. Analysis of founder-specific inbreeding depression on BW in Ripollesa lambs showed per 1% increasing of inbreeding coefficient, BW decreased by 14 gm [13]. Results obtained for Leccese sheep showed decreasing of BW was 19 gm per

1% increasing of inbreeding coefficient. Also, mortality in lambs with high inbreeding coefficient was greater than that of lambs with low inbreeding coefficient [14]. The results reported by researchers for Sardi and Beni Guil sheep showed regression coefficient of BW on inbreeding coefficient were 0.1 and -6.1 gm, respectively [15]. Also, these researchers reported regression of KS on inbreeding coefficient were -0.096. The results obtained for a flock of Hampshire sheep showed regression coefficient of BW and KS on inbreeding coefficient were 22 gm and 1.3%, respectively [16]. The results obtained in this research were in agreement with the range of that reported by other researchers; although, high differences between results could be due to the using of different gene pool at different environments or different statistical models for analysis of the data.

IV. Conclusion:

The results of present research revealed that levels of inbreeding coefficient in a closed flock of the Markhoz goats have increased from 1993 to 2012. The average inbreeding coefficient was low and had not significantly reduced the mean of BW and KS in this flock. Fluctuations in trend of inbreeding coefficient were revealed in the period under study. Frequency of animal at inbreeding coefficient class of 0 and 6.25% was higher than that of other classes. The highest inbred animal in 2012 was observed. Thus, there is a need to control mating system in the flock. Sires imported from the other Markhoz goats flocks, controlling of mating strategies and avoidance of parent-offspring, full-sib and half-sib mating are

proper tools for breeding program mating in this flock.

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