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Inbreeding depression in growth traits of Baluchi sheep

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ABSTRACT

The objective of this study was to evaluate inbreeding and inbreeding depression in Baluchi sheep. Data and pedigree information were retrieved from the Baluchi sheep Breeding Station, Khorasan Razavi, Iran. Traits included were birth weight (BW), weaning weight (WW), 6-month weight (W6), 9-month weight (W9), yearling weight (W12), average daily gain from birth to weaning (ADGa), average daily gain from weaning to 6 months of age (ADGb) and average daily gain from weaning to 12 months of age (ADGc). Animals were grouped in three classes: first class included non-inbred animals (F = 0) and second and third classes included inbred animals ($0 < F \leq 5\%$ and $F > 5\%$, respectively). Inbreeding depression was studied for all traits by fitting individual increase in inbreeding coefficient (ΔF_i) of the lambs as linear covariates under univariate animal models. The mean inbreeding in the whole population was 1.60%. It increased with some fluctuations from 1981 to 2005 and decreased thereafter. The average equivalent complete generation, as a measure of pedigree completeness, in the studied population was 2.49 and the value of effective population size (*Ne*) estimated from the ΔF_i was 166. Of 10863 pedigreed lambs, 5931, 3943 and 989 animals belonged to first, second and third inbreeding class, respectively, with significant differences in their body weights and average daily gains. In some cases, growth traits of male and female lambs as well as single and twin lambs grouped in three inbreeding classes differed significantly. Among traits studied, W6, W9, W12, ADGb and ADGc were significantly affected by inbreeding ($P < 0.01$) in such a way that one percent increase in ΔF_i of the lambs significantly reduced W6, W9, W12, ADGb and ADGc by 18, 10, 131, 1.810 and 1.345 g, respectively. Selection of rams with the lowest relationship with ewes in the flock was recommended to decrease the rate of inbreeding in the population.

1. Introduction

Inbreeding depression is the main consequence of inbreeding which influences the performance of individuals of a population. Currently used selection method of individuals under animal models may result in selection of more closely related animals, makes this concern much more serious by decreasing the genetic variation (Fernandez and Toro, 1999). The knowledge of inbreeding and controlling it at a reasonable level is substantial for replying future generations to selection (Van Wyk et al., 2009). Therefore, it is essential to take into account the effects of inbreeding in any selection program to appropriately adjust the breeding process for the potential decrease in performance.

Several hypotheses have been related for the genetic basis of inbreeding depression namely partial dominance (expression of deleterious recessive alleles as homozygosity increases; Davenport, 1908), over dominance (heterozygotes have higher fitness than homozygotes; East 1908; Shull, 1908) and epistasis (the fitness interactions of alleles at different loci; Jain and Allard, 1965). In a given species, the level of inbreeding depression differed across breeds, given that populations do not share the same demographic and selection history (Mc Parland et al., 2009). Some populations may show a very significant effect of increased inbreeding for a trait, whereas others may not show a significant effect (Analla et al., 1998).

Baluchi is one of the important Iranian sheep breeds and accounts for slightly more than 12% of the total sheep population. It is fat tailed and small-size breed. They are well adapted to dry and hot climatic conditions in eastern Iran, especially in Khorasan Razavi province and because of their large population, play an important role in total lamb and mutton production in Iran. While, there are several reports regarding inbreeding depression in growth and reproductive performances of different sheep breeds (Pedrosa et al., 2010; Eteqadi et al., 2014; Mokhtari et al., 2015), no previous reports based on mixed model equations on inbreeding level and its effects in Baluchi sheep is available. There-

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Table 1
Characteristics of data set and distribution of inbreeding coefficients for body weight and average daily gain at different ages of Baluchi sheep[A].

	BW	WW	W6	W9	W12	ADGa	ADGb	ADGc
Number of records	7225	7169	5854	5162	7468	6356	5768	4726
Mean	4.232	23.552	30.482	34.088	39.077	213.24	70.27	52.58
SD	0.709	5.006	5.418	5.353	6.596	51.935	42.460	20.85
CV	16.75	21.25	17.77	15.70	16.89	10.01	60.65	39.65
Min	1.500	10.00	15.00	15.120	17.00	50.00	−59	−10
Max	6.500	38.00	51.500	56.070	62.00	359	200	110
F = 0	2743	2893	2368	2111	4628	2346	2335	1788
0 < F ≤ 5%	3564	3459	2817	2466	2310	3202	2773	2310
F > 5%	918	844	669	585	530	808	660	628

BW, WW, W6 and W12 in kg, ADGa, ADGb and ADGc in gr.
[A] BW, birth weight; WW, weaning weight; W6, 6-month weight; W9, 9-month weight; W12, 12-month weight; ADGa, average daily gain from birth to weaning; ADGb, average daily gain from weaning to 6 months of age; ADGc, average daily gain from weaning to 12 months of age.

Table 2
Mean and standard error for body weight traits in different inbreeding classes of animals [A].

	BW	WW	W6	W9	W12	ADGa	ADGb	ADGc
F = 0	4.422 ± 0.013^{a}	23.726 ± 0.088^{b}	30.158 ± 0.106^{a}	33.736 ± 0.117^{b}	38.312 ± 0.152^{b}	208.19 ± 1.038^{b}	71.15 ± 0.873^{a}	51.75 ± 0.488^{ab}
0 < F≤5%	4.249 ± 0.011^{ab}	23.860 ± 0.084^{b}	30.851 ± 0.104^{a}	34.505 ± 0.106^{a}	39.710 ± 0.137^{a}	217.40 ± 0.930^{a}	70.13 ± 0.822^{a}	53.46 ± 0.431^{a}
F > 5%	4.190 ± 0.023^{b}	23.232 ± 0.172^{b}	30.072 ± 0.210^{a}	33.599 ± 0.222^{b}	38.555 ± 0.293^{b}	205.46 ± 1.852^{b}	67.73 ± 1.607^{a}	51.55 ± 0.949^{b}

BW, birth weight; WW, weaning weight; W6, 6-month weight; W9, 9-month weight; W12, 12-month weight; ADGa, average daily gain from birth to weaning; ADGb, average daily gain from weaning to 6 months of age; ADGc, average daily gain from weaning to 12 months of age.
BW, WW, W6 and W12 in kg, ADGa, ADGb and ADGc in gr.
[A] Means within a column that do not have a common superscript are significantly different ($P < 0.05$).

fore, the objectives of this study were to estimate the inbreeding level and to investigate the inbreeding effects on body weight at different ages and average daily gain in different growth phases in an experimental population of Baluchi lambs.

2. Materials and method

2.1. Data and management

Data and pedigree information collected during 1981 and 2009 were obtained from the Breeding Station of Baluchi sheep (located in Mashhad, Khorasan Razavi, Iran). The project was started in 1960 by purchasing about 200 mid-aged ewes. In the flock, selection was based on body weight, body conformation score and birth type. Each ram randomly mated with 15 to 25 ewes and almost 50% of sires were kept for 2 to 3 mating seasons and the rest were used once. Ewes were kept in the flock for a maximum of 7 parities (8 years of age). The annual rate of ewe replacement was 25–30%. The mating season commenced between late summer and early autumn and included three oestrous cycles. Lambing started in late January to late March. After lambing, the data of newborn such as sex, birth date, birth type, birth weight, sir ID and dam ID were recorded. Records of body weights for weaning (90 days on average), 6, 9 and 12 months of age were also registered. During spring and summer, flocks were kept on natural pastures and in autumn and winter animals were kept indoors and fed with a ration based on wheat and barley stubble. Supplementary feed was included during pregnancy and included a diet composed of wheat and barley straw, alfalfa hay, dry sugar beet pulp, and concentrate.

2.2. Recorded traits

Traits included were: Birth weight (BW), weaning weight, (WW), 6-month weight (W6), 9-month weight (W9), yearling weight (W12), average daily gain from birth to weaning (ADGa), average daily gain from weaning to 6 months of age (ADGb) and average daily gain from weaning to 12 months of age (ADGc). Weaning weight (WW) was adjusted to 90 days of age by adding 90 times the pre-weaning average daily gain to birth weight. Adjusted 6-month weight (180 days) was obtained by adding t times the post-weaning daily gain to weaning weight, where t is the number of days between weaning and 6-month age. Adjusted 9-month weights (270 days) as well as adjusted yearling weight (365 days) were also calculated in a similar fashion. To calculate the average daily gain, related gain was divided by the number of days in the period

2.3. Statistical analysis

The CFC program (Sargolzaei et al., 2006) was used to calculate inbreeding coefficients of individual animals. In the CFC program, the modified algorithm of Colleau (Sargolzaei et al., 2005) is used to compute inbreeding coefficients. On the basis of individual inbreeding coefficient, animals were grouped in three classes: first class included non-inbred animals (F = 0) and second and third classes included inbred animals (0 < F ≤ 5% and F > 5%, respectively).

Completeness of pedigree was examined by equivalent complete generations. Individual equivalent complete generation for individual i (E_qG_i) were computed according to Maignel et al. (1996) as follows:

$$E_qG_i = \sum \left(\frac{1}{2}\right)^n$$

where, n is the number of generations separating the individual from each known ancestor. Average equivalent complete generations for whole population was computed simply by averaging individual equivalent complete generations.

The coefficients of individual increases in inbreeding (F_i) were computed according to the method described by Falconer and Mackay (1996) and modified by Gonzalez-Recio et al. (2007) and Gutierrez et al. (2009) using the following formula:

$\Delta F_i = 1 - \sqrt[E_qG_i - 1]{1 - F_i}$ Where F_i is the individual coefficient of inbreeding and E_qG_i is the equivalent complete generations.

The coefficients of individual increase in inbreeding (ΔF_i) were averaged and the realized effective population size (Ne) was estimated as follow:

$$N_e = \frac{1}{\Delta \bar{F}}$$