Studies on Inbreeding and Its Effects on Growth and Fleece Traits of Muzaffarnagari Sheep

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ABSTRACT : A pedigree file of 4,738 records of a purebred flock of Muzaffarnagari sheep, maintained at Central Institute for Research on Goats (CIRG), Makhdoom, for a period of 24 years (1978 to 2001) was used to calculate inbreeding coefficients. The lamb traits studied were birth, 3, 6, 9 and 12 months weights as well as 6 and 12 months fleece yields. The lambs' and ewes' inbreeding coefficients ranged from 0 to 26.4% and 0 to 25%, respectively. The average inbreeding coefficient of lambs was higher than that of ewes in all periods as expected in a closed flock. Fluctuations in lamb and ewe inbreeding were observed in the periods under study. The percentages of animals in the higher inbred categories varied somewhat but generally were relatively constant. The mean rate of inbreeding was 0.63% per generation. The effective population size of the flock was 79.1. On average, an increase of 1% individual inbreeding significantly ($p<0.05$) reduced weights at birth by 0.010 kg, at 3 month by 0.048 kg, at 6 month by 0.075 kg, at 9 month by 0.129 kg and at 12 month by 0.112 kg. Ewes' inbreeding had non-significant effects on body weight at all ages. Effects of both lambs' and ewes' inbreeding had negative but non-significant effects on fleece weights at 6 and 12 months of age. Thus, inbreeding depression in lambs significantly reduced body weights from birth to 12 months of age but had a negligible effect on fleece yields. ***(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 10 : 1363-1367)***

Key Words : Inbreeding Depression, Effective Population Size, Growth Traits, Fleece Weight

INTRODUCTION

The inbreeding depression can be expressed as the change in performance per unit of inbreeding. The level of inbreeding is an important genetic property of any population and needs to be known as it can influence breeding decisions and the design of livestock improvement programmes. The inbreeding process increases homozygosity for whatever genes are present, including the less desirable ones, and has been associated with a decline in performance (Burrow, 1993). Falconer (1989) outlined effects of inbreeding as increased homozygosity, redistribution of genetic variances, higher chances of appearance of lethal genes and reduction of performance for inbred lines. Inbreeding is expected to increase in association with changes in breeding practices such as high intensity of selection, use of artificial insemination and more accurate genetic evaluation. Selection in closed populations results in gradual inbreeding due to mating of relatives. Ercanbrack and Knight (1981), Galal et al. (1981), Lamberson et al. (1982), Lamberson and Thomas (1984), Ercanbrack and Knight (1991), Prod'Homme and Lauvergne (1993) and Mandal et al. (2004) have studied the relationship between inbreeding and productivity of sheep.

The objective of this investigation was to document and analyze the inbreeding over time and to determine the effects of inbreeding on production traits in a closed flock of Muzaffarnagari sheep.

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MATERIALS AND METHODS

The breeding flock

The Muzaffarnagari sheep is one of the heaviest and largest breeds in India and is widely distributed in the semi-arid region of western Uttar Pradesh, near Meerut, Muzaffarnagar, Saharanpur, Bijnor and in the some parts of Delhi and Haryana. This breed is considered as unique genotype exhibiting better growth, very good adaptability and a somewhat higher prolificacy than other Indian sheep breeds. A purebred flock of Muzaffarnagari sheep comprising 250 breeding ewes is being maintained by Central Institute for Research on Goats (CIRG), Makhdoom, Mathura, Uttar Pradesh, India. In general, animals were maintained under semi-intensive and intensive feeding management. Animals maintained in the semi-intensive system were provided with 400 g of concentrate ration, 6 h of grazing and *ad libitum* dry and green fodders. After weaning, some lambs were put under an intensive system of feeding management up to 6 months of age. These animals were provided 800 g of concentrate daily, consisting of 72% TDN and 16% DCP. Dry and green fodders were given *ad libitum* but no grazing was allowed. Ewes at 100 days onwards of pregnancy and during lactation were provided supplementary feeding, where as dry sheep received only

Table 1. Summary statistics including average inbreeding of the Muzaffarnagari flock since inception

Parameters	Unit
Number	
Years	24
Lambs	4,368
Ewes with lambs breeding	1,446
Sires of lambs	156
Lambs inbreeding (%)	
Average	1.64
SD	2.9
SE	0.04
Ewes inbreeding (%)	
Average	0.90
SD	1.99
SE	0.03
Range of inbreeding (%)	
Lambs	0-26.4
Ewes	0-25.0

maintenance ration. Generally, the controlled breeding was practiced in the flock. Heat detection of ewes was done in the morning and evening during the breeding season. The ewes in heat were mated with the selected sires in the morning. Mating plan was designed in such way so that one breeding ram was allowed to mate with 20-25 ewes. Ewes were mated twice per oestrus. Breeding seasons was restricted in such a way that the lambing takes place in optimum environmental period of the year. Two breeding seasons namely (1) May- June and (2) October. -November, were practiced with lambing in October-November and March-April months of the year. However, the detailed description, distribution and husbandry practices of this breed have been described by Bhat et al. (1978) and Mandal et al. (2000).

Data

A pedigree file of 4,738 records of Muzaffarnagari sheep, maintained at the Central Institute for Research on Goats (CIRG), Makhdoom, for a period of 24 years (1978-2001) as a part of the All-India Coordinated Research Project on Sheep breeding for mutton production was used for the analysis. All animals born before 1978 were purchased and were assumed to be unrelated and not inbred. Foundation animals included 240 adult ewes and five rams. The flock had been in existence for 26 yrs. and had been closed to outside breeding after the introduction of 10 proven rams between 1982 and 1984. The sons of the best-proven rams were used for about 3 years. Each ram was mated to 20 or more ewes in the two seasons per year.

The lamb traits considered in the study were birth, 3, 6, 9 and 12 months body weights and fleece weights at 6 and 12 months of age.

Statistical analysis

All known relationships among the animals were used to compute inbreeding coefficients according to Wright's formula. A generation code indicating the number of generations between the animal and the reference population was calculated for each animal as $[1+5\ (g_S+g_D)]$ where g_S and g_D are generation codes of sire and dam (Al-Shorepy and Notter, 1997). Foundation animals were assigned a generation code of 0. The effective population size for the flock (N) was estimated as 1/2B, where B is the regression coefficient of inbreeding coefficient on generation number.

Body and fleece weight data were analyzed using linear statistical models (Harvey, 1990) to study the effect of inbreeding of lambs and ewes. The model (Table 3) included main effects for type of management, year of birth, season of birth, parity of dam, sex and type of birth (single or twin) of the lamb, and interaction effects. The year of birth was included to account for periodic changes in management practices like differences in nutritional inputs and different environmental conditions such as ambient temperature, humidity, rainfall etc. Linear and quadratic partial regressions on inbreeding of the lamb and the dam were also included in the model.

In the initial model, all 2-way interactions and quadratic partial regression of inbreeding of lamb and of dam on the dependent variables were found non-significant and were ignored in the final model, which is as follows:

$$Y_{hijklmn} = \mu+M_h+P_i+S_j+A_k+S_l+T_m+b_1L+b_2D+e_{hijklmn}$$

Where,

Y_{ijklmn} is the record for the n^{th} animal

M_h is the effect of the h^{th} type of management

P_i is the effect of the i^{th} year of birth

S_j is the effect of the j^{th} parity of dam

A_k the effect of the k^{th} season of birth

S_l is the effect of the l^{th} sex of lamb

T_m is the effect of the m^{th} type of lambing

b_1 is the linear regression coefficient of the deviation of the lamb inbreeding from the respective mean inbreeding

b_2 is the linear regression coefficient of the deviation of the dam inbreeding from the respective mean inbreeding.

e_{ijklmn} is the residual error with standard assumptions.

RESULTS AND DISCUSSIONS

Descriptive statistics for inbreeding coefficients for lambs and ewes are shown in Table 1. The maximum value of 26.4% inbreeding indicates that repeated mating of sire to daughter and granddaughter occurred at least a few times.

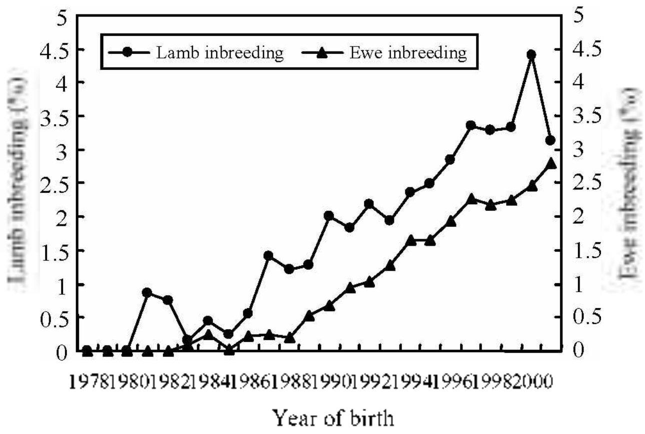

Figure 1. Average inbreeding (%) of lambs and ewes by yearof birth.

Inbreeding trends for lambs and ewes over the last 24 years are presented in Figure 1. There was more or less a linear increase in lamb and ewe inbreeding during this study. However, the mean inbreeding coefficient for lambs was always higher than that for ewes. The increase in inbreeding rates for animals born in the year 1981 and onwards might be associated with the use of a large number of sons and grandsons of a few sires that were considered outstanding during earlier periods. Table 2 shows the distribution of animals with different inbreeding levels during the last 24 years. Animals born during the period of 1978 to 1980 were taken with no inbreeding. In subsequent years, the percentages of noninbred animals essentially declined to 0% during the period of 1999-2001. This pattern occurs simply because the population gradually becomes more related over time. The mean rate of inbreeding measures the decay of heterozygosity due to inbreeding and was 0.63% per generation. The effective population size for the flock was therefore 79.1.

The average weights of lambs at birth, 3, 6, 9 and 12 months are presented in Table 4. Significant ($p<0.01$) negative effects of lamb inbreeding on body weight were observed at all ages. On average, an increase of 1% individual inbreeding decreased birth weight by 0.010 kg, 3 months weight by 0.048 kg, 6 months weight by 0.075 kg, 9 months weight by 0.129 kg and 12 months weight by 0.112 kg. The regression coefficient estimate for birth weight (-0.010 kg/%) is comparable to reported estimates of various publications for different sheep breeds (Ghoneim and McCarty, 1967; Lax and Brown, 1968; Lamberson and Thomas, 1984; Ercanbrack and Knight, 1991; Wiener et. al., 1992; Van Wyk et al., 1993; Boujenane and Chami, 1997; Analla et al., 1998). The effect of lamb inbreeding on weaning weight (-0.048 kg/%) for the present study was in agreement with the estimate of Lamberson et al. (1982) in Hampshire sheep, but a lower estimate was obtained by Boujenane and Chami (1997). However, higher estimates than found in the present study were reported by

Table 2. Number of lambs and distribution on inbreeding classes from 1978 to 2001

Year of birth	No.	F = 0	0<F<6.25	6.25≤F<12.5	12.5≤F<18.75	18.75≤F<25	F≥25
1978-80	348	100.0	0	0	0	0	0
1981-83	652	97.24	0	0.31	1.23	0	1.23
1984-86	534	92.51	4.49	1.69	1.31	0	0
1987-89	727	61.21	32.19	3.71	2.89	0	0
1990-92	534	18.54	73.22	3.37	4.86	0	0
1993-95	633	2.53	91.31	4.27	1.74	0	0.16
1996-98	459	0	91.72	5.01	3.05	0	0.22
1999-2001	481	0	90.64	5.82	2.49	0.21	0.83

Table 3. Least squares analysis of variance for lamb traits

Source of variation	D.F	Birth wt.	3 m wt.	6 m wt.	9 m wt.	12 m wt.	6 m fleece weight	Adult fleece weight
					Mean Squares			
Type of management	1	-	-	12,562.72**	7,560.33**	4,169.99**	4.75**	1.54**
Year of birth	23	16.24**	410.71**	1,173 11**	671 07**	487 19**	0.37**	0.47**
Parity	5	28.18**	343.82**	174.09**	118.71**	83.60**	0.02	0.02
Season	1	0.31	21.64	2,172.63**	1,375.97**	309.86*	0.14**	0.07
Sex	1	30.40**	1779.59**	2,758.20**	6,872.67**	9,752.26**	0.39**	2.51**
Type of birth	1	245.43**	2238.83**	956.96**	774.61**	822.89**	0.18**	0.11**
Regression on lamb inbreeding	1	2.59**	61.54**	108.68**	262.94**	146.58**	0.02	0.05
Regression on ewe inbreeding	1	0.37	0.94	0.21	67.78	5.10	0.01	0.01
Residual		0.34 (4,334)	11.56 (3,883)	20.26 (3,191)	18.30 (2,535)	18.87 (2,121)	0.02 (2,926)	0.02 (2,036)

Figures in parenthesis are error degrees of freedom.
* $p<0.05$, ** $p<0.01$.

Table 4. Least-squares means (±SE) for lamb traits and partial regression coefficients on lamb and ewe inbreeding

Traits	No. of obs.	Mean	Lamb inbreeding coefficient	Ewe inbreeding coefficient
Birth wt. (kg)	4,368	3.21±0.02	-0.010±0.003**	0.005±0.005
3 m wt. (kg)	3,917	14.51±0.11	-0.048±0.021**	-0.029±0.032
6 m wt. (kg)	3,226	23.36±0.16	-0.075±0.032**	-0.004±0.046
9 m wt. (kg)	2,570	26.86±0.18	-0.129±0.034**	-0.092±0.048
12 m wt. (kg)	2,156	30.12±0.020	-0.112±0.040**	-0.029±0.056
6 m-fleece weight (kg)	2,961	0.527±0.006	-0.001±0.001	-0.001±0.002
12 m- fleece weight (kg)	2,071	0.517±0.007	-0.002±0.001	-0.001±0.002

** $p<0.01$.

Ercanbrack and Knight (1991) in Rambouillet, Targhee and Columbia ewes, Van Wyk et al. (1993) in Dormer sheep, and Analla et al. (1998) in Spanish Merino sheep. Significant negative inbreeding effects on 6, 9 and 12-month body weights were reported by Ragab and Asker (1954) in Ossimi sheep. Regression coefficients obtained in that study were very close to those of the present report. The average regression coefficient of 10 to 12 month body weight on lambs' inbreeding reported by Morley (1954) was -0.132 kg/%, which is in agreement with the regression coefficients found in this study (-0.112 kg/% for 12-month weight).

Ewe inbreeding had non-significant ($p>0.05$) effects on body weight at all ages. Non-significant effects of ewes inbreeding on birth weight and post-weaning weight of lambs have been reported (Brown et al., 1961; Lax and Brown, 1967).

The partial regression coefficients of 6- and 12-month fleece weights on lamb and ewe inbreeding are presented in Table 4. Both lamb and ewe inbreeding had negative but non-significant ($p>0.05$) effects on fleece weights at 6 and 12 months of age. Non significant effects of inbreeding of the individual on 12-month fleece weight were reported by Terrill et al. (1947, 1948) and Lamberson et al. (1982) in different breeds of sheep. Inbreeding was reported to decrease 6-month fleece weight by 0.007 kg/%, but this effect was not significant (Lamberson et al., 1982).

CONCLUSION

The present study revealed that levels of inbreeding in a closed flock of the Muzaffarnagari sheep have increased since 1981. The average inbreeding coefficient of lambs was higher than that of ewes in all periods as expected in a closed flock. Fluctuations in lamb and ewe inbreeding were observed in the periods under study. There was a slow trend in accumulation of inbreeding in later years with a marked increase in the number of animals with inbreeding coefficients between 0 and 6.25%. Inbreeding depression in lambs significantly reduced body weights from birth to 12 months of age but had a negligible effect on fleece yields. Inbreeding of the ewe had non-significant effects on lamb body weights and fleece yields at all ages. Because the level of inbreeding of lambs had a detrimental effect on production traits, there is need to control inbreeding in the flock. This may be achieved by restricting the co-selection of siblings, selecting more sires and dams, increasing the ratio of sires to dams, increasing the number of dams from other flocks, creating sublines, or altering the mating strategies in such a way that there should be random mating with avoidance of half-sib and parent-offspring matings.

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