

Effects of Inbreeding on Lamb Survival in a Flock of Muzaffarnagari Sheep

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ABSTRACT : A pedigree file of 4,628 records of Muzaffarnagari sheep, maintained at Central Institute for Research on Goats (CIRG), Makhdoom, was used to calculate the inbreeding coefficient of the flock. The flock had been closed for about 25 years (1978 to 2002). The investigation was aimed to study the effects of inbreeding on survivability of lambs. The cumulative survivability of lambs i.e., lambs survived up to 3, 7 and 15 days, 1, 2, 3, 6, 9 and 12 months after birth was considered for the study. The average level of inbreeding of lambs was 1.60%, ranging from 0 to 26.4%. The average inbreeding coefficient of dam over the periods was 1.00% and it ranged from 0 to 25.0%. Significant ($p < 0.05$) adverse effect of lamb's inbreeding was observed on survivability of lambs at all ages except up to 3 and 7 days after birth. On an average, 1% increase in individual inbreeding coefficient should reduce the 0.31, 0.34, 0.32, 0.31, 0.33, 0.44 and 0.49 percent lamb survival up to the age of 15 day and 1, 2, 3, 6, 9 and 12 months, respectively. Ewes inbreeding had non-significant effects on lamb survival at all ages. (*Asian-Aust. J. Anim. Sci.* 2004. Vol 17, No. 5 : 594-597)

Key Words : Muzaffarnagari Sheep, Inbreeding, Inbreeding Depression, Lamb Survival

INTRODUCTION

The estimation of the level of inbreeding in any closed population is inevitable for designing the future breeding plan in any livestock enterprises for breed improvement programme. The inbreeding depression, expressed as the change in performance per unit of inbreeding, is associated with decreased performance and depends on the rate of inbreeding. The inbreeding process increases homozygosity for whatever genes are present, including the less desirable ones of the trait. Survival of lambs as a trait related to natural fitness could be influenced by the interactive types of gene action, which are of particular importance in cross breeding and inbreeding system. Inbreeding is expected to increase as a result of several changes in breeding practices such as high intensity of selection, use of artificial insemination and more accurate genetic evaluation. The slow inbreeding occurs due to mating of relatives in the flock as a consequence of selection in closed population for a long time when numbers of males are limited. Lax and Brown (1967), Galal et al. (1981), Lamberson et al. (1982), Lamberson and Thomas (1984), Wiener et al. (1992), Ercanbrack and Knight (1991) and Van Wyk et al. (1993) have studied the relationship between inbreeding and survivability of sheep. The purpose of this study was to monitor the level of inbreeding over time and to determine the effects of inbreeding on survivability of lambs in a flock of Muzaffarnagari sheep.

MATERIALS AND METHODS

Study flock

The Muzaffarnagari sheep, a better genotype for mutton production than other Indian sheep breeds, is one of the heaviest and largest breeds in the north-western region of India and known for its faster growth rate and high feed conversion efficiency. The detailed descriptions as well as distribution of this breed have been reported by Bhat et al. (1978). The animals were maintained under two systems of feeding management: semi-intensive and intensive system. The animals maintained under 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 intensive system of feeding management up to 6 months of age where animals were provided with 800g of concentrate daily, consisting of 72% TDN and 16% DCP. Dry and green fodders were given *ad libitum* and not allowed for grazing.

Controlled breeding was practiced in the flock. The ewes in heat were mated with the selected sires in the morning. Individual mating was practiced with 20-25 ewes allocated to each ram during the month of May-June and October -November. Sheep were bred twice in one oestrus. Breeding seasons was restricted in such a way that the lambing takes place in optimum environmental period of the year. However, detailed husbandry practices of the breed were described by Mandal et al. (2000).

Regular treatment and strict prophylactic measures were adopted in terms of vaccination against Enterotoxaemia, Foot and Mouth Disease, Sheep Pox, Haemorrhagic Septicaemia, and Peste des Petits for ruminants (PPR). Deworming with different anthelmintic was done at pre-monsoon and post monsoon seasons and as and when

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

Parameters	Unit
Number	
Years	25
Lambs	4,628
Ewes into breeding	1,446
Sires of lambs	165
Lambs inbreeding (%)	
Average	1.60
SD	2.8
SE	0.04
Ewes inbreeding (%)	
Average	1.00
SD	2.05
SE	0.03
Range of inbreeding (%)	
Lambs	0-26.4
Ewes	0-25.0

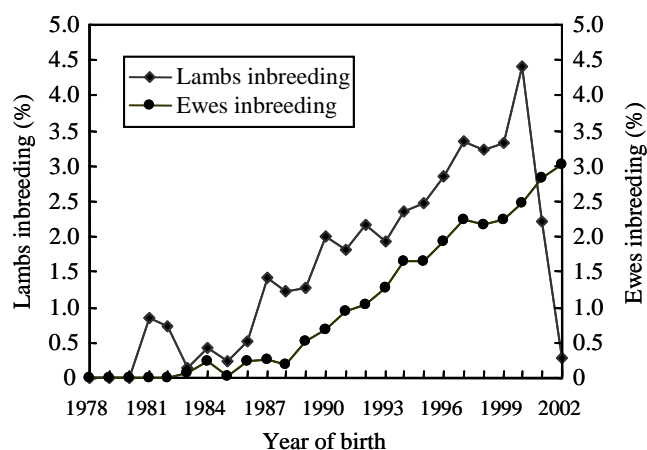
required. Dipping was done twice in a year after each shearing.

Data

Records of 4,628 lambs, the progeny of 165 rams (sires) of the purebred Muzaffarnagari sheep flock, maintained at Central Institute for Research on Goats (CIRG), Makhdoom, collected from All India Coordinated Research Project on Sheep breeding for mutton production for a period of 25 years (1978-2002) were used for the study. The base population year was 1978. All the animals before 1978 were purchased on and assumed to be unrelated and not inbred. The foundation animals included 240 adult ewes. Five rams were used as foundation sires in the initial establishment of the flock. The flock originated in 1976, and since then it had been closed to outside breeding except for 10 proven rams was introduced briefly in 1982 to 1984. Besides this, a total of another set of 10 proven rams was introduced in the year 2001. The breeding system followed to use sons of the best-proven sires and to keep them in service until sufficient ewes (20 or more) were bred to each one in every year. The rams were used for about three years. Dates of death were recorded and necropsy was performed for all dead animals within 24 h of death. The cumulative survivability of lambs i.e., lambs survived up to 3, 7 and 15 days, 1, 2, 3, 6, 9 and 12 months was considered for the study.

Statistical analysis

All known relationships among all animals were used to compute inbreeding coefficients. Inbreeding was measured by Wright's formula and was computed from pedigree traced in all lines to animals. The dependant variable (survival) had the value 1 if the lamb was alive at that particular age and 0 otherwise. The cumulative survivability of lambs at 3, 7 and 15 days, 1, 2, 3, 6, 9 and 12 months of

**Figure 1.** Average inbreeding (%) of lamb and ewes by year of birth.

age were analyzed by mixed model least-squares procedure (Harvey, 1990). The model included main effects for year and season of birth, sex and type of lamb born (single vs. multiple) and interaction effects. The linear and quadratic partial regression of inbreeding of lamb and of dam was fitted along with main effects and their interactions.

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:

$$Y_{ijklm} = \mu + P_i + S_j + A_k + S_l + b_1(X_{ijklm} - \bar{X}) + b_2(X_{ijklm} - \bar{X}) + e_{ijklm}$$

Where, Y_{ijklm} is the record for the m^{th} animal

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

S_j is the effect of the j^{th} season of birth

A_k the effect of the k^{th} sex of lamb

S_l is the effect of the l^{th} type of lambing

b_1 is the linear regression coefficient for the inbreeding of lamb

b_2 is the linear regression coefficient for the inbreeding of the dam

e_{ijklm} is the residual error element with standard assumptions.

RESULT AND DISCUSSION

The number of animals and average inbreeding coefficients of the flock for lamb and ewes from 1978 to 2002 are presented in Table 1. More than half of the animals (52.18%) of the total lambs born during this period were inbred to some extent and a small proportion of these inbred animals (10.4%) had inbreeding coefficient of higher than 6.25%. Considering all lambs born during the last 25 years period, the average level of inbreeding was 1.60% compared to the 3.07% of the inbred lambs, which might be

Table 2. Least squares analysis of variance for lamb traits

Source of variation	D.F	Cumulative survivability (%)								
		Up to 3 days	Up to 7 days	Up to 15 days	Up to 1 month	Up to 2 months	Up to 3 months	Up to 6 months	Up to 9 months	Up to 12 months
		MS								
Year of birth	24	0.19**	0.30**	0.36**	0.45**	0.54**	0.63**	0.87**	1.14**	1.13**
Season of birth	1	0.01	0.0004	0.02	0.0001	0.01	0.01	0.10	0.30	0.05
Sex of animal	1	0.001	0.06	0.001	0.01	0.001	0.004	0.10	0.08	0.07
Type of birth	1	0.16**	0.26**	0.20*	0.34**	0.32**	0.28*	0.78**	0.51**	0.91**
Regression on lamb inbreeding	1	0.02	0.07	0.30**	0.40**	0.32**	0.31*	0.34*	0.60**	0.77**
Regression on ewe inbreeding	1	0.05	0.10	0.04	0.10	0.07	0.25	0.30	0.14	0.08
Residual	4,598	0.02	0.03	0.04	0.05	0.06	0.07	0.09	0.10	0.10

*** Significant at $p < 0.05$ or 0.01 .

Table 3. Lamb trait least-squares means and partial regression coefficient on lamb and ewe inbreeding

Trait	Mean	Lamb inbreeding coefficient	Ewe inbreeding coefficient
Survivability up to 3 days (%)	96.15±0.42	-0.08±0.09	-0.18±0.13
Survivability up to 7 days (%)	94.80±0.49	-0.15±0.10	-0.25±0.15
Survivability up to 15 days (%)	93.99±0.55	-0.31±0.12**	-0.16±0.17
Survivability up to 1 month (%)	92.76±0.06	-0.36±0.13**	-0.25±0.18
Survivability up to 2 months (%)	91.75±0.65	-0.32±0.14**	-0.21±0.20
Survivability up to 3 months (%)	90.75±0.69	-0.31±0.15*	-0.41±0.21
Survivability up to 6 months (%)	87.39±0.79	-0.33±0.17*	-0.44±0.24
Survivability up to 9 months (%)	86.19±0.83	-0.44±0.18**	-0.31±0.25
Survivability up to 12 months (%)	84.74±0.86	-0.49±0.18**	-0.23±0.26

*** Significant at $p < 0.05$ or 0.01 .

because of the introduction of outside rams. The maximum level of lambs inbreeding in the flock was 26.4%. The average inbreeding coefficient of dam over the periods was 1.00% and it ranged from 0 to 25.0%. The maximum level of 26.4% inbreeding for lambs indicates that mating as intense as the repeated mating of sire to daughter and granddaughter may have been practiced at least once for a few animals. The annual inbreeding of lambs and its dams for the last 25 years is illustrated in Figure 1. The accumulated inbreeding of lamb in the flock after 25 years period averaged 0.28%. Figure 1 denotes more or less linear trend of increment of the annual inbreeding of lamb over periods up to the year 2000 and afterwards a decrease was observed. This can be attributed to introduction of 10 proven sires from outside into the flock in the year 2001 as well as increased effort to avoid the mating of closely related animals. There was also more or less linear trend of increment of dams inbreeding over periods in this study. However, magnitude of lambs inbreeding was always higher in all the years than dams inbreeding except for the year 2001 and 2002. The increase in inbreeding rates for later periods might be associated with the use of a large number of sons and grandson of a few sires that were considered outstanding during the period.

The effects of different non-genetic factors on various lamb traits have been presented in Table 2. The least-square mean and regression coefficients of lambs and dams inbreeding for cumulative survival rate of lambs at different ages are presented in Table 3. Inbreeding of the lamb had

highly significant ($p < 0.01$) adverse effect on lamb survival up to 15 days; and 1, 2, 9 and 12 months of age after birth, whereas the effect was significant at 5% level ($p < 0.05$) on lamb survival up to 3 and 6 months of age after birth. On an average, 1% increase in individual inbreeding coefficient should reduce the 0.31, 0.34, 0.32, 0.31, 0.33, 0.44 and 0.49 percent lamb survival up to the age of 15 day; 1, 2, 3, 6, 9 and 12 months, respectively. The effect of inbreeding on lamb survival at different ages has been the subject of several reports and reviews (Doney, 1957; Lax and Brown, 1967; Galal et al., 1981; Wiener et al., 1983; Afifi et al., 1984; Lamberson and Thomas, 1984; Ercanbrack and Knight, 1991) and regression coefficients varied considerably from -0.007 to -0.444. The regression coefficients estimates for lamb survival rate at different ages up to 1 year of age in the present study is well comparable to reported estimates of various workers in different sheep breeds. However, Lamberson et al. (1984) reported higher regression coefficients of inbreeding on lamb survival to 7 day (-1.1%) and 90 day (-1.3%) as compared to the present findings.

The studies on inbreeding from the present experiment showed that considerable inbreeding depression occur for lamb survival at different ages of life. There is linear relationship between lamb's inbreeding and survival, which suggested that dominance was the major factor in the occurrence of depression in the study. Since the trait of low heritability like lamb survival tends to exhibit less additive genetic variation and more dominance deviation, this study

is in general agreement with the dominance theory as an explanation of genetic basis of inbreeding depression (Clarke, 1982). Under the dominance theory, the depression in performance will be more marked the greater the degree of dominance shown at each locus, and the greater the proportion of loci at which the dominant allele (alleles) is associated with favorable expression for the traits (directional dominance). Inbreeding increases the frequency of loci that are homozygous for either dominant or recessive alleles. The effect of increased homozygosity brought about by inbreeding is a decrease in performance. If however, there is no directional dominance and only additive gene effects; there will be no reduction in the population mean from inbreeding (Clarke, 1982).

Ewes inbreeding had no significant ($p>0.05$) effects on lamb survival at all ages, which is in agreement with the findings of Galal et al. (1981), Lax and Brown (1967) and Van Wyk et al. (1993) in different breeds of sheep.

CONCLUSION

The present study revealed that mild inbreeding developed in the flock of Muzaffarnagari sheep since 1981 and thereafter it increased. There was some accumulation of inbreeding as a consequence of the small effective size of some lines. The average lambs inbreeding percent was always higher than ewes from 1981 to 2000. Fluctuations in lambs as well as ewes inbreeding were observed in different years under study. There was a slow trend in accumulation of inbreeding in later periods for animals having inbreeding coefficient from 0 to 6.25 %. The sharp decrease of level of inbreeding of lamb in the flock from the year 2001 occurred due to introduction of proven rams from outside. The resulting inbreeding depression of lambs was significant on lambs' survival up to 15 days, 1, 2, 3, 6, 9 and 12 months of age. Ewes inbreeding had non-significant effects on lamb survival at all ages. As the level of inbreeding of lambs reduced the survivability of lambs, so there is urgent need to control inbreeding in the flock by restricting the co-selection of siblings, selecting more sires and dam, increasing the ratio of sires to dam and increasing the number of dams from commercial herds.

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