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Evaluation of Crossbreeding Effects for Wool Traits in Sheep

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ABSTRACT : Crossbreeding effects for wool quality traits viz. greasy fleece weight (kg), staple length (cm), average fibre diameter (μ) and medulation percentage were estimated using the Dickerson's and Kinghorn's models. The data analyzed involved 15 genetic groups including Nali purebred, F_1's of two and three breeds, F_2's and reciprocal crossbred obtained from the crossing of Nali (N), Merino (M) and Corriedale (C) breeds during 1980-96. Nali and Corriedale breeds had non-significant negative additive genetic effects (Dickerson's model) on greasy fleece weight, while effects of Corriedale were negative for staple length only from both models. In general additive genetic effects of all three breeds were non-significant for all the wool traits except medulation percentage. Non significant heterotic and recombination effects (epistatic loss) were estimated from both models. However, the estimates of crossbreeding effects varied between the models both in magnitude as well as in direction barring few exceptions. Undesirable positive heterosis was found on medulation percentage for all types of combinations involving three breeds. Comparison of least squares means of various genetic groups revealed that both two breed and three breed crosses were superior to the Nali breed for all wool quality traits. Fibre diameter of MN crossbreds was significantly less than CN crossbreds. Results also indicated that as the inheritance of Nali breed in a cross is decreased, the medulation percentage decreases which is desirable. Inter se mating of crossbreds (two breed, three breed) has not resulted in a decline in the wool quality traits. These results indicate that the synthetic population derived from three breeds can be stabilized easily for wool traits as there may not be epistatic loss on subsequent inter se mating of crossbreds. (**Key Words :** Heterosis, Crossbreeding, Epistatic Loss, Synthetic Population)

INTRODUCTION

Indian sheep breeds are known for adaptability under varied climatic conditions. The so-called Bikaneri sheep include brown face breeds viz. Chokla, Magra and Nali found in the North-Western arid region of India (Singh, 2000). Nali is a medium sized animal. Face color is light brown, skin color is pink, both sexes are polled. Ears are large and leafy and tail of this breed is short to medium and thin. Fleece is white, coarse, dense and long stapled.

Crossbreeding of indigenous breeds with exotic breeds has been used as one of the tool for quick improvement in the wool production and wool quality. Characterization of genetic and maternal effects attributable to each breed or breed combinations helps producers who use genetic resources effectively to improve efficiency of production. For utilization of genetic resources, not only the differentiation of genetic and environmental causes of phenotypic variation is needed but also the genetic part has to be separated into direct and maternal effects. In crossing different breeds, heterosis effects can appear. In secondary generations such as backcrosses and F_2 generations and crosses with more than two breeds, epistatic effects may be of further importance. Dickerson (1969, 1973) and Swan and Kinghorn (1992) pointed out that the epistatic loss is larger in crossing more than two breeds than crossing two breeds, because less interaction between genes coming from the same breed occur. If different breeds are crossed over several generations in order to create a new breed, the epistatic losses increase.

For the estimation of crossbreeding effects, dominance model has been widely used. Dickerson (1973) extended the dominance model by "recombination loss" accounting the epistatic effects on the level of the gametes. Another extension of the dominance model where the epistatic effects are considered on the level of genotypes rather than that of gametes was presented by Kinghorn (1980, 1982, 1983). Kinghorn (1987) presented the general model to describe the nature of 2 locus epistatic interaction. However, the comparative results on crossbreeding parameters estimated from same data using the Dickerson's and Kinghorn's models simultaneously are hardly documented

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in the literature. Also very little is known about the magnitude of genetic components of heterosis affecting the wool traits in sheep particularly the cases involving indigenous and exotic fine wool breeds. Keeping this in view the present study has been undertaken to quantify different crossbreeding effects for wool traits in sheep.

MATERIAL AND METHODS

Data on wool traits were collected on 15 genetic groups (F_1's, F_2's and respective inter se crosses etc.) produced over 17 years by crossing Nali (N) with Russian Merino (M) and Corriedale (C) breeds of sheep during 1980 to 1996. During the period of this study animals were kept at the sheep farm in pucca sheds with corrals. As far as possible, uniform managemental practices were followed during this study. The data on the wool traits viz. grease fleece weight (kg), staple length (cm), average fibre diameter (μ) and medulation percentage and weight of dam at lambing was recorded on individual animal of a genetic group. The breeding was restricted to two seasons viz. Spring (February to March) and Autumn (September to November).

The least squares means and standard errors of the genetic groups were obtained for all the traits using the following linear model.

$$Y_{ijklm} = \mu+G_i+S_j+P_k+T_l+\beta(X_{ijklm}-\overline{X})+e_{ijklm}$$

Where,

Y_{ijklm} = The observation on the m^{th} lamb of k^{th} genetic group, j^{th} sex born in i^{th} season of l^{th} year.

μ is population mean, G_i is the effect of i^{th} season of lambing (i = 1, 2), S_j is effect of j^{th} sex (j = 1, 2), P_k effect of k^{th} genetic group (k = 1, 2, … 15), T_l is the effect of l^{th} year (l = 1, 2, …… 17), X_{ijklm} is the weight of dam at lambing, β is regression coefficient of the trait(s) on weight of dam at lambing, and e_{ijklm} is the random error peculiar to ijklmth observation, NID (0, σ^2).

The mean of the various genetic groups were compared as per Kramer's modification of Duncan's Multiple Range Test (Kramer, 1956).

Estimation of crossbreeding effects

For the estimation of crossbreeding effects, observed genetic groups means were equated to their corresponding expectations in terms of a particular genetic model as under:

The Dickerson's model (Dickerson, 1969, 1973):

$$G = m+\sum_i \alpha_i g_i+\sum_{i<j}\delta_{ij}h_{ij}+\sum_{i<j}(4\alpha_i\alpha_j-\delta_{ij})r_{ij}$$

The Kinghorn's model (Kinghorn, 1987):

$$G = m+\sum_i \alpha_i a_i+\sum_{i<j}\delta_{ij}d_{ij}+\{\sum_i \delta_{ii}-(\sum_{j\neq i}\alpha_j)+\sum_{i<j}\delta_{ij}$$
$$-1/8[\sum_{i<j}\delta_{ij}^2+\sum_{j<j<k}(\delta_{ij}\delta_{ik}+\delta_{ij}\delta_{jk}+\delta_{ik}\delta_{jk})]\}e$$

Where,

G is the mean value of the genetic group under consideration, m is overall mean, α_i the proportion of genes from the i^{th} source population in the given genetic group, a_i or g_i are the direct genetic group (additive) of the i^{th} source population, d_{ij} is dominance effect of combination of i^{th} and j^{th} source population, h_{ij} is the heterotic effect for the combination of i^{th} and j^{th} source population, δ_{ij} is probability that at a randomly chosen locus of a randomly chosen individual of the genetic group one allele is from the i^{th} and the other allele from the j^{th} source population, r_{ij} is the recombination loss for the combination of the i^{th} and j^{th} source population, and e is the epistatic effect (loss).

As number of animals differed widely in various genetic groups, so the means of genetic groups were not based on equal variance, the weighted least square technique (Bulmer, 1980) was used to estimate the parameters assuming the following linear model.

$$Y = Xb+e, \qquad Var(y) = V$$

Where, Y is a vector of observed genetic group means, X is the incidence matrix of the coefficients of the parameters in the expected genetic group mean, b is the vector of genetic parameters, e is the vector of residual effects, and V is the diagonal matrix with the variance of the means of genetic groups.

The estimate of b was estimated as

$$\hat{b} = (X'wX)^{-1}X'wy$$

Where, w is V^{-1}, the matrix of weights, is the inverse of diagonal matrix of variances of genetic group means on the assumptions of zero covariances between them.

The standard error of a parameter estimate was obtained by taking the square root of the corresponding diagonal element of the matrix i.e.

$$Var(\hat{b}) = (X'wX)^{-1}$$

Crossbreeding effects were calculated using CBE-General PC programme of Wolf (1995).

RESULTS AND DISCUSSION

Least squares means

Least squares means along with their standard errors for various wool traits of 15 genetic groups are presented in

Table 1. Genetic group wise least squares means for wool traits

Genetic group	N	Grease fleece weight (kg)	Staple length (cm)	Av. fibre diameter (μ)	Medulation percentage
N	404	0.767^{a}±0.015	6.35^{a}±0.11	29.60^{a}±0.43	50.70^{a}±1.20
MN	289	0.777^{a}±0.023	5.26^{b}±0.16	23.26^{cde}±0.60	18.57^{ef}±1.66
CN	200	0.785^{a}±0.025	6.67^{a}±0.15	25.72^{bc}±0.62	31.26^{bc}±1.70
MN×MN	60	0.733^{ab}±0.039	5.90^{d}±0.37	25.94^{d}±1.39	20.78^{d}±3.84
CN×CN	29	0.697^{b}±0.055	5.91^{b}±0.38	25.93^{b}±1.42	28.15^{b}±3.91
MN×CN	166	0.719^{a}±0.025	5.63^{b}±0.17	24.12$^{bcd`e}$±0.06	20.08^{de}±1.83
CN×MN	257	0.745^{a}±0.021	5.57^{b}±0.15	24.81^{bcd}±0.61	23.94^{cd}±1.68
CMN	279	0.754^{a}±0.022	5.29^{b}±0.14	23.52^{cde}±0.53	13.51^{f}±1.46
MCN	181	0.772^{a}±0.025	4.87^{bc}±0.15	22.82^{de}±0.59	10.38^{f}±1.63
MCN×CMN	63	0.757^{a}±0.038	4.86^{c}±0.21	23.83^{cde}±0.81	11.01^{f}±2.23
CMN×MCN	58	0.715^{ab}±0.039	5.16^{bc}±0.22	23.59^{cde}±0.87	11.55^{f}±2.39
CMN×CMN	38	0.802^{a}±0.048	5.38^{bc}±0.28	23.22^{bcde}±1.16	9.12^{f}±3.21
MCN×MCN	28	0.777^{a}±0.066	5.08^{bc}±0.40	21.85^{e}±1.57	12.24^{f}±4.33
CNMN×CNMN	51	0.728^{ab}±0.004	5.71^{b}±0.28	25.10^{bcd}±1.16	22.85^{cd}±3.21
CNMN×MNCN	45	0.758^{a}±0.043	5.49^{bc}±0.26	25.74^{bc}±1.10	18.92^{cde}±3.03

Means bearing different superscripts differ significantly from each other (p<0.05).

Table 2. Estimates of crossbreeding effects for wool traits from Dickerson's model

Parameter	Grease fleece weight (kg)	Staple length (cm)	Av. fibre diameter (μ)	Medulation percentage
g_1	-0.038±0.308	0.738±2.090	-4.169±8.273	-34.627±22.758
g_2	0.076±0.227	0.560±1.535	4.211±5.998	0.711±16.500
g_3	-0.038±0.232	-1.298±1.510	-0.042±5.911	-35.338*±16.26
h_{1x2}	-0.043±0.249	-0.960±1.700	-10.442±6.703	-15.174±18.438
h_{1x3}	0.011±0.253	1.299±1.684	-6.033±6.652	15.546±18.297
h_{2x3}	0.044±0.145	-1.549±1.131	-4.666±4.257	-8.665±11.706
r_{1x2}	-0.048±0.371	-0.709±2.449	5.876±9.914	-33.567±27.269
r_{1x3}	0.005±0.374	-0.299±2.464	8.262±9.964	-6.637±27.408
r_{2x3}	0.130±0.276	-1.457±1.934	2.603±7.734	-19.062±21.272
g_{m1}	0.076±0.382	-0.435±2.529	8.592±10.210	-12.621±28.086
g_{m2}	-0.029±0.192	0.168±1.277	-3.943±5.154	9.809±14.177
g_{m3}	-0.047±0.195	0.267±1.288	-4.649±5.188	2.812±14.272

Subscripts 1, 2, 3 are for Nali, Merino and Corriedale, respectively.
* Significant (p<0.05).

Table 1. The population averages for grease fleece weight, staple length, average fibre diameter and medulation percentage were 0.825±0.008 kg, 5.72±0.04 cm, 24.66±0.17 μ and 23.04±0.62 respectively. Highest grease fleece weight was observed for CMN×CMN group (0.802±0.048 kg) and lowest for CN×CN group (0.697±0.055 kg). Malik et al. (1991) reported grease fleece yield for Nali and its crosses with Corriedale (CN) and Russian Merino (MN) similar to that observed in this study. Nali had significantly (p<0.05) higher staple length than MN, three breed crosses and their inter se crosses. The MN group had significantly (p<0.05) lower staple length than the CN group, while the three breed F_1's (CMN, MCN) were similar for this trait.

Significantly highest fibre diameter and medulation percentage was recorded for Nali purebreds than all other crossbred groups which is obvious as Nali is a carpet type breed. The F_1's of two breeds and three breeds had similar fibre diameter but the CN group had significantly (p<0.05) higher medulation percentage compared to MN group. Gani and Pandey (1993) from the crossbreeding experiment of Rambouillet with Australian Merino observed decreased fibre diameter with the increased Merino inheritance which is in accordance to the present results. Kandasamy and Pant (1987) reported highest fibre diameter and medulation percentage for Nali purebred as compared to its crossbreds with Soviet Merino and Rambouillet. There existed non-significant differences for fibre diameter among the three breed crosses and their reciprocal crosses indicating no deterioration of heterosis due to inter se mating of crossbred. Results indicated that as the inheritance from Nali breed in a cross is decreased, the medulation percentage decreases which is desirable.

Crossbreeding effects

Crossbreeding effects for wool traits estimated from Dickerson's and Kinghorn's models are presented in Table 2 and 3 respectively.

Table 3. Estimates of crossbreeding effects for wool traits from Kinghorn's model

Parameter	Grease fleece weight (kg)	Staple length (cm)	Av. Fibre diameter (μ)	Medulation percentage
a_1	-0.203±0.186	1.777±1.276	0.913±5.054	34.956**±13.902
a_2	0.106±0.161	-0.175±1.104	0.365±4.281	-14.903±11.773
a_3	0.097±0.148	-1.602±1.092	-1.279±4.238	-20.052±11.656
d_{1x2}	-0.280±0.415	1.309±2.844	-8.546±11.367	12.745±31.263
d_{1x3}	-0.281±0.403	3.334±2.854	-5.547±11.393	26.591±31.333
d_{2x3}	-0.159±0.245	0.452±1.663	-4.840±6.672	10.889±18.350
E	0.280±0.553	-2.736±3.856	5.297±15.469	-38.527±42.540
a_{m1}	0.246±0.290	-1.364±2.040	3.858±8.134	-12.338±22.369
a_{m2}	-0.120±0.146	0.584±1.029	-1.860±4.100	6.382±11.277
a_{m3}	-0.126±0.148	0.780±1.036	-1.998±4.126	5.956±11.347

Subscripts 1, 2, 3 are for Nali, Merino and Corriedale, respectively.
** Significant (p<0.01).

Grease fleece weight

Additive genetic effects estimated from Dickerson's model were positive for Merino (0.076 kg) and negative for Nali and Corriedale breeds. The heterosis in this trait for all types of crosses are relatively small and non significant. Recombination effects were negative for Nali×Merino cross while unexpectedly positive for other two crosses. Direct maternal effect was relatively positive and small for Nali while it was negative for Corriedale and Merino breeds. The estimated values of different effects did not vary between the two models both in magnitude and direction and the effects were non significant.

Staple length

Additive genetic effects were positive for Nali and Merino breeds while it was negative for Corriedale which is desirable. Desirable negative heterosis for Nali and Merino cross was observed. Epistatic effects (loss) estimated with Dickerson model ranged between -0.299 to -1.457 cm for staple length. Negative direct maternal effects on this trait were observed for Nali breed (-0.435 cm) while it was positive but relatively small for Merino and Corriedale breeds. The estimates of crossbreeding parameters varied between the two models both in magnitude as well as in direction barring few exceptions. However, the estimates were not significant in both the cases, implying the similarity in both the models.

Average fibre diameter

Additive direct effects estimated with the Dickerson's model were -4.169, 4.211 and -0.042 μ for Nali, Merino and Corriedale breeds respectively. Desirable negative heterosis was observed for all types combinations of the breeds under study. Positive epistatic effects (loss) as expected were estimated for the different crosses involving three breeds. Negative direct maternal effect on this trait was estimated for Merino and Corriedale breeds while it was positive for Nali breed. Barring few exceptions, crossbreeding effects estimated with Kinghorn's model did not differ both in magnitude and direction than those estimated with the Dickerson's model, and were non significant.

Medulation percentage

As expected , highest additive genetic effect estimated with Dickerson's model was observed on medulation percentage for Nali breed. Small and negative additive genetic effect was estimated for Merino and Corriedale breeds. Desirable negative heterosis was estimated for Nali×Merino (p<0.05) and Nali×Corriedale crosses, respectively. Recombination effects were prominent for all the combinations under study. Direct maternal effect was estimated to be negative for Nali breed but positive for Merino and Corriedale breeds. Using the Kinghorn's model, significant (p<0.01) additive genetic effect was estimated for Nali breed only while negative for exotic breeds. The additive genetic effects for medulation percentage estimated from the two models had similar magnitude yet different directions may because different definitions of the models. Undesirable non-significant positive heterosis was estimated for all types of combinations involving three breeds. Prominent epistatic loss (-38.527) though non-significant was estimated for this trait. Negative direct maternal effect was found for Nali breed only. In general, estimates from both the models were non significant.

Results obtained on the wool quality traits in the present study are in accordance to those of Trus and Wilton (1988) who reported that dominance effect are not important in performance testing of rams. Snyman et al. (1995) reported that maternal effects have non significant influence on clean fleece weight or mean fibre diameter in conformity to the present results.

Contrary to the present results, Snyman et al. (1996) reported that grease fleece weight was significantly affected by maternal additive genetic and permanent environmental effects. Direct additive genetic effect had a significant effect on mean fibre diameter.

The crossbreeding effects for wool traits estimated in the present study may not be precise as the standard errors in general are high. Lack of performance records of exotic purebreds (Merino and Corriedale) might have led to under estimation of crossbreeding effects

Inter se mating of F_1's (two breed, three breed) has not resulted in decline in the wool quality traits. Non-significant recombination loss or epistatic loss observed for all the traits from both models showed no or less deterioration of heterosis on inter se mating of crossbreds. These results are of indicative of the fact that the synthetic population can be formed and stabilized for wool traits for commercial exploitation

REFERENCES

Bulmer, M. G. 1980. The mathematical theory of quantitative genetics. Clarendon Press Oxford, London.

Dickerson, G. E. 1969. Experimental approaches in utilizing breed resources. Anim. Breed. Abstr. 37:191-202.

Dickerson, G. E. 1973. Inbreeding and heterosis in animals. Proc. Anim. Breed. Genet. Symp. In honour of Dr. J. L. Lush in Champaign, ILlinois A.S.A., A.D.S.A. 111:54-77.

Gani, T. A. S. and R. S. Pandey. 1993. Comparision of wool traits of Rambouillet and its grades with Australian Merino. Ind. J. Anim. Sci. 63:783-784.

Kandasamy, N. and K. P. Pant. 1987. Effect of crossbreeding on fleece quality of young sheep under semi-arid region in India. Ind. J. Hered. 19:1-5.

Kinghorn, B. P. 1980. The expression of 'recombination loss" in quantative traits. Z. Tierz. Zuchtungsbiol. 97:138-143.

Kinghorn, B. P. 1982. Genetic effects in crossbreeding. I. Models of merit. Z. Tierz. Zuchtungsbiol. 99:59-68.

Kinghorn, B. P. 1983. Genetic effects in crossbreeding. III. Epistasis loss in crossbred mice. Z. Tierz. Zuchtungsbiol. 100:209-222.

Kinghorn, B. 1987. The nature of two locus epistatic interaction in animals: Evidence from Sewal Wright's guinea pig data. Theor. Appl. Genet. 73:595-604.

Kramer, C. Y. 1956. Extension of multiple range test to group means with unequal numbers of replication. Biom. 12:307-310.

Malik, B. S., B. Singh and M. L. Sangwan. 1991. Studies on fleece production in Nali and its crosses. Ind. J. Anim. Res. 24:82-84.

Singh, R. N. 2000. Conservation and management of sheep genetic resources. The Indian J. Anim. Genet. Breed. 22:167-176.

Snyman, M. A., G. J. Erasmus, J. B. Van Wyk and J. J. Olivier. 1995. Direct and maternal (Co) variance components and heritability estimates for body weight at different ages and fleece weight in Afrino sheep. Livestock Production Sci. 44:229-235.

Snyman, M. A., J. J. Olivier and W. J. Olivier. 1996. Variance componenets and genetic parameters for body weight and fleece traits of Merino sheep in arid environment. South-African J. Anim. Sci. 26:11-14.

Swan, A. A. and B. P. Kinghorn. 1992. Evaluation and exploitation of crossbreeding in dairy cattle. J. Dairy Sci. 75:624-629.

Trus, D. and Wilton, J.W. 1988. Dominance model for ram evaluation. Centre for genetic improvement of livestock. Annual Research Report 35-36.

Wolf, J. 1995. CBE-General PC Programme for estimating crossbreeding parameters. Pragus, Czech Republic.