International Journal of All Research Education and Scientific Methods (IJARESM)
ISSN: 2455-6211, Volume 4, Issue 3, March 2016

Experimental Study of Genetic Architecture of Sheep Population

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ABSTRACT

The study was undertaken with the objectives to study the effects of non-genetic factors, to estimate phenotypic and genetic parameters and phenotypic and genetic trends and divergence analysis of synthetic sheep population. The data were collected from records maintained in the project in the Department of Animal Breeding, CCS Haryana Agricultural University, Hisar. The data on economically important traits were collected on 1118 animals for 15 years (1986 to 2000) & these animals were grouped into seven generation viz. G1 to G7. The economic traits studied were: Birth weight (BW), Weaning weight (WW), Six-month body weight (SMW), Pre-weaning average daily gain (PRWDG), Post-weaning average daily gain (POWDG), One year body weight (YBW), Age at first lambing (AFL), Weight at first lambing (WFL), Average lambing interval (ALI), Grease fleece weight (GFW), Staple length (SL), Average fibre diameter (FD) and Medullation per cent (MP). The data were analyzed using Mixed Model Least-squares and Maximum Likelihood computer programme.

Keywords: Studies, Genetics, Architecture, Sheep, Populations.

INTRODUCTION

India is a rich repository of sheep genetic resources having 42 breeds. Majority of these breeds have been defined in terms of phenotypic characteristics, which distinguish them from other populations & have primarily been named after the name of their main habitat. No attempt has been made to define these populations in terms of their phylogeny & genetic structure. Cross breeding of native sheep with exotic breeds has been in practice since long to bring about improvement in both wool & mutton production. The results of such attempts have been the evolution of some superior breeds, viz. Hissardale, Kashmir Merino, Bharat Merino etc.

The economic traits studied in this paper were: Birth weight (BW), Weaning weight (WW), Six-month body weight (SMW), Pre-weaning average daily gain (PRWDG), Post-weaning average daily gain (POWDG), One year body weight (YBW), Age at first lambing (AFL), Weight at first lambing (WFL), Average lambing interval (ALI), Grease fleece weight (GFW), Staple length (SL), Average fibre diameter (FD) and Medullation per cent (MP). The data were analyzed using Mixed Model Least-squares and Maximum Likelihood computer programme (Harvey, 1987).

Effect of year of birth was significant ($P<0.01$) on all the traits under study except YBW and ALI. Effect of season was significant ($P<0.01$) on BW, WW, POWDG, YBW and GFW and non-significant on rest of the traits. Sex of lamb was found to be significant ($P<0.01$) source of variation in all the growth traits and GFW. Effect of dam's age at lambing was significant on BW, WW, SMW and PRWDG, while non-significant on rest of the traits. Dam's weight at lambing significantly affected BW, WW, SMW, PRWDG, YBW, WFL, GFW, FD and MP.

Heritability estimates were moderate to high for most of the traits under study. The phenotypic correlation of BW with WW, SMW, PRWDG, AFL, WFL and GFW was positive and significant ($P<0.01$). The phenotypic correlation of AFL & WFL were positive & significant ($P<0.01$) with GFW; whereas phenotypic correlation of WFL & ALI with FD were negative and significant ($P<0.01$). The phenotypic correlation of GFW with other wool traits was non-significant except with FD, which was significant ($P<0.01$) but negative. The genetic correlations among various traits varied from low to moderate hence, were of little significance except correlations among the growth traits (WWx PRWDG, SMW x POWDG) and some of the reproduction traits (WFL x AFL), which were of higher values.

Divergence analysis revealed that the D2-value was maximum and significant between generation G2 and G7. BW, WW and GFW contributed maximum towards discrimination. G1 and G2; G3 and G4 & G5, G6 and G7 were grouped in cluster

I, II & III respectively, for growth and reproduction traits, indicating that the synthetic sheep population became stable in the last three generations.

MATERIAL AND METHODS

Several methods are being developed to measure the genetic change in animal population. The early attempt of Lortscher (1937) to measure genetic change in herd performance has been criticized because the age correction factors were confounded with year effects. More recently Smith (1962) and Powell and Freeman (1974) gave methods of estimation of genetic change in field records. Further, the aim of the research has also been to evolve new breed/strain through stabilization of the synthetic population of sheep which has been evolved by cross breeding. The crossbreds having 62.5 per cent exotic inheritance from Russian Merino and Corriedale were graded the best for growth and wool traits out of other grades having exotic inheritance of 50 or 75 percent. Inter-se mating of these crossbreds has been in progress for several generations at CCS HAU, Hisar. Divergence is one of the techniques, which can be applied to study distance/difference between subsequent generations of inter-se mating. Stable performance is one of the most desirable properties of a genotype (breed/strain) to be released as a breed for wider utilization by the breeders.

The relevant data for the present investigation were collected from the history cum-pedigree sheets of 1118 animals of synthetic sheep population evolved as the product of the project entitled, "Estimating the cross combining ability of Corriedale and Russian Merino rams with Nali ewes", run in the department of Animal Breeding, CCSHAU, Hisar. The data collected extended over a period of 15 years, from 1986 to 2000.

Health coverage

Lambs were vaccinated against enterotoxaemia and Sheep-Pox at two months of age. Deworming of the flock was done regularly at an interval of four months. To control infestation of ectoparasites, animals were dipped regularly in proper concentration of insecticides after twenty days of shearing.

Breeding policy

The crossbreeding and pure breeding were carried out in the project entitled, "Estimating the cross combing ability of Nali with Corriedale and Russian Merino" to produce various grades of crossbreds ranging from 50 per cent to 75 per cent exotic inheritance and contemporary Nali sheep to compare their performance in terms of growth production and reproduction under similar management and environmental condition. The crossbreds having 62.5 per cent exotic inheritance from Russian Merino and Corriedale were graded the best for growth and wool traits. Inter-se mating of these crossbreds had been in progress during the period under study. The crossbred rams retained for breeding were selected on the basis of six-month body weight along with due emphasis on fleece quality. Mild selection in females was also practiced for body weight and wool quality. Breeding was restricted to two seasons, viz., Spring (February to March) and Autumn (September to November). Aproned rams were used for heat detection in the flock two times daily (morning and evening). The ewes detected in heat were allotted randomly to selected rams to avoid inbreeding.

Recording of information

Birth weights and dam's weights were recorded within sixteen hours of lambing. The weaning weights and six-month body weights in the present study were recorded at 90 days and 180 days of age, respectively.

Grease fleece weight

The grease fleece weights included in the present study were recorded lamb wise at their first clip at the age of six month.

Wool analysis

The wool samples for analysis were collected with the help of scissors from an area of approximately 2" x 2" at the left mid side region of the sheep. The samples were kept in polythene bags with Naphthalene ball in each bag with identification chit marked with animal number.

Staple length

For measuring the staple length ten samples from each animal were collected and staple lengths were measured with the help of measuring scale on un-stretched samples and averages were taken.

Heritability, phenotypic and genetic correlations

Heritability estimates and genetic correlations for different traits were estimated by paternal half-sib correlation method using sire component of variance and covariance.

Phenotypic correlations between different traits were estimated from various components of variance and covariance. The standard error of phenotypic correlation was estimated by using the formula given by Robertson (1959).

Effects of non-genetic factors

The data used in the present study were with unequal subclass frequencies causing the different classes of effects to be non-orthogonal. So, to study the effect of various non-genetic factors on different traits, the Mixed Model Least-squares and Maximum Likelihood computer programme (Harvey, 1987) was used. Least-squares means were compared using Duncan's Multiple Range Test as modified by Kramer (1957). The statistical model used was:

Effect of non-genetic factors

The following mixedmodel least-squares likelihood computer program of Harvey (1987) was used to find out the effect of non-genetic factors.

$$Y_{ijklmn} = \square + S_i + P_j + T_k + B_l + A_m + b\,(X_{ijklmn} - \bar{X}) + e_{ijklmn}$$

Where,

Y_{ijklmn} = Observation on n^{th} lamb belonging to m^{th} age group of dam, of l^{th} sex born in k^{th} season, of j^{th} year, of i^{th} sire.

Overall mean

S_i	=	Random effect of i^{th} sire NID (0, $\sigma^2 s$)
P_j	=	Fixed effect of j^{th} year (j=1, 2, 3…..15)
T_K	=	Fixed effect of k^{th} season (k = 1, 2)
B_I	=	Fixed effect of l^{th} sex (1 = 1, 2)
A_m	=	Fixed effect of m^{th} age group of dam (m = 1,2,3 ...7)
b	=	Partial regression of traits on dam's weight at lambing
X_{ijklmn}	=	Dam's weight
X	=	Mean dam's weight
$\bar{e}_{ijklmn}$	=	Random error assumed to be normally and independently distributed with mean zero and variance σ_e^2.

Various interaction effects were assumed as non-significant. However, to study the effect of various factors on reproduction traits, the above model was used after deleting sex effect.

Test of significance of D^2 value

The test of significance of D^2-value for p-characters, for all the generations pair-wise under study was carried out by using F-test given below:

$$F = \frac{N_1N_2\,(N_1+N_2-p-1)}{p\,(N_1+N_2)\,(N_1+N_2-2)} \times D^2_p$$

Where

p and $N_1 + N_2 - p-1$ are degrees of freedom

p = number of characters included

N_1 & N_2 are number of animals in the two generations.

RESULTS AND DISCUSSION

Seasonal differences on birth weight were found to be significant. Similar finding were reported by Joshi and Datta (1985), Singh *et al*. (1987), Jagtap *et al*. (1992) and Singh (1995) in different breeds of sheep. However non-significant effect of season of birth on birth weight was reported by Sridar *et al*. (1985) in Mecheri, Naikare *et al*. (1987) in Deccani and Roda *et al*. (1990) in Poolworth sheep.

Effect of sex of lamb

The male lambs weighed significantly ($P \leq 0.01$) heavier (3.33±0.02 kg) at birth than female lambs (3.18±0.02 kg). Significant sex differences in birth weight were also reported by Poonia *et al*. (1984), Naikare *et al*. (1987), Singh and Dhillon (1992), Singh *et al*. (1998) and Sharma *et al*. (2003) in different Indian breeds of sheep. This difference of birth weights between the two sexes may be due to hormonal influences.

However, non-significant effect of sex on birth weight was reported by Arora and Batta (1983) in Gaddi and its crosses with Rambouillet and Soviet Merino sheep.

Effect of dam's age at lambing

Age of dam was found to be a significant ($P \leq 0.01$) source of variation in birth weight. Heavier (3.39±0.04kg) lambs were delivered by ewes belonged to 61-72 months age group and the lighter (3.01±0.03 kg) lambs were delivered by ewes belonged to <36 months age group. The present results were in close conformity with the findings of Sheikh *et al*. (1986) and Singh and Dhillon (1992). However, Krishnappa (1980) in Deccani and Negi *et al*. (1987) in Gaddi and its crossbreds found non-significant effect of dam's age on birth weight.

Effect of dam's weight at lambing

Dam's weight at lambing significantly ($P \leq 0.01$) influenced birth weight of lambs. The present results were in accordance with the findings of Poonia *et al*. (1984), Singh *et al*. (1987), Gupta and Reddy (1987), Singh and Dhillon (1992), Singh *et al*. (1995) and Singh *et al*. (1998) in different breeds.

From the present results, it may be concluded that well fed ewes having higher body weights at lambing deliver heavier lambs. So, the breeder should feed the ewes judiciously in later stages of pregnancy to have a better lamb crop.

Weaning weight
Average

The average weaning weight was obtained as 10.66±0.10 kg. The result of the present study were on higher side than those reported by Acharya (1981) and Singh (1995), but on lower side than the results obtained by Poonia *et al*. (1984), Choudhary (1988), Arora *et al*. (1986), Sharma *et al*. (2003) in Nali crosses.

Effect of year of birth

Year of birth significantly ($P \leq 0.01$) influenced the weaning weight of lambs. The present findings were in close agreement with those reported by Poonia *et al*. (1984), Joshi and Datta (1985), Negi *et al*. (1987), Malik *et al*. (1988), Sharma *et al*. (1991), Singh and Dhillon (1992) Singh (1995), Lal *et al*. (2000) and Sharma *et al*. (2003) in different breeds. significant difference due to years could have arisen due to differences in availability of fodder and natural pastures in varying climatic conditions of different years. The availability of fodder to ewes would affect the milk production and thereby affecting the growth of lambs.

Effect of season of birth

Spring born lambs were significantly ($P \leq 0.01$) heavier (11.02 ± 0.10 kg) at weaning than Autumn born lambs (10.09 ± 0.34 kg). This result was in close agreement with those reported by Poonia *et al*. (1984), negi. *et al*. (1987), Naikare and Jagtap (1989) and Lal *et al*. (2000) in different breeds. However, Sridar *et al*. (1985) and Roda *et al*. (1990) found non-significant effect of season on this trait.

Reproduction traits

Least squares means along with their standard errors and the analysis of variance for the reproduction traits are presented in Table 1

Table 1: Analysis of variance for reproduction traits

Source of variation	d.f.	Mean sum of squares		
		AFL	WFL	ALI
Year of birth	13	162873.02**	58.06**	10903.79
Season of birth	1	3119.79	0.44	5608.42
Dam's age at lambing	6	32720.67	5.27	4506.50
Dam's weight at lambing (linear regression)	1	5339.48	193.66**	11437.32
Error		50864.17 (263)	12.46 (264)	9005.48 (245)

* Significant at P≤0.05
** Significant at P≤0.01
Figures within parentheses are respective error d.f.

Table 2: Estimates of heritability for various economic traits

Traits	Heritability ± S.E.
Growth traits	
BW	0.52±0.10
WW	0.32±0.09
SMW	0.37±0.09
PRWDG	0.23±0.08
POWDG	0.77±0.12
Reproduction traits	
AFL	0.70±0.19
WFL	0.87±0.24
ALI	0.39±0.15
Wool traits	
GFW	0.25±0.05
SL	0.45±0.11
FD	0.52±0.12
MP	0.48±0.11

Relative diversities & test of significance of D^2-values

The highly significant D^2-values were found in G1-G6, G1- G7, G2-6, G2- G7, G3- G6, G3- G7, G5- G6, G5- G7 and G6 G7 and significant between G1- G2 and G2- G4 ($P \leq 0.05$). The highest D^2-value was observed between G2 and G7 due to inherent genetic diversity present in these generations whereas the lowest was between G1 and G4. D2 values arranged in increasing order of magnitudes for wool traits are presented in Table 4.22. Narain and Garg (1975) have used wool trait for D^2-statistic among Rambouillet crosses.

Contribution of each wool trait to overall genetic diversity

GFW was found to contribute (76.19%) maximally towards overall discrimination followed by MP (14.28%), SL (4.76%) and FD (4.76%), Jaiswal *et al*. (1992) have done such work on crossbred cattle.

Cluster diagram

Based on D^2 value G1, G2, G3, G4 and G5 were placed on cluster I and G6 and G7 in cluster II. According to the calculated values of average intra and inter cluster distances cluster diagram was formed.

CONCLUSION

The studied flock showed significant ($P<0.01$) phenotypic trend for BW, WW, SMW, POWDG, YBW, AFL, WFL, GFW, SL ($P<0.05$) and FD but favorable for SMW, POWDG, YBW, AFL, SL and FD and unfavorable for BW, WW, WFL & GFW. These estimates of genetic trend showed favorable genetic changes in YBW, WFL, GFW, SL, FD and MP but for rest of the traits these were unfavorable.

Divergence analysis revealed that the D2-value was maximum and significant between G2 and G7 among growth, reproduction and wool traits. In growth and reproduction traits, BW was found to contribute maximally (71.42%) towards discrimination followed by WW (23.80%) and AFL (4.76%). GFW was found to contribute maximally (76.19%) towards discrimination followed by MP (14.28%), SL (4.76%) and FD (4.78%) among wool traits. Based on average inter and intra cluster distances, among different generations for growth and reproduction traits, G1 and G2; G3 and G4; G5; G6 and G7 were grouped in cluster I, II and III respectively, indicating that the synthetic sheep population became stable in the last three generations.

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