Global Journal of Animal Breeding and Genetics

ISSN: xxxx-xxxx Vol. 1 (1), pp. 042-047, November, 2013. © Global Science Research Journals

Full Length Research Paper

Genetic analysis of growth and feed conversion efficiency of Muzaffarnagari lambs under intensive feeding system

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Abstract

Data on 534 Muzaffarnagari lambs, maintained under intensive feeding management system at the Central Institute for Research on Goats, Makhdoom, Mathura, Uttar Pradesh, India were recorded between 1989 to 2002, so as to study the growth performance and feed conversion efficiency of lambs and their genetic control. The overall least-squares means for 3-month weight, 6-month weight and average daily weight gain during 3 to 6 months of age of lambs were 16.11 ± 0.34 kg, 26.84 ± 0.51 kg and 119.23 ± 4.35 g, respectively. The average Feed Conversion Efficiency (FCE) of lambs during this stage of development was 16.24 ± 0.47%. Significant (P<0.01) differences among sires existed for all the growth traits and feed conversion efficiency of lambs. There were marked period-wise differences of all the traits under study but no definite pattern was observed among different birth periods. The parity of dam had only significant (P<0.01) influence on 3 and 6-month body weights of lambs. Season of birth significantly (P<0.01) affected the 3 month weight and average daily weight gain during 3 to 6 months of age of lambs in this study. Male lambs excelled (P<0.01) over their female counterpart in respect of 3 and 6 months weights, average daily weight gain and feed conversion efficiency of lambs during this stage of growth. Single kids had a distinct advantage over those born in multiple births for weights at 3 and 6 months of age. The regression of weight of dam at lambing showed significant (P<0.01) effect on all the traits under study. The heritabilities of 3 and 6 month weight, average daily weight gain and feed conversion efficiency during 3 to 6 months of age were moderate in magnitude ranging from 0.17 to 0.32. Genetic correlations among 3 and 6 month weight, average daily weight gain and feed conversion efficiency of lambs obtained in this study were medium (0.51 ± 0.32) to high (0.97 ± 0.24) except the correlation between average daily weight gain and feed conversion efficiency (0.10) of lambs.

Key words: Average daily weight gain, growth traits, feed conversion efficiency, heritability, Muzaffarnagari sheep.

INTRODUCTION

For genetic improvement in lamb breeding enterprises, the important traits include the growth characteristics of the animal. Economic success of livestock production largely depends on inputs in relation to net outputs, which is most relevant in the case of meat- producing sheep. Thus, feed intake is an important aspect of animal production system because of its close relation to animal performance thereby making profits. The potential of the animal to convert the feed consumed into body biomass is the contributing factor and is dependent not only on quality and quantity of feed consumed but also depends on the genotype transmitted from parents to offspring (Khan and Singh, 1995). The various e nvironmental

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factors which affect the growth traits as well as feed conversion efficiency of animals directly obscure the recognition of the genetic potential of animals. To obtain reliable estimates of inheritance pattern for important economic traits and to increase the accuracy of selection of breeding animals, adjustment of data for environmental factors for the various traits are necessary. The effect of various factors like year/period of birth, parity of dam, season of birth, sex and birth status of lamb on lamb growth traits (Mandal et al., 2003, 2007, Dass et al., 2008) and feed conversion efficiency (Prakash et al., 1990; Mandal et al., 2007) in this breed has been studied earlier.

However, the present study was undertaken to identify various environmental factors (namely; period of birth, parity of dam, season of birth, sex and birth status of lamb) influencing the growth traits as well as, feed conversion efficiency and their genetic control in Muzaffarnagari lambs reared under the intensive system of feeding management.

MATERIALS AND METHODS

Study area

The experiment was carried out at the Genetics and Breeding Division of the Central Institute for Research on Goats (CIRG), Makhdoom, Mathura, Uttar Pradesh, India. The Institute maintains a purebred Muzaffarnagari flock of 250 breeding females. It is situated between Agra and Mathura at 27° 10' N and 78° 02' E, 169 m above the sea level. The climate is almost semi-arid. The temperature ranges from 0 to over 45°C, with an annual precipitation of about 750 mm mainly during the Monsoon from July to September.

Description and management of flock

The Muzaffarnagari sheep is one of the heaviest and largest mutton breeds in India and is widely distributed in the semi-arid region of Western Uttar Pradesh, near Meerut, Muzaffarnagar, Saharanpur and Bijnor and in the some parts of Delhi and Haryana. The breed has better potential for meat and carpet wool production than other Indian sheep breeds (Mandal et al., 2000). The detailed descriptions as well as, the distribution and husbandry practices of this breed have been reported by Mandal et al. (2000). In brief, animals were housed separately according to their ages, sex, physiological and health status and maintained in two feeding systems, semi-intensive or intensive/individual feeding system. Lambs were weaned at the age of 3 months, put in individual feedlot experiment under complete confinement and fed individually *ad-libitum* for a period of 180 days post-weaning to explore their genetic potentiality. The lambs were provided with 500 g of concentrate mixture, consisting of 72% TDN and 16% DCP. The concentrate mixture constituted of 15% maize, 20% barley, 35% ground nut cake, 20% wheat bran, 7% molasses, 1.5% mineral mixture and 1.5% salt. Gram straw (*Cicer arietimum*) was offered *ad-libitum* to all animals. Lambs maintained in March to April were offered *ad-libitum* Bajra fodder whereas, the lambs maintained in October to November were given mixture of Oat and Berseem fodder in the ratio of 50: 50 on DM basis. Fresh drinking water was available to all lambs. Feed and fodder intake was recorded daily by difference of offered and that of left over. Dry matter contents of feed and fodder were estimated on a weekly basis by using standard techniques.

Data

Data on Muzaffarnagari lambs maintained under intensive system of feeding management at the Central Institute for Research on Goats, Makhdoom, Mathura, Uttar Pradesh, India were recorded between 1989 to 2002 for this study. Records on 534 lambs that descended from 68 sires and 148 dams were available for the study. The average number of progeny per sire and dam was 7.85 and 2.01, respectively. The body weight at 3 months of age (WT3M) and weight at 6 months of age (WT6M) of lambs were recorded. The average daily gain (ADG) during 3 to 6 months of age (ADG3-6M) and feed conversion efficiency (FCE) from weaning to 6 month of age were computed. Feed conversion efficiency was computed from actual dry matter intake (DMI) by the lambs as follows:

$$FCE = (\text{Body weight gain} / DMI) \times 100.$$

The data were classified according to the period of birth, parity of dam, season of birth, sex and birth status (single vs. twin) of lamb. The lambing years were divided into seven periods, each comprising of 2 years based on the use of different rams during each period. Each lambing year was also divided into 2 seasons, that is, S-1 (March to April) and S-2 (October to November). The weight of the dams at lambing was considered by linear regression on the body weights of the lamb. Traits considered for these analyses were WT3M, WT6M, ADG3-6M and FCE of lambs during 3 to 6 months of age.

Statistical analysis

The data were analyzed using mixed model least-squares analysis for fitting constants (Harvey, 1990) including all main effects and interaction effects to overcome the difficulty of disproportionate sub-class number and non-orthogonality of data. The statistical model included the fixed effects of period of birth (7 levels), parity of dam (6 levels), season of birth (2 levels), sex of lamb (2 levels) and birth status (single vs. twin) of lamb. The random effect of sire was also considered in the model. The weight of the dams at lambing was fitted as a linear covariate in the model. In the initial model, all 2-way interaction effects were included and all non-significant interaction effects were removed from the final model highlighted as follows:

$$Y_{ijklmnp} = \mu + S_i + P_j + A_k + B_l + E_m + T_n + (P \times B)_{jl} + b(X_{ijklmnp} - \overline{X}) + e_{ijklmnp}$$

Where, $Y_{ijklmnp}$ is the record for the p^{th} animal
μ is the overall mean
S_i is the random effect of the i^{th} sire
P_j is the effect of the j^{th} period of birth
A_k is the effect of the k^{th} parity of dam
B_l is the effect of the l^{th} season of birth
E_m is the effect of the m^{th} sex of lamb
T_n is the effect of the n^{th} birth status of lamb
b is the linear regression coefficient for the weight of the dam at lambing
$X_{ijklmnp}$ is the dam's weight at lambing corresponding to $Y_{ijklmnp}$
$\overline{X}$ is the arithmetic mean of dam's weight at lambing
$e_{ijklmnp}$ is the residual error element with standard assumptions. The comparison of different sub-group means were done by Duncan's multiple range test (DMRT) as described by Kramer (1957).

Paternal half-sib estimates of heritability of all growth related traits under study were computed as four times the ratio of the sire variance component to the sum of the sire and the residual variance components. The standard errors of heritability estimates were obtained by using the formula given by Swiger et al. (1964). Genetic correlations between traits were calculated as the ratio of the sire component of covariance to the square root of the product of the sire component of variances. The standard error of genetic correlation was estimated by using the formula given by Robertson (1959). The phenotypic correlations between traits were calculated as the ratio of the sum of the sire and residual components of covariance to the square root of the product of the sums of the associated sire and residual components of variance. The standard error of phenotypic correlation was computed using the formula given by Snedecor and Cochran (1968).

RESULTS

Growth related traits

The least squares means for body weights at 3 and 6 months of age, average daily weight gain during 3 to 6 months of age and feed conversion efficiency of lambs are presented in Table 1. The overall least-squares means for WT3M, WT6M and ADG3-6M of lambs were 16.11 ± 0.34 kg, 26.84 ± 0.51 kg and 119.23 ± 4.35 g, respectively. The random effects of sire had significant (P<0.01) influence on all growth traits under study. The period of birth had significant (P<0.01) effect on all growth traits considered in this study but there was no definite pattern of growth over the years.

In the present study, there was significant difference in weights between kids born in first parity and in latter parities at 3 to 6 months of age. The season of birth had only significant (P<0.01) impact on WT3M and ADG3-6M in this study (Table 1). Though, lambs born in season 2 had significantly lower body weights than lambs born in season 1 (15.77 vs. 16.45 kg) at 3 months of age but the lambs born in season 2 had faster (P<0.05) average daily gain (126.19 g) than lambs born in season 1 (112.35 g). Male lambs excelled (P<0.01) over their female counterpart in respect of 3 and 6 months weights and average daily weight gain during 3 to 6 months of age. Comparison of least-squares means for lamb weights at different ages showed that the difference between male and female lambs increased from 1.64 to 4.87 kg from weaning to 6 months of age. The average daily weight gains for male and female lambs were 137.14 and 101.32 g, respectively in our study. Single-born lambs were 3.86 kg more heavier than twin lambs at 3 months of age and this difference was almost similar (3.76 kg) up to 6 months of age. The interaction effect between period and season of birth was highly significant (P<0.01) on body weights at 3 and 6 months of age and average daily weight gains at this developmental stages (Table 1). The weight of dam at lambing significantly (P<0.01) influenced the WT3M, WT6M and ADG3-6M of lambs. The regression coefficients of lambs' body weight at 3 and 6 months of age and average daily weight gain at his stage on weight of dam at lambing were 0.18 ± 0.03, 0.27 ± 0.05 and 0.98 ± 0.31, respectively.

Feed conversion efficiency

The overall least-squares mean for feed conversion efficiency (FCE) of lambs during the 3 to 6 months of age was 16.24 ± 0.47% (Table 1). Significant effect of the period of birth on FCE of lambs was also observed in this study. Male lambs had higher (P<0.01) FCE than females and male lambs have responded with 3.10% higher FCE on DM basis as compared to female lambs at 3 to 6 months of age. However, the parity of dam, season of birth and birth status of lamb had no significant (P>0.05) impact on FCE of lambs. Therefore, male lambs are the best suited for mutton production purposes. The interaction effect between period and season of birth was highly significant (P<0.01) on FCE of lambs. The weight of dam at lambing also significantly (P<0.01) affected the FCE of lambs. The regression coefficients of lambs feed conversion efficiency during 3 to 6 months of age was 0.12 ± 0.04 which indicated 1% increase in dam's body weight at lambing increased the FCE of lambs by 12%.

Genetic and phenotypic parameters

The heritability, genetic and phenotypic correlations estimates of growth related traits and feed conversion efficiency of lambs are presented in Table 2. The heritabilities of weights at WT3M, WT6M, ADG3-6M and FCE of lambs were moderate in magnitude ranging from 0.17 to 0.32. The heritability of body weight decreased substantially from weaning to 6 months of age. The phenotypic correlations of 3 and 6 months body weight, average daily weight gain and FCE of lambs ranged from low to high and was positive at (0.14 to 0.73). Similarly, the genetic correlations of 3 months weight were medium to high and positive (ranging from 0.51 to 0.97) with other growth traits and FCE of lambs. The phenotypic correlations of 6 month weight with ADG3-6M and FCE were also significant and high (ranging from 0.67 to 0.80). The genetic correlations of 6 month weight with these traits showed a similar trend. The ADG3-6M of lambs had a significant, high positive phenotypic correlation with FCE but the genetic correlation between these traits was low (0.10) in the present study.

DISCUSSION

Growth related traits and feed conversion efficiency

The overall least-square means for lamb WT3M, WT6M, ADG3-6M and FCE of lambs observed in this study were

Table 1. Least- squares means along with standard errors of growth traits and feed conversion efficiency (FCE) of Muzaffarnagari sheep.

Effects	No. of obs.	Weight at 3 month (kg)	Weight at 6 month (kg)	ADG 3-6M (g)	FCE3-6M (%)
Overall mean	534	16.11 ± 0.34	26.84 ± 0.51	119.23 ± 4.35	16.24 ± 0.47
Period of birth					
PD-1 (1989-90)	51	16.38±1.94^{abc}	26.05±3.21^{ab}	85.17±24.56^{ab}	19.97±2.57^{c}
PD-2 (1991-92)	53	16.44±1.16^{abc}	22.91±1.91^{a}	71.90±14.69^{a}	12.36±1.54^{a}
PD-3 (1993-94)	103	17.66±0.90^{bc}	27.75±1.48^{b}	112.05±11.43^{b}	14.58±1.20^{ab}
PD-4 (1995-96)	81	14.24±0.81^{a}	26.10±1.33^{ab}	131.79±10.29^{bc}	14.19±1.09^{ab}
PD-5 (1997-98)	78	18.01±0.92^{c}	32.64±1.51^{c}	162.61±11.65^{d}	19.43±1.22^{c}
PD-6(1999-2000)	107	15.23±0.92^{ab}	28.14±1.51^{b}	143.46±11.67^{cd}	15.54±1.23^{ab}
PD-7 (2001-02)	61	14.80±1.32^{ab}	26.29±2.19^{ab}	127.63±16.81^{bc}	17.60±1.76^{bc}
Parity of dam					
1	128	15.33 ± 0.43^{a}	25.99 ± 0.67^{a}	118.36 ± 5.46^{a}	15.90 ± 0.59^{a}
2	141	16.58 ± 0.40^{b}	27.21 ± 0.63^{b}	118.19 ± 5.19^{a}	16.35 ± 0.56^{a}
3	106	16.69 ± 0.41^{b}	28.17 ± 0.65^{b}	127.53 ± 5.30^{a}	17.04 ± 0.57^{a}
4	81	16.24 ± 0.43^{b}	26.73 ± 0.67^{b}	116.51 ± 5.47^{a}	15.86 ± 0.59^{a}
5	44	16.15 ± 0.53^{ab}	26.98 ± 0.85^{ab}	120.28 ± 6.76^{a}	16.24 ± 0.72^{a}
6 or more	34	15.66 ± 0.59^{ab}	25.96 ± 0.95^{ab}	114.50 ± 7.49^{a}	16.06 ± 0.80^{a}
Season of birth					
S-1 (March-April)	282	16.45 ± 0.37^{a}	26.56 ± 0.57^{a}	112.35 ± 4.73^{a}	15.92 ± 0.51^{a}
S-2 (Oct.-Nov.)	252	15.77 ± 0.38^{b}	27.12 ± 0.59^{a}	126.19 ± 4.91^{b}	16.57 ± 0.53^{a}
Sex of lamb					
Male	367	16.93 ± 0.34^{a}	29.27 ± 0.52^{a}	137.14 ± 4.40^{a}	17.79 ± 0.48^{a}
Female	167	15.29 ± 0.39^{b}	24.40 ± 0.61^{b}	101.32 ± 5.01^{b}	14.69 ± 0.54^{b}
Birth status of lamb					
Single	496	18.04 ± 0.29^{a}	28.72 ± 0.43^{a}	118.71 ± 3.80^{a}	16.55 ± 0.42^{a}
Twin	38	14.18 ± 0.52^{b}	24.96 ± 0.82^{b}	119.75 ± 6.59^{a}	15.93 ± 0.70^{a}
Interaction effect					
PD-1× S-1	32	15.98 ± 2.09^{abcde}	23.38 ± 3.46^{ab}	82.27 ± 26.49^{ab}	17.99 ± 2.77^{bcde}
PD-1 × S-2	19	16.79 ± 1.90^{bcde}	24.72 ± 3.15^{ab}	88.06 ± 24.09^{ab}	21.98 ± 2.52^{e}
PD-2 × S-1	18	15.41 ± 1.31^{abcd}	21.43 ± 2.16^{ab}	66.88 ± 16.61^{a}	13.08 ± 1.74^{ab}
PD-2 × S-2	35	17.46 ± 1.18^{cde}	24.39 ± 1.95^{ab}	76.92 ± 14.99^{a}	11.65 ± 1.57^{a}
PD-3 × S-1	55	18.73 ± 0.98^{e}	28.03 ± 1.61^{bc}	103.29 ± 12.43^{ab}	13.81 ± 1.31^{ab}
PD-3 × S-2	48	16.59 ± 0.93^{bcde}	27.47 ± 1.52^{bc}	120.81 ± 11.76^{bc}	15.36 ± 1.24^{abc}
PD-4 × S-1	56	15.43 ± 0.87^{abcd}	26.59 ± 1.42^{bc}	123.97 ± 11.00^{bc}	15.33 ± 1.16^{abc}
PD-4 × S-2	25	13.04 ± 1.14^{a}	25.60 ± 1.88^{ab}	139.61 ± 14.51^{bc}	13.06 ± 1.52^{ab}
PD-5 × S-1	28	17.76 ± 1.01^{de}	30.38 ± 1.66^{c}	140.22 ± 12.79^{c}	19.44 ± 1.35^{de}
PD-5 × S-2	50	18.26 ± 0.93^{e}	34.90 ± 1.53^{d}	185.00 ± 11.87^{d}	19.42 ± 1.25^{de}
PD-6 × S-1	53	16.43 ± 0.95^{abcde}	29.26 ± 1.57^{bc}	142.64 ± 12.12^{c}	15.88 ± 1.27^{bc}
PD-6 × S-2	54	14.04 ± 0.96^{ab}	27.02 ± 1.58^{bc}	144.29 ± 12.20^{c}	15.20 ± 1.28^{abc}
PD-7 × S-1	40	15.41 ± 1.27^{abcd}	26.86 ± 2.10^{bc}	127.19 ± 16.17^{bc}	15.89 ± 1.70^{bcd}
PD-7 × S-2	21	14.19 ± 1.49^{abc}	25.71 ± 2.46^{ab}	128.06 ± 18.87^{bc}	19.30 ± 1.98^{cde}

Means with different superscripts differed significantly ($P<0.05$) from each other; figures in parentheses indicate number of observation.

well comparable with the findings of those observed by Prakash et al. (1990), Sinha and Singh (1997) and Mandal et al. (2007) for this breed. Most of the environmental factors (period, parity, season, sex, birth status of lambs and weight of dams at lambing) have proved to be important on these traits of lambs in various breeds (Sinha and Singh, 1997; Waghmode et al., 2008; Reddy and Naidu, 2011). The significant effect of sire on

Table 2. Estimates of heritability (diagonal), genetic correlations (below diagonal) and phenotypic correlations (above diagonal) of growth traits and feed conversion efficiency of Muzaffarnagari sheep.

Traits/parameter	W3M	W6M	ADG3-6M	FCE3-6M
W3M	0.25 ± 0.13(534) †	0.73	0.14	0.38
W6M	0.51 ± 0.32	0.17 ± 0.10(534)	0.80	0.67
ADG3-6M	0.63 ± 0.26	0.69 ± 0.22	0.32 ± 0.14(534)	0.63
FCE3-6M	0.97 ± 0.24	0.81 ± 0.20	0.10 ± 0.31	0.27 ± 0.13(534)

W3M = Weight at 3 months of age, W6M = Weight at 6 months of age, ADG3-6M = Average daily weight gain during 3 -6 months of age, FCE3-6M = Feed conversion efficiency during 3-6 months of age; †figures in parentheses indicate number of observation.

all these traits studied indicated that superior rams could be used effectively for improvement of these traits. These findings are similar to those that observed a significant sire effect on growth related traits (Sinha and Singh, 1997; Mandal et al., 2007) and feed conversion efficiency of lambs (Snowder and Van Vleck, 2003). Significant sire effect on feed conversion efficiency of goats was also reported by Khan and Singh (1995). The significant body weights, ADG and FCE differences among lambs born in different periods may be attributed to differences in management, selection of rams and environmental conditions such as ambient temperature, humidity and rainfall etc. The effect of year of birth on 6 month weight and ADG during 3 to 6 months of age for this breed was also reported by Sinha and Singh (1997).

In the present study, there was significant difference in weights between kids born in first parity and in latter parities (ages) at 3 to 6 months of age, which was in agreement with the findings of Yazdi et al. (1998) in Baluchi sheep and Mandal et al. (2003) in Muzaffarnagari sheep. The relative competition for nutrients between the still growing ewes and the developing fetus may be the reason for the birth weight depression and subsequent body weights (3 and 6 months weight) in lambs born from younger ewes. The process of ageing seemed to have effect in parity 5 or later where after, the body weights of the lambs diminished.

Season of birth was significant for 3 months body weight and average daily weight of lambs in our study, which is corroborated by the earlier findings of Sinha and Singh (1997) and Mandal et al. (2003) for this breed. Comparison of body weights and average daily weight gain lambs born in different seasons in this study revealed that lambs born in October to November, had higher average daily weight gain during 3 to 6 months of age, which may be due to the lambs born in October to November passing through a favourable climate between January and April when grazing material of good quality was available, while those born in March to April spend 3 to 6 months of their life in a hot-humid climate and rainy months (June to August), which is uncomfortable to them and during these months, parasitic infections are high. Sex of lambs was highly significant at (P<0.01) for all the traits under study (Table 1). The increase in the ratio of male to female body weight as the lambs became older and their body weights increased probably arises from the increasing differences in the endocrine system between males and females (Swenson and Reece, 1995). These sex differences are consistent with the results from other investigations (Bhadula and Bhat, 1980; Naikarae and Jagtap, 1989, Mandal et al., 2007).

The pattern of growth of male and female in the present study was in conformity with the results of earlier studies on Sonadi and Sonadi crosses (Sehgal et al., 1983). The significantly lower body weight of multiple-born lambs than single born lambs at 3 and 6 months of age in this study may be due to multiple born lambs sharing their mother's milk and time for caring after birth which causes lower birth and subsequent weights in multiple kids. Similar findings were also obtained by Mandal et al. (2003) in this breed.

Genetic parameters estimates

Although, the heritabilities estimates for body weights and average daily weight gain of intensively managed lambs from weaning to 6 months of age demonstrated in the present study was moderate, but they were within the range of those observed in the other breeds (Khan and Singh, 1995; Sinha and Singh, 1997). The heritability estimates (0.27) of feed conversion efficiency in this study was higher than the estimates of Vesely et al. (1970) for Rambouillet (0.06) and for Romnelet ram lambs (0.18) and of Snowder and Van Vleck (2003) in lambs (0.10). Estimates of heritability of feed conversion efficiency for other species were low to moderate (0.12 for goats), (Khan and Singh, 1995); 0.16 and 0.26 for beef cattle (Fan et al., 1995; Bishop et al., 1991) and 0.14 for cattle (Hoque et al., 2007) and 0.12 for swine (Jungst et al., 1981). The increasing heritability of lambs' weaning weight in our study indicated that environmental factors in relation to additive genetic factors had more influence on weaning weight than on weights of lambs at 6 months of age. The moderate heritability estimates of growth traits and feed conversion efficiency of lambs indicated that some genetic progress for these traits is possible by selection. The moderately high genetic correlation between WT3M and WT6M, ADG3-6M and FCE of lambs in this study indicated that selection for increased body weights at 3 months of age in the sheep will also result in the genetic improvement in the subsequent development of body weight at 6 months of age and will ultimately reflect the average daily weight gain and feed conversion efficiency of lambs at these stages of development.

Conclusion

The present study showed that the various environmental factors (period of birth, parity of dam, season of birth, sex and birth status of lambs) had significant influence on the growth performance, average daily weight gain and feed conversion efficiency of lambs reared under intensive feeding management system during 3 to 6 months of age. Male lambs excelled over their female counterpart in respect of higher body weight gain and feed conversion efficiency, thereby, proving to be an efficient feed converter for mutton production purposes. The moderate heritability estimates of the traits under study reflect that there is some scope of genetic improvement of these traits through selection. The moderately high genetic correlations between the weight traits and average daily weight gain and feed conversion efficiency of lambs indicated that selection for increased body weights of lambs will result in genetic improvement in the average daily weight gain and feed conversion efficiency of lambs.

ACKNOWLEDGEMENTS

The authors are thankful to the Director, CIRG for providing all necessary facilities for the study. The support extended by the Director of the National Dairy Research Institute, Karnal, Haryana, for preparing this manuscript is also acknowledged. We wish to acknowledge the contribution of the staffs of the Muzaffarnagari unit of CIRG for management and recording of animals.

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