

Genetic Evaluation of Growth Traits of Black Bengal Goat

Research Article

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ABSTRACT

Black Bengal goat is the heritage and one of the potential genetic resources of Bangladesh. Least-squares means for body weights at birth, 3, 6, 9 and 12 months of age were 1.09, 5.12, 8.02, 10.92 and 14.47 kg, respectively. Sex of the kid has significant ($P<0.05$) effect on body weights at 6, 9 and 12 months of age. Type of birth and parity of the dam has significant ($P<0.01$) effect on birth weight only, whereas season of birth affected ($P<0.05$) all the body weight traits. Heritability estimates for body weights at birth, 3, 6, 9 and 12 months of age were 0.45, 0.47, 0.45, 0.49 and 0.47, respectively. Genetic correlations between body weight traits ranged from 0.34 to 0.83, whereas phenotypic correlations ranged from 0.34 to 0.90. The high heritability estimates obtained for body weights indicated that mass selection would generate substantial selection responses at all stages of growth.

KEY WORDS Black Bengal goat, fixed factors, genetic parameters, growth.

INTRODUCTION

Production of meat was the earliest objective of domestication of goat. In Bangladesh, the primary objective of rearing goats is to produce high quality meat (Huq, 1988). Compared with beef, kid-meat contains the same amount of protein, but a lower fat percentage (50-60%), compared with broiler meat it also contains 40% less saturated fatty acids (Addrizzo, 1992).

Goat meat is the most expensive meat in Bangladesh and is acceptable to people of all castes, creeds, and religions. The demand of goat meat is increasing because of its nutritional quality and taste.

Body weight and growth rate are economically important breeding objectives that demand special attention in order to improve meat production of the Black Bengal goat. One way to improve growth performance is to select the best

animals in terms of body weight to be used as parents of the next generation.

The growth rate and body size, along with changes in body composition of animals are of great economic importance for efficient production of meat animals. In mammals, growth is influenced by the genes of the individual, environment provided by the dam and other environmental effects (Albuquerque and Meyer, 2001).

There are no reports on genetic parameter estimates for growth traits of Black Bengal goats in Bangladesh. Therefore, the purpose of this study was:

1. Examine the effect of different factors on body weights at different ages.
2. Estimate variance components and heritability for body weights at different ages.
3. Estimate genetic and phenotypic correlations among body weights at different ages.

MATERIALS AND METHODS

Location

The study was conducted in the nucleus breeding flock (NBF) at artificial insemination centre, department of animal breeding and genetics, Bangladesh agricultural university, Mymensingh from April 2007 to March 2011.

Animals and management

A total of 63 Black Bengal does and 17 Black Bengal bucks were used as parental stock in this study. The does were reared semi intensively and stall fed twice daily on a diet consisting of Napier, German and / or maize fodder as per requirement. The feed was supplemented with commercial concentrate (Surma feed, BRAC feed mill, Sreepur, Gazipur) in pelleted form in the morning and again in the afternoon at the rate of 250 g/doe/day (crude protein content: 23%, crude fat: 6.5%, crude ash: 10%, crude fiber: 4%, NFE: 45.45%, moisture: 11% and energy content: 3100 kcal ME/kg DM).

Grazing was also allowed for four hours in the morning throughout the year except during inclement weather. Bucks were reared intensively and housed in individual pens of one square meter, in a separate galvanized iron sheet shed with a wooden slatted floor raised above the ground level. The bucks were kept under zero grazing management and stall fed twice daily on a diet consisting of Napier, German and / or maize fodder *ad libitum*. The feed was supplemented with the same commercial concentrate in the morning and again in the afternoon at the rate of 400 g/buck/day. They were allowed for exercise 1 to two hours every day and supplemented additionally with germinated gram (20 g/buck/day). Clean and safe water was made available at all the time. Throughout the study, feeding regimen of the animals remained uniform. All the females were inseminated routinely with frozen semen of Black Bengal bucks and inbreeding was avoided in the flock. Selection among dams was limited to the culling of diseased animals. All the breeding animals and their progeny were identified with neckband tags in order to maintain their individual identity and pedigree. The identities of newborns and their parents, date of birth, sex of kid, type of birth and parity of the dam were recorded carefully. For each individual under study, a record sheet with full details of each parameter along with pedigree information was maintained. All the female kids were kept in shed with their dams, but males over 3 month of age were housed separately in individual pens of one square meter in the buck-shed to avoid breeding. No castration was performed on the male kids. The birth weight (kg) was recorded for all the kids born alive within 12 hours of their birth with a top-loading balance. Subsequent weights of the kids were recorded at 3 (at weaning), 6, 9 and 12 month of age using a 30 kg digital

balance with an accuracy of 10 g. Kids that did not survive until 3, 6, 9 and 12 month were excluded from the analysis for respective weight traits. Weight was recorded when the animal was stable. Body weight (kg) was recorded only in the stable animals, before offering the feed in the morning.

Statistical analyses

The significance of fixed effects (nongenetic factors) was tested by least squares analyses of variance using the general linear model (GLM) procedure of the statistical analysis system (SAS, 1998) according to the following model:

$$Y_{ijklm} = \mu + S_i + M_j + R_k + T_l + E_{ijklm}$$

Where:

Y_{ijklm} : the dependent variable (individual animal record for the trait).

μ : the overall mean.

S_i : the fixed effect of i^{th} sex of kid.

M_j : the fixed effect of j^{th} type of birth.

R_k : the effect of k^{th} parity of dam.

T_l : the effect of l^{th} season of birth.

E_{ijklm} : the residual error.

The year was divided into three seasons; winter (from November to February), summer (from March to June) and rainy (from July to October). Type of birth was grouped into single, twins and triplets. Sex of the kid was grouped into male and female. Parity of the dam was grouped into first, second and third parity. The statistical package SAS (SAS, 1998) was used to carry out the phenotypic correlation analysis. Genetic parameters were estimated with residual maximum likelihood (REML) procedure, fitting an animal model using VCE 4.2.5 software (Groeneveld, 1998). The models used to estimate genetic parameters included random effects and all fixed effects that were found significant in the least-squares analysis. The genetic correlations between traits were estimated using a two trait animal model. The model fitted for both unitrait and two trait analyses were as follows:

$$Y = Xb + Za + e$$

Where:

Y : vector of observations.

b : vector of fixed effects.

a : vector of random animal effects (direct genetic).

X : incidence matrix for fixed effects.

Z : incidence matrix for random effects.

e : vector of random residual effects.

It was assumed that all effects in the models are independent and normally distributed.

RESULTS AND DISCUSSION

Body weights

Basic statistics of body weights (kg) at different ages of Black Bengal goat are presented in Table 1. Least squares means for body weights at birth, 3, 6, 9 and 12 month of age were 1.09, 5.12, 8.02, 10.92 and 14.47 kg, respectively. The highest coefficient of variation (CV) was observed for body weight at 3 month of age (27.46%) and the lowest CV was for 12 month body weight (13.32%). The CV for 12 month weight was much lower than those for the other stages, probably because of sequential selection of individuals due to death and the individuals who survived were stronger and more productive. Therefore, the productive differences between them are much lower than in previous stages, and the CV is much lower. The mean birth weight in the present study was similar with those reported by Singh *et al.* (1991), Husain *et al.* (1996), Husain *et al.* (1997), Akhter *et al.* (2000) and Hossain *et al.* (2004) in Black Bengal goats. The mean for body weight at 3 month of age in the present study was comparable to earlier reports (Singh and Sengar, 1998; Singh *et al.* 1991; Mia, 1992; Singh, 1997). Husain *et al.* (1996) and Akhter *et al.* (2000) also reported lower values for 3 month body weight than those in the present study. The mean body weight at 6 month of age in the present study was similar to those reported by Singh and Sengar (1990), Mia (1992), Husain *et al.* (1996) and Singh (1997). On the contrary, Husain *et al.* (1996) and Akhter *et al.* (2000) reported lower values for 6 month body weight than those in the present study. The mean body weight at 9 month of age in our study was comparable to those reported by earlier researchers (Singh and Sengar, 1990; Mia, 1992; Husain *et al.* 1996; Singh, 1997). The average body weight at 12 month of age in the present study was comparable to those reported by Singh (1997). Body weight at 12 month of age seems to be higher than those reported earlier (Mia 1992; Husain *et al.* 1996). This could be due to the better managerial conditions that prevailed under the semi-intensive system of rearing. Differences in body weight reported by different authors could be due to the management and environmental variation in different studies.

Fixed effects

Least squares means of body weights (kg) at different age of Black Bengal kids according to the sex, type of birth, parity of dam and season of birth are summarized in Table 2. These parameters had significant effects at various stages of growth of goats ($P < 0.05$).

Sex

The male kids were heavier than females from birth to 12-month of age, and the differences between the two sexes were significant at all ages under study, except at birth and

3 month of age. Sex had an appreciable effect on growth after weaning until mature age of the goat. Our result was in agreement with the reports of Husain *et al.* (1996) and Akhter *et al.* (2000). The superiority of males over females for body weight at birth, 3, 6, 9 and 12 month of ages were 1.85, 5.00, 18.80, 33.80 and 43.77%, respectively. The level of superiority of male kids recorded in this study is comparable to those reported for goat breeds (Blackburn and Field, 1990; Warmington and Kirton, 1990; Hermiz *et al.* 1997). The progressive increases in the body weight of male vis-a-vis the females after puberty suggests that the genetic and hormonal differences that exist between the male and female animals are being manifested after that stage. In this study, males were significantly heavier and grew faster from weaning to onward; implying that sex effect is more pronounced with age after weaning. These effects have been attributed to hormonal differences between sexes and their resultant effects on growth. Our results agreed with the reports of Das *et al.* (1994) and Otuma and Osakwe (2008) on live weights of different tropical goats. Higher body weights of males compared to females at all the ages might be due to aggressive behavior of males during feeding and suckling and male sex hormone, which has an anabolic effect (Hafez, 1993). The heavier body weight of male than female kids may also be due to differences in their endocrine profile. Non significant influence of sex on body weight at birth and 3 month of age in the present study agrees with the findings of Singh and Singh (1998) in Black Bengal and Beetal \times Black Bengal kids but disagrees with the finding of Al-Shorepy *et al.* (2002) in Emirati goat. Singh (1997) reported significant effect of sex on body weights at 3, 6, 9 and 12 month of age. Husain *et al.* (1996) also observed significant effect of sex on body weights at birth, 3, 6, 9 and 12 month of age of Black Bengal goat under the extensive system.

Type of birth

The effect of type of birth was significant ($P < 0.01$) on the body weight at birth only. Single and twin kids had a heavier weight at birth than the triplet, whilst no marked difference was found between single and twin kids. These results are in accordance with those obtained in other goat breeds reared in tropical and subtropical environments (Mourad, 1994). Single born kids were 1.83 times heavier at birth than the average weight of kids born as twins, and 44.15 times heavier than those born as triplets. The lower birth weight with increasing litter size has also been reported earlier (Gokhale *et al.* 1996; Mia and Bhuiyan, 1997; Mourad and Anous, 1998; Al-Shorepy *et al.* 2002). This difference is probably due to the intrauterine environment. This difference is probably due to the intrauterine environment where a higher availability of nutrients to the single kid, lack of competition as well as more space may

Table 1 Basic statistics of body weights (kg) at different ages of Black Bengal goats

Body weights (month)	No of records	Minimum	Maximum	Least squares means	Standard deviation	CV (%)
Birth	166	0.51	2.10	1.09	0.27	23.42
3	113	2.42	9.68	5.12	1.44	27.46
6	88	3.58	13.88	8.02	2.17	25.24
9	79	5.10	17.58	10.92	2.72	18.30
12	68	6.50	22.00	14.47	3.55	13.32

CV: coefficient of variation.

Table 2 Least squares means with standard errors of body weights (kg) at different ages of Black Bengal kids according to sex, type of birth, parity of dam and season of birth

Factors	Body weights (kg)				
	Birth	3 month	6 month	9 month	12 month
Sex of kid	NS	NS	*	**	**
Male	1.10±0.07	5.25±0.67	8.72 ^a ±0.81	12.31 ^a ±0.94	16.85 ^a ±1.14
Female	1.08±0.07	5.00±0.68	7.34 ^b ±0.85	9.20 ^b ±0.99	11.72 ^b ±1.18
Type of birth	**	NS	NS	NS	NS
Single	1.11 ^a ±0.06	5.48±0.51	8.61±0.52	11.69±0.70	15.54±0.88
Twins	1.09 ^a ±0.05	5.20±0.43	7.68±0.40	11.56±0.55	13.57±0.72
Triplets	0.77 ^b ±0.14	4.43±1.53	7.56±1.10	10.20±1.27	12.86±1.64
Parity of dam	**	NS	NS	NS	NS
First	0.99 ^b ±0.05	4.67±0.52	7.74±0.74	10.98±0.83	14.93±1.00
Second	1.15 ^a ±0.06	5.64±0.62	8.50±0.90	10.99±1.03	13.94±1.23
Third	1.25 ^a ±0.06	5.69±0.68	8.09±1.01	10.22±1.30	12.94±1.54
Season of birth	*	*	*	*	*
Winter	1.20 ^a ±0.07	5.54 ^a ±0.62	8.49 ^a ±0.72	10.72 ^a ±0.81	12.91 ^b ±0.94
Summer	1.07 ^{ab} ±0.06	5.08 ^a ±0.63	8.05 ^a ±0.80	11.31 ^a ±0.91	15.35 ^a ±1.05
Rainy	0.94 ^b ±0.09	3.54 ^b ±0.94	5.70 ^b ±1.24	6.90 ^b ±1.56	10.32 ^c ±2.05

The means within the same column with at least one common letter, do not have significant difference ($P>0.05$).NS: non significant; * ($P<0.05$) and ** ($P<0.01$).

facilitate growth. The uterine space and available nutrient shared by more than one kid may be responsible for the reduced birth weight with increasing litter size. Singh *et al.* (1990) noticed that birth weight of single born kids was highest followed by twins and triplets, but the differences in their study were not significant in the local and crossbred kids. Single born kids maintained their highest weight followed by twins and triplets for all the period. These results agree with results reported by Husain *et al.* (1996), Mourad and Anous (1998) and Akhter *et al.* (2000). Singh (1990) reported non significant variation in birth weight of kids because of litter size under the village conditions of management. Husain *et al.* (1996) observed significant effect of type of birth on body weights at birth, 3, 6, 9 and 12 month of age of Black Bengal goat under the extensive system. Negative linear relationship of growth of kids with litter size at birth is probably due to a difference in birth weight and availability of mother's milk to their kids during early stage of life.

Parity of dam

Parity of the dam has significant ($P<0.01$) influence on birth weight. Birth weight increased with the progress of parity. Significantly higher birth weight was observed in 2nd and 3rd parity, and birth weights were lowest in 1st parity. The difference in birth weight between 2nd and 3rd parity

was non significant. Husain *et al.* (1996) observed non significant effect of parity of the dam on body weights at birth, 3, 6, 9 and 12 month of age of Black Bengal goat under the extensive system. Wilson (1987) reported that the effect of age of the dam was significant on birth weight and growth rate at pre-weaning, and those young ewes tend to produce smaller progeny at birth. The mothering ability and milk production increases with parity of the dam. Older ewes are larger in body and tend to be better milkers. The effect of parity of the dam on kids is thus imparted as a maternal influence whose direct influence is limited to the nursing period.

Season of birth

At different stages of growth, the variation in body weights due to season of birth was highly significant ($P<0.05$). Winter born kids were significantly ($P<0.05$) heavier at birth to 9 month of age, than their counterparts from the rainy season. The effect of the season may be explained partly by the climatic conditions, however, the feeding practices at different seasons for dams and offspring were similar. Important influence of the season on kid live weights have been reported in several breeds (Warmington and Kirton, 1990; Hermiz *et al.* 1997). Singh *et al.* (1991), Husain *et al.* (1996) and Singh and Singh (1998) reported non significant effect of the season of birth on body weights at different

stages of growth. However, [Singh \(1997\)](#) observed significant effect of season of birth on body weights at 3 and 6 month of age, whereas non significant effect was noted at 9 and 12 month of age. [Al-Shorepy *et al.* \(2002\)](#) observed non significant effect of the season of birth on birth weight, but a significant effect on weaning weight was observed in Emirati goat.

Seasonal influence on birth weight operates through its effect on the dam's uterine environment, mostly in late gestation. Season of birth also plays an important role in growth performance indirectly, through its influence on the dam's nutrition and hence the amount of milk becomes available to the un-weaned kids. In the post-weaning period its influence is related to its effect on the quality and quantity of pasture available to the weaned kids. The lower body weights of rainy season born kids emphasized the need to provide supplementary feed and adequate management for these kids.

Variance components and heritability estimation

Estimates of additive genetic variance (σ^2_a), residual variance (σ^2_e), phenotypic variance (σ^2_p) and heritability (h^2) of body weights at different ages of Black Bengal kids are given in Table 3.

Table 3 Estimates of additive genetic variance (σ^2_a), residual variance (σ^2_e), phenotypic variance (σ^2_p) and heritability (h^2) of body weights at different ages of Black Bengal kids

Body weights	σ^2_a	σ^2_e	σ^2_p	h^2
Birth	0.029	0.035	0.064	0.45±0.04
3 month	0.889	0.988	1.877	0.47±0.05
6 month	1.715	2.131	3.846	0.45±0.07
9 month	2.173	2.289	4.462	0.49±0.06
12 month	3.099	3.434	6.533	0.47±0.08

Heritability estimates for body weights at birth, 3, 6, 9 and 12 month of age were 0.45, 0.47, 0.45, 0.49 and 0.47, respectively. The results showed that the weight traits have high heritability. According to [De Veer and Van Vleck \(1987\)](#) the genetic differences between animals can be better expressed under intensive conditions than under extensive conditions. Variance components between progeny of animals kept in favorable environments are larger than those kept under less favorable conditions. Heritability estimates under favorable conditions should thus be higher than when estimated under less favorable conditions. This can be the reason for the high heritability for body weights at all ages studied. [Snyman and Olivier \(1999\)](#) found higher heritability estimates for body weight traits from data collected at experimental stations than from performance testing schemes. Among the breeders, there is agreement that any performance trait that has a higher heritability is associated with a simultaneous reduction in the contribution of heterosis. The rapid improvement of such traits is possible

from mass selection. High heritability estimates indicated that the additive genetic variation exists, which can be exploited by mass selection for improving these traits relatively quickly at birth or later at 3, 6, 9 and 12 month of age but mass selection conducted at 3 month of age could be more effective and suitable than other ages. The relatively higher estimates in this study could be due to, among other factors, the fact that maternal genetic effects were ignored in the model. However, the data size and structure for this analysis were considered insufficient to fit maternal effects considering the small number of maternal grand dams with progeny and own records and the few progeny per grand dam. The heritability estimate for birth weight obtained in the present study was comparable to those reported by [Portolano *et al.* \(2002\)](#) of 0.49 in the Sicilian Girgentana goat, [Bosso *et al.* \(2007\)](#) of 0.50 in West African Dwarf goat and [Otuma and Osakwe \(2008\)](#) of 0.41 in Nigerian Sahelian goat, respectively. The heritability estimates for body weight at 3 month of age obtained in the present study was in accordance with those reported by [Singh \(1997\)](#) of 0.47 in Black Bengal goats, [Mourad and Anous \(1998\)](#) of 0.49 in common African and Alpine crossbred goats, and [Otuma and Osakwe \(2008\)](#) of 0.45 in Nigerian Sahelian goat, respectively. The heritability estimate for body weight at 6 month of age obtained in the present study was comparable with those reported by [Singh \(1997\)](#) of 0.48 in Jamunapari × Black Bengal goats and [Mourad and Anous \(1998\)](#) of 0.43 in common African and Alpine crossbred goats, respectively. The heritability estimate for body weight at 9 month of age obtained in the present study was in accordance with those reported by [Singh \(1997\)](#) of 0.53 in Jamunapari × Black Bengal goats.

The heritability estimate for body weight at 12 month of age obtained in the present study was in accordance with those reported by [Singh \(1997\)](#) 0.48 in Beetal × Black Bengal goats and [Otuma and Osakwe \(2008\)](#) 0.45 in Nigerian Sahelian goat, respectively. [Nahardeka *et al.* \(2001\)](#) reported heritability estimates for body weights at 6, 9 and 12 month of age were moderate in Assam local goats and crosses with the Beetal breed. Several factors such as the breed of the animal, genetic variation within population, management and environmental conditions, size of the data set, models fitted, method of estimation used in different studies and etc., would have affected the differences between estimations.

Genetic and phenotypic correlations

Estimates of genetic and phenotypic correlations among body weights at different ages of Black Bengal kids are summarized in Table 4. Genetic and phenotypic correlations between body weights at different ages were positive and moderate to high in magnitude. Positive genetic and phenotypic correlations have also been reported by [Roy *et*](#)

al. (1997) and Singh (1997). Gowane *et al.* (2011) reported high and positive genetic and phenotypic correlations between body weights at different ages in Sirohi goat. The estimates of genetic and phenotypic correlations showed no genetic antagonisms among the weight traits analyzed, which is in agreement with the findings of Al-Shorepy *et al.* (2002).

The largest relationships were found between chronologically adjacent weights. The correlations between body weights at different ages decreased, as the time between measurements increased. In general, this could be explained by an auto correlation which would exist among the genetic and environmental effects associated with the successive measurements. The estimates of phenotypic correlations indicated the presence of desirable association among body weight traits. The correlations between body weights are probably due to greater similarity of environmental and managerial conditions as well as automatic correlation between adjacent records.

Table 4 Genetic correlations (above diagonal) and phenotypic correlations (below diagonal) among body weights at different ages of Black Bengal kids

Body weights	Birth	3 month	6 month	9 month	12 month
Birth	-	0.60±0.08	0.51±0.11	0.34±0.14	0.34±0.12
3	0.66	-	0.79±0.08	0.64±0.09	0.51±0.12
6	0.49	0.75	-	0.80±0.04	0.66±0.09
9	0.34	0.49	0.82	-	0.83±0.07
12	0.35	0.36	0.70	0.90	-

The genetic and phenotypic correlations of birth weight with the body weights at subsequent ages ranged from high to medium and the magnitude of these correlations declined steadily with age. The genetic correlations of 3 month weight with the 6, 9 and 12 month weights were high, but phenotypic correlations ranged from high to medium and declined steadily at later stages. The 6 month weight had a high positive genetic and phenotypic correlation with the 9 and 12 month body weight. Similarly, the 9 month body weight had a high positive genetic and phenotypic correlation with the 12 month body weight. Genetic correlations between body weights at different ages were larger than the corresponding phenotypic correlations in four cases. In five cases phenotypic correlations between body weights at different ages were larger than the corresponding genetic correlations. Genetic correlations between all the body weight traits ranged from 0.34 between birth weight and 9 and 12 month weights to 0.83 between 9 month weight and 12 month weight. The highest genetic and phenotypic correlations were observed between 9 month weight and 12 month weight. The positive genetic correlations existing between body weight traits indicated that genetic improvement in any one of the traits could be made through indirect selec-

tion for correlated traits. Vatankhah and Salehi (2010) reported high (0.89-0.99) genetic correlations between ewe weights at different stages of production in Lori-Bakhtiari ewes.

The phenotypic correlations, ranging from 0.34 between birth weight and 9 month weight to 0.90 between 9 month weight and 12 month weight showed, in general, the same trend as for genetic correlations in accordance with Mourad and Anous (1998), Portolano *et al.* (2002), Al-Shorepy *et al.* (2002) and Boujenane and El Hazzab (2008). Al-Shorepy *et al.* (2002) reported genetic and phenotypic correlations between body weights at birth and 3 month of age to be 0.45 and 0.65, respectively in Emirati goats. Singh *et al.* (1991) in agreement with earlier findings reported estimates of the genetic (phenotypic) correlation between body weight at birth and 3 month were 0.78 (0.51) in the Black Bengal, 0.56 (0.47) in the Jamunapari and 0.49 (0.51) in the Beetal × Black Bengal breeds. Nahardeka *et al.* (2001) reported genetic and phenotypic correlations among body weights were medium to high and in the desirable direction. The positive and high phenotypic and genetic correlation between birth weight and weaning weight indicated that selection for birth weight would increase weight at 3 month of age. Very high phenotypic and genetic correlations were observed among live weights: between 3 and 6 month weight, 6 and 9 month weight and 9 and 12 month weight, indicated that an increase in the former would increase the later at genetic and phenotypic scales. From the results, it is evident that selection for any of the traits analyzed in this study will lead to a correlated increase in the other traits.

CONCLUSION

Estimates of genetic parameters from this study suggest that there exists substantial additive genetic variation in the population that can be utilized for genetic improvement of body weights from birth through 12 month of age in Black Bengal goat. The high heritability estimates obtained in this study indicated that mass selection would generate substantial selection responses at all stages. The estimates of genetic and phenotypic correlations were medium to high and showed no genetic antagonisms among the body weight traits. The high estimate of genetic correlation between chronologically adjacent weights suggested that same genes tend to influence the two growth stages, and that selection for one stage will improve the other as a correlated response. Heritability estimates for all the growth stages are very close thus selection at 3 month of age might be very effective for growth improvement.

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