Estimation of genetic parameters and prediction of breeding values for some economic traits of Black Bengal Goat under farming condition

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Abstract

The study was undertaken to evaluate the genetic progress of Black Bengal Goat (BBG) by estimating genetic parameters viz. heritability and breeding values for economically important productive and reproductive traits (birth weight, weight at 3, 6, 9 & 12 months, daily milk yield, lactation length, total milk yield and litter size of BBG goat population). Variance and co-variance components were analyzed applying Residual Maximum Likelihood (REML) approach by VCE 4.2.5 computer package. The heritability (h^2) of birth weight was estimated as 0.2, which was low. The heritability estimates for 3-month weight (0.40), 6-month weight (0.50), 9-month weight (0.37) and 12-month weight (0.36) were found medium. Estimated h^2 of daily milk yield, total milk yield and lactation length in this study were from 0.55 to 0.82. h^2 of litter size was 0.09. The maximum estimated breeding value (EBV) was found for 6 month body weight (12.94 kg), however, for daily milk yield, the value was 1.513 kg. The results found in this study revealed that genetic improvement of BBG for most of the traits is possible by selection and breeding.

(**Key words:** Goat, (co)variance components, heritability, breeding values, genetic trends)

Introduction

Black Bengal Goat (BBG) is a dwarf breed goats and known to be famous for its high adaptability, fertility, prolificacy, delicious meat and superior skin (Devendra and Burns, 1983; Husain *et al.*, 1998). Though majorities of the BBGs bear black coat color, but other coat color like, black and white, brown, brown and white and white are also common in this population. Both sexes have short cylindrical horns. Older bucks and does have beards. The BBG has several desirable characteristics. They attain sexual maturity quite early (at 6-8 months of age) and breed around the year. They are reported to have resistance against common diseases, can produce and reproduce in very low plane of nutrition and are well adapted to the local environment. They give kids twice a year or more commonly thrice in two years (Devendra and Burns, 1983). They are more or less evenly distributed throughout the country with a relatively higher concentration in the northwestern area of Bangladesh. It is also found throughout the eastern and north eastern India (Choudhury *et al.*, 2012). Though, BBG is famous for its early sexual maturity, fertility, fecundity, delicious meat and superior quality skin but

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slower growth rate, low adult weight, insufficient milk yield and high kid mortality made it less attractive as a commercial meat animal. Devendra and Burns (1983) suggested that using selection tool for increased milk production. Husain *et al.*, (1995) demonstrated that poor pre-weaning kid survivability could be improved by increasing birth weight of kids and milk yield of dam. Since 1998, the Bangladesh Livestock Research Institute (BLRI) is working on improvement of BBG goat through selective breeding. The basis for genetic improvement is the differences among animals resulting from hereditary or genetic differences transmitted by their parents. Three factors: heritability, selection deferential and generation interval control the genetic progress of any trait. Due to slow growth and lower body weight, selection criteria of this breed should be exploited in augmenting higher body weight and milk yield. Thus, the present study was undertaken to estimate the genetic parameters of important economic traits for improvement of the population.

Material and Methods

Source of data

The data used in this study were taken from the original data in the "Improvement of Black Bengal goat through selective breeding" project and then continuation of the project entitled "Improvement of Black Bengal goat through selective breeding improved feeding and management practices" covered a period from 1998 to 2004 at BLRI, Savar, Dhaka.

Management of animals

All studied animals were maintained under intensive and/or semi-intensive management. Goats were housed in permanent house with slated platform of about one meter above the ground. All goats were kept separately according to their sex and age groups. Bucks and buckling were always kept separately from the does flock to avoid random mating. Castrated goats, milking does, dry does and pregnant does were also kept in separate pen. The goats were grazed from 8.00 A.M to 4.00 P.M with 2 hour rest (12.00 A.M to 2.00 P.M). Concentrates (@ of 2% of body weight) along with cut and carry grasses were supplied according to their age, weight and physiological conditions. A selective breeding program was conducted to improve the economically important traits viz, birth weight, growth rate, live weight, milk yield, prolificacy, survivability and feed efficiency. The sign of heat was observed using a buck in the morning. Female in estrous were naturally mated with the buck according to the previously planned mating design. Animals were vaccinated against PPR (Peste Des Petits Ruminants) and anthelmentics were applied twice a year. External parasites were controlled through dipping the animal in 0.5% melathion or diazinon solution on monthly basis. Sick animals or kids, animals with stunted growth, unthrifty conditions, repeat breeding, severe skin diseases were culled from the flock.

Record keeping

All animals were ear tagged individually. Herd book, shed book, milking book, kid book, mating book, health book, feed register were used for record keeping. All information on productive and reproductive performances was recorded in an individual data sheet of a book for each of the animal. Records of all kids on birth weight, sex, parity, dams' body weight etc. were also maintained in another record book according to generation. Then all data stored in computer in different files were used for further analysis.

Parameters estimated for genetic analyses

The variance and covariance analyses, heritability estimates and breeding values of birth weight (Bwt), weight at 3, 6, 9 & 12 months, daily milk yield (DMY), lactation length (LL), total milk yield (TY) and litter size (LS) were recorded. Daily milk yield was estimated from the milk consumed by the kids in a day plus retained milk taken from the udder. Total milk yield was measured by summing up the daily milk yield throughout the total lactation period.

Statistical analysis

Variance and co-variance components were analyzed applying Residual Maximum Likelihood (REML) approach by VCE 4.2.5 computer package (Groeneveld, 1998). The REML estimate variance components were used in estimating breeding values applying Best Linear Unbiased Prediction (BLUP) method of Henderson (1973) by PEST computer program (Groeneveld, 1990).

Estimation of genetic parameters

Heritability

Heritability values were estimated for live weights (at birth, 3, 6, 9 and 12 month of age) and litter size. Data were adjusted for significant sex, litter size and parity effects before estimating variance components. Variance components were calculated using sire, dam and combined sire-dam groups according to the method of Variance Component Estimation (VCE4) computer package (Groeneveld, 1998).

Model: $Y_{ij}=\mu+\alpha_i+e_{ij}$; here, μ is the general mean, α_i is the effect of generation (i=1, 2, 3) or parity (i= 1, 2---8) or sex (i= 1, 2), season (i= 1, 2, 3), e_{ij} is the random error.

Breeding value

Breeding value was measured for birth weight, 3, 6, 9 month of age and daily milk yield of dam. Positive, zero or negative BV indicate that a given animal have either higher, equal or lower estimate of BV respectively than that of the population average for a given trait. The generalized formula followed for estimating breeding values for each parameter is as follows:

$$BV = b\,(P\text{-}\overline{P});$$

Where, P is the trait mean of the animal(s) of record, $\overline{P}$ is the trait mean of contemporary group and b is the regression factor.

Results and Discussion

Estimation of heritability

Heritability estimates of live weights at different ages, daily milk yield, lactation length, total yield and litter size are summarized in Table 1.

Table 1. Estimates of variance component sand heritability for different traits of BBG

Parameter	Variance component		$h^2 \pm SE$
	Additive genetic (σ^2_A)	Total phenotypic (σ^2_P)	
Birth weight (kg)	0.053	0.204	0.26±0.09
3 month body weight (kg)	0.866	2.18	0.40±0.07
6 month body weight (kg)	2.25	4.49	0.50±0.03
9 month body weight (kg)	4.65	12.42	0.37±0.08
12 month body weight (kg)	10.17	27.96	0.36±0.07
Daily milk yield (kg)	0.035	0.064	0.55±0.04
Total milk yield (kg)	1.604	4.733	0.58±0.03
Lactation length (days)	0.070	753	0.82±0.05
Litter size (No.)	0.399	4.208	0.09±0.06

h^2 = heritability; SE = standard error

Birth weight

Heritability value for birth weight is usually low. In the present study, the heritability of birth weight was estimated as 0.26 (Table 1), which is low. The lower estimates of heritability for birth weight in BBG kids were reported by Guha et al., (1968), Moulick and Syrstad, (1970) and Singh et al. (1991) and on the other hand high estimate (0.75±0.48) was reported by Ali and Hasnath, (1977). This variation might be due to several factors such as variation between breeds, places, flocks, sample size and method of estimation. Birth weight is, therefore, subject to fluctuation by various non-genetic factors like birth type, age of dam, milk production by the dam, immune status and sex of the kids. Low heritability of birth weight found in this study however implies that genetic improvements by selection on this basis will not response too much in the next generation.

Live weight

The heritability estimates for 3-month wt. (0.40), 6-month wt. (0.50), 9-month wt. (0.37) and 12-month wt. (0.36) (Table 1) were relatively higher and all the values were much higher than those reported by Chowdhury et al., (2002) and Singh (1994). The values imply that selection of goat on the basis of live weight on those ages will result of improvement in the next generations. Heritability for 6 month body weight was highest among 3, 6, 9 & 12 months values, which is similar to the observations of Mishra and Acharya (1985), Prakash et al., (1987) and Mehta et al., (1997) they suggested that selection of BBG goat for meat production could be based exclusively on the basis of 6-month body weight.

Milk yield

Estimated h^2 for daily milk yield (0.55), total milk yield (0.58) and lactation length (0.82) in this study were higher (Table 1). Castañeda-Bustos *et al.*, (2014) reported heritability of 0.37 for daily milk yield of American dairy goats which is lower than that of this study. The variation could be due to different genotype, environment, sample size or method of estimation. However, high heritability values obtained in this study indicate that additive gene action or hereditary variation was high which implies that milk production could be improved through selective breeding in BBG population.

Litter size

The h^2 of litter size estimated in this study was very low (0.09) which was almost similar to the observation of Chowdhury *et al.* (2002) which indicates that litter size is more controlled by the environment rather than the heredity. Reproductive traits can only be improved by better husbandry, management, feeding and veterinary care (Amin, 2000).

Estimation of breeding values

Estimates of breeding value is a potential tool of breeders to select superior stock based on their genetic worth, although this could be achieved through a longer process which depends upon degree of heritability, intensity of selection, selection differential etc. Improving the productivity of BBG goats through conventional selection and breeding strategies require long term breeding activities and according to Mukherjee (2000) it requires at least 10 years. Qutermain (1991) suggested that for meat type goat breeds under tropical condition, more emphasis should be given on reproduction and survivability rather than growth and carcass quality. As has been shown earlier that the survivability of kid largely depends on the milk production of dam. For meat production, 6th month body weight was reported to be highly heritable (Mishra and Acharya, 1985; Prakash *et al.*, 1987; Acharya, 1988). Total weight of weaned kid per doe is also an important predictor for meat production potentiality of goat. For this reason breeding values were estimated for different important economic

Table 2. Range of estimated breeding values for different traits of BBG at BLRI

Parameter	Range of estimated breeding values		
	Minimum	Maximum	Average
Birth weight (kg)	-1.0422	1.393	0.001514
3m* body weight (kg)	2.1248	8.77	5.5721
6m* body weight (kg)	5.03	12.94	9.4835
9m* body weight (kg)	-12.69	10.93	0.000
Daily milk yield (kg)	0.04	1.513	0.569

*m means months

traits of BBG. Estimated breeding values (EBVs) for birth weight, body weight at 3, 6, 9 month and daily milk yield (DMY) of BBG goat are summarized in Table 2. Among the live weight categories, the maximum EBV was found for the 6 month body weight (12.94 kg) and for daily milk yield the value was 1.513 kg. Based on the estimated breeding values for each of the economic trait animals were ranked (Table 3-7).

Table 3. Ranking of BBG goat based on their EBVs for birth weight

Animal ID	EBV	Rank	Animal ID	EBV	Rank
279	1.393	1	138	0.793	10
214	1.293	2	149	0.793	10
224	1.293	3	225	0.793	10
236	1.293	4	353	0.793	10
288	1.293	5	947	0.793	10
248	1.093	6	948	0.793	10
241	0.993	7	950	0.793	10
1555	0.9578	8	1287	0.793	10
141	0.893	9	1288	0.793	10
211	0.893	9	1295	0.793	10
359	0.893	9			

Table 4. Ranking of BBG goat based on their EBVs for 3 month body weight

Animal ID	EBV	Rank	Animal ID	EBV	Rank
644	8.7746	1	288	6.8307	13
571	8.3472	2	88	6.8222	14
275	8.1815	3	353	6.7407	15
649	8.1659	4	468	6.7246	16
597	7.4746	5	643	6.7064	17
461	7.2746	6	159	6.659	18
944	7.2154	7	225	6.4761	19
141	7.1886	8	213	6.2891	20
1285	7.0654	9	149	6.244	21
564	6.9746	10	201	6.199	22
206	6.9492	11	548	6.1746	23
113	6.9322	12	138	6.1151	24
			648	6.0746	25

Table 5. Ranking of BBG goat based on their EBVs for 6 month body weight

Animal ID	EBV	Rank	Animal ID	EBV	Rank
189	6.3975	1	188	3.3723	13
605	5.3028	2	597	3.3175	14
841	5.2587	3	148	3.2119	15
690	4.9368	4	611	3.1757	16
801	4.7849	5	380	2.9749	17
904	4.5024	6	612	2.9273	18
977	4.2897	7	79	2.8092	19
539	4.1327	8	566	2.7267	20
784	4.1296	9	691	2.6679	21
193	3.8468	10	474	2.6201	22
726	3.8029	11	544	2.6201	23
905	3.6988	12	810	2.6116	24

Table 6. Ranking of BBG goat based on their EBVs for 9 month body weight

Animal ID	EBV	Rank	Animal ID	EBV	Rank
189	10.9066	1	784	4.3415	14
148	6.9066	2	479	4.1665	15
841	6.7185	3	880	4.0185	16
597	6.5514	4	544	4.0165	17
589	6.4514	5	141	3.5415	18
188	6.4066	6	149	3.5415	19
566	5.8514	7	583	3.4165	20
738	5.6165	8	590	3.4014	21
539	5.2665	9	142	3.3415	22
543	5.2514	10	643	3.2514	23
612	4.7665	11	587	3.2165	24
787	4.7415	12	548	3.1514	25
138	4.3415	13			

Table 7. Ranking of BBG goat based on their predicted breeding value for daily milk yield

Animal ID	EBV	Rank	Animal ID	EBV	Rank
1113	1.510	1	521	0.76	14
1436	1.403	2	644	0.753	15
149	1.37	3	159	0.71	16
1536	1.303	4	248	0.70	17
1538	1.133	5	279	0.65	18
74	1.06	6	693	0.647	19
288	1.03	7	1773	0.700	20
1516	1.023	8	950	0.677	21
1897	0.980	9	138	0.67	22
1413	0.953	10	203	0.67	23
860	0.890	11	193	0.66	24
927	0.890	12	390	0.66	25
181	0.83	13			

Estimation of genetic trends

The genetic trend among generations of BBG goat for 3, 6 and 9 month body weight are presented in Figure 1, 2 and 3. In all cases the breeding values in the 1st generation was lower then, it gradually increased in generation 2 and 3. The fact for the lower breeding values for these traits in generation 1 could be due to improper selection of parents to produce first generation. Bai *et al.,* (2006) estimated genetic trends of live body weight of Mongolian White Cashmere Goat and reported that the genetic progress on selection for body weight was not effective although it was very effective for cashmere weight. Their results contradict from this study because the type and purpose of production between breeds are different. Though BBG is a meat type goat, genetic progress for body is possible by selecting best animals to produce future generations. As the number of data in generation 2 and 3 were few, care must be made while interpreting. No more literatures are available on this regards for BBG.

Conclusion

In this study, highest heritability was observed in 6m body weight (0.50).

Therefore, future selection and breeding of BBG should be based on 6 month body weight. Besides, high heritability for milk yield (0.55) observed in the present study indicates that BBG doe could be selected on the basis of milk yield. Genetic trends for body weight after first generation was increased which imply that genetic gain is possible by selection of superior bucks and does through generation after generation. Therefore, more research should be done with larger flock size for more concrete results.

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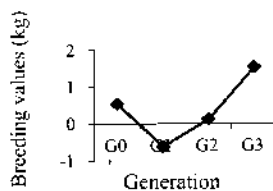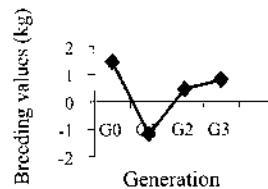
Figure 1 Genetic trend for 3 m bwt (kg) of BBG

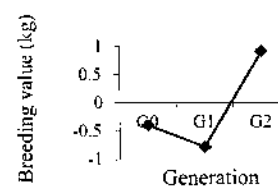
Figure 2 Genetic trend for 6m bwt (kg)

Figure 3 Genetic trend for 9 m bwt (kg)

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