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Genetic and phenotypic performance of three coat color variants of Black Bengal Goat in a closed nucleus flock at BLRI

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Abstract

The objective of this study was to evaluate comparative performance of three coat color variants of Black Bengal Goat. The research was conducted under semi-intensive management system and data were analyzed statistically with R packages and VCE animal model. Irrespective of sex, color type (CT), litter type (LT), kidding parity (KP) and kidding season (KS), overall mean values of birth (BWT), one (1MWT), three (3MWT), six (6MWT) month body weight, growth rate at 0 to 3 (GR_{0-3}) and 3 to 6 (GR_{3-6}) month were 1.14±0.02, 3.52±0.09, 7.24±0.18, 11.64±0.41kg, 58.02±2.02 and 48.80±2.83g/d, respectively. CT had $p<0.05$ effect on 3MWTand 6MWTand $p<0.001$ on $GR_{0-3,}$ Whereas LT had on BWT $p<0.001$ and 6MWT $p<0.05$ effect. Sex, KP and KS had no significant effect on all body weight (BW) traits. Irrespective of CT and KP, overall mean values of age at puberty (AP), age at first kidding (AFK), number of services per conception (NSPC), litter size (LS), post-partum heat period (PPHP) and kidding interval (KI) were 215.5±15.6 d, 374.5±20.0 d, 1.25±0.05 no., 2.37±0.09 no., 43.3±4.01 d and 210.6±7.34 d, respectively. CT had no significant effect on all reproductive traits (RT). KP had $p<0.001$ effect on LS. The BW and GR traits exhibited medium h^2 estimates ranging from 0.463 to 0.493. All RT showed low estimates of h^2 ranging from 0.002 to 0.159, except that of AP (0.490). The strengths of $r_{g\ and}r_p$ correlations among BW and GR traits were medium to strong ($p<0.01$) with positive direction among most pairs of traits. The $r_{g\ and}r_p$ correlations between 6MWT and AP existed to be significantly ($p<0.05$) medium strength -52.0% and- 39.4%. On the other hand, correlations between 6MWT and LS appeared to be significantly ($p<0.05$) medium strength +46.1% and +46.9%. The $r_{g\ and}r_p$ between AP and LS was very low. rg among BW traits indicate that selection of animal based on BWT may have very little chance of improvement for other traits as rg and rp between BWT with weights at other ages are low. However, due to strongly positive rg between 3MWT and 6MWT, early selection at 3MWT could be helpful for breeding purpose in future genetic improvement program.

Keywords: Color goat, Growth, Phenotypic performance, Genetic parameter

INTRODUCTION

Goats are prolific small ruminants mostly reared by ultra-poor and poor people in Bangladesh. That’s why it is said in our country that goat is the poor people’s cow. Goats provide valuable meat and skin which contribute national economy of Bangladesh by earning foreign exchange. There are about 25.77 million goats (DLS, 2016) in our country and about 31.36% households in Bangladesh keep goat with an average number of 2.31 goats per household (Jalil, 2014) and those are mostly reared by landless, small and medium farmers (BBS, 2004). Bangladesh has only one goat breed of its own named popularly as “Black Bengal Goat (BBG)” which is about 90% of the total goat population and others being Jamnapari (popularly known as “Ram Chagol”) and crosses between BBG and Jamnapari (Amin et al., 2001, Husain, 1993). There are varieties of coat color variants in the BBG. Husain (1993) reported that about 80% of BBG are black in color and others being solid white, solid brown, mixed grey or spotted. Chowdhury (2002) also reported BBG to be mostly black in color comprising 69% of the total goat population and rest being white stripe on black (13%), brown (5%), solid white (4%), black with white patches or brown with white or brown with black (9%).

The phenotypic variation in a population arises due to genotype and environmental effects, and the magnitude of phenotypic variability differs under different environmental conditions. According to Gizaw et al. (2007) morphological description is an essential component of breed characterization that can be used to physically identify, describe, and recognize a breed, and also to classify livestock breeds into broad categories. Dossaet al. (2007) reported that morphological measurements such as heart girth, height at withers and body length can be used for rapid selection of large size individuals in the field to enable the establishment of elite flocks. stated earlier that there are variations of coat color patterns amongst the native goat populations in Bangladesh. Very few studies have so far been conducted on the genetic basis of coat color inheritance of native goat in Bangladesh. Genetic control of coat color in goat is complicated which results from the interaction of several independent processes (Sponenburg, 2013). In general consideration, two major types of pigments; eumelanin and pheomelanin are responsible for varying coat color patterns in goat. Those pigments can be present or absent in varying combinations in goat. Some genes affect only one of the two; others affect both. The final color of the goat is due to interaction of eumelanin (black/brown) and pheomelanin (red brown/cream/white) and white spotting (white).

Plenty of works have so far been conducted on the morphological characteristics like body measurements and body weight, as well as distribution of coat color pattern of native goats in Bangladesh. But, inheritance of coat color in goats has received less attention than has that of quantitative economic important traits and lack of a similar importance for color in most goats. However, attempts to develop and conserve different color variety of goat have not yet been done for the satisfaction of consumer’s preference. Coat color is also an identity of a specific breed’s character. However, people have a fascination on color phenotype of animals. Although, lots of solid and mixed colored goats are available in our country, but the studies on coat color inheritance are very scanty in our country. Considering the above circumstances, the present study was undertaken with the objectives to develop pure-line goat genotypes based on coat color variants and phenotypic characterization of different coat color goat genotype.

MATERIALS AND METHODS

The research was conducted at Pachutia goat shed maintained at Biotechnology Division of Bangladesh Livestock Research Institute (BLRI), Savar, Dhaka.

Topography and Climatic Condition of the Study Areas

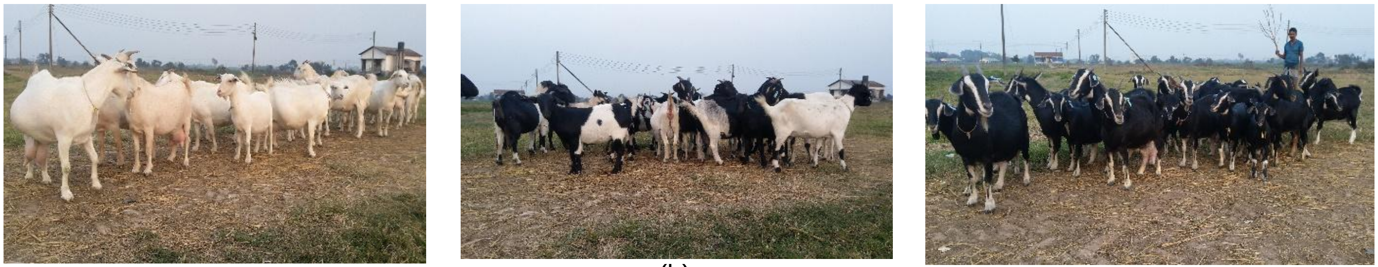
BLRI is located at a distance of about 28 km to the northwest of Dhaka city and lies between 23.8583º North latitude to 90.2667º East longitude. Savar's climate is classified as tropical. In winter, there is much less rainfall than in summer. The climate here is classified as Aw by the Köppen-Geiger system. The average temperature in Savar is 25.8°C. Precipitation here averages 1990 mm(climate-data.org). The land of the Savarupazila is composed of alluvium soil of the pleistocene period. The height of the land gradually increases from east to the west. The southern part of the upazila is composed of the alluvium soil of the Bangshi and Dhalashwari rivers.

Feeding and Management

The goats were semi-intensively managed in research farm of BLRI. Stall feeding was the main feature of feeding through limited grazing from 7 a.m. to 12 noon daily. They were fed two times at 7 to 8 a.m. and 3 to 4 p.m. concentrate (wheat bran, crushed wheat, maize broken, soybean meal, tail oil cake, black gram bran, kheshari bran, DCP and salt) was supplied at 1% of the body weight of the animals. Green grasses were supplied *ad lib*. PPR vaccines were applied two times a year with interval of six months. Deworming was done at a regular interval. All the goats were bred by bucks with similar coat color and pattern of BBG.

Type of Goats and Data

Figure no. 1 shows three coat color variants of BBG such as, Solid white (SW), Dutch belt (DB) and Toggenburg (TB). The following phenotypic traits included both productive and reproductive traits were considered in this study such as birth weight (BWT), one-month body weight (1MWT), three-month body weight (3MWT), six-month body weight (6MWT), growth rate at 0 to 3 month (GR_{0-3}) and 3 to 6 month (GR_{3-6}), age at puberty (AP)(d), age at first kidding (AFK)(d). number of services per conception (NSPC)(no.), litter size (LS)(no.), post-partum heat period (PPHP)(d) and kidding interval (KI)(d).



(a) (b) (c)

Figure 1: Pictorial view of (a) Solid white, (b) Dutch belt and (c) Toggenburg of Bengal goat

Statistical Model and Data Analyses

The animals were of different color genotypes, generation, sex, parity and ages. There was much hierarchy in dataset. So, design of experiment was non-orthogonal factorial in nature. General linear model was applied while analyzing data statistically performed with R packages VCE animal model. The difference between means was statistically significant at ≤5% variation. Mean comparison was performed with Tukey's HSD test of "R' packages and VCE animal model.

RESULTS AND DISCUSSION

The performance of economic important traits of body weight and growth at different ages for different color variants of BB goatis illustrated in Table 1 and discussed thereby

Body Weight at Different Ages

Irrespective of sex, genotype and kidding parity, the overall mean birth weight (BWT), one-month body weight (1MWT), three-month body weight (3MWT) and six-month body weight (6MWT) were 1.14±0.02, 3.52±0.09, 7.24±0.18 and 11.64±0.41 kg, respectively. BWT agrees well with earlier reports estimated from 0.98 to 1.20 kg for BBG (Haque, 2014; Paul et al., 2011; Mia, 2011). In the same studies Mia (2011) and Paul et al. (2011) reported 3MWT to be 5.12 and 5.22±0.33 kg, respectively, which is lower than this study. The 6MWT as obtained in this study was much higher than earlier estimates (8.02±0.31 kg) of Haque (2014) for the same age. BWT of male kids were significantly ($p<0.001$) higher than those of female kids, which agreed well by Amin et al. (2001) and Husain (1999). Actually, variation of BWT between sexes is due to genetic behavior of sex. However, no significant effect on 3MWT, which agreed well by Mia (2011). Sex also exhibited no significant effect on 6MWT. In contrast, Haque (2014), Paul et al. (2011) and Mia (2011) investigated significant variations of 6MWT between sexes. Color genotype had no significant effect on BWT, 3MWT and 6MWT, which agreed well by the recent study of Akhtar (2018) who studied body weight of different color phenotypes in BBG and found no significant variations among them. Kidding parity had no significant effect on BWT, 3MWT and 6MWT. The variations of body weight at different ages among authors for the same genotype could be due to difference of population, sample size, feeding regime or methods of analysis.

Table 1: Body weight and growth at different ages as affected by different non-genetic factors

Factors	**Least squares means (LSM)±SE for different traits**					
	BWT (kg)	**1MWT (kg)**	**3MWT (kg)**	**6MWT (kg)**	**GR$_{0-3}$ (g/d)**	**GR$_{3-6}$ (g/d)**
Sex	NS	NS	NS	NS	NS	NS
Male	1.14±0.02	3.41±0.11	7.19±0.22	11.74±0.46	57.54±2.44	50.33±3.21
	(155)	(102)	(80)	(51)	(80)	(51)
Female	1.15±0.02	3.63±0.12	7.28±0.23	11.54±0.49	58.51±2.60	47.27±3.41
	(151)	(095)	(87)	(57)	(86)	(55)
Color type	NS	NS	*	*	***	NS
Solid White	1.17±0.02	3.55±0.13	6.93^{b}±0.27	11.11^{b}±0.54	64.19^{a}±2.96	48.22±3.82
	(131)	(68)	(58)	(47)	(59)	(48)
Dutch belt	1.13±0.03	3.68±0.12	7.77^{a}±0.25	12.92^{a}±0.55	64.19^{a}±2.77	53.04±3.88
	(92)	(66)	(54)	(31)	(54)	(29)

Table 1 Cont'd

Toggenburg	1.13±0.03	3.33±0.14	7.02[ab]±0.28	10.90[b]±0.68	45.68[b]±3.21	45.15±4.81
	(83)	(63)	(55)	(30)	(53)	(29)
Litter type	***	NS	NS	*	NS	NS
Single	1.36[a]±0.05	3.57[ab]±0.23	7.38±0.46	11.51[ab]±0.95	56.62±5.04	52.03±7.22
	(029)	(20)	(18)	(11)	(19)	(10)
Twin	1.21[b]±0.02	3.74[a]±0.13	7.54±0.27	12.97[a]±0.52	61.48±3.11	56.39±3.68
	(106)	(73)	(61)	(42)	(60)	(42)
Triplet	1.11[b]±0.02	3.49[ab]±0.12	6.63±0.25	10.75[b]±0.56	52.99±2.78	42.80±3.89
	(104)	(63)	(57)	(33)	(56)	(32)
Quadruplet	1.13[b]±0.03	3.50[ab]±0.18	7.39±0.42	12.29[ab]±0.73	60.68±4.72	49.17±5.07
	(052)	(29)	(19)	(17)	(19)	(17)
Five fold	0.90[c]±0.06	3.28[b]±0.29	7.23±0.54	10.69[ab]±1.70	58.33±6.11	43.62±12.98
	(015)	(12)	(12)	(05)	(12)	(05)
Kidding parity	NS	NS	NS	NS	NS	NS
1st	1.06±0.03	3.60[ab]±0.16	7.28[a]±0.32	12.16[a]±0.63	58.72±3.62	50.80±4.54
	(85)	(55)	(49)	(34)	(50)	(35)
2nd	1.12±0.03	3.81[a]±0.15	7.84[a]±0.29	11.96[ab]±0.60	65.47±3.31	47.73±4.21
	(85)	(50)	(47)	(37)	(46)	(36)
3rd	1.19±0.03	3.43[bc]±0.16	7.37[a]±0.33	11.66[b]±0.62	58.22±3.69	50.33±4.49
	(62)	(42)	(33)	(24)	(33)	(22)
4th	1.14±0.03	3.49[abc]±0.18	7.29[a]±0.35	10.79[b]±0.89	58.59±3.94	46.36±6.16
	(48)	(31)	(26)	(13)	(26)	(13)
≥5th	1.21±0.05	3.26[c]±0.24	6.39[b]±0.54	-	49.11±6.43	-
	(26)	(19)	(12)		(11)	
Kidding season	NS	NS	NS	NS	NS	NS
Summer	(080)	3.49±0.14	7.32±0.28	11.74±0.77	60.19±3.25	50.96±5.43
		(59)	(48)	(23)	(47)	(23)
Rainy	(091)	3.47±0.14	7.09±0.28	11.61±0.51	55.66±3.12	47.33±3.74
		(60)	(48)	(30)	(48)	(28)
Winter	(135)	3.59±0.13	7.30±0.26	11.58±0.53	58.22±2.88	48.13±3.72
		(78)	(71)	(55)	(71)	(55)
Minimum	0.40	1.90	3.90	6.40	21.1	16.7
Maximum	2.20	7.30	13.30	20.90	125.6	110.0
CV (%)	19.9	25.3	23.7	22.40	34.4	35.3
Overall mean	1.14±0.02	3.52±0.09	7.24±0.18	11.64±0.41	58.02±2.02	48.80±2.83
	(306)	(197)	(167)	(108)	(166)	(106)

BWT-birth weight; 1MWT-1-month weight; 3MWT-3-month weight; 6MWT-6-month weight; GR_{0-3}-growth rate from 0 to 3 month; GR_{3-6}- growth rate from 3 to 6 month; SE-standard error; g-gram; d-days; CV- coefficient of variation; #Means with uncommon superscript within same column differ significantly (p<0.05); Figures in the parenthesis indicate number of observations, *-p<0.05, **-p<0.01, ***-p<0.001), NS-Non-significant (p>0.05).

Body Weight Gain

Irrespective of sex, colortype and kidding parity, the overall mean growth rate at 0 to 3 month (GR_{0-3}) and at 3 to 6 month (GR_{3-6}) were 58.02±2.02 and 48.80±2.83 g/d, respectively (table 1). Earlier, Majumder (2011) and Haque (2014) reported 39.93 and 56.68 g/d body weight gain at 0-3 month in BBG, which do not conform to this study. In the same study, Haque (2014) obtained 32.64 g/d body weight gain at 3-6 month which is slightly lower than this study. The variations of body weight gain at different ages for the same genotype could be due to plain of feeding and nutrition, management or sample size. Analysis of variance shows that sex, color genotype and kidding parity; any of these factors did not influence growth rates at GR_{0-3} and GR_{3-6} (Table 1). Akhtar (2018) in their recent study did not find any significant variation of body weight gain at 0-3 month due to the effect of sex which is corroborated with this study. In contrast, the same author claimed significant variation of body weight gain at 3-6 month due to the effect of sex. However, body weight gains did not influence significantly for color genotype and kidding parity. Actually, unlike qualitative trait, very little variations have been noticed in quantitative traits of BBG..

The performance of economic important traits of reproduction for different color variants of BB goat is depicted in Table 2 and discussed below.

Table 2. Reproductive performance as affected by color genotype and kidding parity

Factors	Least squares means (LSM)±SE for different traits					
	AP (d)	**AFK (d)**	**NSPC (no)**	**LS (no)**	**PPHP (d)**	**KI (d)**
Color type	NS	NS	NS	NS	NS	NS
White	210.7±22.8	370.5±28.7	1.19±0.08	2.57±0.15	41.9±6.54	209.5±11.87
	(19)	(20)	(59)	(58)	(33)	(32)
Dutch belt	182.5±28.7	349.9±37.8	1.28±0.08	2.06±0.16	42.0±6.82	229.4±12.30
	(15)	(12)	(45)	(46)	(24)	(25)
Toggenburg	253.4±29.3	394.9±37.4	1.27±0.10	2.47±0.18	46.0±7.44	193.3±14.08
	(12)	(12)	(34)	(34)	(21)	(19)
Kidding parity	-	-	NS	***	NS	NS
1st	-	-	1.06±0.08	1.68^{b}±0.15	90.0^{b}±21.01	-
			(50)	(49)	(02)	
2nd	-	-	1.16±0.09	2.24^{a}±0.18	26.9^{a}±6.47	212.0±12.07
			(36)	(37)	(28)	(30)
3rd	-	-	1.37±0.11	2.93^{a}±0.20	39.0^{a}±6.80	206.1±13.03
			(26)	(26)	(25)	(22)
4th	-	-	1.26±0.13	2.84^{a}±0.23	47.4^{a}±8.39	214.9±14.98
			(18)	(18)	(16)	(14)
≥5th	-	-	1.53±0.19	2.50^{a}±0.34	54.0^{a}±12.50	209.3±22.68
			(08)	(08)	(07)	(07)
Minimum	104	210	1	1	7	143
Maximum	566	633	4	5	133	355
CV (%)	46.7	28.3	41.7	42.4	81.1	25.2
Overall mean	215.5±15.6	374.5±20.0	1.25±0.05	2.37±0.09	43.3±4.01	210.6±7.34
	(46)	(44)	(138)	(138)	(78)	(76)

AP-age at puberty; AFK-age at first kidding; SPC-number of services per conception; LS-litter size; PPHP-postpartum heat period; KI-kidding interval; d-days; SE-standard error; CV-coefficient of variation; #Means with uncommon superscript within same column differ significantly ($p<0.05$); Figures in the parenthesis indicate number of observations, ***-$p<0.001$), NS-Non-significant ($p>0.05$).

Age at Puberty (AP)

The overall AP as obtained in this study is215.5±15.6 days, irrespective of genotype. In general agreement, Halimet al. (2011) reported 234.16 days AP for the same genotype reared under farmers' house in Chittagong region. Although, AP is an intrinsic character, however, it may largely depend on feeding & nutrition or climatic condition with very little influence due to genetic factor. However, color genotype had no significant effect on this trait (Table 2). This could be due to same genes controlling on this trait for all population in BBG.

Age at First Kidding (AFK)

The AFK without considering the effect of color genotype and kidding parity was estimated as 374.5±20.0 days. AFK is positively correlated with age at puberty. Though, puberty is an intrinsic character, however, it may be delayed or advanced due to some non-genetic factors as stated earlier. Concurring with this study, Chowdhury et al. (2002) observed that doe under semi-intensive rearing system gave birth to their first kid at an average age of 13.5-months (equivalent to 405 days) and Hossain et al. (2004) reported it to be 401.5 days. Statistical analysis shows no significant variations of this trait for the direct effect ofcolor genotype (Table 2).

Number of Services Per Conception (NSPC)

As shown in Table 2 that overall NSPC was found to be 1.25±0.05, irrespective of color genotype and kidding parity. Hossain et al. (2004) reported 1.27 numbers of services for each conception which is lower than this study. However, higher numbers of 1.45 and 1.76 services per conception were investigated by Chowdhury et al. (2002) and Islam (2014) in their studies for BBG. Lots of non-genetic factors are responsible for NSPC like mating system, heat detection, time of insemination, reproductive disturbance of does, semen quality of buck etc., which may interfere sound conception leading to variation among population. NSPC did not differ significantly for either color genotype or kidding parity. This is in consistence with Hossain et al. (2004), Choudhury et al. (2012), Chowdhury et al. (2002) and Aminet al. (2001) who reported coat color and parity to have no significant effect on this trait.

Litter Size (LS)

The LS of different color genotypes of BBG is averaged to 2.37±0.09, irrespective of color genotype and kidding parity (Table 2). Earlier, Amin (2001) obtained 2.15±0.14 kids per kidding in a selective breeding program under farmer's house for the same breed, which is in accordance with this study. However, there were many published literatures showed LS to be less than 2. This variation could be due to variations of kidding parities among authors from which data were taken, because multiparous does give birth more kids than maiden does (Akhtar, 2018). Selection of parents based on genetic superiority might be another reason for higher LS obtained in this study. Table 2 also shows that variations of LS among three color genotypes were statistically significant ($p<0.05$). Highest LS was obtained in solid white. However, Choudhury et al. (2012) did not observed significant variations of LS due to color genotype in BBG, which is contradicted with this study. Kidding parity had shown to be a highly significant ($p<0.001$) source of variation for LS, which gradually increased in successive parities. Hossain et al. (2004) also investigated the same trend of LS for this breed. However, it was evident from many studies that LS increases with progressing kidding parities. The reproductive organ of does become well developed at older ages, which leads to gain capability to carry multiple fetus.

Postpartum Heat Period (PPHP)

The overall PPHP as depicted in Table 2 is43.3±4.01days without considering the effect of color genotype and kidding parity. Comparatively lower estimates of PPHP were reported by Akhtar (2018), Majumder (2011), Devendra and Burns (1983), Hossain et al. (2004) and Faruque et al. (2010) who published 42.41, 46.3, 60, 43.07 and 28.53 days, respectively for the same breed. In contrast, Haqueet al. (2013) reported very high period of 123.84 days PPHP in BBG. Apparently, generation, parity, better management and nutrition were reported to be the most contributing factors responsible for lowering the post-partum heat period (Hossain et al., 2004). The analysis variance revealed that PPHP varied significantly ($p<0.01$) among color genotypes. Shortest PPHP was obtained in Dutch belt followed by solid white and toggenburg pattern. Parity had significant ($p<0.05$) effect on PPHP with decreasing trend in progressive parities (Table 2). In general concurrence with this study, Hossain et al. (2004) also reported decreasing trend of PPHP with significant ($p<0.01$) variations from 1st to 3rd kidding parity in BBG.

Kidding Interval (KI)

The overall mean KI, irrespective of color genotype and kidding parity was estimated to be 210.6±7.34 days as depicted in Table 2. This estimate is lower than the recent study of Akhtar (2018) who found it 186.44±0.95 days for the same breed. Earlier, Choudhury (2011), Faruque et al. (2010) and Hasan et al. (2014) obtained 188.55±8.82, 181.23±4.55 and 190.2±0.20 days, respectively in their studies for the same genotype. In contrast, Haque et al. (2013) found 302.5±4.55 days KI, which is higher than this study. The variations of KI among different studies are very usual, as KI may be deviated due to difference of management, plain of nutrition, seasonality of reproduction or repeat breeding occurrence. Table 2 shows no significant effect of either color genotype or kidding parity on KI. The identical genetic constituents of different color genotypes within same breed could be the reason for consistency of KI among color genotypes. Earlier, Choudhury et al. (2012) and Hossain et al. (2004) investigated significant ($p<0.05$) differences of KI due to the effects of color genotype and parity, which disagreed with this study.

Variance Components and Heritability Estimates

The variance components and heritability estimates of body weights and daily weight gains at different ages are depicted in Table 3 which shows that all the traits have shown to be medium heritability ranges from 46.3% to 49.3%. Very recently,Akhter(2018)investigated heritability estimates for body weight at birth, 3 months, 6 months and growth rates from birth to 3 month and 3 to 6 month in BBG to be 45%, 53%, 57%, 49% and 42%, respectively which are closely in accordance with our estimates. Our findings are also corroborated with Miaet al*.* (2013) for the same genotype who also reported medium estimates of heritability (45-49%) for those traits. Kuthu et al. (2013) reported heritability estimate of post-weaning growth at 6-month to be 17.0%for teddy goats which is lower than this study. This variation could be due to difference of breed, location, environment, sample size and methods of estimation. The heritability estimates of body weight traits as obtained in this study imply that mass selection is better for more genetic improvement of body weight in Black Bengal goat.

Table 3. Variance components and heritability estimates of body weight and daily weight gain at different ages

Body weight and growth trait	Covariance component			h^2 (±SE)
	σ^2_a	σ^2_e	σ^2_p	
BWT	0.021	0.001	0.043	0.493±0.027
1MWT	0.432	0.017	0.881	0.490±0.037
3MWT	1.720	0.046	3.486	0.493±0.037
6MWT	3.141	0.499	6.781	0.463±0.057
GR_{0-3}	159.587	7.295	326.469	0.489±0.037
GR_{3-6}	144.951	4.369	294.271	0.493±0.052

BWT, birth weight; 1MWT, body weight at 1-month; 3BWT, body weight at 3-month; 6BWT, body weight at 6-month; GR_{0-3}, growth rate at birth to 3-month; GR_{3-6}, growth rate at 3 to 6-month; σ^2_a, additive genetic variance; σ^2_e, environmental variance; σ^2_p, total phenotypic variance; h^2, heritability; SE, standard error.

The heritability estimates of some economic important reproductive parameters are illustrated in Table 4, which shows lower values, except that of age at puberty. Akhter (2018) reported 47% heritability of age at puberty which is coincided by our study, but the author obtained higher estimates of heritability for number of services per conception (38%), litter size (48%) and kidding interval (39%), which could be attributed due to estimation errors associated with population size, data structure or variable management conditions. However, our estimates are in general agreement with Haque et al. (2013) who reported heritability estimates of 14% forlitter size and 17%for kidding interval in the same genotype, but in different population. The heritability estimates for reproductive traits also appeared to be low by the study of Mia et al. (2013). The heritability estimates as obtained in this study confirms that unlike age at puberty, genetic improvement through selection based on number of services per conception, litter size and kidding interval may not be possible as environmental factors are more dominant than genetic influence on those traits..

Table 4: Variance components and heritability estimates of reproductive traits

Reproductive trait	Variance component			h^2 (±SE)
	σ^2_a	σ^2_e	σ^2_p	
AP	6102.315	253.403	12458.033	0.490±0.152
NSPC	0.000	0.006	0.251	0.002±0.057
LS	0.054	0.330	1.042	0.052±0.000
KI	428.535	0.00	2690.695	0.159±0.094

AP, age at puberty; SPC, number of services per conception; LS, litter size; KI, kidding interval;σ^2_a,additive genetic variance; σ^2_e, permanent environmental variance; σ^2_p, total phenotypic variance;h^2,heritability for the trait; SE, standard error of heritability..

Genetic and Phenotypic Correlations

The genetic and phenotypic correlations among body weight and growth rates at different ages are illustrated in Table 5which indeed shows highly significant ($p<0.01$) correlations among most pairs of traits. The strengths of correlations are medium to strongly positive, except between birth weight and growth rate at 3 to 6 month. In the same genotype, but in another population, Akhter (2018) reported low strength of genetic correlations between birth weight and 3-month weight (r_g: 4.3% and r_P: 17.3%, $p<0.01$)and between birth weight and 6-month weight (r_g: 1.7% and r_P: 31.6%, $p<0.01$) which are not in accordance with our study. However, in the same study the author reported strongly positive correlations between 3-month weight and 6-month weight (r_g: 89.6% and r_P: 91.2%, $p<0.01$) which agreed well by our study. Earlier, Mia et al. (2013) estimated genetic and phenotypic correlations of body weight among different ages for same genotype in different population and reported medium to high strength of correlations with positive direction (r_g: 34-90% and r_P: 34-83%) which are in the line of our study. Highly significant ($p<0.01$) medium strength of correlations between weight gain at birth to 3 months and at 3 to 6 month (r_g: 39% and r_P: 34%, $p<0.01$) were also reported by Akhter (2018) which are closely agreed by our estimates. Earlier, Zhou et al. (2015) also claimed positive and relatively low genetic and phenotypic correlations among average daily gain traits for Hainan Black goat in Southern China. The direction and degree of strength for genetic and phenotypic correlations among body weight and growth rate traits reveal that genes controlling for those traits are almost alike. Table 5 also shows that the correlations among body weights at different ages decreased, as the time between measurements increased. This could be due to the fact that there may be very little effects of environment on birth weight rather than weights at later ages resulting lower correlations between birth weights with weight at older ages. The study of genetic correlation indicates that selection of animal based on birth weight may have very little chance of improvement for other traits as genetic and phenotypic correlations between birth weights with weights at other ages are low. However, due to strongly positive genetic correlation between 3-month weight and 6-month weight, early selection at 3-month weight could be helpful for breeding purpose in future genetic improvement program.

Table 5: Genetic correlations (below diagonal) and phenotypic correlations (above diagonal) among body weight and growth rate traits

Traits	BWT	3MWT	6MWT	GR_{0-3}	GR_{3-6}
BWT	100%	41.1% ($p<0.01$)	25.5% ($p<0.01$)	29.3 ($p<0.01$)	-05.4% ($p>0.05$)
3MWT	39.9%	100%	80.1% ($p<0.01$)	99.2% ($p<0.01$)	16.1% ($p>0.05$)
6MWT	41.2%	85.8%	100%	80.5% ($p<0.01$)	72.0% ($p<0.01$)
GR_{0-3}	29.8%	99.4%	84.5%	100%	17.7% ($p>0.05$)
GR_{3-6}	19.9%	21.5%	68.5%	20.1%	100%

BWT, body weight at birth; 3MWT, body weight at 3 months; 6MWT, body weight at 6 months; GR_{0-3}, growth rate at birth to 3 months; GR_{3-6}, growth rate at 3 to 6 month; **, Correlation is significant at 1% level (2-tailed).

The genetic and phenotypic correlations among 6-month body weight, age at puberty and litter size are depicted in Table 6. The genetic and phenotypic correlations between 6-month body weight and age at puberty exist to be significantly ($p<0.05$) medium strength with negative direction. On the other hand, correlations between 6-month body weight and litter size appear to be significantly ($p<0.05$) medium strength with positive direction. The strength and direction of correlations for both pair of traits are desirable to breeder for genetic improvement of more than single trait, because selection with higher body weight will simultaneously help to reduce age at puberty and to increase litter size as well. Table 6 also shows negative genetic and phenotypic correlations between age at puberty and litter size, although the strength of correlation between traits is low. This is in agreement with Akhter (2018) who obtained negative with low strength of correlations (r_g: -8.0%, r_P: -16.0%) between age at puberty and litter size. The study on genetic correlations revealed that 6-month body weight may be a good selection indicator for collateral genetic improvement of age at puberty and litter size.

Table 6: Genetic correlations (below diagonal) and phenotypic correlations (above diagonal) among body weight and reproductive traits

Traits	6MWT	AP	LS
6MWT	100%	-39.4% (p<0.05)	46.9% (p<0.05)
AP	-52.0%	100%	-1.6% (p>0.05)
LS	46.1%	-14.9%	100%

6MWT, body weight at six months; AP, age at puberty; LS, litter size; * Correlation is significant at 0.05% level (2-tailed)

CONCLUSION

The results as obtained in this study show that body weight and growth rate of three coat color variants of Black Bengal goat performed almost similar. However, reproductive performance varied among color types. As coat color variation has no effect on performance of BBG, its effect may be ignored in evaluation of BBG in Bangladesh under same management condition. As a result, an attempt made to develop and conserve different color variety of goat for the satisfaction of consumer's preference. Coat color is also an identity of a specific breed's character. However, people have a fascination on color phenotype of animals. The medium heritability estimates of body weights indicated that there is a good opportunity for genetic improvement of this trait in a selection scheme. However, due to strongly positive genetic correlation between 3MWT and 6MWT, early selection at 3MWT could be helpful for breeding purpose in future genetic improvement program. The heritability estimates of reproductive traits as obtained in this study confirm that unlike age at puberty, genetic improvement through selection based on NSPC, LS and KI may not be possible as environmental factors are more dominant than genetic influence on those traits. Genetic and phenotypic correlations among studied traits imply that there is no genetic antagonism between most pairs of traits, which could be helpful for genetic improvement for multiple traits.

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