Original Research Article

Genetic Expression of Different Coat Color Variants of Black Bengal Goat (BBG)in Bangladesh

ABSTRACT

Aims: To investigate genetic expression of different coat color variants in Black Bengal Goat (BBG) of Bangladesh.

Study design: CRD with non-orthogonal hierarchy.

Place and duration of study: This study was carried out at 3 rural village communities of Bhaluka Upazila in Mymensingh district of Bangladesh from 2009 to 2013.

Methodology: All goats in community breeding program under this study were ear-tagged and maintained under semi-intensive management system with three breeding strategies in progressive generations. Data were collected from a baseline survey for goat population study along with 3 progressive generations produced from the community foundation flocks. The color distribution and the colors of kids from matings among different color parents were observed and recorded accordingly. The recorded data were analyzed by "SPSS 20.0" statistical program.

Result: The highest color populations of about 53% were solid black in color and others being Bejoar (31%), black with Toggenbergpattern (9%), black with Dutch belt pattern (6%) and solid brown (only 0.5%). Sex and generation had no significant effect on coat color expression, while, coat color in different locations differed significantly. For the analysis of coat color inheritance, two categories of offspring were considered in this study; one from known coat color dams mated with unknown coat color sire and another from known coat color parents. In the earlier category, most of the offspring exposed their dam's coat color when mated to unknown coat color sires. For later category, there were varieties of coat colors offspring, produced from matings between two different or same color parents.

Conclusion: Although, the segregation of coat colors among offspring showed dominance of parents` color, there were also offspring`s other than parents` coat colors. This might be due to polymorphism of coat color gene in BBG.

Keywords: Black Bengal Goat (BBG), Coat color variants, color distribution, genetic expression of coat color

1. INTRODUCTION

Bangladesh has only one goat breed of its own named popularly as "Black Bengal Goat (BBG)" which is estimated of about 90% of the total goat population and others being Jamnapari (popularly known as "Ram Chagol") and crosses between BBG and Jamunapari, Amin et al. [1]; Husain [2]. There are varietiesof coat color variants in the BBG. Husain [2] reported that about 80% of BBG are black in color and othersbeing solid white, solid brown, mixed grey or spotted. Chowdhury [3] 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%).

People of different countries have special attention and choice on coat color of goat. According to the observation of Hassen et al. [4], morphological differences have important socio-cultural and economic values to the Ethiopian communities; as a result, most farmers have specific consideration and choices for goat coat colors followed by body sizes. Banerjee et al. [5] who observed that coloration couldbe an adaptive trait or selected through farmers' preference for a specific coat color, Indetie et al. [6]; Manzi et al. [7]. In Ethiopia, goat coat color has a direct effect on goat marketing value. Due to cultural taboo, for

instance, goat with full black coat color is not preferred for slaughtering for home meat consumption. Black colored animals including goats, however, are believed to have superior adaptation to seasonal cold weather or cold nights as the dark pigment helps them to warm up earlier than goats with other coat colors, Robertshaw [8]. However, in Bangladesh goats having black coat color are specially preferred over white or brown color for meat consumption and demand of skin.

Although, there are varieties of coat colorsin BBG, but very few studies have so far been conducted on the genetic basis of coat color inheritance in Bangladesh. Genetic control of coat color in goat is complicated which results from the interaction of several independence processes, Sponenburg [9]. 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). According to the studies of Nozawa et al. [10] and Alam [11], Black Bengal Goats are polymorphic in coat color. At least four loci are responsible for the coat color of goats, such as I, A, D and S. It was found that allele I is dominant over all the alleles at other loci and its presence with any alleles in the remaining loci makes the coat color full white or cream. Considering the importance of coat color variants, the present study was undertaken to know the genetic expression of coat color in BBG.

2. MATERIALS AND METHODS

2.1 LOCATION OF THE STUDY

This research work was carried out at community based goat breeding flocks in three different villagesnamed*Gangatia*, *Borachala* and *Pachpai* of Hobibari union under Bhaluka Upazilain Mymensingh district of Bangladesh under a completed project named “UNEP-GEF-ILRI FAnGR Asia Project” conducted from 2009 to 2013.

2.2 ANIMALS AND DATA

All animals under the study were ear tagged to maintain individual identity. The information on coat color for each parent and progenywasobserved and collected up tothreeprogressive generations along with foundation flock from three different village flocks including their pedigree records. The study covered with information of a total number of 871 individuals including males and females, three different flocks and three progressive generations with foundation stock. The flocks were maintained under the existing semi-intensive management system.

2.3 IDENTIFICATION OF COAT COLOR VARIANTS

In this study five typical coat colors’ along with mixed color goats were identified which are defined below:

Solid Black: Black coat around the body with no pattern (Fig. 1). The gene responsible for black coat is A^{a}.

Dutch belt pattern (S^{d}_): This varies from a nice ring around the barrel of the goat to a nearly white goat with colored tail and head (Fig. 3). Also includes some with single side spots.

Toggenburg pattern (SS): Darkbody, dark belly, pale legs, ears, facial stripes (Fig. 2). The Toggenburg pattern (A^{sm}), when eumelanin is brown.

Brown: Brown eumelanin varies from very dark (B^{d}) to very light brown (B^{l}).

Bezoar (wild type, A_D_ or A_dd): Wild color (A^{+}), tan body, dark head with stripes, pale belly, striped legs and back, black shoulder stripe. More dark in males than in femles.

Others: Combination of different colors or mixed color in the body.

Fig.1 Solid black

Fig. 2 Toggenburg

Fig. 3 Dutch belt

Fig. 4 Brown bezoar

2.4 STATISTICAL ANALYSIS

All information related to coat color of goat including parents and progenies were recorded in excel spreadsheet. The statistical analysis for frequency distribution and *Chi-square* test were analyzed by SPSS 20.0.

3. RESULTS AND DISCUSSION

Table 1 illustrates the distribution of different coat color patterns in BBG population observed in the studied areas.Irrespective of sex, flock and generation, most of the goat populations were solid black followed by Bezoar, black with Toggenberg pattern, black with Dutch belt pattern and solid brown. Coat color did not differ significantly for sex and generation, butdiffered significantly in different locations.The exact distribution of BBG goat population based on different coat color varied among literatures reviewed earlier, but no doubt that black color goats are more visible than those of other colors in Bangladesh. Percent of black coat color as found in this study is lower than the earlier studies of Husain [2] and Chowdhury [3] who reported it to be 80% and 69%, respectively. Islam [12] in his study reported solid black, toggenberg, brown bezoar, silver bezoar and white to be 69, 19, 4, 6 and 2%, respectively in 4 upazilas of Mymensingh district which is not in accordance with this study. Choudhury et al. [13] collected morphometric data of 106 Black Bengal goats and found 16% solid black, 55% toggenberg pattern, 19% brown bezoar, 3% dutch belt and 7% other combinations which does not agree with this findings. The variations of coat color distribution among authors are very usual, because every author worked on a very small sample population which does not represent the population as a whole. Despite this, people of different areas have different choice of color. Further, the color of breeding buck is also an important factor for coat color distribution among the offspring.

To study the coat color inheritance of BBG, the distribution of progeny coat color produced from various matings between known color dam and unknown sire are presented in Table 2 which shows that, offspring being produced from those matings dominantly exposed their dam's color.Although, it may be difficult to explain coat color inheritance without knowing coat color of any of the parents, but the segregation of coat color of offspring from mating known dam color with unknown sire as obtained in this study, however, indicate that color gene in female goat is dominant over color gene in male goat. There is no evidence about the sex link nature of the genes responsible for coat color in goat. More in-depth researches need to be conducted on this aspect.

Table 1: Coat color distribution of BBG according to sex, flock and generation among Black Bengal Goats in Bangladesh

Factors	Frequency of type of goat[#] based on different coat color observation					
	Solid Black	Black with Toggenberg	Solid Brown	BrownBejoar	Black with Dutch belt	Others
Sex			NS			
Male	169 (56.9)	25 (08.4)	1 (0.3)	90 (30.3)	11 (03.7)	1 (0.3)
Female	292 (50.9)	55 (09.6)	3 (0.5)	177 (30.8)	39 (06.8)	8 (01.4)
Flock			***			
1 (*Gangatia*)	164 (48.1)	50 (14.7)	1 (0.3)	119 (34.9)	7 (02.1)	0 (0.0)
2 (*Borochala*)	65 (42.5)	8 (05.2)	3 (02.0)	48 (31.4)	28 (18.3)	1 (0.7)
3 (*Pachpai*)	232 (61.5)	22 (05.8)	0 (0.0)	100 (26.5)	15 (04.0)	8 (02.1)
Generation			NS			
Foundation (G_0)	150 (53.0)	17 (06.0)	0 (0.0)	91 (32.2)	18 (06.4)	7 (02.5)
Generation 1 (G_1)	238 (53.2)	45 (10.1)	4 (0.9)	134 (30.0)	24 (05.4)	2 (0.4)
Generation 2 (G_2)	51 (51.5)	14 (14.1)	0 (0.0)	27 (27.3)	7 (07.1)	0 (0.0)
Generation 3 (G_3)	22 (52.4)	4 (09.5)	0 (0.0)	15 (35.7)	1 (2.4)	0 (0.0)
Overall	461 (52.9)	80 (9.2)	4 (0.5)	267 (30.7)	50 (5.7)	9 (1.0)

Figures in the parenthesis indicate % values; [#]described in methodology; NS-not significant (p>0.05); ***-significant at 0.1% level (p<0.001)

Table 2: Color progeny produced by various matings of does with unknown coat color sires in Black Bengal Goat of Bangladesh

Colors mated		Colors of offspring produced					
Dam	*Sire	Solid Black	Black with Toggenburg	Brown	Bezoar	Black with Dutch belt	Other
Solid Black	Unknown	249 (74.3)	24 (7.2)	0 (0.0)	56 (16.7)	6 (1.8)	0 (0.0)
Black with Toggenburg	Unknown	17 (27.9)	30 (49.2)	1 (1.6)	11 (18.0)	2 (3.3)	0 (0.0)
Bezoar	Unknown	85 (33.1)	14 (5.4)	1 (0.4)	147 (57.2)	7 (2.7)	3 (1.2)
Black with Dutch belt	Unknown	17 (32.7)	5 (9.6)	2 (3.8)	1 (1.9)	26 (50)	1 (1.9)

*Unknown sires were those mated with dam naturally.

There were five distinguished coat colors observed in the offspringfrom variousmatings among black, black with Toggenburg pattern, bezoar and black with Dutch belt pattern parents which are presented in Table 3. Black parents when mated to each other produced most of the black kids followed by bezoar, black with Toggenburg pattern and black with Dutch belt pattern, none of which were solid brown. When black parents mated to bezoar parents produced five colors kids in which most of the kids were black followed by brown, bezoar, black with Toggenberg and black with Dutch belt pattern. Black parents mated to black with Toggenburg pattern parents produced most of the kids with black and Toggenburg pattern followed by bezoar and black with Dutch belt pattern none of which were solid brown. Black parents

mated to black with Dutch belt pattern parents produced two prominent colors kids, one of which were black kids and other being Dutch belt pattern none of which were brown color.Bezoar parents when mated to each other although produced five color kids, but most of the kids were bezoar followed by black, Dutch belt, Toggenburg and brown. When bezoar parents mated to Toggenburg produced most of the kids of Toggenburg followed by black, bezoar, Dutch belt and brown. Bezoar parents mated to Dutch belt produced five colors kids but most of the kids were Dutch belt. Dutch belt parents when mated to each other produced all black kids. When black with Dutch belt pattern parents mated to black with Toggenburg pattern produced most of the kids with Toggenburg pattern followed by balck and Dutch belt, none of which were brown and bezoar. Black with Toggenburg pattern sire and dam mated together produced only two prominent colors kids in which most of the kids were Toggenburg pattern and other being bezoar.

Table 3: Color of offspring produced by various parent color matings in Black Bengal Goat of Bangladesh

Colors mated	Kids produced				
	Black	Toggenburg	Brown	Bezoar	Dutch belt
Black × Black	160 (80.0)	8 (4.0)	-	29 (14.5)	3 (1.5)
Black × Bezoar	112 (51.9)	10 (4.6)	68 (31.5)	25 (11.6)	01 (0.5)
Black × Toggenburg	20 (42.6)	20 (42.6)	-	06 (12.8)	01 (2.1)
Black × Dutch belt	22 (61.1)	01 (2.8)	01 (2.8)	-	12 (33.3)
Bezoar × Bezoar	10 (16.7)	02 (3.3)	01 (1.7)	44 (73.3)	03 (5.0)
Bezoar × Toggenburg	11 (29.7)	13 (35.1)	01 (2.7)	10 (27.0)	2 (5.4)
Bezoar × Dutch belt	01 (5.3)	01 (5.3)	01 (5.3)	01 (5.3)	15 (78.9)
Dutch belt × Dutch belt	03 (100)	-	-	-	-
Dutch belt × Toggenburg	01 (20.0)	03 (60.0)	-	-	01 (20.0)
Toggenburg × Toggenburg	-	10 (83.3)	-	02 (16.7)	-

#Figures in the parenthesis are percentage values

The genetic expression of coat color shows that parents of different colors combinations mated to each other produced kids possessing parents' color dominantly with very few other colors. The segregation of coat color of offspring from mating same color parents is contradicted with the segregation data of Sponenberg and LaMarsh [14] who got all black kids when mated black goats to black goats and all brown kids when mated brown goats to brown goats. The color of offspring other than black obtained from the mating of black parents in our study could be due to the fact that both parents may carry other recessive gene on the B or E locus. The segregation of coat color of the offspring obtained from mating black parents with bezoar parents reveals that black is due to a gene A^a which is dominant to bezoar (wild type, A^+), and all black parents are heterozygous (A^aA^+) produced black offspring carries the Aa (black) agouti allele. The results further postulated that other color offspring being produced from black and bezoar parents might be due to presence of recessive alleles in other locus. This result agrees well with Waller [15]. He reported that any non-black animal bred to a black animal that produces black offspring carries the Aa (black) Agouti allele. He also suggested that the best way to determine if an animal carries but does not express a particular pattern is to breed that animal to a black (preferably solid black) animal. The segregation data on coat color of offspring produced from black parent with other color/pattern parent further shows black to be dominant over other colors which is in agreement with Lauvergne and Howell [16] who postulated that both brown and light brown are recessive to black. On the other hand,Sponenberg and LaMarsh [14] in their study on American Pygmy goats found 40 kids from matings

of black with dark brown parents in which 23 kids were black and 17 kids were dark brown. In other matings between black and medium brown parents, they obtained a total of 66 kids among which 62 kids were black and only 4 kids were medium brown. Finally they concluded that dark brown (B^d) is dominant to black (*wild type,* B^+) and medium brown is recessive to black (*wild type,* B^+). Their findings partially agree with our study. Segregation data on coat color of offspring from matings of parents with other color combination also reveals that all parents are carriers for recessive gene responsible for different coat colors.

4. CONCLUSION

Results of the study suggest that black coat color goats are prominently distributed among BBG population. This indicates that gene responsible for black coat color is dominant over genes responsible for other colors in BBG. The study further reveals that coat color genes are polymorphic in nature and there are multiple loci for coat color of goats.

REFERENCES

1. Amin, M.R., Husain, S.S. and Islam, A.B.MM. Reproductive peculiarities and litter weight in different genetic groups of Black Bengal does. *Asian-Australasian Journal of Animal Science*, 2001;14(3): 297-301.

2. Husain, S.S. A study on the productive performance and genetic potentials of Black Bengal goats. A Ph.D. Thesis, Bangladesh Agricultural University, Mymensingh, 1993; pp. 3-108.

3. Chowdhury, S.A. Goat: Our Natural Resource and Development Opportunities. Proceedings of the workshop on Poverty Alleviation through Goat Production: National Program. Bangladesh Livestock Research Institute, Savar, Dhaka, 2002.

4. Hassen, H., Baum, M., Rischkowsky, B. and Tibbo, M. Phenotypic characterization of Ethiopian indigenous goat populations. *African Journal of Biotechnology*, 2012; **11**(73): 13838-46. http://www.academicjournals.org/AJB.

5. Banerjee, A.K., Animut, G. and Ermias, E. Selection and breeding strategies for increased productivity of goats in Ethiopia. In: R.C. Merkel, G. Abebe and A.L. Goetsch (eds.). Proceedings of a conference on opportunities and challenges of enhancing goat production in East Africa, Institute for goat research, Langston University, 2000; pp.70-79.

6. Indetie, D., Karimi, S., Wandera, F., Lebbie, S. and Mwai, O. Phenotypic characteristics of east African goats in Kajiado districts of Kenya. Sixth Biennial KARI Scientific Conference, 1998.

7. Manzi, M., Rutagwenda, T., Kanuya, N. and Chatikobo, P. Phenotypic characterization of goats raised under traditional husbandry systems in Bugesera and Nyagatare districts of Rwanda. *Journal of Animal Veterinary Adviser*, 2011; 10(24): 3297-3302.

8. Robertshaw, D. Mechanisms for the control of respiratory evaporative heat loss in panting animals. *Journal of Applied Physiology*, 2006; 101:664-668.

9. Sponenberg, D.P. Goat color explained by Dr. Phil Sponenburg. American Fainting Goat Organization, Virginia-Maryland Regional College of Veterinary Medicine, Virginia Tech, Blacksburg, VA 24061, 2013.

10. Nozawa,K., Katsumata, M., Hasanath, M.A., Mostafa, K.G. and Faruque, M.O. Coat colour polymorphism in the Black Bengal Goat. In Genetic Studies on Breed Differentiation of the Native Domestic Animals in Bangladesh. Tukyo University of Agriculture, 1984: 87-99.

11. Alam, M.K. Characterization and performance evaluation of white goat in some selected areas of Bangladesh. MS Thesis, Department of Animal Breeding and Genetics, Bangladesh Agricultural University, Mymensingh, 2006.

12. Islam, A.F.M.F. Study on breeding and performance profile of Black Bengal goats in Mymensingh district. MS thesis, Department of Animal Breeding and Genetics, Bangladesh Agricultural University, Mymensingh, 2014: Pp. 1-45.

13. Choudhury, M.P., Sarker, S.C., Islam, F., Ali, A., Bhuiyan, A.K.F.H., Ibrahim, M.N.M., Okeyo, A.M. Morphometry and performance of Black Bengal goats at the rural community level in Bangladesh. *Bang. J. Anim. Sci.,* 2012; 41 (2): 83-89.

14. Sponenberg, D.P. and LaMarsh, C. Dominant and recessive brown in goats. *Genetic and Selection Evol*ution, 1996;**28**: 117-120.

15. Waller, C.Color genetics in the Nigerian Dwarf Goat, 2006.Available online.http://members.cox.net/foxcroft/genetics.htm.

16. Lauvergne, J.J. and Howell, W.E. Un premier inventaire genetique de la chevre Corse. *Ethnozootechnie*, 1978*;* 22: 86-88.