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Development of breeding strategy based on body coloration and phenotype in Holstein Friesian crossbreds for sustainable milk production

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ABSTRACT

The aim of this study was to implement a sustainable breeding strategy based on phenotypic grading. Holstein Friesian crossbreds were categorize depending on white coloring in body parts, hump status, known genrations derived from controlled breeding and recording, and to reveal the effects of these features on milk production. Data of peak milk production and morphological characteristics were collected on 51 Holstein Friesian crossbred cows after primary sorting from three districts (Sirajganj, Chittagong and Mymensingh) of Bangladesh. The animals were graded according to the white coloring pattern (absent or present) in horn, eyelid and eyelash, muzzle, hoof, tail switch, and the presence of a hump. It was observed that the presence of white color (18.86±1.01 to 22.00±1.57 L) in different body parts of Holstein Friesian crossbreds were significantly ($p<0.001$) associated with higher milk production compared to the absent group (8.95±1.62 to 13.84±1.21 L). Average peak milk production for humpless cows was 15.89±1.16 L, compared to 4.8±0.58 L for humped cows. The grading of cows based on white coloring and hump status showed significant differences ($p<0.001$) in milk production, but the production between medium and higher graded cows were not varied significantly. White color was not found in all studied body parts for lower graded cows while its frequency increased in medium graded (up to 75%) and almost full in higher graded cows except eyelid and eyelash (66.7% white). To prove the above findings, another 10 Holstein females with known genetics of exotic inheritance were evaluated for the same clarifications as reference population and similar trends were revealed with respect to the increasing of white color frequency from the F1 generation (66.7% in hoof and 50% in tail switch) to F2 (25% in horn, 25% in muzzle, and 75% in hoof and tail switch), including 100% humpless characters. It is concluded that milk production varied according to coloring patterns in different body parts and three selected grades and these phenotypic grading-based planned breeding strategies could retain the exotic inheritance level in Holstein Friesian crossbreds.

Keywords: Exotic inheritance, color-based grading, dairy cows, genetic admixture, sustainability

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1 Introduction

Variation of coat color and spotting patterns were an interesting matter to animal breeder for breed identity by color fixing (Olson et al., 1999). About the inheritance of white color in Holstein Friesian, Ibsen (1933), and Cole and Johansson (1948) stated that this breed carries recessive white spotting 's' while the Angus are homozygous self-colored 'SS'. Three pairs of genes could affect the amount of white on the heads of Holsteins resulting at least two homozygous dominants plus either a homozygous or a heterozygous third dominant (Funkquist and Boman, 1923).

The peak milk yield of Holstein Friesian crossbred recorded 9.87 liters compared to indigenous zebu cattle (2.54 L) in Ethiopia (Kumar et al., 2014) while the peak milk production found 18.80 liters for this crossbred in Bangladesh (Shahjahan, 2017b). Madalena et al. (1990) clearly indicated that consistent improvements in most performance traits were achieved in 'upgrading' dairy cattle up to 50% and 62.5% with temperate breeds, respectively. Mekonnin et al. (2015) observed the prevalence of reproductive problems including anestrus (37.8%), repeat-breeding (21.0%), dystocia (11.6%), retained fetal membranes (11.5%), endometritis (6.6%), abortion (6.4%), prolapsed uterus/vagina (2.9%), stillbirth (2.0%) and freemartin (0.2%) in Ethiopian Holstein Friesian×Zebu crossbred.

The review of Mwai et al. (2015) stated that humped or zebu cattle (*Bos indicus*) are easily adapted to local environmental conditions, while the temperate taurine (*Bos taurus*) breeds are unsuitable in this condition for higher temperatures, long period of drought and vector-born disease. To improve the productivity of indigenous cattle, several attempts have been taken using exotic genetics, but the desired achievement was not found (Bhuiyan, 1997). Philipsson (2000) reported that introduction of various exotic breeds including Friesian, Jersey, Guernsey, Ayrshire and Brown Swiss in tropical and sub-tropical areas of the world by artificial insemination following crossbreeding increased milk production in F1 generation, but the trend was not satisfactory for the next generations of those exotic breeds. However, the exotic inheritance level from taurine to zebu cattle has not been recorded by the dairy farmers of most developing countries. Thus, the progeny originated from diverse exotic inheritance levels have no distinct breeding policies for existing and future generations regarding sustainability. It is now urgently required to evaluate Holstein Friesian crossbred cattle that do not have pedigree records and formulate a breeding strategy for these animals.

Therefore, this study was conducted as a first attempt to classify the Holstein Friesian crossbreds based on morphological features and clarify their genetic merit for milk production. In addition, breeding strategies were proposed based on grading to retain desire exotic inheritance level in progeny for sustainability issue. It is expected that such ratio would support the sustainability and minimize the problems linked with such higher inheritance level through random, unplanned and uncontrolled crossbreeding among Holstein×Zebu crossbred in those areas having no distinct breeding record keeping system yet.

2 Materials and Methods

The study was conducted at Sirajganj, Chittagong and Mymensingh districts of Bangladesh in both rural (medium input level) and urban areas (commercial farming) during the period of 2012-2017. Data of white coloring status (present or absent) from several preselected body parts, hump status and peak milk production capability (excluding first lactation) at third month of calving were collected from 51 Holstein Friesian crossbred cows after primary screening from 307 cattle regarding authenticity on milk production records, and genetic admixtures within Local×Holstein Friesian (Shahjahan, 2017a). The cows included in the analysis were classified into three grades (Fig. 1): lower (humped and absence of white color on body parts), medium (humpless and presence or absence of white color on body parts) and higher (humpless and presence of white color on body parts).

In addition, data were also collected from 10 Holstein females as reference population having all pedigree records from pure local dams and 100% imported pure Holstein sires' semen in both F1 (50%) and F2 (75%) generations from a private cattle breeding farm (Lal Teer Livestock Limited) in Mymensingh district. Descriptive statistic and one-way ANOVA including Tukey's HSD *post-hoc* mean separation test were applied to analyses the data.

3 Results and Discussion

3.1 Effect of white color distribution in body on milk production

White colors in different body parts (horn, eyelid and eyelash, muzzle, hoof and tail switch) had significant effects ($p<0.05$ to $p<0.001$) on peak milk production of Holstein Friesian crossbred dairy cows (Table 1). These results suggested that white color has positive association on milk production of cows, which needs further in-depth clarification at molecular level. The differences were more prominent ($p<0.001$) for the presence of white color on horn (average 22 L) and tail switch (average 19 L). Relevant findings are not available but Chongkasikit et al. (2002) found positive correlation between white coat color and milk production from 2,107 Holstein Friesian cows at Chiang Mai,

Table 1. Effect of white coloring on peak milk production at third month in Holstein Friesian crossbred cows

Body parts	White coloration	Number of animal	Avg. milk production (L)	SE	P-value
Horn	Absent	37	12.22	1.24	<0.001
	Present	14	21.64	1.43	
Eyelid and eyelash	Absent	45	13.84	1.21	0.02
	Present	6	22	1.57	
Muzzle	Absent	42	13.57	1.28	0.018
	Present	9	20.56	1.31	
Hoof	Absent	30	11.96	1.63	0.002
	Present	21	18.86	1.01	
Tail switch	Absent	21	8.95	1.62	<0.001
	Present	30	18.9	1.07	
Total		51	14.8	1.14	

Table 2. Effect of grades on peak milk production of Holstein Friesian crossbred cows

Grade of crossbreed	Number of animal	Minimum	Maximum	Mean	SE	P-value
Lower	14	4	7	5.00 b	0.28	<0.001
Medium	28	10	35	17.86 a	1.3	
Higher	9	15	28	20.56 a	1.31	

Table 3. Percentage of white coloring in different body parts of Holstein Friesian crossbred dairy cows

Genetic background (pedigree records)	Grade or generation	White coloration	Horn	Eyelid and eyelash	Muzzle	Hoof	Tail switch
Unknown	Lower grade (n=14)	Absent	100	100	100	100	100
		Present	0	0	0	0	0
	Medium grade (n=28)	Absent	82.1	100	100	57.1	25
		Present	17.9	0	0	42.9	75
	Higher grade (n=9)	Absent	0	33.3	0	0	0
		Present	100	66.7	100	100	100
Known (reference population)	F1 (n=6)	Absent	100	100	100	33.3	50
		Present	0	0	0	66.7	50
	F2 (n=4)	Absent	75	100	75	25	25
		Present	25	0	25	75	75

Table 4. Determination of exotic inheritance levels of non-recorded Holstein Friesian crossbred dairy cows based on morphological characters and production performance

Distinct morphological feature		Expected exotic inheritance level‡	Observed avg. peak milk production (L)	Confirmation of grading‡
White coloration on body parts†	Hump status			
Absent	Present or less dominant	<50%	5	Lower
Absent or Present	Absent	≥50% ∼ ≤75%	18	Medium
Present	Absent	>75%	21	Higher

† Muzzle, horn, eyelid and eyelash, hoof, and tail switch; ‡ Compared with reference population

Table 5. Phenotypic grading-based breeding strategies of Holsten Friesian crossbred dairy cows for sustainability

ID	Selected dam grade (inheritance level)	Suggested sire grade (inheritance level)	Expected progeny grade (inheritance level)
1	Lower (<50%)	Medium (50%)	Lower (<50%)
2	Lower (<50%)	Medium (75%)	Medium (up to 62%)
3	Medium ($\geq$50% ∼ $\leq$75%)	Medium (50%)	Medium (up to 62.5%)
4	Medium ($\geq$50% ∼ $\leq$75%)	Medium (62.5%)	Medium (up to 68.75%)
5	Medium ($\geq$50% ∼ $\leq$75%)	Medium (75%)	Medium (up to 75%)
6	Higher (>75%)	Medium (50%)	Medium (up to 75%)
7	Higher (>75%)	Medium (62.5%)	Medium (up to 81%)
8	Higher (>75%)	Medium (75%)	Medium (up to 87%)

Chiang Rai and Lamphun Provinces in North Thailand. Similarly, Godfrey and Hansen (1994) reported that each 1% increase in white skin color influenced 4.5 pounds milk production in Friesian cows.

a

b

c

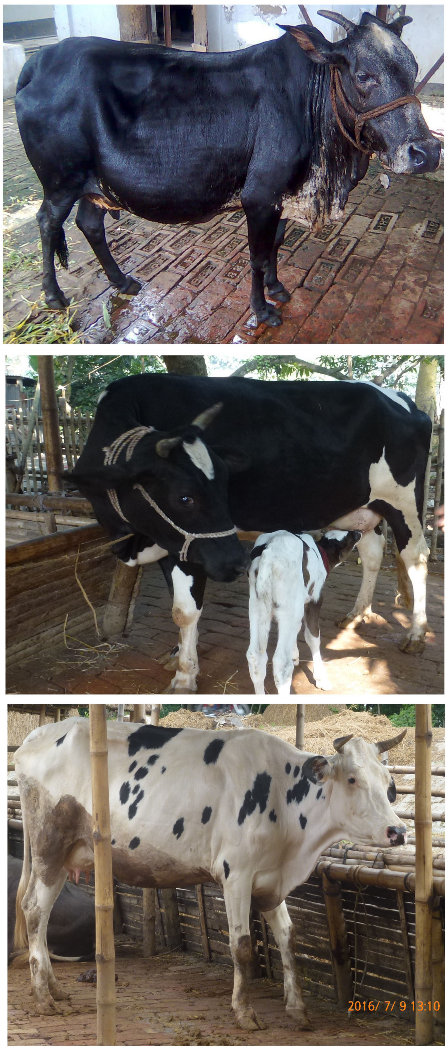


Figure 1. Different grades of Holstein Friesian crossbred: (a) lower grade, (b) medium grade and (c) higher grade

3.2 Effect of grading on milk production

Different grades of Holstein Friesian crossbred based on the presence/absence of white colors in various body parts and hump status showed significant differences (p<0.001) on peak milk production (Table 2). It was observed that lower grade had differences between medium and higher grades individually, while the difference between medium and higher grades was not significant. The results showed that minimum (10 L) and maximum (35 L) milk production of medium grade were not followed the similar trend for higher graded cows, respectively, 15 and 28 L. This might be due to a negative environmental-genetic interaction of those cows had more exotic inheritance. Ahmed et al. (2007) reported that milk production increased in the 50% Kenana-50% Friesian crossbred while no significant differences observed in 25% Kenana-75% Friesian genotype for milk production. This finding agreed with the results of Syrstad (1989) and Rege (1998) where 50% European crossbred (F1) found optimal for production and significant deterioration occurred afterward from 75% (F2) exotic inheritance attributing lower heterosis and segregation of genes.

3.3 Diversity in morphological characters

It was observed that white coloring on studied body parts was absent (100%) for lower grade, while the intensity of white color was predominant in higher grade cows, except for eyelid and eyelash (presence 66.7% white) (Table 3 and Fig. 2). The females derived from known genetics revealed that in the F1 generation (Fig. 3a), all body parts had no evidence of white (100%) except hoof (33.3%), while in the F2 (Fig. 3b), the intensity of white color was increased. These results indicate that the intensity of white coloring on some body parts of Holstein Friesian crossbreds is positively changed by increasing the exotic inheritance levels.

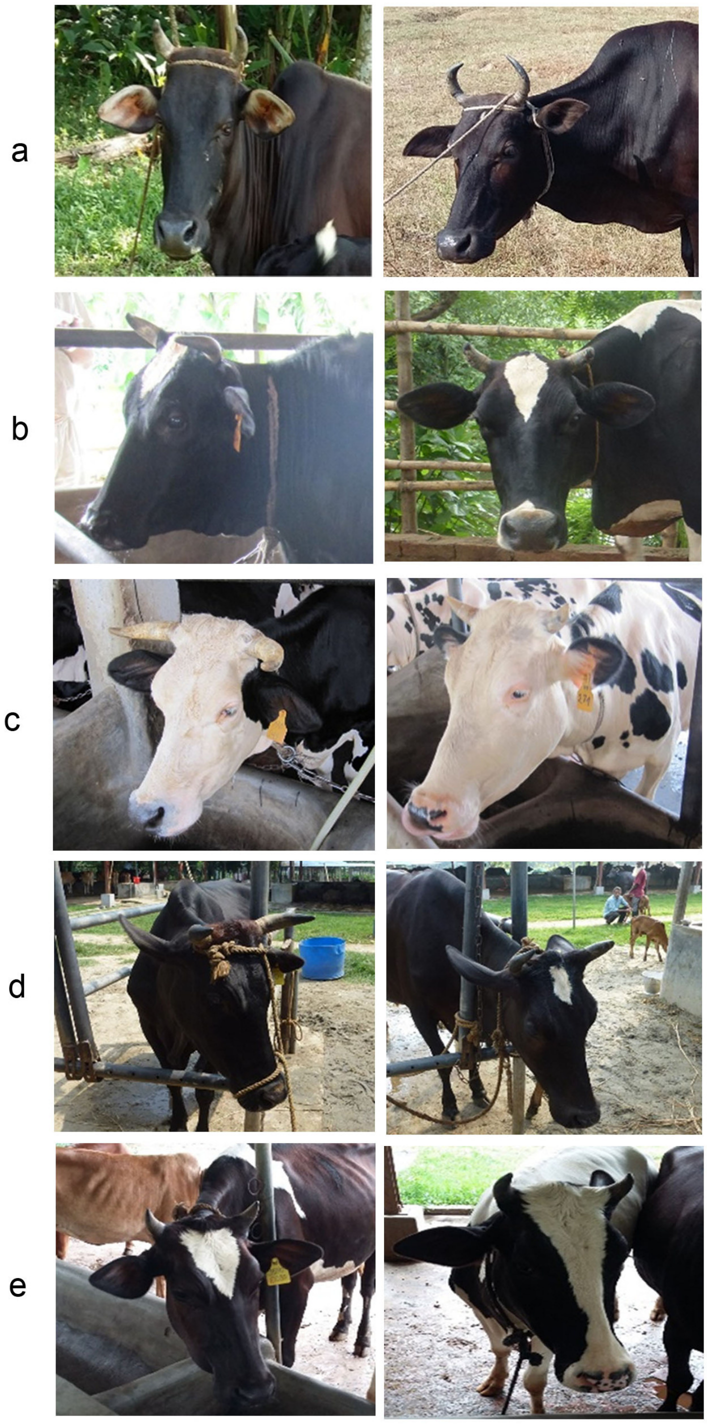
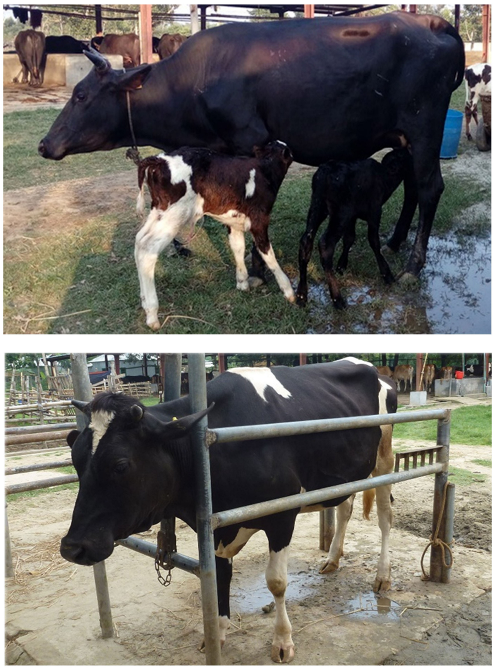


Figure 2. Distinct morphological features of different grades and generations in Holstein Friesian crossbred: (a) absence of white color (full black) in muzzle, horn, eyelid and eyelash with dominated hump in lower graded cows, (b) all features were same as lower graded cows except humpless character and slightly forwarded horn pattern in medium graded cows, (c) presence of white color in muzzle, horn, eyelid and eyelash with pointed and forwarded horn pattern in higher graded cows, (d) all features of F1 known generation were similar with medium graded cows while (e) in F2 generation the morphological features slightly changed to higher graded cows (presence of white color in muzzle with pointed and forwarded horns)

3.4 Determination of exotic inheritance levels

Without detection of the level of exotic inheritance in crossbred cattle it is not possible to design mating plans for sustainability under local management conditions. Based on the results (frequency of white color and milk production capability) of this study including the comparison with reference population a scheme is presented in Table 4 to categorize any Holstein Friesian crossbred for those countries where the results of artificial insemination are not recorded for individual animals.



a

b

Figure 3. Morphological characteristics of known Holstein Friesian crossbred females: (a) F1 cow (50% exotic inheritance) and (b) F2 heifer (75% exotic inheritance)

After the estimation of exotic inheritance levels of Holstein Friesian crossbred dairy cows based on morphological features, the next step would be the selection of appropriate sire for maintaining the desire breeding goals. A total of 8 breeding tools are presented in Table 4 to retain moderate inheritance levels in future progeny of Holstein Friesian crossbred cows. It is observed that the proposed breeding strategies could produce different graded of progeny having distinct exotic inheritance (<50% to ≥87%) sharing half inheritance from each parent. Since cows with higher exotic inheritance levels had reproduction problems, as noted previously (Al-Maruf et al., 2014; Mekonnin et al., 2015), it is urgently required to retain the inheritance levels. Cows having higher levels of foreign inheritance should be positively correlated with the management capability of the farmers for productive traits. Otherwise it might not be profitable for a poor farmer to rear higher graded cows, considering the higher feeding requirements.

In the dairy breeding policy, it is recommended to stabilizing exotic inheritance at 50% in India and further improvement through selective breeding (Singh and Gurnani, 1997). Similarly, it is also suggested to breed Holstein Friesian cows that produce 6–10 liters milk per day by semen of 50% Holstein Friesian at medium level of input system in Bangladesh (MoFL, 2007). The previous studies of Aynalem (2006) and EARO (2001) reported that 50% and 62.5% exotic inheritance levels in Ethiopian crossbred dairy cattle could be suitable for normal and improved management, respectively, optimizing environmental adaptability and production. However, Chebo and Alemayehu (2012) proposed 87.5 to 93.75% exotic inheritance levels in their studies, where management and feeding systems were sufficiently high for Ethiopian crossbred cattle, but they suggested a 50% inheritance level for environment adaptability, satisfactory performance and acceptability to farmers.

4 Conclusion

White coloring in few specific body parts had positive influence on milk production of Holstein Friesian crossbred cows. Medium and higher graded crossbred cows were more milk producer than lower graded cows. The proposed breeding strategy based on grading might play a significant role to control exotic inheritance levels in order to minimize reproductive failures and maximize sustainability in the Holstein Friesian crossbreds.

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References

Ahmed MKA, Teirab AB, Musa LMA, Peters KJ. 2007. Milk production and reproduction traits of different grades of zebu × Friesian crossbreds under semi-arid conditions. Arch Anim Bred 50:240–249. doi: 10.5194/aab-50-240-2007.

Al-Maruf A, Paul AK, Bonaparte N, Bhuyian MH, Shamsuddin M. 2014. Reproductive disorders that limits the reproductive performances in dairy cows of Bangladesh. J Emb Trans 29:189–194. doi: 10.12750/JET.2014.29.2.189.

Aynalem H. 2006. Genetic and economic analysis of Ethiopian boran cattle and their crosses with

Holstein Friesian in Central Ethiopia. Dissertation, Division of Dairy Cattle Breeding National Dairy Research Institute, Karnal-132001 (Haryana), India.

Bhuiyan AKFH. 1997. Cattle breeding and improvement in Bangladesh–past, present and future. Proceedings of the Keynote Paper Presented at National Seminar on Pashur Jat Unnayan and Jatiya Pashu Prajanon Niti. Organized by the Directorate of Livestock Services, Government of the People's Republic of Bangladesh, May 25, Bangladesh Agricultural Research Council, Farmgate, Dhaka, pp. 1–16.

Chebo C, Alemayehu K. 2012. Trends of cattle genetic improvement programs in Ethiopia: challenges and opportunitie. Livestock Res Rural Dev, 24 24.

Chongkasikit N, Vearasilp T, Meulen U. 2002. Variation of skin colour among Holstein Friesian cows of Northern Thailand. Proceedings of the IARD conference, Deutscher Tropentag, Witzenhausen.

Cole LJ, Johansson I. 1948. Inheritance in crosses of Jersey and Holstein-Friesian with Aberdeenangus cattle. II. Color and white spotting. Am Nat 82:202–233. doi: 10.1086/281579.

EARO. 2001. Livestock Breeding Policy. Ethiopian Agricultural Research Organization, Addis Ababa, Ethiopia.

Funkquist H, Boman N. 1923. Vererbung 'weißer abzeichen' bei rindern. Hereditas 4:65–80.

Godfrey RW, Hansen PJ. 1994. Effects of coat color on production and reproduction of dairy cattle on St. Croix. In30. Annual Meeting of the Caribbean Food Crops, St. Thomas (United States Virgin Islands) 30:180–185.

Ibsen HL. 1933. Cattle inheritance. I. color. Genetics 18:441–480.

Kumar N, Eshetie A, Tesfaye A, Yizengaw HA. 2014. Productive performance of indigenous and HF crossbred dairy cows in Gondar, Ethiopia. Vet World 7:177–181. doi: 10.14202/vetworld.2014.

Madalena FE, Lemos AM, Teodoro RL, Barbosa RT, Monteiro JBN. 1990. Dairy production and reproduction in Holstein-Friesian and Guzera crosses. J Dairy Sci 73:1872–1886. doi: 10.3168/jds.S0022-0302(90)78868-6.

Mekonnin AB, Harlow CR, Gidey G, Tadesse D, Desta G, Gugssa T, Riley SC. 2015. Assessment of reproductive performance and problems in crossbred (Holstein Friesian × Zebu) dairy cattle in and around Mekelle, Tigray, Ethiopia. Ethiopia Anim Vet Sci 3:94–101.

MoFL. 2007. National Livestock Development Policy. Ministry of Fisheries and Livestock, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Mwai O, Hanotte O, Kwon YJ, Cho S. 2015. African indigenous cattle: unique genetic resources in a rapidly changing world. Asian-Australasian J Anim Sci 28:911–921. doi: 10.5713/ajas.15.0002R.

Olson T, et al. 1999. Genetics of colour variation. Genet Cattle :33–53.

Philipsson J. 2000. Sustainability of dairy cattle breeding systems utilising artificial insemination in less developed countries-examples of problems and prospects, in Galal S, Boyazoglu J, Hammond K, eds. Proceedings of the Workshop on Developing Breeding Strategies for Lower Input Animal Production Environments, 22–25 September 1999, Bella, Italy, ICAR Technical Series, No 3, pp 551–562.

Rege JE. 1998. Utilization of exotic germplasm for milk production in the tropics. Proc 6th WCGALP, Armidale 25:193–200.

Shahjahan M. 2017a. Genetic admixture and performance diversity of high yielding dairy cows surrounding the Baghabari Milk Vita areas of Bangladesh. Asian J Med Biol Res 3:127–133. doi: 10.3329/ajmbr. v3i1.32048.

Shahjahan M. 2017b. High yielding dairy cattle husbandry and their production performance at Baghabari Milk Vita areas of Bangladesh. Asian-Australasian J BioSci Biotech 2:60–67.

Singh CB, Gurnani M. 1997. Cattle and buffalo breeding policy in India-present status and strategy for future. Ndri, Karnal, India.

Syrstad O. 1989. Dairy cattle cross-breeding in the tropics: performance of secondary cross-bred populations. Livest Prod Sci 23:97–106. doi: 10.1016/0301-6226(89)90008-0.

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