# Sustainable breeding strategies for Holstein Friesian crossbreds in developing countries

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## Summary

This is the first study in which Holstein Friesian crossbreds were categorized based on pigmentation pattern of different phenotypic body parts, hump status, and known generations derived from controlled breeding and recordings. The aim of this study was to implement a sustainable breeding strategy for Holstein Friesian cattle in developing countries, where farm record keepings are not available or well developed. Data of peak milk production and morphological characteristics were collected on 51 Holstein Friesian crossbred cows after primary sorting from three districts of Bangladesh. The data analyses were conducted following one-way ANOVA with descriptive statistics. The animals were graded according to the color of horn, eyelid and eyelash, muzzle, hoof, tail switch, and the presence of a hump. It was observed that white color (18.86-22.00 liters) of different body parts of Holstein Friesian crossbreds were significantly ($p$ <0.001) associated with higher milk production compare to black color (8.95-13.84 liters). Average peak milk production for humpless cows was 15.9 liters, compared to 4.8 liters for humped cows. The grading of cows showed significant differences ($p$ <0.001) in milk production, but medium and higher grades were not significantly different. Black color found 100% in all studied body parts for lower graded cows while white color 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 blood were evaluated for the same studies and similar trends were revealed with respect to the increasing of white color over black 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 a planned breeding strategy could be designed according to the phenotypic characteristics to retain the exotic blood level. It is expected that such ratio would support the sustainability and minimize the problems linked with such higher blood level through random, unplanned and uncontrolled crossbreeding in the developing countries so far.

*Keywords: exotic blood, phenotypic color, dairy cows, genetic admixture, sustainability*

## Introduction

Holstein Friesian is the most widely used cattle breed for dairy production in the world. The artificial insemination and modern biotechnological approaches spread this breed worldwide via crossbreeding with respective local zebu cows of different countries initially. However, the introduction of this exotic blood from taurine cattle has not been recorded by dairy farmers. Thus the progeny originated from diverse exotic blood levels have no distinct breeding policies for existing and future generations regarding sustainability. Recently farmers rearing Holstein Friesian crossbreds complain of high frequencies of reproductive abnormalities and high non-conception rates.

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. 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). West (2003) showed that the life span of Holstein Friesian cows decline as temperature increases. Data recording of functional traits such as reproduction, treatment, calving, etc. are essential for sustainable breeding goals, which have been accurately recorded by the Nordic countries for the last four decades (Heringstad *et al.*, 2000). The breeding program of a particular area mainly depends on environmental conditions, production systems and breeding for specific cultural and market oriented facilities (Philipsson *et al.*, 2011).

It is 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 systematically classify these Holstein Friesian crossbreds. In addition, possible breeding strategies were proposed to retain exotic blood in crossbreds required for sustainability in the adverse climate of tropical or sub-tropical countries of the developing world.

## Materials and methods

The study was conducted in three major dairy pocket areas of Bangladesh at the Sirajganj, Chittagong and Mymensingh districts during the period of 2012-2017. Data of two pigmentation patterns (full black and full white/whitish) from several preselected body parts, hump status and peak milk production at third month of calving were collected from 51 Holstein Friesian dairy cows after primary selection from about five times the number of selected cattle regarding authenticity on milk production records, and genetic admixtures within Local×Holstein Friesian (Shahjahan, 2017). Presence of white color (even slightly) in any of the body parts was considered as "whole" for that body part. In addition, data were also collected from 10 Holstein females having all pedigree records from pure local dams and 100% imported pure Holstein sires' semen in both F1 and F2 generations from a private cattle breeding farm (Lal Teer Livestock Limited) in Mymensingh district. The cows included in the analysis were classified into three grades: lower (humped and full black body parts), medium (humpless and full black or white/whitish body parts) and higher (humpless and full white body parts). Descriptive statistic and one-way ANOVA including Tukey's HSD *post hoc* mean separation test were applied to analyses the data.

## Results and discussion

### Phenotypic characters of Holstein Friesian dairy cows

The effect of black and white colors on 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 pigmentation has positive association on milk production of cows, which needs further indepth clarification at molecular level. The differences were more prominent (*p* <0.001) for the color of horn (average 22 liters for predominant white colored cows) and tail switch (average 19 liters for predominant white colored cows). In addition, absence of hump was indicative of high yielding cows (*p* <0.01) due to the induction of exotic blood to zebu cattle (humped) in previous generations.

*Table 1. Relation among different phenotypic characters of Holstein Friesian crossbred cattle on peak milk production (liter) at third month.*

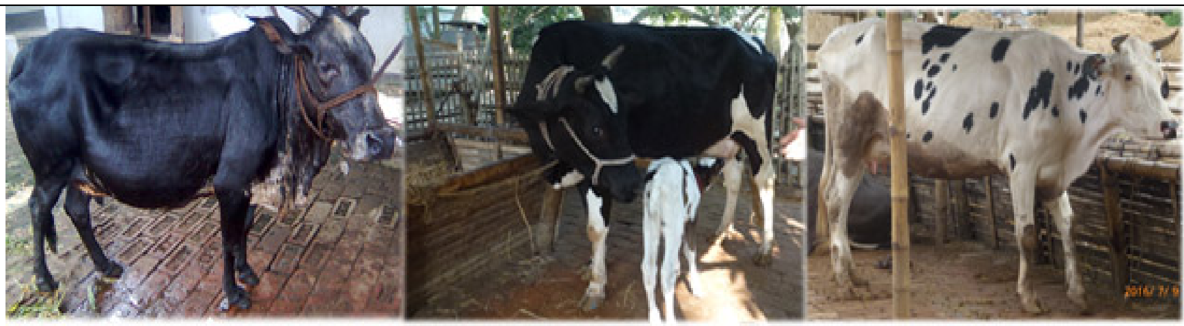
| Body parts | Color | n | Mean | SE | P-value |
|---|---|---|---|---|---|
| Horn | Black | 37 | 12.22 | 1.24 | <0.001 |
| | White | 14 | 21.64 | 1.43 | |
| Eyelid and eyelash | Black | 45 | 13.84 | 1.21 | 0.020 |
| | White | 6 | 22.00 | 1.57 | |
| Muzzle | Black | 42 | 13.57 | 1.28 | 0.018 |
| | White | 9 | 20.56 | 1.31 | |
| Hoof | Black | 30 | 11.96 | 1.63 | 0.002 |
| | White | 21 | 18.86 | 1.01 | |
| Tail switch | Black | 21 | 8.95 | 1.62 | <0.001 |
| | White | 30 | 18.90 | 1.07 | |
| Hump | Present | 5 | 4.80 | 0.58 | 0.003 |
| | Absent | 46 | 15.89 | 1.16 | |
| Total | | 51 | 14.80 | 1.14 | |

**Milk production diversity based on grade of cows**

Different grades based on colors of various body parts (Figure 1) and hump status showed significant differences (*p* <0.001) on peak milk production of Holstein Friesian crossbred dairy cows (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 milk production (15 liters) was higher in higher graded as compared to medium (10 liters) but reversed for maximum milk production; respectively, 35 and 28 liters. This might be due to a negative environmental-genetic interaction of those cows that have more exotic blood.

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

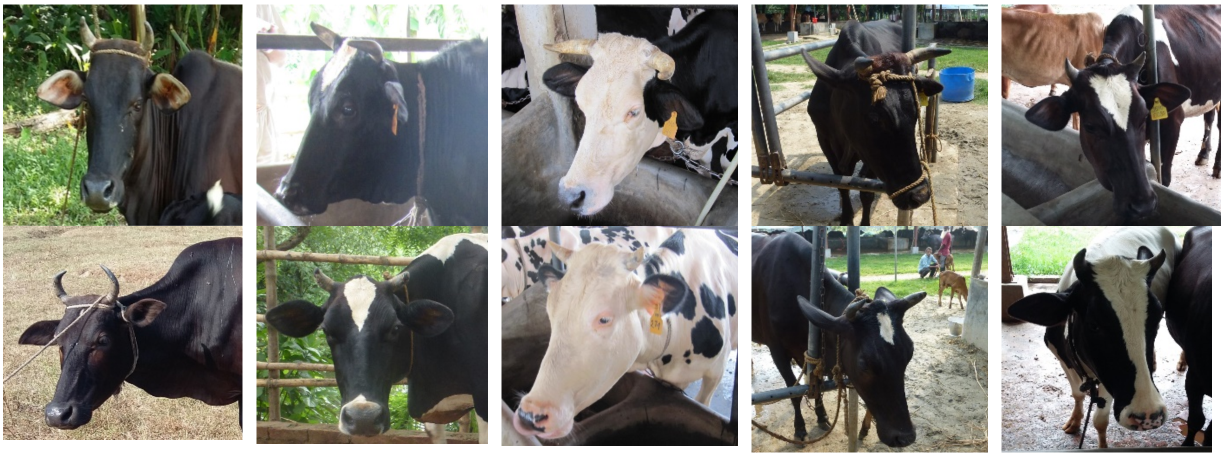
| Grade of crossbreed | n | Minimum | Maximum | Mean | SE | P-value |
|---|---|---|---|---|---|---|
| Lower | 14 | 4 | 7 | $5.00^{b}$ | 0.28 | <0.001 |
| Medium | 28 | 10 | 35 | $17.86^{a}$ | 1.30 | |
| Higher | 9 | 15 | 28 | $20.56^{a}$ | 1.31 | |



a b c

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

The frequency of black and white pigmentation patterns in grades and generations of Holstein Friesian crossbred cows is shown in Table 3 and Figure 2. It was observed that the color of body parts was full black (100%) for lower grade, while the intensity of white color was predominant in higher grade cows, except for eyelid and eyelash (66.7% white). The females derived from known genetics revealed that in the F1 generation (Figure 3a), all body parts were full black (100%), except hoof (33.3%), while in the F2 (Figure 3b), the intensity of black color was decreased. These results indicate that the black color of some body parts of Holstein Friesian crossbreds is changed by increasing the exotic blood levels.



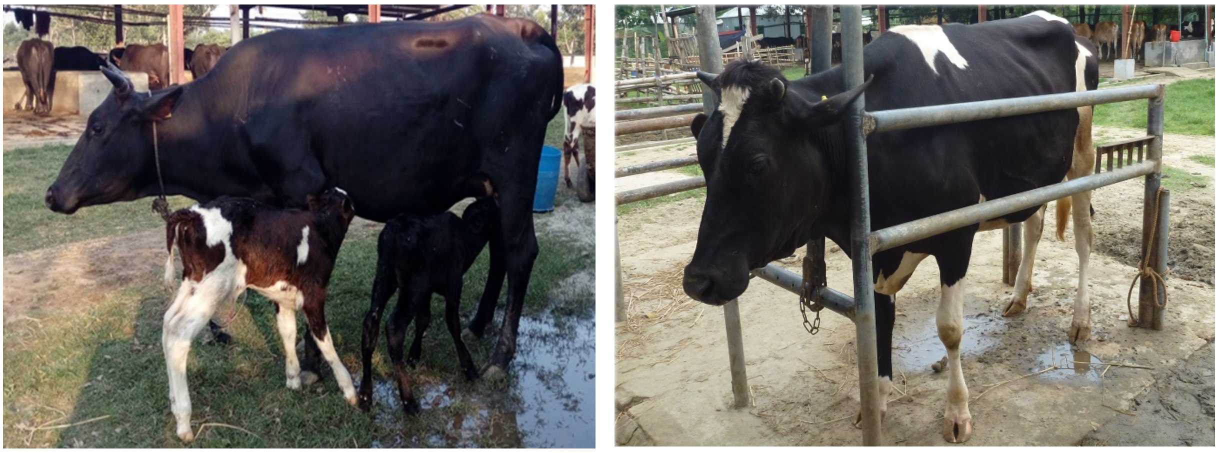
a. Lower b. Medium c. Higher d. F1 (50%) e. F2 (75%)

*Figure 2. Distinct morphological features of different grades/generations in Holstein Friesian crossbred: (a) muzzle, horn, eyelid and eyelash were full black including 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) muzzle, horn, eyelid and eyelash were whitish or white included 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 (whitish muzzle and, pointed and forwarded horns).*

*Table 3. Percentage of coloring pattern on different body parts of Holstein Friesian crossbred*

*dairy cows.*

| Genetic background (pedigree records) | Grade or generation | Color | Horn | Eyelid and eyelash | Muzzle | Hoof | Tail switch |
|---|---|---|---|---|---|---|---|
| Unknown | Lower grade (n=14) | Black | 100 | 100 | 100 | 100 | 100 |
| | | White | 0 | 0 | 0 | 0 | 0 |
| | Medium grade (n=28) | Black | 82.10 | 100 | 100 | 57.10 | 25 |
| | | White | 17.90 | 0 | 0 | 42.90 | 75 |
| | Higher grade (n=9) | Black | 0 | 33.30 | 0 | 0 | 0 |
| | | White | 100 | 66.70 | 100 | 100 | 100 |
| Known | F1 (n=6) | Black | 100 | 100 | 100 | 33.30 | 50 |
| | | White | 0 | 0 | 0 | 66.70 | 50 |
| | F2 (n=4) | Black | 75 | 100 | 75 | 25 | 25 |
| | | White | 25 | 0 | 25 | 75 | 75 |



a b

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

**Association of hump status in different grades/generations of Holstein Friesian crossbred**

The hump status of analyzed cows showed that only 35.7% cows were humped for lower graded cows but medium and higher graded cows were humpless (Figure 4a), including the F1 and F2 crosses (Figure 4b). These findings indicate that the humpless character is dominant in crossbred Holstein Friesian cows with at least 50% exotic blood.

a b

*Figure 4. Hump status of Holstein Friesian crossbred cows: (a) based on grades and (b) known generations.*

**Hypothesis of exotic blood levels and breeding policies for Holstein Friesian crossbred cows**

Without prediction of the level of exotic blood in crossbred cattle it is not possible to design mating plans for sustainability under local management conditions. Based on the results of this study 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.

*Table 4. Hypothesis of exotic blood levels of non-recorded Holstein Friesian dairy cows based on morphological characters.*

| Distinct morphological feature | | Expected exotic blood level | Suggested for grading |
|---|---|---|---|
| Colors on body parts (muzzle, horn, eyelid and eyelash, hoof, and tail switch) | Hump status | | |
| Black | Present or less dominant | <50% | Lower |
| Black or Whitish | Absent | ≥50%-≤75% | Medium |
| White | Absent | >75% | Higher |

After the estimation of exotic blood levels of cows, the next step in a breeding program is to select the appropriate sire grade for maintaining a sustainable breeding strategy. Since cows with higher exotic blood levels had reproduction problems, as noted previously, it is urgently required to retain the blood levels by formulating a planned mating design. A total of 8 breeding tools are presented in Table 5 to retain moderate blood levels in future progenies of Holstein Friesian crossbred cows. Cows having higher levels of foreign blood 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.

*Table 5. Suggested breeding strategies for Holsten Friesian crossbred dairy cows in developing countries with no or moderate record keeping system.*

| ID of breeding tool | Selected dam grade (blood level) | Suggested sire grade (blood level) | Expected progeny grade (blood level) | Recommended management |
|---|---|---|---|---|
| 1 | Lower (<50%) | Medium (50%) | Lower (<50%) | Low input |
| 2 | Lower (<50%) | Medium (75%) | Medium (up to 62%) | Low input |
| 3 | Medium (≥50%-≤75%) | Medium (50%) | Medium (up to 62.5%) | Medium input |
| 4 | Medium (≥50%-≤75%) | Medium (62.5%) | Medium (up to 68.75%) | Medium input |
| 5 | Medium (≥50%-≤75%) | Medium (75%) | Medium (up to 75%) | High input |
| 6 | Higher (>75%) | Medium (50%) | Medium (up to 75%) | High input |
| 7 | Higher (>75%) | Medium (62.5%) | Medium (up to 81%) | High input (only commercial) |
| 8 | Higher (>75%) | Medium (75%) | Medium (up to 87%) | High input (only commercial) |

In the dairy breeding policy, it is recommended to stabilizing exotic inheritance at 50% in India and further improvement through selective breeding (Singh & 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 blood levels in Ethiopian crossbred dairy cattle could be suitable for normal and improved management, respectively, optimizing environmental adaptability and production. However, Chebo & Alemayehu (2012) proposed 87.5 to 93.75% exotic blood levels in their studies, where management and feeding systems were sufficiently high for Ethiopian crossbred cattle, but they suggested a 50% blood level for environment adaptability, satisfactory performance and acceptability to farmers.

## Conclusions

Morphological characters and genetic merit of milk production were compared in different grades of Holstein Friesian crossbred according to exotic blood levels. The proposed breeding strategy might play a significant role to control exotic blood levels in order to minimize reproductive failures and maximize sustainability in the developing countries worldwide.

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