**Effects of Genotype, Parity, Season and Their Interactions on Milk Yield in Crossbred Dairy Cows**

****

**A Report by**

Roll No: 15/17; Reg. No: 01432

Intern ID: 16; Session: 2014-2015

A production report submitted in partial satisfaction

of the requirements for the degree of

**Doctor of Veterinary Medicine**

**(DVM)**

Faculty of Veterinary Medicine

Chattogram Veterinary and Animal Sciences University

Khulshi, Chattogram-4225, Bangladesh

**September 2020**

**Effects of Genotype, Parity, Season and Their Interactions on Milk Yield in Crossbred Dairy Cows**

****

**A Report by**

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**(Karabi Barua)**

Roll No: 15/17; Reg. No: 01432

Intern ID: 16; Session: 2014-2015

Approved as to style and contents by

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

(Prof. Md. Emran Hossain, PhD)

**Supervisor**

Department of Animal Science and Nutrition

Faculty of Veterinary Medicine

Chattogram Veterinary and Animal Sciences University

Khulshi, Chattogram-4225, Bangladesh

**September 2020**

**TABLE OF CONTENTS**

[**1.** **Introduction** 1](#_Toc50390084)

[**2.** **Materials and methods** 3](#_Toc50390085)

[2.1 Study area 3](#_Toc50390086)

[2.3 Data collection 3](#_Toc50390087)

[2.4 Data analysis 3](#_Toc50390088)

[**3. Results** 3](#_Toc50390089)

[3.1 Animal effect on milk yield 3](#_Toc50390090)

[3.2 Genotype effect on milk yield 4](#_Toc50390091)

[3.3 Parity effect on milk yield 5](#_Toc50390092)

[3.4 Monthly effect on milk yield 5](#_Toc50390093)

[3.5 Seasonal effect on milk yield 6](#_Toc50390094)

[3.6 Interaction effect on milk yield 6](#_Toc50390095)

[3.7 Lactation curve 9](#_Toc50390096)

[**4.** **Discussion** 9](#_Toc50390097)

[4.1 Animal effect 9](#_Toc50390098)

[4.2 Genotype effect 10](#_Toc50390099)

[4.3 Parity effect 10](#_Toc50390100)

[4.4 Monthly effect 11](#_Toc50390101)

[4.5 Seasonal effect 11](#_Toc50390102)

[4.6 Interaction effect 13](#_Toc50390103)

[4.7 Lactation curve 13](#_Toc50390104)

[**5.** **Conclusion** 13](#_Toc50390105)

[**References** 13](#_Toc50390106)

[**Appendix I** : Analysis report 21](#_Toc50390107)

**LIST OF TABLES**

[Table 1. Animal effect on milk yield of dairy cows in a commercial dairy farm at Hathazari, Chattogram, Bangladesh 4](#_Toc50390881)

[Table 2. Month wise milk yield of dairy cows in a commercial dairy farm at Hathazari, Chattogram, Bangladesh 5](#_Toc50390882)

[Table 3. Effects of genotype, parity, season and their interactions on milk yield of dairy cows in a commercial dairy farm at Hathazari, Chattogram, Bangladesh 7](#_Toc50390883)

**LIST OF FIGURES**

[Figure 1. Effects of genotype on milk yield in dairy cows (N=16425) 4](#_Toc50390338)

[Figure 2. Effects of parity on milk yield in dairy cows (N=16425) 5](#_Toc50390339)

[Figure 3. Effects of season on milk yield in dairy cows (N=16425) 6](#_Toc50390340)

[Figure 4. Interactions of genotype and parity (N=16425) 7](#_Toc50390341)

[Figure 5. Interactions of parity and season (N=16425) 8](#_Toc50390342)

[Figure 6. Interactions of genotype and season (N=16425) 8](#_Toc50390343)

[Figure 7. Interactions of animal and parity (N=16425) 8](#_Toc50390344)

[Figure 8. Fractional polynomial graph of lactation period (N=16425) 9](#_Toc50390345)

**Effects of Genotype, Parity, Season and Their Interactions on**

**Milk Yield in Crossbred Dairy Cows**

**Abstract**

The study was conducted to investigate the effects of genotype, parity, season and their interactions on milk yield of the crossbred dairy cows in a dairy farm at Hathazari upazila, Chattogram district, Bangladesh for a period of three years from January 2016 to December, 2019. Cows holding at least individual records of milk yield for subsequent three lactations were selected for the study purpose. Retrospective data representing milk yield of 15 multiparous Holstein-Friesian×Local zebu (*Bos indicus*) or Sahiwal crossbred dairy cows from the 1st to the 3rd parities were collected from the record sheet of the dairy farm. Results indicated that the genotype, parity, season and their interactions had substantial impacts (p<0.001) on milk yield in the crossbred dairy cows. The herd level highest least squared mean milk yield (N=16,425) was 12.2±0.147 kg/d (CI=11.9-12.4; p≤0.001). Overall, Sahiwal×Friesian1 crossbreds provided highest milk yield (11.9±0.038 kg/day; p<0.001). Maximum average daily milk yield was recorded in the 2nd parity (11.55±0.038 kg/d; CI=11.42-11.69; p<0.001) and minimum in the the 1st parity (10.65±0.038 kg/d; CI=10.53-10.78; p<0.001). Highest milk yield (11.93±0.038 kg/d; CI=11.8-12.0; p<0.001) was recorded in the spring (February-April) followed by the winter (November-January), the summer (March-May) and the fall (September-November) seasons. It was concluded that the milk production was affected by genotypic variability, seasonal changes, parity of the milking cow and their interactions. Changing patterns of milk yield in different seasons and parities could provide scientific evidence for improving feeding strategies to optimize herd level milk yield in the crossbred dairy cows at commercial dairy farms under tropical perspectives.

**Keywords:** Crossbred dairy cow, genotype, lactation, milk yield, parity, season

# 1. Introduction

Livestock plays important role in agriculture contributing 3.10% to the gross domestic products and 6% to the total foreign exchange earnings in Bangladesh (BER, 2015). However, dairy sectors are not well developed yet and most of the farmers have only 2-3 cows with half acre of land (Quddus, 2018). There are some commercial dairy farms where herd size is ranges from 30 to 50 cows (Quayyum et al., 2018). Introduced exotic breeds like Holstein-Friesian, Jersey, Sahiwal, Sindhi and Sahiwal-Friesian crossbreds are also available in Bangladesh that contribute about 24% of the 6.9 million breedable cows and heifers (Huque *et al*., 2011). In Bangladesh, milk production performance of Friesian×Local crossbred cows substantially advanced over the last decades (Bhuyian, 2011). The average milk production of the crossbred cattle ranges from 600 to 800 liter per lactation in a 210 to 240 day lactation period (Hossain & Routledge, 1982). Thus to meet up the upcoming challenge of milk and milk products, crossbreeding has been practiced (Shibru *et al*., 2019). The cattle of tropical and sub-tropical countries have average lower milk yield and lactation length than the cattle of temperate countries (Rege, 1998). Cross breeding with European dairy breeds has been widely used as a method to improve milk yield of dairy cows in tropical and subtropical regions. The first crossbred generation (F1) derived from indigenous (*Bos indicus*) female mated with exotic bulls (*Bos taurus*) performed very well in almost all cases (Kiwuwa *et al*., 1983). Rege (1998) reviewed the results of 80 cross breeding experiments involving European and indigenous breeds in the tropics. High heterotic contribution to milk production traits in F1  cows was reported and a significant deterioration was found in the performance of F2 generation in all traits compared with F1 generation. Asimwe and Kifaro (2007) and Ahmed *et al*., (2007) reported that HF 75% and HF 87.5% had significantly different lactation periods (305.09 vs. 347.07 days), respectively. Therefore, the exotic breed, i.e., Holstein-Friesian, Jersey and Sahiwal have been crossed with indigenous breed to increase the overall milk yield in Bangladesh.

The amount of milk produced per lactation is affected by the breed (Gregory *et al*., 1992), parity (Maltz *et a*l.,1991; Hansen *et al.,* 2006; Nielsen *et al.,* 2003), seasons (Lampo *et al*., 1966; Ng-Kwai-Hang *et al*., 1982; Ray *et a*l., 1992; Auldist *et al*., 1998; Hammoud *et al*., 2010), calving interval (Morales *et al*., 1989), stage of lactation (Sharma *et al*., 1985), availability of feeds (Mackle *et al*., 1999), environmental factors (Bajwa *et al*., 2004; Javed *et al*., 2004; M’hamdi *et al*., 2012) and disease incidence (Hansen *et a*l., 2006; Msanga *et al*., 2000). Oravacová *et a*l. (2006) further reported that the effect of parity on milk yield in dairy cows was prominent and cows in different parities had different milk yield depending on type of feed supplementation (Mackle *et al*., 1999) and body weight (Ríos-Utrera *et al*., 2013). Most of the milk producers understand that milk yield fluctuates up and down from one lactation to the next which is depicted from the lactation curve from colostrum to dry off (Mason, 2000).

Environmental factors affecting variability in the daily milk yield are widely documented in dairy cattle (Dědková & Němcová, 2003). The crossbred cows are sensitive to seasonal changes on their lactation performance. It was observed that temperature, sunshine hours and wind speed were correlated with lactation length (M’hamdi *et al*., 2012; Mote *et al*., 2016). Milk production falls down in hot humid temperature and increases with the winter season (Hammoud *et al*., 2010). Studies have further shown that higher milk yield and composition of fat percentage were recorded in dry season and higher protein percentage during the wet season (Shibru *et al.,* 2019). Consistent reports from systematic studies are inadequate in Bangladesh regarding the interactions of the genotype, parity and season and their subsequent effects on milk in the crossbred cattle. We therefore aimed to elucidate the impacts of genotype, parity and seasonal interactions on milk yield in the crossbred dairy cattle.

# 2. Materials and methods

# Study area

The study was conducted in a dairy farm at Hathazari upazila, Chattogram district, Bangladesh from January 2016 to December 2019. Hathazari upazila is located in between 22°24´ to 22°38´north latitudes and 91°41´ to 91°54´ east longitudes. The climate is tropical at Hathazari, Chattogram and the average annual temperature is 25.7°C (78.2°F); 110.0 inch (2794 mm) of precipitation falls annually. And also the average annual relative humidity is 78.0%. The farm has its own fodder plot for cultivating napier, para, german grass and leguminous plants. Cattles of different ages are being kept into separate shed. Cattles are fed according to their stage of production, age, physiological condition. Green grass is provided at the rate of 3% of their body weight and concentrates are provided according to milk production. Calves are fed by bottle milking system. Pregnant and sick animals are given separate ration in separate manager. The animals are fully stall fed. The cows are milked twice a day in the respective pen.

# 2.3 Data collection

Monthly milk yield data from January 2016 to December 2019 were collected from the farm register and active surveillance data were collected by asking questions to the farm officials. Data pertinent to the milk yield of 15 cows according to their parities were taken from register.

# 2.4 Data analysis

Data were collected and compiled into Microsoft excel-2010. Outliers and multicolliniarity were checked by inter quartile range test and variance inflation factors. Equality of variances in the response variable was checked by Shapiro Wilk test. Individual variation in milk was considered as the random effect and genotype, parity and season were considered as the fixed effects in the model. Finally, a TWO-WAY ANOVA was used to partition the variances of the test statistic. Duncan’s new multiple range test was used to separate the means. Profile plots were used to measure the interactions of the covariates. Lactation curve was generated by using fractional polynomial line.

# 3. Results

## 3.1 Animal effect on milk yield

The average daily milk yield of 15 multiparous cows is presented in Table 1. Least squared means of the daily average milk yield significantly differed (p<0.001) among the milking cows irrespective of the parity and season of the respective years.

Table . Animal effect on milk yield of dairy cows in a commercial dairy farm at Hathazari, Chattogram, Bangladesh

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Animal ID | No. of obs. | Mean±SE | 95% Conf. Interval | | Sig. |
| 1 | 852 | 11.2±0.129cde | 10.9 | 11.4 | \*\*\* |
| 2 | 881 | 10.4±0.144a | 10.1 | 10.7 |
| 3 | 822 | 11.8±0.149fgh | 11.5 | 12.1 |
| 4 | 777 | 12.0±0.139gh | 11.6 | 12.2 |
| 5 | 875 | 11.4±0.157def | 11.1 | 11.7 |
| 6 | 830 | 10.7±0.158ab | 10.4 | 11.0 |
| 7 | 864 | 11.4±0.153def | 11.1 | 11.7 |
| 8 | 876 | 10.8±0.132abc | 10.5 | 11.0 |
| 9 | 826 | 10.8±0.162abc | 10.4 | 11.1 |
| 10 | 869 | 11.3±0.132de | 11.1 | 11.6 |
| 11 | 889 | 11.1±0.142bcd | 10.8 | 11.4 |
| 12 | 723 | 12.2±0.147h | 11.9 | 12.4 |
| 13 | 870 | 11.0±0.151bcd | 10.7 | 11.3 |
| 14 | 882 | 11.0±0.153bcd | 10.7 | 11.3 |
| 15 | 871 | 11.6±0.142efg | 11.3 | 11.8 |

SE= Standard error; \*\*\*=Significant (p<0.001); abcdefgh=Means bearing different superscripts in the same column differ significantly (p<0.05)

## 3.2 Genotype effect on milk yield



Figure . Effects of genotype on milk yield in dairy cows (N=16425)

Effects of genotype on milk yield in dairy cows are depicted in Figure 1. The three genotypes had substantially different (p<0.001) milk yield within a typical lactation period for 305 days. Sahiwal×Friesian1 produced 7.7% more milk than Local×Friesian1 and 5.3% more milk than Local×Friesian2 genotype.

## 3.3 Parity effect on milk yield

Average daily milk yield in three consecutive parities are depicted in Figure 2. Parity 2 superseded parity 3 followed by parity 1 irrespective of genotype and season.



Figure . Effects of parity on milk yield in dairy cows (N=16425)

## 3.4 Monthly effect on milk yield

Maximum daily average milk yield was recorded in April (12.1±0.125 kg/day) which was 15.2% more than minimum in November (10.5±0.132 kg/day). After November, milk yield gradually increased and went off peak at the April.

Table . Month wise milk yield of dairy cows in a commercial dairy farm at Hathazari, Chattogram, Bangladesh

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Month | Obs. | Mean±SE | 95% Conf. Interval | | Sig. |
| January | 1217 | 11.3±0.128cd | 11.0 | 11.6 | \*\*\* |
| February | 1162 | 11.7±0.117ef | 11.5 | 12.0 |
| March | 1176 | 12.0±0.109f | 11.8 | 12.2 |
| April | 1069 | 12.1±0.125f | 11.8 | 12.3 |
| May | 1084 | 11.0±0.124bc | 10.8 | 11.2 |
| June | 1045 | 10.5±0.139a | 10.2 | 10.7 |
| July | 950 | 11.9±0.162ef | 11.5 | 12.1 |
| August | 851 | 10.8±0.154ab | 10.5 | 11.1 |
| September | 942 | 10.5±0.136a | 10.3 | 10.8 |
| October | 1052 | 10.6±0.137a | 10.3 | 10.8 |
| November | 1055 | 10.5±0.132a | 10.3 | 10.8 |
| December | 1104 | 11.5±0.116de | 11.3 | 11.8 |

SE=Standard error; \*\*\*=Significant (p<0.001); abcdef=Means bearing different superscripts in the same column differ significantly (p<0.05)

## 3.5 Seasonal effect on milk yield

Seasonal variation in the daily milk yield (DMY) for the three genotypes of cows according to parities are presented in Figure 3. In all cases, median of daily average milk yield for the spring season (February-April) dominated over the winter (November-January followed by the summer (May-July) and the fall (August-October).



Figure . Effects of season on milk yield in dairy cows (N=16425)

## 3.6 Interaction effect on milk yield

Genotype, parity and seasons interacted among themselves (p<0.001) for daily average milk yield (Table 3; Figures 4-7). Genotype × parity had more pronounced effects than genotype × season followed by parity × season.

Table . Effects of genotype, parity, season and their interactions on milk yield of dairy cows in a commercial dairy farm at Hathazari, Chattogram, Bangladesh

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Main effects** | No. obs. | Milk yield | 95% Conf. Interval | | SEM | Sig. |
| **Genotype** |  |  |  |  |  |  |
| Local×Friesian1 | 5077 | 11.03a | 10.90 | 11.15 | 0.038 | \*\*\* |
| Local×Friesian2 | 6763 | 11.28b | 11.18 | 11.38 |
| Sahiwal×Friesian1 | 867 | 11.88c | 11.61 | 12.16 |
| **Parity** |  |  |  |  |  |  |
| Parity 1 | 4476 | 10.65a | 10.53 | 10.78 | 0.038 | \*\*\* |
| Parity 2 | 3883 | 11.55b | 11.42 | 11.69 |
| Parity 3 | 4348 | 11.51b | 11.38 | 11.64 |
| **Season** |  |  |  |  |  |  |
| Winter (Nov-Jan) | 3376 | 11.14b | 11.00 | 11.29 | 0.038 | \*\*\* |
| Spring (Feb-April) | 3407 | 11.93c | 11.80 | 12.06 |
| Summer (May-July) | 3079 | 11.06b | 10.90 | 11.22 |
| Fall (Aug-Oct) | 2845 | 10.64a | 10.48 | 10.80 |
| **Interaction effects** |  |  |  |  |  |  |
| Genotype×Parity | 12707 | 11.24b | 11.14 | 11.72 | 0.066 | \* |
| Genotype×Season | 12707 | 11.19a | 11.03 | 11.69 | 0.077 | \*\*\* |
| Parity×Season | 12707 | 11.19a | 10.88 | 11.38 | 0.076 | \*\*\* |

SEM=Standard error of the means; \*=Significant (P<0.05); \*\*\*=Significant (P<0.001); ab=Means bearing different superscripts in the same column differ significantly (p<0.05)



Figure . Interactions of genotype and parity (N=16425)



Figure . Interactions of parity and season (N=16425)



Figure . Interactions of genotype and season (N=16425)



Figure . Interactions of animal and parity (N=16425)

## 3.7 Lactation curve

The average daily milk yield of the three genotypes and the fitted lactation curve generated by the fractional polynomial model was plotted in **Figure 8**. The figure showed that the time of peak milk yield predicted from the raw data was near about 100 days in milk yield irrespective of season and genotype followed by a gradual decline up to 305 days.



Figure . Fractional polynomial graph of lactation period (N=16425)

# 4. Discussion

## 4.1 Animal effect

In the recent years, the crossbred cattle are becoming more popular in the private dairy farming sectors in Bangladesh. It appeared from this study that in commercial dairy farming the majority of the dairy cattle were crossbred type, i.e., either crosses of Sahiwal or Holstein Friesian. This study aimed to show the effects of individual variability on parity and seasonal variances on milk yield of those crossbred cattle. Variations in calculated or predicted lactation yields among different seasons and parity due to variability of individuality under intensive farming conditions are likely phenomena (Samková *et al*., 2018). In current study, the actual milk yields calculated from the raw data were different for individual cow which could have been due to differences in the age of the cow (Lush and Shrode, 1950), body condition score (Domecq *et al*., 1997) and health status (Windig *et al*., 2006). Rehman et al (2008) observed that total milk yield per lactation was affected by the differences of the herd. Similarly, variations in milk yield due to differences in herd management systems were reported elsewhere (Val-Arreola *et al*, 2004; Perochon *et al*, 1996).

## 4.2 Genotype effect

Variations in milk yield due to differences in genotype are commonly accepted phenomena (Zhou *et al*., 2015). The Holstein Friesian is a world famous dairy breed for higher milk production under intensive farming conditions (Oltenacu & Broom, 2010). However, the breed is prone to hot humid high temperature of the tropical countries (Usman *et al*., 2013). As a result, in tropical environment, it is a common practice to upgrade the local cattle by crossing with Holstein Friesian. Since the principal milk line of the crossbred cattle is the Holstein Friesian, therefore, variation due to use of exotic blood (50%, 75%, 87.5% or 93.8% of HF) with the local zebu or Sahiwal dominates productivity of the crossbred cattle. It was reported that, the higher milk yield in commercial dairy herd was mainly due to genotype (Ageeb and Hayes, 2000; Buckley *et al*., 2000 Kennedy *et al*., 2003; Chagunda *et al*., 2004; Çardak, 2005; Molee *et al*., 2011). Consistent with these findings, Intisar *et al.* (2012) reported higher milk yield for the crossbred cows in the same environment. It was further reported that in the highland climatic zone, the milk yield for cows with 50 percent *Bos taurus* genes was 2.6 times higher than that of the indigenous cows and cows with exotic inheritance of 75 percent *Bos taurus* genes with an average daily milk yield of 2.7 times higher than that of the local cows (Galukande *et al.,* 2013). Similar result was reported by Nantapo *et al*., (2014) where milk yield and fat percent of milk differed due to genotype. Contrastingly, Kennedy et al. (2003) reported that increasing the proportion of exotic genes in a cow simultaneously decreased milk components.

## 4.3 Parity effect

Generally, milk yield per lactation, average daily yield or milk yield per calving interval increase with elevated lactation number. The average daily milk yield for the crossbred cows from first to third parity was shown in Figure 2. Cows in the first parity yielded less milk (p≤ 0.001) per lactation per day than the 2nd and the 3rd parities. This finding corresponds with other studies and may be partly explained by the highest milk yield capacity accompanied with greater feed intake in older cows than the young ones (Jhonson *et al*., 2002). This result also concurs with the findings of Mohammad (2004) and Qureshi *et al*. (2020) who reported that milk production increased with advanced lactation up to 4th parity. Some studies further reported that the daily milk yield in the 1st parity was lower than other parities (p≤ 0.05). The main reason is that heifers need more amino acid and fat for their body growth (Oltner *et al*., 1985). In contrast, body condition score lost in early lactations reflected a negative energy balance on the later ones which antagonized the parity as explained by Waltner *et al*. (1993).

However, cows after 1st lactation were better producers of milk, i.e., those in their 2nd and 3rd lactations. Javed (1999) reported increased milk yield towards the 5th parity and declined thereafter up to the 12th parity (Bajwa *et al*., 2004). It was speculated that cows in 3rd lactation produced highest amount of milk which was in alignment with Vijayakumar et al. (2017). Almost similar result was reported by Ray *et al*., (1992) who found highest milk yield in 4th parity. It was reported that, the aged cow contributed to the reduced milk yield through turnover rate of secretory cells, i.e., with higher numbers of newly produced active secretory cells (Qureshi *et al*., 2020). Dhumal *et al*. (1989) found no relationship between milk yield and parity although the 4th parity was detected with the highest production by Bajwa *et al*. (2004). The younger cows are not physically mature and take longer time to attain peak milk yield than older cows. When they are approaching their first time lactation they are in a different metabolic state than the other multiparous cows  because they require nutrients for their continued growth in addition to that of their udder development and milk synthesis ([Wathes](https://www.sciencedirect.com/science/article/pii/S0022030211004632" \l "bib0210) *[et al.](https://www.sciencedirect.com/science/article/pii/S0022030211004632" \l "bib0210)*[, 2007](https://www.sciencedirect.com/science/article/pii/S0022030211004632" \l "bib0210)).

## 4.4 Monthly effect

Our study elucidated that, the milk yield in different months was significantly different from each other. Best performance was recorded at the month of March and April. The reasoning could be that, during March until May temperature ranges from 25.7°C to 28.5°C and humidity ranges from 65 to 78% (“Chattogram Climate”, 2020). This is a comfortable zone for the crossbred cattle with minimum environmental stress due to genotype-environment interactions (Burrow, 2012). During April pastures are abundantly available than the months in the winter or the fall seasons. Conversely, the average monthly milk yield for the entire period of lactation with high temperature was higher (Broucek et al., 2007).

## 4.5 Seasonal effect

In the present study, the highest average milk yield was recorded in the spring and the winter seasons followed by the summer and lowest in the fall season which is in agreement with another report where cows in the spring and the winter produced more milk over 1.43 and 0.93 kg/day, respectively, than cows in the summer (Yoon *et al.,* 2004). In our study, the seasonal influence of milk yield of the crossbred cows was significant (P≤ 0.001). The result is supported by Ahmed *et al*., (2007) and Ray *et al*., (1992) who reported that the seasons and year affected the milk yield performance of dairy cows. Overall, the average milk production during the three seasonal categories was significant. Regarding the daily milk yield and lactation length, cows had the highest milk yield in the winter than all other seasons (Mellado *et al*., 2011). Smith *et al.,* (2013) reported that the milk yield of Holstein cows decreased during heat stress.

Dairy cattle across Bangladesh are subjected to high ambient temperature and high relative humidity for the summer season from May to July. Hot climate causes heat stress of animals and result in elevated body temperature, which in turn initiate compensatory and adaptive mechanisms to reestablish homeothermy and homeostasis. Stott (1981) stated that these readjustments to maintain homeostasis are referred to as adaptations and may be favorable or unfavorable to the economic interests of humans, and that, they are essential for survival of the animal. A reduced rate of metabolism, decreased the daily milk yield and nutrient intake, and altered water metabolism in response to heat stress. Unfortunately, responses to heat stress often have negative effects on the physiology of the cow and on milk yield. Feed dry matter intake starts to decline and maintenance expenditure increase when environmental temperatures exceed 25°C (NRC, 1981).

Milk yield declined when body temperature exceeded 38.9°C and for each 0.55°C increase in rectal temperature, milk yield and intake of TDN declined 1.8 and 1.4 kg, respectively (Johnson *et al*., 1963). Thus during the summer and the fall, hot weather influenced cows to produce less milk containing higher milk fat and protein percent. Studies conducted elsewhere have shown that hot climatic condition significantly reduced the daily milk yield indirectly through its effect on feed intake (Mayer *et al*., 1999; West, 2003), feed quality and quantity (Javed et al., 2002). Use of sprinklers may increase peak milk production in the high producing cows and could be recommended for reducing heat and total stress during this time. Similarly, supply of abundant green fodder in the winter as compared to the summer season was given a plausible cause (Bajwa *et al*., 2004).

In Bangladesh, different seasonal leguminous fodders specially cowpea (*Vigna unguiculata*), berseem (*Trifolium alexandrinum*) and lucerne (*Medicago sativa*) are planted in the late rainy season and grown up during the winter season. These plants are enriched with higher crude protein to feed the crossbred cows. Besides, maize stover (*Zea mays*) and oats (*Avena sativa*) are most abundant during the winter season that is cultivated for grains and green fodders. They are rich in vitamins, minerals, carbohydrates, proteins, fats and oils. It may, therefore, be speculated that when there is abundance of green grasses by way of green forages containing relatively higher nutritive value of crude protein, production potential for the dairy animal reaches the highest level, despite the fact that lots of energy is utilized for the maintenance of the body temperature during the winter. Those fodders are fed into dairy cows for their higher milk production and are continued up to the spring (March, April) and therefore, the highest milk yield chronologically reaches the peak on April.

Maize fodder (*Zea mays*) and green grasses, e.g., Napier (*Pennisetum purpureum*), para (*Brachiaria mutica*) and german (*Echinochloa polystachya*) are stored and utilized as silage for the winter season because of scarcity of fodder. Although, in rainy season, animals have access to green grasses but the nutrient content of those grasses are low. As a result milk production cannot reach as high as in the winter and the spring season. The difference in milk production was also due to adaptability, feed intake, compatibility and other management practices (Orgmets *et al.,* 2002). In the summer season, feed intake decreases due to temperature stress and moreover, green fodders are shanty or not available to the animals. Additionally, animal consumes more water to maintain thermoregulation of the body causing reduction of milk yield (Singh *et al.,* 2015).

Controversy to our study, Lampo *et al*. (1966) reported higher milk production in May to June during the summer season and Epaphras *et al*. (2004) reported the highest milk yield at both cow and farm level during the long rains. Another studies have shown that Israeli high yielding cows responded negatively to temperature in the winter and the spring season in Mediterranean zone so that the elevated milk yield increased overall thermal load because of increased metabolic heat production (Barash *et al*., 2001).

## 4.6 Interaction effect

Our study showed that interaction of genotype, parity and seasons significantly affected milk yield of the crossbred dairy cows. This result is in line with Shibru et al. (2019) who reported that the interaction of season and genotype influenced milk yield. The interaction of genotype with environment (Gebreyohannes *et al*., 2014) and genotype with parity (Ledinek *et al*., 2018) was significant for lactation yield, initial milk yield and peak milk yield (p<0.001) and also the interaction between parity and month showed significant effect on the daily milk yield (p<0.05) (Yang *et al*., 2013).

## 4.7 Lactation curve

We obtained high milk yield from the cows at the mid and late lactations in this study which agrees with the report of Mech *et al*., (2008). They reported that milk yield increased up to 90 days and remained high for a while and then declined in the later stage of lactation in all parities. It was also shown that the crossbred cows showed significantly (P≤0.001) higher daily milk yield in mid and late stages of lactation irrespective of the parity and season (Deng *et a*l., 2012; EI *et al*., 2016).

# 5. Conclusion

Milk yield of the crossbred cows in the tropical environment is influenced by genotype, season, parity and their interactions as well. Milk yield was maximum during the spring and the winter seasons and minimum during the summer and the fall seasons. When designing breeding plans for selection purposes, genotype, parity and season specific typical pattern of milk yield evaluated here should be adjusted for environmental effects. To improve the lower level of milk production in the summer and the fall season, improving feeding management including addition of fans and sprinklers, orientation of barns and design of passive ventilations should be taken into consideration to enhance heat loss and thereby improve the dry matter intake for optimizing the daily milk yield in the crossbred dairy cows.

# References

Ageeb, A.G., Hayes, J.F., 2000. Genetic and environmental effects on the productivity of Holstein-Friesian cattle under the climatic conditions of Central Sudan. Trop. Anim. Health Prod. 32, 33–49. https://doi.org/10.1023/A:1005241002743

Ahmad, B., Khan, S., Manan, A., Abdullah, 2007. Production and reproduction performance of jersey cattle at cattle breeding and dairy farm Harichand. J. Agric. Biol. Sci. 2, 1–5.

Asimwe, L., Kifaro, G.C., 2007. Effect of breed, season, year and parity on reproductive performance of dairy cattle under smallholder production system in Bukoba district, Tanzania. Livest. Res. Rural Dev. 19, 1–9.

Auldist, M.J., Walsh, B.J., Thomson, N.A., 1998. Seasonal and lactational influences on bovine milk composition in New Zealand. J. Dairy Res. 65, 401–411. https://doi.org/10.1017/S0022029998002970

Bajwa, I.R., Khan, M.S., Khan, M.A., Gondal, K.Z., 2004. Environmental Factors Affecting Milk Yield and Lactation Length in Sahiwal Cattle. Pak. Vet. J. 24, 23–27.

Barash, H., Silanikove, N., Shamay, A., Ezra, E., 2001. Interrelationships among ambient temperature, day length, and milk yield in dairy cows under a mediterranean climate. J. Dairy Sci. 84, 2314–2320. https://doi.org/10.3168/jds.S0022-0302(01)74679-6

BER, 2015. BER, 2015. Bangladesh Economic Review (BER), Economic Division, Ministry of Finance. The Government of the People’s Republic of Bangladesh, from http://www.mof.gov.bd.

Bhuiyan, A., Rashid, M.M., Khan, R.A., Habib, M.A., Bhuiyan, M.S.A., Faiz, M.A., 2015. Progeny tested bull production for dairy cattle development in Bangladesh. Bangladesh J. Anim. Sci. 44, 106–112. https://doi.org/10.3329/bjas.v44i2.26010

Broucek, J., Mihina, S., Ryba, S., Uhrincat, M., Travnicek, J., Soch, M., 2007. Effects of high temperatures on milk production of dairy cows in east central Europe, in: American Society of Agricultural and Biological Engineers - 6th International Dairy Housing Conference 2007. American Society of Agricultural and Biological Engineers, pp. 248–252. https://doi.org/10.13031/2013.22792

Buckley, F., Dillon, P., Crosse, S., Flynn, F., Rath, M., 2000. The performance of Holstein Friesian dairy cows of high and medium genetic merit for milk production on grass-based feeding systems. Livest. Prod. Sci. 64, 107–119. https://doi.org/10.1016/S0301-6226(99)00167-0

Burrow, H.M., 2012. Importance of adaptation and genotype × environment interactions in tropical beef breeding systems. Animal 6, 729–740. https://doi.org/10.1017/S175173111200002X

Çardak, A.D., 2005. Effects of genetic variants in milk protein on yield and composition of milk from Holstein-Friesian and Simmentaler cows. South African J. Anim. Sci. 35, 41–47. https://doi.org/10.4314/sajas.v35i1.4047

Chagunda, M.G.G., Bruns, E.W., Wollny, C.B.A., King, H.M., 2004. Effect of milk yield-based selection on some reproductive traits of Holstein Friesian cows on large-scale dairy farms in Malawi. Livest. Res. Rural Dev. 16, 20–32.

Climate-data.org, 2020. Chattogram climate (Bangladesh).

Council, N.R., 1981. Effect of Environment on Nutrient Requirements of Domestic Animals, Effect of Environment on Nutrient Requirements of Domestic Animals. National Academies Press. https://doi.org/10.17226/4963

Dědková, L., Němcová, E., 2003. Factors affecting the shape of lactation curves of Holstein cows in the Czech Republic. Czech J. Anim. Sci. 48, 395–402.

Deng, M.P., Badri, T.M., Atta, M., Hamad, M.E., 2012. Relationship between udder dimensions and milk yield of Kenana × Friesian crossbred cows. Res. Opin. Anim. Vet. Sci. 2, 49–54.

Dhumal, M. V, Salhare, P.G., Deshpande, K.S., 1989. Factors affecting lactation milk yield and lactation length in Red Kandhari and crossbred cows. Indian J. Dairy Sci 42, 102–104.

Domecq, J.J., Skidmore, A.L., Lloyd, J.W., Kaneene, J.B., 1997. Relationship between Body Condition Scores and Conception at First Artificial Insemination in a Large Dairy Herd of High Yielding Holstein Cows. J. Dairy Sci. 80, 113–120. https://doi.org/10.3168/jds.S0022-0302(97)75918-6

El Zubeir, I.E., Shuiep, E.S., 2016. Effect of Stage of Lactation and order of Parity on Milk Composition and Daily Milk Yield among Local and Crossbred Cows in South Darfur State, Sudan. J. Sci. Technol. 17.

Epaphras, A., Karimuribo, E.D., Msellem, S.N., 2004. Effect of season and parity on lactation of crossbred Ayrshire cows reared under coastal tropical climate in Tanzania. Livest. Res. Rural Dev. 16, 42–46.

Galukande, E., Mulindwa, H., Wurzinger, M., Roschinsky, R., Mwai, A.O., Sölkner, J., 2013. Cross-breeding cattle for milk production in the tropics: achievements, challenges and opportunities. Anim. Genet. Resour. génétiques Anim. genéticos Anim. 52, 111–125. https://doi.org/10.1017/s2078633612000471

Gebreyohannes, G., Koonawootrittriron, S., Elzo, M.A., Suwanasopee, T., 2014. Genotype by environment interaction effect on lactation pattern and milk production traits in an Ethiopian dairy cattle population. Kasetsart J. - Nat. Sci. 48, 38–51.

Gregory, K.E., Cundiff, L. V, Koch, R.M., 1992. Effects of breed and retained heterosis on milk yield and 200-day weight in advanced generations of composite populations of beef cattle. J. Anim. Sci. 70, 2366–2372. https://doi.org/10.2527/1992.7082366x

Hammoud, M.H., El-Khateeb, S.Z., Oudah, E.Z.M., 2010. Effect of sire, age at first calving, season and year of calving and parity on reproductive performance of Friesian cows under semiarid conditions in Egypt. Arch. Zootech. 13, 60–82.

Hansen, J. V, Friggens, N.C., Højsgaard, S., 2006. The influence of breed and parity on milk yield, and milk yield acceleration curves. Livest. Sci. 104, 53–62. https://doi.org/10.1016/j.livsci.2006.03.007

Hossain, M.A., Routledge, S.F., 1982. Performance of crossbred and local cattle under village condition in Pabna District of Bangladesh, in: Proceedings of the 3rd Seminar on Maximum Livestock Production from Minimum Land. pp. 161–167.

Huque, K.S., Dev, G.K., Jalil, M.A., 2011. High yielding dairy breed development in Bangladesh-limitations and opportunities, in: International Workshop on “High Yielding Dairy Breed Development in Bangladesh” Held at Bangladesh Livestock Research Institute, Dhaka From. pp. 28–29.

Ihsanullah, Qureshi, M.S., Akhtar, S., Suhail, S.M., 2020. Seasonal stress affects reproductive and lactation traits in dairy cattle with various levels of exotic blood and parities under subtropical condition. Pak. J. Zool. 52, 147–155. https://doi.org/10.17582/journal.pjz/2020.52.1.147.155

Intisar, Y.T., Mawhip, A.M., Muna, E.K., Miriam, S.A., Omer, M.E., Hammed, M.E., 2012. Effect of Feeding systems on Milk Yield and Composition of Local and Cross Bred Dairy Cows. Int. J. Sci. Technol. 2, 5–9.

JAVED, K., 1999. Genetics and Phenotypic Aspects of Some Performance Traits in a Purebred Herd of Sahiwal Cattle in Pakistan.

Javed, K., Afzal, M., Ahmad, I., 2002. Environmental effects on lactation milk yield of Jersey cows in Pakistan. J. Anim. Plant Sci 12, 66–69.

Johnson, C.R., Lalman, D.L., Appeddu, L.A., Brown, M.A., Wettemann, R.P., Buchanan, D.S., 2002. Effect of parity and milk production potential on forage intake of beef cows during late gestation. TEKRAN United States Department of Agriculture, Agricultural Research Service. 2002.

Johnson, H.D.., Ragsdale, A.C.., Berry, I.L.., Shanklin, M.D., 1963. Temperature-humidity effects including influence of accli- mation in feed and water consumption of Holstein cattle., Missouri Agricultural Experiment Station Bul.

Kennedy, J., Dillon, P., Delaby, L., Faverdin, P., Stakelum, G., Rath, M., 2003. Effect of genetic merit and concentrate supplementation on grass intake and milk production with Holstein Friesian dairy cows. J. Dairy Sci. 86, 610–621. https://doi.org/10.3168/jds.S0022-0302(03)73639-X

Kiwuwa, G.H., Trail, J.C.M., Kurtu, M.Y., Worku, G., Anderson, F.M., Durkin, J., 1983. Crossbred dairy cattle productivity in Arsi Region, Ethiopia, ILCA Research Report No. 11. ILCA.

Lampo, P., Willems, A., Vanschoubroek, F., 1966. Effect of season, calving period and stage of lactation on milk yield and milk composition in the cow. Ned. Melk-en Zuiveltijdschr. 20, 17–36.

Ledinek, M., Gruber, L., Steininger, F., Zottl, K., Royer, M., Krimberger, K., Mayerhofer, M., Egger-Danner, C., Fuerst-Waltl, B., 2018. Analysis of lactating cows in commercial Austrian dairy farms: Diet composition, and influence of genotype, parity and stage of lactation on nutrient intake, body weight and body condition score. Ital. J. Anim. Sci.

Lush, J.L., Shrode, R.R., 1950. Changes in Milk Production with Age and Milking Frequency. J. Dairy Sci. 33, 338–357. https://doi.org/10.3168/jds.S0022-0302(50)91909-6

M, M.A., 2004. Studies of some performance traits of Butana cattle in Atbara live-stock research station. MSc thesis University of Khartoum, Sudan.

Mackle, T.R., Bryant, A.M., Petch, S.F., Hill, J.P., Auldist, M.J., 1999. Nutritional influences on the composition of milk from cows of different protein phenotypes in New Zealand. J. Dairy Sci. 82, 172–180. https://doi.org/10.3168/jds.S0022-0302(99)75221-5

Maltz, E., Kroll, O., Spahr, S.L., Devir, S., Genizi, A., Sagi, R., 1991. Milk Yield, Parity, and Cow Potential As Variables for Computerized Concentrate Supplementation Strategy. J. Dairy Sci. 74, 2277–2289. https://doi.org/10.3168/jds.S0022-0302(91)78400-2

Mason S, 2000. Lactation curves.

Mayer, D.G., Davison, T.M., McGowan, M.R., Young, B.A., Matschoss, A.L., Hall, A.B., Goodwin, P.J., Jonsson, N.N., Gaughan, J.B., 1999. Extent and economic effect of heat loads on dairy cattle production in Australia. Aust. Vet. J. 77, 804–808. https://doi.org/10.1111/j.1751-0813.1999.tb12950.x

Mech, A., Dhali, A., Prakash, B., Rajkhowa, C., 2008. Variation in milk yield and milk composition during the entire lactation period in Mithun cows (Bos frontalis). Livest. Res. Rural Dev. 20.

Mellado, M., Antonio-Chirino, E., Meza-Herrera, C., Veliz, F.G., Arevalo, J.R., Mellado, J., de Santiago, A., 2011. Effect of lactation number, year, and season of initiation of lactation on milk yield of cows hormonally induced into lactation and treated with recombinant bovine somatotropin. J. Dairy Sci. 94, 4524–4530. https://doi.org/10.3168/jds.2011-4152

Mhamdi, N., Bouallegue, M., Frouja, S., Ressaissi, Y., Kaur, S., Ben, M., 2012. Effects of Environmental Factors on Milk Yield, Lactation Length and Dry Period in Tunisian Holstein Cows, in: Milk Production - An Up-to-Date Overview of Animal Nutrition, Management and Health. IntechOpen. https://doi.org/10.5772/50803

Molee, A., Boonek, L., Rungsakinnin, N., 2011. The effect of beta and kappa casein genes on milk yield and milk composition in different percentages of Holstein in crossbred dairy cattle. Anim. Sci. J. 82, 512–516.

Morales, F., Blake, R.W., Stanton, T.L., Hahn, M. V, 1989. Effects of Age, Parity, Season of Calving, and Sire on Milk Yield of Carora Cows in Venezuela. J. Dairy Sci. 72, 2161–2169. https://doi.org/10.3168/jds.S0022-0302(89)79341-3

Mote, S.S., Chauhan, D.S., Ghosh, N., 2016. Effect of environment factors on milk production and lactation length under different seasons in crossbred cattle. Indian J. Anim. Res. 50, 175–180. https://doi.org/10.18805/ijar.9496

Msanga, Y.N., Bryant, M.J., Rutam, I.B., Minja, F.N., Zylstra, L., 2000. Effect of environmental factors and of the proportion of Holstein blood on the milk yield and lactation length of crossbred dairy cattle on smallholder farms in north-east Tanzania. Trop. Anim. Health Prod. 32, 23–31. https://doi.org/10.1023/A:1005288918672

Nantapo, C.T.W., Muchenje, V., Hugo, A., 2014. Atherogenicity index and health-related fatty acids in different stages of lactation from Friesian, Jersey and Friesian × Jersey cross cow milk under a pasture-based dairy system. Food Chem. 146, 127–133. https://doi.org/10.1016/j.foodchem.2013.09.009

Ng-Kwai-Hang, K.F., Hayes, J.F., Moxley, J.E., Monardes, H.G., 1982. Environmental Influences on Protein Content and Composition of Bovine Milk. J. Dairy Sci. 65, 1993–1998. https://doi.org/10.3168/jds.S0022-0302(82)82449-1

Nielsen, H.M., Friggens, N.C., Løvendahl, P., Jensen, J., Ingvartsen, K.L., 2003. Influence of breed, parity, and stage of lactation on lactational performance and relationship between body fatness and live weight. Livest. Prod. Sci. 79, 119–133. https://doi.org/10.1016/S0301-6226(02)00146-X

Oltenacu, P.A., Broom, D.M., 2010. The impact of genetic selection for increased milk yield on the welfare of dairy cows. Anim. Welf. 19, 39–49.

Oltner, R., Emanuelson, M., Wiktorsson, H., 1985. Urea concentrations in milk in relation to milk yield, live weight, lactation number and amount and composition of feed given to dairy cows. Livest. Prod. Sci. 12, 47–57. https://doi.org/10.1016/0301-6226(85)90039-9

Oravcová, M., Margetín, M., Peškovičová, D., Daňo, J., Milerski, M., Hetényi, L., Polák, P., 2006. Factors affecting milk yield and ewe’s lactation curves estimated with test-day models. Czech J. Anim. Sci. 51, 483–490. https://doi.org/10.17221/3968-cjas

Orgmets, E., Saveli, O., Voore, M., 2002. The milk performance and body conformation of cows on Polula Experimental Farm. J. Agric. Sci. 13, 182.

Pérochon, L., Coulon, J.B., Lescourret, F., 1996. Modelling lactation curves of dairy cows with emphasis on individual variability. Anim. Sci. 63, 189–200. https://doi.org/10.1017/S1357729800014740

Quayyum, S.N., Clarke, D.J., 2018. Bangladesh-Policy Options for Agriculture Insurance. The World Bank.

Quddus, A., 2018. Smallholder Dairy Farming in Bangladesh: a Socioeconomic Analysis. Bangladesh J. Agric. Econ. 37.

Ray, D.E., Halbach, T.J., Armstrong, D. V, 1992. Season and Lactation Number Effects on Milk Production and Reproduction of Dairy Cattle in Arizona. J. Dairy Sci. 75, 2976–2983. https://doi.org/10.3168/jds.S0022-0302(92)78061-8

Rege, J.E.O., 1998. Utilization of Exotic Germplasm for Milk Production in the Tropics, in: Proceedings of the 6th World Congress on Genetics Applied to Livestock Production. pp. 551–556.

Rehman, Z.U., Sajjad Khan, M.S., Bhatti, S.A., Iqbal, J., Iqbal, A., 2008. Factors affecting first lactation performance of Sahiwal cattle in Pakistan. Arch. Anim. Breed. 51, 305–317. https://doi.org/10.5194/aab-51-305-2008

Rios-Utrera, A., Calderon-Robles, R.C., Galaviz-Rodriguez, J.R., Vega-Murillo, V.E., Lagunes-Lagunes, J., 2013. Effects of Breed, Calving Season and Parity on Milk Yield, Body Weight and Efficiency of Dairy Cows under Subtropical Conditions. Int. J. Anim. Vet. Adv. 5, 226–232. https://doi.org/10.19026/ijava.5.5602

Samková, E., Koubová, J., Hasoňová, L., Hanuš, O., Kala, R., Kváč, M., Pelikánová, T., Špička, J., 2018. Joint effects of breed, parity, month of lactation, and cow individuality on the milk fatty acids composition. Mljekarstvo 68, 98–107. https://doi.org/10.15567/mljekarstvo.2018.0203

Sharma, R.B., Agarwal, J.P., 1985. Influence of stage of lactation on the chemical composition of cross-bred cows milk. J. Agric. Sci. Res 27, 11–14.

Shibru, D., Tamir, B., Kasa, F., Goshu, G., 2020. Effect of Season, Parity, Exotic Gene Level and Lactation Stage on Milk Yield and Composition.

Shuiep, E.S., Zubeir, E., 2016. Effect of Stage of Lactation and order of Parity on Milk Composition and Daily Milk Yield among Local and Crossbred Cows in South Darfur State, Sudan. SUST J. Agric. Vet. Sci. SUST J. Agric. Vet. Sci. J. 17.

Singh, V.P., Dubey, M., Chaubey, A.K., 2015. Seasonal Influence on Milk Production Performance in Different Breeds of Dairy Cows. Environ. Ecol. 33, 371–374.

Smith, D.L., Smith, T., Rude, B.J., Ward, S.H., 2013. Short communication: Comparison of the effects of heat stress on milk and component yields and somatic cell score in Holstein and Jersey cows. J. Dairy Sci. 96, 3028–3033. https://doi.org/10.3168/jds.2012-5737

Stott, G.H., 1981. What is animal stress and how is it measured? J. Anim. Sci. 52, 150–153. https://doi.org/10.2527/jas1981.521150x

Val-Arreola, D., Kebreab, E., Dijkstra, J., France, J., 2004. Study of the lactation curve in dairy cattle on farms in central Mexico. J. Dairy Sci. 87, 3789–3799. https://doi.org/10.3168/jds.S0022-0302(04)73518-3

Vijayakumar, M., Park, J.H., Ki, K.S., Lim, D.H., Kim, S.B., Park, S.M., Jeong, H.Y., Park, B.Y., Kim, T. Il, 2017. The effect of lactation number, stage, length, and milking frequency on milk yield in Korean Holstein dairy cows using automatic milking system. Asian-Australasian J. Anim. Sci. 30, 1093–1098. https://doi.org/10.5713/ajas.16.0882

Waltner, S.S., McNamara, J.P., Hillers, J.K., 1993. Relationships of Body Condition Score to Production Variables in High Producing Holstein Dairy Cattle. J. Dairy Sci. 76, 3410–3419. https://doi.org/10.3168/jds.S0022-0302(93)77679-1

Wathes, D.C., Cheng, Z., Bourne, N., Taylor, V.J., Coffey, M.P., Brotherstone, S., 2007. Differences between primiparous and multiparous dairy cows in the inter-relationships between metabolic traits, milk yield and body condition score in the periparturient period. Domest. Anim. Endocrinol. 33, 203–225. https://doi.org/10.1016/j.domaniend.2006.05.004

West, J.W., 2003. Effects of heat-stress on production in dairy cattle. J. Dairy Sci. 86, 2131–2144.

Windig, J.J., Calus, M.P.L., Beerda, B., Veerkamp, R.F., 2006. Genetic correlations between milk production and health and fertility depending on herd environment. J. Dairy Sci. 89, 1765–1775. https://doi.org/10.3168/jds.S0022-0302(06)72245-7

Yoon, J.T., Lee, J.H., Kim, C.K., Chung, Y.C., Kim, C.H., 2004. Effects of milk production, season, parity and lactation period on variations of milk urea nitrogen concentration and milk components of Holstein dairy cows. Asian-Australasian J. Anim. Sci. 17, 479–484. https://doi.org/10.5713/ajas.2004.479

Zhou, H., Cheng, L., Azimu, W., Hodge, S., Edwards, G.R., Hickford, J.G.H., 2015. Variation in the bovine FABP4 gene affects milk yield and milk protein content in dairy cows. Sci. Rep. 5, 10023. https://doi.org/10.1038/srep10023

# Acknowledgement

I would like to express the deepest sense of gratitude and sorts of praises to the God, the creator and supreme ruler of the Universe who had bestowed upon me to do this work successfully.

The author is also grateful to honorable professor Dr. Abdul Ahad, Dean, Faculty of Veterinary Medicine of Chattogram Veterinary and Animal Sciences University and professor Dr. A.K.M. Saifuddin, Director of External Affairs, Chattogram Veterinary and Animal Sciences University for arranging this type of research work as a compulsory part of this internship programme.

The author expresses her sincere gratitude, humble respect heartfelt thanks to my internship supervisor, Md. Emran Hossain, Professor, Department of Animal Science and Nutrition, Chattogram veterinary and animal sciences university for his scholastic guidance, kind cooperation, sincere help, valuable suggestions, inspiration, who was involved with this study from its inception. I ever remain grateful to him.

The final acknowledgments and gratitude is for my sweet family that supported me and helped to be in the course and managed to live without me, always encouraged me and without their kind assistance it was very difficult to stay long days far from the home.

Finally I would like to thank everybody who contributed to the course and expressing my apology that I couldn’t mention personally each one by one.

**Biography**

****

I am Karabi Barua, daughter of Mr. Nihar Kusum Barua and Mrs. Minati Barua. I passed my Secondary School Certificate (SSC) examination from Banskhali Govt. Girls’ High School, Chattogram in 2012 and Higher Secondary Certificate (HSC) examination from Chattogram college, Chattogram in 2014. I enrolled for Doctor of Veterinary Medicine (DVM) degree in Chattogram Veterinary and Animal Sciences University (CVASU), Chattogram, Bangladesh in 2014-2015 session. At present I am doing my internship program which is compulsory for awarding my degree of Doctor of Veterinary Medicine (DVM) from CVASU. In the near future, I would like to work and have massive interest in Zoo and Wild Animal Medicine.

# Appendix I: Analysis report

\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_ (R)

/\_\_ / \_\_\_\_/ / \_\_\_\_/

\_\_\_/ / /\_\_\_/ / /\_\_\_/ 14.2 Copyright 1985-2015 StataCorp LLC

Statistics/Data Analysis StataCorp

4905 Lakeway Drive

Special Edition College Station, Texas 77845 USA

800-STATA-PC http://www.stata.com

979-696-4600 stata@stata.com

979-696-4601 (fax)

Single-user Stata perpetual license:

Serial number: 401406299878

Licensed to: Md. Emran Hossain

Chattogram Veterinary and Animal Sciences University

Notes:

1. Unicode is supported; see help unicode\_advice.

2. Maximum number of variables is set to 5000; see help set\_maxvar.

. \*(18 variables, 16425 observations pasted into data editor)

. sum

Variable | Obs Mean Std. Dev. Min Max

-------------+---------------------------------------------------------

cow | 16,425 8 4.320625 1 15

parity | 16,425 2 .8165214 1 3

day | 16,425 15.72055 8.796515 1 31

year | 16,425 183 105.3692 1 365

month | 16,425 6.526027 3.447956 1 12

-------------+---------------------------------------------------------

season | 16,425 2.50411 1.12173 1 4

yield | 12,707 11.22078 4.288517 .5 22

genotype | 16,425 1.663562 .6017328 1 3

h\_season | 0

h\_genotype | 0

-------------+---------------------------------------------------------

h\_parity | 0

parity\_1 | 365 10.39419 1.908205 6.7 14

parity\_2 | 365 11.53512 .9920518 6.5 13.65

parity\_3 | 365 11.47129 1.895961 7.31 15.58

parity\_com | 365 11.13326 .7530407 8.77 12.8

-------------+---------------------------------------------------------

genotype\_1 | 365 10.96104 .9911737 8.36 13.41

genotype\_2 | 365 11.31151 .9107992 8.55 13.25

genotype\_3 | 365 12.10011 1.776534 7.5 16

. anova yield genotype parity season genotype#parity genotype#season parity#season

Number of obs = 12,707 R-squared = 0.1098

Root MSE = 4.04995 Adj R-squared = 0.1082

Source | Partial SS df MS F Prob>F

----------------+----------------------------------------------------

Model | 25653.402 23 1115.3653 68.00 0.0000

|

genotype | 265.04014 2 132.52007 8.08 0.0003

parity | 1581.2385 2 790.61925 48.20 0.0000

season | 812.33959 3 270.77986 16.51 0.0000

genotype#parity | 170.99599 4 42.748999 2.61 0.0339

genotype#season | 1107.5897 6 184.59829 11.25 0.0000

parity#season | 18832.288 6 3138.7146 191.36 0.0000

|

Residual | 208027.44 12,683 16.402069

----------------+----------------------------------------------------

Total | 233680.84 12,706 18.391377