Mathematical models for the prediction of quantitative traits of different crosses of Holstein-Friesian cows in different farming conditions

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List of Acronyms

CDC: Crossbred Dairy Cattle

HF: Holstein- Friesian

SL: Sahiwal

L: Local

CMA: Chattogram Metropolitan Area

DAMY: Daily Average Milk Yield

PY: Peak Yield

SE: Standard Error

LSD: Least Significant Difference

R^2: Coefficient of regression

CV: Coefficient of variance

LWT: Live Weight

GDP: Gross Domestic Product

Abstract

Background: To meet up the milk demand of growing population, farmers have to be adopted crossbred cattle and among various foreign breeds Holstein-Frisian crossbred became popular in terms of production results and high performance than other cattle genotype. For better decision making and proper management, use of mathematical models to predict values from partially or incompletely recorded data can be a great option. Predicted values from mathematical models may reduce the confusion for calculating the yield. Therefore, this study was conducted to determine suitable and easier mathematical model by comparing their predicted values. This study also targeted to identify better cross of Holstein by visualizing the differences in their production level.

Methods: Recorded data of single lactation milk yield of two crossbred of Holstein-Frisian (Holstein-Friesian (HF)× Sahiwal (SL) and Holstein-Friesian (HF)× Local (L)) were used to calculate the mean value of daily average milk yield, lactation yield, peak yield and live weight of cattle. Four equational models (Linear, Exponential, Polynomial and logarithm) were used to determine their predicted value and based on fit statistics (R^2 and CV) these models were evaluated.

Result: The daily average milk yield and lactation yield was higher in HF×SL in farm A. Variation between two genotypes and among farms were observed. Live weight gain was greater in Sahiwal cross with Holstein-Friesian. Better production level was noticed in their 3rd lactation at four farming conditions. To determine the suitable model fit statistics were used and based on that polynomial model had shown great result and was considered as fit model.

Key words: Crossbred, Fit statistics, Models, Milk yield, Live weight.

Chapter-1: Introduction

In many emerging nations, agricultural development is a key factor in total economic growth. Bangladesh is primarily an agricultural nation, and the sector's contribution to rapid economic growth is crucial. In order to guarantee long-term food security for humans, it is crucial to create a lucrative, sustainable, and environmentally friendly agricultural system. (Chapter 7 Agriculture, 2017.)

Livestock plays a significant role in the development of Bangladesh's economy. The cattle industry directly employs about 20% of the population and generates about 16.5% of the nation's GDP (Kabir & Kisku, 2013). Cattle production is a crucial component of livestock. Among the other animals raised in our nation, cattle play a significant part in the production of milk and meat. Though demand for meat has exceeded supply, we still need to concentrate on raising milk production to meet demand.

Although milk is regarded as the perfect diet for humans, the daily average milk production of indigenous dairy cows was recorded (1.18 ± 0.10 kg day^{-1}) (Hamid et al., 2017). As a result, the demand for crossbred cows is currently significantly higher due to the increased milk production (which ranges between 8 and 15 liters per day) (Uddin et al., 2008). The most popular crossbred temperate breeds are the Holstein Friesian (HF) and Jersey, and these were introduced in 1973. The HF offers better production results than the local and other crossbred dairy cattle (CDC) that are accessible in Bangladesh (Adhikary et al., 2020). The HF was crossed with regional and other breeds in order to develop high performance CDC. Crossbred cattle cannot produce to their full potential in Bangladesh because of the country's difficult environmental circumstances, lack of green forage and fodder, inexperienced management, and ignorance of medical procedures. Despite these disadvantages, adopting crossbreeding technology is one of the ways to guarantee improved dairy productivity; this is a claim that has been corroborated by several empirical investigations conducted in various nations (Bayan & Dutta, 2017). Crossbreeding has a greater impact on milk production. Estimates of cow value added are estimated to be 10 times higher in farms with crossbreds than in farms with local cattle found in Bhutan (1030 vs. 107 US dollars) (Udo et al., 2011). The higher income and nutritional security benefit of commercial dairy farming, which appears to arise from adoption of crossbreeding technologies, has been confirmed by numerous cross-country studies (Bayan & Dutta, 2017). Research by Alary et al., 2011 in Office du Niger, Mali; Melesse & Jemal, 2013 in Ada'a and Lume districts of Central Ethiopia; Quddus, 2012 in Bangladesh; Udo & Steenstra, 2010 in Indonesia, among others, has discovered a positive effect of crossbreeding technology adoption on income and nutritional security of dairy farm households. Although crossbred cattle require more nourishment than native varieties, they are also more adaptable than pure types. Adopting crossbreeds is a viable and sustainable strategy to improve income and ensure food security.

The two main crossbreeds utilized in commercial dairying in Bangladesh are Holstein crossbred (Holstein Local zebu) and Sahiwal crossbreed (Sahiwal Local zebu) even if Holstein crossings are more common (Haque et al., 2013). Over the years, HF × L crossbred cows' milk production performance under Bangladeshi conditions gradually improved (Bhuiyan et al., 2015). As a result, the majority of commercial dairy producers use various HF crossbreeds that are currently on the market to produce more milk on their farms, both in terms of quantity and quality.(Khan et al., 2012).

Proper management should be the farm owners' main priority in order for the dairy farm to be successful. Recording is the most crucial management tool (Silver, 2006). However, maintaining accurate records can be difficult, and Bangladesh and other underdeveloped nations who practice cow rearing frequently find it impossible to do so. It is simple to calculate the productivity of cows on a farm using mathematical models. One can predict values from incomplete or imperfectly recorded data using models (Sultana et al., 2022). By estimating the model parameters, it also minimizes the confusion associated with computing the yield. By graphically showing age and weight data, mathematical models are utilized to forecast the growth of cattle (Bathaei & Leroy, 1996). As an alternative, Souza et al., 2010 employed non-linear models to describe the growth curve of cattle.

In this study, the anticipated values of milk production and live weight were determined using a variety of mathematical models (linear, exponential, polynomial, and logarithmic), and the variation in those values was evaluated to establish the best appropriate model (s).

The objectives of this study were to:

1.To compare the daily average milk yield, peak yield among the HF crossbreds in different farms.

2. To compare a number of mathematical models simulating milk yield, lactation yield, and live weight of different HF crosses

3. To choose the most suitable mathematical model for computing milk yield under commercial dairying of Bangladesh.

Chapter 2: Materials & Methods

Study area & period: The study was conducted for a period of three months, from March 2022 to May 2022 in Chattogram Metropolitan Area (CMA) and Boalkhali upazilla (sub-district) of Chattogram, Bangladesh.

Data collection & sample selection: A total of 4 farms was randomly selected based on availability of target crossbred, proper record, same housing, number of cattle (>15) and data used in this study was single lactation daily milk yield, peak milk yield, average milk yield and live weight records from two crosses of Holstein-Friesian. In this study a total number of cows were 24 in heterogeneous age. The available genotypes were Holstein-Friesian (HF) × Sahiwal (SL) (12) and Holstein-Friesian (HF) × Local (L) (12) crossbreds. The ratio of genotype was 75%×25% in both crosses. Among the cows, 4 of them were in 1st lactation, 12 were in 2nd lactation and 8 were in 3rd lactation.

A pre-designed questionnaire that was relevant to the study objective was prepared to collect the data. Face-to-face interviews and on-the-spot data computing were commended on daily average milk yield, peak yield, total milk production on single lactation period and live weight; was performed by the appointed data collector.

Actual Value of the traits: The actual value of milk yield of single lactation was calculated from the recorded data. The mean and standard error for the four traits (daily average milk yield (DAMY), peak yield (PY), lactation yield (LacY) and live weight (LWT)) of HF × L and HF × SL crossbred cows under four different farming conditions was analyzed using Proc GLM of SAS (SAS, 2008).

Mathematical models for performances: Following four mathematical equations were fitted in Microsoft Excel 2020 to estimate their parameters.

- Linear regression: $Y=a+bx$
- Quadratic polynomial: $Y=a+bx+cx^2$
- e-Exponential regression: $Y=ae^{bx}$
- Logarithmic regression: $Y= a+b\ln(x)$

Y is the predicted value of the traits (DAMY, LacY and LW), x is lactation length in days for milk yield and age in year for live weight, and a, b and c is the parameters that exhibits shape of the curve.

The goodness-of-fit of predicted values to actual records, and model performances were compared by fit statistics: co-efficient of determination (R^2) and coefficient of variation (CV). The R^2 and CV were obtained by fitting each predicted value from linear regression, quadratic polynomial, exponential and logarithmic regression. The predicted values of DAMY, LacY and Live weight from the addressed four models were obtained by including its parameter values in Proc GLM of SAS (SAS, 2008).

The given statistical model was adopted to get the least square means for every parameter, goodness of fit (R^2 and CV) and predicted values of the addressed regression models. The model is given as:

$$Y_{ij}= \mu+ A_i + eij$$

Where, Y_{ij} is the predicted value of the trait, μ is the overall mean, A_i is the effect of ith breed (HF×L and HF×SL) and eij is the residual effect distributed as N (0 σ^2). The mean differences were compared using least significance difference (lsd) at 5% level of significance.

Chapter 3: Result & Discussion

Productive performance of HF crossbred: The mean ± standard error values of different productive and reproductive traits of HF crossbred are shown in Table 1 and 2. Table 1 indicates comparison of DAMY and PY values between two HF crossbred. DAMY and PY both are higher in HF×SL than HF×L under different farm condition(s). Cows in their 3rd lactation showed more DAMY than their 2nd lactation.

Table 1. Estimated Mean & Standard error of daily average milk yield and peak milk yield at different lactation level under different farm condition of two crossbred

Farm	**Breed**	**Traits**					
		DAMY (Mean±SE)			**PY(Mean±SE)**		
		Lactation No.			**Lactation No.**		
		1	2	3	1	2	3
A	HF×SL		16±0.38	16.9±0.1		18±0.55	21.25±1.25
	HF×L		13.13±0.625	10.5±0.4		14.7±0.23	13.8±0.54
B	HF×SL		13.7±0.47			15.8±0.2	
	HF×L	9.29±0.09	9.7±0.24		12.45±0.45	13.4±0.7	
C	HF×SL		14.9±0.322	14.65±1.15		19.55±1.18	20.56±0.44
	HF×L	12.5±0.78	11.9±1.2	10.5±0.8	13.6±1.2	14.3±1.77	11.2±0.34
D	HF×SL		15.41±0.42			24±1.15	
	HF×L		11.2±0.44	13.24±0.51		12.5±0.98	14±0.1

Note: The mean value are differed at 5% level of significance among farms within genotype. HF= Holstein-Friesian, SL= Sahiwal, L=Local, DAMY=Daily average milk yield, PY= Peak yield

Numerous studies (Ray et al., 1992), (Arbel et al., 2001) have demonstrated how dairy cattle's milk production during gestation and parturition is influenced by the number of lactations. In essence, all studies have demonstrated that milk production increases as the number of lactations increases. (Vijayakumar et al., 2017).

The daily milk output of various lactations varied significantly ($p < 0.05$), according to statistical analysis. From the first to the third lactation, milk production gradually increased. The highest milk yield was recorded in 3rd lactation (16.9±0.1L) in HF × SL and in case of HF × L it was 13.24±0.51L. Moreover, lactation number had significant effect ($p < 0.05$) on daily milk yields of dairy cows. There is no relation observed in peak yield with lactation number.

Table 2 denotes lactation yield of single lactation period and live weight of cows in different lactation groups. It is observed that lactation yield is higher in HF × SL crossbred (4700±32.11, 4166.67±88.2, 4400±52.34, 4566.67±66.6L) in every farm condition than HF × L (3300±20.03, 3266.67±30.86, 3500±20.97, 3800±25.4L).

Table 2. Estimated Mean & Standard error of lactation milk yield and live body weight at different lactation level under different farm condition of two crossbred

Farm	**Breed**	**Traits**					
		LacY (Mean±SE)			**LWT(Mean±SE)**		
		Lactation No.			**Lactation No.**		
		1	2	3	1	2	3
A	HF×SL		4700±32.11	5150±50		390±14.76	410±21.33
	HF×L		3300±20.03	3100±13.52		325±15	300±10.34
B	HF×SL		4166.67±88.2			346.67±32.83	
	HF×L	2725±25	3266.67±30.86		270±12.2	290±9.2	
C	HF×SL		4400±52.34	4535±435.06	290±7.6	300±13.8	300±11.07
	HF×L	2790±32.14	3500±20.97	3100±10.91		300±12.04	335±15
D	HF×SL		4566.67±66.6			350±11.55	
	HF×L		3800±25.4	3450±250.04		315±10.7	310±10

Note: The mean value are differed at 5% level of significance among farms within genotype. HF= Holstein-Friesian, SL= Sahiwal, L=Local, LacY= Lactation yield, LWT= Live weight

From Table 2, it was also observed that HF cross with Sahiwal has higher live weight than those crosses with local. Relation between body weight and milk production has been noticed from Table 2. Cows having greater body weight have more lactation yield. HF × SL in their 2nd lactation, of 390±14.76 kg body weight produces 4700±32.11L whereas cows of 350±11.55 kg produces 4566.67±66.6 L. In case of HF × L this fact also been spotted. Handcock et al., 2019 found positive curvilinear relationships between BW and milk production. Milk yield increased with WT although the marginal effect decreased as cows got heavier (D P Berry 1 et al., 2007). The higher production could be due to the effect of Genotype × Environment interactions in that particular farm observed that total milk yield per lactation affected by the difference of herd. Similarly, milk production between breed groups, seasons and management systems were reported by other researchers (Val-Arreola et al., 2004).

Model fittings: The least square estimation of parameters a, b, c of four mathematical models (Linear regression, Exponential regression, Quadratic polynomial regression and logarithmic regression) of two cattle genotypes (HF×SL and HF×L) with the co-efficient of determination (R^2) and co-efficient o variance (CV) values were presented in Table 3 and 4.

These two fit statistics were used to evaluate the performance of the four models. The higher values of R^2 and CV indicate a good fit among models and lower values indicate differences among models (Alam et al. 2009; Khan et al. 2012).

Model parameters: Among three nonlinear models, value of R^2 that we got from polynomial model was higher than other models. This result was applicable for all three traits we considered of two different HF crossbred. The predicted values in polynomial model were slightly higher than the actual values of DAMY and LWT of HF × SL crossbred and LacY predicted value was higher in logarithm.

In linear regression, actual and predicted values were almost similar in different traits of HF crosses except DAMY and LacY of HF × SL crossbred.

Table 3. Estimated model co-efficient, fit statistics and predicted values of different traits of HF × SL

Breed	Traits				
	Models	Fit statistics	DAMY	LacY	LWT
HF×SL	Linear	a	-9.5668	-6956.7	227.36
		b	0.0833	38.641	42.192
		R^2	0.4969	0.6658	0.127
		CV	0.732	2.241	1.99
		Actual	15.083	4456.46	381.04
		Predicted	15.069	4471.376	381.04
	Exponential	a	2.8182	309.61	264.74
		b	0.0057	0.009	0.0978
		R^2	0.5181	0.6946	0.1015
		CV	0.846	1.511	2.29
		Actual	15.083	4456.46	381.04
		Predicted	15.226	4446.57	378.33
	Polynomial	a	-906.86	-288639	8215.8
		b	6.2262	1967	-4359.3
		c	-0.0105	-3.2972	598.91
		R^2	0.7262	0.8067	0.9324
		CV	2.735	4.569	2.36
		Actual	15.083	4456.46	381.04
		Predicted	15.377	4466.83	381.11
	Logarithm	a	-124.36	-60048	194.24
		b	24.51	11341	145.19
		R^2	0.5029	0.6713	0.1125
		CV	1.32	2.72	2.5
		Actual	15.083	4456.46	381.04
		Predicted	15.08	4472.096	381.03

Note: HF= Holstein-Friesian, SL= Sahiwal, a=Intercept, b=Slope, c= Curve shape, LacY= Lactation yield, LWT= Live weight, R^2= Coefficient of regression, CV= Coefficient of variance

In case of HF × L , the predicted values of DAMY and LWT were higher in polynomial model but predicted value of LacY was higher in logarithm. In comparison to all predicted values of different traits of two crossbred in four models, exponential model had given lowest values

Table 4. Estimated model co-efficient, fit statistics and predicted values of different traits of HF × L

Breed	Traits				
	Models	Fit statistics	DAMY	LacY	LWT
HF×L	Linear	a	2.1299	4678	287.65
		b	0.033	-5.6432	4.2014
		R^2	0.1512	0.1133	0.0278
		CV	11.11	1.587	3.57
		Actual	11.295	3110.625	302.29
		Predicted	11.296	3110.601	302.29
	Exponential	a	4.865	5405.6	287.72
		b	0.003	-0.002	0.0138
		R^2	0.1447	0.1327	0.0269
		CV	7.994	3.285	3.125
		Actual	11.295	3110.625	302.29
		Predicted	11.2012	3102.627	301.91
	Polynomial	a	644.34	-91586	910.87
		b	-4.6129	690.75	-375.99
		c	0.0084	-1.2569	56.063
		R^2	0.7743	0.472	0.9971
		CV	7.203	2.22	4
		Actual	11.295	3110.625	302.29
		Predicted	12.442	3109.243	302.31
	Logarithm	a	-38.547	11675	291.82
		b	8.859	-1522	8.502
		R^2	0.1423	0.1076	0.0103
		CV	6.159	2.242	1.59
		Actual	11.295	3110.625	302.29
		Predicted	11.291	3112.683	302.29

Note: HF= Holstein-Friesian, L= Local, a=Intercept, b=Slope, c= Curve shape, LacY= Lactation yield, LWT= Live weight, R^2= Coefficient of regression, CV= Coefficient of variance

In the HF × SL crossbred, the value of a for DAMY and LacY was greater in exponential, while the value of LWT was in polynomial. The value of b for DAMY and LWT was higher in logarithm, and the value of b for LacY was higher in exponential. For the second crossbred group, the polynomial model had greater values of a for DAMY and LWT, whereas the logarithm model had higher values for LacY. DAMY and LWT had greater values of b in the logarithm, and LacY had higher values in the polynomial regression model. The breed groups within each model as well as the models themselves differed in terms of the model co-efficient a, b, and c. Other researchers had previously observed that breed differences caused changes in model co-efficients (Alam et all, 2009) ,(Pérochon et al., 1996).

Between breed groups and also between farms, there were differences in the values of two fit statistics. For the quadratic polynomial model, the larger values of R^2 (0.7262, 0.8067, 0.9324) and COV (2.735, 4.569, 2.36) for the HF × SL crossbred DAMY, LacY and LWT and R^2 (0.7743, 0.472, 0.9971) and COV (7.203, 2.22, 4) for the HF × L crossbred DAMY, LacY and LWT were observed that pointed the superiority of model in the Holstein-Frisian × Sahiwal and Holstein-Frisian × Local crossbred in the four farming conditions.

Variation in milk production was also observed among four farms. Among the four farms, farm A had the milk yield while farm B had lowest milk yield for Holstein-Frisian×Sahiwal crossbred. For Holstein-Frisian × Local crossbred, farm D showed greater milk production. Overall production level was greatly equipped in farm D. Good production level is the result of good farm management. Data on the cattle' own fertility and production helped us characterize the habitat in part. The rationale behind this is that the herd's fertility and production are sensitive indicators of the farm's overall management (Windig et al., 2005). Significant difference in production performance may be attributed to the variations in the level of management (Chanda et al., 2021).

The goodness of fit: For linear, exponential, and logarithmic models, the R^2 and CV values demonstrated unfit. Values of fit statistics were higher in polynomial equation where HF×SL was maximum R^2 value for LacY and LWT and HF×L had highest R^2 value for DAMY and LWT. Though values of R^2 for all traits was not over 90%, polynomial showed overall good fit to the data. If a model achieves R^2 above 90% indicates close agreement with predicted value (Khan et al., 2012). Among four implemented models, quadratic polynomial model showed best fit for both genotypes and give closer predicted value to actual yield and live weight.

Actual and predicted value of different traits in different models: In Figure 1.1 to 1.6, comparison of actual and predicted value in the different mathematical equation was shown. Though the value of R^2 and CV was not satisfied for other models except polynomial, the predicted value was similar to the actual values of the different traits.

In HF×SL, the predicted DAMY value was lower in the exponential and linear regression models and higher in the polynomial model; it was equal in the logarithm regression model. For LacY, linear, polynomial, and logarithm equations all predicted values were higher, but in the exponential model, the predicted lower values were obtained. In the case of the LWT, greater values were predicted by polynomials, but lower values were obtained by exponential, and equal value by the logarithms and linear regression.

For DAMY, the predicted value in HF×L was greater for polynomial models and lower for the exponential model; it was equal for linear regression and logarithm regression models. For LacY, the logarithm equation predicted a higher number, whereas the exponential, linear, and polynomial models indicated a lower value. In the case of the LWT, greater values were predicted by polynomials, but lower values were obtained by the exponentials, and equal values by logarithms and linear regression.

Fig. 1.1. DAMY of HF×L

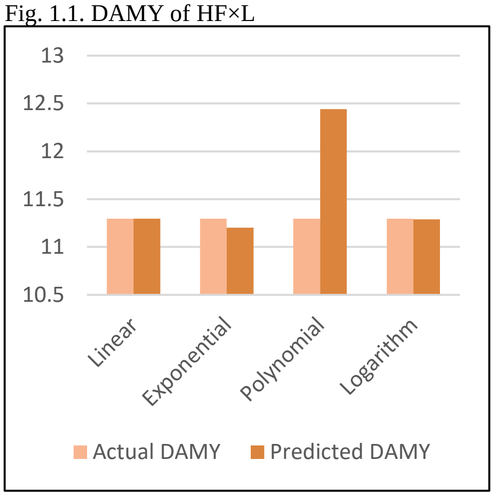

Fig. 1.2. DAMY of HF×SL

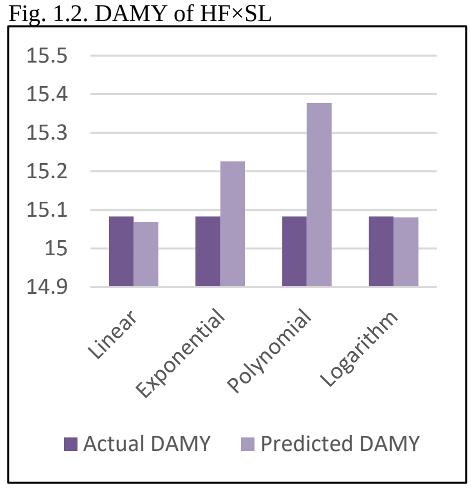

Fig. 1.3. LacY of HF×L

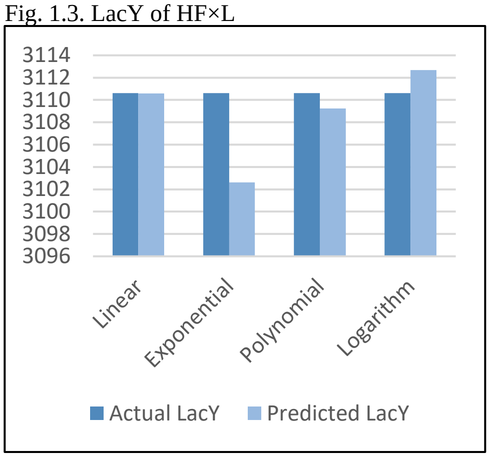

Fig. 1.4. LacY of HF×SL

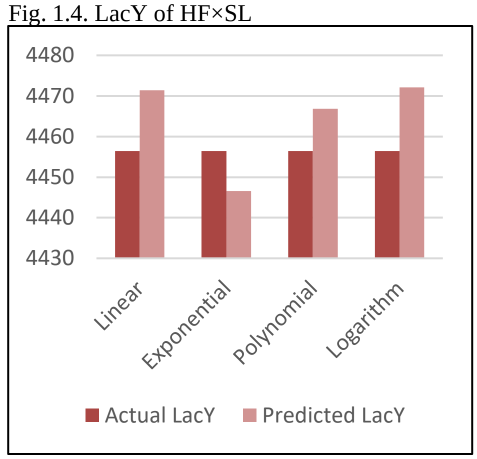

Fig. 1.5. LWT of HF×L

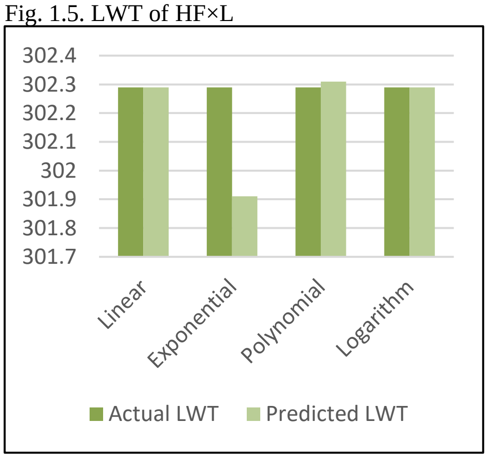

Fig. 1.6. LWT of HF×SL

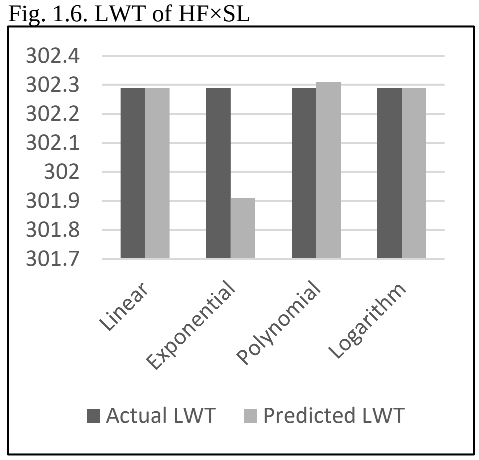

Figure 1. Actual and Predicted value DAMY(Fig 1.1, 1.2), LacY(Fig 1.3, 1.4), LWT(Fig1.5, 1.6) of two HF crossbred

Curve shape: In this investigation, the lactation curve was fitted in four models using data from the DAMY and LacY of the lactation periods (Figures 4 and 5) and (Figure 2 and 3), respectively. In Figures 2 and 3, the x axis defined as lactation period in days and the y axis determined LacY (liters). Figures 2 and 4 defined for HF×L crossbred while Figures 3 and 5 indicated by lactation curve for the HF×SL crossbred. Here, the average values of the lactation duration and LacY across many farms within the same genotype was used to determine both variables in mean form.

In the polynomial model, lactation curves to the LacY of the Lactation period data of HF×SL (Figure 3), HF×L (Figure 2), and HF×L (Figure 3) were increased up to 299 days and 277 days, respectively, and then slightly dropped. However, other models produced steady lines.

The lactation curves to the DAMY of the Lactation period data of HF×SL gradually increased up to 294 days, then it was in a steady state up to 298 days, and gradually decreased up to the end of lactation in the case of the polynomial equation, as shown in Figure 5. The peak milk yield calculated from raw data was approximately 302 days.

In the case of HF×L, Figure 4 depicted a decrease in DAMY up until 271 days of lactation length before an increase in the final days of lactation. The lactation curve in the polynomial model showed a progressive drop up to 277 days before beginning to incline.

Other models' lactation curves appeared steady and practically straight. The polynomial regression and the other three models exhibited various regression forms for the same attribute. How steep or flat the curve was depended on the number of records, the mathematical functionality of the models, and the model parameters (a, b, and c). Brown et al. (2001), Vargas et al. Other authors, including Pérochon et al. (1996), also mentioned related factors (Alam et al., 2009).

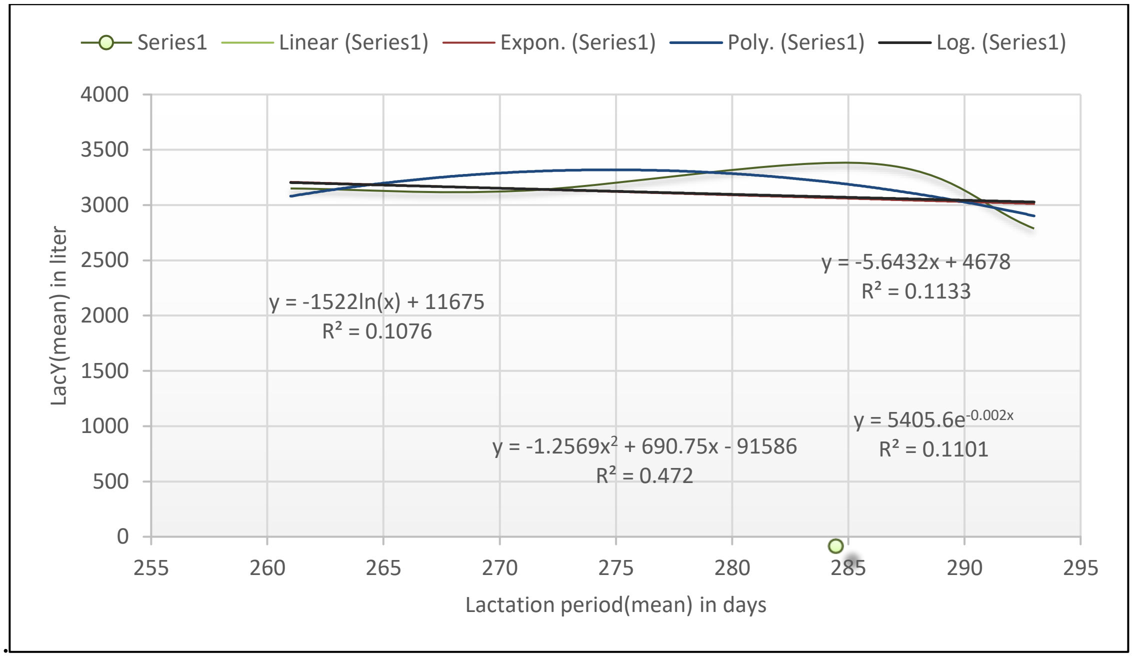

Figure 2 Lactation curve (LacY-Lactation period data plotted) of HF×L in different model

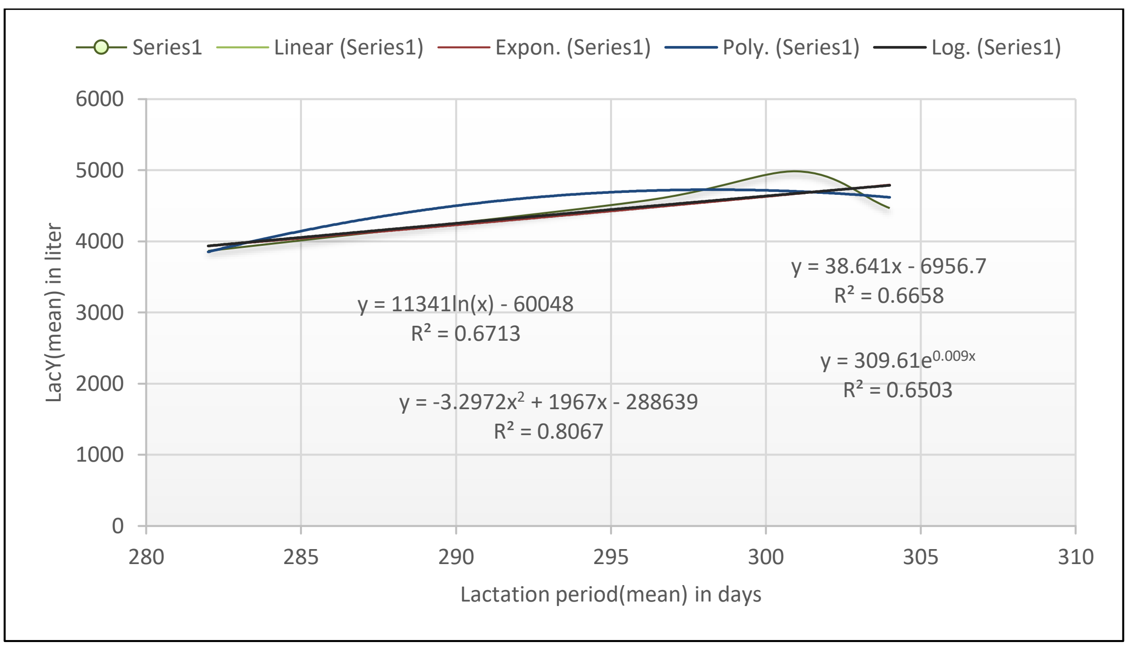

Figure 3 Lactation curve (LacY-Lactation period data plotted) of HF×SL in different model

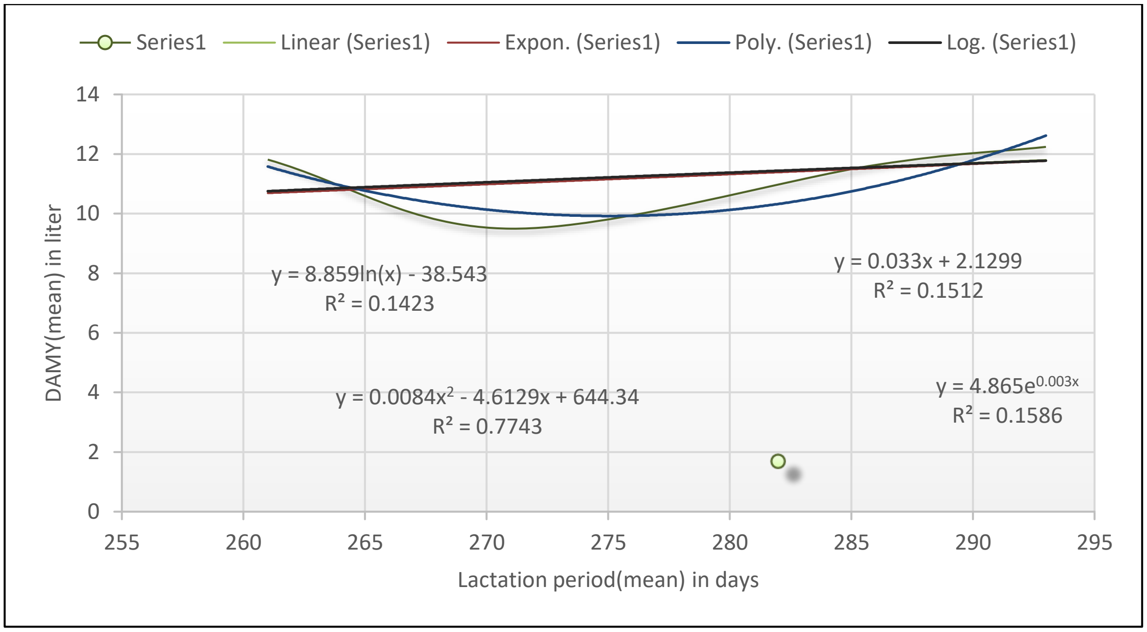

Figure 4 Lactation curve(DAMY-Lactation period data plotted) of HF×L in different model

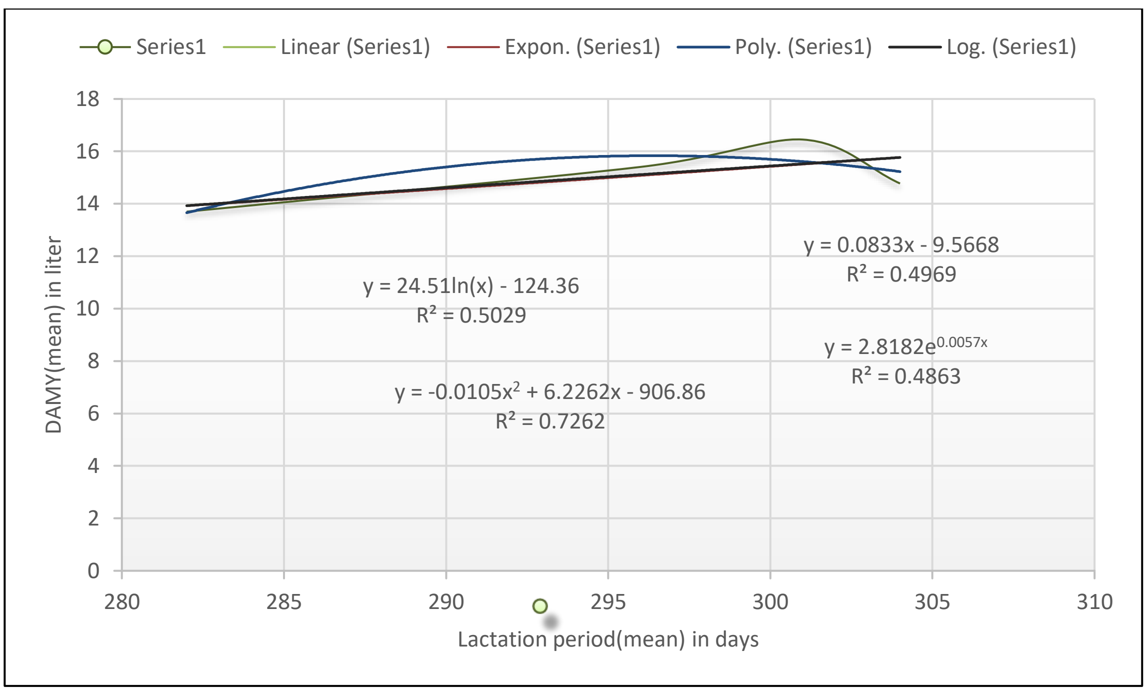

Figure 5 Lactation curve(DAMY-Lactation period data plotted) of HF×SL in different model

However, the quadratic polynomial regression model showed the typical milk yield curve form. Numerous studies (Macciotta et al., 2005; Nasri et al., 2008) has demonstrated that the beginning of lactation, the degree of incline and decline before and after peak yield, days in milk at peak, and peak lactation yields of lactation curves are related to differences in general shape and differences of model parameters.

Due to breed effects and the expected ability of the model parameters, the predicted milk yield of the Holstein-Friesian-Sahiwal was much higher. The variations in anticipated milk output from other lactation curve studies have been attributed to similar causes Pérochon et al., 1996; Vargas et al., 2000; Brown et al., 2001.

Chapter 4: Conclusion

In conclusion, it was observed that Holstein-Friesian × Sahiwal crossbred showed greater production performance than the Holstein-Friesian × Local in terms of daily milk yield, lactation yield for all model. The incredible performance of Holstein-Friesian × Sahiwal would become a great success in our farming conditions and it might be more profitable than rearing Holstein-Friesian × Local crossbred cows. This study also showed application of different mathematical models, those can be implemented to predict milk yield and body weight of cattle and among four used models, quadratic polynomial model showed best fit for both genotypes and give closer predicted value to actual yield and live weight. This study also determined easier and suitable mathematical model to predict values of different traits. It could be beneficial for the scientist to conduct additional research on the genetic improvement program for dairy cattle under various farm conditions, including large-hard size management systems. In addition, this study may be helpful for policymakers for making decision on breeding and culling for appropriate management to run a profitable dairy farm. For the estimation of the expected total yield, further non-linear and logistic models as well as more study are required to support the outcome.

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I'm Arifa Akter passed my SSC in 2013 and HSC in 2015 with GPA-5 from Dhaka board. I'm currently enrolled in Chattogram Veterinary and Animal Sciences University as an intern student. Me as a person is full of passion, encouragement and dedication.

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