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**Plagiarism certificate………**

This report is a significant new work/knowledge. No sentence, equation, diagram, table, paragraph or section has been copied verbatim from previous work unless it is placed under quotation marks and duly referenced. The work presented is original and own work of the author (i.e. there is no plagiarism). No ideas, processes, results or words of others have been presented as Author own work. There is no fabrication of data or results which have been compiled/analyzed. There is no falsification by manipulating research materials, equipment or processes, or changing or omitting data or results such that the research is not accurately represented in the research record.

**Author**

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**Abstract**

The study was conducted to develop lactation curve for crossbred cows and to choose suitable mathematical models of lactation curves using fit statistics. For this study data was collected from a dairy farm named Molla dairy farm situated at Chittagong , Bangladesh from May 2015 to October 2015. The mean and standard error for 210 days milk yield of Holistein- Friesian × Local cows were analysed using PROG GLM of SAS (2012). Two lactation curve models were used to predict the 210 days milk yield from the milk recording. The average milk yield is highest at September month which was 13.68 liter and lowest milk yield at June month with 10.8 liter per cow per day. Calving interval was worse for lactation7 (3.9±1.03 years) and better for lactation5 (3.05±1.7 years). Age at first calving at lactation6 was 3.67±01.98 years and at lactation7 it was 2.77±1.26 years. . The Predicted Milk Yield (PMY) and Actual Milk Yield (AMY) for different models were varied with lactation number, season, age of first calving, and calving interval). Fit statistics (R2: Co-efficient of determinant, RMSE: Root Mean Square Error, CV: Co- efficient of variation) were used. Finally Wood model is more suitable .

Key words: Cross breed, milk yield, lactation curve, calving interval

Chapter-I

Introduction

In Bangladesh dairy sector is not well developed. Most of the farmers have only 2-3 cows with half acre of land. However, there are some commercial dairy farms whose hard size is ranging from 30 to 50 cows. For dairy cow evaluation and taking culling decision recording is very important. Milk recording system is not well developed in Bangladesh. In Bangladesh the owners are not usually maintain a record-keeping system as in economic consideration or lack of technical know-how regarding farm management. But in the present some farmers keep record in their farm. Although this recording is not complete most of them are inadequate. The most important management tool is proper record keeping (Silver, 2006). Studies have shown that, the efficiency of milk production can be increased through the practice of using a simple, precise, understandable and easy to maintain recording system (Chagunda et al., 2006).

Genetic evaluation and genetic improvement programme of a dairy cattle and the research under different management schemes are difficult for small dairy farmers. Record keeping system is very important in developing lactation curve. The graphical representation of daily milk yield against time after calving is called a lactation curve (Sherchand et al., 1995).

Record keeping and good documentation practices are aimed at proper monitoring and effective evaluation and improvement of any business. Milk recording procedures constitutes an economic alternative to reduce operational costs in low input production systems. The effect of reducing tests to measure the accuracy of 305 days milk yields was investigated by Hammami *et al*. (2004). Study on farmer perception on record keeping and factors affecting its adoption were conducted by Chagunda *et al*. (2006) where the results indicated a positive relationship between participation in dairy recording and the individual assigned the recording task. Properly managed simplified milk-recording schemes could permit a substantial decrease of costs of milk recording per cow without damaging the efficiency of progeny testing in tropical areas with small herd size (Duclos *et al*., 2008). A similar study was done by Khan et al. (2012) and Ghosh and Khan (2013) under small scale dairying conditions in Bangladesh.

Therefore, the current study was design to fitting the tree parametric polynomial and wood model in order to predict the milk yield for a particular time period with the following objectives:

(1) to examine the lactation curves for crossbred cows under intensive farming;

(2) to compare two mathematical models of lactation curves using fit statistics; and

(3) to determine the most suitable mathematical model(s) for predicting milk yield.

Chapter-II

Methodology

The dataset used in this study was obtained from a farm named Molla dairy farm situated in south-eastern coastal region of Chittagong in Bangladesh. Molla dairy farm is a well known farm in Bangladesh .This farm was established at 1993.Now there are 175 dairy cows , 80 milking cow and 28 calves in the farm . Total milk yield is 1064 liter (average) per day .The cows are mainly cross breed of HF ,shahiwal and local breed containing more than 50% HF blood .The total farm area is 10 acres .They have own fodder land and they cultivate napier and para grass . There are 18 labors in the farm . Cattle of separate ages are being kept into separate shed. In this farm there is Calf shed, shed for heifer, shed for milch cow, isolation shed present. This shed are made according to space requirement of each animal. Each shed has electricity, fan & lighting facility. In the animal shed there is enough space for exercising of animal. In this farm , they usually use artificial insemination system for inseminate the cow when it comes into estrous. They have no any advance estrous detection system; they just do it by observing the cow at regular interval. They properly maintain record book for preventing inbreeding among the cow. Cattle of Molla dairy farm are fed according to their stage of production, age, physiological condition such as pregnancy or sickness etc. Green grass is usually provided at the rate of 3%of body weight of the cow. Concentrates are usually provided according to amount of milk production. Sick & pregnant animals are provided separate ration in separate manger. Calves are usually provided milk from dam & then milk replacer when needed. This farm has no grazing system. They use stall feeding system. They provide clean & cool water to their cattle.Though all the hygienic measures are not properly maintained in this farm but they practiced some essential measures such as they use disinfectant before milking, Segregate milk harvested from sick or treated animals for appropriate disposal, Avoid contaminants in milk, Prepare animals for hygienic milking Use suitable, well maintained and clean equipment for milking and milk storage, properly clean the farm premises & use disinfectant on it. They properly maintain waste & carcass disposal activities.In this farm they usually practice hand milking system. They use separate milking record for each cow. Two times daily they have to practice milking their cow. After complete milking they sell their daily produced milk to Fulkoli & other sweetmeat shop.

Dataset was taken 250 days from February 2015 to October 2015.The available genotype was crossbred (Holstein-Friesian×Local). The dataset used for analyses included information from 2 first, 16 second, 6 third,13 fourth , 6 fifth ,3 sixth,4 seventh lactations of 50 cows.

Milk recording was performed from daily record book of farm. The daily milk yield was estimated by adding the morning (AM) and evening (PM) milk yield.

**Actual milk yield:** The actual 210 days milk yield per cow was calculated at seven days interval. The mean and standard error for 210 days milk yield of Holistein- Friesian × Local cows were analysed using PROG GLM of SAS (2012).

**Models for the lactation curve:** Following two lactation curve models were used to predict the 210 days milk yield from the milk recording :

 1. Polynomial : Y= a +bx +cx2

 2. Wood (Wood 1967) : Y= axb e-cx

Where ,Y is milk yield (kg day-1 ) , x is the days in milk and a,b,c and d are co-efficient that define the shape of the lactation curve.

**Statistical analysis:** The Wood model was log linear transformed ;then for the Wood model and quadratic polynomial regression equation, the test day milk yield was set as dependent variable and days in milk was as independent variable for obtained the model parameters. The model was analysed by using Proc linear of SAS ( SAS, 2012). Along with the model parameters the fit statistics ,R2 (co-efficient of determinants), CV (coefficient of variation) and RMSE (Root mean square error) were also obtained by using SAS analysis. The predicted milk yields were obtained by using the model parameter with days in milk as independent variables. To obtain different mean value of different components (model co-efficient, fit statistics and predicted 210 days milk yields), the linear mixed procedure of SAS (2000) was used in the following model:

 Yijk =µ + Ti + Aj + eijk

Where, Yijk represents the value of predicted milk yield, a, b, c, d, k and fit statistics:

µ = Mean of the data

Ti = Effect of the ith time (month)

Aj = Effect of the jth Age (Year)

eijk = Random residual effect distributed as N (0,ơ2)

 The differences of model co-efficient, predicted milk yield and fit statistics were tested with the probability value of p≤0.5.



 **FIG: 1; Entrance of farm FIG: 2; Milking procedure**

****

**FIG: 3 ; Packaging process FIG:4; Record keeping system**

Chapter-III

Results

Different traits of crossbred cows according to time (month) and age under intensive farming condition is presented in Table 1. From Table 1, it can be seen that the average milk yield is highest at September month which was 13.68 liter and lowest milk yield at June month with 10.8 liter per cow per day. In May, milk yield was highest at lactation1 (15.1±0.7 liter) and lowest at lactation5 (10.17±0.67) liter. In June, milk yield was highest at lactation 1(14.01±0.7 liter) and lowest at lactation 6(7.04±0.64) liter and milk yield was 10.84 liter per cow per day. In the month of September the milk yield was highest at lactation5 (15.14±0.7 liter) and lowest at lactation1 (11.5±0.64) liter and average milk yield was 13.68 liter. In October, milk yield was highest at lactation1 (15.017±0.7 liter) and lowest at lactation5 (10.17±0.67) liter and milk yield was 12.45 liter. There are some irregularity in milk yield which is occurred due to feeding, environmental condition and farm management.

 From Table 1, it can be seen that there was a relation between lactation number and calving interval. Calving interval was worse for lactation7 (3.9±1.03 years) and better for lactation5 (3.05±1.7 years). There was also a relation between age at first calving and lactation number. Age at first calving at lactation6 was 3.67±01.98 years and at lactation7 it was 2.77±1.26 years.

**Fig: 5.** Lactation curve for lactation 2 **Fig: 6.** Lactation curve for lactation 4

 **Fig: 7.** Lactation curve for average milk yield

**Table**-1: Different traits of crossbred cows according to time (month) and age under intensive farming condition.

|  |  |
| --- | --- |
|  |  **MONTH** |
| **TRAIT** |  **MAY** |  **JUNE** |
| **AGE** | **3.5y** | **4.5y** | **6.0y** | **7y** | **8.5y** | **9.5y** | **10.5y** | **AVG** | **3.5y** | **4.5y** | **6.0y** | **7y** | **8.5y** | **9.5y** | **10.5y** | **AVG** |
| **LAC 1**  | **LAC 2** | **LAC 3** | **LAC 4** | **LAC 5** | **LAC 6** | **LAC 7** | **LAC 1**  | **LAC 2** | **LAC 3** | **LAC 4** | **LAC 5** | **LAC 6** | **LAC 7** |
| **CI (Yr)** | - | 3.5 | 3.17 | 3.15 | 3.05±1.07 | 3.4±1.03 | 3.1±1.034 | 3.23 | - | 3.5 | 3.17 | 3.25 | 3.05±1.07 | 3.4±1.03 | 3.9±1.03 | 3.23 |
| **MY (kg)** | 15.17 ±0.7 | 11.91 ±0.27 | 12.44 ± 0.23 | 13.97 ± 0.97 | 10.17 ± 0 .67 | 10.64 ±1.25 | 12.72 ±1.11 | 12.43 | 14.01±0.7 | 9.92±0.23 | 11.07±0.37 | 12.57±0.17 | 10.86±1.22 | 7.04±0.64 | 10.38±1.05 | 10.84 |
| **AFC (Y)** | 2.80 ±1.67 | 3.42 ±1.98 | 3.67 ±1.98 | 2.77 ±1.26 | 3.3 ±1.27 | 3.97 ± 2.12 | 3.5 | 3.35 | 2.80 ±1.67 | 3.42 ±1.98 | 3.67 ±1.98 | 2.77 ±1.26 | 3.3 ±1.27 | 3.97 ± 2.12 | 3.5 | 3.35 |

Here: CI= calving interval, MY= milk yield, AFC=age at first calving, LAC= lactation, Y= year, AVG= average.

|  |  |
| --- | --- |
|  |  **MONTH** |
| **TRAITS** |  **September** |
| **AGE**  |  | **AVG** | **3.5y** | **4.5y** | **6.0y** | **7y** | **8.5y** | **9.5y** | **10.5y** | **AVG** |
| **LAC 1**  | **LAC 2** | **LAC 3** | **LAC 4** | **LAC 5** | **LAC 6** | **LAC 7** |
| **CI (Yr)** |  | 3.65 | - | 3.5 | 3.17 | 3.25 | 3.05±1.07 | 3.4±1.03 | 3.9±1.03 | 3.31 |
| **MY(Kg)** |  | 11.7 | 11.5 ±0.74 | 11.7 ±0.42 | 11.9 ± 0.37 | 14.3 ±0.36 | 15.14 ±0.34 | 15.13 ± 1.62 | 15.12±0.5 | 13.68 |
| **AFC(yr)** |  | 3.7 | 2.80 ±1.67 | 3.42 ±1.98 | 3.67 ±1.98 | 2.77 ±1.26 | 3.3 ±1.27 | 3.97 ± 2.12 | 3.5 | 3.35 |

Continuation of Table 1……..

|  |  |
| --- | --- |
| **TRAITS** |  **OCTOBER** |
| **AGE** | **3.5y** | **4.5y** | **6.0y** | **7y** | **8.5y** | **9.5y** | **10.5y** | **AVG** |
| **LAC 1**  | **LAC 2** | **LAC 3** | **LAC 4** | **LAC 5** | **LAC 6** | **LAC 7** |
| **CI** | - | 3.5 | 3.17 | 3.25 | 3.05±1.07 | 3.40±1.03 | 3.9±1.03 | 3.31 |
| **MY** | 15.17±0.7 | 11.91±0.27 | 12.44 ±0.23 | 13.97 ±0.97 | 10.17 ± 0 .67 | 10.64±1.25 | 12.72±1.11 | 12.45 |
| **AFC** | 2.80 ±1.67 | 3.42±1.98 | 3.67 ±1.98 | 2.77 ±1.26 | 3.3 ±1.27 | 3.97 ± 2.12 | 3.5 | 3.35 |

**Table 2:** Estimated model parameter, fit statistics and the predicted milk yield of two models for crossbreed cows under intensive farming condition.

|  |  |  |  |
| --- | --- | --- | --- |
| **MODEL** | **PARAMETER** |  MONTH |  |
|  MAY |
| **3.5 yr** | **4.5 yr** | **6.0 yr** | **7 yr** | **8.5 yr** | **9.5 yr** | **10.5 yr** |  |
|  **POLYNOMIAL**  | **A** | 12.94±7.9 | 12.94±7.9 | 12.94±7.9 | 12.94±7.9 | 12.94±7.9 | 12.94±7.9 |  2.94±7.9 |
| **B** | -0.05±2.73 | -0.05±2.73 | 0.05±2.73 | -0.05±2.73 | 0.05±2.73 | -0.05±2.73 | 0.05±2.73 |
| **C** | .0009 | .0009 | .0009 | .0009 | .0009 | .0009 | .0009 |
| **R2** | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 | 0.024 |
| **CV** | 14.85±4.14 | 14.85±4.14 | 14.85±4.14 | 14.85±4.14 | 14.85±4.14 | 14.85±4.14 | 14.85±4.14 |
| **Root MSE** | 1.85±9.93 | 1.85±9.93 | 1.85±9.93 | 1.85±9.93 | 1.85±9.93 | 1.85±9.93 | 1.85±9.93 |
| **AMY** | 378.95 | 339.14 | 297.83 | 411.01 | 361.51 | 254.39 | 359.13 |
| **P MY** | 594.94 | 594.94 | 594.94 | 594.94 | 594.94 | 594.94 | 594.94 |
|  **WOOD MODEL** | **A** | - | - | - | -3.41 | -3.41 | -3.41 | -3.41 |
| **B** | - | - | - | 1.35 | 1.35 | 1.35 | 1.35 |  |
| **C** | - | - | - | -.006 | -.006 | -.006 | -.006 |
| **R2** | - | - | - | .027 | .027 | .027 | .027 |
| **CV** | - | - | - | 7.835 | 7.835 | 7.835 | 7.835 |
| **Root MSE** | - | - | - | 0.194 | 0.194 | 0.194 | 0.194 |
| **AMY** |  |  |  | 411.01 | 361.51 | 254.39 | 359.13 |  |
| **P MY** | - | - | - | 259.86 | 259.86 | 259.86 | 259.86 |

|  |
| --- |
| Continuation of Table 2……. |
| **MODEL** | **PARAMETER** | **MONTH** |
|  **SEPTEMBER** | **OCTOBER** |
| **3.5 yr** | **4.5 yr** | **6.0 yr** | **7 yr** | **8.5 yr** | **9.5 yr** | **10.5 yr** | **3.5 yr** | **4.5 yr** | **6.0 yr** | **7 yr** | **8.5 yr** | **9.5 yr** | **10.5 yr** |
|  **POLYNOMIAL**  | **a** | 43.13±3.31 | 43.13±3.31 | 43.13±3.31 | 43.13±3.31 | 43.13±3.31 | 43.13±3.3 | 43.13±3.3 | 57.55±1.6 | 57.55±1.6 | 57.55±1.6 | 57.55±1.6 | 57.55±1.6 | 57.55±1.6 | 57.55±1.6 |
| **b** | -.42±0 | -.42±0 | -.42±0 | -.42±0 | -.42±0 | -.42±0 | -.42±0 | -.5±2.59 | -.5±2.59 | -.5±2.59 | -.5±2.59 | -.5±2.59 | -.5±2.59 | -.5±2.59 |
| **c** | 0.0014±5.0 | 0.0014±5 | 0.0014±5.0 | 0.0014±5.05 | 0.0014±5.0 | 0.0014±5 | 0.0014±5 | .001±5.05 | .001±5.05 | .001±5.05 | .001±5.05 | .001±5.05 | .001±5.05 | .001±5.05 |
| **R2** | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.013±6.81 | 0.013±6.81 | 0.013±6.8 | 0.013±6.81 | 0.013±6.81 | 0.013±6.81 | 0.013±6.81 |
| **CV** | 17.82±7.9 | 17.82±7.9 | 17.82±7.9 | 17.82±7.9 | 17.82±7.9 | 17.82±7.9 | 17.82±7.9 | 16.37 | 16.37 | 16.37 | 16.37 | 16.37 | 16.37 | 16.37 |
| **RMSE** | 2.029±1.03 | 2.029±1.03 | 2.029±1.03 | 2.029±1.0 | 2.029±1.03 | 2.029±1.0 | 2.029±1.0 | 1.846±0.93 | 1.846±0.93 | 1.846±0.9 | 1.846±0.93 | 1.846±0.93 | 1.846±0.93 | 2.029±1.03 |
| AMY | 378.95 | 339.14 | 297.83 | 411.01 | 361.51 | 254.39 | 359.13 | 378.95 | 339.14 | 297.83 | 411.01 | 361.51 | 254.39 | 359.13 |
| **P MY** | 601.45 | 601.45 | 601.45 | 601.45 | 601.45 | 601.45 | 601.45 | 696.32 | 696.32 | 696.32 | 696.32 | 696.32 | 696.32 | 696.32 |
|  | **a** | - | - | 5.56 | 5.56 | 5.56 | 5.56 | 46.84 | 46.84 | 46.84 | - | - | - | - | - |
| **b** | - | - | -0.95 | -0.95 | -0.95 | -0.95 | -10.4 | -10.4 | -10.4 | - | - | - | - | - |
| **c** | - | - | .009 | .009 | .009 | .009 | 0.055 | 0.055 | 0.055 | - | - | - | - | - |
| **R2** | - | - | .0015 | .0015 | .0015 | .0015 | 0.0054 | 0.0054 | 0.0054 | - | - | - | - | - |
| **CV** | - | - | 19.47 | 19.47 | 19.47 | 19.47 | 7.89 | 7.89 | 7.89 | - | - | - | - | - |
| **RMSE** | - | - | .452 | .452 | .452 | .452 | .184 | .184 | .184 | - | - | - | - | - |
| **AMY** | - | - | 297.83 | 411.01 | 361.51 | 254.39 | 359.13 | 378.95 | 339.14 |  |  |  |  |  |
| **P MY** | - | - | 531.92 | 531.92 | 531.92 | 531.92 | 531.92 | 613.4 | 613.4 | 613.4 | 613.4 | 613.4 | 613.4 | 613.4 |

Here: a=intercept, b= shape of curve, c= placement of the curve, R2= Co-efficient of determination, RMSE= Toot Mean Square Error, CV= co-efficient of variation, AMY= actual milk yield, PMY=predicted milk yield

**Actual and predicted milk yield:** The mean value along with their Standard Error (SE) of actual milk yield of crossbreed (Holistein –Friesian × local) in a Mollah dairy farm is presented in Table 2. The Predicted Milk Yield (PMY) and Actual Milk Yield (AMY) for different models were varied with lactation number, season, age of first calving, and calving interval (Table 2). From Table 2, it can be seen that the highest milk production was 411.01 liter and lowest milk production was 354.39 liter. For the Wood model, the actual lactation yield was calculated from the raw data was not close to that of the PLMY. The PLMY for seven days interval fitting after Wood model were different with the changes of month.

**Use of models to predict milk yield:** The mean value of the estimated model parameters ( a Intercept, b Shape of the curve, c Placement of the curve); fit statistics ( R2: Co-efficient of determinant, RMSE: Root Mean Square Error, CV: Co- efficient of variation) and Predicted Milk Yield for two models along with their standard error for different traits were shown in Table 2. The model parameters a, b and c are different for the changes of month, age and lactation number.

In Polynomial model, a, b and c were different for different month but same within a month. In this model the highest Actual Milk Yield was 411.01 liter and highest Predicted Milk Yield was 696.32 liter. Here, Predicted Milk Yields were same for specific month but this value differ from month to month. Actual Milk Yields were different among month but same for the same age and lactation number.

 Chapter-IV

 Discussion

From the study it has been observed that the highest 210 days milk yield was found in Holistein Friesian× Local genotype in the Mollah dairy farm. The variation was due to the effect of feeding and also due to the effect of different environment surrounding both the farms. The higher production could be due to the effect of genotypes and environment interactions in that particular farm. Rehman et al (2008) 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; Perochon et al,1996).

The model parameters a ,b and c for different models were varied among month within the model and also between the models. The differences of model parameters were differed due to the differences in season were previously reported by other workers (Khan et al, 2012).

There was a variation in predicted lactation milk yield among the different season under intensive farming condition. For Polynomial model, the lactation yield varied with different month. For the Wood model, the predicated lactation yield was also varied with the change of month. The actual milk yields calculated from the raw data were different for different age, lactation number but same for all month. Finding of Alam et al.(2009) and Khan et al(2012) were similar to the results of the study.

The model parameters a, b and c for different interval were same for a specific month and varied among month within the models. Three fit statistics (R2, CV and RMSE) values were used to evaluate the model performance. The values of fit statistics varied among different months for same intervals. The smaller value of RMSE was considered to be superior but for R2 and CV the bigger values. The variation of fit of models among different traits may have arisen from differences of test-day yield, the amount of data, the number of test records and the intervals between tests. The effects of the number of test day records and the intervals between tests on the estimation of fit statistics and also their fitting ability, was reported by Tekerli et al.(2000) and Wiggans et al.(2002).

 This study indicated that the Wood model was the most suitable to transform test-day milk yields into a 210 days predicated milk yield for crossbreed based on higher R2 and CV and lower RMSE values. It was seen that one week (7 days) interval test-day milk recording was good fit with actual 210 days yield. However, research is needed with more order polynomials and other non-linear and logistic models for the estimated total yield to confirm the results.

 Chapter-V

 Conclusion

The study was conducted to discuss two mathematical model Polynomial and Wood model and develop lactation curve for different traits like lactation number, age, season, calving interval, age of first calving. For this reason data was collected form Molla dairy farm at 7 days interval from May to October month. Record book of farm was act as data provider. 50 cows were selected for the study. The study indicat that Molla dairy farm is a moderately good farm with average milk production. The management , hygienic measurement is also good. Moreover, there are many errors in results of the mathematical models that can be due to genetic and environmental effect such as feeding, hygienic procedure etc or due to mistakes in record keeping .Futhermore, more research work can be undertaken with different types of dairy cattle under different management schemes with various data levels through applying different models.

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**Biography**

Tamanna Suriya Turna is an intern at Chittagong Veterinary and Animal Sciences University (CVASU), originally from Gazipur, Dhaka. By this December she will receive his Doctor of Veterinary Medicine (DVM) degree with lots of real life experience. She finished her primary, secondary and higher secondary education from school of Chittagong board’s. She has more interest on genetics and biotechnology, microbiology, and epidemiological field area. She is a well rounded individual who lives with passion, dedication, and grace.

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