Biotechnology in Animal Husbandry 34 (1), p 119-126 , 2018 ISSN 1450-9156
Publisher: Institute for Animal Husbandry, Belgrade-Zemun UDC 636.234
https://doi.org/10.2298/BAH1801119L

MILK YIELD PREDICTION BETWEEN BUNAJI HOLSTEIN FRIESIAN CROSS BRED AND HOLSTEIN FRISIAN COWS USING LINEAR, CUBIC AND QUADRATIC MODELS

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Communication

Abstract: The aim of this study was to compare three different models (Linear, cubic and quadratic) to find best model for predicting milk yield. Data originated from the monthly milk yields records of 251 Bunaji Holstein Friesian crossed and Holstein Friesian cows from 2010 to 2015. The daily milk yield data were regressed against time (day of lactation) for individual cow, using the procedure of SAS, (2002). The resulting polynomial regression coefficients (linear, quadratic and cubic) were then subjected to variance of analysis. All models provided an acceptable level of accuracy in predicting milk yield for Bunaji Holstein Friesian crossed and Holstein Friesian cows, but cubic model is observed to be the most suitable with (R^2) values of (0.659, 0.582, 0.810 and 0.621) followed by quadratic model (0.447, 0.516, 0.614 and 0.605) while linear model has the least R^2 values (0.02, 0.496, 0.548 and 0.309) in all the study farms.

Keywords: Bunaji, Holstein Friesian, polynomial regression coefficients, milk yield, Nigeria.

Introduction

In Nigeria, cattle provides more than 90% of the total annual domestic milk output (*Walshe et al., , 1991)* with the White Fulani or 'Bunaji' breed recognized as the principal producer (*Adeneye, 1989*). Unfortunately, the domestic output of about 407,000 metric tons of milk (*Olaloku, 1999*) from an estimated 14 million cattle (*RIM, 1992*) can hardly satisfy the dairy demands of an everincreasing population of Nigerians (*Ibeawuchi et al., 2000*). It is documented that milk yield increases from calving to the peak production, which is attained between 20 and 70 days post-partum, there after decreases smoothly until the end of lactation (*Scott et al., 1996; Val-Arreola et al., 2004*). Knowledge of milk yield in dairy cattle is important for decision making on herd management and selection strategies, and it is also a key element in determining optimum strategies for insemination and replacement of dairy cows *(Olori et al., 1999; Koçak and Ekiz, 2008).* It has been acknowledged that milk yield is influenced by environmental factors such as the herd, year of calving, parity, age and season of calving (*Wood, 1967; Tekerli et al., 2000*). Most of mathematical functions proposed to fit lactation patterns in dairy cattle are mainly aimed at describing the phenomenon. Their basic assumption is that lactation is characterized by a continuous and deterministic component with an increasing phase till a maximum followed by a decreasing slope (*Macciotta et al., 2011*). Early models paid more attention to the deterministic component of the lactation pattern, being essentially aimed at describing average lactation curves of homogeneous groups of animals for management purposes (*Tekerli et al., 2000*). An efficient model was therefore required to unravel the general frame of the process from environmental perturbations and to predict milk yield with good accuracy. No comprehensive study has been carried out concerning milk yield prediction in Bunaji Holstein Friesian and Nigerian Holstein-Friesian dairy cows. Therefore, this study was aimed at comparing the goodness of fit of three models (linear, cubic and quadratic) to predict milk yield of Bunaji Holstein-Friesian and Holstein-Friesian cows in North Central Nigeria using field data from dairy farms.

Materials and methods

The data used for this study originated from the monthly milk yields records of 251 cows of Bunaji (White Fulani) crossed with Holstein Friesian cow and exotic Holstein Friesian cow from 4 dairy farms. The data were collected from 2010 to 2015 and the animals were kept under semi -intensive system with natural and established pasture for grazing. The study farms include National Veterinary Resource Institute Vom and Agric Services and Training Centre in Jos, Farm Fresh Jos (Plateau State) and Nagari farm Keffi (Nasarawa State). Plateau State is situated in the tropical zone, has a near temperate climate with an average temperature of between 18 and 22 °C while the geographical coordinates of Jos are 9.8965^0N and 8.8583^0E. Harmattan winds cause the coldest weather between December and February. The warmest temperatures usually occur in the dry season months of March and April. The mean annual rainfall varies 131.75 cm (52 in) in the southern part to 146 cm (57 in) on the Plateau (Blench 1999). The highest rainfall is recorded during the wet season months of July and August. Nasarawa

State lies within the guinea Savannah region and has tropical climate with moderate rainfall (annual mean rainfall of 1311:75cm) (52 in) with average annual temperature of 28.4 °C (Blench 1999). Nasarawa state is made up of plain lands and hills measuring up to 300ft above the sea level at some points. Keffi town is Local Government Area in Nasarawa State and its headquarters is Keffi and the geographical coordinates are 8.8471^0N and 7.8776^0E. Economic and technical data from two commercial private farms (Farm fresh, Jos and Nagari farm, Keffi) and two government farms (National Veterinary Research Institute, Vom and Agricultural Services and Training Centre, Jos.) were used for the study.

Experimental Procedure

Data used for the study were extracted from records kept for Bunaji (White Fulani) Holstein Friesian cross bred cows and exotic Holstein Friesian cows from 2010 to 2015. The raw data entered into the computer (MS EXEL environment) were average number of cow per farm, number of cows in milk, milk yield (kg/cow in flock/305 days).

Statistical Analysis

Predicting milk yield

The daily milk yield data were regressed against time (day of lactation) for individual cow, using the procedure of *SAS, (2002).* The resulting polynomial regression coefficients (linear, quadratic and cubic) were then subjected to variance analysis (*Allen et al., 1983, Morris 1999*), using GLM procedure of SAS, (2002). The following models equation of polynomial regression was fitted for expressing the regression of daily milk yield against time:

$Y= b_0 + b_1X + e$ 1 (linear model) *equation (i)*

$Y= b_0 + b_1 X + b_2 X^2 + e$ 2 (quadratic model) *equation (ii)*

$Y= b_0 + b_1 X + b_2 X^2 + b_3 X^3 + e$ 3 (cubic model) *equation (iii)*

Y = Milk yield
b_0 = the intercept
X = independent variables (Day of lactation)
b_1, b_2 and b_3 = regression coefficients
e = random error.

The full regression model of the measured milk yield over lactation period (days) was defined as:

$Y = a + b_1X^1 + b_2X^2 + b_3X^3$
where,
Y = dependent or endogenous variable (Milk yield)
a = intercept
b ‘s = regression coefficients
X’s = independent or exogenous variables (lactation period)

Results and Discussion

Milk yield prediction over a period of time is presented in the Tables. The coefficient of determination (R^2) values from the tables for the three models in all the farms were all highly significant (P<0.01). However, the cubic regression model has the highest (R^2) values of (0.659, 0.582, 0.810 and 0.621) followed by quadratic model (0.447, 0.516, 0.614 and 0.605) while linear model has the least R^2 values (0.02, 0.496, 0.548 and 0.309) in all the farms.

Table 1. Prediction of milk yield on day of collection using linear, quadratic and cubic models at ASTC Govt. Farm, Jos

Model	**Equation**	**R^2**	**Adjusted R^2**	**Significance**
Linear	MY= 15.622 – 0.002D	0.02	0.02	**
Quadratic	MY= 8.381 + 0.038D – 0.00003613D^2	0.447	0.446	**
Cubic	MY= 2.355 + 0.103D + 0.000D^2 + 0.0000000913D^3	0.659	0.658	**

MY= milk yield; D= day; R^2= coefficient of determination. ** Significant at P<0.01.

Table 2. Prediction of milk yield on day of collection using linear, quadratic and cubic models at Nagari Farm, Keffi

Model	**Equation**	**R^2**	**Adjusted R^2**	**Significance**
Linear	MY= 2.995 + 0.004D	0.496	0.495	**
Quadratic	MY= 3.376 + 0.001D + 0.000003994D^2	0.516	0.515	**
Cubic	MY= 4.181– 0.012D + 0.00004609 D^2 – 0.00000003713D^3	0.582	0.580	**

MY= milk yield; D= day; R^2= coefficient of determination. ** Significant at P<0.01.

Table 3. Prediction of milk yield on day of collection using linear, quadratic and cubic models at Farm Fresh, Jos, Plateau State

Model	Equation	R^2	Adjusted R^2	Significance
Linear	MY= 11.067 + 0.031D	0.548	0.545	**
Quadratic	MY= 10.016 + 0.073D + 0.000D^2	0.614	0.609	**
Cubic	MY= 12.193 – 0.099D + 0.003D^2 – 0.00001265D^3	0.810	0.806	**

MY= milk yield; D= day; R^2= coefficient of determination. ** Significant at P<0.01.

Table 4. Prediction of milk yield on day of collection using linear, quadratic and cubic models at National Veterinary Research Institute, Vom, Jos

Model	Equation	R^2	Adjusted R^2	Significance
Linear	MY= 5.220 – 0.013	0.315	0.309	**
Quadratic	MY= 4.318 + 0.035D + 0.000D^2	0.605	0.598	**
Cubic	MY= 4.571 + 0.009D + 0.000D^2 –0.000003609D^3	0.621	0.610	**

MY= milk yield; D= day; R^2= coefficient of determination. ** Significant at P<0.01.

It can be said that the models were adequate for predicting milk year over a period of time but cubic model was the best predictor of milk yield, on day of collection compared to quadratic and linear regression models. *Birol-Dag et al, (2006)* reported that estimated total milk yield according to the cubic model was very close to total milk yield calculated by the Fleischmann method. However, differences between models were not statistically significant. The findings of this study is also in line with the report of (*Cankaya et al., 2014*) who noted that cubic regression model gave best values when comparing with other models for the first lactation curve of jersey cows. *Yakubu et al., (2013)* also reported that cubic model appeared to produce better goodness of fit when traits are considered singly. The result also agreed with the report of *Druet et al., (2003*) and *Silvestre et al., (2006)* who used the Wood models and cubic spline regression models for modeling lactation curves. Also, *White et al., ,(1999), Sahin and Efe, (2010); Nicolo et al., (2010); Koncagul and Yazgan, (2011); Geha et al., (2011)* used cubic spline regression for modeling of lactation curves of dairy cattle and all reported that cubic model produce a better fit when compared to other models.

Conclusion

All the three models could be used in predicting milk yield over time but cubic regression model gave a best fit in predicting of milk yield, on day of collection compared to quadratic and linear regression models.

Predviđanje prinosa mleka meleza bunaji holštajn - frizijskih i holštajn-frizijskih krava koristeći linearne, kubične i kvadratne modele

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Rezime

Cilj ove studije bio je upoređivanje tri različita modela (linearni, kubični i kvadratni) kako bi se pronašli najbolji modeli za predviđanje prinosa mleka. Podaci potiču iz mesečne evidencije prinosa mleka 251 krava meleza Bunaji i holštajn-frizijske rase i holštajn-frizijskih krava od 2010. do 2015. godine. Dnevni podaci o prinosu mleka su se regresirani prema vremenu (dan laktacije) za pojedinačnu kravu, koristeći proceduru *SAS (2002).* Rezultujući polinomski regresioni koeficijenti (linearni, kvadratni i kubični) potom su podvrgnuti varijansi analize. Svi modeli daju prihvatljiv nivo preciznosti u predviđanju prinosa mleka za meleze Bunaji i holštajn-frizijske rase i holštajn-frizijske krave, ali je kubni model najprikladniji sa (R^2) vrednostima (0.659, 0.582, 0.810 i 0.621), a zatim kvadratni model (0.447, 0.516, 0.614 i 0.605), dok linearni model ima najmanje vrednosti R^2 (0.02, 0.496, 0.548 i 0.309) na svim ispitivanim farmama.

Ključne reči: Bunaji, holštajn-frizijska rasa, polinomski regresioni koeficijenti, prinos mleka, Nigerija.

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Received 30 January 2018; accepted for publication 23 March 2018