



Prediction of lifetime milk production in synthetic crossbred cattle strain Vrindavani of North India

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ABSTRACT

Ten-year data records on growth (birth weight-BWt), five initially reproductive traits (age at first calving-AFC, first dry period-FSP, first dry period-FDP, first calving interval-FCI and first lactation length-FLL) along with the part lactation records of 100, 170 and 240days of first lactation (my100_1, my170_1 and my240_1) and second lactation (my100_2, my170_2 and my240_2) and their respective total milk yields (total lactation milk yield of first lactation-TLMY1 and total lactation milk yield of second lactation-TLMY2) were used to predict LTMY5 (lifetime milk yield as total milk yield up to 5 lactations) and LTMY4 (lifetime milk yield as total milk yield up to 4 lactations).

It was observed that first calving interval (FCI) happens to be important predictor (out of initially expressed growth – birth weight(BWt), reproductive traits- AFC, FSP, FDP, FCI, FLL and first lactation milk traits- my100_1, my170_1, my240_1 and TLMY1) for lifetime prediction (both LTMY4 and LTMY5). Prediction of LTMY4 and LTMY5 with respect to initial growth (birth weight), reproductive traits (AFC, FSP, FDP, FCI, FLL) and first 2 lactations (my100_1, my170_1 my240_1, TLMY1, my100_2, my170_2 my240_2 and TLMY2) indicated the contribution of my240_2 followed by TLMY1 and my170_2. They jointly explained 40.32% variation in estimated value of LTMY4. However, prediction of LTMY5, with respect to these predictors showed my240_2 together with FLL jointly explained 26.71% variation in estimated value.

Key words: Vrindavani cattle, Lifetime milk production, Part lactation

India with 199.08 million heads of cattle (33.06 million crossbreds and 166.02 million indigenous) and 105.34 million heads of buffaloes (BAHS 2010) is the largest producer of milk among the countries of the world (112.5 million tones during 2009–10). The contribution of agriculture to total gross domestic product has declined (34.72% in 1980–81 to 10.99% in 2008–09) whereas the livestock sector has also decreased slightly from 4.82% (1980–81) to 3.26% (2008–09; GOI 2010). However, the contribution of livestock sector to agricultural GDP has increased from 13.88% (1980–81) to 29.64% (2009–09, GOI 2010). This indicated towards the importance of livestock sector in the Indian agriculture. As per the economic survey for 2011–12, the country's per capita milk availability in 2009–10 was at 263 g/day still below the world average of 279.4 g/day (PTI, February 25, 2011-ProfitNDTV.com).

Panda *et al.* (2006), predicted total milk yield based on most frequent daily milk yield and highest daily milk yield

(of a month in Sahiwal cows with accuracy. Malhotra and Singh (1980) predicted lifetime production (total milk yield in the first 3 lactations) for Red Sindhi cows on the basis of traits available in early life. Puri and Sharma (1965) studied first lactation yield and age at first calving on lifetime production and determined the relative importance of them for selection purposes in Red Sindhi and crossbred cows. They have taken yield up to 5 lactations. Prediction of lifetime milk production using artificial neural network and multiple regressions was also carried out in Sahiwal cattle (Gandhi *et al.* 2000); the traits involved were age at first calving, first lactation 305-day or less yield, first lactation length, first service period and first dry period. Shinde *et al.* (2010) predicted lifetime milk production up to third lactation in Phule Triveni cows. Vrindavani cattle, synthetic a crossbred cattle strain of India developed at IVRI, has exotic inheritance of Holstein-Friesian, Brown Swiss, Jersey and indigenous inheritance of Haryana cattle (Singh *et al.* 2011). Lifetime production is an important economic parameter when defining the breeding objectively. Gugger *et al.* (2007) used lifetime production (LP, production to sixth lactation) and productive life (PL, number of completed lactations) to obtain daughter averages to estimate heritabilities in cattle

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populations in Switzerland. The importance raises the question of whether the performance of a cow in subsequent lactations is repetitive enough genetically. Performance in first lactation can contribute useful information also about later lactations. In this study, it was aimed to find out the lifetime milk yield prediction models to be used as tools to evaluate the potential of Vrindavani cattle for selection.

MATERIAL AND METHODS

The present study was undertaken on Vrindavani cattle maintained at cattle and buffalo farm, Indian Veterinary Research Institute, Izatnagar, India. Data from 1999 to 2009 (ten-year) on growth (birth weight- BWt), 5 initially expressed reproductive traits (age at first calving-AFC, first dry period-FSP, first dry period-FDP, first calving interval-FCI and first lactation length-FLL) along with the part lactation records of 100, 170 and 240days of first lactation (my100_1, my170_1 and my240_1) and second lactation (my100_2, my170_2 and my240_2) and their respective total milk yields (total lactation milk yield of first lactation-TLMY1 and TLMY2) of cattle having more than 99days FLL, were used in the study. Total milk yield up to 4 lactations (LTMY4) and up to 5 lactations (LTMY5), were taken as life time production (Puri and Sharma 1965, Gugger *et al.* 2007, Shinde *et al.* 2010).

Step-wise regression analysis for LTMY4 and LTMY5 with 5 initially expressed traits, viz. BWt, AFC, FDP, FSP, FCI, FLL, and part days milk yield (100, 170 and 240 days) of first lactation and first 2 lactations (BWt, AFC, FLL, FCI, FSP, FDP, my100_1, my170_1, my240_1, TLMY1, my100_2, my170_2, my240_2, TLMY2) as predictors, was done using Proc Reg procedure of SAS 12.0. In step-wise procedure, criterion of significance at 5% was fixed. Prediction equation was evolved on the basis of per cent variation explained in predicted variable (R^2) together with Cp-statistics and Fit diagnostics of the model Mallows' (1973; SAS Institute Inc. 2009).

Nine mathematical models (linear, logarithmic, inverse, quadratic, cubic, power, compound, S-curve, growth and exponential) were evolved for lifetime milk yield (LTMY4 and LTMY5) with most important initially expressed growth, reproduction and milk production traits as indicated by stepwise regression analysis as predictors based on significance level ($P < 0.01$) (Draper and Smith 1966 –SPSS 12.0).

RESULTS AND DISCUSSION

Lifetime production (LTMY4)

On the basis of first-lactation data: Step-wise regression analysis for LTMY4 with respect to BWt, AFC, FLL, FCI, FSP, FDP, my100_1, my170_1, my240_1, tlm1, could retain first calving interval (FCI) as lone predictor (when significance level was fixed at 5%) and explained 11.63% variation in estimated value of LTMY4. All variables left in

the model are significant at the 0.1500 level.

$$\text{LTMY4} = 10120 + 6.31745^{**} \text{FCI}; R^2 = 11.63\%; \text{Adj. } R^2 = 10.05\% \text{ and } Cp = 1.9357$$

*,significant of coefficient ($P < 0.05$) **,significant of coefficient ($P < 0.01$)

Curve estimation shows appropriateness of quadratic function in prediction of LTMY4 with FCI as predictor and could explain 20.30% in estimated values (Fig. 1)

$$\text{LTMY4} = 4234.61 + 24.3589 (\text{FCI}) - 0.0137 (\text{FCI})^2; R^2 = 20.30\%$$

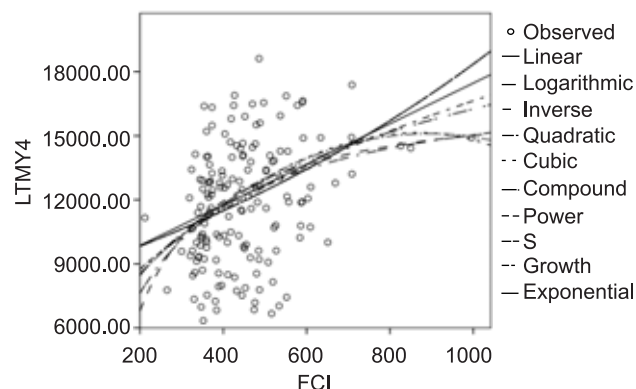


Fig. 1. Predicted versus Observed Lifetime Milk Yield (LTMY4) in Vrindavani Cattle.

On the basis of first two lactation records: Stepwise regression analysis for LTMY4 with respect to BWt, AFC, FLL, FCI, FSP, FDP, my100_1, my170_1, my240_1, TLMY1, my100_2, my170_2, my240_2, TLMY2, could retain part total milk yield at 240 days of second lactation (my240_2) together with first lactation milk yield (TLMY1) and part total milk yield at 170 days of second lactation (my170_2) as predictors and jointly explained 40.32% variation in estimated value. The my240_2 was the main contributor (21.625) followed by TLMY1 (12.55%) and my170_2 (6.15%) respectively.

$$\text{LTMY4} = 6702.109 + 0.96292^{**} \text{TLMY1} - 3.46840^{*} \text{my170}_2 + 4.23887^{**} \text{my240}_2; R^2 = 40.32\%; \text{Adj. } R^2 = 36.59\%$$

Fit diagnostics for LTMY4 shows appropriateness of the model. Examination of residual plots indicated that residuals appear to be a random scatter around a zero reference line and display no heteroscedasticity. The quantile plot and histogram of residuals shows no problem with the normality assumption. The plot of the observed values versus the predicted values indicate a good fit for the model. The Fit-mean residual plot indicates the model accounts for a good deal of the variability in the LTMY4 (Fig. 2).

Lifetime production (LTMY5)

First lactation data: Step-wise regression analysis for LTMY5 with respect to BWt, AFC, FLL, FCI, FSP, FDP, my100_1, my170_1, my240_1, tlm1, could retain first calving interval (FCI) as lone predictor (when significance

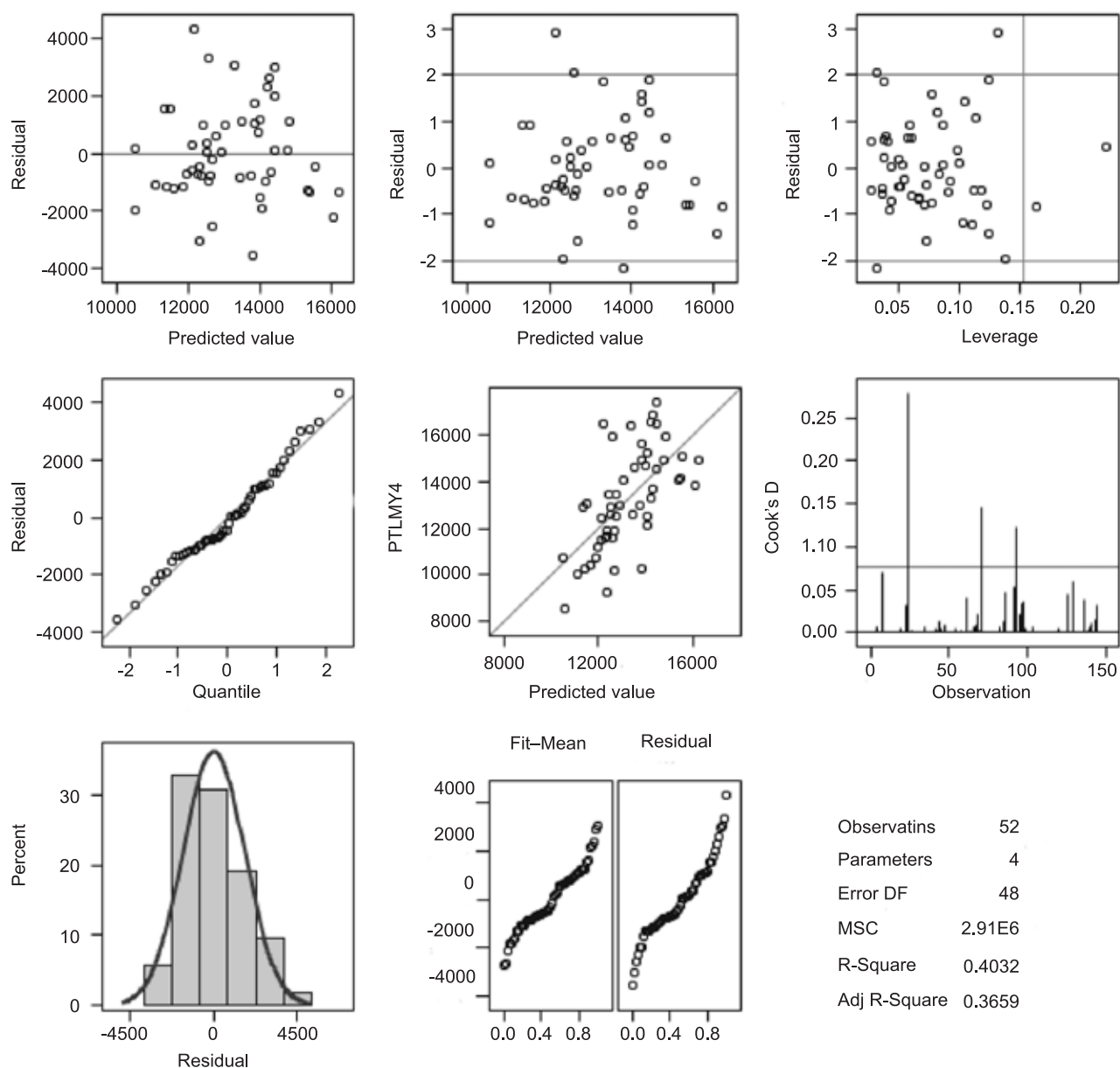


Fig. 2. Fit diagnostics plots for lifetime milk yield: LTM4.

level was fixed at 5%) and explained 9.96% variation in estimated value. All variables left in the model are significant at the 0.1500 level.

$LTM5 = 12677 + 7.75544 * FCI$, $R^2 = 9.96\%$; Adj. $R^2 = 8.35\%$ and $C_p = -2.3411$

Curve estimation shows appropriateness of quadratic function in prediction of LTM5 with FCI as predictor and could explain 16.10% in estimated values (Fig. 3).

$LTM5 = 7799.26 + 21.6363 (FCI) - 0.0098 (FCI)^2$; $R^2 = 16.10\%$

First two-year records: Step- wise regression analysis for LTM5 with respect to BWt, AFC, FLL, FCI, FSP, FDP, my100_1, my170_1, my240_1, TLMY1, my100_2, my170_2, my240_2, tmy2, could retain part total milk yield at 240 days of second lactation (my240_2) together with first

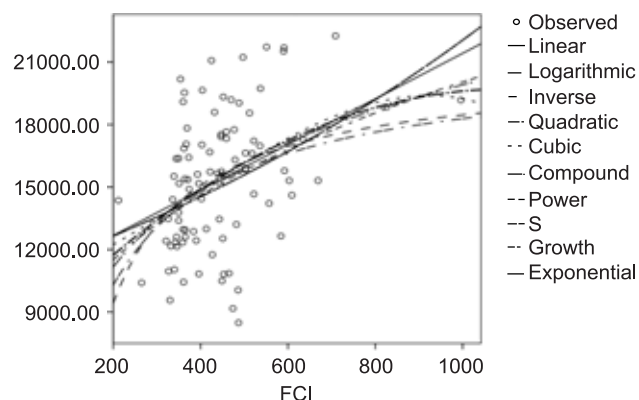


Fig. 3. Predicted versus observed lifetime time milk yield (LTM5) in Vrindavani cattle

lactation length (FLL) as predictors and jointly explained 26.71% variation in estimated value. The my240_2 was the main contributor (18.74%) followed by FLL (7.97%) respectively.

$$\text{LTM Y5} = 6706.13935 + 14.47479 * \text{FLL} + 2.02141 ** \text{my240_2}$$

$$R^2 = 26.71\%; \text{Adj. } R^2 = 23.71\%$$

Fit diagnostics for LTM Y5 showed appropriateness of the model as has been indicated for LTM Y4 (Fig. 4).

Puri and Sharma (1965) studied lifetime prediction models in Tharparkar, Sahiwal, and Red Sindhi breeds and one-half Jersey $\times$ one-half Thari crossbred cows and found good precision of accuracy based on first lactation yield and age at first calving. In present study first calving interval (FCI) found to be important predictor for both LTM Y4 and LTM Y5

explaining 20.30 and 16.10% in the estimated values, as quadratic model. This implies that the early expressed traits had an important role in assessment of lifetime milk yield. Gandhi *et al.* (2009) also find appropriateness of age at first calving (AFC), first lactation 305 day or less milk yield (FL305DMY), first lactation length (FLL), first service period (FSP) and first dry period (FDP) and full models explained 25.92% variation in the estimated values. In the present study, based on initial growth, reproduction traits and first two year part-lactation records and respective total milk yield as predictors, found part total milk yield at 240 days of second lactation (my240_2) together with first lactation milk yield (LTM Y1) and part total milk yield at 170 days of second lactation (my170_2) explained 40.32%

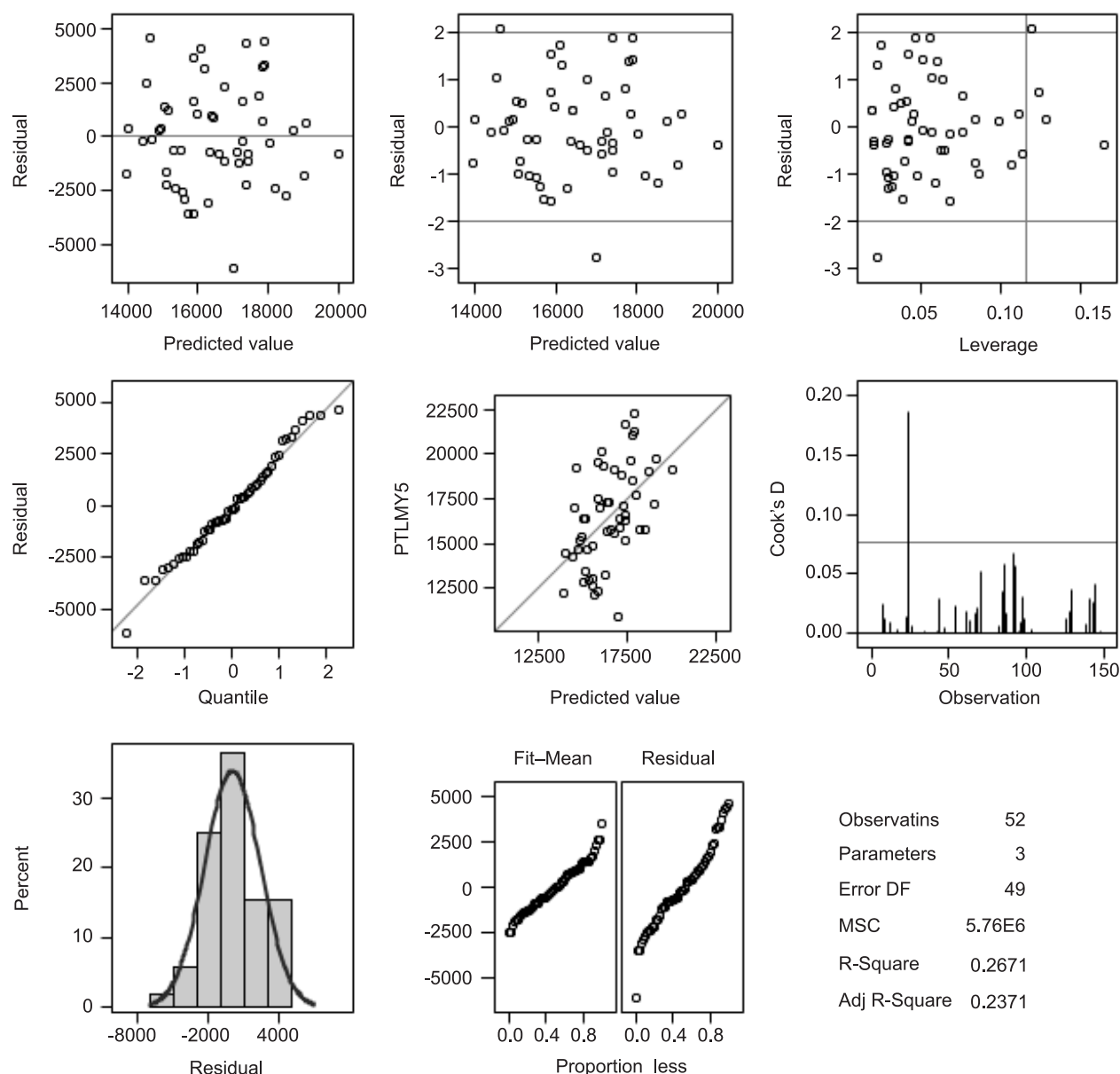


Fig. 4. Fit diagnostics plots for lifetime milk yield: LTM Y5.

variation in estimated value of LTMY4. However in LTMY5, part total milk yield at 240 days of second lactation (my240_2) together with first lactation length (FLL) jointly explained 26.71% variation in estimated value.

Based on these findings it is concluded that the models $LTMY4 = 4234.61 + 24.3589 (FCI) - 0.0137 (FCI)^2$, $LTMY4 = 6702.109 + 0.96292 TLMY1 - 3.46840 my170_2 + 4.23887 my240_2$, $LTMY5 = 7799.26 + 21.6363 (FCI) - 0.0098 (FCI)^2$ and $LTMY5 = 6706.13935 + 14.47479 FLL + 2.02141 my240_2$, can be used as tool for early selection of crossbred cattle.

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