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RESEARCH ARTICLE

Prediction of lifetime milk yield and breeding values of sire in Frieswal cattle

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Abstract: Lifetime milk yield (LTMY) is a crucial economic trait in dairy farming directly affecting farm profitability and sustainability. Identifying high-yielding animals for LTMY at early age is advantageous which can help to select genetically superior animals, optimizing breeding decisions, improving herd productivity and reducing costs associated with low yielding cows. An extensive dataset was analyzed comprising records from 3,425 Frieswal cows and 239 sires over 36 years including 9,094 lactations. The data were obtained from the Military Farm, Pune of Maharashtra state. LTMY was categorized into three groups based on completed lactations viz. LTMY up to three (LTMY3), five (LTMY5) and seven (LTMY7). Prediction models used early life traits such as birth weight, milk yields from the first three lactations and age at first calving to estimate LTMY at different stages of the cow's productive life. Statistical analysis using SAS 9.13 showed highest prediction accuracy for LTMY3 followed by LTMY5 and LTMY7 indicating that early-life production traits are strong indicators of lifetime productivity. Accuracy improved with more lactation records included in the models. These models also estimated sire breeding values, revealing high rank correlations between breeding values predicted using LTMY3 and LTMY5 models and those estimated through BLUP (Best Linear Unbiased Prediction). These findings suggest that early prediction models are valuable tools for dairy farmers and breeders enabling accurate selection of high-yielding animals. Their application could enhance genetic progress, improve herd productivity and contribute to the economic sustainability of dairy farming by ensuring that only the most productive animals are retained for future generations.

Keywords: Breeding values of sire, Frieswal cattle, Lifetime milk yield, Prediction model

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Introduction

India is mainly an agricultural country, contributing about 19.9% to GDP from agriculture with the sector growing by 3.6% in 2020-21 and 3.9% in 2021-22 as reported in the Economic Survey of India (2021-2022). Livestock farming contributes around 25.6% of agricultural GDP with dairy farming being the most significant for nutrition and employment for rural households. As per 20th livestock census, India has approximately 535.78 million livestock including 192.49 million cattle and 109.85 million buffaloes. The country produced 230.6 million tons of milk in 2022-23 but according to the National Dairy Development Board demand is expected to increase million metric tons by 2030. To meet this demand, enhancing dairy productivity is crucial as increasing livestock numbers is challenging due to resource constraints. In this context LTMY is very important trait of dairy cow. Early identification of high-yielding females is vital to achieve the target milk yield. It can be achieved based on the traits which are early expressed during the life of the individual. Early selection of high yielding cows saves cost of rearing the unproductive animals. Similarly, sire evaluation also significantly impacts genetic improvement in dairy herds. Success in sire selection program relies on how accurately & early genetic potential of young bulls is evaluated. Thus, the present investigation aims to create such a prediction models which can estimate LTMY of cows as well as assess breeding values of sires. By integrating early-life production traits it seeks to enhance dairy selection efficiency, genetic progress and support India's milk demand. These models will help dairy farmers and breeders to make informed decisions for sustainable industry development and increased productivity.

Materials and Methods

Source and collection of data

Data were collected from Frieswal cattle maintained at the Military Dairy Farm, Pimpri, Pune from 1983 to 2018 including 9,094 lactation records from 3,425 cows and 239 sires and analyzed using SAS 9.13 for statistical evaluation and modeling.

Location and climatic condition of the farm

The Military Dairy Farm in Pimpri Chinchwad, Pune (18.6121° N, 73.8097° E) has a tropical wet and dry climate with temperatures averaging 21.7°C to 28°C. Annual rainfall is about 100 mm with monsoons (June–September) averaging 262 mm. Humidity varies seasonally from 35% in March to 88% in July and August affecting dairy farming and cattle performance (climate-data.org).

Management practices

The Farm is a well-managed facility run by a retired military officer under the Director General's directives. It maintains optimal animal care with a structured management system. Cows are housed in sheds separately for dry, lactating and advanced pregnant cows. Breeding data and pedigree records are carefully documented. Daily heat detection ensures timely estrus identification and pregnancy checks are performed 45 to 65 days post-insemination for effective reproductive management.

Data standardization

Cows affected by disease, those died before three lactations and sires with fewer than five progenies were omitted. Records were standardized by removing cows with age at first calving over 1250 days, lactation length below 100 days or over 365 days, lactation milk yield below 1000 kg and inter-calving periods under 250 days.

Statistical procedures

Analysis of data like descriptive analysis, estimation of correlation and development of prediction models were carried out using the PROC UNIVARIATE, PROC MEAN, PROC CORR and PROC GLM procedures in SAS 9.13 version, respectively.

Development of prediction models for lifetime milk yield

The lifetime milk yields up to three (LTMY3), five lactations (LTMY5) and seven lactations (LTMY7) were predicted using several independent early traits like birth weight (BW), age at first calving (AFC), first, second and third lactation milk yields (LMY1 and LMY2) etc. The general model used to predict LTMY was

$$Y_{ij} = \mu + X_i + e_{ij} \quad \text{..... (i)}$$

Where, Y_{ij} = Dependent variable lifetime milk yield

μ = Overall mean

X_i = Independent variable/s

e_{ij} = randomly distributed error.

Validation of prediction models

The dataset for LTMY was split into 80% training and 20% testing data for model development and validated in multiple trials. Predicted LTMY values from the training data were compared to actual values from the testing data to assess model accuracy. This was repeated ten times to enhance reliability and reduce biases.

Evaluation of sire

Sire breeding values for LTMY were estimated using both i.e. BLUP Method and prediction models developed for LTMY. Rank correlation between BLUP estimates and model-derived values were calculated to assess model effectiveness. A high correlation suggests the models are reliable for genetic selection in dairy breeding.

Results and Discussion

The descriptive analysis was performed to find out the means and variations and the models for prediction of LTMY3, LTMY5

Table 1: Descriptive statistics for early traits and lifetime milk yield traits

Variable	N	Minimum	Maximum	Mean±SE	C. V. (%)
BW	1229	13.00	40.00	26.26±0.11	14.67
AFC	1597	704.00	1248.00	951.63±3.06	12.86
LMY1	1597	1048.00	4267.00	2617.65±15.40	23.51
LMY2	1589	1308.00	6702.00	3294.50±23.37	28.28
LMY3	1096	1130.00	7458.00	3656.58±35.93	27.88
LTMY3	1581	4111.00	16726.00	9486.66±50.97	21.36
LTMY5	796	7446.00	27068.00	16324.62±117.89	20.38
LTMY7	285	12961.00	33529.00	22210.78±251.82	19.14

(LMY – Lactation milk yield, LTMY – Lifetime milk yield)

and LTMY7 were developed and validated for their prediction ability and the results of analyses are shown in Table 1, 2, 3,4 and 5.

Descriptive analysis using SAS examined the mean and variation of variables. The least-square means for early expressed traits like BW, AFC, LMY1, LMY2 and LMY3 were 26.26 ± 0.11 kg, 951.63 ± 3.06 days, 2617.65 ± 15.40 kg, 3294.50 ± 23.37 kg, 3656.58 ± 35.93 kg. Similarly, for lifetime traits like LTMY3, LTMY5 and LTMY7 the observed least squared means were 9486.66 ± 50.97 kg, 16324.62 ± 117.89 kg and 22210.78 ± 251.82 kg, respectively. Murdia and Tripathi (1991) reported comparatively lower mean of LTMY up to three and four lactations as 12651.40±138.70 kg and 15893±211.52 kg, respectively in Jersey cows. Similarly, Goshu (2005), Guggar et al. (2007), Dash et al. (2018) noted least square means for LTMY as 12749±483 kg, 15768 kg , 15946 ± 256.85 kg in Friesian-Boran crossbred cows, Simmental Swiss Fleckvieh and Red Holstein population, respectively. However, Novakoviæ et al. (2014) observed higher least square means for LTMY as 25002.66 ± 775.53 kg in, Karan Fries cattle.

Pearson's correlation analysis revealed low, non-significant correlations between BW and AFC with LTMY in Frieswal cattle indicating their minimal influence on production. Strong and significant correlations were found between LMY1, LMY2, LMY3 and LTMY traits. Therefore, these variables were included while developing the models for prediction of lifetime milk yield. The correlation of BW with LTMY 3, LTMY5 and LTMY7 was 0.034, 0.019 and 0.012 which indicates that the impact of birth weight goes on reducing with advancement of lactation. Similarly, AFC also has low correlation with lifetime milk yield. This minimal relationship suggests that animals giving birth earlier or later do not significantly vary in their total milk production over their lifetimes, suggesting that other elements might have a greater influence on overall productivity. A weak correlation could be due to the compensatory influences of management practices, nutrition and reproductive efficiency throughout the animal's life. The slight increase in the AFC positively influences persistent milk production while early calving has been shown to adversely affect both milk yield and longevity (Pirlo et al. 2000). The findings of present study align with the work of Dalal

Table 2: Pearson's correlation matrix for early traits and lifetime milk yield traits

	BW	AFC	LMY1	LMY2	LMY3	LTMY3	LTMY5	LTMY7
BW	1.00	0.003	0.092	0.062	0.082	0.034	0.019	0.012
AFC		1.00	0.075	0.011	0.025	0.044	0.017	0.010
LMY1			1.00	0.397**	0.315**	0.658**	0.556**	0.520**
LMY2				1.00	0.471**	0.825**	0.761**	0.707**
LMY3					1.00	0.816**	0.779**	0.709**
LTMY3						1.00	0.915**	0.848**
LTMY5							1.00	0.950**
LTMY7								1.00

**P≤ 0.01 (highly significant)

(BW – Birth weight, AFC- Age at first calving, LMY – Lactation milk yield, LTMY- Lifetime milk yield)

Table 3: Prediction models developed for lifetime milk yield

Trait	Prediction models	R^2 (%)
LTMY3	3834.83 + 2.15 LMY1	43.05
LTMY3	3430.18 + 1.84 LMY2	71.28
LTMY3	1472.40 + 1.17 LMY1 + 1.50 LMY2	81.58
LTMY5	4152.30 + 1.71 LMY2 + 1.83LMY3	77.21
LTMY5	2441.46 + 1.15 LMY1 + 1.40 LMY2 + 1.75 LMY3	80.97
LTMY5	4053.68 + 0.10 AFC + 1.71 LMY2 + 1.83 LMY3	77.21
LTMY5	5029.87 – 43.19 BW + 1.77 LMY2 + 1.83 LMY3	78.41
LTMY5	3378.61 – 34.24 BW + 1.07 LMY1 + 1.47 LMY2+ 1.73 LMY3	81.29
LTMY7	7890.00 + 2.27 LMY2 + 2.08 LMY3	68.75
LTMY7	5959.74 + 1.38 LMY1 + 1.95 LMY2 + 1.92 LMY3	72.31
LTMY7	6138.37 + 1.81 AFC + 2.28 LMY2 + 2.08 LMY3	69.02
LTMY7	8995.99 – 61.31 BW + 2.30 LMY2 + 2.16 LMY3	69.73
LTMY7	6503.02 – 22.18 BW + 1.28 LMY1 + 2.01 LMY2+ 1.94 LMY3	72.45

(LTMY -Lifetime milk Yield, LMY – Lactation milk)

et al. (2004) who found no significant correlation between AFC and LTMY in Hariana cattle. Comparable results were reported by Murdia and Tripathi (1991) in Jersey cattle, Gandhi and Singh (2000) in Murrah buffaloes and Puri and Sharma (1965) in Tharparkar (-0.11), Sahiwal (-0.13) and Red Sindhi (-0.16) cows, respectively. Furthermore, Sawa et al. (2018) identified weak negative correlations (-0.11 to 0.09) between AFC and both LTMY and yield per milking day. These results advocate that while AFC may affect early lactation performance, its overall impact on the lifetime productivity of dairy cattle is limited. The present study revealed a strong positive correlation between early lactation milk yield and lifetime milk yield indicating that animals producing higher milk quantities during early lactation tend to maintain superior milk production throughout their productive life and early lactation performance is a reliable predictor of overall lifetime productivity. A high positive correlation may be attributed to the expression of inherent genetic potential during early lactation. Animals with higher early lactation yields are likely to possess superior set of gene for milk production which continues to be expressed across subsequent lactations. Furthermore, increased initial yields might be the indication of enhanced physiological adaptability, effective metabolic processes and superior udder development, all of which support prolonged milk production over the long period of time.

The prediction models for LTMY3, LTMY5 and LTMY7 were developed. LMY1 as independent variable for LTMY3 had low accuracy while LMY2 showed higher accuracy. The best accuracy for predicting LTMY3 was achieved with combination of LMY1 and LMY2. Similarly, for LTMY5, including BW, LMY1, LMY2 and LMY3 resulted in accuracy of 81.29%, with LMY3 being the most influential. Including BW with LMY2 and LMY3 slightly improved accuracy. The model for LTMY7 with BW, LMY1, LMY2 and LMY3 yielded highest accuracy of selection with LMY2 most impactful. It was observed that additional lactations improved accuracy but AFC and BW had minimal impact on LTMY7. The findings regarding LTMY in this study are consistent with those of several researchers including Murdia and Tripathi (1991) who reported mean LTMY after three and four lactations as 12651.40±138.70 kg and 15893±211.52 kg, respectively in Jersey cows. Similarly, Goshu (2005), Guggar et al. (2007), Dash et al. (2018) and Novakoviæ et al. (2014) reported least square means for LTMY as 12749±483 kg, 15768 kg, 15946±256.85 kg and 25002.66±7755.39 kg in Friesian-Boran crossbred cows, Simmental Swiss Fleckvieh & Red Holstein populations and Karan Fries cattle and high-yielding dairy cows, respectively. Most early milk yield traits (LMY2, LMY3) exhibited a strong correlation with lifetime traits indicating that improvements in these early traits are likely to result in higher LTMY. Puri and Sharma (1965) identified substantial and significant correlations between the yield of the first lactation and the yields from five subsequent lactations in Tharparkar (0.86), Sahiwal (0.83), and Red Sindhi (0.66) cows. Furthermore, Dalal et al. (2004) documented notably high correlations between the LMY1 and LTMY across three lactations (0.77 ± 0.03) and five lactations (0.63 ± 0.04) in Hariana cows. These results underscore that performance during the initial lactation serves as a robust predictor of overall lifetime productivity making it a valuable criterion for early selection and genetic enhancement in dairy cattle.

The predictive accuracy of the models when utilizing LMY1 to estimate LTMY3 was found to be relatively low in comparison to the LMY2. This suggests that the majority of the variability in LTMY3 is more effectively accounted for by LMY2 than by LMY1. Comparatively low predictive capability of LMY1 may be linked to the underdeveloped state of reproductive organs during the first lactation which tends to allocate more energy towards their growth rather than towards milk production. Additionally, early lactation in dairy cows is often marked by a negative energy balance as the intake of nutrients and energy frequently fails to satisfy the elevated energy requirements for milk production (Zollitsch et al. 2004). Novak et al. (2009) also noted significant disparities between the milk yields of first and second lactations in dairy cattle indicating that while peak milk yield is generally attained by the fourth lactation, it does not significantly differ from the average of the third lactation. The highest coefficient of determination for LTMY3 in present investigation was recorded when employing a combination of LMY1 and LMY2 as independent variables (Fig. 1). These results imply that the accuracy of predictions is enhanced when successive lactations are incorporated into the model. Among the independent variables, LMY2 exhibited the most substantial effect on LTMY3 with a regression coefficient of 1.50 while LMY1 demonstrated a lesser influence. The optimal model for LTMY3 presented an intercept value of 1472.40 (μ) underscoring the significance of including multiple lactations to achieve a more precise estimation of LTMY in Frieswal cattle.

The highest coefficient of determination for predicting LTMY across five lactations was achieved by utilizing BW as well as the milk yields from the first three lactations as independent variables (Fig. 2). This enhancement indicates that cows with greater BW may reach maturity sooner, resulting in increased milk production during lactation. Nevertheless, when AFC was incorporated alongside LMY2 and LMY3, the predictive accuracy did not change. This may be attributed to the fact that AFC has a more pronounced effect on the yield of the first lactation while its influence tends to diminish in later lactations. Consequently, although BW plays a role in LTMY5, the primary predictors continue to be the milk yields from the first three lactations with LMY3 being particularly significant.

Prediction models for LTMY7 demonstrated the highest accuracy when utilizing BW, LMY1, LMY2 and LMY3 as independent variables with LMY2 being the most significant contributor in the optimal model. Here also the accuracy of the predictions improved with the inclusion of additional lactations. However, the addition of AFC and BW did not significantly enhance the

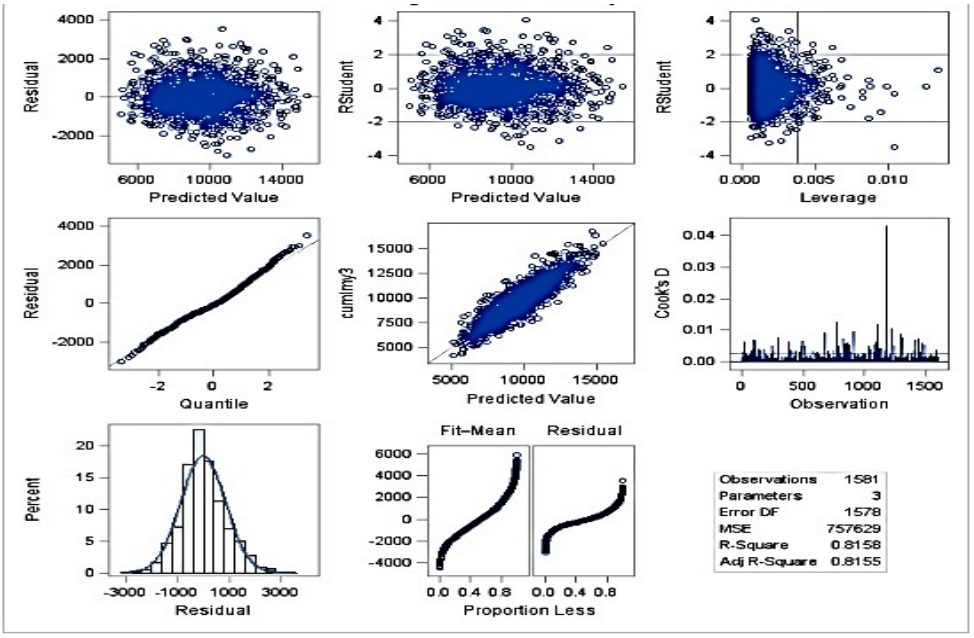


Fig. 1: Fit diagnostics and fit plot for prediction of LTMY3 with LMY1 and LMY2 as independent variable

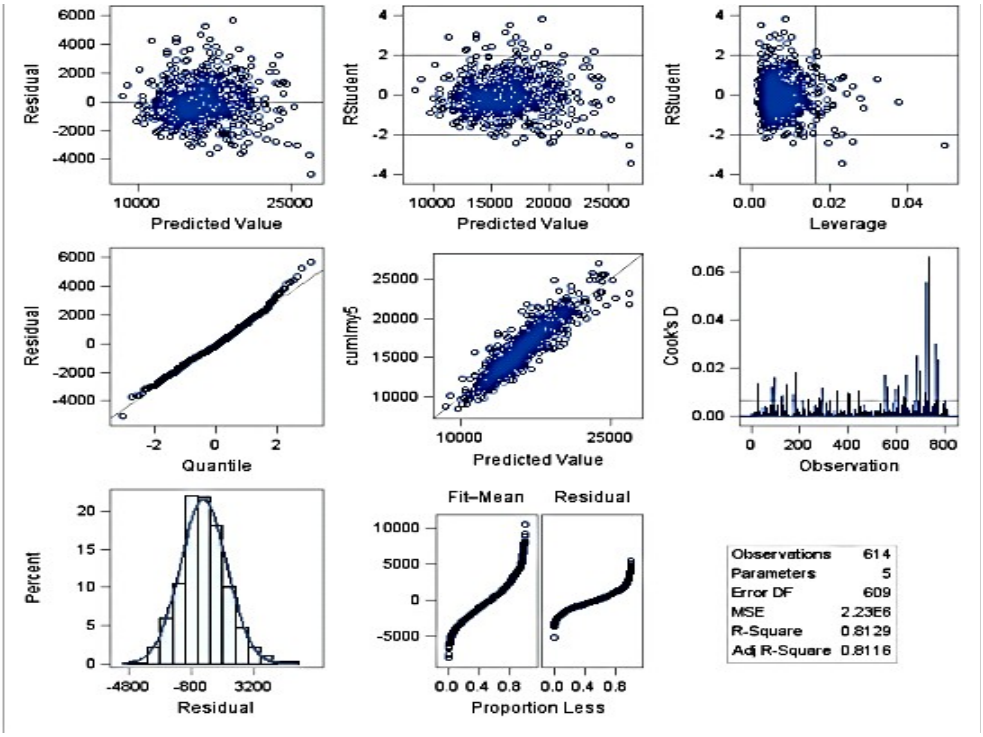


Fig. 2: Fit diagnostics and fit plot for prediction of LTMY5 with BW, LMY1,LMY2 and LMY3 as independent variable

prediction accuracy for LTMY7 indicating their limited influence. Sundaresan et al. (1954) estimated LTMY using only AFC and the LMY1 in Indian cattle achieving an accuracy of 8.3% in Jersey crosses which decreased to 7.1% when LMY1 was incorporated. Puri and Sharma (1965) reported higher accuracy rates of 75%, 77%, 77% and 40% for Tharparkar, Sahiwal, Red Sindhi and crossbred cattle, respectively when employing AFC and LMY1. Similarly, Dalal et al. (2004) included multiple traits such as AFC, lactation milk yields, lactation length, peak yield, service period, dry period and calving interval achieving an accuracy of 61.49% with first lactation traits alone (Set I) which increased to 91.27% when both first and second lactation traits were considered (Set II). Kakkar et al. (2004) defined LTMY as the cumulative milk yields from at least four lactations, reporting an R^2 of 44.96% using LMY1 and lactation length which rose to 70% with the inclusion of second lactation traits and further to 86% when third lactation traits were added in Murrah Buffalo.

Table 4: Correlation coefficients between the predicted values and actual values for prediction of lifetime milk yield

Model	Correlation between actual and predicted values (LTMY3)									
Trials	1	2	3	4	5	6	7	8	9	10
LTMY3= LMY1	0.64	0.68	0.68	0.68	0.60	0.63	0.64	0.66	0.66	0.67
LTMY3 =LMY2	0.85	0.88	0.85	0.83	0.86	0.81	0.86	0.85	0.83	0.84
LTMY3 = LMY1 + LMY2	0.90	0.91	0.91	0.90	0.91	0.89	0.91	0.91	0.89	0.91
Model	Correlation between actual and predicted values (LTMY5)									
LTMY5 = LMY2+ LMY 3	0.84	0.88	0.85	0.85	0.84	0.86	0.86	0.89	0.88	0.89
LTMY5 = LMY 1+ LMY 2+ LMY 3	0.88	0.91	0.89	0.88	0.85	0.87	0.89	0.91	0.90	0.91
LTMY5 = AFC + LMY 2+ LMY 3	0.84	0.88	0.85	0.85	0.84	0.86	0.86	0.89	0.88	0.89
LTMY5 = BW+ LMY 2+ LMY 3	0.86	0.89	0.87	0.86	0.86	0.86	0.87	0.91	0.89	0.90
LTMY5= BW + LMY 1+ LMY 2+ LMY 3	0.89	0.91	0.89	0.88	0.86	0.87	0.89	0.92	0.91	0.92
Model	Correlation between actual and predicted values (LTMY7)									
LTMY7 = LMY2+ LMY 3	0.90	0.87	0.89	0.89	0.90	0.86	0.91	0.91	0.90	0.90
LTMY7 = LMY 1+ LMY 2+ LMY 3	0.92	0.90	0.92	0.91	0.93	0.88	0.92	0.92	0.92	0.92
LTMY7 = AFC + LMY 2+ LMY 3	0.90	0.87	0.88	0.89	0.90	0.86	0.91	0.90	0.90	0.90
LTMY7 = BW+ LMY 2+ LMY 3	0.90	0.89	0.89	0.89	0.92	0.85	0.92	0.91	0.92	0.88
LTMY7= BW + LMY 1+ LMY 2+ LMY 3	0.91	0.91	0.92	0.91	0.93	0.87	0.93	0.92	0.94	0.91

(LTMY – Lifetime milk yield, LMY – lactation milk yield)

Table 5: Spearman's rank correlation between actual and predicted breeding values of sires up to three and five lactations

Prediction Models	Spearman rank correlation between actual and predicted breeding values of sires
MODEL31	0.60*
MODEL32	0.72**
MODEL33	0.73**
MODEL51	0.45*
MODEL52	0.46*
MODEL53	0.49*
MODEL54	0.49*
MODEL55	0.46*

(MODEL31- First model for prediction of lifetime milk yield up to three lactations, MODEL32- Second model for prediction of lifetime milk yield up to three lactations, MODEL33- Third model for prediction of lifetime milk yield up to three lactationsMODEL51 - First model for prediction of lifetime milk yield up to five lactations, MODEL52- second model for prediction of lifetime milk yield up to five lactations, MODEL53- Third model for prediction of lifetime milk yield up to five lactations, MODEL54- fourth model for prediction of lifetime milk yield up to five lactations, MODEL55- Fifth model for prediction of lifetime milk yield up to five lactations)

The validation of prediction models was assessed by their consistency across different data sets. The correlation between predicted and actual values from training and testing data is shown in Table 4. The model for LTMY3 using LMY1 and LMY2 together was most accurate followed by models using them separately. This confirms the prediction models for LTMY3 were effective across various data sets. For LTMY5 and LTMY7 also the correlation between predicted and actual values remained consistently high across all ten data sets giving their robustness in predicting the milk yield. The aforementioned literature clearly demonstrates that the accuracy of predictions improves with an increase in the number of independent variables across various breeds which align with the findings of the current study. Notably, the prediction models established in this study achieved higher accuracy levels while utilizing a minimal number of independent variables, thus positioning them as superior to the previously discussed models. Furthermore, these models exhibited consistent efficiency when evaluated across different datasets over ten consecutive trials. Similar investigations were conducted by Gandhi et al. (2012), who categorized data from the 4th to 6th parities into set II (N=583) and those with more than six parities into set III (N=360), subsequently dividing each set into training and testing subsets to evaluate the correlation between actual and predicted milk yields. Their results indicated a strong correlation between the actual and predicted values. Mayeres et al. (2004) compared observed and predicted test-day milk yields reporting moderate to high correlations that affirm the reliability of the prediction models.

Spearman's Rank correlation assessed accuracy of prediction models for sire performance, comparing breeding values from

BLUP and other developed models for LTMY. Correlation values for LTMY up to three lactations were 0.60, 0.72 and 0.73 while for five lactations were 0.45, 0.46, 0.49, 0.49 and 0.46, respectively. Thus, a high correlation of these values for prediction of sire breeding values estimated by BLUP and the models developed for prediction of LTMY was observed. The highly significant correlations between these breeding values suggest that the developed prediction models for LTMY are equally effective in estimating the breeding values of sires.

The model suitability was assessed using best fit diagnostic plots for LTMY3 and LTMY5 as shown in figure 1 and figure 2. Both the models developed for prediction of LTMY3 and LTMY5 are having good predicting ability. The fit diagnostic plot for LTMY3 and LTMY5 revealed that the residuals appear to be randomly distributed around the zero-reference line, with no heteroscendasticity. The quantile plot and residual histogram prove that the normality assumptions are valid. Whereas, the fit mean residual plot illustrates that the model accounts for a significant amount of variability in predicting lifetime milk yield in Frieswal cattle.

Conclusion

The present study conclude that models developed in the present investigation demonstrate high accuracy in predicting LTMY and sire breeding values while utilizing minimal independent variables. This efficiency makes them highly suitable for practical application in dairy cattle breeding programs. The robustness of these models is further reinforced by the use of a large dataset ensuring reliability and applicability across different populations of Frieswal cattle. Given their predictive strength, these models can serve as valuable tools for selecting high-yielding Frieswal cows and sires thereby contributing to genetic improvement and enhanced productivity in dairy herds. Additionally, the study's findings provide a scientific basis for refining selection strategies and optimizing breeding programs aimed at improving LTMY.

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References

Anonymous (2019) 20th Livestock census Ministry of Fisheries, Animal Husbandry & Dairying, Government of India, Krishi Bhawan, New Delhi

Dalal DS, Malik ZS, Chhikara BS, Chander R (2004) Prediction of lifetime milk production from early lactation traits in Hariana Cattle. Ind J Ani Sci 74: 1145– 1149

Dash SK, Gupta AK, Manoj M, Kumar V, Shivhre PR, Valsalan J (2018) Analysis of lifetime performance in Karan Fries Cattle. Indian J Ani Res 52: 761-767

Gandhi RS, Raja TV, Ruhil AP, Kumar A (2012) Artificial neural network versus multiple regression analysis for prediction of lifetime milk production in Sahiwal cattle. J Appl Ani Res 38 : 233-237

Goshu G (2005) Breeding efficiency, lifetime lactation and calving performance of Friesian-Boran crossbred cows at Cheffa farm, Ethiopia. Liv Res Rural dev http://www.lrrd.org/lrrd17/7/gosh17073.htm

Gugger M, Menetrey F, Rieder S, Schneeberger M (2007) Heritability of lifetime milk yield and productive life and their relationship with production and type traits in the Simmental, Swiss Fleckvieh and Red Holstein populations in Switzerland. EAAP 2007: Paper 39.4

Kakkar S, Pander BL, Dhaka SS, Singh S (2004) Prediction of lifetime yield traits from lactation traits in graded Murrah buffaloes. Ind J Ani Sci 74: 77-79

Mayers P, Stoll J, Bormann J, Reents R, Gengler N (2004) Prediction of daily milk, fat, and protein production by a random regression test-day model. J Dairy Sci 87:1925–1933

Ministry of Finance, Government of India, 'Economic Survey 2021-22,' Department of Economic Affairs [2021-22]

Murdia CK, Tripathi VN (1991) Prediction of lifetime milk production on the basis of first lactation traits in Jersey cattle. Ind J Dairy Sci 44: 598-601

Novac P, Vokralova J, Broucek J (2009) Effects of the stage and number of lactation on milk yield of dairy cows kept in open barn during high temperatures in summer months. Arch Ani Breed 52: 574-586

Novakovic Z, Ostojic-Andric D (2014) Lifetime production of high-yielding dairy cows. Biotech in Ani Hus 30: 399-406

Pirlo G, Miglior T, Speroni M (2000) Effect of age at first calving on production traits and on difference between milk yield returns and rearing costs in Italian Holsteins. J Dairy Sci 83: 603-608

Puri TR, Sharma KNS (1965) Prediction of lifetime production on basis of first lactation yield and age at first calving for selection of dairy cattle. J Dairy Sci 48: 462– 67

Sawa A, Siatka K, Krê¿el-Czopek S (2018) Effect of age at first calving on first lactation milk yield, lifetime milk production and longevity of cows. Ann Ani Sci Doi: 10.2478/aoas-2018-0044

Shinde NV, Mote MG, Khutal BB, Jagtap DZ (2010) Prediction of lifetime milk production on the basis of lactation traits in Phule Triveni crossbred cattle. Ind J Ani Sci 80: 986-988

Steel GD, Torrie H (1960) Principles and procedures of statistics. New York: McGraw

Sundaresan D, Eldridge FE, Atkeson FW (1954) Age at first calving used with milk yield during first lactation to predict lifetime production of Indian cattle. J Dairy Sci 37**:** 1273-1282

Zollitsch (2004) *www.sciencedirect.com/topics/agricultural-and-biological-sciences/early-lactation.*