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Prediction of Lifetime Performance Traits from First Production and Reproduction Traits in Hariana Cattle

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ABSTRACT

The data of 655 Hariana cattle on first lactation and lifetime production and reproduction reared during 1965-2020 at State Livestock and Agriculture Farm, Babugarh, Hapur, India was used for prediction analysis. The accuracies obtained in predictive models for predicting various lifetime production traits (dependent variable) from first lactation traits (explanatory variables) had ranged from 12.2 – 57.9%. The lifetime traits BET and TLMYP/PD can be predicted from first lactation traits with 57.9 and 51.6% accuracies using equations. Accuracies for the rest of the prediction models for lifetime traits from first lactation traits were less than 50%.

HIGHLIGHTS

- Data of 655 Hariana cattle during 1965-2020 was used for prediction analysis.
- Predicting of lifetime production traits from first lactation traits.

Keywords: Prediction, Lifetime, First lactation and Hariana cattle

Throughout the world's farms, cattle are the most prevalent and widespread species. They are raised primarily for their manure, milk, and hides. Cows typically produce milk for 80 to 90 % of this time, with the remaining time being spent in the dry season getting ready for the next calving. The natural life expectancy of dairy cattle is approximately 20 years (De Vries and Marcondes, 2020). From 512 million in 2012 to around 536 million in 2019, India's total livestock population increased by 4.8% (GOI, 20th Livestock Census, 2019). Cattle with a population of 193.46 million play a crucial role in the Indian animal husbandry sector. This encompasses 142.11 million indigenous livestock (GOI, 20th Livestock Census, 2019). Millions of rural households depend on cattle for their livelihoods across the nation. The number of indigenous cattle has decreased by 6.0 percent from 2012 to 2019 on average. Among indigenous cattle breeds, Hariana cattle is famous for its remarkable power of endurance for hot climate of tropics, resistance to tropical diseases and has low maintenance cost besides providing A2 milk (Kumar *et al*., 2019). Milk production from Hariana cattle ranges from 693 to 1745 kg each lactation, with a milk fat content of about 4.5 percent (GOI, 2019). This breed possesses

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great strength, flexibility, disease resistance, and efficiency in converting available coarse feed in harsh conditions.

The ability of the animal to reproduce is influenced by its genetic potential. Hariana cattle's reproductive performance varies temporarily among and within herds. Additionally, model development for the prediction of reproductive efficiency is an important facet that should usually be undertaken in research. Reproductive traits are imperative factors in determining the profitability of dairy production (Lobago *et al*., 2007). The present study undertakes Hariana cattle performance with a focus on genetic evaluation of productive and reproductive performance for first lactation and lifetime records along with modelling. The information generated through this research work on productive and reproductive performance will provide baseline average values to the farmers rearing Hariana cattle.

MATERIALS AND METHODS

In the current study, breeding data from Hariana cattle kept at State Livestock and Agriculture Farm, Babugarh were used. This data came from history sheet registers and herd inventory registers etc. Babugarh is a town, near Hapur city in Hapur district, in the state of Uttar Pradesh. The data on 949 Hariana cattle that had at least one lactation completed throughout a 55-year period from 1965 to 2020 were used in the present study. For this study, the records of cows with normal lactation were utilized. The data was entered into a Google Sheet where it was exposed to various built-in functions and formulas for screening, standardization, estimation of lifetime attributes, coding, and generation of pedigree and sub data files. The lower and upper bound and their corresponding skewness and kurtosis estimates for various traits considered for present study had been presented in Table 1. To ensure the normal distribution of records, the outliers were removed. The lower and upper bound for various traits were adjusted keeping in mind physiological limits, previous studies and final measure of skewness and kurtosis lied between -1 to +1 in processed data. Finally, a sub data set of 655 Hariana cattle was selected and subjected to further analysis. The pedigree and data files generated using sub data sets were used for further analysis by different statistical softwares.

First lactation traits analysed in our study were first lactation traits, viz., AFC in days, First Total Lactation Milk Yield in Pail (FLTMYP) in kg, First Standard Lactation Milk Yield in Pail (FSLMY) in kg, First Lactation Length (FLL) in days, First Dry Period (FDP) in days, First Service Period (FSP) in days, First Calving Interval (FCI) in days. Lifetime performance traits used were Herd Life (HL) in days, Productive Life (PL) in days, Productive Days (PD) in days, Unproductive Days (UPD) in days, Breeding Efficiency by Tomar method (BET) in %, Breeding Efficiency by Wilcox method (BEW) in %, Total Lifetime Milk Yield in Pail (TLTMYP) in kg, Total Standard Lifetime Milk Yield in Pail (TSLMYP) in kg, Total Lactation Milk Yield in Pail / Productive Life in Pail (TLMYP/PL) in kg/day, Total Lactation Milk Yield in Pail / Productive Days (TLMYP/PD) in kg/day, and Total Lactation Milk Yield in Pail / Herd Life (TLMYP/HL) in kg/day.

Table 1: Normalization and standardization of data

Sl. No.	Trait	Lower bound	Upper bound	Skewness	Kurtosis
1	AFC	1000	2450	0.16	-0.93
2	FTLMYP	100	2400	0.41	0.53
3	FSLMYP	100	2400	0.53	0.72
4	FSP	30	900	0.62	0.47
5	FLL	100	740	0.39	0.59
6	FDP	30	500	0.99	0.94
7	FCI	290	1350	0.46	-0.26
8	BET	60	120	0.53	0.08
9	BEW	45	110	0.12	-0.64
10	TLMYP	500	19000	0.88	0.50
11	TSLMYP	500	19000	0.84	0.34
12	HL	1300	8000	0.26	-0.74
13	PL	300	6000	0.29	-0.99
14	PD	100	6000	0.44	-0.75
15	UPD	50	3300	0.69	-0.05
16	TLMYP/HL	0.1	3.85	0.66	0.86
17	TLMYP/PL	0.2	5.8	0.37	0.27
18	TLMYP/PD	0.2	7	0.39	0.39

The herd life was considered the duration from birth to disposal of the animal. Productive life was defined as total days from date of first calving to date of last dry or date of disposal if the animal is in lactation. Productive days were the sum of the number of days in milk in different lactations in the same herd. Unproductive days were the sum of dry periods in different lactations in the same herd. Total lactation milk yield in pail was defined as total amount of milk produced by cattle within a pail from the initiation of first lactation until the last day in milk in the herd. Total standard lactation milk yield in pail was defined as total amount of milk produced by cattle within a pail from the 300 days of every lactation up to last lactation. Total lactation milk yield in pail per day of productive life was measured as lifetime milk yield divided by the productive life. Total lactations milk yield in pail per day of productive days was measured as lifetime milk yield divided by the productive days. Total lactation milk yield in pail per day of herd life was measured as lifetime milk yield divided by herd life.

STATISTICAL ANALYSIS

Multiple Regression Analysis

The multiple regression analysis was used as suggested by Draper and Smith (1987) with help of the following model:

Model for prediction

$$Y_i = a + b_1X_1 + b_2X_2 + \ldots + b_nX_n + e_i$$

Where,

Y_i is the variable to be predicted (Lifetime trait)

$a, b_1, b_2, \ldots, b_n$ are unknown parameters to be estimated.

$X_1, X_2, \ldots, X_n$ first lactation traits whose values are known.

e_i = random residual, NID $(0, \sigma^2_e)$

Estimation of coefficient of determination (R^2)

The coefficient of determination (R^2) indicated that out of hundred percent of variability of the dependent variable, how much variation was contributed by a set of independent variables and is expressed in terms of percentage. The R^2 estimated in different models from the following analysis of variance.

Source of variation	Df	S. S.	M. S.
Regression	k-1	SS_r	MS_r
Residual	N-k	SS_e	MS_e
Total	N-1	SS_t	

Thus,

$$R^2 = (SS_r / SS_t) \times 100$$

The regression analysis was carried out using step down linear multiple regression method (SPSS Statistics 20.0 software) to identify optimum model. In step down multiple regression analysis optimum model was considered in which significance of F change on inclusion of explanatory variable in model was equal to or less than 0.001.

RESULTS AND DISCUSSION

Prediction models for predicting various lifetime production traits (dependent variable) from first lactation traits (explanatory variables) have been presented in Table 2. Stepwise regression procedure was carried out to predict lifetime traits from first lactation traits. In prediction of HL from first lactation traits the optimum model had identified FTLMYP as a significant explanatory variable explaining 12.2% variation in HL. The impact of FTLMYP on HL was found to be directly proportional. The final regression equation obtained was HL= 3144.88 + 1.09 × FTLMYP. The PL was found to be best predicted from FTLMYP and AFC. The order of importance for these first lactation traits in the predictive model was FTLMYP > AFC. The effect of FTLMYP was found to be directly proportional, whereas that of AFC was inversely proportional to PL. These two first lactation traits were able to explain 17.2% variation in PL. The regression equation obtained to predict was PL= 2450.65 + 1.075 × FTLMYP – 0.675 × AFC.

The prediction of PD from first lactation traits the optimum model had identified FTLMYP > AFC as significant explanatory variable explaining 19.5% variation in PD. The impact of FTLMYP on PD was found to be directly proportional, whereas that of AFC was inversely proportional to PD. The regression equation obtained to predict was PD= 1444.200 + 0.863 × FTLMYP – 0.391 × AFC. The UPD was found to be best predicted from AFC, FSLMYP and FDP. The order of importance for these first lactation traits in the predictive model was AFC > FSLMYP > FDP. The outcome of FSLMYP and FDP were found to be directly proportional whereas that of AFC was inversely proportional to UPD. These three first lactation traits were able to explain 15.1% variation in UPD. The regression equation obtained to predict was UPD= 546.224

Table 2: Predictive models of various lifetime production traits in Hariana cattle

Sl. No.	Dependent Variable	(R^2× 100) %	Constant	Regression weights for first lactation traits (explanatory variables) in selected predictive model						
				FTLMYP	FSLMYP	FLL	AFC	FDP	FSP	FCI
1	HL	12.2	3144.88	1.09^{b1}	—	—	—	—	—	—
2	PL	17.2	2450.65	1.075^{b1}	—	—	-0.675^{b2}	—	—	—
3	PD	19.5	1444.20	0.863^{b1}	—	—	-0.391^{b2}	—	—	—
4	UPD	15.1	546.22	—	0.389^{b2}	—	-0.220^{b1}	1.238^{b3}	—	—
5	BET	57.9	135.507	$-0.290^{b3} \times 10^{-2}$	—	—	$-0.210^{b1} \times 10^{-1}$	—	—	$-0.320^{b2} \times 10^{-1}$
6	BEW	36.3	114.266	$-0.400^{b2} \times 10^{-2}$	—	—	—	—	—	$-0.625^{b1} \times 10^{-1}$
7	TLMYP	33.5	2459.207	2.200^{b3}	3.902^{b1}	—	-1.567^{b2}	—	—	—
8	TSLMYP	27.0	2325.979	—	5.578^{b1}	—	-1.170^{b2}	—	—	—
9	TLMYP/ HL	47.1	1.056	$0.500^{b3} \times 10^{-3}$	$0.553^{b1} \times 10^{-3}$	—	$-0.430^{b2} \times 10^{-3}$	—	$-0.500^{b4} \times 10^{-3}$	—
10	TLMYP/ PD	51.6	2.382	$0.135^{b3} \times 10^{-2}$	$0.720^{b1} \times 10^{-3}$	$-0.350^{b2} \times 10^{-2}$	—	—	—	—
11	TLMYP/ PL	47.8	1.162	$0.700^{b3} \times 10^{-3}$	$0.710^{b1} \times 10^{-3}$	—	—	$-0.985^{b2} \times 10^{-4}$	$-0.114^{b4} \times 10^{-2}$	—

b1, b2, b3 and b4 as superscripts for regression weights were assigned in order of importance in the predictive model; — excluded explanatory variables.

– 0.220 × AFC + 0.389 × FSLMYP + 1.238 × FDP. The BET was found to be best predicted from AFC, FCI and FTLMYP. The order of importance for these first lactation traits in the predictive model was AFC > FCI > FTLMYP. The impact of AFC, FCI and FTLMYP on BET was found to be inversely proportional. These three traits were able to explain 57.9% variation in BET. The regression equation obtained to predict was BET = 135.507 – (0.210×10^{-1}) × AFC – (0.320×10^{-1}) × FCI – (0.290×10^{-2}) × FTLMYP. In prediction of BEW from first lactation traits the optimum model had identified FTLMYP and FCI as significant explanatory variables explaining 36.3% variation in BEW. The order of importance for these first lactation traits in the predictive model was FCI > FTLMYP. The effect of FCI and FTLMYP on BEW was found to be inversely proportional. The regression equation obtained to predict was BEW= 114.266 – (0.625×10^{-1}) × FCI – (0.400×10^{-2}) × FTLMYP.

The TLMYP was found to be best predicted from FSLMYP, AFC and FTLMYP. The order of importance for these first lactation traits in the predictive model was FSLMYP > AFC > FTLMYP. The effect of FSLMYP and FTLMYP were found to be directly proportional, whereas that of AFC was inversely proportional to TLMYP. These three first lactation traits were able to explain 33.5% variation in TLMYP. The regression equation obtained to predict was TLMYP= 2459.207 + 3.902 × FSLMYP – 1.567 × AFC + 2.200 × FTLMYP. In prediction of TSLMYP from first lactation traits the optimum model had identified FSLMYP and AFC as significant explanatory variables explaining 27.0% variation in TSLMYP. The effect of FSLMYP on TSLMYP was found to be directly proportional, whereas that of AFC was inversely proportional to TSLMYP. The final regression equation obtained was TSLMYP= 2325.979 + 5.578 × FSLMYP – 1.170 × AFC. The prediction of TLMYP/HL from first lactation traits the optimum model had identified FSLMYP, AFC, FTLMYP and FSP as significant explanatory variables explaining 47.1% variation in TLMYP/HL. The order of importance for these first lactation traits in the predictive model was FSLMYP > AFC > FTLMYP > FSP. The effect of all these first lactation traits on TLMYP/HL was found to be directly proportional. The final regression equation obtained was TLMYP/HL = 1.056 + (0.553 × 10^{-3}) × FSLMYP – (0.430 × 10^{-3}) × AFC + (0.500 × 10^{-3}) × FTLMYP – (0.500 × 10^{-3}) × FSP.

The TLMYP/PD was found to be best predicted from FSLMYP, FLL and FTLMYP. The order of importance for these first lactation traits in predictive model was FSLMYP > FLL > FTLMYP. The effects of FSLMYP and FTLMYP were found to be directly proportional, whereas that of FLL was inversely proportional to TLMYP/PD. These three first lactation traits were able to explain 51.6% variation in TLMYP/PD. The regression equation obtained to predict was TLMYP/PD = 2.382 + (0.720 × 10^{-3}) × FSLMYP – (0.350× 10^{-2}) × FLL + (0.135 × 10^{-2}) × FTLMYP. In TLMYP/PL was found to be best predicted from FSLMYP, FDP, FTLMYP and FSP. The order of importance for these first lactation traits in predicted model was FSLMYP > FDP > FTLMYP > FSP. The effects of FSLMYP, FDP and FTLMYP were found to be directly proportional, whereas that of FSP was inversely proportional to TLMYP/PL. These four first lactation traits were able to explain 47.8% variation in TLMYP/PL. The regression equation obtained to predict was TLMYP/PL = 1.162 + (0.710 × 10^{-3}) × FSLMYP – (0.985 × 10^{-4})× FDP + (0.700 × 10^{-3}) × FTLMYP – (0.114 × 10^{-2}) × FSP. Pander *et al*. (2001) reported that LMY could be predicted by using a linear combination of age at third calving, third lactation yield and peak yield with an accuracy of 72.06%. Sah *et al*. (2013) using milk yield of 125th, 155th and 185th day of lactation can predict the lactation yield with 77.6% accuracy in Kankrej cows. Dongre and Gandhi (2014) observed R^2 and RMSE values as 95.6% and 0.037 kg, respectively in Sahiwal cattle. Gupta *et al*. (2016) reported R^2 values to be ranged from 72.96% (0.154 kg) for Wilmink's function in first lactation to 99.98% (0.0.043 kg) for inverse polynomial function in third lactation. Ratwan *et al*. (2017) evolved the equation, LTMY4 = 2400.56 + 0.698 PC could explain 48.8% variation in the estimated values with adjusted R^2 = 48.5%. Sharma *et al*. (2019) reported that prediction equations based on 125th, 155th and 185th day would be quite useful and reliable for prediction of FL305DMY with 66.8%, 70.4% and 75.1% accuracies, respectively in crossbred cattle. Dev *et al*. (2017) observed the prediction of phenotypic values of lifetime performance traits. Generally, the FLY, FPY and FCI of all lactations contributed max R^2 value for all lifetime traits. Therefore, it may be concluded that selection on the basis of first lactation milk yield, first peak yield and first calving interval would also improve the lifetime performance in Murrah buffalo. Verma *et al*. (2018) observed R^2 for the prediction of lifetime milk yield based on FL305DMY, FLL and FSP traits were 51.48, 53.62, and 53.97%, respectively.

CONCLUSION

From this research the accuracy obtained in predictive models for predicting various lifetime production traits from first lactation traits had ranged from 12.2 – 57.9%. The lifetime traits BET and TLMYP/PD can be best predicted from first lactation traits (FTLMYP, AFC and FCI) and (FTLMYP, FSLMYP and FLL) with 57.9 and 51.6% accuracies respectively.

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