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Modeling of lactation curves for prediction of standard lactation milk yield in Marathwadi buffaloes

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Marathwada region of Maharashtra is considered as the most drought prone region in India. The cattle and buffalo breeds in this region are well adapted to the harsh climatic conditions. Marathwadi buffalo is only buffalo breed found in this region with larger built and long flat horns. These buffaloes have breeding tract in Marathwada region of Western India especially in Parbhani, Nanded, Beed, Hingoli, Jalna and Latur districts. The average total lactation milk yield across different lactations is 1,118 kg and average milk fat is 8.8% ranging from 6.25 to 10.50% (Kataria *et al.* 2012, NBAGR 2016). Modeling of lactation curves in dairy animals is important for prediction of milk yield, nutritional interventions, breeding management etc (Sahoo *et al.* 2017). This property of the model can prove beneficial in case of incomplete lactation records. Various lactation curve models have been fitted in cattle and in buffalo (Eahin *et al.* 2015, Soysal *et al.* 2016, Singh *et al.* 2017). The present investigation was therefore conducted to fit the different models in Marathwadi buffalo using monthly milk yields and further the best fitted model to be used for prediction of standard lactation milk yield.

The monthly milk yields and 305 days milk yield data were collected from the history-cum-pedigree sheets and daily milk record registers of Marathwadi buffalo maintained at cattle breeding farm, College of Veterinary and Animal Sciences, Udgir Dist-latur Maharashtra spread over a period of 9 years (2008–2016). The monthly milk yield was recorded at 6th, 36th, 66th and so on till standard lactation with 30 days interval. The records of the animals with normal lactation were considered for this study. Culling, disposal in middle of lactation, abortion, stillbirth and other pathological conditions which affected the lactation yield were considered as abnormalities and hence such records were excluded from analysis. The climate of the farm is semi arid in nature. The minimum temperature falls to 12–18°C in winter months, whereas the maximum temperature goes up to 43–45°C in summer. The annual rainfall is about 500 to 1100 mm out of which most of the rainfall is received during July and August. Good quality green fodder *ad lib.* along with eight hours free grazing was practiced. Concentrate was provided to cows as per their milk production only during milking hours. Three different linear lactation curve models studied in the present work are as follows:

Inverse polynomial model:

$$Y_t = t(a + bt + ct^2)^{-1}$$ (Nelder 1966)

Parabolic exponential model:

$$Y_t = a \exp(bt–ct^2)$$ (Sikka 1950)

Mixed log function

$$Y_t = a + bt^{½} + c\log t + e_t$$ (Guo and Swallve 1995)

where Y_t, average monthly yield in the tthstage of lactation; a, initial milk yield after calving; b, ascending slope parameter up to the peak yield; c, descending slope parameter; t, length of time since calving; e_t, residual error. The above stated models were fitted on monthly milk yield records for prediction of 305-day milk yields in Marathwadi buffaloes. The most suitable model was identified on the basis of the highest R^2 value and root mean square error (RMSE) which was further used in prediction.

The milk production of Marathwadi buffalo was slightly lower with peak monthly milk yield of 129.66 litres in second month of lactation. The persistence phase of the lactation was well maintained with the peak achieved early as compared to the other buffalo breeds which normally achieve the peak yield in 2nd to 4th month of the lactation. Although, the breed is low yielder but the consistency of milk production is better.

The inverse polynomial function could not explain the peak phase of the lactation. However, lesser error in prediction was noticed during descending phase of the lactation in which the buffaloes are more persistence in milk production. Similarly, parabolic exponential model could not explain peak phase but lesser error as compared to the inverse polynomial function was observed during

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persistence phase and during this phase, the lactation curve model, i.e. parabolic exponential model fitted best. The best fit model was observed to be mixed log function, in which all three phases, i.e. ascending phase, peak phase and descending or persistence phase of the lactation could be predicted with better accuracy. However, Kumar (2007) and Singh *et al.* (2015) observed 99.16 and 98.65% R^2 value for parabolic exponential model in Murrah buffaloes. Similar results were observed by Sahoo *et al* (2017) in Murrah buffaloes.

Comparative evaluation amongst different lactation curve models revealed that inverse polynomial model was least fitted and mixed log function was best fitted on monthly milk yields in Marathwadi buffaloes (Figs 1 and 2).

The estimated lactation curve parameters for ascending, peak and descending phase (a, b, c) of lactation curve models were made (Table 1) using monthly milk yield records of Marathwadi buffaloes to fit into the mathematical models and obtain the predicting equation.

The best was observed in mix log function and therefore it was used for prediction of standard lactation milk yield of Marathwadi buffaloes. In the model, all three phases, i.e. ascending, peak and descending phases are represented by the regression coefficients which are derived from regression analysis, viz. 317.575, –247.128 and 495.169, respectively (Table 2). The equation was then fitted on monthly milk yield records for prediction of standard lactation milk yield.

It is therefore concluded that for modeling lactation curves in low yielding buffalo, i.e. Marathwadi, mixed log function is the best fitted linear model and it is further inferred that for prediction of standard lactation milk yield based upon monthly milk yield records the aforesaid model could be promising.

Table 1. Estimated lactation curve parameters of different functions

Lactation curve function	Parameter		
	a	b	c
Inverse polynomial function	83.664	14.520	–1.963
Parabolic exponential model	4.173	0.290	–0.036
Mixed log function	317.575	–247.128	495.169

Table 2. Estimators derived using linear lactation curve models on monthly milk yields in Marathwadi buffalo for prediction of standard lactation milk yield

Model	Derived equation	R^2 value (%)	Adjusted R^2 value (%)	RMSE
IPF	$\hat{Y} = t\ (83.664 + 14.520 * t - 1.9637 * t^2)^{-1}$	82.70	78.37	4.611
PEM	$\hat{Y} = 4.173 * \exp(0.290 \times t + 0.0363\ t^2)$	95.00	93.76	3.549
MLF	$\hat{Y} = 317.575 - 247.128 \times t^{½} + 495.169 \times \log t + e_1$	97.36	97.04	1.705

IPF, inverse polynomial function; PEM, parabolic exponential model; MLF, mixed log function.

Table 3. Actual vs predicted average monthly milk yields in Marathwadi buffalo obtained from best fitted model (mixed log function)

Month of the lactation	Actual average monthly milk yields (Litres)	Predicted average monthly milk yields (Litres)	Error in prediction (Litres)
1	64.52	70.45	5.93
2	129.66	117.14	–12.51
3	127.14	125.79	–1.34
4	117.49	121.44	3.95
5	106.77	111.09	4.32
6	97.31	97.56	0.25
7	84.69	82.20	–2.49
8	61.56	65.78	4.21
9	44.17	48.70	4.53
10	29.39	31.26	1.87
11	22.33	13.61	–8.72

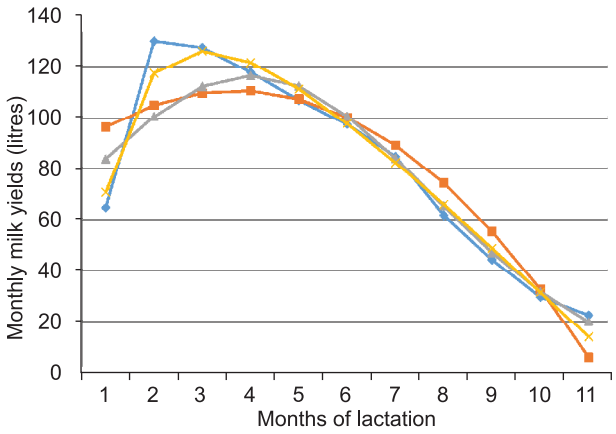

Fig. 1. Comparison of different lactation curve models fitted on monthly milk yields in Marathwadi buffaloes.

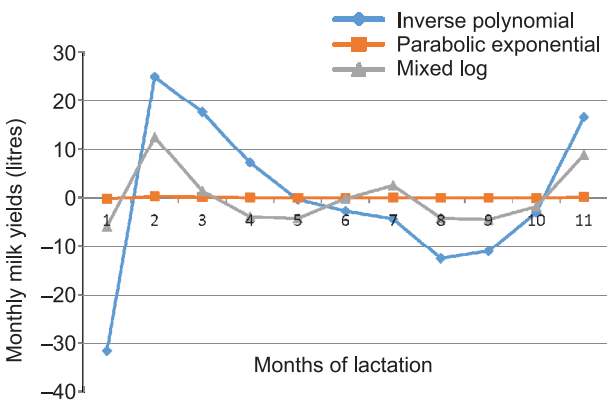

Fig. 2. Residuals plotted for fitting different lactation curves models in Marathwadi buffaloes.

SUMMARY

The present study was carried out on 538 monthly milk yield records of Marathwadi buffaloes maintained at Cattle Breeding Farm, College of Veterinary and Animal Sciences, Udgir Dist-Latur Maharashtra spread over a period of 9 years. The monthly milk yield was recorded at 6^{th}, 36^{th}, 66^{th} and so on till standard lactation with 30 days interval. The goodness of fit of 3 lactation curve models, viz. parabolic exponential function, inverse polynomial function and mixed log function were used on monthly milk yields in Marathwadi buffaloes. The highest coefficient of determination for fitting of lactation curve models was with mixed log function (97.63%), followed by parabolic exponential function (95%) and inverse polynomial function (82.70%). Further, the root mean square error was found least for mixed log function (1.70), followed by parabolic exponential function (3.55) and inverse polynomial function (4.61). It is therefore inferred that mixed log function fitted best for prediction and modeling of lactation curves based upon monthly milk yields.

REFERENCES

Kataria R S, Kathiravan P, Mishra B P, Sadana D K, Gujar B V, Vohra V and Joshi B K. 2012. *Buffalo Genetic Resources of India: Marathwadi*. Monograph. National bureau of Animal Genetic Resources, Karnal.

Soysal M, Gurcan E K and Aksel M. 2016. The comparison of lactation curve with different models in Italian origined water buffalo herd raised in Istanbul Province of Turkiye. *Journal of Tekirdag Agricultural Faculty* **13**(4): 139–44.

Singh N K, Singh R, Gupta A, Aashaq H D and Kurat A. 2017. Comparison of three different lactation curve models for prediction of monthly test day milk yields in first lactation Murrah buffaloes. *International Journal of Livestock Research* **7**(6): 125–30.

Guo Z and Swalve H H. 1995. Modelling of the lactation curve as a sub-model in the evaluation of test day records. Proceedings of Interbull Mtg. Prague, Uppsala, Interbull Bull. No. 11.

Sikka L C.1950. A study of lactation as affected by heredity and environment. *Journal of Dairy Research* **17**: 231–52.

Nelder J A. 1966. Inverse polynomials, a useful group of multi-factor response functions. *Biometrics* **22**: 128–41.

Kumar S. 2007.'A comparative study of lactation curve models for prediction of lactation milk yield in Murrah buffaloes'. MVSc Thesis, NDRI (Deemed University), Karnal, India.

Sahoo S K, Avtar Singh, Dash S K and Ambhore G S. 2017. Modeling lactation curve for genetic evaluation of Murrah buffaloes. *Indian Journal of Animal Research* **52**(12): 1675–79.

Singh M, Singh A, Gupta A K, Dash S K, Gupta A, Sahoo S K, Dash S and Shivahre P R. 2015. Comparative evaluation of different lactation curve models in prediction of monthly test-day milk yields in Murrah buffaloes. *Journal of Animal Res*earch **5**(1): 189–93.