Indian Journal of Animal Sciences **91** (12): 1085–1088, December 2021/Article
https://doi.org/10.56093/ijans.v91i12.119832

Test day yield, lactation curve and production potential of Gir cattle under hot and humid conditions of Tamil Nadu

VENKATARAMANAN[1], S MEENAKSHI SUNDARAM[2✉], VRINDA B AMBIKE[3], T MUTHURAMALINGAM[4] and M MANOBHAVAN[2]

Tamil Nadu Veterinary and Animal Sciences University, Chennai, Tamil Nadu 600 007 India

Received: 5 August 2021; Accepted: 20 September 2021

ABSTRACT

Test day milk yield records (5130), milk production and milk composition traits from 19 lactations of Gir cows collected for two years (2019 and 2020) were used to understand the performance of Gir breed in hot and humid conditions of Tamil Nadu. Different lactation curve models were used for modelling test day records and model diagnostics like adjusted R-square, BIC and RMSE were used to obtain the model of best fit. The mean test day yield, fat per cent, SNF (%), total milk yield, peak yield, days to attain peak yield and calving interval observed were 5.78 kg, 5.05%, 7.65%, 1507 kg, 9.23 kg, 46.5 days and 447 days respectively. Ali and Shaeffer model offered the best fit for lactation curve in Gir cows. Mahadevan method and Gamma function were used to calculate the persistency of milk yield which was obtained as 1.33 and 6.348 respectively. Results of the study indicated that Gir cattle were able to adapt themselves through maintenance of reproductive traits comparable with that of the native tract but the new humid environment has caused a slight decrease in the performance of milk production traits.

Keywords: Gir, Hot and humid, Lactation curve models, Test day yield

Gir cattle is one of the most important milch breeds of India known for its heat tolerance and disease resistance in India as well as other tropical countries (Araújo *et al.* 2018) like Brazil where it has been used in the development of several other milch breeds (Daltro *et al.* 2021). In Tamil Nadu, all the recognized breeds are of draught utility and majority of the milch animals that farmers maintain are crossbred animals with exotic inheritance. However, small farmers with fewer resources are unable to maintain the crossbreds, which leads to poor production, reproduction and loss due to mortality and thus it is beneficial to upgrade with high yielding indigenous breeds. The compact size and heat tolerance of the Gir cattle makes it suitable for such conditions. However, it is important to understand the production potential of the breed under various agro-climatic conditions prevailing in the state for successful use of the breed as purebred or for upgrading of non-descript cattle. Recording 305-day yield can be a tedious process and so use of test day (TD) records is gaining popularity as the data is adjusted for stage of lactation and TD models account for environmental variations on each test day like management, days in milk and day of the year (Jamrozik and Schaeffer 1997). Lactation curves facilitate visualization of milk yield against days from calving and thus help in understanding the peak yield and persistency of the lactation. Moreover, test-day models also help in prediction of milk yield of a breed under unique conditions. Hence, this study was undertaken to understand the performance of Gir cattle under the hot and humid conditions of Tamil Nadu.

Data comprising of 5130 test day records from 19 lactations of 10 Gir cows maintained at Livestock Farm Complex of Tamil Nadu Veterinary and Animal Sciences University (LFC, TANUVAS), Chennai was utilized for this study. The cows were purchased from the native tract of Gujarat during November 2018 and data was collected for two years during the period from January 2019 to December 2020. Along with test day yield, information on the production, reproduction, persistency and milk composition were also studied.

The LFC, TANUVAS is located in Chennai district of Tamil Nadu, India with co-ordinates 13.15°N 80.24°E and features a tropical hot and humid climate for most of the year. The animals were managed under intensive system of management with green fodder (20 kg/day), paddy straw (1–2 kg/day) and concentrate (1.0 kg for maintenance and additional 400 g per liter of milk produced) feeding.

Total lactation yield (kg), peak yield (kg), days at peak

Present address: [1]Tamil Nadu Veterinary and Animal Sciences University, Chennai, Tamil Nadu. [2]Livestock Farm Complex, Madhavaram Milk Colony, Chennai, Tamil Nadu. [3]Madras Veterinary College, Chennai, Tamil Nadu. ✉Corresponding author email: drsundha22@gmail.com

yield (days), 180-day yield (kg), 305-day yield (kg), lactation length (days), dry period (days) and calving interval (days) were analyzed for the effect of season of calving (Equation 1). For test day yield (TDY), season of recording was taken as fixed effect, days from calving were taken as a covariate ranging from 1 to 396 and animal as the random effect. Milk composition traits like fat yield (%), SNF (%) and total solids (%) were analyzed to understand the effect of season of calving and stage of lactation. Seasons were formed by grouping the months of milk collection as winter (January, February, November and December), summer (March to June) and monsoon (July to October). Stage of lactation was taken as a fixed factor which was obtained by dividing the lactation length into three parts and animal was taken as a random effect (Equation 2).

Persistency of milk yield was calculated using the Mahadeven method and gamma function (Tekerli *et al.* 2001)

Descriptive and exploratory analyses were done for all the economic traits studied using R software (R core team, 2020). General linear model (GLM) analysis was done for the effect of fixed factors and Tukey post-hoc test was used to compare the pair-wise means. Packages used were lme4, emmeans, psych, agricolae and ggplot2. A repeatability model with animal as random effect along with season and test day (as covariate) was used for the test day yield which corrected for the correlation between measurements from the same animal. The models used for test day yield, production and reproduction traits and milk composition traits could be represented as:

$$Y_{ijkl} = E_i + I_j + M_k + e_{ijkl} \quad (1)$$

where Y_{ijkl}, Test day yield; E_i, fixed effect of i^{th} season (i=1 to 3); I_j, effect of days from calving as a covariate (j= 1 to 396); M_k, random effect of k^{th} cow (k=1 to 10), NID (0, σ^2_b); e_{ijkl}, random residual associated with each observation, NID (0, σ^2_e).

$$Y_{ijkl} = E_i + I_j + M_k + e_{ijkl} \quad (2)$$

where Y_{ijkl}, milk production, reproduction or composition traits; E_i, fixed effect of i^{th} season of calving (i=1 to 3); I_j, fixed effect of j^{th} stage of lactation for milk composition traits (j= 1 to 3); M_k, random effect of k^{th} cow (k=1 to 10), NID (0, σ^2_b); e_{ijkl}, random residual associated with each observation, NID (0, σ^2_e).

Various lactation curve models were fitted to understand the trajectory of milk yield against days in milk for Gir cows (Biswal *et al.* 2017).

The models were then ranked based on their adjusted R^2, Root mean square error (RMSE) and Bayesian Information Criterion (BIC). Friedman's test was used to

Table 1. Descriptive statistics and effect of season and stage of lactation for milk production, reproduction and composition traits

Trait	TDY (kg)	Fat (%)	SNF (%)	TS (%)	TLY (kg)	PY (kg)	Days at PY	180-day yield	305-day yield	LL (days)	DP (days)	CI (days)
N	5130	140	140	140	19	19	19	20	19	19	13	13
Min	0.30	1.32	0.79	5.80	447.00	7.00	6.00	447.00	447.00	142.00	79.00	269.00
Max	11.80	11.40	10.00	18.37	2098.00	11.80	147.00	1415.00	2043.00	396.00	282.00	617.00
Mean	5.78	5.05	7.65	12.70	1507.00	9.23	46.50	1070.00	1450.00	279.00	160.77	447.00
SE	0.03	0.12	0.13	0.22	119.12	0.39	9.09	57.19	106.01	17.59	16.93	28.44
SD	2.07	1.47	1.53	2.59	519.25	1.69	39.64	255.76	462.08	76.67	61.04	102.55
CV	0.36	0.29	0.20	0.20	0.34	0.18	0.85	0.24	0.32	0.27	0.38	0.23
Effect of season on milk production and composition traits												
	**				*				*			
Summer	6.82± 0.05^a	5.18± 0.45	7.50± 0.24	12.60± 0.65	1387± 201	9.26± 0.73	24.70± 15.40	1156.00± 93.70	1378± 180	250.00± 32.40	166.00± 46.50	355.00± 69.90
Rainy	4.98± 0.04^b	4.25± 0.75	7.23± 0.39	11.30± 1.06	1026± 224	8.00± 0.82	39.00± 18.90	808.00± 114.80	1012± 202	236.00± 36.30	136.00± 46.50	404.00± 69.90
Winter	5.59± 0.05^c	5.40± 1.07	8.38± 0.60	14.00± 1.55	1759± 142	9.70± 0.52	62.60± 11.90	1123.00± 72.60	1660± 128	311.00± 22.90	165.00± 21.90	477.00± 33.00
Effect of stage of lactation on milk composition traits												
Early	–	5.36± 0.56	7.88± 0.41	13.50± 0.90	–	–	–	–	–	–	–	–
Mid	–	4.97± 0.50	8.02± 0.33	13.00± 0.75	–	–	–	–	–	–	–	–
Late	–	4.50± 0.59	7.21± 0.44	11.50± 0.95	–	–	–	–	–	–	–	–

Where TDY, Test day yield; SNF, Solid non-fat; TS, Total solids; TLY, Total lactation yield; ADY, Average daily yield; PY, Peak yield; LL, Lactation length; DP, Dry period; CI, Calving interval; SD, Standard deviation; CV, Coefficient of variation. *indicates P<0.05 level of significance and **indicates P<0.01 level of significance. [a,b,c]indicate the superscripts obtained from Tukey test.

check whether the models were statistically different based on the ranks obtained through the different model diagnostics. The models of best fit were identified based on their mean ranks and then best six models along with the actual yield were plotted as graph and 305-day milk yield was predicted. Persistency of lactation was also calculated.

Results of descriptive analysis and effect of season and stage of lactation on milk production, reproduction and composition traits have been summarized in Table 1. The average TDY was similar to that obtained by Dora *et al.* (2020) for Gir cattle maintained at Chattisgarh but lower than Bangar and Verma (2017) and Gadariya *et al.* (2017) which could be a result of increased humidity as native tract (Gujrat) has hot and arid climate. Gir cattle maintained at Brazil (Araujo *et al.* 2018, Pereira *et al.* 2019) were found to have higher average TDY which could be due to the intense selection practiced in the country for improvement of milk yield. Season of recording significantly affected the TDY with higher yield during the summer season as Gir animals are well adapted to the hot summer months. Fat, SNF and TS content of milk observed for Gir cattle in the present study were in accordance with the results obtained by Araújo *et al.* (2018), Gajbhiye *et al.* (2019) and Dora *et al.* (2020).

Total lactation yield, 305-day yield and the lactation length observed in the present study were lower as compared to other studies (Gaur *et al.* 2003, Savaliya *et al.* 2016, Gadariya *et al.* 2017) from the native tract. Peak yield and days to attain peak yield observed in this study were in accordance with Patbandha *et al.* (2020) who reported that peak yield was attained in 6–8 weeks after calving. Gaur *et al.* (2003) and Savaliya *et al.* (2016) reported a lower value for dry period but the value of calving interval was similar to the present study whereas Gadariya *et al.* (2017) reported a higher calving interval. The milk composition traits were not affected by the climatic conditions and the results were

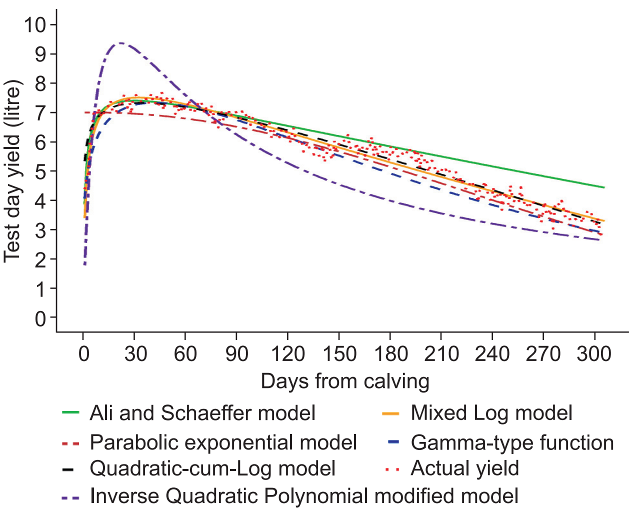

Fig. 1. Various lactation curve models along with the actual yield.

comparable to other studies.

The lower lactation length could be due to the better performance with respect to reproduction as caused by early pregnancy in the subsequent parity. This finding is also supported by the values of calving interval, which was comparable to values recorded in the native tract (Gadariya *et al.* 2017). Thus the Gir cattle are able to adapt themselves through maintenance of reproductive traits comparable with that of the native tract but the new humid environment has caused a slight decrease in the performance of milk production traits which could be increased through selection.

In the present study, season and stage of lactation did not influence the milk composition traits while earlier studies (Gajbhiye *et al.* 2019) reported significant effect of season and stage of lactation on milk constituent traits. Uniform plane of nutrition in the intensive management system followed in the farm could be the probable reason for absence of differences between season and stage of lactation. Significantly positive correlation ($P<0.01$) of 0.59 (fat-SNF), 0.91 (fat-TS) and 0.87 (SNF-TS) was observed which agreed with the results obtained by Dora *et al.* (2020).

Among the various models used to study the lactation curve, Ali and Schaeffer model was the best fitting model whereas Wilmink's models did not provide a good fit (Table 2). RMSE (Root mean square error) values were lower and similar for all the models except Inverse quadratic polynomial model. Friedman's test gave non-significant results which showed that ranks obtained from all the model diagnostic criteria were similar. Best six models based on their mean rank obtained through BIC, adjusted R^2 and RMSE were Ali and Schaeffer model, Parabolic exponential model, Inverse quadratic polynomial modified model, Quadratic cum log model, Mixed log model and Gamma-type function have been plotted in Fig. 1. The predicted 305-day yields from these models were 1845.935, 1633.173, 1540.196, 1719.196, 1711.945 and 1620.361 respectively. Gamma-type function was given as the best fitting model adjudged in earlier studies by Bangar and Verma (2017) and Savaliya *et al.* (2017).

Persistency calculated using Mahadevan method was 1.33±0.08 which was comparable to other studies done for HF crossbred cattle in India (Sharma *et al.* 2018) and using Gamma function was 6.348 which was similar with the study done on Gir crossbreds (Bangar and Verma 2017).

The production parameters of Gir cattle were slightly lower than other studies conducted in the native tract of the breed in India. Milk composition and reproduction parameters such as calving interval were comparable with that of the results observed in the native tract. Thus, the Gir cattle are able to adapt themselves through maintenance of reproductive traits comparable with that of the native tract but the new humid environment has caused a slight decrease in the performance of milk production traits. Ali and Schaeffer model can be used for predicting the milk yield of Gir cattle reared in hot and humid conditions of Tamil Nadu.

Table 2. Lactation curve models

Model name	Adjusted R-Square	BIC	RMSE	Mean rank
Ali and Schaeffer model	0.449	20275	1.570	4.333
Parabolic exponential model	0.427	4768	0.375	4.667
Inverse quadratic polynomial modified model	0.255	–4773	0.155	5.000
Quadratic cum log model	0.448	20275	1.571	5.000
Mixed log model	0.448	20267	1.571	5.333
Gamma function	0.421	4826	0.377	6.000
Exponential decline function	0.391	5086	0.386	7.000
Cubic model	0.443	20323	1.578	7.000
Quadratic Model	0.441	20338	1.582	8.000
Wilkmink model (k=0.05)	0.433	20416	1.593	9.000
Inverse quadratic polynomial	0.588	54780	38.226	9.667
Wilkmink model (k=0.065)	0.433	20419	1.594	9.667
Wilkmink model (k=0.1)	0.432	20425	1.595	11.000
Wilkmink model (k=0.61)	0.431	20433	1.596	12.000

Where BIC, Bayesian information criterion; RMSE, Root mean square error.

ACKNOWLEDGEMENT

The authors thank the Director, Centre for Animal Production Studies for permitting to utilize the data from LFC, TANUVAS for the study.

REFERENCES

Araújo T P M, Rangel A H D N, Lima G F D C, Peixoto M G C D, Urbano S A and Bezerra J D S. 2018. Gir and Guzerat cow milk production and composition according to lactation stage, somatic cell count, physiological state and body condition. *Acta Scientiarum Animal Sciences* **40**(1): 39352.

Bangar Y C and Verma M R. 2017. Non-linear modelling to describe lactation curve in Gir crossbred cows. *Journal of Animal Science and Technology* **59**(1): 1–7.

Biswal S, Thirunavukkarasu M, Selvam S, Venkataramanan R and Pandian A S S. 2017. Modeling lactation curve in jersey crossbred cows. *Journal of Entomology and Zoology Studies* **5**(6): 1282–85.

Daltro D D S, Padilha A H, Gama L T D, Silva M V G B D and Cobuci J A. 2021. Breed, heterosis, and recombination effects for lactation curves in Brazilian cattle. *Revista Brasileira de Zootecnia* 50.

Dora D S, Chourasia S K, Sahu S S, Paikra D and Bara S. 2020. Relationship between different milk constituents of GIR cow. *Journal of Entomology and Zoology Studies* **8**(2): 551–53.

Gadariya M R, Vataliya P H, Murthy K S and Gajbhiye P U. 2017. Breeding and lactation efficiencies, production profile, productive herd life and lifetime productivity of Gir cows in their home tract. *Indian Journal of Veterinary Sciences and Biotechnology* **13**(02): 26–30.

Gajbhiye P U, Ahlawat A R, Sharma H A and Parikh S S. 2019. Effect of stage, season and parity of lactation on milk composition in Gir cattle. *International Journal of Current Microbiology and Applied Sciences* **8**(3): 2419–25.

Gaur G K, Kaushik S N and Garg R C. 2003. The Gir cattle breed of India-characteristics and present status. Animal Genetic Resources **33**: 21–29.

Jamrozik J and Schaeffer L R. 1997. Estimates of genetic parameters for a test day model with random regressions for yield traits of first lactation Holsteins. *Journal of Dairy Science* **80**(4): 762–70.

Mahadevan P. 1951. The effect of environment and heredity on lactation. II. Persistency of lactation. *Journal of Agricultural Science* **41**(1–2): 89–93.

Patbandha T K, Sabapara G P, Savaliya B D, Dash S K, Parikh S S and Ali M. 2020. Physical characteristics and production performance of Gir cattle in India. *International Journal of Livestock Research* **10**(8): 1–11.

Pereira R J, Ayres D R, Santana Junior M L, Faro L E, Vercesi Filho A E and Albuquerque L G D. 2019. Test-day or 305-day milk yield for genetic evaluation of Gir cattle. *Pesquisa Agropecuária Brasileira* 54.

R Core Team. 2020. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Version: 3.6.1.

Savaliya B D, Parikh S S, Ahlawat A R and Makwana R B. 2017. Comparative efficiency of various mathematical functions of lactation curve in Gir cattle using weekly milk yields. *International Journal of Livestock Research* **7**(5): 112–20.

Savaliya B D, Parikh S S, Gamit P M and Gajbhiye P U. 2016. Environmental factors affecting economic traits in Gir cattle. *International Journal of Science, Environment and Technology* **5**(4): 2467–75.

Sharma N, Narang R, Kashyap N, Kumari S, Kaur S and Ratwan P. 2018. Genetic analysis of persistency in HF crossbred cattle at an organized farm of northern India. *Tropical Animal Health and Production* **50**(6): 1219–25.

Tekerli M, Akinci Z, Dogan I and Akcan A. 2000. Factors affecting the shape of lactation curves of Holstein cows from the Balikesir province of Turkey. *Journal of Dairy Science* **83**(6): 1381–86.