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ESTIMATION OF GENETIC AND NON-GENETIC FACTORS FOR MONTHLY TEST DAY MILK YIELD IN GIR CATTLE

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Abstract: Data on 358 Gir cows maintained at the Cattle Breeding Farm, Junagadh from 1986-2014 were analyzed to assess the influence of various environmental factors on monthly test day milk yield and to estimate various genetic parameters for first lactation traits *viz,* Monthly test day milk yield, Age at first calving (AFC), First lactation 305-day milk yield (FLY305MY) and Lactation length (FLL). The least squares means for individual MTDMYs varied from 2.74 ± 2.0 Litres to 6.35 ± 0.26 Litres. The effect of season of calving on first monthly test day was highly significant whereas the effect of Age at first calving and period of calving did not have any significant effect on monthly test day milk yields. Average heritability estimates of FL305DMY, LL and AFC were found to be 0.069 ± 0.04, 0.019 ± 0.032 and 0.303 ±0.063 respectively. Heritability estimates of all MTDMYs ranged from 0.011 to 0.089. Genetic correlations among TD4, TD5, TD6, TD9 and TD10 found to be high and positive and ranged from 0.79 ± 0.32 to 0.93 ± 0.90. Phenotypic correlation coefficient among all MTDMYs and with FL305DMY were high and positive.

Keywords: Gir Cow, Non-genetic factors Test-day milk yield, First lactation 305-day milk yield, Age at first calving, Lactation length.

Introduction

India is believed to be a rich reservoir of livestock biodiversity with fifty-three registered cattle breeds. The state of Gujarat located on western coast of India has a total cattle population of 9.46 million of which 1.40 million are Gir animals. The Gir cow is one of the principal zebu breeds known as milch breed of dairy cow. Gir animals are known for their tolerance to stress

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condition and resistance to various tropical diseases. Pure breeding is preferentially practiced throughout Saurashtra region of Gujarat State.

Studies conducted in the past revealed that genetic analysis of production traits in dairy cattle could be enriched by utilizing test day models instead of aggregated 305 days lactational milk yield record (Singh *et al*., 2016) [1]. Modeling the systematic environmental and genetic effects along the lactation trajectory using test-day milk yield records has been widely used for dairy cattle genetic evaluation, because it provides higher accuracy than genetic evaluation based only on total lactation yield or 305-day milk yield (Wahinya *et al*., 2020) [2]. For establishing any selection or breeding programme, the knowledge of genetic and non-genetic factors influencing productive traits is of prime importance (Chaudhari *et al*., 2013) [3].

The estimates of genetic parameters are useful in determining the appropriate method of selection that could further be implemented in the breed improvement programme (Rana *et al*.,2020)[4].The estimation of genetic parameters plays an important role in determining the appropriate method of selection to predict direct and correlated response to selection, and formulating optimum breeding strategies for future genetic improvement of dairy animals (Singh *et al*., 2020)[5]; A basic prerequisite for planning of breeding program is the variability existing in the population and how much of this is caused by differences in the genetic make-up of the individuals The genetic parameters are essential tools in animal breeding programme and in the designing and application of practical breeding programme (Koots *et al*. 1994)[6].

Materials and Methods

The data for the present investigation were obtained from the records of Cattle Breeding Farm (CBF), Kamdhenu University, Junagadh for various production traits pertaining to first lactation records of 358 daughters born to 40 sires of Gir cattle, spread over a period of 29 years (1986– 2014). Animals were fed with sufficient quality ad lib green fodder and were maintained on uniform feed and managemental conditions and offered concentrate and fodder as per ICAR standards. The records of animals with less than 300 kg of milk production or less than 100 days of lactation length were also discarded. The monthly test day records with an interval of 30 days (i.e. 4th day, 34th day,64thday......, 204th and 304th day of lactation) were recorded. Genetic parameters for Monthly test day milk yield, Age at first calving (AFC), first lactation 305-day milk yield (FLY305MY) and Lactation length (FLL) were estimated Monthly test day records with an interval of 30 days (i.e. 4th day, 34th day, 64th day……and 304th day of lactation). All the experimental data was classified according to period of calving, season of calving and age at first calving. The years were classified in four periods of five-year duration except first period which was of five years duration (1986-1990, 1991- 1998,1999-2006 and 2007-2014). Based upon the seasonal variation, the year was divided into five seasons viz. Summer (April-June), Rainy (July-September), Autumn (October- November), Winter (December-January), Spring (February-March). The age at first calving was classified in seven groups i.e. less than 1200 days, 1201-1400, 1401-1600, 1601- 1800, 1801-2000 and more than 2200 days. The data was subjected to least squares analysis to know the effect of different non-genetic factors on various first lactation traits. The outliers (±2SD) were removed from the present study. The data were analyzed to study the effect of non-genetic factors (season, period and age at first calving) on all monthly test day milk records using fixed effect linear model by least squares and maximum likelihood analysis method for non-orthogonal data.

Where,

$Y_{ijkl} = \mu + si + aj + b k + e_{ijkl}$

Y ijkl = Observation on the l^{th} individual in i^{th} season, j^{th} period and k^{th} age group.

μ = Overall population mean

si = Effect of i^{th} Season of calving (i = 1 to 5)

aj = Effect of j^{th} period of calving (j = 1 to 4)

bk = Effect of k^{th} age group (k = 1 to 7)

eijkl=Random error, NID (0)

Duncan's multiple range test as modified by Kramer (1957) [7] was used for testing differences among least squares means. The sires with three or more number of progenies were considered for the estimation of heritability. The data adjusted for significant effects of non-genetic factors was used for the estimation of heritability. Data were analyzed using Least Squares and maximum likelihood computer program (LSMLMW) of Harvey (1987) [8]. Heritability, genetic correlations and phenotypic correlations were calculated by paternal half-sib correlation method. The standard error of heritability was estimated as per the procedure given by Swiger *et al*., (1964) [9] The genetic correlation was calculated from sire component of variance and covariance. The genetic and phenotypic correlations among different monthly test day milk yields, peak yield and FL305DMY were calculated from the analysis of variance and covariance among sire groups (Becker, 1975)[10]. The standard error of genetic and phenotypic correlations was computed according to Panse and Sukhatme (1967)[11].

Results and Discussion

The records comprised of data on various production traits of 358 first lactation records of daughters born to 40 sires of Gir cattle, spread over a period of 29 years (1986 – 2014). Overall least squares means for different individual test day milk yields in Gir cows ranged from 2.74±2.0 to 6.35±0.26 liters (Table 1)

Effect of non-genetic factors

The effect of season of calving on MTDMY1 was found to be highly significant (P<0.01) (Table 1). However, on other test day records it was found to be non- significant. Similar findings were also reported by Monalisa *et al*. (2010) [12] in Sahiwal cows, Japheth *et al*. (2015) [13] and Singh *et al*. (2016) [1] in Karan Fries cattle. However, Bhadouria *et al*. (1986) [14] have reported the significant effect of season of calving on all the monthly milk yields except the 5th and 6th months in Jersey cows. Effect of Period of calving on all monthly test-day milk yields was found to be non- significant in the present study (Table 1). Similar observation has been made by Monalisa *et al*. (2010) [12] and Japheth *et al*. (2013) [13] in Sahiwal cows and Karan Fries cattle, respectively. Effect of Age at first calving on test-day milk yield was found to be non-significant on all MTDYs in present study. The present results are in agreement with Rose (2008) [15] who reported that the age at first calving had no significant effect on any of the monthly test day milk yields in the first lactation of Karan Fries cows. Observation of non-significant effect of season, period and age on second and subsequent test day records might be due to scientific managemental practices adopted in the farm since its inception.

Genetic parameters of Production traits in Gir cow

The heritability estimates of FL305DMY estimated using intra class correlation among half-sib method was low (0.069 ± 0.04), indicating low genetic variability in theFL305DMY in Gir cows. Similar findings have also been reported in different herds by Kathiravan (2009) [16] and Raja (2010) [17]. Comparatively higher heritability of FL305DMY was reported by Gajbhiye and Dhanda (1987) [18] in the same herd at cattle breeding farm, Junagadh in Gir cattle. Higher estimates were also reported by Kannan (2002) [19], Dubey and Singh (2005) [20] in Sahiwal cattle.

Heritability estimates for TDMY1 to TDMY11 ranged from 0.011 to 0.089(Table 2). All the estimates were low indicating existence of very low additive genetic variance for TDMY traits in Gir Cow. This is indicative of the fact that as overall 305FLY also had very heritability, the milk yield character as a whole is lowly heritable at all the stages of lactation. Banik and Gandhi (2010) [21] studied first lactation records of 1367 Sahiwal cows, found heritability of FL305DMY as 0.22 which higher than the heritability value obtained in the present study. Estimates in general were lower at the beginning of lactation and then it increased consistently towards the end of lactation before starting to decline in late lactation. The main reasons for the slightly lower heritabilities observed at both ends of the lactation trajectory could be due to the higher estimates of permanent environmental effects. All the heritability estimates were statistically highly significant ($P<0.01$) except for TD-2-and TD-11- yields, which were having higher proportion of standard errors as compared to estimates.

Heritability of FLL

Heritability of First Lactation length in Gir herd was found to be 0.019 ±0.032 which is low. Similar low estimates for heritability (0.01) were also reported by Badri *et al*. (2011) [22] in Butana Dairy cows. Low to moderate h^2 estimate for lactation length were observed by Ankuya *et al*. (2016) [23] in Kankrej herd and Subhalakshmi *et al*. (2010) [24] in HF X Sahiwal crosses. Pirzada (2012) [25] reported higher magnitude of heritability for first lactation length in Tharparkar cattle. The low heritability of FLL illustrates that a major part of the variation in these characters are environmental and improvement can be made by improving environmental conditions such as nourishing and management systems.

Heritability of AFC:

Heritability estimate of Age at First Calving in Gir cows was 0.303 ± 0.063 and hence the character seems to be genetically open for improvement. Corresponding values of heritability have also been reported by Singh *et al* (2016) [1] in Gir cows and Ratwan *et al* (2019) [26] in Sahiwal cows. Moderate estimates of h^2 were obtained by Mahadevan *et al*. (1962) [27] in Sahiwal, Jegan and Tomar (1983) [28] in Hariana, and Badri *et al*. (2011) [25] in Butana Dairy cows.

Genetic and phenotypic correlation

Genetic correlation of first lactation 305-day milk yield with other traits in Gir cows:

The estimates of Genetic correlations among all the monthly test day milk yields (Table 2) were high and positive, which ranged from 0.67 to >1. The estimates of genetic correlation of monthly test day yields with 305-day milk yield ranged from 0.87 with TDMY8 to 1.81 with TDMY2.

Genetic correlations between test-day yields were higher between days adjacent to each other and then decreased as the distance in time between the test-days increased. Genetic correlation between TDMY4, TDMY5, TDMY6, TDMY9 and TDMY10 were high and positive ranging from 0.79 ± 0.32 to 0.93 ± 0.90. Thus 4th, 5th, and 6th month test day milk yield which are from the mid of the lactation period seem to be important readings which determine the total lactation yield as these are genetically and positively associated with FL305DMY. Rests of the estimates for genetic correlations were overestimated and superfluous. Positive genetic correlations estimated between yields in different days within lactations indicate that genetic gain in the mid- and later lactation could be achieved by selecting for yield early in lactation. Hence important decisions based on expected production of an animal can be taken using TDMY of mid lactation. Wahinya *et al* (2020) [2] reported lowest correlations were estimated between yields at the beginning and end of the lactations. Positive and higher genetic correlations were reported between different lactation traits and monthly test day milk yields are reported by Gajbhiye *et al*. (2004) [29] in kankrej cattle, Dongre and Gandhi (2014) [30] in Sahiwal cows, Singh *et al*. (2016) [31] in Karan Fries cattle and Santos *et al*. (2013) [32] in Guzerat cows.

Phenotypic correlation of first lactation 305-day milk yield with other traits in Gir cows: The phenotypic correlations among all monthly test day milk yields and with 305-day milk yield (Table 2) were positive and significant. The estimates of phenotypic correlations between all the monthly test day milk yields with FL305DMY ranged from 0.36 to 0.88. The estimates of phenotypic correlations among monthly test day yields ranged from 0.28 to 0.85. Thus, all the test day milk yield estimates were phenotypically positively associated among themselves. Generally, the phenotypic correlation among various individual monthly milk yields followed a definite trend as the estimates were higher for the adjacent monthly yields and decreased with increase in the gap between months. Similar finding were also reported by Gajbhiye *et al*. (2004) [29] in kankrej cattle and Costa *et al*. (2007) [33] in Brazilian Holstein cows. Whereas, Kumar (2015) [34] reported low to high estimates of phenotypic correlations among test day milk records ranged from 00.11 to 0.75

Conclusions The effect of season of calving on first monthly test day was highly significant A low heritability estimate for FL305DMY (first lactation 305-day milk yield) indicates that genetic variability plays a smaller role in determining this trait within the population. Heritability estimates for TDMY1 to TDMY11 ranged from 0.011 to 0.089 for TDMY7. All the estimates were low indicating existence of very low additive genetic variance for TDMY traits in Gir Cow. Heritability of first lactation length and Age at First Calving in Gir was found to be 0.019 ± 0.032 and 0.303 ± 0.063. Genetic correlation between TDMY4, TDMY5, TDMY6, TDMY9 and TDMY10 were high and positive. The test day milk yield from mid of the lactation period seems to be important readings which determines the total lactation yield as these are genetically and positively associated with FL305DMY. Hence important decisions based on expected production of an animal can be taken using TDMY of mid lactation. The phenotypic correlations among all monthly test day milk yields and with 305-day milk yield were positive and significant.

Conflict of interest The authors declare that they have no conflict of interest.

Ethical standards: Experiments comply with the current laws of the country in which they were performed.

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Table 1: Least squares means along with their standard errors for factors affecting monthly test-day milk yields and first lactation 305-day milk yield in Gir cows:

Traits	TD1	TD2	TD3	TD4	TD5	TD6	TD7	TD8	TD9	TD10	TD11	SLY
Overall	4.65± 0.19	6.21 ± 0.20	6.35 ± 0.26	6.06 ± 0.26	5.64 ± 0.25	5.25 ± 0.24	4.85 ± 0.25	4.41 ± 0.24	3.90 ± 0.26	3.54 ± 0.20	2.74 ± 0.2	1517.31 ± 65.14
Season												
1	4.16 ± 0.31[a]	5.72 ± 0.35	5.94 ± 0.39	5.54 ± 0.39	4.91 ± 0.37	4.76 ± 0.35	4.39 ± 0.36	3.97 ± 0.37	3.69 ± 0.37	3.40 ± 0.34	2.31 ± 0.35	1417.92 ± 97.02
2	4.58 ± 0.30[b]	5.83 ± 0.35	5.63 ± 0.39	5.85 ± 0.39	5.53 ± 0.37	5.22 ± 0.35	4.78 ± 0.36	4.21 ± 0.36	3.90 ± 0.37	3.49 ± 0.34	3.01 ± 0.35	1496.54 ± 96.63
3	4.71 ± 0.37[b]	6.33 ± 0.43	6.88 ± 0.47	6.68 ± 0.46	6.27 ± 0.43	5.83 ± 0.42	5.49 ± 0.43	5.01 ± 0.44	4.23 ± 0.44	3.98 ± 0.42	2.99 ± 0.43	1660.07 ± 115.59
4	4.38 ± 0.31[ab]	6.54 ± 0.36	6.56 ± 0.40	6.13 ± 0.39	5.66 ± 0.37	5.08 ± 0.36	4.70 ± 0.36	4.28 ± 0.37	3.78 ± 0.38	3.23 ± 0.34	2.61 ± 0.35	1491.98 ± 97.72
5	5.41 ± 0.27[c]	6.62 ± 0.31	6.72 ± 0.35	6.10 ± 0.35	5.83 ± 0.33	5.36 ± 0.32	4.91 ± 0.33	4.57 ± 0.33	3.93 ± 0.34	3.60 ± 0.30	2.78 ± 0.31	1520.03 ± 87.58

Period												
1	4.21 ± 0.52	5.39 ± 0.61	5.77 ± 0.65	5.11 ± 0.63	4.59 ± 0.59	4.37 ± 0.58	4.34 ± 0.58	4.06 ± 0.60	3.88 ± 0.60	3.53 ± 0.59	2.93 ± 0.60	1378.99 ± 157.76
2	5.66 ± 0.54	6.88 ± 0.64	6.67 ± 0.68	6.80 ± 0.65	6.13 ± 0.61	5.07 ± 0.60	4.26 ± 0.60	3.95 ± 0.63	2.95 ± 0.62	2.02 ± 0.61	1.76 ± 0.63	1568.08 ± 163.84
3	5.26 ± 0.61	6.12 ± 0.72	6.40 ± 0.76	6.02 ± 0.73	5.87 ± 0.69	5.19 ± 0.67	4.86 ± 0.67	4.13 ± 0.71	4.06 ± 0.70	3.47 ± 0.69	2.53 ± 0.71	1455.31 ± 183.74
4	3.46 ± 0.57	6.44 ± 0.68	6.54 ± 0.72	6.31 ± 0.70	5.98 ± 0.65	6.38 ± 0.64	5.94 ± 0.64	5.47 ± 0.67	4.71 ± 0.66	4.35 ± 0.65	3.76 ± 0.67	1666.85 ± 174.57
AFC												
1	4.30 ± 0.51	5.69 ± 0.61	6.62 ± 0.65	6.11 ± 0.63	5.96 ± 0.59	5.43 ± 0.57	4.45 ± 0.57	4.07 ± 0.60	3.36 ± 0.60	2.86 ± 0.58	2.20 ± 0.60	1495.88 ± 156.89[b]
2	4.52 ± 0.32	5.72 ± 0.37	5.54 ± 0.41	5.35 ± 0.40	4.90 ± 0.38	4.64 ± 0.36	4.35 ± 0.37	3.85 ± 0.38	3.31 ± 0.38	2.60 ± 0.35	2.38 ± 0.36	1286.55 ± 99.98[a]
3	4.76 ± 0.26	6.21 ± 0.30	6.22 ± 0.34	5.97 ± 0.34	5.61 ± 0.32	5.17 ± 0.31	4.81 ± 0.32	4.23 ± 0.32	3.87 ± 0.33	2.26 ± 0.29	2.82 ± 0.29	1529.98 ± 84.51[b]

4	4.94 ± 0.29	6.70 ± 0.33	6.73 ± 0.37	6.34 ± 0.37	5.79 ± 0.35	5.37 ± 0.34	5.05 ± 0.34	4.98 ± 0.35	4.47 ± 0.35	3.86 ± 0.32	3.01 ± 0.33	1692.17 ± 92.16[c]
5	4.76 ± 0.37	6.76 ± 0.44	6.86 ± 0.47	6.26 ± 0.46	6.20 ± 0.44	5.25 ± 0.42	5.05 ± 0.43	4.89 ± 0.44	4.33 ± 0.44	3.62 ± 0.42	3.07 ± 0.43	1657.25 ± 116.30[c]
6	4.31 ± 0.48	6.59 ± 0.57	6.49 ± 0.61	6.51 ± 0.59	5.80 ± 0.55	5.71 ± 0.54	5.44 ± 0.54	4.58 ± 0.57	4.61 ± 0.56	4.54 ± 0.55	3.03 ± 0.56	1670.88 ± 148.06[c]
7	4.95 ± 0.78	5.79 ± 0.93	5.97 ± 0.97	5.88 ± 0.93	5.22 ± 0.87	5.19 ± 0.85	4.82 ± 0.85	4.25 ± 0.90	3.38 ± 0.88	4.05 ± 0.88	2.68 ± 0.91	1288.43 ± 233.42[a]

(TD = test day)

Table 2:Heritability, Genetic and Phenotypic correlation among test-day milk yields and with standard lactation milk yield in Gir cows

Traits	TD1	TD2	TD3	TD4	TD5	TD6	TD7	TD8	TD9	TD10	TD11	SLY
TD1	**0.036±0.035**	0.67± 1.097	0.43± 0.505	0.19±0.51	0.12±0.50	0.03±0.39	0.39± 0.44	0.19±0.55	0.42±0.45	0.27±0.75	0.38±0.93	0.52±0.45
TD2	0.34	**0.011± 0.03**	1.56±1.54	1.76±1.91	1.62±1.74	1.83±2.06	1.84± 2.14	1.79±2.05	1.82±2.18	1.40±1.62	2.60±3.87	1.81±2.00
TD3	0.33	0.77	**0.058±0.03**	1.02±0.07	0.98± 0.08	1.07± 0.10	1.07± 0.12	1.02±0.16	0.96±0.16	0.81±0.47	1.25±0.90	1.05±0.08
TD4	0.33	0.73	0.84	**0.073± 0.04**	0.97±0.06	0.85±0.11	0.93± 0.10	0.71±0.22	0.68±0.22	0.66±0.44	0.95±0.68	0.93±0.9
TD5	0.31	0.68	0.82	0.85	**0.086±0.042**	1.00±0.05	0.88± 0.10	0.68±0.21	0.65±0.21	0.31±0.53	0.70±0.59	0.86±0.11
TD6	0.33	0.68	0.78	0.82	0.85	**0.073±0.04**	1.00± 0.06	0.82±0.16	0.82±0.15	0.45±0.48	1.20±0.82	0.88±0.10
TD7	0.33	0.61	0.73	0.74	0.78	0.81	**0.089± 0.04**	1.00±0.06	0.90±0.09	1.08±0.40	1.52±1.07	1.02±0.06
TD8	0.33	0.55	0.67	0.68	0.73	0.74	0.85	**0.060±0.03**	0.90±0.09	0.95±0.30	1.36±0.85	0.087±0.12
TD9	0.28	0.49	0.62	0.63	0.65	0.70	0.78	0.84	**0.087±0.04**	1.16±0.35	1.72±1.25	0.92±0.09
TD10	0.29	0.44	0.51	0.55	0.56	0.62	0.67	0.73	0.83	**0.023±0.03**	1.42±0.78	0.79±0.32
TD11	0.25	0.41	0.48	0.51	0.50	0.56	0.63	0.66	0.76	0.83	**0.016±0.03**	1.17±0.70
SLY	0.36	0.73	0.82	0.88	0.83	0.83	0.84	0.83	0.80	0.70	0.66	**0.069± 0.04**

[Note: Figures along the diagonal in bold scripts are the heritabilities; Figures above the diagonal are the genetic correlations.]