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Accuracy of part yield in estimating lactation milk yield of Gir (*Bos indicus*) cows

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Abstract
Standard lactation milk yield (SLMY) was predicted by simple regression equation from weekly, fortnightly and monthly, individual and cumulative part yields in Gir cows. A total of 300 normal lactations of Gir cows from 1st to 6th parity with lactation length >210 days were utilized. Correlation coefficients between 305-day milk yield (SLMY) and different weekly (1st to 25th week), fortnightly (1st to 10th fortnight) and monthly (1st to 5th month), individual and cumulative part lactations were positive and significant (P<0.01) and showed increasing trend with advancement of lactation. Reliability of prediction for standard lactation milk yield (SLMY) was reasonably high, *i.e.*, about 85% with 20th, 21st, 22nd or 24th week yield, 9th or 10th fortnight yield and 5th month part lactation yields. Individual part yields were found to be more reliable than cumulative respective (weekly, fortnightly and monthly) part yields for prediction of SLMY. WY14 or FNY7 milk yield as part lactation covered 78.18-79.85% of variation in SLMY in of Gir cows. R^2 value of 72.26% for first 100-day milk yield as part lactation was quite reliable to determine production potential in terms of SLMY of Gir cows. However, considering 4th or 5th month (120 to 150-days) milk yield alone of the cows gave still higher reliability (R^2, 82.27 to 87.40%) of SLMY.

Keywords: Cumulative milk yield, Gir cows, lactation milk yield, part yield, prediction

Introduction
Information on exact production potential of milch bovines is utmost important for taking decision as regards to its own retention in the herd or culling from the dairy farm and also of daughters of the sires covered under progeny testing programmes. For earlier and preliminary evaluation of sires, part lactation milk yield records of daughters have been advocated by several researchers (Madden *et al.*, 1955; Searle, 1961; Vinothraj *et al.*, 2017) [3, 8, 13] and it can be taken as criterion instead 305-day lactation milk yield records. The recording method should be economical and physically feasible, yet reliable one. To overcome the difficulties of daily milk yield recording, test day records and part yields have been used to prediction of lactation milk yield in dairy bovines by several researchers (Ranjan *et al.*, 2005; Singh, 2006; Bansal, 2009; Chakraborty *et al.*, 2010; Sah *et al*., 2013; Singh and Tailor, 2013) [5, 9, 10, 1, 2]. There is dearth of such study in of Gir cows. Therefore, it was attempted to predict standard lactation milk yield from weekly, fortnightly and monthly, individual and cumulative part yield in Gir cows.

Materials and Methods
The records (N=2,34,748) on daily morning and evening milk production performance of Gir cows lactating at the Cattle Breeding Farm, Junagadh Agricultural University, Junagadh, Gujarat over a period of 31 years (1986-2016) were used for the study. A total of 300 normal lactations of Gir cows (N=50) from 1st to 6th parity with lactation length >210 days were analysed. The data on daily milk production during lactation of each animal were divided into 25 weeks, 10 fortnights and also in 5 months and used for correlation efficient and regression analysis for prediction of standard lactation milk yield by using SPSS software. (SPSS Inc., 2008). Simple regression equation aimed at predicting the standard lactation milk yield (SLMY) on the basis of weekly, fortnightly and monthly, individual and cumulative part yields as independent variables was as follows:

$$\hat{Y} = a + bx$$

Where

$\hat{Y}$, predicted standard lactation milk yield,

a, intercept value,

b, regression coefficient of lactation yield (Y) on part yield (x), and x, independent variables (weekly, fortnightly and monthly part yield)

The coefficient of determination (R^2) was calculated on the basis of following formula:

$$R^2 = \frac{\text{Regression sum of square}}{\text{Total sum of square}} \times 100$$

The data were subjected to simple regression equation taking SLMY as dependent and part yield as independent variable (Snedecor and Cochran, 1994) [11] and the findings were incorporated accordingly.

Results and Discussion

Averages ± SE(s) for 1st to 25th weekly (individual and cumulative) milk yields of Gir cows from early- and mid-lactation considered for the study as part lactation yield have been furnished in Table 1 and 2. Overall milk yields from 1st to 10th fortnights averaged 149.43±2.60, 157.30±2.56, 156.54±2.50, 153.96±2.43, 149.62±2.36, 144.71±2.31, 139.63±2.27, 134.39±2.28, 128.74 ±2.21 and 123.19 ±2.15 lit., respectively (Table 3), whereas monthly milk yields for first 5 months were found to be 306.74±5.04, 310.50±4.86, 294.33±4.63, 274.02±4.52 and 251.93±4.32 lit. (Table 5). Standard (305-day) lactation milk yield (SLMY) of Gir cows averaged 2347.05±37.33 lit.

Individual Weekly and Cumulative Weekly Milk Yield for Prediction of SLMY

Regression analysis of weekly milk yield for prediction of standard (305-day) lactation milk yield (SLMY) in Gir cows is presented in Table 1.

Correlation coefficients between SLMY and different weekly (1st to 25th week) part lactations of Gir cows were significant (P<0.01), positive and ranged from 0.697 for WY1 (1st week) to 0.922 for WY24 (24th week), then after it showed reduced association (r-value) with SLMY. The findings are in consonance with those of Singh (2006) [10], who also observed that association and accuracy of prediction of SLMY based on part milk yields exhibited consistently increasing trend with advancement of lactation. Perusal of data in Table 1 revealed that the estimates of phenotypic correlations between SLMY and different weekly part lactations increased from 0.697 to 0.702 for WY1 to WY5, 0.749 to 0.832 for WY6 to WY8, 0.852 to 0.894 for WY9 to WY16 and 0.901 to 0.923 for W17 to W25. Further, weekly yields, separately till WY5 covered a variation of less than 51% whereas WY6 to WY8, 56 to 69%, WY9 to WY16, 72 to 80% and WY17 to WY25, 81 to 85% variation in SLMY. Reliability of prediction for SLMY was quiet high and maximum of 84 to 85 % when WY20 to WY24 individual weekly part lactation yields were used as independent variable.

Table 1: Regression analysis of individual weekly milk yield for prediction of SLMY in Gir cows

Trait (variable)	Trait (variable)			r value*	Intercept		b value		R^2 %
	N	Mean	SE		Mean	SE	Mean	SE	
WY1	300	67.61	1.22	0.697	908.33	89.83	21.28	1.27	48.42
WY2	300	71.53	1.26	0.714	838.47	89.72	21.09	1.20	50.75
WY3	300	72.66	1.23	0.695	814.01	95.85	21.10	1.27	48.07
WY4	300	73.74	1.20	0.713	709.76	96.97	22.20	1.27	50.63
WY5	300	73.94	1.20	0.702	728.74	98.88	21.89	1.29	49.05
WY6	300	72.69	1.19	0.749	638.07	90.90	23.51	1.20	56.02
WY7	300	72.66	1.17	0.810	467.48	81.88	25.87	1.09	65.46
WY8	300	71.96	1.15	0.832	406.44	77.77	26.97	1.04	69.12
WY9	300	70.83	1.10	0.852	304.30	75.23	28.84	1.03	72.54
WY10	300	69.92	1.12	0.862	344.27	70.86	28.65	0.98	74.19
WY11	300	68.97	1.10	0.863	329.53	71.05	29.25	0.99	74.35
WY12	300	67.76	1.10	0.875	331.35	67.12	29.75	0.95	76.47
WY13	300	66.74	1.07	0.880	303.24	66.25	30.62	0.96	77.41
WY14	300	65.52	1.06	0.885	311.66	64.55	31.07	0.95	78.18
WY15	300	64.67	1.08	0.887	362.32	62.37	30.69	0.93	78.56
WY16	300	63.64	1.08	0.894	375.09	59.57	30.99	0.90	79.90
WY17	300	62.04	1.07	0.901	395.55	56.90	31.46	0.88	81.06
WY18	300	60.85	1.05	0.914	367.52	53.13	32.53	0.84	83.48
WY19	300	59.83	1.04	0.909	401.69	53.84	32.52	0.86	82.64
WY20	300	58.49	1.01	0.921	364.78	50.66	33.89	0.83	84.80
WY21	300	57.23	1.01	0.922	403.81	49.25	33.96	0.82	85.06
WY22	300	56.65	1.02	0.923	425.35	48.44	33.92	0.82	85.22
WY23	300	55.35	1.01	0.917	477.35	49.36	33.78	0.85	84.07
WY24	300	54.76	1.01	0.922	488.75	47.32	33.94	0.82	85.04
WY25	300	53.41	1.00	0.911	536.86	50.01	33.89	0.89	82.88

WYi = individual weekly yield in ith week, *Correlation and regression coefficients, significant (P<0.01)

Trend of correlation (r) and coefficient of determination (R^2) values on progressively extended cumulative weekly (part) lactation milk yield in predicting SLMY in of Gir cows is furnished in Table 2.

Phenotypic correlations between SLMY and different cumulative weekly part lactation milk yields were positive and ranged from 0.721 for WY1-2 to 0.906 for WY1-22 (P<0.01). The estimates of phenotypic correlations between SLMY and different weekly part lactations increased from 0.721 to 0.768 from WY1-2 till WY1-7, 0.784 to 0.863 from

WY1-8 till WY1-16 and almost static 0.871 to 0.906 from WY1-17 to WY1-22. Thus, in present study part lactation yield till WY1-12 in of Gir cows could cover about 68.95% of variation in the SLMY, whereas WY1-17 to WY1-22 showed higher prediction reliability of 75.71 to 80.08% for SLMY. Further, accuracy of first 100 days milk yield in estimating SLMY was found to be 72.26%.

Table 2: Trend of r and R^2 values on cumulative weekly milk yield in prediction of SLMY in Gir cows

Trait (variable)	Trait (variable)			r value*	Intercept		b value		R^2 %
	N	Mean	SE		Mean	SE	Mean	SE	
WY1-2	300	139.15	2.43	0.721	808.39	89.56	11.06	0.62	51.78
WY1-3	300	211.81	3.59	0.726	748.87	91.41	7.55	0.41	52.54
WY1-4	300	285.55	4.72	0.733	693.16	92.53	5.79	0.31	53.55
WY1-5	300	359.49	5.83	0.738	648.27	93.50	4.73	0.25	54.29
WY1-6	300	432.18	6.92	0.751	594.96	92.61	4.05	0.21	56.24
WY1-7	300	504.84	7.99	0.768	535.98	90.69	3.59	0.17	58.86
WY1-8	300	576.80	9.05	0.784	482.67	88.64	3.23	0.15	61.32
WY1-9	300	647.63	10.07	0.798	432.20	86.79	2.96	0.13	63.54
WY1-10	300	717.55	11.11	0.811	390.90	84.64	2.73	0.11	65.65
WY1-11	300	786.52	12.13	0.821	358.94	82.88	2.53	0.10	67.30
WY1-12	300	854.28	13.14	0.831	329.49	80.95	2.36	0.09	68.95
WY1-13	300	921.01	14.11	0.840	299.31	79.12	2.22	0.08	70.54
WY1-14	300	986.53	15.09	0.848	275.58	77.40	2.10	0.08	71.91
First 100-d	300	1005.16	15.36	0.851	269.28	76.95	2.07	0.07	72.26
WY1-15	300	1051.20	16.07	0.856	255.62	75.59	1.99	0.07	73.23
WY1-16	300	1114.84	17.05	0.863	238.87	73.77	1.89	0.06	74.48
WY1-17	300	1176.87	18.02	0.871	223.95	71.91	1.80	0.06	75.71
WY1-18	300	1237.72	18.96	0.878	208.13	69.98	1.73	0.05	76.96
WY1-19	300	1297.55	19.89	0.884	192.62	68.09	1.66	0.05	78.17
WY1-20	300	1356.04	20.78	0.892	173.99	66.08	1.60	0.05	79.46
WY1-21	300	1413.27	21.65	0.899	155.24	63.92	1.55	0.04	80.79
WY1-22	300	1469.91	22.51	0.906	137.59	61.74	1.50	0.04	82.08

WY1-i = cumulative weekly milk yield from 1st week till ith week, *Correlation and regression coefficients, significant (P<0.01)

Thus, it could be noticed that weekly yield in 20th to 24th week alone was found more reliable and sufficient in predicting SLMY with acceptable R^2 value of 84.06 to 85.22 %, rather than cumulative WY1-21 or WY1-22 (R^2 80.79 to 82.08%).

Individual Fortnightly and Cumulative Fortnightly Milk Yield for Prediction of SLMY

Details on regression analysis of fortnightly milk yield for prediction of standard lactation milk yield in Gir cows is given in Table 3.

The correlation coefficients between SLMY and different fortnightly (1st to 10th fortnight) part lactations in Gir cows were positive (P<0.01) and varied from 0.721 for FNY1 (1st fortnight) to 0.93 for FNY10 (10th fortnight). The correlation coefficients between SLMY and first and second fortnight part lactation was 0.712 to 0.721, R^2 value being 50.57 to 51.84% in the present study on of Gir cows, which explained least share of first two fortnights in total variation of SLMY. These findings are in accordance with the findings of Singh and Tailor (2013) [9], who also observed low R^2 values for prediction of lactation milk yield in Surti buffaloes when first and second fortnight (21.5 to 39 %) were used as a part lactation records.

Table 3: Regression analysis of individual fortnightly milk yield for prediction of SLMY in Gir cows

Trait (variable)	Trait (variable)			r value*	Intercept		b value		R^2 %
	N	Mean	SE		Mean	SE	Mean	SE	
FNY1	300	149.43	2.60	0.721	801.78	89.81	10.34	0.58	51.84
FNY2	300	157.30	2.56	0.712	711.46	96.99	10.40	0.59	50.57
FNY3	300	156.54	2.50	0.759	571.40	91.54	11.34	0.56	57.46
FNY4	300	153.96	2.43	0.839	366.59	77.20	12.86	0.48	70.26
FNY5	300	149.62	2.36	0.867	297.35	70.74	13.70	0.46	75.09
FNY6	300	144.71	2.31	0.885	273.76	65.43	14.33	0.44	78.31
FNY7	300	139.63	2.27	0.894	294.92	61.90	14.70	0.43	79.85
FNY8	300	134.39	2.28	0.906	355.54	56.25	14.82	0.40	81.98
FNY9	300	128.74	2.21	0.920	348.40	51.52	15.52	0.38	84.55
FNY10	300	123.19	2.15	0.930	358.51	47.39	16.14	0.37	86.53

FNYi = individual fortnightly yield in ith fortnight, *Correlation and regression coefficients, P<0.01

Data in Table 3 indicated that the correlation coefficient values between SLMY and different fortnightly part lactations gradually increased with advancement of lactation. the r-values being, 0.839 to 0.894 for FNY4 to FNY7 and 0.906 to 0.93 for FNY8 to FNY10. SLMY could be estimated with quiet high accuracy of 81.98 to 86.53% by incorporating FNY8 (8th fortnight), FNY9 (9th fortnight) and FNY10 (10th fortnight) as independent variable in the prediction equation. This revealed a greater contribution of FNY8, FNY9 and FNY10 in total variation in SLMY. Our results conform the findings of Nagarcenkar and Basvaiah (1981) [4], who reported that a single part record during 11th fortnight was

best predictor for lactation milk yield in Murrah buffaloes. Singh and Tailor (2013) [9] reported quite more accuracy, 52 to 55%, for 6th and 7th fortnight indicating a greater part of total variation in SLMY of Surti buffaloes. The findings on precision of 6th to 8th fortnight yield (R^2, 78.31 to 81.98%) found in our study are in agreement with the results of Saigaonkar *et al.* (1981) [7] who found the significance of 6th and 8th fortnight, revealing slightly higher accuracy (76%) of prediction of 26 fortnights' milk yield in Sahiwal cattle.

Trend of correlation (r) and coefficient of determination (R^2) values on progressively extended cumulative fortnightly (part) lactation milk yield for prediction of SLMY of Gir cows is furnished in Table 4.

Correlation coefficients between SLMY and different cumulative fortnightly (part) lactation milk yield were positive (P<0.01) and ranged from 0.734 for FNY1-2 (cumulative first two fortnights) to 0.902 for FNY1-10. The estimates of phenotypic correlations between SLMY and different fortnightly cumulative part lactations increased from 0.734 to 0.792 for FNY1-2 to FNY1-4, 0.818 to 0.872 for FNY1-5 to FNY1-8 and 0.887 to 0.902 for FNY1-9 to FNY1-10. Part lactation yield in early lactation i.e., FNY1-5 (till 5th fortnight) in Gir cows could cover about 66.85% of variation in the SLMY, whereas FNY1-9 and FNY1-10 showed a higher prediction determination value of 78.54 to 81.34 % for SLMY.

Table 4: Trend of r and R^2 values on cumulative fortnightly milk yield in prediction of SLMY in Gir cows

Trait (variable)	Trait (variable)			r value*	Intercept		b value		R^2 %
	N	Mean	SE		Mean	SE	Mean	SE	
FNY1-2	300	306.74	5.04	0.734	680.83	92.95	5.43	0.29	53.67
FNY1-3	300	463.28	7.37	0.759	566.39	91.78	3.84	0.19	57.46
FNY1-4	300	617.24	9.65	0.792	455.20	87.56	3.07	0.14	62.57
FNY1-5	300	766.86	11.84	0.818	367.75	83.36	2.58	0.11	66.85
FNY1-6	300	911.57	13.98	0.839	303.26	79.36	2.24	0.08	70.33
FNY1-7	300	1051.20	16.07	0.856	255.62	75.59	1.99	0.07	73.23
FNY1-8	300	1185.59	18.15	0.872	221.76	71.60	1.79	0.06	75.90
FNY1-9	300	1314.33	20.14	0.887	187.29	67.52	1.64	0.05	78.54
FNY1-10	300	1437.52	22.01	0.902	147.42	63.00	1.53	0.04	81.34

FNY1-i = cumulative fortnightly yield from 1st till ith fortnight, *Correlation and regression coefficients, significant (P<0.01)

It is remarkable from the above results that, part fortnightly yield in 8th, 9th and 10th fortnight alone was found more reliable and sufficient in predicting SLMY with acceptable R^2 value of 81.98 to 86.53 %, rather than cumulative FNY1-8, FNY1-9 or FNY1-10 (R^2, 75.90 to 81.34%).

Individual Monthly and Cumulative Monthly Milk Yield for Prediction of SLMY

Regression analysis of first to fifth monthly (part) lactation milk yield for prediction of SLMY in Gir cows is detailed in Table 5.

Phenotypic correlations between SLMY and different monthly lactation milk yield were positive (P<0.01). Perusal of data in the table shows that correlation of SLMY was 0.734 for MTY1 (1st month), accuracy of prediction being only 53.67%, which gradually increased to 0.935 with R^2 value of 87.4% for 5th month. The accuracy of prediction of SLMY was 78.03% with MTY3 and 82.27% with MTY4. Singh (2006) [10] also found similar reported R^2 value (51%) of SLMY based on first 30-days part yield. The results on importance of 4th and 5th month of milk yield in estimating SLMY were in consonance with findings of Ranjan *et al.* (2005) [5], who obtained highest R^2 value (58.41%) for 3rd month followed by 5th (57.97%) and 4th (50.48%) month milk yields, while constructing prediction of SLMY in Sahiwal cows. Sah *et al.* (2013) also opined from their study on Kankrej cattle that milk records of 4th and 5th month along with peak yield are helpful for prediction of LY with high accuracy (75.8%), which conforms the results of present study.

Table 5: Regression analysis of individual monthly milk yield for prediction of SLMY in Gir cows

Trait (variable)	Trait (variable)			r value*	Intercept		b value		R^2 %
	N	Mean	SE		Mean	SE	Mean	SE	
MTY1	300	306.74	5.04	0.734	680.83	92.95	5.43	0.29	53.67
MTY2	300	310.50	4.86	0.810	417.21	83.95	6.22	0.26	65.44
MTY3	300	294.33	4.63	0.884	248.89	66.67	7.13	0.22	78.04
MTY4	300	274.02	4.52	0.907	291.24	57.36	7.50	0.20	82.27
MTY5	300	251.93	4.32	0.935	309.84	46.65	8.09	0.18	87.40

MTYi = individual monthly yield in ith month, *Correlation and regression coefficients, P<0.01

Trend of correlation (r) and coefficient of determination (R^2) values on cumulative monthly milk yield for prediction of SLMY of Gir cows is presented in Table 6.

Correlation coefficient values of 0.792 to 0.839 with R^2 value of 62.57 to 70.33% were found when MTY1-2 and MTY1-3 were used as independent variables for estimating SLMY. The SLMY could be predicted with reasonably high accuracy of 75.90 and 81.34%, respectively, incorporating MTY1-4 and MTY1-5 as independent variables in the regression equation. Singh (2006) [10] reported that accuracy of prediction of SLMY based on cumulative part milk yields varied from 51% for 30-days to 89% for 270-day and exhibited consistently increasing trend with advancement of lactation of crossbred cattle. Bansal (2009) [1] evolved prediction equations for LMY in Sahiwal cattle and found that actual 300-d milk yields were very close to predicted values on the basis of 120 days' milk yield, hence may be used to select sires with good reliability rather than to wait for 300-days or TLMY.

Table 6: Trend of r and R^2 values on cumulative monthly milk yield in prediction of SLMY in Gir cows

Trait (variable)	Trait (variable)			r value*	Intercept		b value		R^2 %
	N	Mean	SE		Mean	SE	Mean	SE	
MTY1-2	300	617.24	9.65	0.792	455.20	87.56	3.07	0.14	62.57
MTY1-3	300	911.57	13.98	0.839	303.26	79.36	2.24	0.08	70.33
MTY1-4	300	1185.59	18.15	0.872	221.76	71.60	1.79	0.06	75.90
MTY1-5	300	1437.52	22.01	0.902	147.42	63.00	1.53	0.04	81.34

MTY1-i = cumulative monthly yield from 1st to ith month, *Correlation and regression coefficients, significant (P<0.01)

Thus, it is noteworthy that MTY4 alone was found to be more reliable than cumulative MTY1-4 (R^2, 82.27 vs 75.90%). Similarly, MTY5 alone gave more accuracy than cumulative MTY1-5 (R^2, 87.40 vs 81.34%). Therefore, instead cumulative MTY1-4 or MTY1-5 (R^2, 75.90 to 81.34%), 4th or 5th month yield alone could be used to predict SLMY with acceptable R^2 value of 82.27 to 87.40 %.

Conclusions

The findings of the present study on of Gir cows, tended to indicate and infer that, reliability of prediction for standard lactation milk yield (SLMY) was reasonably high, *i.e.*, about 85% with 20th, 21st or 22nd week, for 9th or 10th fortnight and 87.40% with 5th month part lactation yields. From 22nd week onward, the correlation and accuracy of regression for SLMY were reduced. Further, individual part yields were found to be more reliable than cumulative respective (weekly, fortnightly and monthly) part yields for prediction of SLMY. Moreover, the results indicated that WY14 or FNY7 milk yield as part lactation covered 78.18-79.85% of variation in SLMY in of Gir cows. Precision value of 72.26% for first 100-day yield as part lactation indicated that one can rely on first 100-day yield /part lactation of daughters covered under progeny testing programmes or while determining and comparing herd performance in terms of lactation milk yield in Gir cows. However, it could be desirable to consider 4th or 5th month (120 to 150-days) yield alone instead first 100-days milk yield of the cows for still higher reliability (R^2, 82.27 to 87.40%) of SLMY.

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Conflict of Interest: None

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