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# Comparison of heritabilty estimates from time series and least squares adjustments in Sahiwal cattle

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The animal breeding records comprising various economic traits spread over a longer period of time are subjected to various environmental fluctuations. Hence, data have to be adjusted for significant non-genetic factors to get precise estimate of the genetic parameters of the population. The least squares analysis (Harvey 1960) is the conventional method of fitting constants. However, this method does not consider the periodic/cyclical component over years as periods are formed arbitrarily. On the contrary, time series analysis takes into account the trend, cyclical and seasonal components to smoothen the animal breeding data. The exact periods ascertained from deseasonalized data along with monthly/seasonal indices developed from time series analysis could be used for adjustment of the animal breeding data for non-genetic factors in a population. Hence, the present investigation was proposed to decompose various components of time series records to determine exact periodicity and compare the heritability estimates of various first lactation traits from data adjusted through time series with least squares analysis.

First lactation records (594) of Sahiwal cows spread over 46 years (1961–2006) were analyzed for evolving correction factors to adjust the data for non-genetic factors by least squares and time series analyses.

The traits considered were age at first calving (AFC), first lactation total milk yield (FLTMY), first lactation 305-day or less yield (FL305DMY), first lactation length (FLL), first dry period (FDP), first service period (FSP), and first calving interval (FCI). Records having lesser than 100-day lactation length were considered abnormal and were not included in the study. The data were classified into 15 periods of 3 years each and 12 months of birth/calving. The age at first calving was used as co variable for other traits. For time series, the following multiplicative model was used:

$$Y_{ijk} = T.S.C.E.$$

where, $Y_{ijk}$, observation of an individual animal in $i^{th}$ season, $j^{th}$ year and $k^{th}$ period. T, a long term-trend (growth or decay); S, seasonal component superimposed on the trend which are generally short-term fluctuations of a recurring pattern conformed within year; C, cyclical fluctuation of specified periodicity; E, random fluctuation.

Two methods namely ratio to trend and link relative method were used to calculate monthly indices. The cyclical component of the data was ascertained to have exact period or cycle from deseasonlized data using periodogram analysis as described by Chakravarti *et al.* (1967). The data were adjusted by the correction factors evolved by both the methods and heritability was estimated by paternal half sib method as given by Becker (1975). Data on daughters of 60 sires having at least 3 or more progeny were included. Four sets of data were used to estimate heritability. Set-I had data adjusted for periods (15 of 3 years each), months (12) and AFC as covariable. Set-II had data adjusted by AFC, monthly indices and periods (3 years). Set-III included exact periods (3–7 years) for various traits estimated by time series analysis, months (12), AFC as co variable. The fourth set (Set-IV) incorporated data adjusted by exact periods (3–7 years), monthly indices and AFC as a covariable.

The monthly indices constructed from ratio to trend method gave more consistent indices as compared to link relative method and hence the former indices were used for further investigations (Sentitula *et al.* 2008). The monthly indices revealed that the heifers born during the month of June took comparatively higher time (1.9 % more) for first calving than those born during the other months. However, the cows born during May had about 3.4% lower AFC than other cows in the herd. The cows calving for the first time during January had about 3.79% higher FLYMY. Similarly, cows calving in December and January had 3–4% higher FL305DMY. This may be attributed to ensuing favorable climate of winter and availability of lush green fodder in winter. The heifer calving in January also had the longer (2.92%) FLL. The heifers calving during July had higher FDP (10.29%). The heifer calving during June and August had comparatively more FSP and FCI.

The least squares means for AFC, FLTMY, FL305DMY, FLL, FDP, FSP, and FCI were 1152 .27±8.36 days,

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1956.47±48.70 kg, 1721.30±36.50 kg, 302.20±5.91 days, 113.11±4.97 days, 142.38±6.38 days and 426.69±6.74 days, respectively. The exact periods formulated through time series were 7 years for AFC, 6 years for FLTMY, 7 years for FL305DMY, 4 years each for FLL and FDP, 5 years each for FSP and FCI. The least squares means estimated for these traits with the above exact periods were 1143 .31±8.02 days, 1961.96±47.15 kg, 1753.35±35.52 kg, 298.89±6.02 days, 112.25±5.03 days, 143.44±6.48 days and 428.50±6.87 days, respectively. Least squares analysis of variance showed nonsignificant effect of month on all the first lactation traits and highly significant influence (P<0.01) of periods on all the first lactation traits in both the methods. Banik (2004), Raja (2004), Singh *et al*. (2005) and Kumar (2007) reported non-significant influence of months of birth on AFC. Most of the workers (Reddy 1983, Singh 1986, Yadav *et al.* 1992 and Singh *et al*. 2005) reported significant influence of periods on first lactation milk yield.

Moderate to high estimates of heritability of various traits were observed for different sets of data (Table 1). The estimate of heritability for AFC from Set-I was 0.24±0.12, which was having high standard error. Similar results were reported by Reddy (1983), Raja (2004) and Banik (2004) in Sahiwal cattle. Comparatively higher estimates of heritability of AFC were observed from sets II, III and IV for this trait. These higher estimates of heritability for AFC indicated that the adjustments of data by exact periods, monthly indices or both derived from time series analysis were more effective as compared to adjustments derived from least squares analysis in set-I. These findings were in agreement with the findings of Kumbhare and Gandhi (2007) in Karan Fries cattle. On the contrary, Singh and Sharma (1983) reported lower estimate of heritability of this trait in Indian cattle. The $R^2$ - values of fitting the various models on AFC from data sets I, II, III and IV were 16.2, 27.51, 19.06 and 28.55%, respectively (Table 2). Comparatively higher accuracies of fitting models from set–II and IV further substantiated the findings of higher estimates of heritability from time series adjustments attributed to more effective correction of data as compared to least squares analysis. These results indicated that time series adjustments lowered the environmental fluctuations more effectively over the periods which has led to enhanced estimates of heritability of this trait. The estimate of heritability of first lactation total milk yield from Set-I was 0.20±0.12, which was not significantly different from zero. Similar findings were reported by Deb *et al.* (1981), Reddy (1983) and Banik (2004). Comparatively higher estimates of heritability of FLTMY were observed from Sets II, III and IV. Similar findings were also reported by Kumbhare and Gandhi (2007) in Karan Fries cattle. Higher estimate of heritability for FLTMY from data adjusted by exact periods and monthly indices (single or both) from time series analysis revealed that this method seemed to be more efficient than least squares method for adjustment of data for this trait. The $R^2$-values of fitting the various models on data Sets-I, II, III and IV were 20.78, 29.05, 29.32 and 29.96%, respectively (Table 2). Comparatively higher accuracies of fitting models from Sets II, III and IV revealed that correction factors developed from time series analysis reduced environmental fluctuations to a considerable extent resulting in increased estimate of heritability of this trait. The estimate of heritability of first lactation 305 days or less milk yield from Set-I was 0.33±0.13, which was close to the values reported by Yadav *et al.* (1992), Gandhi and Gurnani (1988) and Banik (2004). The heritability was also estimated using sets II, III and IV, which were found to be more than one. The $R^2$- values of fitting the various models on data Sets I, II, III and 1V were 18.50, 33.10, 33.60 and 32.79 %, respectively. Comparatively higher accuracies of fitting models from sets II, III and IV were also observed for this trait. The heritability estimates of first lactation length for set-I was 0.18±0.11, which was not significantly different from zero. Similar results were reported by Reddy (1983) and Banik (2004). Higher estimates of heritability observed from sets II, III and IV revealed that the monthly indices and exact periods from time series analysis were more effective than least squares analysis for adjustment of data for this trait. The $R^2$- values of fitting the various models on data Sets I, II, III and IV were 15.20, 26.18, 25.68 and 26.55%, respectively. Comparatively higher accuracies of fitting models from set II, III and IV were also observed for this trait. The heritability estimate of FDP from Set I was 0.28±0.15. Similar findings were reported by Ahmad and Sivarajasingham (1998) and Javed *et al.* (2001). However, higher estimates of heritability were found in set-II, III and IV. The $R^2$- values of fitting the various

Table 1. Heritability estimates of first lactation traits in Sahiwal cattle

| Traits | SET-I | SET-II | SET-III | SET-IV |
|---|---|---|---|---|
| AFC | 0.24±0.12 | 0.38±0.14 | 0.39±0.13 | 0.38±0.15 |
| FLTMY | 0.20±0.12 | 0.83±0.18 | 0.85±0.18 | 0.82±0.17 |
| 305DMY | 0.33±0.13 | >1 | >1 | >1 |
| FLL | 0.18±0.11 | 0.69±0.16 | 0.69±0.17 | 0.71±0.18 |
| FDP | 0.28±0.15 | 0.75±0.19 | 0.78±0.20 | 0.74±0.19 |
| FSP | - | 0.20±0.13 | - | 0.21±0.13 |
| FCI | - | 0.24±0.14 | - | 0.25±0.14 |

Table 2. $R^2$ Values (%) of fitting the models on different data sets for first lactation traits

| | LSA | | TSA | |
|---|---|---|---|---|
| | Set-1 | Set-II | Set-III | Set-IV |
| AFC | 16.2(3) | 27.51 | 19.06(7) | 28.55 |
| FLTMY | 20.78(3) | 29.05 | 29.32(6) | 29.96 |
| 305DMY | 18.50(3) | 33.10 | 33.60(7) | 32.79 |
| FLL | 15.20(3) | 26.18 | 25.68(4) | 26.55 |
| FDP | 19.00(3) | 28.29 | 22.88(4) | 28.19 |
| FSP | 7.66(3) | 16.56 | 12.00(5) | 28.19 |
| FCI | 7.87(3) | 17.48 | 11.00(5) | 17.71 |

(Figures in parentheses indicate the number of years in a period).

models on data sets I, II, III and IV were 19.00, 28.29, 22.88 and 28.19 %, respectively. Comparatively higher accuracies of fitting models from set II, III and IV revealed that time series adjustments were more appropriate than least squares adjustments to nullify environmental fluctuations and hence enhancing the heritability estimate of this trait. The heritability estimate of FSP from Set-I was not estimatable. However, Reddy and Nagarcenkar (1989), and Raja (2004) reported estimate of heritability, which was not significantly different from zero. When data were adjusted by monthly indices along with exact periods (T=5 years), single or both, the heritability estimates further increased but had higher standard errors. The $R^2$- values of fitting the various models on data sets I, II, III and IV were 7.66, 16.56, 12.00 and 28.19%, respectively. Comparatively higher accuracies of fitting models from set II, III and IV were also observed for this trait. The heritability estimate of FCI was not estimatable, which indicates that managemental practices along with better feeding would result in the improvement of this trait. Lower estimates of heritability of this trait ware reported by Yadav *et al.* (1992) and Raja (2004). The heritability estimate of FCI was not statistically different from zero (0.24±0.14) for data Set-II and data set-III (0.25±0.14) as standard errors were higher. The $R^2$-values of fitting the various models on data Sets-I, II, III and IV were 7.87, 17.48, 11.00 and 17.71%, respectively. Comparatively higher accuracies of fitting models from Sets II, III and IV were also observed for this trait. Higher estimates of heritability of majority of the traits from data adjusted by monthly indices and exact periods derived from time series analysis revealed that these indices and exact periods derived from time series analysis were comparatively more efficient than months and arbitrary periods used under least squares analysis to adjust the data for non-genetic factors.

## SUMMARY

The data on 594 first lactation records of Sahiwal cows spread over 46 years (1961–2006) were analyzed by least squares and time series analyses for ascertaining correction factors to adjust the data for non-genetic factors to estimate heritability of first lactation traits. The traits considered were, age at first calving (AFC), first lactation total milk yield (FLTMY), first lactation 305-day or less yield (FL305DMY), first lactation length (FLL), first dry period (FDP), first service period (FSP) and first calving interval (FCI). A least-squares model incorporating 15 periods (3 years each), 12 months and AFC as co variable was fitted for all the traits except for AFC (Set-1). Least squares model comprising months, exact periods (3–7 years for various traits) and AFC as co variable comprised Set-III and Set-IV incorporated data adjusted by AFC, exact periods (3–7 years) and by monthly indices derived from time series analysis. The data were adjusted for significant non-genetic factors to estimate heritability from all the four sets. Higher estimates of heritability of majority of the traits from data adjusted by monthly indices and exact periods derived from time series analysis as compared to least squares adjustments revealed that the correction factors derived from time series analysis seem to be more appropriate to adjust the animal breeding data for non-genetic factors in Sahiwal cattle.

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