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Time series analysis of economic traits in Karan Fries cattle

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The present investigation was proposed to decompose various components of time series records and to determine periodicity of time series data.

Data on 2602 lactation records of 1037 Karan Fries cattle maintained at NDRI Karnal and calved over the period 1974 to 2003 were analyzed for evolving correction factors to adjust the data for non-genetic factors by time series analysis. The traits considered were age at first calving (AFC), lactation total milk yield (LTMY), lactation 305-day or less yield (L305DMY), lactation length (LL), calving interval (CI) and service period (SP). Records having lesser than 100 days lactation length were considered abnormal and were not included in the study. A least squares model incorporating periods (10), months (12) and parity (10) was used for analysis of data for all the traits except for AFC (parity not included in the model). The data were classified under periods and months of birth/calving. The time series multiplicative model used was :

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

where, Y_{ijk}, is 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 were generally short term fluctuations of a recurring pattern conformed within year; C, cyclical fluctuation of specified periodicity; and E, random fluctuation.

Ratio to trend and link relative methods were used to calculate monthly indices for seasonal effect. The ratio to trend method assumes that monthly variation for a given month was constant fraction of trend. The various steps were:

i. Obtain trend values by least squares method.
ii. Divide original data month by month by the corresponding trend values and multiply the ratio by 100.
iii. To free the values from irregular and cyclical movements the values given for the various years were averaged.
iv. The seasonal index for each month was expressed as a percentage of the average month.
v. The sum of all 12 values must equal 1200 or 100% and if it is not, an adjustment was made by multiplying each index by suitable factor.

For link relative method, the following steps were used to calculate the monthly indices:

i. Calculate the link relatives of the monthly figures. Link relatives were calculated by dividing the figure of each month by the figure of the immediately preceding month and multiplying it by 100. These percentages were called link relatives
ii. The average of the link relatives for each season was calculated.
iii. These averages were converted into chain relatives on the basis of the first month.
iv. The chain relatives of the first month on the basis of last month were calculated.
v. The corrected chain relatives were expressed as percentages of their averages.

The cyclical component of the data were ascertained to have exact period of cycle using periodogram analysis from deseasonlized data. The following trigonometric model as suggested by Chakravarti *et al.* (1967) was used :

$$C_t = \mu + \beta \, Sin \frac{2\pi t}{T} + \gamma \cos \frac{2\pi t}{T} + e_t$$

where, T, is period of cycle and t, years within a period (t=1, 2, ….., T). The period T, and estimates of a, b and g were ascertained by the above method.

The overall least squares population means for age at first calving (AFC), lactation total milk yield (LTMY), 305-day milk yield (L305DMY), lactation length (LL), calving interval (CI) and service period (SP) are given in Table 1. The least squares analysis of variance revealed that month/ period of birth had significant influence on AFC. The parity had highly significant effect ($P<0.01$) on all the remaining

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five traits. The month of calving had highly significant effect (P<0.01) on L305DMY, CI and SP. The influence of period of calving was highly significant (P<0.01) on LTMY, L305DMY and LL, whereas its effect on CI and SP was non-significant (Table 1). Most of the workers (Saha 2001, Mishra 2004, Kumbhare and Gandhi 2006, Sentitula *et al*. 2008) reported significant influence of periods on first lactation milk yield.

To study the seasonality, the monthly indices were estimated by 2 methods namely ratio-to-trend and link relative methods (Tables 2, 3). Month to month variation was observed in all the traits from both the methods. However, comparatively higher variation during various months of year was revealed by link relative method. However, comparative lower ranges of monthly indices for various economic traits from ratio to trend method as compared to link relative method revealed that monthly indices formulated by former method were more appropriate.

From time series analysis of data, the exact periods for various traits were formulated as per Chakaravarti *et al*. (1967) The exact periods for AFC, LTMY, L305DMY, LL, CI and SP were 4, 4, 6, 5, 7 and 6 years, respectively. The moving average method was used to simulate the corrected means of various traits over years using these exact periods. The ranges of corrected averages for the above mentioned traits over the years were 919 – 1079 days, 3193 – 3990 kg, 2817 – 3657 kg, 303 – 342 days, 377 – 395 days and 72 – 93 days, respectively. These ranges were lower than the ranges observed for the unadjusted or non-smoothened data.

A trigonometric model as described by Chakaravarti *et al.* (1967) was used to fit periodic function for various

Table 1. Least squares analysis of variance (mean squares only) for various economic traits in Karan Fries cattle

Traits	Parity	Months	Periods	Regression	Error
AFC	-	34176 (11)**	453472 (9)**	-	18746 (1016)
TLMY	7686283 (9)**	2942106 (11)	19418592 (9)**	1635307 (1)	1722453 (2571)
L305DMY	14989988 (9)**	3344722 (11)**	20281944 (9)**	264673 (1)	934428 (2570)
LL	102373 (9)**	17551 (11)	34771 (9)**	2040 (1)	9936 (2567)
CI	8620 (9)**	12590 (11)**	5315 (9)	9058 (1)	3083 (1567)
SP	7347 (9)**	11869 (11)**	4186 (9)	9235 (1)	2842 (1568)

**Significant at P< 0.01;*significant at P< 0.05. Figures in parentheses indicate the degrees of freedom.

Table 2. Monthly indices estimated by ratio to trend method for various economic traits in Karan Fries cattle

Traits	Months											
	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
AFC	102.66	99.71	99.15	95.92	101.81	98.38	96.76	96.62	100.98	104.50	101.18	102.50
LTMY	106.81	102.18	101.58	91.24	96.97	97.85	98.70	101.82	98.82	99.49	101.58	102.95
L305DMY	105.19	99.26	99.60	88.92	94.04	95.99	100.28	101.53	101.72	104.42	105.52	103.52
LL	103.79	102.99	102.50	97.08	101.49	104.01	100.71	103.32	95.02	93.23	96.93	98.93
CI	98.56	101.20	101.50	103.35	102.79	102.62	99.60	100.78	97.04	97.03	96.97	98.56
SP	94.80	104.22	102.02	111.61	109.80	111.15	97.57	102.89	92.09	88.20	89.95	95.70

Table 3. Monthly indices estimated by link relative method for various economic traits in Karan Fries cattle

Traits	Months											
	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
AFC	92.75	88.30	83.48	75.18	96.96	120.94	123.60	115.07	104.7	101.99	100.39	96.79
LTMY	110.74	102.87	99.14	85.62	92.85	98.17	101.17	100.84	94.98	104.36	105.12	104.13
L305DMY	107.23	99.13	97.43	85.86	91.90	96.74	101.20	99.69	99.07	108.67	108.77	104.32
LL	105.05	103.80	102.17	95.19	101.01	104.21	101.10	103.09	93.51	93.14	97.72	100.02
CI	98.24	100.58	100.83	102.72	102.74	102.84	100.18	101.01	97.30	98.28	96.98	98.31
SP	112.34	107.99	95.76	98.94	101.74	106.57	96.78	108.36	85.31	80.47	89.29	116.45

Table 4. Periodic function for various first lactation traits

Traits	Periodic function	R^2-value (%)
AFC	C_t = 992.74 +424.37 sin 2 π t/T – 191.41 cos 2Π t/T	86.00
L305DMY	C_t = 3284.84 + 24.25 sin 2 π t/T – 81.73 cos 2 Π t/T	58.67
LTMY	C_t = 3512.3 – 6.65 sin 2 π t/T + 137.65 cos 2 Π t/T	96.31
LL	C_t = 321.48 + 7.68 sin 2 π t/T – 6.93 cos 2 Π t/T	55.51
CI	C_t = 386.1 – 4.47 sin 2 π t/T + 3.69 cos 2 Π t/T	35.04
SP	C_t = 105.98 + 3.96 sin 2 π t/T – 0.67 cos 2 Π t/T	52.74

economic traits. The periodic functions for various traits are given in Table 4.

The R^2 values of fitting the above periodic function for various traits ranged from 35.04 (CI) to 96.31% (LTMY). These R^2 -values revealed that a large portion of variation in these traits attributed to cyclical fluctuations was eliminated effectively in all the traits except for CI. Similar findings were reported by Kumbhare and Gandhi (2006) in Karan Fries cattle and Sentitula *et al*. (2008) in Sahiwal cattle. Higher R^2 values of fitting the function were reported by Singh and Sharma (1983) and Jaiswal and Khanna (2001) for age at first calving. Although, the periodicity in CI was worked out to be 7 years, yet 5 years period in this trait gave better fit. This may be attributed to less number of cycles for 7 years period. Had there been longer period of study, there could have been a possibility of getting better periodic function for period of 7 years.

It can be concluded that the time series analysis of data indicated the periodicity in data over the years and hence the animal breeding data has to be adjusted for cyclicity to have more accurate estimates of population parameters of economic traits of Karan Fries cattle. Further, the monthly indices estimated by ratio to trend method seem to be more appropriate as compared to monthly indices estimated by link relative method to adjust the data for months/seasons and months within year as well.

SUMMARY

The data on 2602 lactation records of 1037 Karan Fries cows spread over 30 years (1974 – 2003) were analyzed for evolving correction factors to adjust the data for non-genetic factors by time series analysis. The traits considered were age at first calving (AFC), lactation total milk yield (LTMY), lactation 305-day or less yield (L305DMY), lactation length (LL), calving interval (CI) and service period (SP). A periodicity of 4,4,6,5,7 and 6 years was observed in the above traits. Maximum variation in the above traits ranged from 35.04 (CI) to 96.31% (LTMY) revealed the periodicity of data over the years for majority of traits. Hence, animal breeding data have to be adjusted for cyclicity over the years. The monthly/seasonal indices estimated by ratio to trend method accounted for more environmental fluctuations and were appropriate for decomposing the time series data.

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