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Impact of environmental trend in relation to genotypic and phenotypic trend on traits of economic interest in Kankrej cattle

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ABSTRACT

Indiscriminate selection of animals in order to enhance milk production has led to less attention to other traits important in dairying, viz. reproduction; owing to negative association. The production and reproduction records of total 403 Kankrej cows maintained at Livestock Research Station, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, over a period of 35 years from 1979 to 2013, were analyzed to study the production and reproduction traits, viz. 305 day milk yield (305 MY), lactation length (LL), dry period (DP), age at first calving (AFC) and service period (SP). The data were used to investigate the effect of environmental factors as well as estimation of genetic parameters of production and reproduction traits. Genetic, phenotypic and environmental trends were estimated to assess the breeding programme undergoing in the Kankrej herd over the years. The average performance of traits under study was obtained as 2128.64 kg, 282.60 days, 146.13 days, 1366.90 days and 158.06 days for 305 MY, LL, DP, AFC and SP, respectively. The heritability estimates obtained for these traits were 0.31, 0.17, 0.16, 0.05 and 0.96 for 305 MY, LL, DP, SP and AFC respectively. The estimated phenotypic and genetic trends were 7.66 and 23.10 Kg for 305 MY, –0.007 and –0.61 days for LL, 0.022, and –0.032 days for DP, –4.53 and –11.89 days for AFC and –0.07 and –1.61 days for SP, respectively. The results revealed that great improvement in Kankrej herd has been achieved in last 35 years. However, there is further scope of genetic improvement. Designed genetic programme has had great impact on improvement of milk production and AFC but very less impact on the reproductive traits.

Key words: Environmental, Genetic, Kankrej cattle, Phenotypic, Production traits, Reproduction traits

Livestock is an important sub sector of the agriculture of Indian economy. At constant prices the value of output from livestock is about 29% of the value of the output from total agriculture and allied sector (DAHD 2018). Majority of the milk produced (48%) comes from cattle (DAHD 2018). There are 41 recognized breeds of cattle in India, in addition to large number (52%) of non-descript cattle. In recent times, several of the indigenous breeds suffered decline mainly because they are becoming uneconomical under changed utilization pattern. Draught breeds utility has decreased because of mechanization in agriculture. Under this backdrop Kankrej breed is able to maintain high levels of performance in Semi-arid region of tropical environments due to its rusticity and adaptability.

In 1978, Livestock Research station under the aegis of erstwhile Gujarat Agricultural University was established to conserve the Kankrej cattle breed, aiming its genetic improvement thereby improvement in milk production. Kankrej is most prized dual purpose breed of indigenous cattle of western hot semi-arid climatic region of Indian subcontinent (Ekka *et al.* 2014a). These cattle are— well adapted to the of North Gujarat region, good milker in the extreme climatic conditions, with higher ability to convert poor quality fodder, and also playing a great role in the rural economy of North Gujarat due to high demand and price of Kankrej milk. The number of this animal is gradually depleting and its conservation and development is earnestly needed (Ekka *et al.* 2014b). In any genetic improvement, there is a need to monitor the results periodically to evaluate the progress, so as to optimise the genetic gain in the farm thereby positive economisation of farm can be ascertained. A genetic trend is defined as the change in performance per unit of time due to change in mean breeding value (Canaza-Cayo *et al.* 2016). Knowledge of genetic and environmental influences and relationships for production traits in Kankrej cattle is essential for proper planning and evaluation of improvement programs that are being implemented. The genetic selection programmes and the role the environment plays are necessary to be understood and included in these programs.

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Success of any breeding programme that establish the utility of native breed in its breeding tract can be achieved by improving its productive and reproductive traits as the profitability of dairy farming depends on this. Genetic composition of the animal greatly determines the physiological factors; proper selection and mating strategy can be adopted to suitably modify the genetic worth of the animal. However, environmental factors significantly influence the expression of a particular genotype, are more complicated and largely affect the productivity of Kankrej cattle (Ekka *et al.* 2014a). Among the many environmental factors important ones are season of calving (Hassan *et al.* 2017), age at first calving (Penchev *et al.* 2011), parity (Bampidis *et al.* 2012; Hassan *et al.* 2017), and period of calving (Sahin *et al.* 2012). Further, development of animal breeding plans requires knowledge of heritability, phenotypic and genetic correlations of the traits that are included. These parameters are needed to evaluate the breeding plan itself as well as to predict breeding values of the animals. The objectives of this study were to identify the important environmental causes of variation in various traits of economic importance. Genetic, environmental, and phenotypic trends were estimated to assess the results of breeding programs practiced and environmental changes across the years.

MATERIALS AND METHODS

The production and reproduction records of total 403 Kankrej cows maintained at Livestock Research Station, Sardarkruhinagar Dantiwada Agricultural University, Sardarkrushinagar, over a period of 35 years from 1979 to 2013, were analyzed. Prior to analysis, records were normalized and abnormal records were deleted from the data set. The effect of environmental influences, viz. season of calving/birth (four classes), period of calving/birth (five classes), parity (seven classes), and AFC (three classes) were ascertained using Univariate General Linear Model as below:

$$Y_{ijklm} = \mu + S_i + P_j + Pa_k + A_l + e_{ijklm}$$

where, Y_{ijklm}, response variable; μ, overall mean for each trait; S, fixed effect of i^{th} season of calving [i=1 (January to March), 2 (April to June), 3 (July to September), 4 (October to December)]; Pj, fixed effect of jth period [j = 1 (1979–85), 2 (1986–92), 3 (1993–99), 4 (2000–2006), 5 (2007–2012)]; Pa_k, fixed effect of k^{th} parity; A_l, fixed effect of l^{th} AFC group [1 (≤1142 days), 2 (1143 to 1574 days), (≥1,575 days); and e_{ijklm} random error, with zero and constant variance.

After getting the estimates of effect of various environmental factors on economic traits, the genetic parameters, viz. heritability, genetic correlations etc. of various traits under study were calculated by paternal half-sib correlation method. Mixed Model Least squares and Maximum Likelihood Computer Programme PC2 developed by Harvey (1990) was used for the analysis of variance.

Estimation of genetic, phenotypic and environmental trends: The population performance was the period wise average (least squares means) of various traits for which we had estimated the trend. The rate of change per period, obtained by the above procedure, was converted into the rate of change per year. Henderson's principle (Henderson 1973) was applied for estimation of genetic trend which consisted of regression of the weighted average transmitting abilities of the sires for each period on time (period). The fixed effect models comprising period, season, sires and AFC group were run for all the economic traits under consideration and the least squares constants for the sires were obtained. The Expected Breeding Values (EBV) of each sire obtained as per Lush (1935).

$$EBV = \frac{0.5nh^2}{1+(n-1)t} (LSC)$$

where, EBV, expected breeding value; h^2, heritability of the trait; t, intra class correlation (0.25 h^2, for the half sib progeny); n, number of half sib progenies, and LSC, least squares constant. The expected transmitting abilities (ETA) were obtained by dividing the respective EBVs by 2. The weighted averages of sire's transmitting abilities for years were then regressed on years. The regression value, thus obtained, was the annual genetic change. The population performance (P) was when regressed (bPT) on time (T) and by that phenotypic trends ("P") were obtained. The genetic trends when subtracted from the phenotypic trends, environmental trends were obtained.

RESULTS AND DISCUSSION

Effect of different environmental factors on various production and reproduction traits

The least squares analysis of variance for various production and reproduction traits revealed that all the traits under study were significantly (P<0.01) affected by period in which the animals were calved. Similarly, the parity of animal was also significantly influencing the performance. However, animals born/calved in any of the season as well animal born by dam of any Age at First Calving group did not differ significantly between each other.

The significant effect of period is the reflection of differences in the prevailing microclimatic conditions, feed and fodder availability during different periods influencing the growth rate and age at first calving in the heifers. The nonsignificant effect of season indicated that the Kankrej is well adapted to the seasonal environmental fluctuation of area (North Gujarat) and is not much susceptible to the changes in the temperature and humidity. Further, with the advancement in parity, milk production tended to increase significantly. This may be due to the fact that the increased body weight and size of the cows with a greater number of lactations leads to a greater availability of body reserves for the synthesis of milk components. Secondly, the greater development of the udder glandular tissues as the number of lactations rises could also result in an increased synthesis of milk constituents. Another possible explanation could be an improved efficiency of the homeorhetic dynamics

involved in the partitioning of the nutrients for the processes of lactogenesis and galactopoiesis as the number of lactations increases.

Genetic parameters of various production and reproduction traits

The estimated heritabilities, phenotypic and genetic correlations are shown in Table 2. Heritability estimates of lactation length and dry period were moderately low but significantly different from zero. Similarly, heritability estimates for milk production traits were moderately high and significant, which advocated that further improvement in milk production is possible by taking appropriate individual and pedigree selection strategy. The moderately high estimates of heritability for milk production traits found this study for the Kankrej herd, is indicative of existence of large additive genetic variance for these traits. The individual selection for the trait would be highly effective with high accuracy. The heritability estimate of 0.31 indicated that the magnitude of environmental variance is also very large (69%) and there should be due attention for environmental management to improve upon the milk production. Heritability estimates for fertility traits, viz. service period and dry periods were very low and moderately low, respectively. However, AFC was observed to have very high heritability, which revealed that this trait is largely under the genetic control and is very little influenced by the environmental factors. Lactation length was found positively correlated (both genetic and phenotypic) with milk production (Table 2). The genetic correlation between lactation length and first lactation 305-day milk yield was moderately high and positive. However, the phenotypic correlation between these two traits was very low and not significantly different from zero. This signifies that the effect of environmental causes are in opposition to the genetic improvements, and effort to select animals with high AFC in hope to have better milk production will not yield good result.

Trends for various production and reproduction traits

Lactation 305 day milk yield: The genetic, phenotypic, and environmental trends for 305 MY were 7.66, 23.10 and 15.44 kg, respectively (Table 3). Observed phenotypic and environmental trends are in desirable direction i.e. positive. Magnitudes of phenotypic changes over the years are in accordance with the improvement that Kankrej herd has registered in the last few decades. Similar trends were also observed by Sahin *et al.* (2012) in Holstein cattle of Turkey, Nehra *et al.* (2012) and Dash *et al.* (2016) in Karan Fries cattle. However, Singal (1993) in Tharparkar and Sahiwal herds and Singh *et al.* (2002) in Hariana cattle reported the negative trend. The obtained phenotypic trend (Fig. 1) is in conformity with the least square estimate of the total milk yield. Conversely, magnitude of genetic changes does not conform to the phenotypic trend, it indicated very good managemental practices being adopted in the herd and it also indicated that there is a need to revisit the existing genetic improvement programme adopted in the farm. The lower magnitude of the genetic trend also pointed in the direction that limited number of sires have been used in the farm in the past and continuous use of these sires might have led to the certain magnitude of inbreeding. The

Table 1. Least squares means of various production and reproduction traits in Kankrej cattle

	305 MY (kg)	LL (Days)	DP (Days)	AFC (Days)	SP (Days)
μ	2128.64±18.65	282.60±1.96	146.13±5.14	1366.90±9.39	158.06±7.64
Period	**	**	**	**	**
1	1833.10±36.98	289.91±3.94	141.87±6.88	1466.95±28.26d	174.74±9.91
2	1924.22±23.47	286.23±2.56	154.55±5.66	1439.01±17.67d	174.10±8.37
3	2098.58±25.58	275.75±2.79	154.18±5.88	1381.29±16.92c	155.35±8.68
4	2212.59±30.45	276.66±3.31	150.59±6.32	1257.95±22.16a	155.44±9.34
5	2574.73±41.83	284.43±3.73	129.48±6.80	1289.32±15.16b	130.67±9.92
Season	NS	NS	NS	NS	NS
1	2161.29±24.87	282.38±2.57	144.08±5.53	1368.06±14.36	155.83±8.20
2	2101.45±26.86	285.22±2.79	148.94±5.86	1392.87±16.97	167.33±8.63
3	2136.25±29.53	282.73±3.14	141.61±6.17	1372.00±19.60	153.14±9.09
4	2115.57±29.35	280.05±3.16	149.91±6.09	1334.69±18.89	155.95±8.94
Parity	**	**	**		**
1	1810.78±24.19	300.76±2.45	168.26±3.24		204.37±4.58
2	2015.60±26.40	287.15±2.75	145.03±3.63		163.40±5.23
3	2155.56±29.70	285.35±3.16	137.42±4.07		148.26±5.93
4	2207.20±33.27	282.33±3.59	135.50±4.95		144.27±7.16
5	2225.98±39.76	276.41±4.32	120.77±5.97		123.29±8.70
6	2240.66±48.22	276.14±5.27	128.87±7.63		114.71±11.35
7	2244.73±62.33	270.01±6.78	187.08±32.19		208.14±48.11
AFC	NS	NS	NS		NS
1	2098.64±31.97	282.98±3.33	146.98±6.28		159.77±9.29
2	2142.35±18.17	286.33±1.90	147.02±5.03		163.15±7.49
3	2144.94±32.83	278.47±3.53	144.40±6.54		151.27±9.56

phenotypic trend does not exactly match with genetic trend which indicated importance of several other factors such as management, nutrition, health, etc. in controlling the phenotype of the animals.

Lactation length: The genetic, phenotypic, and environmental trends for LL were –0.007, –0.61 and –0.54 days, respectively. Genetic trend did not show any definite trend and it keeps on changing almost randomly over the years. The negative phenotypic trend for FLL was reported by Singh (1995), Ambhore *et al.* (2017) in Karan Fries cattle at NDRI farm and Mukherjee (2005) Frieswal cattle at military dairy farm. However, a positive genetic trend for FLL was reported by Ambhore *et al.* (2017) and Nehra *et al.* (2012). If we see phenotypic trend for the trait, it appears to be static over the period and same is reflected in the estimates of period wise least squares means. Low magnitudes of both genetic and phenotypic trends as well as estimate of least squares mean (Table 1) advocate improvement in the same by both breeding and managemental interventions. Genetic trends (Fig. 2) fail to draw any concrete conclusion and estimates fluctuate around the mean.

Dry period: The genetic, phenotypic, and environmental trends for DP were 0.022, –0.032 and –0.054 days, respectively. All the observed trends are in desirable direction. Exactly similar phenotypic, genetic and environmental trends of first dry period were estimated in Phule Triveni cattle (Ambhore *et al.* 2017). Low magnitudes of these trends are due to the fact that the dry period has not changed in linear fashion over the years. So far improvement in this trait may be attributed to the improved managemental conditions of the farm. The positive genetic change in dry period over the years indicated that there is a need for adoption of proper strategy for genetic selection of animals to decrease the same. From the Fig. 3, it can be observed that the there is substantial decrease in the dry period in the fifth period (Table 1), however, genetic improvement was almost negligible. This further indicated that whatever improvement in the dry period is observed, it is mainly due to improvement in the environmental conditions. Looking into the environmental conditions, it was observed that during this period rainfall average was relatively higher, and temperature was also lower than the average temperature and this might be the reason for desirable improvement in the dry period in Kankrej cows.

Age at first calving: The genetic, phenotypic, and environmental trends for AFC were estimated to be –4.53, –11.89 and –7.36 days, respectively (Table 3). Though the observed trends are in desirable direction i.e. negative, but phenotypic changes were low in magnitude. It is possibly because the AFC has not changed in linear fashion over the years. In fact, there was substantial desirable genetic change in AFC (decreased) during the year 2002–04. The average temperature of the farm during the period was high, having low relative humidity and low average rain fall; which is typical to this climatic region. The observation further strengthens the statement that Kankrej are well adapted to this geographical area. This may be concluded that the apparent decline in AFC in the said period might also be due to the improvement in the managemental factors such as feeding and effective management of the herd. On the same line, Balasubramaniam *et al.* (2013) estimated the phenotypic, genetic and environmental trends as –17.79, –14.43 and –3.36 days, respectively, in Sahiwal cattle. The phenotypic trend (Fig. 5) does not exactly match with genetic trend which indicated importance of environmental factors in controlling the phenotype of the animals. However, same direction of both genetic and environmental trends approves the selection strategy adopted in herd for improvement of Kankrej cattle. The environmental trend counts for the residual change from genetic to phenotypic trend. The greater difference in the phenotypic and genetic trend calls for necessary steps to improve the AFC genetically through stringent selection of sires and dams.

Service period: The genetic, phenotypic (Fig. 4), and environmental trends for SP were –0.07, –1.61 and –1.54 days, respectively. All three, phenotypic, genetic and environmental trends observed for service period are in desirable direction i.e. negative, but are very low in magnitude. In contrast to our finding (though unfavorable) El-Shalmani (2011) and Dash *et al.* (2016) reported positive phenotypic, genetic and environmental trends in Friesian and Karan Fries cattle. Low, positive and nonsignificant genetic trend of 0.073±0.346 days was observed in Holstein cows in Egypt (Hammoud and Salem 2013). Low magnitude of annual change in this trait may be due to very

Table 2. Estimates of heritability, genetic, phenotypic correlations among various production and reproduction traits

Trait	305 MY	LL	DP	AFC	SP
305 MY	0.31± 0.07	0.64± 0.02	–0.13± 0.03	0.09± 0.05	0.19± 0.03
LL	0.41± 0.16	0.17± 0.05	–0.76± 0.12	0.25± 0.21	0.28± 0.37
DP	–0.19± 0.24	–0.14± 0.29	0.16± 0.07	–0.30± 0.30	0.34± 0.28
AFC	0.26± 0.27	–0.002± 0.05	–0.06± 0.06	0.96± 0.20	–0.03± 0.05
SP	–0.28± 0.31	0.42± 0.03	0.70± 0.02	–0.25± 0.56	0.05± 0.05

Diagonal elements, Heritability; Above diagonal, Genetic correlation; Below diagonal, Phenotypic correlation.

Table 3. Estimates of genetic phenotypic and environmental trends of various production and reproduction traits

Trait	Genetic Trend	Phenotypic Trend	Environmental Trend
305 MY (kg)	7.66	23.1	15.44
LL (Days)	–0.07	–0.61	–0.54
DP (Days)	0.022	–0.032	–0.054
AFC (Days)	–4.53	–11.89	–7.36
SP (Days)	–0.07	–1.61	–1.54

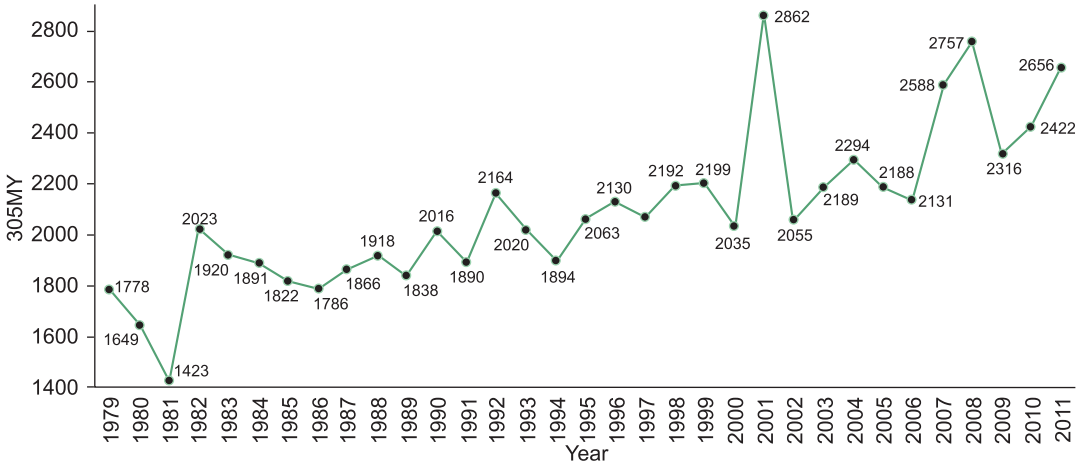

Fig. 1. Phenotypic trend for 305 MY (kg) in Kankrej cows.

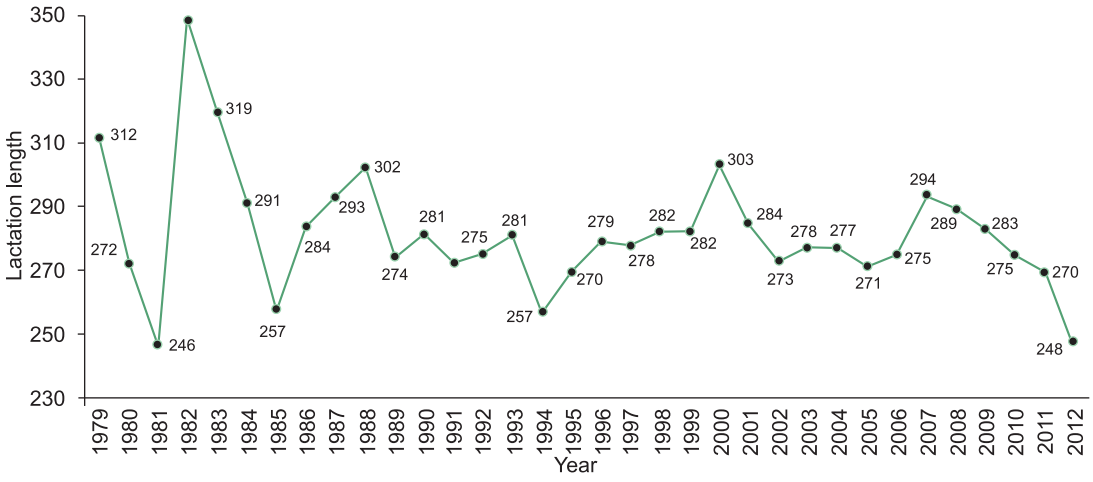

Fig. 2. Phenotypic trend for LL (Days) in Kankrej cows.

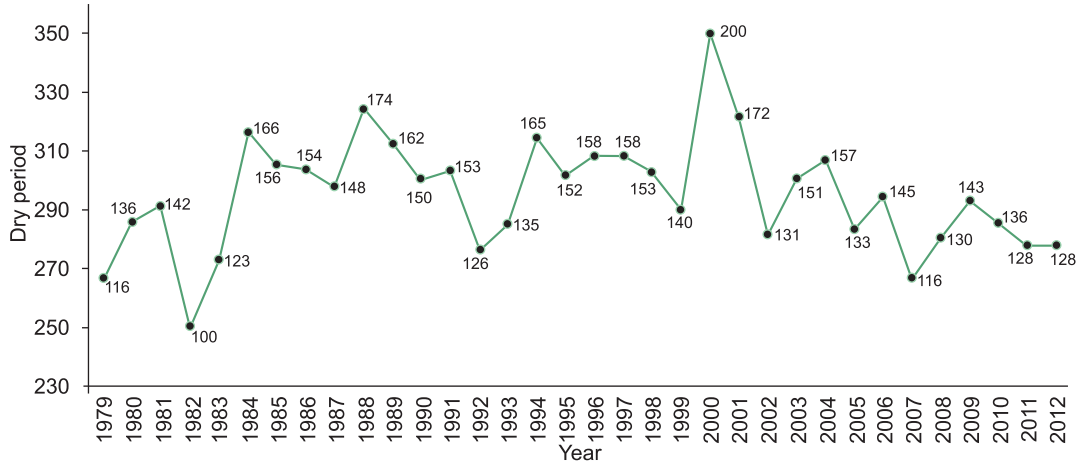

Fig. 3. Phenotypic trend for DP (days) in Kankrej cows.

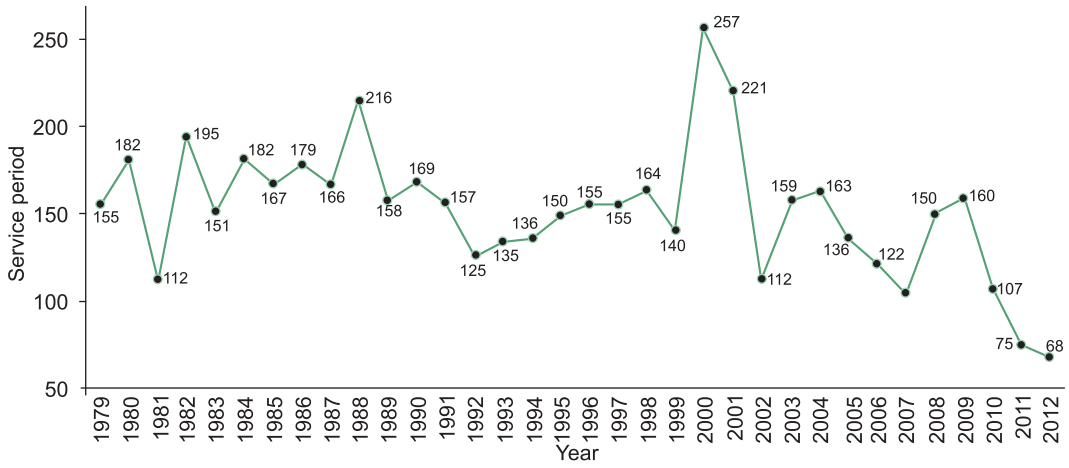

Fig. 4. Phenotypic trend for SP (Days) in Kankrej cows.

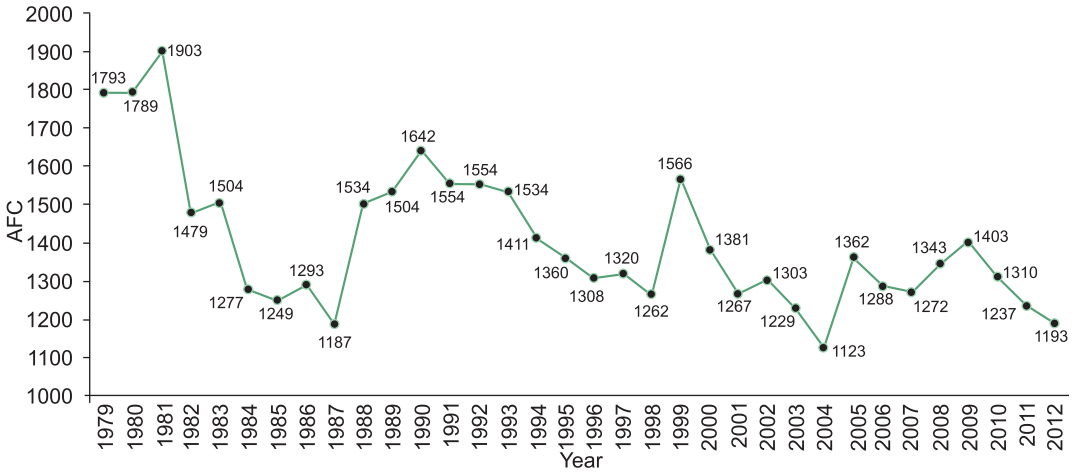

Fig. 5. Phenotypic trend for AFC (Days) in Kankrej cow.

low estimate of heritability estimate of this trait. Looking into the trend and estimate of genetic parameters it can be concluded that improvement in this trait may be brought about by improving the management of the farm as well as indirect selection strategy may be adopted. Improvement in the service period estimates of Kankrej cow in later half period of study was probably due to the improvement in the average rainfall of the area during this period.

Period of birth for AFC and period of calving for other traits showed significant effect on all the traits under consideration. However, season of calving as well as AFC group showed nonsignificant effect. Moderate to high magnitude of heritability for most of the production traits indicated ample scope for selection for these traits in the farm. Positive genetic correlation of first lactation 305 day milk yields with AFC needs to be explored properly, for taking appropriate measures. Our results revealed that great improvement in Kankrej herd was achieved in last 35 years, however, there is further scope of genetic improvement. Better managemental practices that are being adopted in the herd over the years are reflected by the high magnitudes of phenotypic trends. Designed genetic programme has had great impact on improvement of milk production and AFC but very less impact on the reproductive traits.

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