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Estimation of Genetic, Phenotypic and Environmental Trends in Various Production and Reproduction Traits of Tharparkar Cattle at Organized Farm at Bikaner

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ABSTRACT

A total of 284 performance records belonging to 63 Tharparkar cows in at least three lactations or more spread over a period of fifteen years (2002 to 2016) were utilized to estimate the trends in various traits. The estimates of phenotypic trends for AFC, SP, CI, DP, LL, LMY, MYPD and MYCI were -11.054±9.41 days/year (0.70% of HA), 0.841±0.42 days/year (0.61% of HA), 2.061±1.04 days/year (0.496% of HA), 1.682±1.04 days/year (1.21% of HA), 2.70±2.31 days/year (0.95% of HA), 19.42±7.21 kg/year (0.96% of HA), 0.033±0.07kg (0.60% of HA) and 0.023±0.03kg (0.55% of HA), respectively. Phenotypic trend was observed positive and significant (P≤0·05) for calving interval, service period and lactation milk yield. Age at first calving and service period shown increase genetic trend in present study. Comparison of methods of estimation of genetic trend showed that the BLUP method should be used for estimation of genetic trends of economic traits as this method has lower magnitude of standard error in comparison to other methods. For overall improvement in production, emphasis should be given to some reproductive traits like AFC and SP along with lactation milk yield while planning selection strategies.

Keywords: BLUP method, Genetic trend, Phenotypic trend, Tharparkar

Animal breeders are primarily concerned with the genetic improvement of the animal by making suitable selection and breeding policies and their implementation. The ultimate goal in animal breeding is to rank the animals according to their genetic merit for the desired characters and to use them efficiently in breeding programmes. The genetic evaluation of animals is, therefore a key issue. For a breeding programme, it is pre-requisite to know about the changes occurring in a given population over the years to maximize genetic gain. The change or variation in average performance of a herd per unit of time is an indicator of the phenotypic trend and does not indicate the improvement in genetic potential of the animals. Genetic trend is the change in performance per unit time due to the change in mean breeding value (Harville and Henderson 1967). Golverdi *et al.* (2012) used DFREML animal model procedure for the estimation of genetic trend of first lactation 305 days milk yield, fat yield and fat percent in Holsteins. The genetic trends of all three studied traits were calculated using regression of means of breeding values over the years. The genetic trends were positive for milk (6.791) and fat (0.139) yields and negative for fat percent (-0.04). The effectiveness of breeding programme implemented in herd and management practices are indicated by the positive or favourable genetic and environmental trends. Therefore, to determine the effectiveness of genetic selection, genetic trends in the herd can be considered. The phenotypic trend has two components these are the genetic and environmental trend. The environmental trend is the change in performance per unit time due to change in mean environment.

Hence, present study was undertaken to estimate the genetic and phenotypic trends in various traits in

Tharparkar cattle, so as to generate information that will be helpful in developing selection programmes for genetic improvement of the breed.

MATERIALS AND METHODS

A study was conducted on 284 lactation records of 63 Tharparkar cows and 9 bulls maintained at the Livestock Research Station, Beechwal, Bikaner,spanning the period from 2002 to 2016 to estimate genetic, phenotypic and environmental trends in production and reproduction traits. The traits selected for trend analysis were age at first calving (AFC), lactation milk yield (LMY), calving interval (CI), dry period (DP), service period (SP), lactation length (LL), milk yield per day of lactation length (MYPD) and milk yield per day of calving interval (MYCI).

Estimation of phenotypic trend

The change in annual mean phenotypic effects over years represented the phenotypic trend over time. After standardization of data according the fixed effects, the phenotypic trend was calculated by taking regression of yearly mean performance of the population on the year as:

$$P = b_{P.T} = \sum pt / \sum t^2$$

Where,

$b_{P.T}$ = linear regression of population performance (P) on time (year) of calving (T)

$\sum pt$ = corrected sum of products for performance of trait and time

$$= \frac{\sum PT - \sum P \sum T}{N}$$

$\sum t^2$ = corrected sum of squares for time taken as deviation from its mean.

$$= \frac{\sum T^2 - \left(\sum T\right)^2}{N}$$

Standard error of phenotypic trend were estimated as:

$$\text{S.E.} = \left(\frac{\sum P^2 - b_{P.T}\left(\sum pt\right)^{1/2}}{\left(\sum t\right)^2 (N-2)} \right)$$

$\sum p^2$ = Corrected sum of square for trait performance

$$= \frac{\sum P^2 - \left(\sum P\right)^2}{N}$$

Where N = total number of records.

Estimation of Genetic trend

The genetic trends were estimated by following four methods.

Smith method1 (SM1) and Smith method 2 (SM2)

The regression of performance (P) on year of calving (T), $b_{P.T}$ consists of two component genetic trend and environmental trend. While expectation of intra-sire regression *($b_{P \cdot T/S}$)* is only *1/2g* + t as the sire did not vary and only the dams contribute to genetic progress. The expected value of the regression of deviation from the contemporary average (P) on time (T), $b_{(p-P).T/S}$ is equal to *(1/2* g + t) - (g + t) or -1/2g. The following expectations of regression have found the method of Smith (1962) or some modification of it,

$E(b_{P.T}) = g+t$

$E(b_{P.T/S}) = 0.5g+t$

$E(b_{(p-P).T/S}) = -0.5g$

$E(b_{P.T/SD}) = t$

Where,

g = Genetic trends

t = environmental trend

$b_{P.T}$ = regression of population performance on time

$b_{P.T/S}$ = within sire regression of progeny performance on time

$b_{(p-P).T/S}$ = within sire regression of progeny performance on time record being deviated from population mean.

$b_{P.T/SD}$ = regression of performance on time within sire and dam

The above expectations lead to the following two regressions

Methods (SM1 and SM2) for estimating the genetic trends:

(1.) $g\hat{} = 2(b_{P.T} - b_{P.T/S})$ Smith method I

i.e. twice the difference in the regression performance on time and pooled intra sire regression of sire progeny performance on time.

$$SE_{(g)} = 2\sqrt{Vbp\bullet T + Vbp\bullet T/S}$$

(2.) $g\hat{} = -2(b_{(p-P).T/S})$ Smith method II

i.e. negative twice the pooled intra-sire regression of the records of sire progeny on time, each record being expressed as a deviation from the herd mate average (the average of all records made in a year excluding the record of the animal and its paternal half-sibs i.e. contemporary ,year average). This method avoids year to year fluctuations in the environment and hence it gives more realistic estimate as compared to the first method.

$$SE_{(g)} = 2\sqrt{Vb(p-p)\bullet T/S}$$

Least Squares method of Burnside and Legate (LSMBL)

In this method, $b(\Delta G/2 + \Delta E)$ was obtained from the weighted regression of year constants on years and these year constants were obtained from least squares analysis making adjustment for sire, year and season. Differences in these year constants, which was adjusted for sires, reflected the differences in the dam effects and the environmental effects associated with different years, i.e. one half of genetic trend plus the environmental trend, b ($\Delta G/2 + \Delta E$).

$$\Delta G = 2\,(b_{\Delta G+\Delta E} - b_{\Delta G/2+\Delta E})$$

Where,

$b_{\Delta G+\Delta E}$ = weighed regression of year constants on years which indicate the phenotypic change

$b_{\Delta G/2+\Delta E}$ = weighed regression coefficient which expressed one half of genetic trend plus environmental trend.

$b_{\Delta G/2+\Delta E}$ was estimated using the following model:

$$Y_{ijkl} = \mu + S_i + M_j + P_k + b\,(X_{ijkl} - X) + e_{ijkl}$$

Where,

Y_{ijkl} = Observation on the l^{th} progeny of i^{th} sire under j^{th} season in k^{th} period

μ = overall mean

s_i = random effect attributed to i^{th} sire

M_j = fixed effect of j^{th} season of calving

P_k = fixed effect of k^{th} period of calving

b = regression coefficient of Y_{ijkl} on AFC

X_{ijkl} = age at first calving corresponding l^{th} animal

X = mean of X_{ijkl}

e_{ijkl} = residual random error under standard assumption which make the analysis valid, i.e. NID $(0,\sigma^2)$

For estimation of genetic trends of age at first calving (AFC), the model was the same as that used for least squares analysis of AFC data taking year of birth and season of birth without regression effect in the model.

BLUP method

The genetic trends were estimated by calculating the transmitting ability (ETA) of sires. The transmitting ability of sire is half of additive genetic value and therefore genetic trends were obtained as 2 times regression of weighted average of sire's transmitting abilities (WAETA) for each year on year as: (Hintz *et al.,* 1978)

$$WAETA = \sum n_{ik}\, s_i / n.k$$

Where,

n_{ik} = Number of daughter of sire i (i= 1, 2, … ..,m) in k^{th} year

S_i = Estimated Transmitting ability (ETA) of sire i^{th}

n.k = Number of daughters of m sires in the k^{th} year

Transmitting ability is half of the additive genetic value and additive genetic value calculated by BLUP (best linear unbiased prediction) method (Henderson, 1975).

Estimation of Environmental trends

Environmental trend (ΔE was obtained by subtracting the genetic trend (ΔG) from the overall phenotype trend (ΔP).

$$\Delta E = \Delta P - \Delta G$$

The standard error of environmental trend, SE (ΔE) was calculated as:

$$S.E.(\Delta E) = \sqrt{S.E.(\Delta P)^2 + S.E.(\Delta G)^2}$$

RESULTS AND DISCUSSION

The estimates of phenotypic trends are presented in Table 1 and shown in Fig. 1 to 8 and estimates of genetic and environmental trends are presented in Table 2.

Genetic, phenotypic and environmental trends in AFC

Estimate of phenotypic trend for AFC was -11.054±9.41 days/year (0.70% of HA) and decreasing trend in AFC was observed in desirable direction. Similar pattern was also reported by Singh and Gurnani (2004) in Karan Fries and Karan Swiss and Sivamani *et al.* (2013) in Sahiwal cows. Whereas, Kothekar (1981) and Nehara (2012) reported positive trend in this trait.

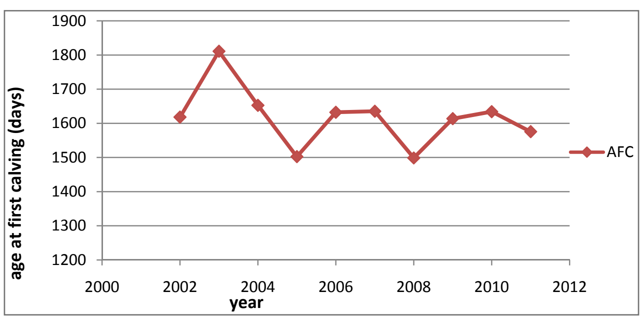

Fig 1: Annual Phenotypic trend for age at first calving in Tharparkar cattle (ΔP= -11.054±9.41 days/year, 0.70% of HA)

Genetic trend was significant and positive by BLUP method for AFC which was similar to results of Singh and Sangwan (2002) in Hariana cattle. It may be concluded that the apparent decline in AFC from 2004 onwards might be due to the improvement in the environmental factors such as feeding and effective management of the herd. The increase in the trend calls for necessary steps to improve the AFC genetically through stringent selection of sires and dams. The negative genetic trends were observed by Murdia and Tripathi (1991) in Jersey cattle and Effa *et al.* (2011) in long-term dairy cattle.

The negative environmental trend shows that there are need to improve managemental and environmental practices at farm. Similar result also reported by Gupta (1994) in Red Sindhi at Hosur.

Table 1: Phenotypic trend in lactation traits of Tharparkar cattle

Sl. No.	Trait		Phenotypic trends
1	AFC	ΔP	-11.054±9.41 days/year
		% of HA	0.70
2	CI	ΔP	2.061±1.04* days/year
		% of HA	0.496
3	SP	ΔP	0.841±0.42* days/year
		% of HA	0.61
4	DP	ΔP	1.682±1.04 days/year
		% of HA	1.21
5	LL	ΔP	2.70±2.31 days/year
		% of HA	0.95
6	LMY	ΔP	19.42±7.21* kg/year
		% of HA	0.96
7	MYPD	ΔP	0.033±0.07
		% of HA	0.60
8	MYCI	ΔP	0.023±0.03
		% of HA	0.55

Genetic, phenotypic and environmental trends in calving interval

The phenotypic change in CI was not favorable as evident from significantly increase by 2.061±1.04 days per year (0.496 % of HA) and this trait show fluctuation over the period. A reduction in calving interval can be achieved through better feeding, management, disease control and efficient heat detection and timely service programme. These results are consistent with other reports in literature such as Tomar and Singh (1981) in Hariana cattle and Nehra 2012) in Karan Fries cattle, but were not in agreement with reports by Kothekar (1981) in *Bos tarus* and its crosses and Singh and Gurnani (2004) in Karan Fries and Karan Swiss.

CI show negative genetic trend by SM1, SM2 and BLUP method which is favorable in direction similar to results of Murdia and Tripathi (1991), Singh and Gurnani (2004) and Nehra (2012). Singh and Sangwan (2002) reported positive genetic trend in calving interval. The results of this study indicate that the management influence calving interval of Tharparkar herds performing in a climate of

Bikaner more than additive genetic factors. The genetic trend for CI obtained was in a favorable direction but little in magnitude. There is need to revise the selection strategies and improvement in these herds can be carried out through the implementation of effective breeding programs.

The undesirable environmental trend was observed as similar to results of Muridia and Tripathi (1991) in Jersey cattle at various state farms.

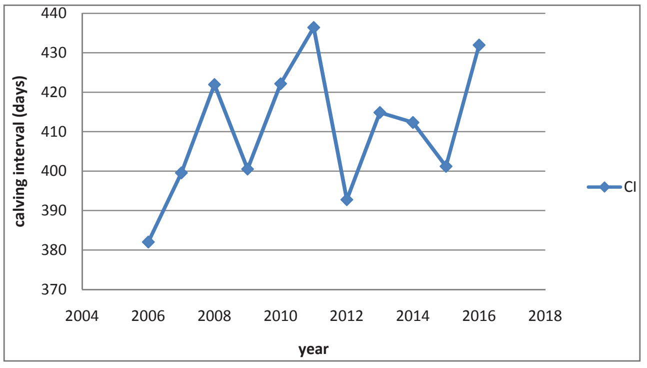

Fig. 2: Annual Phenotypic trend for calving interval in Tharparkar cattle (ΔP= 2.061±1.04* days/year, 0.496% of HA)

Genetic, phenotypic and environmental trends in service period

A positive and significant phenotypic trend of 0.841±0.42 days/year (0.61% of HA) was observed as similar to results observed by Kothekar (1981) in *Bos tarus* and its crosses. There was sudden increase in service period as shown in Fig 3. It might be due to changes in managemantal and feeding schedule at farm.

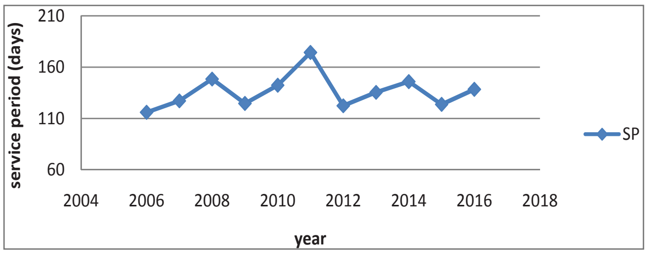

Fig. 3: Annual Phenotypic trend for service period in Tharparkar cattle (ΔP= 0.841±0.42* days/year, 0.61% of HA)

A positive and significant genetic trend was reported by BLUP method in service period. Favorable annual genetic progress in SP was also reportd by Kothekar (1981) in *Bos tarus* and its crosses.

Positive environmental trend was observed as similar to reports of Muridia and Tripathi (1991) in Jersey cattle at various state farms.

Table 2: Genetic and environmental trends for various traits of Tharparkar cattle by different methods

Sl. No.	Trait	Trends	Smith method		LSMBL	BLUP
			SM1	SM2		
1	AFC	ΔG	-14.86 ± 30.3	-6.29 ± 33.2	17.44 ± 21.41	13.64 ± 6.8*
		% of HA	0.94	0.40	0.87	0.86
		ΔE	3.81 ± 31.72	-4.76 ± 34.50	-28.49 ± 23.38	-24.69 ± 11.6*
2	CI	ΔG	-2.03 ± 11.28	-2.58 ± 17.2	4.09 ± 13.11	-0.098 ± 0.184
		% of HA	0.49	0.62	0.98	0.023
		ΔE	4.1 ± 11.32	4.641 ± 17.23	-2.09 ± 13.15	2.159 ± 1.56
3	SP	ΔG	-1.68 ± 13.9	0.392 ± 21.08	-3.53 ± 12.28	0.425 ± 0.156**
		% of HA	1.2	0.28	2.59	0.31
		ΔE	2.521 ± 13.91	0.45 ± 21.14	4.371 ± 12.38	0.416 ± 1.62
4	DP	ΔG	-2.34 ± 12.58	-0.390 ± 14.06	-4.71 ± 11.77	-0.697 ± 0.35*
		% of HA	1.68	0.281	3.40	0.50
		ΔE	4.02 ± 12.62	2.072 ± 14.09	6.392 ± 11.81	2.379 ± 1.09*
5	LL	ΔG	4.28 ± 11.2	0.251 ± 23.14	6.97 ± 10.52	1.40 ± 0.31**
		% of HA	1.51	0.09	2.47	0.49
		ΔE	-1.58 ± 11.4	2.449 ± 23.25	-4.27 ± 10.77	1.30 ± 2.33
6	LMY	ΔG	2.301 ± 24.84	-8.62 ± 29.6	11.97 ± 19.63	3.90 ± 1.99*
		% of HA	0.114	4.30	0.59	0.194
		ΔE	17.11 ± 25.86	28.04 ± 30.46	7.45 ± 20.91	15.52 ± 7.47*

7	MYPD	ΔG	-0.125 ± 0.69	-0.23 ± 5.68	0.093 ± 3.79	-0.062 ± 0.014*
		% of HA	1.8	3.45	1.39	0.93
		ΔE	0.158 ± 0.71	0.263 ± 5.68	-0.06 ± 1.94	0.095 ± 0.071
8	MYCI	ΔG	-0.029 ± 0.312	-0.014 ± 9.04	0.032 ± 6.13	0.0099 ± 0.007
		% of HA	0.71	0.33	0.79	0.22
		ΔE	0.052 ± 0.313	0.037 ± 9.05	-0.009 ± 6.13	0.021 ± 0.03

Genetic, phenotypic and environmental trends in dry period

Non-significant and positive phenotypic trend in dry period was found and the values were 1.68±1.04 days/year (1.21 per cent of HA) and this trait show decrease pattern observed after 2015 (Fig. 4). These results are similar to results of Khan *et al*. (1998) in Sahiwal cows. While, Singh and Nagarcenkar (2000) reported negative phenotypic trend in dry period of Sahiwal herds.

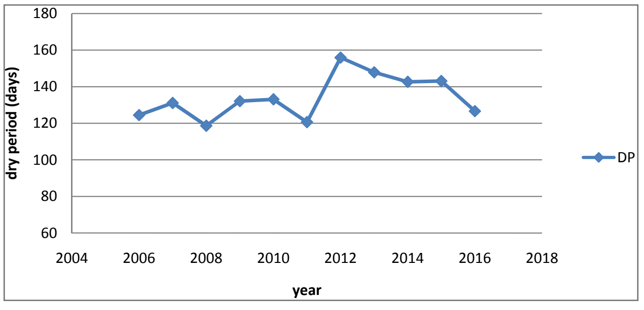

Fig. 4: Annual Phenotypic trend for dry period in Tharparkar cattle (ΔP= 1.682±1.04 days/year, 1.21% of HA)

According to BLUP method result there was negative and significant genetic trend was observed in present study which is in direction of improvement. Murdia and Tripathi (1991) in Jersey bull and Gaur *et al.* (2003) in Frieswal bulls also reported overall significant declining genetic trend for dry period.

Genetic, phenotypic and environmental trends in lactation milk yield

A positive and significant phenotypic trend of 19.42±7.21 kg/year was estimated for lactation milk yield as similar to results of Singh and Gurnani (2004) in Karan Swiss cattle and Kaygisiz (2010) in Brown Swiss cattle. On the other hand, Kumar and Narain (1979) reported negative phenotypic trend in lactation milk yield.

Milk yield showed positive and significant genetic trend by BLUP method which is indication of good managemental practices and feeding management at farm. The negative genetic trends revealed that the sires used in later years were of inferior genetic worth to those used in early years. This might be attributed to the lack of systematic breeding plans, effective selection and/or acclimatization of animals. Singh and Sangwan (2002), Gaur *et al.* (2003) and Ambhore *et al.* (2017) also reported positive genetic trend in milk yield. However, Bakir and Kaygisiz (2009) in Holstein Friesian carried out negative genetic trend in milk yield.

Positive environmental trends indicated that phenotypic improvement is higher to genetic gain in lactation milk yield.

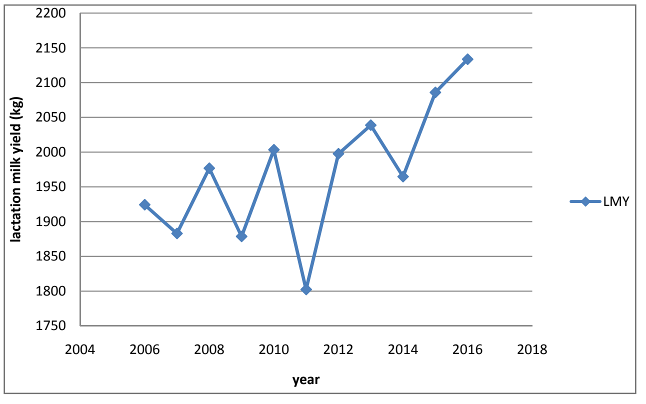

Fig. 5: Annual Phenotypic trend for lactation milk yield in Tharparkar cattle (ΔP= 19.42±7.21* kg/year, 0.96% of HA)

Genetic, phenotypic and environmental trends in lactation length

Positive but non-significant estimate of phenotypic change in lactation length was observed to be 2.70±2.31 days/year (0.95 % of HA) in present study. Tomar and Singh (1981) also observed positive phenotypic trend in lactation length of Hariana cattle. Bakir and Kaygisiz (2009) reported negative phenotypic trend in lactation length of Holstein Friesian.

Positive and significant genetic trend observed by BLUP method in lactation length in present study was similar to results of Ambhore *et al.* (2017), Singh and Sangwan (2002) in Hariana cattle. Bakir and Kaygisiz (2009) reported negative genetic trend in lactation length of Holstein Friesian

Positive genetic trend in lactation length indicate favorable result for farm. But environmental trend in this trait was obtained negative, which is not desirable. There might be several possible reasons for negative environmental trends in lactation length such as increase in size of herds over the years and major managemental changes such as shifting from individual to large group feeding resulting in decreased individual attention per animal.

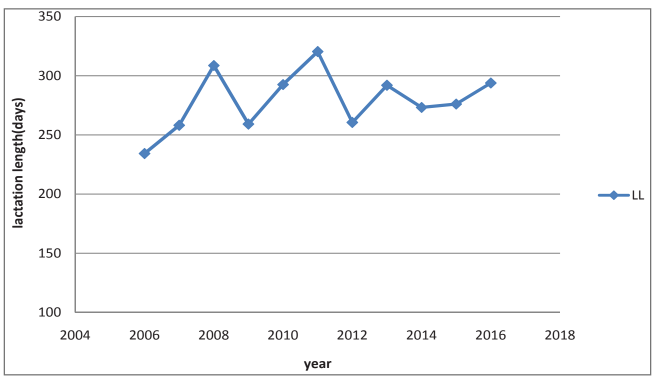

Fig. 6: Annual Phenotypic trend for lactation length in Tharparkar cattle (ΔP= 2.70±2.31 days/year, 0.95% of HA)

Genetic, phenotypic and environmental trends in MYPD and MYCI

The phenotypic trend in MYPD and MYCI were observed to be positive and non-significant and values were 0.033±0.07 (0.60% of HA) and 0.023±0.03 (0.55% of HA), respectively.

Little improvement has been observed over the years in these traits as these are ratio traits. Negative and significant genetic trend was observed in MYPD while Positive and significant for MYCI by BLUP method. Kumar and Narain (1979) reported negative genetic trend in MYPD and MYCI in Sahiwal herd. Singh and Sangwan (2002) observed positive genetic trend in both traits in Hariana cattle. Kothekar *et al.* (1981) reported almost zero improvement in ratio traits such as MYPD and MYCI in Jersey cattle.

Ilatsia *et al*. (2007) reported that genetic trends were estimated close to zero for all traits, while environmental and phenotypic trends fluctuated over the study period in Sahiwal cattle.

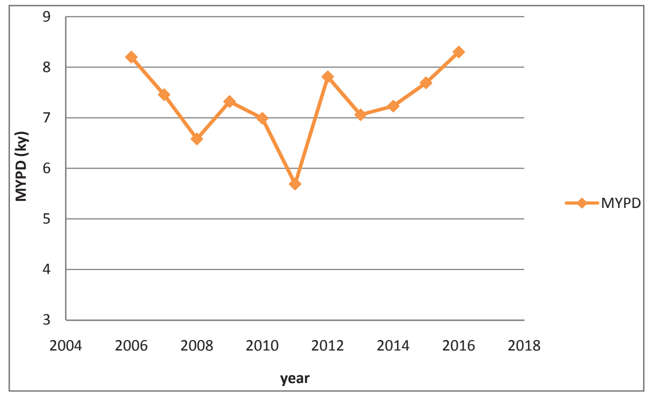

Fig. 7: Annual Phenotypic trend for milk yield per day of lactation length in Tharparkar cattle (ΔP= 0.033±0.07 kg/day/year, 0.60% of HA)

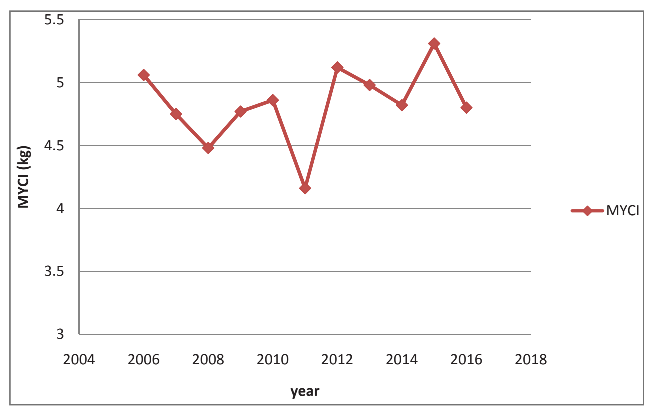

Fig. 8: Annual Phenotypic trend for milk yield per day of calving interval in Tharparkar cattle (ΔP= 0.023±0.03 kg/day/year, 0.55% of HA)

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