



## Phenotypic, genetic and environmental trends of production traits in Phule Triveni synthetic cow

G S AMBHORE<sup>1</sup>, AVTAR SINGH<sup>2</sup>, D K DEOKAR<sup>3</sup>, MANVENDRA SINGH<sup>4</sup> and S K SAHOO<sup>5</sup>

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ICAR-National Dairy Research Institute, Karnal, Haryana 132 001 India

### ABSTRACT

The research data spread over a period of 37 years (1976 to 2012) were utilized to study the production traits, viz. first lactation 300 day milk yield (FL300DMY), first lactation total milk yields (FLTMY), first lactation length (FLL) and first dry period (FDP). The 493 first lactation performance records of Phule Triveni cows reared at Research Cum Development Project on Cattle, Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri was used to investigate the effect of environmental factors on first lactation production traits. Phenotypic, genetic and environmental trends were estimated using Smith II (SM-II) and best linear unbiased prediction (BLUP) methods in these traits. The estimated annual phenotypic, genetic and environmental trends were  $-20.70 \pm 1.42$  kg,  $33.38 \pm 48.99$  kg (SM-II) and  $1.31 \pm 0.60$  kg (BLUP) and  $-54.08 \pm 49.01$  kg (SM-II) and  $-22.01 \pm 1.58$  kg (BLUP) for FL300DMY,  $-21.01 \pm 4.18$ ,  $21.35 \pm 60.09$  kg (SM-II) and  $2.15 \pm 0.73$  kg (BLUP) and  $-42.36 \pm 60.23$  kg (SM-II) and  $-23.16 \pm 4.24$  kg (BLUP) for FLTMY,  $-0.44 \pm 0.30$  days,  $4.27 \pm 4.94$  (SM-II) and  $0.09 \pm 0.13$  (BLUP) days for FLL,  $0.98 \pm 0.24$  days,  $-0.99 \pm 3.58$  (SM-II) and  $-0.11 \pm 0.08$  (BLUP) days,  $1.97 \pm 3.59$  (SM-II) and  $1.09 \pm 0.25$  (BLUP) days for FDP, respectively. The genetic trends for most of the production traits were positive except FDP revealing desirable improvement in performance traits over time.

**Key words:** Environmental, Genetic, Phenotypic, Phule Triveni, Production traits

India has 39.73 million crossbred cattle (Livestock census 2012), which play a key role in the rural economy of the country. Crossbred cattle contribute more than 24% in the total milk produced in the country (BAHS 2014). The Phule Triveni cattle were developed under the All India Coordinated Research Project (AICRP) on cattle to produce 3,000 litre/lactational milk yield with fat > 3.5%. The Phule Triveni cattle are a triple cross of milch breeds of cattle viz. Holstein Friesian, Jersey and Gir (50% HF, 25% Jersey and 25% Gir). 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. The accuracy of identifying genetically superior animals is the basic requirement for genetic improvement through selection. As, assessment of the true breeding value of an animal is not possible so, estimated breeding values (EBVs) are calculated which are the estimates of the true breeding value of an animal. The best linear unbiased predictions (BLUP) procedure is widely used across the globe not only to evaluate sires but also to estimate the

genetic trends along with combining ability (Minfeng *et al.* 1988). The main advantage of using BLUP animal model is that, it utilizes information from all relatives, no matter how distantly the relative is related to animal and all animals of a breed are evaluated simultaneously (Wiggans *et al.* 1988). 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 defined as the change in performance per unit time due to the change in mean breeding value (Harville and Handerson 1967). The effectiveness of breeding programme implemented in herd is indicated by the positive or favorable genetic trend. The phenotypic trend has two components that is the genetic and environmental trend. The environmental trend is the change in performance per unit time due to change in mean environment. The present study was aimed to investigate the phenotypic, genetic and environmental trends of first lactation production traits in order to evaluate whether continual selection in production traits resulted in decline in performance in respect to production performance of Phule Triveni synthetic cattle in hot and semiarid climatic conditions of Maharashtra.

### MATERIALS AND METHODS

The data on 493 pedigree, breeding and first lactation performance records of Phule Triveni cattle maintained at

Present address: <sup>1</sup> SMS (drgsambhore@gmail.com), CBF, Igatpuri (MAFSU). <sup>2</sup> Principal Scientist (avtar54@gmail.com), <sup>4</sup> Ph.D. Scholar (manav21vet@gmail.com), AGB Division. <sup>3</sup> Assistant Professor (deokardk68@gmail.com), RCDP, MPKV, Rahuri. <sup>5</sup> Assistant Professor (saroj6804@gmail.com), AGB, GADVASU, Ludhiana.

Research Cum Development Project on Cattle, MPKV, Rahuri during 1976 to 2012 were utilized for the present study.

Incomplete lactations for any recorded reason or lactations showing any abnormality were not utilized in the analysis. Records having less than 150 days of lactation length were not used. In addition to the basic edits of consistency for dates and animal identity, the data were checked for other unrealistic entries and out liars. Records outside a range of 3 standard deviations from the phenotypic mean were also removed. All the available information was included in the analysis to minimise the bias due to selection and non-random mating. The parameters included were identity of animals, sire, dam, dates of birth, calving, drying, lactation length and total lactation milk yield. The data were analysed by the least squares technique (Harvey 1990) and the following mathematical model was designed to determine the effect of environmental factors affecting the traits under consideration.

$$Y_{ijklm} = \mu + P_i + S_j + M_k + A_l + e_{ijklm}$$

where,  $Y_{ijklm}$ , observation on the  $m^{\text{th}}$  progeny in  $l^{\text{th}}$  age group  $k^{\text{th}}$  season  $j^{\text{th}}$  sire and  $i^{\text{th}}$  period;  $\mu$ , overall mean;  $P_i$ , fixed effect of  $i^{\text{th}}$  period;  $S_j$ , random effect of  $j^{\text{th}}$  sire;  $M_k$ , fixed effect of  $k^{\text{th}}$  season;  $A_l$ , fixed effect of  $l^{\text{th}}$  age group;  $e_{ijklm}$ , the random error which is NID  $(0, \sigma_e^2)$ .

After standardization of data according to the fixed effects, the phenotypic trend was calculated by taking regression of performance of the population on the year as

$$\Delta P = b_{P,T} = \Sigma Pt / \Sigma t^2$$

where,  $b_{P,T}$ , linear regression of population performance (P) on time (year) of calving (T);  $\Sigma Pt$ , corrected sum of products for trait (P) and time (t);  $\Sigma t^2$ , corrected sum of squares for time taken as deviation from its mean.

Smith Method II (Smith 1962) and BLUP (Best linear unbiased prediction) methods were used for estimation of genetic trends.

*Smith Method II:* The procedure utilizes the fact that progeny of sires used in several years provides some continuity of genotypes over years from which the genetic change may be estimated. Annual change in performance consists of 2 parts, viz.  $\Delta G$  genetic trends;  $\Delta E$  environmental trends.

When sires were used over several years, their genetic contribution to the daughters was the same for all years. Therefore, the genetic change from sire side was zero. Other half of the genotype was contributed by changing group of females to which the sire was mated in his first, second and subsequent years of service. Hence comparison of performance of paternal sisters calving in continuous years should indicate  $t + \frac{1}{2}g$ . Thus Smith's methods were based on following expectation (Smith 1962):

$$E(b_{P,T}) = g + t; E(b_{P,T/S}) = 0.5g + t; E(b_{(p-p)_{T/S}}) = -0.5g; E(b_{P,T}) = g + t$$

where,  $b_{P,T}$ , 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.

Estimation of genetic trends can be obtained by combining the above expectations to give two estimates of trends as:  $\hat{g} = -2(b_{(p-p)_{T/S}})$

*BLUP Method:* (Co) variance components of all traits were estimated by the average information maximum likelihood method (AIREML) algorithm in WOMBAT (Meyer 2007) genetic analysis tool. Best linear unbiased estimation (BLUP) of breeding values was carried by the following model:

$$Y = Xb + Zu + e$$

where, Y, vector of observations for  $i^{\text{th}}$  trait; b vector of  $i^{\text{th}}$  fixed effects; u, vector of  $i^{\text{th}}$  random effects (sire/animal); X and Z, incidence matrices pertaining for fixed and random sire/ animal effect respectively.

Genetic trend was computed by the formula suggested by Hintz *et al.* (1978) utilizing the breeding value estimated by BLUP univariate sire model. The transmitting ability (ETA) of sire is half of additive genetic value and therefore genetic trends was obtained as 2 times regression of weighted average of sire's transmitting abilities (WAETA) for each year on year.

$$WAETA = [\Sigma n_{ik} \hat{S}_i] / n_k$$

where,  $n_{ik}$ , number of daughter of sire  $i$  ( $i = 1, 2, \dots, m$ ) in  $k^{\text{th}}$  year;  $\hat{S}_i$ , estimated transmitting ability (ETA) of sire  $i^{\text{th}}$ ;  $n_k$ , number of daughters of  $m$  sires in the  $k^{\text{th}}$  year.

Environmental trend ( $\Delta E$ ) was calculated by subtracting the genetic trend ( $\Delta G$ ) from the overall phenotype trend ( $\Delta P$ ) as:  $\Delta E = \Delta P - \Delta G$  (Kunaka and Makuza 2005).

The standard error of environmental trend, SE ( $\Delta E$ ) is calculated as:

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

Estimates of genetic trends obtained by the 2 methods were compared by their standard errors.

## RESULTS AND DISCUSSION

Phenotypic, genetic, and environmental trends were estimated for FL300DMY, FLTMY, FLL and FDP are presented in Table 1.

*Phenotypic, genetic and environmental trends in first lactation 300 day or less milk yield (FL300DMY):* Annual phenotypic trend for FL300DMY was  $-20.70 \pm 1.42$  kg ( $-0.78\%$  of herd average) and was statistically significant ( $P < 0.05$ ). The overall average FL300DMY of Phule Triveni cow was estimated as  $2647 \pm 39$  kg. The average FL300DMY did not exhibit a definite trend over the years (Fig.1). The variations in this trait reflect the level of management, as well as environmental effects. The level of management varies according to the ability of farm manager, his efficiency in the supervision of the labour,

Table 1. Phenotypic, genetic and environmental trends for first lactation production traits of Phule Triveni cattle

Traits	Trends	Methods	
		Smith II	BLUP
FL300DMY (kg)	$\Delta P$	$-20.70 \pm 1.42$	
	% of HA	0.78	
	$\Delta G$	$33.38 \pm 48.99$	$1.31 \pm 0.69$
	% of HA	1.26	0.05
	$\Delta E$	$-54.08 \pm 49.01$	$-22.01 \pm 1.58$
FLTMY (kg)	$\Delta P$	$-21.01 \pm 4.18$	
	% of HA	0.74	
	$\Delta G$	$21.35 \pm 60.09$	$2.15 \pm 0.73$
	% of HA	0.75	0.08
	$\Delta E$	$-42.36 \pm 60.23$	$-23.16 \pm 4.24$
FLL (days)	$\Delta P$	$-0.44 \pm 0.30$	
	% of HA	0.13	
	$\Delta G$	$4.27 \pm 4.94$	$0.09 \pm 0.13$
	% of HA	1.29	0.02
	$\Delta E$	$-4.71 \pm 4.95$	$-0.53 \pm 0.33$
FDP (days)	$\Delta P$	$0.98 \pm 0.24$	
	% of HA	1.05	
	$\Delta G$	$-0.99 \pm 3.58$	$-0.11 \pm 0.08$
	% of HA	1.06	0.11
	$\Delta E$	$1.97 \pm 3.59$	$1.09 \pm 0.25$

$\Delta P$ , Phenotypic trend;  $\Delta G$ , Genetic trend;  $\Delta E$ , Environmental trend and % of HA, Herd average.

system of crop husbandry, method and intensity of culling. Mukherjee (2005) observed the phenotypic trend in Frieswal cattle as  $19.75 \pm 4.73$  and Nehra *et al.* (2012) observed  $20.74 \pm 6.01$  kg (0.64% of herd average) in Karan Fries cattle for FL305DMY.

The annual genetic trend for FL300DMY was  $33.38 \pm 48.99$  kg (1.26% of herd average) and  $1.31 \pm 0.60$  kg (0.05% of herd average) by SM-II and BLUP method. The genetic

trends were statistically nonsignificant by SM-II method but the genetic trend estimated by BLUP method was significant ( $P < 0.05$ ) and had relatively lower standard error compared to SM-II method. Genetic trends by both methods for FL300DMY depicted positive trends indicating a genetic improvement in the present Phule Triveni herd. These results could be due to the use of semen of sires having better breeding value for this trait. Mukherjee (2005) reported the genetic trend by SM-II method in Frieswal cattle as  $34.24 \pm 35.36$ . Nehra *et al.* (2012) and Dash (2014) reported annual genetic trend estimated by BLUP method as  $4.85 \pm 5.62$  kg (0.15% of herd average) and  $0.10 \pm 2.13$  kg (0.003% of herd average), respectively, in Karan Fries cattle.

Environmental trends were  $-54.08 \pm 49.01$  and  $-22.01 \pm 1.58$  kg per year by SM-II and BLUP methods, respectively, for FL300DMY. Environmental trends were in negative direction by both the methods but statistically significant by BLUP method. The negative magnitude of environmental trend for FL300DMY resulted in worsening the phenotypic trend. Nehra *et al.* (2012) reported environmental trends as  $26.94 \pm 35.33$  and  $15.89 \pm 10.55$  kg by SM-II and BLUP methods in Karan Fries cattle which were in positive direction.

*Phenotypic, genetic and environmental trends in first lactation total milk yield (FLTMY):* The annual phenotypic trend of FLTMY was  $-21.01 \pm 4.18$  kg (0.74% of herd average) and was statistically significant ( $P < 0.05$ ). The overall average FLTMY of Phule Triveni cattle was  $2855 \pm 43$  kg. There was a fluctuating trend (Fig. 2) in yearly averages during the period from 1976 to 2012. Contrary to our results, Nehra *et al.* (2012) reported positive phenotypic trend for FLTMY in Karan Fries cattle at NDRI farm.

Genetic trends for FLTMY were found as  $21.35 \pm 60.09$  kg and  $2.15 \pm 0.73$  kg per year by SM-II and BLUP methods.

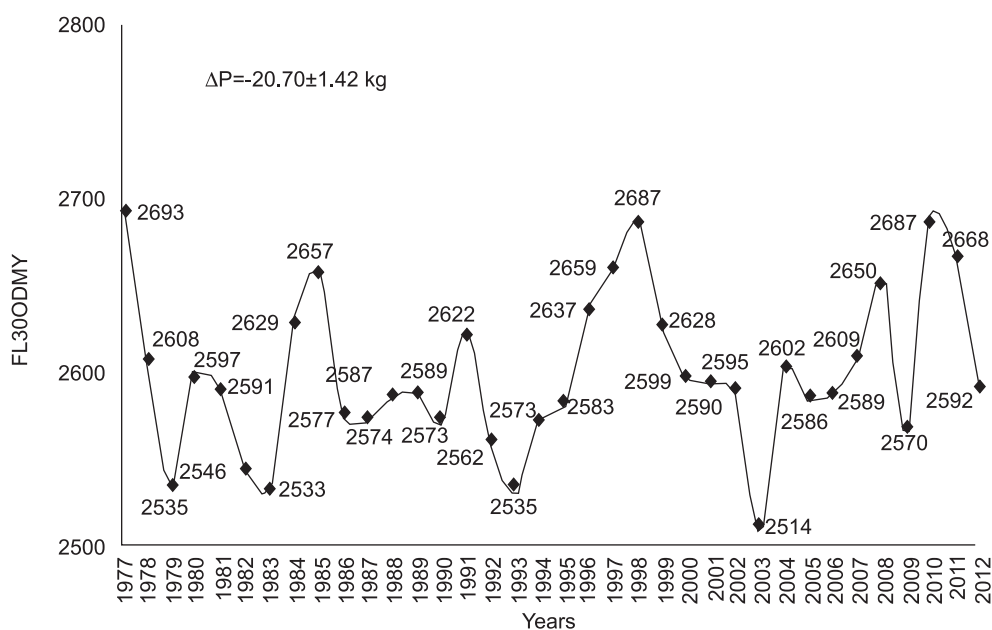


Fig. 1. Phenotypic trend for FL300DMY (kg) in Phule Triveni cows.

The genetic trend was positive but nonsignificant ( $P < 0.05$ ) by SM-II method but positive, significant ( $P < 0.05$ ) and low by BLUP method. The estimate and standard error, however, was lower by BLUP method as compared to SM-II method. Genetic trends for FLTMY were reported as  $- 8.20 \pm 51.08$  (SM-II) and  $3.44 \pm 2.60$  (BLUP) by Nehra *et al.* (2012) in Karan Fries cattle at NDRI farm.

The environmental trends were  $- 42.36 \pm 60.23$  kg and  $- 23.16 \pm 4.24$  kg per year by SM-II and BLUP methods, respectively. Environmental trend by SM-II method was found to be statistically nonsignificant but significant ( $P < 0.05$ ) by BLUP method and were in negative direction by both the methods. This showed that decline in milk

production over years was due to deterioration in environmental conditions coupled with management. Contrarily, the positive environmental trends for FLTMY by these methods were reported by Nehra *et al.* (2012) as  $42.24 \pm 51.80$  and  $38.47 \pm 12.90$  by SM-II and BLUP methods in Karan Fries cattle.

*Phenotypic, genetic and environmental trends in first lactation length (FLL):* The overall average for FLL in Phule Triveni cows was  $331 \pm 3$  days. The yearly averages for FLL followed fluctuating trend across the years (Fig. 3). The average change in yearly averages quantified by the phenotypic trend was  $- 0.44 \pm 0.30$  days per year (0.13% of HA) which was negative but statistically nonsignificant.

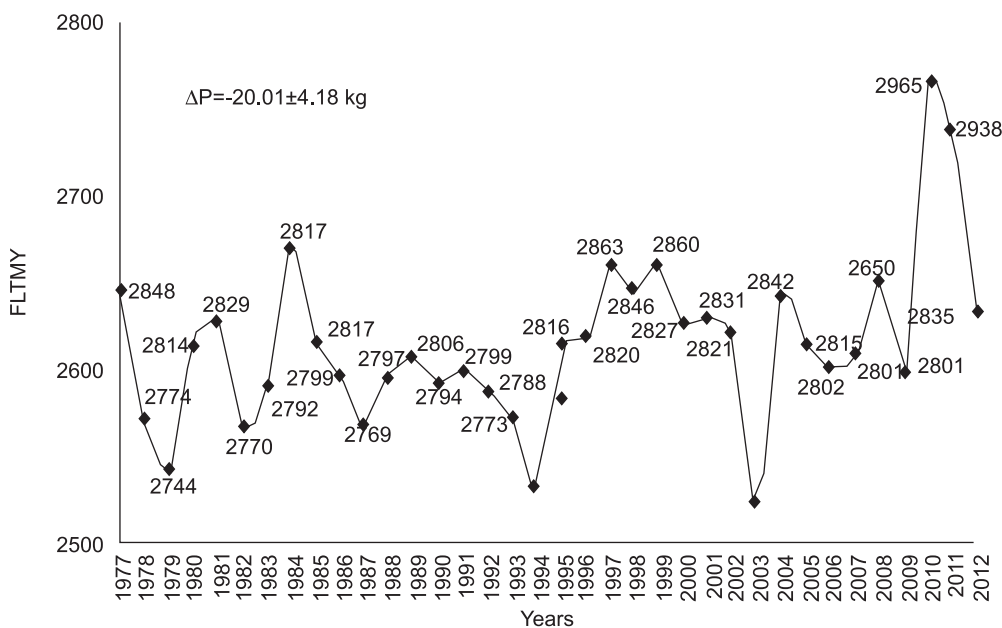


Fig. 2. Phenotypic trend for FLTMY (kg) in Phule Triveni cows.

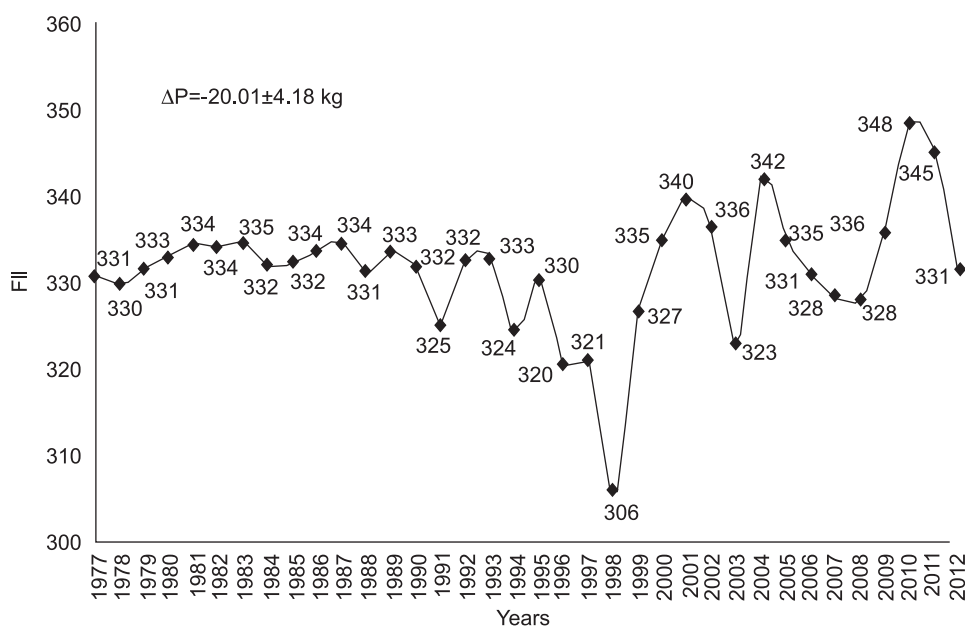


Fig. 3. Phenotypic trend for FLL (days) in Phule Triveni cows.

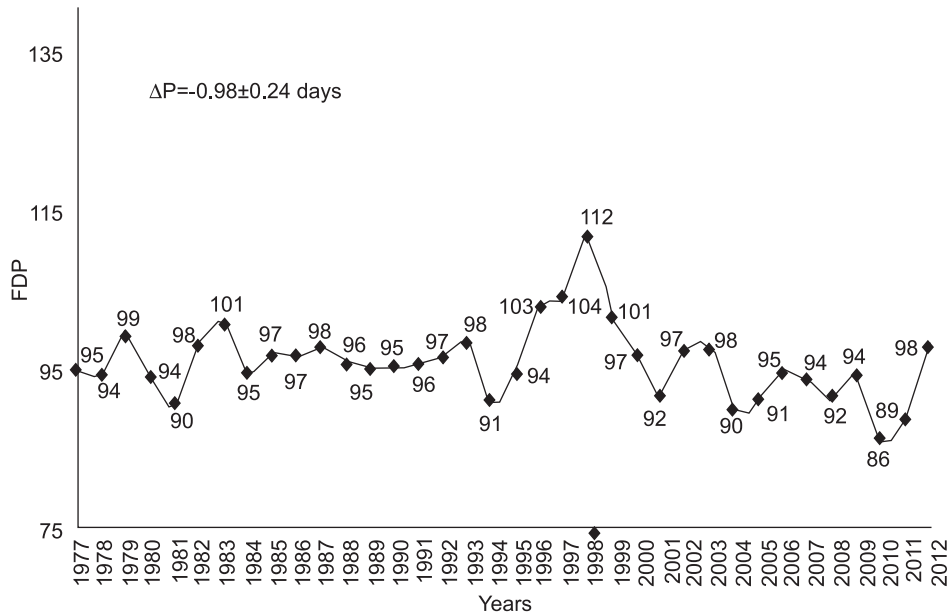


Fig. 4. Phenotypic trend for FDP (days) in Phule Triveni cows.

The negative phenotypic trend for FLL were reported by Singh (1995) and Mukherjee (2005) as  $-1.85 \pm 1.4$  and  $-1.53 \pm 4.48$  in Karan Fries cattle at NDRI farm and Frieswal cattle at military dairy farm. However, Nehra *et al.* (2012) reported positive phenotypic trend  $1.02 \pm 0.65$  days per year (0.28% of HA) in Karan Fries cattle at NDRI farm.

Genetic trends for FLL were estimated to be  $4.27 \pm 4.94$  and  $0.09 \pm 0.13$  days per year by SM-II and BLUP method respectively which were statistically nonsignificant by both the methods. The positive genetic trends for FLL were also reported by Gaur (2003) and Nehra (2011) as 4.37 by BLUP method in Frieswal cattle at military dairy farm and  $0.59 \pm 3.89$  (17% of HA) and  $0.58 \pm 0.24$  (0.16% of HA) by SM-II and BLUP methods in Karan Fries cattle at NDRI farm.

The environmental trends were  $-4.71 \pm 4.95$  and  $-0.53 \pm 0.33$  days per year by SM-II and BLUP respectively. Environmental trends were also statistically nonsignificant and in negative direction. Contrarily, Nehra (2011) reported positive environmental trends for FLL in Karan Fries cattle as  $0.43 \pm 3.95$  and  $1.59 \pm 0.69$  by SM-II and BLUP methods, respectively.

*Phenotypic, genetic and environmental trends in first dry period (FDP):* The overall average for FDP in Phule Triveni cows was  $93 \pm 3$  days. The yearly averages for FDP followed fluctuating trends across the years (Fig. 4). The average change in yearly averages quantified by the phenotypic trend was  $0.98 \pm 0.24$  days per year (1.05% of HA) which was statistically significant and positive indicating undesirable trend in FDP.

The genetic trends for FDP were estimated to be  $-0.99 \pm 3.58$  and  $-0.11 \pm 0.08$  days per year by SM-II and BLUP method, respectively, which were statistically nonsignificant by SM-II method and significant by BLUP method. The genetic trends for FDP were in desirable direction.

Environmental trends were  $1.97 \pm 3.59$  and  $1.09 \pm 0.25$  days per year by SM-II and BLUP methods respectively. Environmental trends were statistically nonsignificant by SM-II method and positive and significant by BLUP method.

The genetic trends for most of the production traits (FL300DMY, FLTMY and FLL) were positive except FDP revealing desirable improvement in performance traits over time. The negative phenotypic trends for production traits might be attributed to the adverse environmental trend (-ve  $\Delta E$ ) in the herd. This calls for improvement in the environment of animals through better shelter and overall management.

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