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Genetic evaluation of lifetime performance of Phule Triveni cows by univariate and multivariate methods

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ABSTRACT

Data pertaining to 509 Phule Triveni cows sired by 102 bulls maintained at Research-Cum Development Project on Cattle, Mahatma Phule Krishi Vidyapeeth, Rahuri District Ahmadnagar (Maharashtra) were analysed to study the performance of Phule Triveni cows for lifetime traits. Least-squares means and genetic parameters were estimated for different lifetime traits. The observed least squares means for actual life time milk yield (ALTMY), herd life (HL), productive life (PL) and breeding efficiency (BE) were 12767 ± 207 kg, 2863 ± 29 days, 1875 ± 28 days and 77.00 ± 0.71%, respectively. The estimates of heritability (h^2) for all these lifetime traits under univariate methods (LSML and REML) were 0.15 ± 0.11 and 0.22 ± 0.08 for ALTMY, 0.10 ± 0.12 and 0.19 ± 0.06 for HL, 0.10 ± 0.11 and 0.16 ± 0.05 for PL and 0.01 ± 0.11 and 0.10 ± 0.07 for BE, respectively. The h^2 estimates obtained by REML method were higher as compared to LSML. The h^2 estimates for ALTMY under two traits models were 0.27 ± 0.08, 0.20 ± 0.08 and 0.20 ± 0.06 for ALTMY + PL, ALTMY + HL and ALTMY + BE traits combinations, respectively. The observed estimates of h^2 for ALTMY in combination with PL were higher than the estimates obtained under univariate model by REML method. The estimates of h^2 for ALTMY were 0.54 ± 0.03, 0.54 ± 0.06 and 0.49 ± 0.02 for ALTMY + PL + HL, ALTMY + PL + BE and ALTMY + HL + BE traits combinations, respectively. The h^2 estimates of ALTMY under three trait models were quite high, positive and significant compared to two trait and unitrait models by REML method. The lifetime trait combinations of ALTMY, HL, PL and BE could be used for genetic evaluation and selection of cows in the herd at any point of time. The genetic and phenotypic correlations among the lifetime traits in the present study were 0.90 ± 0.10 and 0.92 ± 0.11, 0.88 ± 0.17 and 0.98 ± 0.11 and 0.17 ± 0.08 and 0.06 ± 0.26 within ALTMY and PL, ALTMY and HL and ALTMY and BE, respectively. The high genetic and phenotypic correlations between ALTMY, HL and PL revealed that selection can be based on any one of these lifetime traits to bring improvement in other lifetime traits.

Key words: Genetic and non-genetic factors, Lifetime traits, Phule Triveni cow, Univariate and multivariate evaluation

Crossbreeding programme in India has made significant impact on milk production in the country. The overall productivity of a dairy animal depends on its lifetime performance rather than on a single lactation performance. A number of factors, viz. total period of stay of a cow in a herd, numbers of its completed lactations and total number of calves dropped during entire lifetime determine the economic productivity of a cow. Once the genetic constitution of a cow is established, genetic and other non-genetic factors come into play over her lifetime performance.

The purpose of any breeding programme in dairy cattle is to increase milk production without increasing cost of milk production. In order to make dairying an economically viable enterprise, it would be desirable that the improvement in lifetime productivity is made. Waiting for longer period or productive life of animals would not be desirable from the point of view of genetic improvement per unit of time. Therefore, the selection of females is generally done on the basis of lifetime traits on that time. So, the present investigation was undertaken to evaluate the performance of synthetic strain of cattle (Phule Triveni) at an organized farm for evaluating the performance and the effect of different environmental factors on different lifetime parameters and devising selection criteria for enhancing their lifetime production.

MATERIALS AND METHODS

The performance records of 509 daughters of 102 sires maintained at Research Cum Development Project on cattle (RCDP) of Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri, District Ahmadnagar of Maharashtra (India) during 1977 to 2012 were analysed. Cows with abnormal and incomplete records were excluded from the study. Also,

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the cows completed only one lactation were excluded and only the cows completed more than two lactations with minimum lactational yield of 1,500 kg with more than 150 days lactation lengths included in the present study. Each year was divided into 3 seasons viz. summer (February to May), rainy (June to September) and winter (October to January) based on climatological conditions. Periods were grouped into 12 groups on the basis of period in which their first daughter was calved. The effects of age at first calving were studied in five groups and seven parity's, assuming no interaction among them as a fixed effect and sire as random effect. The lifetime traits considered for the study were actual Lifetime total milk yield (ALTMY), herd life (HL), productive life (PL) and Breeding efficiency.

BE (%) = [365(N-1) 100] / D (Wilcox 1957).

The data for each trait were analysed using LSML package (Harvey 1990) and REML using WOMBAT software (Meyer 2007).

The effects of genetic (sire) and non-genetic factors (periods, season and age) were analysed using the following mixed model (Harvey 1990) for various life time traits:

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

where, Y_{ijklm}, observation on the m^{th} progeny in l^{th} age group, k^{th} season, j^{th} sire and i^{th} period; μ, population mean; P_i, fixed effect of i^{th} period (i = 1 to 12); S_j, random effect of j^{th} sire which is NID (0, σ_s^2); M_k, fixed effect of k^{th} season (k = 1 to 3); A_l, fixed effect of l^{th} age group (l = 1 to 5); e_{ijklm}, the random error which is NID (0, σ_e^2).

The heritability, genetic and phenotypic correlations were obtained from the above LSML software. DMRT as modified by Kramer (1957) was used for testing differences among least square means (using the inverse coefficient matrix).

The (co) variance components were estimated by the restricted maximum likelihood (REML) algorithm in WOMBAT genetic analysis tool (Meyer 2007) for single and multi trait models. The following animal model was used:

$$Y = Xb + Zu + e$$

For three traits, the model was expressed as:

$$\begin{pmatrix} Y_1 \\ Y_2 \\ Y_3 \end{pmatrix} = \begin{pmatrix} X_1 & 0 & 0 \\ 0 & X_2 & 0 \\ 0 & 0 & X_3 \end{pmatrix} \begin{pmatrix} b_1 \\ b_2 \\ b_3 \end{pmatrix} + \begin{pmatrix} Z_1 & 0 & 0 \\ 0 & Z_2 & 0 \\ 0 & 0 & Z_3 \end{pmatrix} \begin{pmatrix} u_1 \\ u_2 \\ u_3 \end{pmatrix} + \begin{pmatrix} e_1 \\ e_2 \\ e_3 \end{pmatrix}$$

where,Y, vector of observations for traits under study; b, vector of observations of unknown fixed effects of period and season; u, vector of observations of unknown random effects (animals); X and Z, the incidence matrices pertaining for fixed and random animal effect respectively. The following are the assumptions of the model:

E (Y) = Xb, Var (s) = G, Var (h) = R and Cov (s, e′) = 0 so that,

$$V(y) = ZGZ' + R$$

RESULTS AND DISCUSSION

The results of least squares analysis carried out for lifetime traits are presented in Tables 1 and 2. The various factors considered in the analysis were season of birth, period of birth, age at first calving groups (AFC groups) and normal lactations completed (parity).

Herdlife (HL): Herdlife is defined as true longevity/ stayability or the length of time between dates of birth to date of culling/death of animal. In the present study, the average herdlife was found 2863 ± 29 days (7.84 years) (Table 2), which was higher than values reported by most of the workers (Deshmukh 2008 and Dash 2014) in Phule Triveni and Karan Fries Cattle. However, Shinde (2002) reported higher herdlife 2885.20 ± 55.46 days (7.90 years) in Phule Triveni cattle. This trait was significantly influenced by period of calving whereas season of calving had no effect; the findings were in agreement with Shinde (2002) in Phule Triveni cattle and Dash (2014) in Karan Fries cattle. The cows in the period 9 (1998–2000) was found to have longest herdlife 3335 ± 198 days (9.13 years) however, the shortest herdlife 2604 ± 339 days (7.13 year) was found in period 11 (2004 –2006). The effect of parity was highly significant (P≤0.01) on herdlife. The cows completed ≥VIIth parity had the highest 3653 ± 71days (10 years) herdlife whereas cows completed only IInd parity had least herdlife 1638 ± 46 days (4.48 years). The period of first calving contributed significantly (P≤0.05) to the total variation in herdlife (Table 1). The positive relationship was indicative that if age at first calving was reduced by selection then herdlife would also be reduced. The longest herdlife 3149 ± 62 days (8.62 years) was observed when the cows had ≥ 1170 days age at first calving (AGE-5) and the least herdlife 2615 ± 33days (7.16 years) was noticed when the cows had ≤ 804 days age at first calving (AGE-1). Similar

Table 1. Mix model ANOVA showing mean sum of squares for factors affecting life time traits

Source of variation	Mean sum of squares			
	Herd life (HL)	Productive life (PL)	Actual life time milk yield (ALTMY)	BE (%)
Season of calving	274008	191632.61	23090534	77.33
Period of calving	173727*	173727.27*	3608513.11*	270.01*
Sire	174738	166999.82	9496430.63	120.75
Parity	44007435**	44217218.08**	3323674395.24**	2058.90**
AFC	1938766**	17681.47	1258411.58	502.76*
Error	151151.70	146392.55	8817566.50	120.80

*P≤ 0.05 (significant) and **P≤ 0.01 (highly significant) observation was reported by Chaudhry and Shafiq (1995) in Holstein × Sahiwal cattle in Pakistan, Singh *et al*. (2002) in Holstein Friesian cows and Dash (2014) in Karan Fries cattle. However, the effect due to sire was non-significant on herdlife.

Productive life (PL): The average productive life in Phule Triveni cows was 1875 ± 28 days (5.13 years). The effect period of calving was significant (P≤0.05) whereas; season of calving had non-significant effect on productive life. The findings of present study were in agreement with Shinde (2002) and Deshmukh (2008) in Phule Triveni cattle and Dash (2014) in Karan Fries cattle. The longest productive life, 2200 ± 195 days (6.02 years) was found in period 9 (1998 – 2000) whereas, least productive life 1658 ± 25 days (4.54 years) was noticed in period 1 (1974–1976). The effect of parity was highly significant (P≤0.01) on productive life whereas; age at first calving and sire had non-significant effect on productive life. The significant effect of parity on productive life was also observed by Chaudhry and Shafiq (1995) in Holstein × Sahiwal cattle in Pakistan, Singh *et al*. (2002) in Holstein Friesian cows and Dash (2014) in Karan Fries cattle.

The high per cent of variability explained by productive life in the present study is due to inclusion of all production records of the cows which has completed IInd to last parity. The present results indicate that lifetime traits could be controlled by manipulating the productive life, which could be achieved by proper postpartum care of cows, early detection of heat and timely insemination. This results in narrowing down the unproductive part of life; hence the cost of rearing of the cow was reduced.

Actual lifetime milk yield (ALTMY): The average actual lifetime milk yield (ALTMY) was 12767 ± 207 kg. The estimate was lower to the estimates reported by Shinde (2002) and higher than the estimates reported by Deshmukh (2008) in Phule Triveni cattle as 16382 ± 363 and 11186 ± 358 kg, respectively. The effect of season of calving on actual lifetime milk yield was non-significant was in close agreement with the non-significant effect of season of birth on lifetime milk yield as observed by Deshmukh (2008) in Phule Triveni cattle, Joshi (2009) in HF × G crossbreds and Dash (2014) in Karan Fries cattle. However, the period of calving has significant effect (P≤0.05) on actual lifetime milk yield, indicating thereby the effect of fluctuation in management over the periods. The cows calved during period 3 (1982 – 1984) had highest (13862 ± 1548 kg) and the cows calved during period 8 (1995 – 1997) had lowest (11990 ± 1313 kg) ALTMY. Shinde (2002), Deshmukh (2008) in Phule Triveni cattle and Dash (2014) in Karan Fries cattle also reported significant effect of period of calving on ALTMY. The effect of parity (normal lactations completed) on ALTMY was observed to be highly significant (P≤0.01). The cows completed ≥VIIth parity produced highest ALTMY (19240 ± 540 kg) whereas; the cows completed only IInd parity produced lowest ALTMY (3347 ± 344 kg). The effect of sire and age at first calving was found to be non-significant on ALTMY were in

Table 2. Least squares means of various factors affecting lifetime traits

Effect	No. Obs.	Herd life (HL) (days)	Productive life (PL) (days)	ALTMY (kg)	BE (%)
Overall (μ)	509	2863 ± 29	1875 ± 28	12767 ± 207	77.00 ± 0.71
Seasons of Calving					
Season-1 (Winter)	196	2905 ± 39	1911 ± 38	13230 ± 289	77.21 ± 1.02
Season-2 (Summer)	163	2814 ± 41	1835 ± 40	12503 ± 30	76.05 ± 1.09
Season-3 (Rainy)	150	2871 ± 41	1880 ± 40	12569 ± 301	77.64 ± 1.07
Periods of Calving					
Period-1 (1976-1978)	65	2764 ± 262^{de}	1658 ± 25^{fg}	13375 ± 1999^{ab}	94.37 ± 7.29^{a}
Period-2 (1979-1981)	93	2761± 220^{de}	1749 ± 217^{ef}	13479 ± 1680^{ab}	95.23 ± 6.13^{a}
Period-3 (1982-1984)	69	2661 ± 203^{ef}	1768 ± 200^{def}	13862 ± 1548^{a}	90.05 ± 5.65^{b}
Period-4 (1985-1987)	46	2714 ± 182^{e}	1816 ± 179^{de}	13462 ± 1386^{ab}	84.39 ± 5.05^{cd}
Period-5 (1986-1988)	59	2792 ± 165^{de}	1894 ± 163^{cd}	13693 ± 1261^{a}	86.49 ± 4.59^{bc}
Period-6 (1989-1991)	57	2983 ± 149^{c}	2038 ± 147^{b}	13136 ± 1137^{ab}	86.89 ± 4.14^{bc}
Period-7 (1992-1994)	31	2949 ± 160^{c}	1990 ± 158^{bc}	12461 ± 1222^{bc}	80.44± 4.45^{d}
Period-8 (1995-1997)	34	2890 ± 172^{cd}	1854 ± 170^{de}	11990 ± 1313^{cd}	72.84 ± 4.79^{e}
Period-9 (1998-2000)	23	3335 ± 198^{a}	2200 ± 195^{a}	13161 ± 1509^{ab}	66.67 ± 5.50^{f}
Period-10 (2001-2003)	15	3202 ± 210^{b}	2177 ± 207^{a}	11391 ± 1602^{de}	58.32 ± 5.84^{g}
Period-11 (2004-2006)	08	2604 ± 339^{f}	1580 ± 334^{g}	10353 ± 2588^{e}	52.52 ± 9.44^{h}
Period-12 (2007≥2009)	09	2702 ± 448^{ef}	1779 ± 441^{def}	12843 ± 3421^{abc}	55.34 ± 12.99^{gh}
Age Groups					
Age-1 (≤804)	108	2615 ± 33^{c}	1860 ± 52	12824 ± 397	79.33 ± 1.42^{a}
Age-2 (805-904)	133	2732 ± 46^{c}	1878 ± 45	12754 ± 344	76.13 ± 1.23^{ab}
Age-3 (905-1021)	117	2846 ± 45^{b}	1883 ± 44	12920 ± 335	73.20 ± 1.20^{b}
Age-4 (1022-1169)	89	2948 ± 51^{b}	1898 ± 50	12410 ± 379	78.82 ± 1.36^{a}
Age-5 (≥1170)	62	3149 ± 62^{a}	1858 ± 61	12929 ± 466	77.33 ± 1.68^{a}
Parity					
Parity-II	115	1638 ± 46^{f}	664 ± 45^{f}	3347 ± 344^{f}	65.77 ± 1.23^{b}
Parity-III	129	1960 ± 43^{e}	937 ± 42^{e}	4843 ± 322^{e}	78.87 ± 1.15^{a}
Parity-IV	75	2348 ± 53^{d}	1405 ± 52^{d}	8415 ± 398^{d}	79.02 ± 1.43^{a}
Parity-V	57	2838 ± 61^{c}	1861 ± 60^{c}	12362 ± 457^{c}	78.15 ± 1.65^{a}
Parity-VI	61	3233 ± 58^{b}	2236 ± 57^{b}	15865 ± 434^{b}	77.16 ± 1.56^{a}
Parity≥VII	72	3653 ± 71^{a}	2666 ± 70^{a}	19240 ± 540^{a}	78.89 ± 1.95^{a}

agreement with the findings of Singh *et al.* (2002) in Holstein Friesian cows and Dash (2014) in Karan Fries cattle.

Breeding efficiency (BE): Season of calving had non-significant effect on BE. Similar findings were reported by Shinde (2010) in HF crossbreds and Kohle (2011) in 5/8 Gir crossbred cows. Period of calving had significant effect ($P \leq 0.05$) on breeding efficiency (BE). Kohle (2011) in 5/8 Gir crossbred cows and Dash (2014) in Karan Fries cow also observed significant effect of period of calving on BE. The highest BE (95.23 ± 6.13) was noticed in period 2 (1979 – 1981) and the lowest BE (52.52 ± 9.44) was found in period 11 (2004 – 2006). The age at first calving (AFC) had significant ($P \leq 0.05$) effect on breeding efficiency (BE). The contradictory finding to the present study was reported by Hammoud and Salem (2013) in HF cattle. The highest BE (79.33 ± 1.42%) was observed in AGE-1 (≤ 804 days) and the least (73.20 ± 1.20%) in AGE-3 (905–1021 days). The effect of parity was highly significant ($P \leq 0.01$) on breeding efficiency. Similar observation was reported by Dash (2014) in Karan Fries cattle. The BE was highest (78.89 ± 1.95%) for the cows that has completed ≥VII parity and the least (65.77 ± 1.23%) for the cows that remained in the herd up to II parity.

The overall least squares mean for BE was 77.0 ± 0.71% in the present study. Zol *et al.* (2009) however, reported higher BE (92.71 ± 0.66) in Phule Triveni cattle, whereas, Kohle (2011) reported BE somewhat higher (83.47 ± 0.81) than the present study in 5/8 Gir crossbred cattle.

Heritability estimates of lifetime traits by univariate and multivariate model: The heritability estimates of lifetime traits were obtained using LSML for univariate model and REML (WOMBAT) procedure for univariate and multivariate models are presented in Table 3. The h^2 estimates by LSML and REML procedure revealed that the h^2 estimates for all the lifetime traits were higher by REML than LSML method. Further, the h^2 estimates of lifetime traits had low to medium magnitude indicating that these traits can be improved through selection. The overall BE showed lower h^2 estimates by both the methods indicating that this trait was influenced to a greater extent by non-genetic causes and can be improved through better management. Dash (2014) reported similar findings of heritability estimates for ALTMY, PL, HL and BE in Karan Fries cattle.

The heritability estimates for lifetime traits do not hold much promise for enhancing lifetime performance of Phule Triveni cows through direct selection but emphasis should be given to herdlife (HL) and actual lifetime milk yield (ALTMY).

Two-trait models: The heritability estimates of ALTMY was positive and high (0.27 ± 0.08) in combination with PL (ALTMY + PL) than the heritability estimates observed by single trait model as 0.22 ± 0.08. However, the heritability estimates of ALTMY with combination of HL (ALTMY + HL) and BE (ALTMY + BE) was found to be slightly lower than the single-trait ALTMY (REML method). The heritability estimates for ALTMY under two trait models were positive and moderate in magnitude do not holds much promise for enhancing lifetime performance in Phule Triveni cows but emphasis must be given to actual lifetime milk yield and productive life (ALTMY+ PL) at the time of selection of cows.

Three-trait models: The heritability estimates for ALTMY under three-trait models of lifetime traits were quite high, positive and significant compared to heritability estimates of two-trait and single-trait models in the present study. In practical situation for cow selection, it was inferred that ALTMY, PL and BE could be used for genetic evaluation and selection of cows in the herd at any point of time.

Estimates of genetic and phenotypic correlation among lifetime traits: The genetic (r_g) and phenotypic (r_p) correlations were estimated among lifetime traits (ALTMY, PL HL and BE) and are depicted in Table 4.

Genetic and phenotypic correlation between ALTMY and other lifetime traits: The observed genetic correlations of ALTMY with other lifetime traits *viz.* ALTMY with HL and PL were high, positive and significant; whereas, the genetic correlation between ALTMY and BE was positive, significant and of low magnitude (ranged between 0.17 ± 0.08 to 0.90 ± 0.10). The highly positive genetic correlation between ALTMY, HL and PL revealed that selection can be based on any one of these lifetime traits. Kaushik *et al.* (1994) and Singh *et al.* (1995) also reported that the genetic correlations among lifetime traits were highly positive in Haryana and Karan Swiss cattle, respectively.

Table 3. Heritability estimates of lifetime traits for univariate and multivariate models

Trait	LSML	REML
ALTMY	0.15 ± 0.11	0.22 ± 0.08
HL	0.10 ± 0.12	0.19 ± 0.06
PL	0.10 ± 0.11	0.16 ± 0.05
BE	0.01 ± 0.11	0.10 ± 0.07
Two – trait model		
ALTMY + PL	-	0.27 ± 0.08
ALTMY + HL	-	0.20 ± 0.08
ALTMY + BE	-	0.20 ± 0.06
Three – trait model		
ALTMY, PL and HL	-	0.54 ± 0.03
ALTMY, PL and BE	-	0.54 ± 0.06
ALTMY, HL and BE	-	0.49 ± 0.02

Table 4. Genetic and phenotypic correlations among lifetime traits

Trait	Genetic (r_g)	Phenotypic (r_p)
ALTMY and other lifetime traits		
ALTMY and PL	0.90 ± 0.10**	0.92 ± 0.10**
ALTMY and HL	0.88 ± 0.17**	0.98 ± 0.11**
ALTMY and BE	0.17 ± 0.08*	0.06 ± 0.26

*Significant at P≤0.05; **highly significant at P≤0.01

The phenotypic correlations of ALTMY with HL and PL were high, positive and significant; while with BE was low, positive and non-significant (ranged between 0.06 to 0.98 ± 0.11). The ALTMY had positive and high phenotypic correlation with HL and PL which was desirable indicating that selection on ALTMY would be sufficient to bring improvement in other traits also. These results were in close agreements with the results of Kaushik *et al*. (1994), Singh *et al*. (1995) and Dalal *et al*. (2002).

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