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Association of Age at First Calving (AFC) on Production Trait in HF x Gir Crossbred

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ABSTRACT

The least-squares means (\pm standard error) for first-lactation traits were $2,780.17 \pm 37.31$ kg for 300-day milk yield (FL300DMY), 15.28 ± 0.16 kg for peak milk yield (FLPMY), and 326.77 ± 1.81 days for first-lactation length (FLL). The period of calving exerted a significant effect ($p < 0.05$) on FL300DMY, FLPMY, and FLL. In contrast, the season of calving and age at first calving group had no significant influence ($p > 0.05$) on any of the first-lactation production traits.

Introduction

India is the largest producer and consumer of milk globally. The livestock sector plays an increasingly important role in socio-economic development and food security by providing affordable and nutritionally rich food to a large proportion of the Indian population, while also generating substantial employment opportunities in rural areas throughout the year. Milk production is a highly complex biological process influenced by both genetic and non-genetic factors. Genetic potential of the animal interacts with non-genetic factors such as season and period of calving, age at first calving, lactation order,

as well as environmental factors including feeding regime, management practices, and disease control.

Crossbreeding is recognized as one of the most rapid and effective approaches for improving economically important traits in dairy cattle. In crossbreeding programs, indigenous cows are mated with genetically superior exotic dairy breeds characterized by higher milk yield, improved milk composition, and better adaptability. This strategy exploits both heterosis (hybrid vigor) and the additive genetic effects of high-producing exotic breeds, thereby enhancing overall productivity.

Milk yield is a major economic trait in dairy animals and constitutes the primary source of income in most dairy production systems. Although economic traits are largely governed by genetic factors, environmental influences such as year of calving, season of calving, age at first calving, and parity exert significant effects on milk yield. These non-genetic factors may mask the true genetic potential of animals and introduce bias in selection decisions. Consequently, adjustment for environmental effects is essential for accurate estimation of genetic merit. The primary objective of animal breeding is not only the development of superior individual animals but also the overall genetic improvement of the herd through the selection of genetically superior sires and dams for future generations (Bourdon, 1997).

The average age at first calving has not shown substantial reduction over recent decades, largely due to the perception that early calving may adversely affect milk production and longevity. Although lowering the age at first calving is considered one of the most effective strategies for reducing replacement costs, many dairy farmers remain reluctant to calve heifers before 24 months of age (Pirlo, 1997). Previous studies have reported that a reduction in age at first calving may negatively influence first-lactation milk yield and milk fat percentage.

The objective of the present study was to evaluate age at first calving and its effect on production traits in crossbred cattle.

Materials and Methods

For the present investigation, data maintained at the Research Cum Development Project on Cattle (RCDP), Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri, District Ahilyanagar, Maharashtra, were utilized. The Research Cum Development Project on Cattle at MPKV, Rahuri was initiated under the All India Coordinated Research Project (AICRP) of the Indian Council of Agricultural Research (ICAR), New Delhi, during the Fourth Five-Year Plan period.

The foundation stock comprised Gir cows, which were inseminated with frozen semen from proven sires of Holstein Friesian (HF) and Jersey breeds during the period from 1971 to 1975. As a result, 277 Friesian × Gir (FG) and 170 Jersey × Gir (JG) F₁ halfbred progenies were produced. Subsequently, second-generation crosses possessing 50 per cent inheritance from Holstein Friesian

and 50 per cent from the indigenous Gir breed were developed and maintained through inter se mating.

The herd was continuously inherited through inter se breeding, and the comparative performance of successive inter se generations was evaluated up to the ninth generation.

Statistical analysis

Statistical analysis of data was carried out bottom the following headings

Least squares analysis

Least squares means of AFC was estimated by considering the effects of genetic (sire) and non-genetic factors (period and season of birth) by using following model.

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

Where,

Y_{ijkl} = Observations on AFC of lth animal belonging to ith period of birth, jth season of birth and kth sire

μ = Overall mean

P_i = Fixed effect of ith period of birth (I = 1, 2...7) S_j =

Fixed effect of jth season of birth (j = 1, 2 and 3) M_k =

Random effect of kth sire (k= 1, 2...n)

e_{ijkl} = Random errors associated with NID (O, σ_e²)

Result and Discussion

The AFC is an important economic trait in dairy cows and genetic improvement being lowering AFC is desirable for reducing unproductive period, culling uneconomic animals at an early age and increasing their lifetime milk production. Such an improvement could only be brought about, firstly by knowing accurate magnitude of the AFC, its heritable fraction or variance and planning an appropriate selection system that can be adopted being achieving the desired goal.

The overall least squares means of age at first calving in HF x Gir halfbred cows was 940.05 + 5.85 days. Almost similar estimates of average AFC were observed by Jadhav and Khan (1996), Panja (1997), Mukherjee (2005) and Rathee (2015) in HF crossbred cattle. The present results were higher than Bhoite (1996) reported in JG halfbred.

However, the age at first calving was lower than Thombare *et al.*, (2002) observed in HF x D halfbreds and Dubey and Singh (2005) in Sahiwal crossbred.

Effect of period of birth

The period of birth was found to have significant ($P < 0.01$) influence on AFC in HF x Gir halfbred (Table 1). The difference in age at first calving of cows born during period P4, P5 and P6 were at par with each other and significantly higher than cows born in P1, P2 and P3 periods (Table 2).

Similar results were reported by Singh *et al.*, (2014) and Rathee (2015) in Frieswal cattle. The differences in AFC during different periods may be due to reason that feeding and management practices of young stock varied from year to year and young stock raised during the year of better nutrition grew faster than others.

Effect of season of birth

The influence of season of birth on age at first calving of HF x Gir halfbred was non- significant. The highest age at first calving (days) was observed in heifers born during rainy season (946.00 ± 9.49) followed by summer (944.24 ± 9.25) and winter (929.92 ± 8.85) season.

These results were in agreement with Bhoite (1996), Mukherjee (2005) and Singh *et al.*, (2014) reported in HF crossbred cattle. Whereas, contradictory results were noticed by Akhtar *et al.*, (2003), PDC AR (2003-04) and in different crossbred cattle.

Effect of sire

The effect of sire on AFC was significant ($P < 0.05$). The significant effect of sire on AFC was also reported by Jadhav (1990) in HF x SW cattle, Akhtar *et al.*, (2003) in 5/8 HF x 3/8 SW cattle, Singh *et al.*, (2014) in Frieswal and Ambhore *et al.*, (2017) in Phule Triveni cattle.

First Lactation 300DMY

The milk yield is the basic and most important economic trait on which the whole economy of dairying is based. The FL300DMY provides most efficient measure to assess the inherent capacity of an individual and indicate the breeding value of a dairy animal accurately. Therefore, it has been internationally agreed that the milk yield during first 300 days after calving be considered for

comparison of production performance of dairy cattle.

The least squares mean of FL300DMY in HF x Gir halfbred was 2780.17 ± 37.31 kg (Table 4). The present results were in consonance with the reports of Saha (2001) reported in Karan Fries and Shelke (2012) and Ambhore *et al.*, (2017) in Phule Triveni cattle. Rathee (2015) found higher estimates (3292.61 ± 53.6 kg) in Frieswal cattle. The differences in the estimates of average FL300DMY reported by many researchers could have been due to sampling variations, as different studies were based on small and different number of observations or herd to herd differences or differences that might have occurred over time depending on the period to which the data pertained.

Effect of period of calving

The analysis of variance showed that the period of calving had significant ($P < 0.01$) effect on FL300DMY (Table 4). The DMRT revealed that the 300 days milk yield of cows calved during P1 (3279.70 ± 70.83 kg) was significantly higher than those calved in P2 to P6 period. The 300 days milk yield recorded during period P3, P4, P5 and P6 were at par with each other. The present results were in accordance with the reports of Saha (2001), Annual Report, PDC (2003-04), Mukherjee (2005), Kokate (2009), Shelke (2012) and Ambhore (2017) reported in various crossbreds. However, Singh and Gurnani (2004), and Divya (2012) reported non-significant effect of period of calving on FL305DMY.

Effect of season of calving

The influence of season of calving on 300 days milk yield was found to be non- significant in HF x Gir halfbred cows. It may hence be deduced that the milch stock was maintained under optimum management conditions round the year. The non-significant effect of season of calving on FL300DMY was also reported by many workers (Divya, 2012) in KF cattle. Contrary to the present results, significant effect of season of calving on FL300DMY had been documented by Singh and Gurnani (2004), Mukherjee (2005), Kokate (2009) and Rathee (2015) in different crossbred cattle. The cows calved during summer season (2820.86 ± 57.87 kg) had higher 300 days milk yield than winter (2745.85 ± 55.73 kg) and rainy season (2773.79 ± 59.90 kg). However, the differences between different seasons were not statistically significant.

Effect of age at first calving group

The least squares analysis revealed that the AFC group had non-significant effect on FL300DMY (Table 4). Similar results were reported by, Panja (1997) and Divya (2012) in KF cattle. However, significant effect of AFC on the FL300DMY was noticed by Saha (2001) in KF cattle, Annual Report PDC (2003-04) and Mukherjee (2005) in Frieswal cattle.

Effect of sire

Significant variation (P<0.05) due to sire was observed in FL300DMY in HF x Gir halfbred (Table 4.3). These results corroborated with the results of Mukherjee (2005), and Divya (2012) in Frieswal and Karan fries cattle and Ambhore et al., (2017) in Phule Triveni cattle.

However, Pol et al., (2013) and Gaikwad (2010) observed non-significant effect of sire on FL300DMY in Phule Triveni cow.

First lactation peak milk yield

As the first lactation yield becomes available at an early age and has high correlation with later lactation yield, it gives an indication on genetic potential of animals. However, as the milk producing ability is influenced by a number of genetic and non-genetic factors as well, the use of information on first lactation production is essential for bringing about genetic improvement through selection. The overall least squares mean of FLPMY was 15.28 ± 0.16kg (Table 4). Almost similar estimates of average FLPMY were observed by Saha (2001) in KS cattle, Akhtar et al., (2003) in HF x S crossbred, Kumar et al., (2008) in Frieswal, in KF cattle and Ambhore et al., (2017) in Phule Triveni cattle. However, Singh et al., (2008) in HF x S crossbred, in KF cattle reported higher estimate of FLPMY. The difference in average FLPMY reported by many researchers may be attributed to difference in breeds used for crossing, herds,

reproductive management strategies and time/ period considered.

Effect of period of calving

The effect of period of calving on FLPMY was significant (P<0.01). Similar result was reported by Mukherjee (2005), Kumar et al., (2008) and Rathee (2015) in Frieswal cattle. However, the highest FLPMY (16.23 ± 0.31 kg) was recorded during P1 (1974-1980) and the lowest (14.44 ± 0.39 kg) during P3 (1988-1994). The DMRT revealed that the FLPMY recorded during period P4, P5 and P6 was at par with each other. The results indicated that FLPMY gradually declined from cows calved during P1 to P3.

Effect of season of calving

The influence of season of calving on FLPMY was non-significant (Table 3). The first lactation peak milk yield (Table 4) was highest (15.34 ± 0.25 kg) in summer calvers followed by winter (15.30 ± 0.24 kg) and rainy season (15.20 ± 0.26 kg) calvers. The non-significant effect of season of calving on first lactation peak milk yield was reported by Singh et al., (2008) in HF x SW crossbred, Chavan (2010) in HF x Gir halfbred and their interbreeds in HF crossbred. However, significant effect of season of calving on FLPMY was observed by Bhoite (1996), Mukherjee (2005) in Frieswal and in Phule Triveni cows.

Effect of age at first calving group

The least squares analysis revealed that the age at first calving had non-significant effect on the FLPMY (Table 3). Similar to the present findings, Saha (2001) reported non-significant effect of AFC on FLPMY in KS and KF cattle, respectively. However, Saha (2001) in KF cattle; Akhtar et al., (2003) in HF x S and Mukherjee (2005) in Frieswal cattle observed significant variation in FLPMY due to the age at first calving.

Table.1 ANOVA of age at first calving as affected by genetic and non-genetic factors in HF x Gir halfbred

Source of variation	Mean sum of squares (AFC)
Period of birth	527377.82**
Season of birth	10639.42
Sire	10798.38*
Error	9892.39

*P<0.05 and **P<0.01

Table.2 Least squares means of age at first calving as affected by various factors in HF x Gir halfbred

Factors	N	Mean \pm S.E
Overall mean	403	940.05\pm 5.85
Periods of birth		
P1 (1974-1980)	163	806.69 \pm 7.85 ^c
P2 (1981-1987)	60	914.88 \pm 12.85 ^b
P3 (1988-1994)	51	957.64 \pm 14.02 ^b
P4 (1995-2000)	64	991.38 \pm 12.44 ^a
P5 (2001-2008)	41	1000.42 \pm 15.60 ^a
P6 (2009 and above)	24	969.43 \pm 20.40 ^a
Season of birth		
S1 Rainy	131	946.00 \pm 9.49
S2 Winter	146	929.92 \pm 8.85
S3 Summer	126	944.24 \pm 9.25

Table.3 ANOVA of various first lactation production traits as affected by genetic and non-genetic factors in HF x Gir halfbred

Traits	Mean sum of squares		
	FL300DMY	FLPMY	FLL
Source of variation			
Period of calving	5488652.63 ^{**}	28.98 ^{**}	278.30
Season of calving	185220.20	0.63	178.18
Age at first calving group	47868.43	1.85	22.99
Sire	437426.13 [*]	6.69 [*]	894.51
Error	378267.73	7.48	893.25

*P < 0.05 and ** P < 0.01

Table.4 Least squares means (\pm SE) of first lactation milk production traits of HF x Girhalfbred

Factors	N	FL300DMY (kg)	FLPMY (kg)	FLL (days)
		Mean \pm S.E	Mean \pm S.E	Mean \pm S.E
Overall mean	403	2780.17 \pm 37.31	15.28 \pm 0.16	326.77 \pm 1.81
Periods of calving				
P1 (1974-1980)	163	3279.70 \pm 70.83 ^a	16.23 \pm 0.31 ^a	325.10 \pm 3.44 ^{bc}
P2 (1981-1987)	60	2907.82 \pm 80.40 ^b	14.76 \pm 0.35 ^{bc}	328.83 \pm 3.90 ^b
P3 (1988-1994)	51	2431.92 \pm 87.58 ^c	14.44 \pm 0.39 ^c	325.15 \pm 4.25 ^{bc}
P4 (1995-2000)	64	2587.11 \pm 81.01 ^{bc}	15.05 \pm 0.36 ^b	327.57 \pm 3.93 ^c
P5 (2001-2008)	41	2715.49 \pm 100.4 ^{bc}	15.64 \pm 0.44 ^b	330.63 \pm 4.87 ^a
P6 (2009 and above)	24	2758.97 \pm 126.4 ^{bc}	15.56 \pm 0.56 ^b	323.36 \pm 6.14 ^{bc}
Season of birth				
S1 Rainy	131	2773.79 \pm 59.90	15.20 \pm 0.26	325.46 \pm 2.90
S2 Winter	146	2745.85 \pm 55.73	15.30 \pm 0.24	327.05 \pm 2.70
S3 Summer	126	2820.86 \pm 57.87	15.34 \pm 0.25	327.81 \pm 2.81
Age group				
A1 (< 950 days)	226	2790.38 \pm 62.56	15.42 \pm 0.27	326.84 \pm 3.04
A2 (951-1050 days)	72	2751.96 \pm 74.94	15.11 \pm 0.33	327.28 \pm 3.64
A3 (1051 days and above)	105	2798.16 \pm 66.14	15.31 \pm 0.29	326.20 \pm 3.21

Effect of sire

Least-squares ANOVA revealed significant ($P < 0.05$) variation due to sire in FLP MY (Table 4.3). [Hedge et al., \(2009\)](#) reported significant ($P < 0.01$) effect of sire on FLP MY in Sahiwal x Jersey crossbred cattle at Bull Mother Farm, Wadsa, District Gadchiroli (M.S.). While, [Ambhore et al., \(2017\)](#) observed non-significant effect of sire in Phule Triveni.

First lactation length

The value of a milch breed to the practical dairyman is dependent not only upon the quantity of milk the cow gives, but also upon the number of days she remains in milk. Milk production in lactation generally increases with an increase in lactation length. A lactation length of more than 305 days is not optimum as it amounts to enhanced calving interval. A shorter duration also cannot be beneficial as it would not be possible to reduce inter calving period to less than one year.

The overall least-squares mean of FLL in HF x Gir halfbred was 326.77 ± 1.81 days (Table 4). The estimate obtained in the present study was in close agreement with those reported by [Saha \(2001\)](#) in KF cattle and [Mukherjee \(2005\)](#) and [Kumar et al., \(2008\)](#) in Frieswal. However, various other workers ([Ambhore et al., 2017](#)) reported higher estimates of FLL than obtained in the present study.

Effect of period of calving

The difference due to period of calving in FLL was non-significant. The highest (330.63 ± 4.87 days) FLL was recorded in cows calved during P5 (2001-2008) and lowest (323.36 ± 6.14 days) calved during P6 (2009-2017). Similar results were noticed by [Saha \(2001\)](#) and [Akhtar et al., \(2003\)](#) in different HF crossbred cattle. While, [Mukherjee \(2005\)](#), [Kumar et al., \(2008\)](#), reported significant effect of period of calving on FLL in different HF crossbred cattle.

Effect of season of calving

The effect of season of calving on FLL was non-significant (Table 3). The highest FLL was recorded in calves calved during summer (327.81 ± 2.81) and lowest (325.46 ± 2.91 days) calved during rainy season. The non-significant effect of season of calving on FLL

observed in the present study was in agreement with [Saha \(2001\)](#) in KF, [Akhtar et al., \(2003\)](#) in 5/8 HF x 3/8 SW and [Mukherjee \(2005\)](#) reported significant effect of season of calving on FLL in different HF crossbred cattle.

Effect of age at first calving group

The influence of AFC group on the FLL was found to be statistically non-significant (Table 4.3). It was apparent from the results that there was no much variation in FLL among the cows of different AFC groups. The non-significant effect of AFC on FLL in different HF crossbred cattle was also noted by [Saha \(2001\)](#), in KF cattle. However, [Mukherjee \(2005\)](#), [Rathi \(2015\)](#) in Frieswal and [Ambhore et al., \(2017\)](#) reported significant ($P < 0.05$) effect of AFC group on FLL in Phule Triveni cattle.

Effect of sire

Least-squares ANOVA showed non-significant variation due to sire in FLL (Table 4.3). The results were inconsonance with [Akhtar et al., \(2003\)](#) and [Ambhore et al., \(2017\)](#) noticed in 5/8 HF x 3/8 SW and Phule Triveni cattle, respectively. The results of present study were not in agreement with [Mukherjee \(2005\)](#) observed in Frieswal and [Hedge et al., \(2009\)](#) in Jersey x Sahiwal crossbred cows.

In conclusion, Reduction in age at first calving is a critical management intervention for improving economic efficiency in dairy herds. Age at first calving exerts a substantial effect on major production parameters, including lactation milk yield, lifetime milk yield, and productive life. Considering the extensive benefits of early calving, alongside inherent biological and operational constraints, strategic modifications of heifer rearing programs are essential to enable early calving and to fully exploit its associated productive and economic advantages.

Author Contributions

O. V. Shinde: Investigation, formal analysis, writing—original draft. Y. B. Kandalkar: Validation, methodology, writing—reviewing. S. A. Dhage:—Formal analysis, writing—review and editing. U. S. Gaikwad: Investigation, writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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