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Influence of genetic and non-genetic factors on age at first calving and first lactation milk yield of crossbred cattle in Kerala

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Abstract
The present study was carried out to study the significant effect of genetic and non-genetic factors on age at first calving (AFC) and first lactation milk yield (FLMY) in crossbred cattle of Kerala. The first lactation records of 898 crossbred cows sired by 203 bulls distributed over a period of 18 years (2002-2019) collected from different field centres of ICAR-Field Progeny Testing Scheme Kerala Veterinary and Animal Sciences University (KVASU). The effect of various genetic factors such as sire groups and batches whereas non-genetic factors including the period, season of birth for AFC, period, season and age at first calving for first lactation milk yield (FLMY) and source of sire for both AFC and FLMY were analyzed through Least squares analyses using Harvey software. The present study revealed that overall least square means (±standard error) for AFC was 1041.66± 6.73 days and for FLMY 2780.17 ± 15.72kg. The batches of sire had significant influence ($P<0.01\%$) on AFC and FLMY. The period and season of birth was found to have no significant effect on AFC. Effect of period of calving was significant ($P<0.05\%$) on FLMY. However, season of calving and classes of AFC was found to have non-significant influence on FLMY. The genetic group of sire and sources of sire showed non-significant influence on both traits under study.

Keywords: genetic, non-genetic factors, first calving. first lactation milk yield. crossbred cattle

Introduction
According to the 20th All India Livestock Census 2019, India has the distinction of having largest cattle population in the world (192.49 million) out of which 142.11 million are indigenous and 50.42 million are crossbreds. The number of crossbred cattle has increased in 2020 as compared to 2012 from 39.73 million to 50.42 million. Even though the population of crossbred cattle is low when compared to indigenous cattle, the contribution of crossbred cattle to milk production (27.68 per cent) is significantly higher than indigenous cattle (9.63 per cent) (BAHS, 2020) [1].

India is contributing about 22 per cent to the global milk pool and there has been quantum increase of 6 to 7 times in the last four decades, (FAO, 2021) [9] but Indian dairy sector is an example of production by masses rather than mass production which grew at the rate of 5.68 per cent to 198.4 million tonnes in 2019-2020 as against 187.7 million tonnes in 2018-2019 which was more than double the growth of world milk production (Economic Survey, 2019-2020) [8]. Despite being ranked number one in milk production, the average annual productivity of cattle in India is 1,777 kg per year, whereas the world average is 2699 kg during 2019 (FAO, 2021) [9].

In Kerala, the milk production from crossbred cattle is estimated to be 93.17 per cent of the total milk production (BAHS, 2020) [1]. The systematic implementation of a breeding programme with the dynamic involvement of the farmers produced good quality animals with marked rise in the production potential of the animals that brings remarkable progress in the cattle of the state. In Kerala, the crossbreds are the major milk producers. The assessment of AFC and FLMY of crossbred cattle is important for that fact that, crossbred constitutes more than 95 per cent of cattle of the state. Furthermore the crossbreeding policy for dairy cattle of this state is in force since five decades and an assessment of production potential of the cows is the need of the hour. Thus the present study was undertaken to study the influence of various genetic and non-genetic factors on productive and reproductive performance of crossbred cattle in Kerala.

Materials and Methods

A total of 898 first lactation records of crossbred cows pertaining to the period between 2002 and 2019, were utilised for the present study. Data were collected on production performance of crossbred cattle from history sheets and reproduction records maintained at ICAR-Field Progeny Testing (FPT) scheme, KVASU. For analysis the records of only those animals with known pedigree and normal lactation were considered. The calving should be under normal physiological conditions. Incomplete or incorrect records due to disposal, culling of animals in the middle of lactation or death of animals and other pathological conditions were also excluded from the study. The records of animals with less than 100 days of lactation length and less than 500kg lactation milk yield were also discarded. The outliers beyond three-standard deviation on both the tail ends of normal distribution were excluded from the data. After normalization, the number of crossbred cattle in first lactation was reduced from 898 to 879. Further genetic analysis was done with using 879 records of crossbred progenies.

Experimental design and classification of data

The data were categorized into eleven batches of bull and four genetic groups of bulls to find out impact of genetic factors. Non-genetic factors for AFC, the data were classified into six periods of birth, each year was further classified into three seasons of birth namely rainy (June-September), post monsoon (October-January) and summer (February-May) based on local climatic conditions. Non-genetic factors for FLMY the data were classified into nine periods of calving and three seasons of calving (Prakash, 2017) [23]. Thus age at first calving of crossbred cows classified into eleven groups based on Strug's rule to assess the influence of non-genetic factors of age at first calving on first lactation milk yield. The cows at the project area are bred through artificial insemination with the frozen semen from the PDC, BAIF and GADVASU. These three sources of sires were non genetic factors for both AFC and FLMY. Age at first calving and first lactation milk yield are the two traits considered for the present study. Due to non-orthogonal and disproportionate nature of records of first lactation traits of crossbred cattle were analyzed by Least Squares Analysis (LSA) technique of fitting constants in order to examine the various genetic and non-genetic factors affecting both traits. For significant effects, the differences between pairs of levels of effects were tested by Duncan's multiple range test (DMRT).

Results and Discussion

Age at first calving: The overall mean of age at first calving (AFC) for the crossbred cows in present investigation is observed to have 1041.66± 6.73 days with coefficient of variation 18.15% which was represented in Table 1.

Table 1: Means, standard error, standard deviation and coefficient of variation of AFC and FLMY of crossbred cattle of Kerala

Traits	No of observations	Mean ± S.E	S.D	C.V (%)
AFC	879	1041.66± 6.73 days	189.10 days	18.15
FLMY	879	2780.17 ± 15.72 kg	400.01 kg	14.39

Analysis of variance (M.S values) for AFC was shown in Table 2. The AFC estimated was more or less similar to the previous studies of Goni *et al.,* (2001) [10], Nehra *et al.,* (2012) [21], Divya *et al.,* (2014) [6] and Kumar *et al.,* (2017) [16].

Table 2: Analysis of variance of AFC of crossbred cattle

Source of Variation	Degrees of freedom	M.S values
Source	2	6653.69
Season of birth	5	55423.36
Period of birth	3	56742.09
Genetic group	2	9894.36
Batch of sire	10	105234.35**
Error	857	33758.70

**(P<0.01) Significant at 1% level.

Effects of non-genetic factors on AFC

In the present study, source of sire had no significant effect on AFC. The period of birth were found to have non-significant influence on AFC (Table 2). This may be due to overlapping of batches of sire in subsequent batches. In crossbred cattle the AFC was not significantly affected by season of birth. Similar results were reported by Kumar *et al.*, (2008) [15], Bajetha and Singh (2011) [2], Nehra *et al.*, (2012) [21], Chaudhari *et al*., (2013) [5], Lodhi *et al*., (2016) [18] and Kokati *et al*., (2017) [14] in crossbred cows. Least squares mean along with standard error for non-genetic factors are shown in the Table 3.

Effects of genetic factors on AFC

The influence of batches of bull on AFC was significant at P<0.01% level. A trend of decreasing age at first calving was also observed in subsequent batches. The highest value for AFC was observed in Batch 5 i.e. 1173.40±55.51 days while lowest value of 902.53±63.17 days was observed in Batch 14 The genetic group of bull was found to have non-significant influence on AFC. The progenies of bulls from three centres had no significant difference in AFC which indicates these centres maintain test bulls of similar genetic superiority. The finding of this study was that there is no influence of exotic inheritance level of breeding bulls on age at first calving of progenies needs further studies. The bulls used in this study are mostly *interse* mated and the exotic inheritance level in these will not accurate can be a reason for non-effect of exotic level. Dubey and Singh (2005) [7], Singh (2007) [27], Shahi and Kumar (2010) [26], Bajetha and Singh (2011) [2], Hassan and Khan (2013) [12] and Kumari *et al.,* (2019) [17] found to be non-significant effect of genetic group of bulls in various crossbred cattle population. Least squares mean along with standard error for genetic factors are shown in the Table 3.

Table 3: Least squares means (± S.E) for age at first calving (AFC) in crossbred cattle

Effects	AFC (DAYS)
Overall mean	1041.66± 6.73 (879)
Source of sire	
PDC (S1)	1072.93±48.51 (354)
BAIF (S2)	1093.04±22.71 (422)
GADVASU (S3)	1078.01±29.92 (103)
Season of birth	
Rainy (June-September) (S1)	1077.08±18.16 (321)
Post Monsoon (October-January) (S2)	1080.18±19.40 (260)
Summer (February-May) (S3)	1086.73±19.76 (298)
Period of birth	
1998-2001 (P1)	1213.34±106.85 (22)
2002-2004 (P2)	1082.37±47.43 (89)
2005-2007 (P3)	1056.44±37.26 (129)
2008-2010 (P4)	991.29±31.56 (132)
2011-2013 (P5)	1071.56±34.90 (228)
2014-2017 (P6)	1072.94± 42.12 (279)
Genetic group of sire	
50% (G1)	1107.38±33.84 (98)
50% to 62.5% (G2)	1090.39±35.92 (77)
62.5% to 75% (G3)	1057.61±24.20 (367)
Frieswal (G4)	1069.92±49.37 (337)
Batch of sire**	
Batch 4 (B1)	1157.28±88.86^{e} (26)
Batch 5 (B2)	1173.40± 55.51^{d} (41)
Batch 6 (B3)	1046.39± 38.84^{bc} (93)
Batch 7 (B4)	1108.30± 44.11^{c} (53)
Batch 8 (B5)	1125.12± 35.37^{bc} (78)
Batch 9 (B6)	1146.70± 45. 31^{bc} (48)
Batch 10 (B7)	1113.28± 41.00^{bc}(91)
Batch 11 (B8)	1075.94 ± 47.02^{bc} (116)
Batch 12 (B9)	1020.64 ±49.61^{b} (161)
Batch 13 (B10)	1024.99± 54.95^{b} (141)
Batch 14 (B11)	902.53± 63.17^{a} (31)

Means bearing same letters in the superscript did not differ significantly.

First lactation milk yield

The overall mean of the first lactation milk yield was observed to have 2780.17±15.72 kg with 14.39% of coefficient of variation which was shown in Table 1. Analysis of variance (M.S values) for FLMY was shown in Table 4.

The lactation yield is lower in comparison with previous report of crossbred cows of Divya *et al*., (2014) [6], Japheth *et al*., (2015) [13], Kokati *et al*., (2017) [14] and Tripathy *et al*., (2017) [29].

Table 4: Analysis of variance of FLMY of crossbred cattle

Sources of variation	Degrees of freedom	M.S values
Source of sire	2	58904.31
Season of calving	2	176873.24
Period of calving	8	320653.12*
AFC	10	65644.39
Genetic group	3	82543.73
Batch of sire	10	480476.11**
Error	844	160011.1

* (P<0.05), ** (P<0.01).

Effects of non-genetic factors on FLMY

The effect of source of sire was found to have non-significant. Similar result was obtained by (Prakash *et al*., 2020) [24] and season of calving was also not significantly different. Similar results were estimated by Dubey and Singh (2005) [7], Bajetha and Singh (2011) [2], Banu (2010) [3], Nehra *et al*., (2012) [21], Hassan and Khan (2013) [12], Divya *et al*., (2014) [6], Lodhi *et al*., (2016) [18], Kokati *et al*., (2017) [14] and Girimal (2017) and Tripathy *et al*., (2017) [29] in crossbred cows. The period of calving had significant effect on FLMY at P<0.05% level (Table 4). FLMY during P7 was highest value i.e. 2838.11±82.61 kg whereas lowest during P1 i.e. 2478.68±271.16 kg (Table 5). The increase in milk production was attributed by effective selection strategies under this project. These results were supported by Nehra *et al*., (2012) [21], Divya *et al*., (2014) [6], Kokati *et al*., (2017) [14] and Tripathy *et al*., (2017) [29] in crossbred cows.

The age at first calving had non-significant effect on FLMY. The results were close to Rao *et al*., (2000) [25], Mandal *et al*., (2013) [19], Bhadauria and Katpatal (2003) [4], Dubey and Singh (2005) [7], Divya *et al*., (2014) [6] and Patond and Gulhane (2014) [22]. Least square means and standard errors for non-genetic effects are summarized in Table 5.

Table 5: Least squares means (± S.E) for first lactation milk yield (FLMY) in crossbred cattle

Effects	FLMY (KG)
Overall mean	2780.17 ± 15.72 (879)
Source of sire	
PDC (S1)	2624.93±106.95 (354)
BAIF (S2)	2726.42±61.57 (422)
GADVASU (S3)	2744.82±75.12 (103)
Season of calving	
Rainy (June-September) (S1)	2720.93±54.70 (296)
Post Monsoon (October-January) (S2)	2702.39±53.16 (231)
Summer (February-May) (S3)	2672.87±54.66 (352)
Period of calving*	
2002-2003 (P1)	2478.68±271.16^{f} (6)
2004-2005 (P2)	2801.11±212.75^{e} (20)
2006-2007 (P3)	2776.78±133.91^{cde} (87)
2008-2009 (P4)	2573.14±109.38^{de} (81)
2010-2011 (P5)	2554.49±83.58^{cde} (92)
2012-2013 (P6)	2694.62±73.08^{cd} (95)
2014-2015 (P7)	2838.11±82.61^{bc} (108)
2016-2017 (P8)	2777.43±96.43^{b} (229)
2018-2019 (P9)	2794.19±122.14^{a} (161)
Age at first calving	
614-716 (A1)	2628.95±101.67 (19)
716-818 (A2)	2744.53±57.27 (80)
818-920 (A3)	2721.97±47.81 (159)
920-1022 (A4)	2695.23±49.29 (186)
1022-1124 (A5)	2692.03±52.19 (171)
1124-1226 (A6)	2656.32±58.18 (111)
1226-1328 (A7)	2676.14±70.00 (77)
1328-1430 (A8)	2744.81±83.95 (39)
1430-1532 (A9)	2682.65±107.39 (19)
1532-1634 (A10)	2681.12±134.92 (11)
1634-1736 (A11)	2762.27±167.00 (7)
Genetic group of sire	
50% (G1)	2713.91±80.15 (98)
50% to 62.5% (G2)	2656.35±82.05 (77)
62.5% to 75% (G3)	2666.44±60.84 (367)
Frieswal (G4)	2758.20±113.02 (337)
Batches of sire**	
Batch 4 (B1)	2285.17±183.67^{f} (26)
Batch 5 (B2)	2501.33±128.56^{de} (41)
Batch 6 (B3)	2541.83±98.86^{de} (93)
Batch 7 (B4)	2589.95±92.51^{e} (53)
Batch 8 (B5)	2762.78±91.16^{cd} (78)
Batch 9 (B6)	2705.30±103.98^{cd} (48)
Batch 10 (B7)	2583.68±105.32^{cd} (91)
Batch 11 (B8)	2664.21±126.30^{c} (116)
Batch 12 (B9)	2871.70±142.00^{b} (161)
Batch 13 (B10)	3072.64±159.77^{a} (141)
Batch 14 (B11)	3107.42±183.42^{a} (31)

Means bearing same letters in the superscript did not differ significantly.

Effects of genetic factors on FLMY

The effect of batches of bull was significant on FLMY at *P*<0.01% level. Maximum FLMY was reported in Batch14 i.e. 3107.42±183.42 kg while minimum at Batch 4 i.e.2285.17±183.67 kg. These results indicate that the continuous genetic improvement in breeding bulls of subsequent batches. This increase in milk production over subsequent batches may not only be caused by climatic changes but also encompass favourable management changes.
Other genetic factor like genetic group of bulls was found to have non-significant effect on FLMY. These results were similar to Singh *et al.*, (2010) [28], Moges *et al.*, (2009) [20], Shahi and Kumar (2010) [26] and Verma (2016) [30]. Least square means along with standard errors for random effects are summarized in Table 5.

Conclusion

The estimated overall least squares means of AFC and FLMY traits in this study indicate production potential of crossbred cows and refine or review the ongoing breeding programme for the genetic improvement of crossbred cattle germplasm. The information thus obtained might help us to understand the performance of these cows under field conditions. In the present study, effect of genetic and non-genetic factors on AFC and FLMY were studied. Study of variation in production and reproduction of crossbred cattle will give an idea about effectiveness of application of selection procedure for future genetic improvement of the stock. Batches of bull had significant influence on both age at first calving and first lactation milk yield in the present study, which suggest that superior sires can be used effectively to improve economic traits in crossbred cattle.

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