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Genetic Studies on Productive and Reproductive Traits of Crossbred Jersey (Jersey × Nondescript) Cattle

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ABSTRACT

The southern Indian states depend mainly on crossbred cattle for milk production. For maintaining a high level of milk productivity of crossbred cattle and their further genetic improvement, it is necessary to know the genetic parameters and influence of various non-genetic and genetic factors on economic traits. Hence, in the present study, we estimated the heritability and influence of non-genetic factors on production and reproduction traits in crossbred Jersey cattle (Jersey × nondescript). The overall least-squares means (±standard error) of age at first calving (days), calving interval (days), services per conception, service period (days), dry period (days), lactation milk yield (liters), and lactation length (days) were 1057.83±21.25, 449.52±8.55, 2.55±0.11, 176.31±7.67, 130.27±6.73, 2265.24±63.44, and 318.61±5.62 respectively. Period of calving had a significant ($p<0.05$) effect on all economic traits studied except the dry period. Calving interval and service period were affected by the season of calving. The heritability estimates of age at first calving, calving interval, services per conception, service period, dry period, lactation milk yield, and lactation length were 0.289±0.06, 0.306±0.09, 0.123±0.18, 0.329±0.33, 0.381±0.48, 0.508±0.88, and 0.455±0.45 respectively. This information will be useful to disclose action plans to make scientific interventions on the production and reproduction of crossbred Jersey cattle to exploit its maximum genetic potential.

HIGHLIGHTS

- The overall least-squares means and heritability for various economic traits were estimated.
- Period of calving had a significant effect on all traits except dry period.

Keywords: Crossbred Jersey, heritability, period, season, parity, traits

Dairying has become an important secondary source of income-generating and employing millions of marginal and women farmers in India (Vijayakumar *et al*., 2019; Singaravadivelan *et al*., 2021). Crossbreeding of high-yielding exotic milch cattle breeds with indigenous non-descript cattle has emerged as an effective and suitable strategy to increase milk production in non-descript cattle (Singh *et al*., 2016). In the absence of milch cattle breeds in south India, the southern Indian states depend mainly on crossbred cattle for milk production. As per the 20th Livestock Census, Tamil Nadu has 95.19 lakh cattle and 5.19 lakh buffaloes. Out of this, 81.15% are crossbred and exotic cattle, and 18.85% are indigenous cattle (Anon, 2020). Further, this state has a robust breeding policy that encourages the farmers for rearing the cross-bred Jersey cattle in the plains region of Tamil Nadu.

For maintaining a high level of milk production/ productivity of crossbred cattle and their further

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improvement, it is necessary to know the genetic parameters, the influence of various non-genetic and genetic factors on various production and reproduction traits (Ali *et al*., 2019). Frequent updating of the available knowledge of genetic parameters, factors influencing various economic traits in crossbred cattle is an important and recommended practice in crossbred cattle breeding programs (Caetano *et al*., 2013). However, a very limited number of reports are available for crossbred Jersey cattle (Jersey x nondescript). Hence, the present investigation was undertaken to study the estimation of heritability and influence of various non-genetic factors on production and reproduction traits in crossbred Jersey cattle. This study will be valuable to suggest suitable selection programs and breeding strategies along with management practices for genetic improvement of crossbred Jersey cattle under the Cauvery delta region of Tamil Nadu state.

MATERIALS AND METHODS

Herd Structure

The present study was carried out at the Dairy unit of Livestock Farm Complex, Veterinary College and Research Institute, Orathanadu, Tamil Nadu, India. The Dairy Unit was established under National Agriculture Development Programme (NADP) sponsored scheme on 'Establishing Nucleus Jersey Crossbred Bull-Mother Farm'. Crossbred Jersey cows (Jersey x nondescript) were purchased based on phenotypic characters and production records (personal recording of milk yield during peak lactation) from milk shed areas in Vellore, Thiruvannamalai, Namakkal, Madurai, Erode, and Theni districts of Tamil Nadu. The exact genetic composition (inheritance level of Jersey/non-descript) of these crossbred cows is unknown. This population constitutes of various inheritances level of Jersey and non-descript cross.

Farm Management Practices

All crossbred Jersey animals were kept in the same environment with similar management practices. All animals were kept under an intensive system of management. The newborn calves were weaned on day-old and pail milk feeding was practiced. The adult animals were fed with 20-30 kg green fodder and 5-7 kg of dry fodder daily. The concentrate feed of 2 kg was provided for maintenance and additional feed was given at the rate of 400 g for every kg of milk production. Milking was carried out twice a day at 12 hrs intervals. Periodical disease screening for Tuberculosis, Johne's disease, and Brucellosis were carried out. Animals were vaccinated against Foot-and-mouth disease and Hemorrhagic septicemia. Animals were observed for estrus signs and artificial insemination was carried out after 12 hrs of the onset of estrus signs.

Data Analysis

The data collected from the farm records for a period of 8 years from 2013 to 2021 was taken for this study. A total of 350 records obtained from 115 crossbred Jersey cattle were analyzed to assess the production and reproduction performance of crossbred Jersey cattle. Incomplete records due to death or disposal were eliminated from the analysis. To ensure the normal distribution, the outliers beyond two-standard deviation on both the tail of the distribution were expelled from the original data. The economic traits studied were lactation length (days), lactation milk yield (liters), age at first calving (days), calving interval (days), services per conception, dry period (days), and service period (days). The factors studied were a period of birth, a season of birth, period of calving, the season of calving, and parity. The Year of calving was divided into three periods (2013-2015, 2016-2018, and 2019-2021). Four calving seasons were defined: cold weather period (Jan-Feb), summer (Mar-May), southwest monsoon season (Jun-Sep), and northeast monsoon season (Oct-Dec). Parity was divided into six groups (first, second, third, fourth, fifth, and sixth and above parity).

The general linear model analysis implemented in the IBM SPSS Statistics package was used to estimate and study the effect of non-genetic factors on various production and reproduction traits in crossbred Jersey cattle. The following models were used:

For age at first calving

$$Y_{ijk} = \mu + S_i + P_j + e_{ijk}$$

Where, Y_{ijk}= Age at first calving of the k^{th} heifer, born in the i^{th} period, and j^{th} season, μ = Overall population mean,

S_i = Effect of the i^{th} season (i = 1-4), P_j = Effect of the j^{th} period (j = 1-3) and e_{ijk} = Random error, NID (0, $\sigma^2 e$).

For other economic traits

$$Y_{ijkl} = \mu + S_i + P_j + A_k + e_{ijkl}$$

Where Y_{ijkl} = response variable on the l^{th} individual in i^{th} season, j^{th} period and k^{th} parity.

μ = Overall population mean

S_i = Effect of the i^{th} season (i= 1-4)

P_j = Effect of j^{th} period (j = 1-3)

A_k=Effect of parity (k = 1-6)

e_{ijkl} = Random error, NID (0, $\sigma^2 e$)

The least-square (LS) means were compared through Tukey's Honest Significant Difference test for testing differences among LS means. Heritability and (co) variance components were estimated by restricted maximum likelihood (REML) fitting an animal model (Meyer, 2007). The fixed non-genetic factors that were found to be significant ($P < 0.05$) from the least-squares analyses were fitted for each trait to estimate heritability.

RESULTS AND DISCUSSION

The age at first calving (AFC) and calving interval (CI) is the main economic traits in lactating animals and lesser AFC and CI increase the economic profit in the dairy animal in terms of the number of calf crops per cow. The mean age at first calving estimated in the present study was 1057.83 ±21.25 days (Table 1) and the period of born had a significant effect on AFC which was support in Singh and Raut (1980). While Hadge *et al*. (2009) and Vinothraj *et al*. (2016) reported a non-significant effect of the period of born on this trait. The non-significant effect of season of born on this trait is in close agreement with Govindaiah *et al*. (1998) and Deokar and Ulmek (1999). This estimated LS mean of AFC was lower in comparison with Sahiwal × Jersey (Hadge *et al.,* 2009), Jersey x Sahiwal (Varaprasad *et al*., 2013) and Jersey x Red Sindhi (Vinothraj *et al*., 2016) crossbred cows. The mean calving interval estimated from the data is 449.52±8.55 days. The overall calculated LS mean in the present study was lower in comparison with Mondal *et al*. (2005); Hadge *et al*. (2009); Dandapat *et al*. (2010); and Vinothraj *et al*. (2016). In contrast, Hussain *et al*. (2012) reported 393.68±1.64 days as calving interval for Jersey × Local cross cows. The least-square analysis shows that period of calving and the seasons of calving have a significant effect on calving interval. In confirmatory with the present findings Gogoi (1991), Das (1995) and Hussain *et al*. (2012) reported a significant effect of season of calving, and Hadge *et al*. (2009) reported a significant effect of the period of calving on this trait. In contrast, Vinothraj *et al*. (2016) reported a non-significant effect of the period of calving and seasons of calving on this trait.

The number of services required per conception is important in the breeding management of dairy cattle and it depends on management, breeding, and environmental effects. The period of calving had a significant effect and the season of calving and parity has a non-significant effect on this trait. Sultana (1995) observed non-genetic factors had no significant effect on service per conception in exotic cattle breeds and their crosses. In the present study, the number of service per conception is 2.55±0.11 (Table 1) and it's higher than the earlier reports for crossbred Jersey cows which ranged from 1.52 to 2.5 (Mondal *et al*., 2005; Haque *et al*., 2011; Goni *et al*., 2015; Vinothraj *et al*., 2016).

The service period play important role in the number of calves produced in the productive lifespan of dairy cattle. The LS mean of the service period of crossbred Jersey cattle was 176.31±7.67 days (Table 2) which is in close agreement with the results of Subramanian & Ulaganathan (1990) and Vinothraj *et al*. (2016) for Jersey-Red Sindhi crossbred cows. However, this LS mean is longer in comparison with Jersey × Local cows (Hussain *et al*., 2012) and shorter than Sahiwal x Jersey crossbred cows (Hadge *et al*., 2009). The season of calving and period of calving has a significant effect on the service period which was in support with Hussain *et al*. (2012). However, contrary to present observation Singh and Raut (1980), Hadge *et al*. (2009) and Vinothraj *et al*. (2016) did not observe a significant effect on this trait. The overall mean dry period of crossbred Jersey was 130.27±6.73 days (Table 2), which is in close agreement with findings of Vinothraj *et al*. (2016) for Jersey x Red Sindhi crossbred cows. However longer dry period was reported for Sahiwal x Jersey crossbred cows (Hadge *et al*., 2012) and a shorter dry period was reported for different genetic groups of

Table 1: Least squares means along with their standard errors for non-genetic factors affecting the age at first calving (days), calving interval (days) and services per conception traits in crossbred Jersey cattle

Effect	Age at first calving (days)		Services per conception		Calving interval (days)	
	n	Mean±SE	n	Mean±SE	n	Mean±SE
Overall mean (μ)	53	1057.83 ±21.25	306	2.55±0.11	198	449.52±8.55
Period of calving	—	*	—	*	—	*
P1 (2013-15)	15	955.05±39.49[b]	102	3.25±0.19[a]	61	484.34±15.60[b]
P2 (2016-18)	17	1149.54±35.95[a]	118	2.39±0.16[b]	95	446.56±10.95[a]
P3 (2019-21)	21	1068.91±31.61[a]	86	2.01±0.21[b]	42	417.65±16.10[a]
Season of calving	—	NS	—	NS	—	*
Cold weather period (Jan-Feb)	7	1122.44±55.10	65	2.43±0.21	21	468.79±22.63[a]
Summer (Mar-May)	15	1007.42±37.46	48	2.48±0.25	53	445.75±14.16[ab]
South West monsoon season (Jun-Sep)	17	1023.06±34.96	108	2.69±0.17	63	471.69±13.03[b]
North East monsoon season (Oct-Dec)	14	1078.42±39.17	85	2.59±0.19	61	411.84±13.19[c]
Parity	—	—	—	NS	—	NS
First	—	—	102	2.37±0.17	34	484.50±17.32
Second	—	—	51	2.27±0.25	42	442.15±16.57
Third	—	—	53	2.61±0.24	37	442.38±17.10
Fourth	—	—	42	2.37±0.27	37	446.79±17.88
Fifth	—	—	29	2.65±0.32	26	426.61±21.48
Sixth and above	—	—	29	3.01±0.32	22	454.67±22.79

(*p<0.05. Means having same superscript does not differ significantly (p>0.05). n=Number of observations, NS=Not significant, SE=Standard error).

Table 2: Least squares means along with their standard errors for non-genetic factors affecting the service period (days), dry period (days), lactation milk yield (liters), and lactation length (days) traits in crossbred Jersey cattle

Effect	Dry period (days)		Service period (days)		Lactation milk yield (liters)		Lactation length (days)	
	n	Mean±SE	n	Mean±SE	n	Mean±SE	n	Mean±SE
Overall mean (μ)	195	130.27±6.73	229	176.31±7.67	241	2265.24±63.44	216	318.61±5.62
Period of calving	—	NS	—	*	—	*	—	*
P1 (2013-15)	74	129.65±11.57	71	207.56±14.56[a]	90	2660.59±112.11[a]	67	354.43±10.65[a]
P2 (2016-18)	85	124.34±8.85	97	164.32±10.95[b]	95	2441.93±92.71[a]	94	323.07±7.98[b]
P3 (2019-21)	36	136.83±13.23	61	157.04±14.26[b]	56	1693.19±124.05[b]	55	278.33±10.74[c]
Season of calving	—	NS	—	*	—	NS	—	NS
Cold weather period (Jan-Feb)	21	154.48±17.52	28	195.41±19.99[a]	28	2237.11±167.97	27	318.35±14.63
Summer (Mar-May)	49	132.11±11.51	63	183.30±13.21[ab]	71	2394.30±105.31	59	323.43±9.82
South West monsoon season (Jun-Sep)	63	129.15±10.21	72	190.01±12.38[ab]	76	2297.65±102.00	66	326.45±9.31
North East monsoon season (Oct-Dec)	62	105.35±10.13	66	136.50±12.97[ac]	66	2131.88±108.24	64	306.22±9.37
Parity	—	NS	—	NS	—	NS	—	NS
First	36	160.65±13.00	43	196.59±16.04	48	2090.11±127.53	41	323.32±11.80
Second	44	121.78±12.86	44	198.76±16.48	47	2241.39±137.13	39	323.03±12.51
Third	40	129.56±12.91	44	159.77±16.07	49	2273.89±129.97	41	318.30±11.91
Fourth	33	124.53±14.59	40	160.73±17.40	40	2399.27±147.16	39	316.86±12.76
Fifth	24	111.75±17.10	28	155.49±21.12	31	2369.99±168.68	31	319.74±14.49
Sixth and above	18	133.37±19.17	30	186.51±19.90	26	2216.77±176.97	25	310.41±15.45

*p<0.05. Means having same superscript does not differ significantly (p>0.05). n=Number of observations, NS=Not significant, SE=Standard error.

Table 3: Heritability estimates along with their standard error for various production and reproduction traits in crossbred Jersey cattle

Traits	Error variance	Phenotypic variance	Additive genetic variance	Heritability
Age at first calving	15039	21140.3	6101.23	0.289±0.06
Services per conception	1.85205	2.11237	0.260321	0.123±0.18
Calving interval	7161.62	10316.4	3154.79	0.306±0.09
Dry period	5274.48	8518.42	3243.94	0.381±0.48
Service period	8641.07	12875.3	4234.18	0.329±0.33
Lactation milk yield	243623	494912	251289	0.508±0.88
Lactation length	2395.8	4392.44	1996.64	0.455±0.45

cows (Haque *et al*., 2011). All the non-genetic factors such as period of calving, the season of calving, and parity have a non-significant effect on this trait which was supported in Vinothraj *et al*. (2016).

The overall mean of lactation milk yield of crossbred Jersey cows is 2265.24±63.44 liters (Table 2). Further, this lactation yield was higher in comparison with Jersey crosses such as Jersey × Local, Jersey × Friesian, crossbred Jersey, and Sahiwal × Jersey crossbred cows (Haque *et al*., 2011; Hadge *et al*., 2012; NDDB, 2014). The period of calving had a significant effect on lactation milk yield. The season of calving and parity does not significantly affect the milk yield. The present estimate for lactation length in Sahiwal cows is similar to those reported by Deshmukh *et al*. (1995) for Jersey × Friesian crosses, while Mondal *et al*. (2005) and Hadge *et al*. (2012) reported lower estimates of lactation length. Dandapat *et al*. (2010) reported higher estimates of lactation length for crossbred cattle (HF × Jersey × Sahiwal) than the present findings. The period of calving had a significant effect and the season of calving and parity does not significantly affect the lactation length.

Heritability

The heritability estimate of age at first calving was 0.289±0.06 in the present study (Table 3), which was most closely in agreement with the heritability estimate of crossbred cows (Dubey and Singh, 2005; Vinothraj *et al*., 2016). Heritability estimates of calving interval estimated in this study was 0.306±0.09 (Table 3). Gaikwad-inamdar and Narayankhedkar (2002) reported similar heritability estimates (0.39 ± 0.28) for crossbreed (Gir × Holstein Friesian and Gir × Jersey) cows. Vinothraj *et al*. (2016) and Ali *et al*. (2019) reported lower heritability estimates for calving intervals in different grades of dairy cattle and Sahiwal cows respectively. The heritability estimates for services per conception (0.123±0.18) of crossbred Jersey herd (Table 3) are higher than the earlier report (Vinothraj *et al*., 2016). The service period is an important trait of dairy animals and directly impacts the calving interval period. The estimated heritability of the service period is 0.329±0.33 (Table 3), which was in close agreement with the results of Dubey and Singh (2005) for Sahiwal and crossbred cows. However, lower estimates of heritability were reported for Jersey × Red Sindhi crossbreds (Vinothraj *et al*., 2016). The present study lactation milk yield heritability estimate was 0.508±0.88 for crossbred Jersey herd. However, Rehman *et al*. (2008) reported a lower heritability estimate of 0.11 ± 0.03 of lactation yield for Sahiwal cows. Previous works of the literature showed that heritability estimates of the lactation milk yield ranged widely from 0.06 to 0.69 (Dubey and Singh, 2005; Cilek and Sahin, 2009; Hadge *et al*., 2012; Singh and Singh, 2016; Ali *et al*., 2019). The heritability estimate of lactation length for crossbred Jersey herd was 0.455±0.45 (Table 3). However, Hadge *et al*. (2012) reported higher heritability estimates of 0.919+0.503 for Sahiwal × Jersey crossbred cows and Ali *et al*. (2019) reported lower heritability estimates of 0.04 ± 0.212 for different breeds.

CONCLUSION

In conclusion, our results indicate the effect of non-genetic factors such as period, season, and parity on production and reproduction traits in crossbred Jersey cattle. The heritability and LS mean obtained for various economic traits provide inputs to refine selection programs and breeding strategies along with management practices for genetic improvement of crossbred Jersey cattle of Tamil Nadu state.

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