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Genetic analysis of milk production efficiency traits in Jersey crossbred cattle

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ABSTRACT

Present study was carried out with the aim to determine the effect of genetic and non-genetic factors on milk production efficiency traits and their genetic control. Data on milk production efficiency traits i.e. total milk yield per day of lactation length and total milk yield per day of calving interval in Jersey crossbred animals maintained at organized herd of ICAR-National Dairy Research Institute, Eastern Regional Station, Kalyani, Nadia, West Bengal spread over 29 years (1986-2014) were analyzed in the study. The overall least-squares means of total milk yield per day of lactation length and total milk yield per day of calving interval were estimated as 6.97±0.21 and 6.02±0.23 kg/day, respectively. The data was grouped into different sub-classes of season of calving, period of calving, parity and genetic group of animals. The random effect of sire had shown significant ($p<0.01$) influence on milk production efficiency traits. Various environment factors significantly affected the milk production efficiency traits indicating the scope of improvement in management of these crossbred animals. The heritability estimates of 0.54 for TMY/LL and 0.63 for TMY/CI were high in magnitude which suggests that fast genetic progress can be made, if these animals are selected based on the milk production efficiency traits.

Key words: Crossbred cattle, Genetic factors, Heritability, Milk production efficiency traits, Non-genetic factors.

INTRODUCTION

For selection of dairy animals generally lactation milk yield is used as a criterion. However, we can select better dairy animals based on their milk production efficiency compared to milk yield. Higher production efficiency in livestock production is an economically desirable attribute that targets for genetic up gradation. In fact, the economy of dairy industry mainly rely upon the performance traits among dairy animals, therefore, it becomes more relevant to tackle out the means for ameliorating the performance efficiencies by developing certain guidelines for improved selection in dairy animals. The milk yield expressed as total milk yield per day of lactation length (TMY/LL) and total milk yield per day of calving interval (TMY/CI) are reliable measures of both the reproduction and production performance of an individual animal. Such traits are reported to have moderate to high heritability and significant positive correlation with lifetime performance traits in native cattle of India (Gandhi and Gurnani, 1992; Singh *et al*., 2005) however limited references are available in Jersey crossbreds of India. Therefore, present investigation was undertaken to study the effect of different genetic and non-genetic factors on milk production efficiency traits and their genetic control.

MATERIALS AND METHODS

The present study was conducted on data pertaining to Jersey crossbred cattle maintained at organized herd of Eastern Regional Station of ICAR- National Dairy Research Institute, Kalyani, Nadia, West Bengal over 29 years (1986-2014). The normal lactation was considered as the period of milk production by cattle for at least 100 days and has given minimum 500 kg of milk. Cattle calved and dried under normal physiological conditions were included in the present study. Generally there would be difference in the production of cattle from period to period due to differential fodder and feed availability, management practices and under different environment conditions. Entire span of 29 years for which data collected was divided into 6 periods; each period of 5 years. Based on prevalent climatic conditions of the area, year of calving was divided into 3 seasons- winter (November to February), summer (March to June) and rainy (July to October). The parities of animals were classified as 7 groups. Sires having 3 or more progenies were considered in the study. The data was distributed into 9 genetic groups as ½ J × ½ RS, ½ J × ½ T, ½ J × ¼ (HF/BS) × ¼ (Sahiwal/RS), ½ J × ¼ T × ¼ (RS/Desi), 50% J, ½ J Miscellaneous group, <50% J, >50% to 62.5% J and >62.5% J inheritance of animals.

The measures of milk production efficiency considered were total milk yield per day of lactation length (TMY/LL) derived by dividing lactation yield (in kg) by lactation length (in days) and total milk yield per day of calving interval (TMY/CI) derived by dividing lactation yield (in kg) by calving interval (in days). The data were analyzed using a mixed model least-squares analysis for fitting constants (Harvey, 1990) due to non-orthogonal and disproportionate sub-class frequencies. The following model

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was used with assumptions that different components being fitted into the model were independent and additive.

$$Y_{ijklmn} = \mu + S_i + (Sea)_j + P_k + (Pa)_l + (GG)_m + e_{ijklmn}$$

where, Y_{ijklmn} is n^{th} total milk yield per day of lactation length (TMY/LL) or total milk yield per day of calving interval (TMY/CI) of cattle which is progeny of i^{th} sire, calved in j^{th} season, k^{th} period, l^{th} parity and m^{th} genetic group of the animal; μ is overall mean, S_i is random effect of i^{th} sire, Sea_j is fixed effect of j^{th} season of calving, P_k is fixed effect of k^{th} period of calving, Pa_l is effect of l^{th} parity, GG_m is effect of m^{th} genetic group and e_{ijklmn} is random error associated with each observation assumed to be NID (0, σ_e^2).

The differences of means between subclasses of periods, seasons, parity and genetic groups were tested for significance using Duncan's multiple range test as modified by Kramer (1957). The analysis of variance for season, period of calving, parity and genetic group of animal affecting milk production efficiency traits were computed and presented in Table 1.

Table-1: Analysis of variance (M.S. Values) of milk production efficiency traits in Jersey crossbred cattle.

Sources of variation	TMY/LL (kg/day)	TMY/CI (kg/day)
Sire	13.56^{**} (41)	10.13^{**} (33)
Season of calving	38.14^{**} (2)	5.67^{NS} (2)
Period of calving	12.99^{**} (5)	10.08^{**} (5)
Parity of animal	19.58^{**} (6)	8.35^{**} (6)
Genetic group of animal	16.22^{**} (8)	7.59^{**} (8)
Error	3.18 (970)	2.50 (618)

Figures in parentheses indicate respective degrees of freedom. *p<0.05, **p<0.01, NS: Non-significant.

RESULTS AND DISCUSSION

The overall least squares means were estimated as 6.87±0.20 and 5.91±0.24 kg/days for total milk yield per day of lactation length (TMY/LL) and total milk yield per day of calving interval (TMY/CI), respectively in the present study (Table 2). Das *et al.* (2002) reported overall mean of MY/CI as 5.104±0.129 kg/day in Jersey × Red Sindhi which is comparable to the present findings. Several other workers observed similar results in different breeds of cattle (Saha *et al.*, 2010; Lakshmi *et al.*, 2009; Verma and Thakur, 2013). However, Tekerli and Gundogan (2005) in Holstein cattle, Singh *et al.* (2013) in Frieswal cattle and Japheth *et al.* (2015) in Karan Fries cattle reported higher least squares means of TMY/LL and TMY/CI as compared to our results.

Sire had significant (p<0.01) influence on both the traits viz. TMY/LL and TMY/CI in present study. Similar results were observed by Singh and Gurnani (2004) and Verma and Thakur (2013) in crossbred cattle. This suggests that superior sires can be used effectively to improve milk production efficiency traits in crossbred cattle.

Table-2: Least-squares means along with standard errors of milk production efficiency traits in crossbred cattle

Effect	TMY/LL	TMY/CI
Overall mean (μ)	6.87±0.20 (1033)	5.91±.236 (673)
SEASON OF CALVING		
S1 (Winter)	7.21 ± 0.22^{a} (333)	6.10 ± 0.25^{a} (228)
S2 (Summer)	6.91 ± 0.22^{a} (355)	5.79 ± 0.25^{a} (225)
S3 (Rainy)	6.51 ± 0.21^{b} (345)	5.84 ± 0.25^{a} (220)
PERIOD OF CALVING		
Pd 1 (1986-1990)	5.52 ± 0.48^{c} (89)	5.03 ± 0.56^{b} (56)
Pd 2 (1991-1995)	6.19 ± 0.35^{bc} (135)	5.48 ± 0.40^{b} (81)
Pd 3 (1996-2000)	7.00 ± 0.27^{ab} (214)	6.23 ± 0.32^{ab} (143)
Pd 4 (2001-2005)	7.68 ± 0.27^{a} (193)	6.81 ± 0.31^{a} (136)
Pd 5 (2006-2010)	7.34 ± 0.33^{a} (241)	6.05 ± 0.38^{ab} (181)
Pd 6 (2011-2014)	7.50 ± 0.42^{a} (161)	5.88 ± 0.48^{ab} (76)
PARITY		
P 1	6.43 ± 0.24^{b} (316)	5.46 ± 0.27^{b} (229)
P 2	6.99 ± 0.23^{ab} (241)	5.97 ± 0.27^{ab} (165)
P 3	7.08 ± 0.24^{ab} (170)	6.25 ± 0.28^{a} (106)
P 4	7.36 ± 0.25^{a} (115)	6.19 ± 0.29^{ab} (75)
P 5	7.27 ± 0.28^{a} (81)	5.97 ± 0.32^{ab} (51)
P 6	6.65 ± 0.31^{ab} (56)	5.74 ± 0.40^{ab} (26)
P 7 (> 6 all lactations)	6.33 ± 0.35^{b} (54)	5.82 ± 0.47^{ab} (21)
GENETIC GROUP OF ANIMAL		
GG1 (½ J ×½ RS)	7.39 ± 0.28^{a} (92)	6.41 ± 0.31^{a} (74)
GG2 (½ J × ½ T)	7.67 ± 0.34^{a} (162)	6.61 ± 0.39^{a} (111)
GG3 [½ J × ¼ (HF/BS) × ¼ (Sahiwal/RS)]	6.26 ± 0.34^{bc} (71)	5.69 ± 0.39^{ab} (52)
GG 4 [½ J × 1/4 T × ¼ (RS/Desi)]	7.38 ± 0.27^{a} (154)	6.32 ± 0.32^{a} (94)
GG 5 (50% J)	6.56 ± 0.26^{bc} (156)	5.71 ± 0.30^{ab} (99)
GG 6 (½ J Miscellaneous group)	6.88 ± 0.31^{ab} (76)	5.87 ± 0.35^{ab} (51)
GG 7 (<50% J)	6.86 ± 0.31^{ab} (99)	5.69 ± 0.37^{ab} (60)
GG 8 (>50% to 62.5% J)	7.05 ± 0.25^{ab} (157)	5.95 ± 0.30^{ab} (95)
GG 9 (>62.5% J)	5.80 ± 0.34^{c} (66)	4.97 ± 0.41^{b} (37)

Figures in parentheses indicate number of observations.
Dissimilar superscript indicates significant (p<0.01 and p<0.05) difference of means.

Season of calving significantly (p<0.01) influenced TMY/LL but had no influence on TMY/CI in this study. The least-squares mean was high during winter season as compared to summer and rainy season. It may be due to variations in the availability of good fodder over whole year. Singh *et al.* (2005) also found significant effect of season on FLMY/FLL in crossbred cattle. Japheth *et al.* (2015) reported significant effect of season of calving on both TMY/LL and TMY/CI in Karan Fries cattle. However, Verma and Thakur (2013) observed non-significant effect of season of calving on milk efficiency traits in Red Sindhi × Jersey cattle.

In the present study, period of calving had highly significant (p<0.01) effect on both TMY/LL and TMY/CI. Singh and Gurnani (2004), Singh *et al.* (2005), Lakshmi *et al.* (2010) and Japheth *et al.* (2015) also reported significant effect of period of calving on milk production efficiency traits in crossbred cattle. On contrary, Verma and Thakur

(2013) reported non-significant effect of period of calving in Red Sindhi × Jersey cattle. The significant differences in different periods may be attributed to differences in management, selection of sires and different environmental conditions such as temperature, rainfall, humidity etc.

Parity of animal significantly ($p<0.01$) influenced TMY/LL and TMY/CI. Similarly, Lakshmi *et al*. (2010), Verma and Thakur (2013) and Japheth *et al*. (2015) reported significant effect of parity on both traits. On perusal of Table 2, it is evident that animals in third and fourth parities produced comparatively more total milk per day of lactation length and total milk per day of calving interval as compared to animals of earlier and later parities. This suggests that milk yield increases as parity proceeds because due to large body size and increased development of udder tissue large cows produce more milk than cows of earlier parities/heifer (Nyamushamba *et al.*, 2014). The milk yield was also lower in early parities because the energy derived from feed that was provided to the heifers was also channeled to their growth. Further, with increase in parity/older age, the milk yield of cows declined due to decline in body condition and degeneration of the body system over the recurring pregnancies.

Milk production efficiency traits were significantly ($p<0.01$) affected by the genetic groups of animals in the present study. Das *et al.* (2002), Singh *et al.* (2006) and Lakshmi *et al*. (2010) reported similar findings in crossbred cattle. On contrary, Verma and Thakur (2013) reported non-significant effect of genetic group in Red Sindhi × Jersey cattle.

The heritability estimates for TMY/LL and TMY/CI were 0.54 and 0.63, respectively. These estimates were in accordance with the estimates obtained by Singh and Gurnani (2004) and Singh *et al*. (2005). However, Haile *et al*. (2009) in Ethiopian Boran cattle and Saha *et al*. (2010) in Karan Fries cattle reported lower heritability estimates as compared to the present findings. High heritability estimates for milk production efficiency traits in this study indicates that faster genetic progress is possible through selection for these traits.

CONCLUSION

The overall least-squares means of total milk yield per day of lactation length (TMY/LL) and total milk yield per day of calving interval (TMY/CI) were 6.97±0.21 and 6.02±0.23 kg/day, respectively. Milk production efficiency traits *viz*. TMY/LL and TMY/CI of Jersey crossbred cattle were significantly influenced by majority of genetic and non-genetic factors. Sire had shown significant influence on milk production efficiency traits which suggests that superior sires can be used effectively to improve milk production efficiency traits in crossbred cattle. Differences in milk production efficiency traits over different periods and seasons may be attributed to differences in management, selection of sires and different environmental conditions such as temperature, rainfall, humidity etc. The heritability estimates for TMY/LL and TMY/CI were high i.e. 0.54 and 0.63, respectively which suggests that fast genetic progress can be made, if these animals are selected based on the milk production efficiency traits.

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