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Genetic and Phenotypic Parameters of First Lactation Performance traits in Crossbred Cattle – A Review

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ABSTRACT

The success of dairy industry largely depends on the level of production and reproduction performance of the animals and in dairy cattle, milk yield is considered as the most important trait. Crossbreeding programmes has significantly enhanced milk production in India. Despite having less population than indigenous cattle, crossbred cattle have more contribution in milk production of India. Information on first lactation traits enables the breeder to predict the later lactation performance of the animals due to their high correlation with the future performance traits. Performance of these traits in crossbred cattle is generally affected by various genetic and non genetic factors. Proper evaluation or unbiased prediction of genetic worth depends upon the adjustment of effect of these factors on the performance traits. The literature pertinent to genetic and phenotypic parameters of first lactation performance traits i.e. first lactation milk yield (FLMY), first lactation length (FLL), first lactation peak yield (FPY), first dry period (FDP), age at first calving (AFC), first service period (FSP) and first calving interval (FCI) were reviewed in crossbred cattle. In order to improve performance of dairy animals, it is necessary to develop an understanding of the factors affecting first lactation performance traits.

Key words: *Crossbred cattle, Heritability, Non-genetic factors*

INTRODUCTION

India is predominantly an agricultural country with nearly two third of its population being involved in agriculture and rearing of livestock. Livestock is part and parcel of our agricultural system. In India, cattle constitute a major part of livestock. Cattle population of India is 183.7 million. Out of which, crossbred cattle population is 36.8 million and indigenous cattle population is 146.9 million[3]. Total number of female crossbred cattle of India is 31.2 million. Total milk production of India was 132.4 million tons in 2012-2013. Exotic/crossbred cows contributed 24% of milk production of India in 2012-2013, whereas share of indigenous/non-descript was 21%[3]. So it is evident from the data that in India the population of crossbred cattle is less in comparison to indigenous cattle, still their contribution in milk production is higher.

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In dairy cattle, milk production is the most important economic trait. It is conceded that average yield of an indigenous cow has turned out to be the Achilles' heel in context of current Indian production scenario due to their low milk productivity. Low milk production in India is probably due to the low genetic potential of animals for milk production, poor nutrition, farm management, unfavourable agro climatic conditions, poor veterinary and extension services[7]. To meet the ever rising demand of milk, improving milk productivity of indigenous cows has remained the prime focus of all breeding programmes since independence. Cross breeding with exotic breeds is the best alternative to improve the genotype and milk producing capability of the low yielding Indian cows. Crossbreeding of indigenous cow (*Bos indicus*) with exotic (*Bos taurus*) bulls was started to improve their genetic potential for milk production. Basic theme was to confluene the milk yield potential of exotic breeds and the competence of indigenous breeds for stress sustainability and disease resistance[5]. In India, crossbreeding of Zebu cows with exotic dairy breed bulls has enhanced milk production in cattle and has also resulted in development of several new crossbred strains/breeds[20].

The success of dairy industry is much dependent on level of production and reproduction performance of the animals. Precise and accurate information on the first lactation performance traits and the population parameters of these traits is essential to formulate an effective and suitable breeding strategy, as selection is primarily done on the basis of first lactation traits[22]. Information on first lactation traits enables the breeder to predict the later lactation performance of the animals as it is highly correlated with the future performance traits[15]. The success of any breeding programme lies on the accuracy of selection and genetic correlation between performance traits. The estimates of genetic parameters are helpful in determining the method of selection to predict direct and correlated response to selection, in selecting a breeding system to be adopted for future improvement and in the estimation of genetic gains. Varying reports in vast amount about the genetic and phenotypic parameters of first lactation performance traits in crossbred cattle are available in literature, out of which recent studies has been reviewed.

Factors affecting first lactation performance traits

The important first lactation performance traits are first lactation milk yield (FLMY), first lactation length (FLL), first lactation peak yield (FPY), first dry period (FDP), age at first calving (AFC), first service period (FSP) and first calving interval (FCI). The available literature pertinent to these traits indicated that FLMY, FLL, FPY, FDP, AFC, FSP and FCI, ranged from 832.80±40.34 to 3243±47 Kg; 240±5.5 to 375.25± 0.05 days; 10.23 to 13.30 kg; 75.24±6.65 to 318±21.4 days; 891.6±13.5 to 1371.06±15.49 days; 125±5 to 272±17.1days and 405±5 to 543±17.9 days, respectively. Highest milk yield was reported by Nehra[24] in Karan Fries cattle whereas, lowest milk yield (832.80±40.34) was reported by Kharat *et al.*[16] in Holstein Friesian crossbred cows maintained at the Cattle Breeding Farm, Borgaon Manju (M.S.). There is a vast scope of improvement in all first lactation production and reproduction traits due to existence of large amount of variation.

Effect of sire group: Singh *et al.*[32] reported non-significant effect of sire group on FPY, whereas, significant effect of sire group on FPY was reported by Verma[36]. Singh and Gurnani[31] and Nehra[24] reported significant effect of sire group on FLMY, whereas, non-significant effect of sire group was reported by Verma[36] and Kumar[18] in crossbred cattle. Divya[8] and Singh *et al.*[33] observed significant effect of sire group on AFC in Karan Fries cattle and Frieswal cattle, respectively. Kumar[17] and Kumar[18] reported non-significant effect of sire group on FLMY, FLL, FPY, FDP, FSP and FCI in crossbred cattle; however, effect of sire group on AFC was reported to be significant by Kumar[18]. So, various authors observed significant effect of sire group on different traits in their findings.

Effect of period of calving: Kumar *et al.*[19] Singh *et al*.[35], Lakshmi *et al.*[20], Hassan and Khan[14], Divya *et al.*[9] and Verma[36] reported significant effect of period of calving on FLMY and FLL whereas, non-significant effect was reported by Kharat *et al.*[16] and Kumar[17] on both these traits in crossbred cattle (Table 1). Significant effect of period of calving on FPY was observed by Verma[36] and Kumar[18] in Frieswal and crossbred cattle, respectively while, Kumar[17] observed non-significant effect. The effect of period of calving on FCI and FSP was observed as significant by Dubey and Singh[10], Hassan and Khan[14], Chaudhari *et al.*[5], Divya *et al.*[9], Lodhi *et al.*[21] and Deokar *et al.*[6] whereas, Saha *et al.*[27] and Kumar[18] found non-significant effect of period of calving in crossbred cattle. The effect of period of calving on FDP was reported to be significant by Akhter *et al*.[1], Dubey and Singh[10], Singh *et al*.[35], Hassan and Khan[14], Chaudhari *et al.*[5] and Lodhi *et al.*[21] in crossbred cattle whereas, non-significant effect was observed by Bajetha[4], Kumar[17], Verma[36] and Kumar[18]. Almost all authors reported significant effect of period of calving on AFC in crossbred cattle while Nehra[24] observed non-significant effect. The variation due to period reflects differences in management practices, quality and quantity of feed and fodders available during different periods.

Effect of season of calving: Effect of season of calving on various first lactation traits has been reviewed and presented in Table 1,2 and 3. The contents of Table 1 to 3 depicted that the effect of season of calving was reported as non-significant on FLMY and FLL by Kumar *et al.*[19], Singh *et al.*[35], Kharat *et al.*[16], Hassan and Khan[14], Divya *et al.*[9] and Kumar[17] whereas, Saha *et al.*[27], Lakshmi *et al.*[20], Lodhi *et al.*[21], Verma[36] and Kumar[18] reported significant effect on FLMY in crossbred cattle. Non-significant effect of season of calving on FLL was observed by almost all the authors. FPY was reported to be significantly influenced by season of calving as observed by Arya and Tailor[2] in Gir and crossbred cattle, Kumar[17] and Verma[36] in Frieswal cattle and Kumar[18] in crossbred cattle, while, non-significant effect were observed by Singh *et al.*[34] in Sahiwal and crossbred cattle. The significant effect of season of calving on FCI and FSP was reported by Saha *et al.*[27], Chaudhari *et al.*[5], Hassan and Khan[14], Verma[36] and Kumar[18] whereas findings of Dubey and Singh[10], Bajetha[4], Divya *et al.*[9], Kumar[17] and Lodhi *et al.*[21] were contrary in crossbred cattle. The effect of season of calving on FDP was reported to be significant by Akhter *et al.*[1], Hassan and Khan[14], Chaudhari *et al.*[5], Kumar[17], Verma[36] and Kumar[18] in crossbred cattle. All studies regarding effect of season of calving on AFC indicated non-significant effect which further indicates that season of calving has no influence on age at first calving of animal.

Effect of age at first calving: Various authors reported significant effect of AFC on different traits. Sahana[29] reported significant effect of AFC on FSP; Sahana and Gurnani[30] on FCI; Mukherjee[23] and Nehra[24] on FLMY, whereas, non-significant effect was reported by Saha[28] on FSP and FCI, Rao *et al.*[25] on FLMY in different breeds of cattle. Kumar[17] reported significant effect of AFC on FLMY and FPY in Frieswal cattle while effect on FLL, FSP, FDP and FCI was non-significant. Kumar[18] observed significant effect of age at first calving on FDP, FSP and FCI.

Estimates of genetic and phenotypic parameters for first lactation performance traits

Estimates of Heritability: Estimates of heritability of a trait are useful for construction of selection indices, prediction of genetic response to selection and for deciding how much one can rely upon individual's own phenotype for selection. So, accurate estimates of heritability for different economic traits are desirable for bringing improvement through various animal breeding programs. The available literature pertaining to estimates of heritability of various first lactation performance traits has been presented in Table 1 to 4. Critical review of these tables concluded that the heritability estimates for production traits viz., FLMY, FLL, FPY, FDP ranged from 0.12 to 0.48; 0.04 to 0.35; 0.16 to

0.31; 0.01 to 0.43; and for reproduction traits viz., AFC, FCI and FSP ranged from 0.12 to 0.46; 0.06 to 0.47 and 0.01 to 0.49, respectively. From the reports of various workers it may be concluded that first lactation production traits had low to moderate estimates of heritability. So, individual selection and/or progeny testing could be a tool for bringing out desirable changes in these traits. Except few reports, all reproduction traits showed low estimates of heritability which indicated that these traits can be improved by better managemental practices.

Estimates of genetic and phenotypic correlations: The available literature pertinent to the genetic and phenotypic correlations among and with in various production and reproduction traits have been reviewed.

Genetic correlation: Grosshans *et al.*[13] reported that genetic correlation of AFC with FSP was negative while, genetic correlation between FSP and FCI was very high (0.98) in seasonal dairy cows in New Zealand. The genetic correlation between AFC and FLMY was observed as positive with low magnitude by Bajetha[4] whereas, the genetic correlation between AFC and FDP was very high (1.00). Kumar *et al.*[19] found negative genetic correlation between FLMY and AFC in Frieswal cattle. Saha *et al.*[27] reported that FLMY and FLL had positive and significant genetic correlation with FCI in Karan Fries cattle. Genetic correlations of FSP with FDP and FCI were positive but low to moderate in magnitude. Goshu *et al.*[12] reported that the genetic correlations of FLMY with FSP, FDP and FCI were negative however; the genetic correlations for FSP with FDP and FCI; and FDP with FCI were high in Holstein Friesian cattle. Kumar[17] reported high genetic correlation among FLMY, FLL and FPY. Kumar[18] while studying genetic and phenotypic parameters in crossbred cattle observed moderate to high positive genetic correlation of FLMY with FLL, FPY, FSP and FCI. Verma[36] reported negative genetic correlation of AFC with all first lactation traits. High genetic correlation between FSP and FCI was reported by Grosshans *et al.*[13], Chaudhari *et al.*[5], Goshu *et al.*[12], Kumar[17], Kumar[18] and Verma[36]. High genetic correlation among production traits i.e. FLMY, FLL and FPY was reported by Kumar[17], Kumar[18] and Verma[36]. These results indicated that if we select the animal on the basis of FPY it will automatically improve FLMY and will reduce the generation interval, cost of recording and maintaining low producing animal in the herd because of early selection. Lodhi *et al.*[21] observed positive genetic correlation of FLMY and FLL with FCI and FSP; and negative genetic correlation of AFC with FLMY, FDP and FCI.

Phenotypic correlation: Grosshans *et al.*[13] reported negative phenotypic correlation between AFC with FSP whereas, phenotypic correlation of FSP and FCI was high. Kumar *et al.*[19] and Kumar[17] reported that the phenotypic correlation between lactation length and lactational milk yield was high and significant in crossbred cattle. Saha *et al.*[27] reported that FLMY and FLL had positive and significant correlation with FSP and FCI; and the phenotypic correlation of FSP with FDP and FCI was significant and positive, in Karan Fries cattle. Goshu *et al.*[12] reported low phenotypic correlation of AFC with all other traits. The correlations of FLMY with FSP, FDP and FCI were negative however high positive correlations were found for FSP with FDP and FCI; and FDP with FCI in Holstein Friesian cattle. Kumar[18] reported that FLMY had moderate to high positive phenotypic correlation with FLL, FPY, FSP and FCI, whereas, significant and negative with FDP. Verma[36] observed high positive phenotypic correlations of FLL with FSP and FCI and negative with FDP. FLMY also had positive and significant phenotypic correlation with all other production traits except FDP.

Genetic improvement through selection in a breeding program depends on the accuracy of identifying genetically superior animals. Selection of dairy animals is generally based on the records of performance traits. As per the literature, genetic and non-genetic factors had significant influence on the performance traits in crossbred cattle.

Therefore, adjustment of effect of non-genetic factors becomes essential for accurate and unbiased estimates of genetic parameters. Heritability estimates indicated that individual and progeny testing could be a tool for bringing out desirable changes in production traits, whereas improvement in reproduction traits can be done through better managemental practices. High genetic and phenotypic correlations of FLMY with FPY indicated that preliminary selection of animals can be done on the basis of FPY; it will automatically improve FLMY and will reduce the generation interval.

Table 1: Least squares mean, heritability estimates and effect of non-genetic factors on first lactation milk yield (FLMY) and first lactation length (FLL)

First lactation milk yield (FLMY)					First lactation length (FLL)				
Mean ± SE (Kg)	Heritability h^2 ± SE	Non-Genetic Factors		References	Mean ± SE (days)	Heritability h^2 ± SE	Non-Genetic Factors		References
		Season	Period				Season	Period	
2871.11±32.64	0.35±0.11	NS	S	Kumar *et al.*[19]	313.34±2.21	0.04±0.06	NS	S	Kumar *et al.*[19]
3064.74±49.40	0.12±0.06	NS	S	Singh et al.[35]	375.25±0.05	-	NS	S	Singh *et al.*[35]
832.80±40.34	0.40±0.38	NS	NS	Kharat *et al.*[16]	258.82±8.35	0.35±0.36	NS	NS	Kharat *et al.*[16]
2822.88±121.94	0.26±0.06	S	S	Saha *et al.*[27]	315.25±10.10	0.21±0.05	NS	NS	Saha *et al.*[27]
3076 ± 22	0.20 ± 0.06	NS	-	Rashia[26]	329.03±5.36	0.06±0.05	NS	S	Lakshmi *et al.*[20]
2593.84±90.26	0.18±0.07	S	S	Lakshmi *et al.*[20]	359.92 ± 4.33	0.19 ± 0.11	-	-	Nehra[24]
3243 ± 47	0.48 ±0.01	NS	NS	Nehra[24]	240±5.5	-	NS	S	Hassan and Khan[14]
1613±49.03	-	NS	S	Hassan and Khan[14]	337±5	-	NS	S	Divya *et al.*[9]
3236 ±50	-	NS	S	Divya *et al.*[9]	314.72±9.88	0.28±0.19	NS	NS	Kumar[17]
2331.18±52.16	0.17±0.19	NS	NS	Kumar[17]	320.46±5.52	0.12±0.04	NS	S	Lodhi *et al.*[21]
2733±73.14	0.12±0.04	S	NS	Lodhi *et al.*[21]	305.80±6.41	0.29±0.18	NS	NS	Kumar[18]
2177.61±62.06	0.28±0.02	S	S	Kumar[18]	307.27±5.93	0.21±0.18	NS	S	Verma [36]
2262.98±57.52	0.32±0.17	S	S	Verma[36]					

NS: Non-significant, S: Significant

Table 2: Least squares mean, heritability estimates and effect of non-genetic factors on first calving interval (FCI) and first service period (FSP)

First calving interval (FCI)					First service period (FSP)				
Mean ± SE (days)	Heritability h^2 ± SE	Non-Genetic factors		References	Mean ± SE (days)	Heritability h^2 ± SE	Non-Genetic factors		References
		Season	Period				Season	Period	
421 ± 10	0.06 ±0.03	S	S	Mukherjee[23]	127 ±11	0.16 ± 0.75	S	NS	Saha[28]
494.45 ± 5.05	0.47 ± 0.10	NS	S	Dubey and Singh[10]	-	0.49± 0.21	S	S	Gaur[11]
538.60±6.66	0.16±0.05	NS	S	Bajetha[4]	143.22±11.02	0.01±0.07	S	NS	Singh and Gurnani[31]
529.48±8.51	0.09±0.06	NS	S	Singh *et al.*[35]	223.00±6.12	0.36 ± 0.09	NS	S	Dubey and Singh[10]
423.20±13.17	0.35±0.10	S	NS	Saha *et al.*[27]	271.32±0.75	0.15±0.05	NS	NS	Bajetha[4]
438± 5	-	NS	S	Nehra[24]	127.69±11.27	0.16±0.07	S	NS	Saha *et al.*[27]
420.8±3.41	0.16±0.10	S	S	Chaudhari *et al.*[5]	131.26±3.15	0.40±0.14	S	S	Chaudhari *et al.*[5]
543±17.9	-	S	S	Hassan and Khan[14]	272±17.1	-	S	S	Hassan and Khan[14]
405±5	-	NS	S	Divya *et al.*[9]	125± 5	-	NS	S	Divya *et al.*[9]
415.26±4.87	0.12±0.18	NS	NS	Kumar[17]	131.80±4.82	0.02±0.17	NS	S	Kumar[17]
433.54±7.91	0.15±0.04	NS	S	Lodhi *et al.*[21]	178.88±8.30	0.11±0.03	NS	S	Lodhi *et al.*[21]
429.08±7.08	0.28±0.19	S	NS	Kumar[18]	148.46±6.99	0.22±0.22	S	NS	Kumar[18]
412.70±5.60	0.31±0.22	S	NS	Verma[36]	132.09±5.61	0.36±0.21	S	NS	Verma[36]
453.91±9.05	-	NS	S	Deokar *et al.*[6]	169.95±9.02	-	NS	S	Deokar *et al.*[6]

NS: Non-significant, S: Significant

Table 3: Least squares mean, heritability estimates and effect of non-genetic factors on age at first calving (AFC) and first dry period (FDP)

Age at first calving (AFC)					First dry period (FDP)				
Mean ± SE (days)	Heritability $h^2 \pm SE$	Non-Genetic factors		References	Mean ± SE (days)	Heritability $h^2 \pm SE$	Non-Genetic factors		References
		Season	Period				Season	Period	
962.13±6.34	0.27±0.10	NS	S	Kumar *et al.*[19]	85.59+2.69	-	S	S	Akhter *et al.*[1]
1371.06±15.49	0.12±0.06	NS	S	Singh *et al.*[35]	-	0.43±0.19	-	-	Gaur[11]
1006 ± 8	0.43 ± 0.13	NS	NS	Nehra[24]	75.24±6.65	0.01±0.08	-	-	Singh and Gurnani[31]
1023±5	-	NS	S	Divya[8]	165.49±5.64	0.35±0.09	NS	S	Dubey and Singh[10]
1300±5.5	-	-	-	Hassan and Khan[14]	177.20±6.47	0.18±0.05	NS	NS	Bajetha[4]
1213.54±8.85	0.46±0.20	NS	S	Chaudhari *et al.*[5]	172.85±7.23	0.09±0.06	NS	S	Singh *et al.*[35]
891.6±13.5	-	-	-	Singh *et al.*[33]	318±21.4	-	S	S	Hassan and Khan[14]
1227.41±18.81	0.16±0.14	NS	S	Kumar[17]	105.00±2.73	0.32±012	S	S	Chaudhari *et al.*[5]
1153.10±24.84	0.14±0.04	NS	S	Lodhi *et al.*[21]	102.46±4.88	0.38±0.23	S	NS	Kumar[17]
1242.75±16.46	0.38±0.14	NS	S	Kumar[18]	113.06±5.12	0.10±0.03	NS	S	Lodhi *et al.*[21]
1245.36±16.97	0.44±0.24	NS	S	Verma[36]	110.97±6.47	0.24±0.22	S	NS	Kumar[18]
975.13±12.83	-	NS	S	Deokar *et al.*[6]	107.46±5.02	0.25±0.20	S	NS	Verma[36]

NS: Non-significant, S: Significant

Table 4: Least squares mean and heritability estimates for First lactation peak yield (FPY)

Mean ± SE (kg)	Reference	$h^2 \pm SE$	Reference
13.30±0.20	Lakshmi *et al.*[20]	0.16±0.12	Lakshmi *et al.*[20]
10.80±0.12	Arya and Tailor [2]	0.26±0.22	Kumar[17]
10.86±0.16	Kumar[17]	0.28±0.17	Verma[36]
10.30±0.21	Verma[36]	0.31±0.23	Kumar[18]
10.23±0.20	Kumar[18]		

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