https://doi.org/10.56093/ijans.v90i12.113198

Indian Journal of Animal Sciences **90** (12): 1622–1627, December 2020/Article

Effect of non-genetic factors on first lactation production and reproduction traits in Frieswal cattle

RAJEEV[1], RAVINDER KUMAR[2], RAJBIR SINGH[3] and T V RAJA[4]✉

Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh 250 110 India

Receievd: 4 January 2020; Accepted: 19 December 2020

ABSTRACT

The present study was undertaken on first lactation production and reproduction records of 1470 Frieswal cows maintained over a period of 10 years (2003–2012) at two military farms, viz Meerut and Ambala at CIRC, Meerut, Uttar Pradesh. The data were classified according to farm, season, period, and age groups. The overall least squares means of AFC, FL305DMY, FLMY, FLL, FSP, FDP and FCI were 921.35±05.17 days, 2658.57±42.59 kg, 2718.28±44.40 days, 304.15±1.4 days, 163.19±24.75 days, 114.20±5.94 days and 459±8.06 days, respectively. Period had highly significant effect on AFC, FL305YP, FLMY, and FLL, while it had non-significant effect on FSP, FDP and FCI. The effect of season of birth on AFC was statistically non-significant. The average FL305DMY for Meerut farm was 2879.13±41.28 kg while the corresponding estimate for Ambala farm was 2438.02±61.79 kg and the difference was statistically highly significant. The analysis on the effect of season on FL305DMY revealed that the cows calved in summer season had the maximum FL305DMY of 2700.61±57.02 kg followed by the winter (2639.75±50.38 kg) and rainy calvers (2635.37±65.81 kg). The study also revealed that the differences between different seasons were not statistically significant. The least squares analysis revealed that the AFC group had highly significant effect on the FL305DMY.

Keywords: First lactation traits, Frieswal cow, Production, Reproduction

Frieswal is one of the superior crossbred cattle developed in India by crossing the indigenous milch breed with the temperate dairy breed. The Frieswal project was started on 23rd May, 1985 by the Indian Council of Agricultural Research in collaboration with the Ministry of Defence, Government of India for developing a strain of cattle by crossing the Sahiwal cattle with the Holstein Friesian bulls. The primary objective of the project was to evolve a national milch breed yielding 4,000 kg of milk with 4% butter fat in a standard lactation of 300 days. Presently the crossbred cattle available at the Military farms having 62.50% HF inheritance are genetically considered as Frieswal cattle. The traditional genetic evaluation of Frieswal bulls based on the first lactation 305-days or less milk yield of their daughters increases the generation interval thereby reduces the genetic gain per unit of time and increases the cost of sire evaluation.

Most of the daughters with incomplete records are eliminated from the evaluation programme which causes biasness in the sire evaluation and indirectly reduces the accuracy of selection. In view of the above facts, the present study was undertaken to assess the effect of various genetic and non-genetic factors on first lactation individual monthly milk yields in Frieswal cattle.

MATERIALS AND METHODS

The data on Frieswal cattle born over a period of 10 years (2003–2012) at two Military dairy Farms, viz. Ambala and Meerut were utilized for the present study. The details on pedigree and first lactation production and reproduction traits of Frieswal cows were collected from the history and pedigree sheets while the daily milk yield records of cows calved during the period from 2005–2014 were collected from the daily milk yield registers. The Military farm at Meerut is 65 km away on the North-East of the national capital, New Delhi. The average height above the mean sea level is 219 meters and the average annual rainfall ranges between 70–80 mm. The temperature varies with a wide range of 4°C during peak winter and 44°C during summer. The Military farm, Ambala is located in the cantonment area on the South-East of Ambala city. The average height above mean sea level is 277 meters. The records of the animal of known pedigree and normal lactation only were considered for this study. Information on first lactation records of 1,470 Frieswal cows were collected for generating the first lactation production, reproduction and part lactation traits. Information of animals with abnormalities such as culling or disposal in middle of

Present address: [1]Dolphin PG College of Science and Agriculture. [2]Central Institute for Research on Cattle, Meerut. [3]SVPUAT, Meerut. ✉Corresponding author email: venkatesanraja 09@gmail.com

lactation, abortion, stillbirth and other pathological conditions were excluded from analysis. The records of animals with less than 100 days of lactation length or 300 kg of milk production were also discarded. To ensure the normal distribution, the outlines were removed and data within the range of mean±2SD were only considered for the study. For genetic studies, sires having three or more daughters were only considered. The seasonal variation experienced by the animals is considered as one of the main factors of the environment that affects the performance. In both the farms, there is a wide variation of climatic conditions throughout the year, differences being more between the seasons and less within the seasons. Thus, the year was divided in to three seasons on the basis of rainfall, temperature and humidity. The classification of season of calving was done as follows: S^1 Winter (November–February), S2 Summer (March–June), S3 rainy (July–October) and for classification of period of calving, the total span 10 years for which data collected, was divided into five periods (P1 to P5) and each spanned around one year. The classification of animal age groups into eight code (C1 to C8). The first production and reproduction traits considered in the study were age of calving (AFC), first lactation 305 day milk yield (F305DMY), first lactation milk yield (FMY), first lactation length (FLL), first dry period (FDD) and first calving interval (FCI). The analysis was carried out using least-squares and maximum likelihood computer program of Harvey (1990). The influence of various non-genetic factors on different first lactation production and reproduction traits was studied by least squares analysis of variance for unequal non-orthogonal data using the technique described by Harvey (1966).

The following statistical models were used for different traits described in this section.

For age at first calving

$$Y_{ijkl} = \mu + F_i + S_j + P_k + e_{ijkl}$$

where Y_{ijkl}, Dependent trait (AFC) of l^{th} cow born at i^{th} farm in j^{th} season and k^{th} period; μ, Overall mean; S_i, Effect of i^{th} farm; F_j, Effect of j^{th} season; P_K, Effect of k^{th} period; e_{ijkl}, Random error, assumed to be normally and independently distributed with mean zero and constant variance, i.e. NID (0, σ_e^2).

Production and reproduction traits

$$Y_{ijklm} = \mu + F_i + S_j + P_k + A_l + e_{ijklm}$$

where Y_{ijklm}, Dependent trait of m^{th} cow born at i^{th} farm in j^{th} season, k^{th} period and l^{th} age group; μ, Overall mean; S_i, Effect of i^{th} farm; F_j, Effect of j^{th} season; P_K, Effect of k^{th} period; A_e, Effect of l^{th} age group; e_{ijklm}, Random error, assumed to be normally and independently distributed with mean zero and constant variance, i.e. NID (0, σ_e^2).

RESULTS AND DISCUSSION

The least squares means of first lactation production and reproduction traits are presented in Tables 1 and 2. The overall least squares mean for AFC was 921.35±04.17 days. The average estimate of AFC obtained in the present study is similar to the estimates reported by Rathee (2015). However, AFC estimates higher than the present study were reported by Saha (2001), PDC AR (2003–04), Dubey and Singh (2006), Mukherjee (2005), Nehra (2011), Divya (2012). The least squares analysis of variance revealed that the age at first calving of Frieswal cows maintained in Ambala and Meerut farms did not differ significantly. Similar to the present findings, Rathee (2015) reported non-significant effect of farm on AFC in Frieswal cattle. On the contrary, Mukherjee (2005) reported significant variation in AFC estimates obtained from different farms. The effect of season of birth on AFC was statistically non-significant. Similar to the present findings, many workers (Saha 2001, Mukherjee 2005, Simran *et al.* 2014) reported non-significant effect of season of birth on AFC in different crossbred cattle. However, significant influence of season of birth on AFC was reported by Dubey and Singh (2005) and Rathee (2015). The least squares analysis of variance revealed that the period of birth had highly significant (P<0.01) effect on AFC in Frieswal cattle. Saha (2001), Mukherjee (2005) and Simran *et al.* (2014) reported significant variation in the AFC of animals born in different periods. On the contrary, non-significant effect of period of birth on AFC was also reported by Dubey and Singh (2005). Rathee (2015) also reported non-significant effect of year of birth on AFC in Frieswal cattle.

The least squares analysis revealed overall least squares mean of 2658.57±42.59 kg for FL305DMY in Frieswal cattle. The average estimate obtained in the present study was near to the average values reported by Mukherjee (2005) and Rathee (2015). On the contrary, Saha (2001) reported a lower average of 2,470 kg in Karan Fries cattle.

Table 1. Least squares means for age at first calving (days) in Frieswal cattle

Overall	No. of observations	Mean±SE
	1113	921.35±4.17
Farm^{NS}		
Ambala	328	924.76±6.91
Meerut	785	917.94±4.56
Season of birth^{NS}		
Winter	513	914.98±5.58
Summer	253	927.17±7.45
Rainy	347	921.99±6.44
*Period of birth***		
2003–2004	102	965.97±11.83^c
2005–2006	183	956.46±8.57^c
2007–2008	288	914.67±6.99^b
2009–2010	343	891.09±6.69^a
2011–2012	197	878.58±8.34^a

Means bearing same superscript in a group did not differ significantly; **significant at 1% level (P< 0.01); NS, Non-significant.

Table 2. Least-squares means of first 305 day milk yield, first lactation milk yield, first lactation length, first dry period, first service period and first calving interval traits in Frieswal cattle

Effect	FL305DMY (kg)	FLMY (kg)	FLL (days)	FDP (days)	FSP (days)	FCI (days)
Overall (μ)	2658.57±42.59 (876)	2718.28±44.40 (876)	304.15±1.40 (876)	114.20±5.94 (220)	163.19±24.75 (300)	459.29±8.06 (267)
Farm						
Ambala	2438.02±61.79 (239)	2495.30±64.41^{a} (239)	304.36±2.04 (239)	101.69±8.81^{a} (42)	147.92±12.20 (297)	493.07±11.15^{a} (79)
Meerut	2879.13±41.28 (637)	2941.27±43.03^{b} (637)	303.93±1.36 (637)	126.71±6.83^{b} (178)	178.47±45.84 (3)	425.51±9.27^{b} (188)
Season of calving						
Winter	2639.75±50.38^{a} (380)	2684.42±52.45 (380)	301.28±1.66^{a} (380)	101.34±6.98^{a} (93)	139.87±25.19^{a} (142)	446.98±9.32 (114)
Summer	2700.61±57.02^{b} (315)	2773.47±59.44 (315)	308.44±1.87^{b} (315)	122.02±7.58^{b} (81)	196.02±26.49^{b} (96)	473.27±10.85 (99)
Rainy	2635.37±65.81^{a} (181)	2696.965±68.59 (181)	302.71±2.16^{a} (181)	119.26±8.75^{b} (46)	153.76±25.34^{a} (62)	457.69±11.99 (54)
Period of Calving						
2005–06	2692.87±131.77^{b} (37)	2740.13±137.36^{c} (37)	303.54±4.34^{ab} (37)	100.99±14.78 (93)	115.33±58.66 (2)	437.67±23.27 (12)
2007–08	2435.85±66.91^{a} (157)	2529.09±69.75^{ab} (157)	308.903±2.20^{b} (157)	112.84±7.91 (81)	179.10±24.50 (34)	451.15±11.05 (78)
2009–10	2927.08±52.93^{b} (255)	2968.62±55.17^{c} (255)	298.37±1.74^{a} (255)	131.19±6.69 (46)	178.87±23.27 (85)	463.35±9.09 (90)
2011–12	2671.74±63.07^{b} (215)	2749.92±65.75b^{c} (215)	306.82±2.078^{b} (215)	113.99±9.05 (46)	177.95±24.84(42)	460.06±12.08 (58)
2013–14	2565.39±59.11^{a} (212)	2603.65±61.62^{a} (212)	303.100±1.95^{ab} (212)	112.07±18.56 (8)	164.75±24.01 (137)	484.28±17.65 (29)
Age Groups						
<723	2698.96±163.43^{ab} (23)	2748.54±170.37^{ab} (23)	306.44±5.39 (23)	106.76±25.18^{ab} (4)	206.15±32.21 (10)	451.29±35.14 (5)
723–789	2383.05±94.30^{a} (76)	2447.64±98.31^{a} (76)	306.22±3.11 (76)	128.57±10.67^{b} (29)	141.43±26.90 (26)	486.80±14.23 (35)
790–855	2506.99±64.17^{a} (198)	2563.51±66.90^{a} (198)	302.53±2.11 (198)	114.48±8.37^{ab} (53)	169.05±26.30 (86)	467.28±10.36 (77)
856–922	2642.98±61.58^{ab} (200)	2694.58±64.19^{ab} (200)	302.25±2.03 (200)	101.72±8.61^{ab} (51)	145.57±26.08 (65)	453.01±11.15 (61)
923–989	2690.19±73.11^{ab} (129)	2752.61±76.21^{ab} (129)	306.16±2.40 (129)	110.68±9.88^{ab} (33)	150.32±27.23 (51)	461.66±13.66 (37)
990–1056	2670.74±81.13^{ab} (107)	2728.77±84.58^{ab} (107)	301.86±2.67 (107)	105.37±12.19^{a} (19)	164.54±32.47 (15)	447.03±18.05 (20)
1057–1123	2847.32±102.06^{b} (62)	2926.14±106.39^{b} (62)	301.55±3.36 (62)	97.05±15.16^{a} (12)	156.94±31.03 (20)	460.72±22.82 (12)
1124 and above	2828.36±90.37^{b} (81)	2884.50±94.20^{b} (81)	306.15±2.98 (81)	148.94±12.03^{b} (19)	171.59±28.59 (27)	446.53±17.50 (20)

Figures in parentheses indicate the degrees of freedom; **, significant at 1% level (P< 0.01); *, significant at 5% level (P< 0.05).

The average FL305DMY for Meerut and Ambala farms were found to be statistically highly significant (P<0.01). Similar to the present findings, Mukherjee (2005) while studying the effect of farm on FL305DMY found statistically significant difference among six different farms, viz. Meerut, Lucknow, Ambala, Jabalpur, Dehradun and Jallandhar. However, Rathee (2015) reported non-significant difference among the FL305DMY averages of Frieswal animals maintained at Ambala and Meerut Military farms. The average FL305DMY classified according to different season of calving. The study also revealed that the differences between different seasons were not statistically significant. The non-significant effect of season of calving on FL305DMY was also reported by Singh *et al.* (2006), Rashia (2010), Nehra (2011), Divya (2012) and (Rathee 2015) in different crossbred cattle. Contrary to this finding, significant effect of season of calving on FL305DMY has also been documented by Mukherjee (2005) and Kokate (2009) in different HF crossbred cattle. The FL305DMY of cows calved during different periods showed a wide variation and the effect of period was highly significant (P<01). The present finding was in accordance with the reports of Mukherjee (2005), Singh *et al.* (2006), and Kokate (2009). Rathee (2015) also reported significant variation among the Frieswal cows calved in different years. The least squares analysis revealed that the AFC group had highly significant (P<0.01) effect on the FL305DMY. This finding was similar to Annual Report PDC (2003–04), Mukherjee (2005), and Rathee (2015) in Frieswal cattle. However, Divya (2012) reported non-significant effect of AFC on FL305DMY in KF cattle.

The overall least squares mean for FLMY was 2718.28±44.40 kg. Almost similar estimates of average FLMY were observed by Saha (2001) and Bhattacharya *et al.* (2002) in crossbred cattle. However, estimates of FLMY lower than the present study were reported by Radhika *et al.* (2012), Hassan and Khan (2013) and Sooraj (2013) in different crossbred cattle. On the contrary, Singh *et al.* (2008) in HF×S crossbred, Nehra (2011) in KF and Rathee (2015) in Frieswal cattle reported higher estimate of FLMY. The least squares analysis of variance revealed highly significant (P<0.01) variation in the FLMY of Frieswal cows maintained at two different farms. Similar to the present findings, the earlier studies (Mukherjee 2005, Hassan and Khan 2013) reported significant effect of farm on this trait. However, Rathee (2015) reported non-significant differences among the FLMY of Frieswal cows maintained at two different farms. The study also revealed that the season had highly significant (P<0.01) effect on FLMY in Frieswal cattle. The significant effect of season of calving on FLMY observed in the present study was in agreement with the findings of Akhtar *et al.* (2003) and Mukherjee (2005) in different crossbred cattle. On the other hand, Singh *et al.* (2008), Rashia *et al.* (2009), Nehra (2011), Radhika *et al.* (2012), Hassan and Khan (2013) and Rathee (2015) reported non-significant effect of season of calving on FLMY. The period of calving had highly significant (P<0.01) effect on the FLMY. Similar to the present results, Akhtar *et al.* (2003), Mukherjee (2005), Kumar *et al.* (2008), Singh *et al.* (2008), Rashia *et al.* (2009), Sooraj (2013) and Hassan and Khan (2013) had found significant effect of period of calving on FLMY in crossbred cattle. On the contrary, Bhattacharya *et al.* (2002), Nehra (2011) and Radhika *et al.* (2012) reported non-significant variation in FLMY of crossbred animals calved in different periods. The least squares analysis revealed that the age at first calving had highly significant effect (P<0.01) on the FLMY. Similar to the present findings, Akhtar *et al.* (2003) in HF×S, Mukherjee (2005) and Rathee (2015) in Frieswal showed significant variation in FLMY due to the age at first calving. However, Saha (2001) and Nehra (2011) reported non-significant effect of AFC on FLMY in KS and KF cattle.

The least square estimate of overall population mean for FLL was 304.15±1.40 days. The estimate was near to the values reported by Bhattacharya *et al.* (2002), Kumar *et al.* (2008), Saha *et al.* (2010), and Rathee (2015) in different crossbred cattle. On the contrary, present estimate was higher than the value reported by Bhattacharya *et al.* (2002). The study revealed that the differences between farms were found to be statistically non-significant. Similar to the present findings, Rathee (2015) also reported non-significant variation in FLL of animal maintained in Ambala and Meerut farms. However, Mukherjee (2005) reported significant variation in FLL of Frieswal cattle maintained in six different Military Farms. The results of the present study revealed that the influence of season of calving on FLL was statistically highly significant in Frieswal cattle. The significant effect of season of calving on FLL observed in the present study was in agreement with the findings of Gurnani (2000) and Mukherjee (2005) in different crossbred cattle. On the other hand, Saha (2001), (Bhattacharya *et al.* 2002), (Akhtar *et al.* 2003), (Saha *et al.* 2010), (Nehra *et al.* 2011) and Rathee (2015) reported significant effect of season of calving on FLL. The effect of period of calving on FLL was statistically highly significant (P<0.01).(Nehra *et al.* 2011), Rathee (2015) reported significant variation in the FLL of crossbred cows during different period. On the other hand, Saha *et al.* (2010) reported non-significant influence of period of calving on this trait. The effect of age groups on the FLL was found to be statistically non-significant. It was apparent from the results that there was no wide variation in FLL among different age groups. The non-significant effect of AFC on FLL in Sahiwal cattle was also reported by Nehra *et al.* (2011), Rathee (2015) in different HF crossbred cattle. However, Mukherjee (2005) reported statistically significant effect of AFC on FLL in crossbred cattle.

The least squares overall mean FDP was 114.20±5.94 days. This average was near to the estimates reported by Mukherjee (2005) and Rathee (2015) in HF crossbred cattle. However, average FDP estimates lower than the present study was also reported by Akther *et al.* (2003), Singh and Gurnani (2004) and Saha *et al.* (2010). On the contrary, higher average estimate of 147 days was also reported by PDC AR (2008–09) in Frieswal cattle. The least squares analysis of variance showed that the farm had significant (P<0.05) effect on FDP in Frieswal cattle. Similar to the present findings, Mukherjee (2005) reported significant effect of farm on FDP in Frieswal cattle. On the contrary, Rathee (2015) found non-significant effect of farm on the FDP in Frieswal cattle. The influence of season of calving on FDP was significant (P<0.05). The significant effect of season of calving on FDP was also reported by earlier workers (Mukherjee 2005, Saha *et al.* 2010). However, many other workers (Sahana and Gurnani 2000, Saha 2001, Singh and Gurnani 2004, Rathee 2015) reported non-significant effect of season on FDP in different crossbred cattle. The least squares analysis of variance revealed that the period of calving did not have significant effect on FDP in Frieswal cattle. Similar to this finding, Singh and Gurnani (2004) and Saha *et al.* (2001) reported non-significant influence of period of calving on this trait in different crossbred cattle. On the other hand, Akther *et al.* (2003), Mukherjee (2005) and Rathee (2015) reported significant influence of period of calving on FDP. The analysis on the effect of AFC groups on the FDP revealed that the differences were statistically significant (P<0.05). This result was in accordance with the results of Mukherjee (2005) who found was significant effect of AFC on FDP in Frieswal cattle. Saha (2001) and Rathee (2015) reported that the effect of AFC on FDP was statistically non-significant in different crossbred cattle.

The overall least squares mean for FSP was found to be 163.19±24.75 days. This estimate was near to the estimates reported by Mukherjee (2005) and Rathee (2015) in different crossbred cattle. Contrary to the present findings, Saha (2001) and Divya (2012) reported lower average FSP estimates in different crossbred cattle. The least squares analysis of variance revealed non-significant variation in FSP between the animals maintained in Meerut and Ambala farms. Contrary to the present findings, Mukherjee (2005) and Rathee (2015) reported significant variation in FSP of Frieswal animals maintained in different Military Farms. The results of the present study revealed that the season of calving had highly significant (P<0.01) influence on the FSP. Similar to the present findings, Saha (2001) and Mukherjee (2005) reported significant effect of season of calving on FSP in crossbred cattle. On the other hand, Divya (2012) reported non-significant effect of season of calving on this trait. The period of calving had statistically non-significant influence on FSP in Frieswal cattle. The non-significant influence of period of calving on FSP was also reported by Saha (2001) in different crossbred cattle. On the contrary, Mukherjee (2005) and Divya (2012) found significant effect of period of calving on FSP in crossbred cattle. The analysis on the effect of AFC groups on the FSP was statistically non-significant. This result is in agreement with the findings of Saha (2001), Divya (2012) and Rathee (2015) who reported non-significant effect of AFC on FSP in crossbred cattle. On the other hand, Mukherjee (2005) reported significant influence of AFC on FSP in KF and Frieswal cattle, respectively.

The results of the least squares analysis of variance revealed an overall average calving interval of 459.29±8.06 days in Frieswal cattle. This estimate is nearer to the estimates reported by Mukherjee (2005) and Rathee (2015) in the same breed. However, most of the workers (Akhter *et al.* 2003), reported estimates lower than the value obtained in the present study. The results of the least squares analysis revealed highly significant difference in FCI of the animals maintained in Meerut and Ambala farms. Similar to the present findings, Mukherjee (2005) and Rathee (2015) also reported significant effect of farm on FCI in Frieswal cattle. The effect of season of calving had non-significant influence on the FCI in Frieswal cattle. On the contrary, Akhter *et al.* (2005), Mukherjee (2005) and Rathee (2015) in HF × S crossbreds; while, Sahana and Gurnani (2000), Saha (2001) in KF crossbreds found significant effect of season of calving on FCI. The least squares analysis revealed non-significant variation in the FCI of Frieswal cattle calved in different periods. Similar to the present findings, Saha (2001) and Akhter *et al.* (2003) reported non-significant effect of period of calving on the FCI in various crossbred cattle. On the other hand, Mukherjee (2005) and Rathee (2015) reported significant effect of period of calving on FCI in different HF crossbred cattle. Analysis on the effect of AFC groups on FCI revealed statistically non-significant variation in Frieswal cattle. Similar to Saha (2001), Rathee (2015) also found non-significant effect of AFC group on FCI in crossbred cattle. On the contrary, Sahana and Gurnani (2000) and Mukherjee (2005) reported significant variation in FCI among the AFC groups in KF and Frieswal crossbred cattle, respectively.

ACKNOWLEDGEMENT

Authors are highly thankful to the Director, ICAR Central Institute for Research on Cattle, Meerut Cantt., Meerut for providing necessary facilities during the dissertation work at institute.

REFERENCES

Annual report (2003–04). Project Directorate on Cattle, Meerut.

Divya P. 2012. Single versus multi-trait models for genetic evaluation of fertility traits in Karan Fries cattle. M.V.Sc. Thesis, National Dairy Research Institute, Karnal, India.

Dobos R C, Nandra K S, Riley K, Fulkerson W J, Alford A and Jean I J. 2004. Effects of age and live weight of dairy heifers at first calving on multiple lactation production. *Australian Journal of Experimental Agriculture* **44**: 969–74.

Dubey P P, Singh CV and Prasad R B. 2006. Relationship between sire's estimated breeding values for first lactation and lifetime traits and ranking of sires in Sahiwal and its cross. *Indian Journal of Animal Sciences* **76**(10):824–828.

Gader A Z A, Mohammad A K, Ahmed M L, Musa A and Peters K J. 2007. Milk yield and reproductive performance of Friesian cows under Sudan tropical conditions. *Archiv Tierzucht Dummerstorf* **50**: 155–64.

Hare E, Norman H D and Wright J R. 2006. Trends in calving ages and calving intervals for dairy cattle breeds in the United States. *Journal of Dairy Science* **89**: 365–70.

Heinrichs A J, Wells S J, Hurd H S, Hill G W and Dargatz D A. 1994. National Dairy Heifer Evaluation Project: profile improvement programs in the central tropical highlands of Ethiopia. *Journal of Cell Animal Biology* **5**: 96–104.

Japheth K P, Mehla R K and Imtiwati *et al.* 2015. Effect of non-genetic factors on various economic traits in Karan Fries crossbred cattle. *Indian Journal of Dairy Science* **68**(2): 163–69.

Kokate L S. 2009. Genetic evaluation of Karan Fries sires based on test day milk yield records. M.V.Sc. thesis, National Dairy Research Institute (Deemed University), Karnal, India.

Kumar M, Vohra V and Ratwan P *et al.* 2016. Estimates of genetic parameters for fat yield in Murrah buffaloes. *Veterinary World* **9**(3): 295–98.

Kumar S, Singh Y P and Kumar D. 2008. Genetic studies on performance traits in Frieswal cattle. *Indian Journal of Animal Science* **78**(1): 107–110.

Lucy M C. 2001. ADSA Foundation Scholar Award Reproductive Loss in High-Producing Dairy Cattle: Where Will It End? *Journal of Dairy Science* **84**: 1277–93.

Mandal A and Sachdeva G K. 2001. Factors affecting production and reproduction performance of crossbred cattle. *Indian Veterinary Journal* **78**(8): 745–47.

Mandal A, Roy P K and Ghosh M K *et al.* 2013. Genetic and environmental effects on first lactation traits of Jersey crossbred cattle in an organized herd of Eastern India. *Indian Journal of Dairy Science* **66**(2): 130–133.

Mukherjee S. 2005. Genetic evaluation of Frieswal cattle. Ph.D. Thesis, NDRI (Deemed University), Karnal, India.

Nehra M. 2011. Genetic analysis of performance trends in Karan-Fries cattle. M.Sc. Thesis, National Dairy Research Institute (Deemed University), Karnal, India.

Rashia B. 2010. Genetic evaluation of the lactation curve in Karan-Fries cattle. Ph.D. Thesis, National Dairy Research Institute, Karnal, India.

Rathee. 2015. Genetic evaluation of Frieswel cattle for life time traits. Ph.D Thesis, National Dairy Research Institute, Karnal, India.

Saha S, Joshi B K and Singh A. 2010. Generation wise genetic evaluation of various first lactation traits and herd life in Karan Fries cattle. *Indian Journal of Animal Sciences* **80**(5): 451–56 p. 23.

Saha S. 2001. Generation-wise genetic evaluation of Karan-Swiss and Karan-Fries cattle. Ph.D. Thesis, National Dairy Research Institute (Deemed University), Karnal.

Sahana G and Gurnani M. 2000. Performance of crossbred cattle and comparison of sire evaluation methods under organized farm condition. *Indian Journal of Animal Sciences* **70**(4): 409–14.

Sattar A, Mirza R H, Niazi A A K and Latif M. 2005. Productive and reproductive performance of Holstein Friesian cows in Pakistan. *Pakistan Veterinary Journal* **25**: 75–81.

Singh Simran, Das A K, Chakraborty D, Taggar R K, Kumar N, Gupta P and Mahajan V. 2014. Studies on genetic and non-genetic factors affecting performance traits of Frieswal cows. *Indian Journal of Animal Res*earch **48**(6) 537–40.

Singh V K, Singh C V, Kumar D and Sharma R J. 2008. Genetic parameters for first lactation and lifetime performance traits in crossbred cattle. *Indian Journal of Animal Sciences* **78**(5): 497–501.

Sooraj 2013. Estimation of genotypic and phenotypic trends in milk yield of cross breed cattle. M.V.Sc. Thesis, Kerala Veterinary and Animal Science University, Kerala.

Thombre B M, Mitkari K R, Padghan P V, Shaikh F G and Chavan K R. 2002. Studies on age at first calving and first lactation performance in Holstein Friesian × Deoni straight breds. *Indian Jouranl of Animal Research* **36** (2): 144–46.

Younas M, Bilal M, Babar M E, Yaqoob M and lqbal A. 2008. Reproductive profile of Holsteins kept at Balochistan province of Pakistan. *Pakistan Journal of Agriculture Science* **45**: 280–87.