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Factors influencing production and reproductive performance of Frieswal cattle maintained at organized farm conditions

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ABSTRACT

The effect of certain genetic and non-genetic factors, viz. sire, month, year, age group, and service period on the first lactation production and reproduction traits of Frieswal cattle reared at organized farm under tropical condition was assessed. The records on first lactation production and reproduction performance of 1,225 Frieswal cattle spread over a period of 24 years (1988–2011) were used for the study. The first lactation traits were first lactation milk yield (FLMY), first lactation 305 day or less milk yield (FL305DMY), first lactation length (FLL), age at first calving (AFC), first service period (FSP), first dry period (FDP) and first calving interval (FCI). The genetic and non-genetic factors incorporated in the models for FLMY, FL305MY, FLL, AFC, FSP, FCI and FDP accounted for 31.34, 26.42, 70.60, 15.87, 21.82, 21.60 and 71.97% of total variations, respectively. The effect of sire, year of calving, first service period and age at first calving had highly significant effect on FLMY, FL305MY and FLL. Among the non-genetic factors, year and month had highly significant effect on all reproductive traits except the effect of month on FDP. The effect of farm was significant on FSP and FCI and not on AFC and FDP. The effect of FSP was significant on FDP. The overall least squares averages of AFC, FSP, FCI and FDP were 949.32±5.47, 153.26±3.79, 432.92±3.73, 127.17±1.43, respectively in Frieswal cattle. It was concluded that the first lactation reproduction traits were influenced by the year of birth/ calving. The overall least squares averages for FLMY, FL305 and FLL were 2920.86±47.07 kg, 2765.92±42.84 kg and 307.49±1.51 days, respectively.

Key words: Cattle, Frieswal, Non-genetic factors, Production performance, Reproductive traits

Frieswal is a synthetic strain of cattle developed by crossing Holstein Friesian (62.5%) and Sahiwal (37.5%) at military dairy farms. The Frieswal cows yielding 4000, 4500 and 5000 kg milk yield in any of the first, second and third and above parities, respectively with 4% fat in a standard lactation length of 305 days are declared as elite cows and eligible to become the bull mothers. To formulate an effective and suitable breeding strategy, precise and accurate information on the first lactation production and reproduction performance is highly essential as selection is primarily done on the basis of first lactation production and reproduction traits. Variation in climatic conditions over the years influence the production and reproduction performance of the animals leading to alteration in the estimates of genetic parameters which may indirectly affect the genetic progress. The herd of Frieswal cattle maintained at Military dairy farms Meerut (Uttar Pradesh) and Ambala (Haryana) is exposed to extreme climatic conditions throughout the year, which certainly affect the performance of cows. Considering the above facts, present investigation was undertaken to study the effect of certain genetic and non-genetic factors, viz. sire, month, year, age group and service period on first lactation production and reproduction traits in Frieswal cattle raised under organized farm conditions.

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MATERIALS AND METHODS

The present investigation was undertaken on the Frieswal cows maintained at the cattle yard of Military dairy farms, viz. Ambala (Haryana) and Meerut (Uttar Pradesh), India. *Ad lib.* feeding of good quality green fodder throughout the year has been the policy of the farms. Silage and hay have also been used during lean periods. Concentrate was provided to cows as per their milk production and loose housing system was followed.

Data generation and standardization: The records on first lactation production and reproduction performance of 1225 Frieswal cattle spread over a period of 24 years (1988–2011) were used for study. The first lactation traits considered were first lactation milk yield (FLMY), first lactation 305 days or less milk yield (FL305DMY), first lactation length (FLL), age at first calving (AFC), first service period (FSP), first calving interval (FCI) and first dry period (FDP). The records of the animals with known pedigree and normal lactation were considered for the study. The records with disposal in middle of lactation, abortion, stillbirth and other pathological conditions were excluded from analysis. The records of animals with less than 500 kg of milk production or less than 150 days of lactation length were also excluded. To ensure the normal distribution, the outliers 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.

To study the effect of non-genetic factors, the data were classified into 2 farms. The month and year of birth were taken for AFC while month and year of calving were taken for all other productive and reproductive traits. To study the difference due to service period, the data were classified into 9 groups each of 21 days interval. To study the effect of age at first calving, the data were also classified in 9 groups at the interval of 66 days.

Statistical analysis: The influence of various genetic and 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 statistical model used for least squares analysis of variance for production and reproduction traits was as follows:

$$Y_{ijklmno} = \mu + S_i + F_j + M_k + P_l + A_m + B_n + e_{ijklmno}$$

where, $Y_{ijklmno,}$ traits under study, viz. first lactation milk yield, first lactation 305 days or less milk yield, first lacation length, age at first calving, first service period, first calving interval and first dry period; μ, overall mean; S_i, effect of i^{th} sire; F_j, effect of j^{th} farm; M_k, effect of k^{th} month of birth/ calving; P_l, effect of l^{th} year of birth/ calving; A_m, effect of m^{th} age at first calving; B_n, effect of n^{th} service period; e_{ijklmn}, random error assumed to be normally and independently distributed with mean zero and constant variance i.e. NID $(0, \sigma_e^2)$.

For AFC, the factors AFC group and service period group were excluded while for FSP and FCI only the service period group was excluded. Duncan's multiple range test as modified by Kramer (1975) was used for testing the difference among least squares means (using the inverse coefficient matrix).

RESULTS AND DISCUSSION

The least squares analysis of variance to study the effect of various genetic and non- genetic factors on different first lactation traits in Frieswal cattle are presented in Table 1. The genetic and non-genetic factors incorporated in the model for AFC, FSP, FDP, FCI, FLMY, FL305DMY and FLL accounted for 15.87, 21.82, 21.60, 71.97, 31.34, 26.42 and 70.60% of total variation, respectively. Among non-genetic factors, the year of birth/ calving had highly significant effect on all the traits considered. The effect of service period group was highly significant effect on all production traits. The month of birth/calving had highly significant effect on all reproduction traits except FDP. The AFC group had significant effect on first lactation milk yield and 305 days or less milk yield.

Age at first calving (AFC): The overall least squares mean for AFC in the present study was 949.32±05.47 days (Table 2). Almost similar estimates of average AFC were observed by Singh (1995), Jadhav and Khan (1996), Sahana (1996), Panja (1997) and Mukherjee (2005) in HF crossbred cattle. This average estimate of AFC was lower than the values reported by other workers (Jadhav 1990, Rana 1991, Rathi *et al.* 1992, Arora *et al.* 1993, Nayak and Raheja 1996, Saha 2001, Thombre *et al.* 2002, Akhter *et al.* 2003, PDC Annual Report 2003–04, Dubey and Singh 2005, Nehra 2011, Divya 2012 and Dash 2014). On the other hand, Singh *et al.* (2014) reported lower estimate of 903.48 days in Frieswal cattle. The difference in the estimates of average AFC in crossbred cattle reported by many researchers may be attributed to the difference in herds, reproductive management strategies and time/ year considered.

The AFC of animals maintained at military dairy farm Meerut (UP) and Ambala (Haryana) did not differ significantly. However, cows maintained at Ambala farm had slightly higher AFC of 956.74±8.51 days than the Meerut farm (941.51±5.83 days). The variation in AFC depends mainly on the management practices followed in a farm, the health condition of the animals and the climatic conditions of the region. As both the farms studied are in the same agro-climatic condition, the same management practices followed as stipulated by the Frieswal project could justify the non-significant variation in AFC.

The effect of month of birth on AFC was highly significant statistically (Table 1). The cows born during February had the longest AFC of 979.95±15.58 days, while the cows born in December month had lowest AFC of 906.84±13.48 days (Table 2). Similar to these findings, Jadhav (1990), Arora *et al.* (1993), Jadhav and Khan (1996), Nayak and Raheja (1996), Panja (1997) Akhtar *et al.* (2003), PDC AR (2003–04) and Dubey and Singh (2005) reported significant influence of season of birth on AFC. On the contrary, non-significant influence of season on AFC was reported by Rana (1991), Singh (1995), Sahana (1996), Saha (2001), Mukherjee (2005) and Singh *et al.* (2014) in HF crossbred cattle.

Year of birth had highly significant (P<0.01) effect on AFC (Table 1). The cows born during 1992 had maximum average AFC of 1045.94±33.00 days, while the cows born during 2007 had the lowest mean of 852.04± 34.50 days (Table 2). This may be due to the fact that feeding and management practices of young stock varied from year to year and the young stock raised during the year of better nutrition grew faster than others.

The AFC in the years from 1998 was comparatively lower than the earlier years (1988 to 1997) and the decline in the AFC over the years may be due to the differential culling levels on the basis of reproductive fitness and variation in the feeding and management practices. In agreement to the present findings, Jadhav (1990), Singh (1995), Jadhav and Khan (1996), Nayak and Raheja (1996),

Table 1. Least squares analysis of variance (mean sum of squares) of first lactation reproduction traits

Effect	Trait						
	AFC	FSP	FCI	FDP	FLMY	FL305DMY	FLL
Sire (87)	18569.21	4994.98	4898.22	687.59	626254.64**	524371.84*	706.56
Farm (1)	37974.17	53383.90**	58111.92**	158.19	234536.98	476969.89	556.27
Month of birth/ calving (11)	38874.45**	61360.95**	59825.59**	541.36	381664.59	385161.33	391.92
Year of birth/ calving (20)	62768.79**	12745.46**	12374.30**	4923.77**	1909681.80**	1971107.26**	4904.85**
First service period groups (8)	—	—	—	202514.23**	13567366.67**	5669378.13**	166372.58**
AFC groups (8)	—	7295.79	7963.23	252.53	1303996.16**	1321141.53**	179.08
Error	16001.33 (1105)	4821.71 (1097)	4808.14 (1097)	638.81 (1089)	434726.58 (1089)	372488.51 (1089)	572.51 (1089)
R^2 value (%)	15.87	21.82	21.60	71.97	31.34	26.42	70.6

*Significant at 5% level (P<0.05); **Significant at 1% level (P<0.01).

Sahana (1996), Panja (1997), Saha (2001), Akhtar *et al.* (2003), PDC AR (2003–04), Mukherjee (2005), Dash (2014), Singh *et al.* (2014) reported significant effect of period of birth on AFC. However, the nonsignificant effect of year of birth on AFC was reported by Rana (1991), Arora *et al.* (1993) and Dubey and Singh (2005).

First service period (FSP): The overall least squares mean for FSP was 153.26±3.79 days (Table 2). Contrary to the present findings, many workers reported higher average FSP (Bhatia and Pandey 1990, Arora *et al.* 1993, Mukherjee 2005, PDC AR 2010–11) in HF crossbred cattle. However, lower estimates of average FSP were also obtained by Singh and Tomar (1991), Pyne and Dattagupta (1994), Singh (1995), Sahana (1996), Panja (1997), Saha (2001), Divya (2012) and Dash (2014) in HF crossbreds. The variation in FSP reported by different workers may be due to variation in the reproductive efficiency in terms of oestrus detection efficiency and timely breeding followed in different herds.

The least squares analysis revealed highly significant (P<0.01) variation in FSP between animals maintained in Meerut and Ambala farms. The FSP of Ambala farm (144.53±5.20 days) was significantly lower than the Meerut farm (161.98±3.93 days). Similar to the present finding, Mukherjee (2005) also reported significant variation in FSP of Frieswal animals maintained in different Military Farms. The significant difference between farms may be due to the variation in management efficiency like maintenance of reproductive history, proper heat detection, timely insemination and proper follow up for reinsemination etc.

Month of calving had statistically highly significant (P<0.01) influence on the FSP (Table 1). The shortest FSP of 118.95±10.55 days was reported for animals calved in October while the animals calved in April had the longest FSP of 196.58±7.06 days. Similar to the present findings, Arora *et al.* (1993), Sahana (1996), Panja (1997), Saha (2001), Mukherjee (2005) and Dash (2014) found significant variation in FSP of animals calved in different seasons. However, Singh (1995) and Divya (2012) found nonsignificant influence of season of calving on FSP.

The year of calving also had statistically highly significant influence (P<0.01) on FSP and the cows calved during year 2011 had the lowest service period of 61.77 ±45.50, while the cows calved during the period 1993 had the longest FSP of 196.39±19.95 days. Perusal of the Table 2 revealed no definite increasing or decreasing trend in FSP over the years which indicates the annual variation in reproductive efficiency due to the changes in feeding, breeding and reproductive management conditions in the herd over the years. Similar to the present finding, Sahana (1996), Panja (1997), Mukherjee (2005), Divya (2012) and Dash (2014) found significant effect of period of calving on FSP. On the contrary, Bhatia and Pandey (1990), Singh (1995) and Saha (2001) reported nonsignificant effect of period of calving on first service period.

The effect of AFC groups on the FSP was statistically nonsignificant. Panja (1997), Saha (2001) and Divya (2012) also reported nonsignificant effect of AFC on FSP in KF cattle. On the other hand, Sahana (1996) and Mukherjee (2005) reported significant influence of AFC on FSP in KF and Frieswal cattle, respectively. Our results revealed that cows with AFC lower than 789 days and higher than 923 days had comparatively longer service period than animals with the AFC range of 790–922 days indicating that the animals in this optimum AFC group are reproductively sound enough to conceive earlier than the animals in other AFC groups.

First dry period (FDP): The overall average FDP was 127.17±5.66 days in Frieswal cattle, which is well within the range reported by various workers in crossbred cattle of India. However, most of the workers (Singh and Tomar 1991, Singh 1995, Nayak and Raheja 1996, Panja 1997, Sahana and Gurnani 2000, Saha 2001, Akhtar *et al.* 2003, Singh and Gurnani 2004, Mukherjee 2005) estimated lower values than the value obtained in the present study. However, higher FDP value of 147 days in the same breed was reported in the Annual Report PDC (2008–09).

The present study showed nonsignificant influence of farm on the FDP in Frieswal cattle. The average FDPs in

Table 2. Least squares mean and standard error of age at first calving (AFC), first service period (FSP), first calving interval (FCI), first dry period (FDP), first lactation milk yield (FLMY), 305 days or less milk yield (FL305DMY) and first lactation length (FLL)

Effect	Nos.	AFC (days)	Nos.	Mean±SE					
				FSP (days)	FCI (days)	FDP (days)	FLMY (Kg)	FL305DMY (Kg)	FLL (Days)
Overall	1225	949.32±5.47	1225	153.26±3.79	432.92±3.73	127.17±1.43	2920.86±47.07	2765.91±42.84	307.49±1.51
Meerut	804	941.91±5.83	804	161.98b±3.93	442.02b±3.87	127.65±.48	2939.38±48.19	2792.33±43.89	306.59±1.56
Ambala	421	956.74±8.51	421	144.53a±5.20	423.81a±5.15	126.68±1.94	2902.33±58.16	2739.50±53.24	308.40±1.91
January	131	935.98^{bc}±12.72	147	143.63^{cd}±6.94	423.33^{cd}±6.90	128.16±2.58	2997.58±73.18	2837.80±67.27	307.41±2.54
February	80	979.95^{f}±15.58	111	165.10^{g}±7.64	445.15^{g}±7.60	131.02±2.84	2903.74±79.49	2781.63±68.46	303.40±2.78
March	93	962.85^{e}±14.59	130	178.05^{h}±7.07	457.26^{h}±7.03	125.05±2.63	2938.27±74.46	2763.47±68.46	309.12±2.59
April	86	945.9^{d}±15.33	135	196.58^{j}±7.06	476.91^{j}±7.02	126.99±2.64	2897.01±74.71	2729.69±68.69	308.46±2.60
May	75	967.06^{e}±16.36	110	187.22^{i}±7.66	465.97^{i}±7.62	124.21±2.83	2879.23±79.27	2715.00±72.94	309.71±2.77
June	58	966.19^{e}±18.46	73	159.86^{f}±9.09	437.70^{f}±9.05	122.74±3.35	2923.60±91.89	2757.40±84.68	310.68±3.24
July	107	930.21^{b}±13.94	80	150.77^{e}±8.82	429.67^{e}±8.78	125.37±3.24	2810.28±89.22	2655.67±82.20	308.79±3.14
August	120	943.27^{cd}±12.88	47	145.54^{d}±11.10	426.39^{de}±11.07	128.33±4.09	2943.20±110.48	2769.55±101.96	304.65±3.93
September	94	935.07^{b}±14.45	55	140.87^{c}±10.40	419.60^{c}±10.36	125.03±3.82	2849.99±103.62	2721.94±95.59	307.88±3.68
October	126	975.14^{f}±12.55	53	118.95^{a}±10.55	398.42^{a}±10.52	131.36±3.90	2881.52±105.62	2730.36±97.44	303.86±3.75
November	140	943.43^{cd}±12.22	122	131.65^{b}±7.24	413.14^{b}±7.20	129.68±2.69	2989.97±75.82	2844.01±69.73	307.38±2.64
December	115	906.84^{a}±13.48	162	120.84^{a}±6.48	401.44^{a}±6.44	128.06±2.45	3035.90±70.11	2884.46±64.40	308.61±2.42
1988	15	978.19^{j}±46.76	-	-	-	-			
1989	29	1000.81^{l}±36.56	-	-	-	-			
1990	33	975.65^{j}±35.54	-	-	-	-			
1991	35	961.62^{i}±34.76	22	163.67^{hi}±22.61	443.58^{hi}±22.57	119.61^{e}±8.26	2706.32^{c}±217.28	2522.65^{c}±200.96	314.26^{k}±7.85
1992	70	1045.94^{n}±33.00	35	148.96^{ef}±18.68	429.97^{e}±18.64	118.87^{e}±6.83	3110.74^{l}±180.35	2871.41^{gh}±166.75	315.92^{l}±6.50
1993	32	1038.02^{n}±32.51	34	196.39^{l}±19.95	476.11^{m}±19.91	105.38^{b}±7.30	2929.36^{f}±192.66	2605.97^{d}±178.16	330.09^{o}±6.95
1994	63	1001.76^{l}±21.09	36	143.69^{d}±18.02	424.77^{d}±17.98	114.47^{c}±6.18	2750.85^{d}±174.14	2518.45^{c}±160.99	321.57^{n}±6.27
1995	62	1009.45^{m}±25.22	62	134.02^{c}±16.87	415.57^{c}±16.84	122.88^{f}±5.23	2597.76^{b}±163.76	2396.97^{ab}±151.37	313.04^{k}±5.89
1996	52	1006.46^{lm}±22.94	36	160.21^{h}±14.26	439.94^{gh}±14.22	116.26^{d}±4.27	2602.17^{b}±139.38	2373.69^{a}±128.77	318.27^{m}±5.00
1997	69	991.17^{k}±19.94	66	179.04^{k}±11.64	458.63^{l}±11.60	92.42^{a}±4.72	2738.80^{d}±114.95	2418.28^{b}±106.11	342.31^{p}±4.10
1998	74	936.3^{g}±21.50	58	160.41^{h}±12.91	438.81^{g}±12.88	136.85^{j}±4.42	2949.40^{fg}±126.34	2884.16^{ghi}±116.68	296.12^{e}±4.52
1999	81	924.15^{ef}±20.18	53	161.46^{h}±12.07	438.93^{g}±12.03	137.13^{j}±3.80	2852.11^{e}±118.79	2797.99^{e}±109.67	294.44^{d}±4.24
2000	123	902.84^{d}±18.06	76	175.12^{k}±10.35	454.09^{k}±10.32	131.55^{i}±4.25	3138.07^{l}±103.28	3022.17^{j}±95.26	301.96^{g}±3.66
2001	129	898.93^{d}±20.01	72	154.58^{g}±11.56	434.43^{f}±11.53	132.13^{i}±3.46	3383.35^{m}±114.48	3232.44^{k}±105.66	303.79^{h}±4.08
2002	76	865.86^{b}±20.83	115	167.06^{ij}±9.42	446.55^{ij}±9.39	128.59^{h}±3.39	3065.28^{k}±94.76	2913.55^{i}±87.35	307.03^{i}±3.35
2003	67	930.42^{fg}±20.37	147	134.28^{c}±9.19	414.62^{c}±9.16	125.31^{g}±3.81	2996.65^{hi}±92.87	2826.50^{ef}±85.59	308.22^{i}±3.28
2004	59	945.99^{h}±22.35	100	145.11^{de}±10.40	422.87^{d}±10.36	119.95^{e}±4.25	3013.62^{ij}±103.53	2851.76^{fg}±95.51	309.75^{j}±3.67
2005	60	917.99^{e}±23.02	57	160.82^{h}±11.57	440.24^{gh}±11.54	131.00^{i}±4.53	2689.08^{c}±114.59	2578.47^{d}±105.77	304.43^{h}±4.08
2006	47	888.43^{c}±25.33	56	168.98^{j}±12.36	447.55^{ij}±12.32	138.80^{k}±4.40	2971.93^{gh}±121.65	2872.48^{gh}±112.33	297.51^{f}±4.34
2007	29	852.04^{a}±34.50	71	121.31^{b}±11.95	401.32^{b}±11.91	126.63^{g}±4.31	2677.01^{c}±118.20	2526.59^{c}±109.12	308.41^{ij}±4.22
2008	20	863.79^{b}±47.78	68	150.68^{fg}±11.73	431.35^{ef}±11.69	144.09^{l}±4.31	2494.42^{a}±116.02	2424.79^{b}±107.10	290.71^{c}±4.14
2009	-	-	34	169.64^{j}±16.19	450.70^{jk}±16.15	150.76^{n}±5.92	3035.82^{jk}±157.13	3013.60^{j}±145.23	284.74^{a}±5.65
2010	-	-	24	161.17^{h}±20.96	440.61^{gh}±20.92	146.98^{m}±7.68	3579.44^{n}±202.33	3526.97^{l}±187.12	287.8^{b}±7.30
2011	-	-	03	61.77^{a}±45.50	340.57^{a}±45.43	130.82^{i}±16.65	3055.8^{k}±435.23	2905.32^{hi}±402.79	307.01^{i}±15.77
1. (45–66)	-	-	-			94.08^{a}±2.64	2342.98^{a}±74.58	2329.15^{a}±68.57	243.33^{a}±2.59
2. (67–88)	-	-	-			95.64^{b}±2.49	2554.47^{b}±71.01	2532.3^{b}±68.57	261.45^{b}±2.45
3. (89–110)	-	-	-			102.22^{c}±2.62	2646.11^{c}±74.22	2633.14^{c}±68.24	277.41^{c}±2.58
4. (111–132)	-	-	-			103.52^{cd}±2.60	2822.21^{d}±73.64	2787.04^{d}±67.70	296.67^{d}±2.55
5. (133–154)	-	-	-			104.05^{d}±2.78	2920.75^{e}±77.93	2784.38^{d}±71.70	320.66^{e}±2.72
6. (155–176)	-	-	-			113.90^{e}±2.89	3126.67^{f}±80.75	2899.34^{e}±74.32	331.01^{f}±2.82
7. (177–220)	-	-	-			134.86^{f}±2.48	3254.93^{g}±7079	2973.81^{f}±65.04	342.49^{g}±2.45
8. (221–264)	-	-	-			178.77^{g}±2.60	3329.04^{i}±73.74	3033.45^{g}±67.79	342.90^{g}±2.56
9. (> 265)	-	-	-			217.46^{h}±2.62	3290.55^{h}±74.14	2920.62^{e}±68.16	351.54^{h}±2.57
1. (590–722)	-	-	23	152.06±15.46	433.63±15.43	127.17±5.66	2785.95^{b}±150.36	2576.80^{a}±138.95	310.23±5.40
2. (723–789)	-	-	113	150.27±7.46	430.05±7.42	125.31±2.75	2753.17^{a}±77.24	2603.45^{a}±71.05	308.59±2.69
3. (790-855)	-	-	240	140.19±5.64	419.11±5.59	128.30±2.10	2814.74^{c}±61.88	2678.16^{b}±56.72	306.46±2.10
4. (856-922)	-	-	258	142.61±5.43	421.48±5.39	127.32±2.02	2836.62^{d}±60.01	2693.71^{b}±54.97	306.71±2.03
5. (923-989)	-	-	212	152.54±5.90	431.75±5.85	128.03±2.19	2911.81^{e}±63.84	2757.64^{c}±58.55	306.44±2.18
6. (990-1056)	-	-	146	157.63±6.74	437.37±6.69	127.05±2.48	3019.96^{f}±7088	2874.35^{e}±65.13	308.65±2.45
7. (1057–1123)	-	-	99	159.30±7.93	437.97±7.90	123.84±2.92	3103.56^{h}±81.36	2964.99^{f}±74.89	308.86±2.85
8. (1124-1190)	-	-	68	159.79±9.37	439.63±9.33	129.05±3.44	3058.03^{g}±94.10	2907.82^{e}±86.73	305.34±3.32
9. (1191 >)	-	-	66	164.90±9.56	445.23±9.52	128.42±3.51	3003.87^{f}±95.91	2836.32^{d}±88.42	306.17±3.39

Means bearing same superscript in a column did not differ significantly.

Meerut and Ambala farms were estimated as 127.65±1.48 and 126.68±1.94 days, respectively. However, Mukherjee (2005) in his study on Frieswal cattle found significant effect of farm on the FDP. This variation of the effect of farm on FDP might be due to different farms included in the study, management practices followed and availability of feed resources etc.

The influence of month of calving on FDP was nonsignificant. The cows calved during June had the lowest dry period of 122.74±3.35 days (Table 2). The cows calved in October had the longest average dry period of 131.36 ± 3.90 days. The non-significant effect of season of calving on FDP was also reported by earlier workers (Singh and Tomar 1991, Singh 1995, Panja 1997, Sahana and Gurnani 2000, Saha 2001, Singh and Gurnani 2004) in different crossbred cattle. However, a few workers (Nayak and Raheja 1996, Akhtar *et al.* 2003, Mukherjee 2005) reported significant effect of season on FDP in crossbred cattle.

The least squares analysis of variance revealed that the year of calving had highly significant (P<0.01) effect on FDP (Table 1) in Frieswal cattle. Similar to this finding, Akhter *et al*. (2003) and Mukherjee (2005) reported significant influence of period of calving on FDP. However, nonsignificant influence of period of calving on this trait was also observed by Panja (1997), Sahana and Gurnani (2000), Saha (2001) and Singh and Gurnani (2004) in different crossbred cattle. The FDP was the shortest (92.42 ±4.72 days) for the year 1997 and the longest (150.76±5.92 days) for the year 2009. Based on the results obtained in the present study, it may also be inferred that the FDP was comparatively lower during the period from 1991–1997 while it was higher in the later years which was evident during the period from 2008–2011. The variation in DP over the years may be due to the variation in the management practices viz., variation in the reproductive management, health status of the animals, heat detection, AI efficiency etc.

The results of the least squares analysis revealed that the service period had highly significant (P<0.01) effect on the FDP. From the Table 2 it may be noticed that the FDP was the longest (217.46±2.62 days) for those animals having longest days open (>265 days) and shortest (94.08±2.64 days) for animals having the shortest service period (<66 days). The study also revealed a definite increasing trend of FDP on increase in the FSP.

The effect of AFC groups on the FDP was nonsignificant (Table 1). This result was in accordance with the results of Panja (1997), Sahana and Gurnani (2000) and Saha (2001) who reported that the effect of AFC on FDP was nonsignificant in different KF cattle. However, Mukherjee (2005) found significant effect of AFC on FDP in Frieswal cattle. The FDP was longest (129.05±3.44 days) for the AFC group of 1124–1190 days and lowest (123.84±2.92 days) for the AFC group of 1057–1123 days.

First calving interval (FCI): The least squares analysis of variance revealed an overall average calving interval of 432.92±3.73 days in Frieswal cattle and is similar to the estimate of 435.31±2.69 days reported by Mukherjee (2005) in the same breed. Jadhav (1991), Rana (1991) and Raheja (1994) also found similar estimates in HF × S crossbreds. However, Panja (1997), Sahana and Gurnani (2000), Akhtar *et al.* (2003) and Dash (2014) reported lower estimates 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. The Meerut farm had an average FCI of 442.02±3.87 days while the Ambala farm had 423.81±5.15 days. The higher FCI in Meerut farm was as expected because of the increased FSP found in that farm. As the FCI directly depends on the FSP, reducing this trait could have increased the FCI of the Meerut farm. In accordance with the result obtained in the present study, Mukherjee (2005) also reported significant effect of farm on FCI in Frieswal cattle.

The month of calving had highly significant (P<0.01) effect on the FCI in Frieswal cattle which confirms the reports of Jadhav *et al.* (1991), Rana (1991), Raheja (1994), Akhter *et al.* (2005) Mukherjee (2005) in HF × S crossbreds, while Panja (1997), Sahana and Gurnani (2000), Saha (2001) and Dash (2014) also found similar results in KF crossbreds. The animals calved in the month of October had the lowest FCI of 398.42±10.52 days while the animals calved in April had the highest FCI of 476.91±7.02 days. The figures given in Table 2 also showed that the FSP estimates corresponding to these months also revealed the similar trends indicating that the FSP mainly determines the FCI.

The FCI in Frieswal cattle was significantly (P<0.01) different among the different years of calving. The animals calved during 1993 had the highest FCI of 476.11±19.91 days while the year 2011 had the lowest FCI of 340.57±45.43 days. The results of the study could not reveal any specific trend in FCI over the years but were similar to the changes noticed in FSP. Jadhav *et al.* (1991), Rana (1991), Raheja (1994) and Mukherjee (2005) found significant effect of period of calving on FCI in HF × S cattle. Dash (2014) found significant effect of period of calving on FCI in KF cattle. However, Panja (1997), Saha (2001) and Akhter *et al.* (2003) found nonsignificant effect of period of calving on the FCI in various crossbred cattle.

The analysis of the effect of AFC groups on FCI revealed statistically nonsignificant variation in Frieswal cattle. Similar to the present result, Panja (1997) and Saha (2001) also found non-significant effect of AFC group on FCI in KF 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. The results of the study revealed that cows with AFC range of 790–922 days had the lowest FCI indicating that animals in this AFC group are reproductively sound enough to calve earlier than the animals in other AFC groups.

First lactation milk yield (FLMY): The overall least squares mean for FLMY in the present study was

2920.86±47.07 kg (Table 2) which is well within the range of the earlier studies reported in crossbred cattle. Similar estimates of average FLMY were observed by Mandal and Sachdeva (2001) in KS cattle, Akhtar *et al.* (2003) in HF × S crossbred, Kumar *et al.* (2008) in Frieswal and Rasia *et al.* (2009) in KF cattle. This average estimate of FLMY was higher than the values reported by other workers (Nayak and Raheja 1996, Dutt and Kumar 2000, Saha 2001, Thakur and Singh 2001, Bhattacharya *et al.* 2002, Radhika *et al.* 2012, Hassan and Khan 2013, Sooraj 2013) in different crossbred cattle. On the other hand, Sinha (1999) in KF, Annual Report PDC (1999–2000) in Frieswal, Sahana and Gurnani (2000) in KF, Singh *et al*. (2008) in HF × S crossbred and Nehra (2011) and Dash (2014) in KF reported higher estimate of FLMY in crossbred cattle. The difference in the estimates of average FLMY reported by many researchers may be attributed to the difference in the breeds used for crossing, herds, reproductive management strategies and time/ period considered.

The effect of farm on FLMY was found to be statistically nonsignificant (Table 1). However, the cows in Meerut farm had higher FLMY of 2939.38±48.19 kg, while in Ambala farm the yield was 2902.33±58.16 kg (Table 2). However, the earlier studies (Annual report PDC 1999–2000, Mukherjee 2005, Hassan and Khan 2013) reported significant effect of farm on this trait. The difference in the effect of farm on FLMY might be attributed to the different farms included in the study. Only two farms were selected for the present study, situated in a similar agro-climatic region maintained under similar managemental conditions.

Month of calving did not influence the FLMY significantly. The cows calved during July had the lowest average FLMY of 2810.28±89.22 kg, while the highest average yield of 3035.90±70.11 kg was found during December. In general, the FLMY was higher during winter compared to summer. The variation in the FLMY may be attributed to the change in climatic conditions as maximum FLMY was obtained during the winter while the FLMY was lowest during the summer even though the difference was not statistically significant which could be due to the endurance of Frieswal cattle to the hot tropical climatic conditions with respect to FLMY. Singh and Gurnani (2004), Mukherjee (2005), Kokate (2009) found significant effect while Sivakumar (1998) and Nehra (2011) found nonsignificant effect of season of calving on this trait in different crossbred cattle.

The year of calving had highly significant ($P<0.01$) effect on the FLMY and the least squares average for FLMY ranged between 2494.42±116.02 kg during the year 2008 to 3579.44±202.33 kg during the year 2010. It was also noticed that the average FLMY was higher during the years 2000–2004 and 2009–2011. During the initial stages of crossbreeding experiment to develop the Frieswal cattle, the low producing indigenous cattle having mixed blood of Sahiwal, Tharparkar etc. were used which resulted in lower average FLMY; with the introduction of superior exotic germplasm and scientific selection of cows and bulls in the later years helped to increase the FLMY to a larger extent. No study is available on the effect of year of calving on FLMY as most of the workers have combined the years into periods. Mandal and Sachdeva (2001), Saha (2001), Bhattacharya *et al*. (2002), Akhtar *et al*. (2003) and Mukherjee (2005) reported significant effect of period of calving while Sinha (1999), Sahana and Gurnani (2000), Saha (2001), Nehra (2011), Radhika *et al.* (2012) reported non-significant effect of period of calving on first lactation milk yield.

The results revealed the highly significant ($P<0.01$) influence of service period on FLMY (Table 1). Least squares means showed a definite increasing trend with the increase in service period. The average FLMY was lowest (2342.98±74.58 kg) for the animals having the lowest service period of 45–66 days while it was highest (3329.04±73.74 kg) for the animals having service period of 221–264 days. From the results it can be inferred that the animals having short service period had lesser FLMY than the animals having longer service period and it may be due to the fact that early conceivers become dry earlier to facilitate the second calving and the late conceivers may be in milk for a comparatively longer period.

The least squares analysis revealed that the age at first calving had highly significant effect ($P<0.01$) on the FLMY (Table 1). Similar to the present findings, Sahana and Gurnani (2000) and Saha (2001) in KF cattle; Akhtar *et al.* (2003) in HF × S and Mukherjee (2005) in Frieswal showed significant variation in FLMY due to the age at first calving. However, Saha (2001) and Nehra (2011) reported nonsignificant effect of AFC on FLMY in KS and KF cattle, respectively. In the present study, lowest FLMY of 2753.17±77.24 kg was obtained for the AFC group of 723–789 days while highest average of 3103.56±81.36 kg was noticed for animals having AFC between 1057–1123 days. Based on the results obtained in the present study, it may be inferred that the early first calvers may not be able to cope up with the energy requirement for higher milk production while the cows calved at an optimum age have sufficient energy reserve to retain the higher milk production as well as to maintain the optimum lactation length.

First lactation 305-day or less milk yield (FL305DMY): The least squares analysis revealed an overall least squares mean of 2765.91±42.84 kg for FL305DMY in Frieswal cattle which was comparable with the earlier reports of Annual Report PDC (2003–04) and Mukherjee (2005) for the same breed. However, Saha (2001) found a lower estimate of 2470.00±20.00 kg, while Dash (2014) found higher estimates (3027.11±2031 kg) in KF cattle. The differences in the estimates of average FL305DMY reported by many researchers could be due to sampling variations, as different studies were based on small and different number of observations or herd to herd differences or differences that might have occurred over time depending on the period to which the data pertained.

The average FL305DMY for Meerut farm was 2792.33±43.89 kg, while the corresponding estimate for

Ambala farm was 2739.50 ± 53.24 kg and the differences were statistically non-significant. The similar managemental practices followed in both the farms and similar climatic conditions have resulted in similar FL305DMY. Mukherjee (2005) also found nonsignificant difference between Ambala and Meerut farms.

The cows calved in December had the maximum FL305DMY of 2884.46±64.40 kg followed by the November calvers (2844.01±69.73 kg). Similar to the FLMY, the average FL305DMY of animals calved in winter i.e. November to February was higher than the animals calved in other months which may be due to availability of good quality fodder in sufficient amount and favourable climatic conditions. On the contrary, the animals calved during the summer months had comparatively lower FL305DMY which may be due to higher humidity and heat stress. However, the differences between different months were statistically nonsignificant and hence it may be deduced that the milch stock was maintained under optimum management conditions round the year. The nonsignificant effect of month/ season of calving on FL305DMY was also reported by many workers (Singh 1995, Panja 1997, Sivakumar 1998, Singh *et al.* 2006, Rashia 2010, Nehra 2011, Divya 2012) in KF cattle. Contrary to the present study, significant effect of month/season of calving on FL305DMY has been documented by Sahana (1996), Sinha (1999), Saha (2001), Annual Report PDC (2003–04), Singh and Gurnani (2004), Mukherjee (2005), Kokate (2009) in different crossbred cattle.

The FL305DMY of cows calved during different years showed a wide variation and the effect of year was highly significant (P<0.01). The present finding was in accordance with the reports of Singh (1995), Sahana (1996), Sinha (1999), Saha (2001), Annual Report PDC (2003–04), Mukherjee (2005), Singh *et al.* (2006), Kokate (2009) and Dash (2014) who found significant effect of period of calving on this trait. However, Panja (1997), Sinha (1999), Singh and Gurnani (2004), Nehra (2011) and Divya (2012) reported that the effect of period on FL305DMY was not significant. It can be noticed from the Table 2 that there was no specific trend for this trait throughout the years of study and the average FL305DMY was highest (3526.97±187.12 kg) for the cows calved during 2010 and lowest (2373.69±128.77 kg) during the year 1996. The differences in FL305DMY over the periods may be attributed to the differential culling levels on the basis of production and difference in feeding and managemental practices besides the changing genetic structure of the population.

The results of the least squares analysis revealed statistically highly significant (P<0.01) effect of service period on FL305DMY (Table 1). Maximum average FL305DMY of 3033.45±67.79 kg was obtained for animals having days open between 221–264 days and the yield was minimum (2329.15±68.57 kg) for the animals having days open between 45–66 days. From the Table 2, it can be inferred that the animals having shorter daysopen had lesser FL305DMY than the animals having longer days open as seen in the FLMY.

The least squares analysis revealed that the AFC group had highly significant (P<0.01) effect on the FL305DMY (Table 1). This finding was similar to the results reported by Sahana (1996) in KF cattle, Annual Report PDC (2003–04) and Mukherjee (2005) in Frieswal cattle. However, Singh (1995), Panja (1997) and Divya (2012) reported non-significant effect of AFC on FL305DMY in KF cattle. Highest average FL305DMY of 2964.99±74.89 kg was obtained for cows with the AFC ranging from 1057–1123 days while lowest yield was recorded for animals within the range of 590–722 days of AFC. The study also revealed that the increase in AFC up to 1123 days showed an increase in the FL305DMY and further increase resulted in decreased FL305DMY.

First lactation length (FLL): The least square estimate of overall population mean for FLL in Frieswal cattle was 307.49±1.51 days (Table 2) which is similar to the value reported by Kumar *et al.* (2008) in the same breed. Various workers (Biradar *et al.* 1993, Saha 2001, Bhattacharya *et al.* 2002) reported similar estimates in different crossbred cattle. However, various other workers (Singh 1995, Nayak and Raheja 1996, Sahana 1996, Panja 1997, Sivakumar 1998, Sinha 1999, Sahana and Gurnani 2000, PDC AR 2003–04, Nehra *et al.* 2011, Dash 2014) reported higher estimates of FLL than the value obtained in the present study.

The study revealed that the FLL of Frieswal cattle maintained at Ambala farm (308.40±1.91 days) was slightly higher than the Meerut farm (306.59±1.56 days) and the difference between farms was statistically non-significant (Table 1). However, Mukherjee (2005) reported significant variation in FLL of Frieswal cattle maintained in 6 different Military Farms.

The results of the study revealed that the influence of month of calving on FLL was statistically non-significant (Table 1). The animals calved during February had shortest FLL of 303.40±2.78 days and the June calvers had longest lactation length of 310.68±3.24 days, and the estimates obtained for different months were well within this short range. The non-significant effect of month/season of calving on FLL observed in the present study was in agreement with the findings of Nayak and Raheja (1996), Saha (2001), Bhattacharya *et al.* (2002), Akhtar *et al.* (2003) and Nehra *et al.* (2012). However, Jadhav (1993), Singh (1995), Sahana (1996), Panja (1997), Sahana and Gurnani (2000), PDC AR (2003–04), Mukherjee (2005) reported significant effect of season of calving on FLL in different HF crossbred cattle.

The effect of year of calving on FLL was statistically highly significant (P<0.01). The average FLL was highest (342.31±4.10 days) for the year 1997 and lowest (284.74±5.65 days) in the year 2009 (Table 2). Most of the workers (Biradar *et al.* 1993, Jadav 1993, Singh 1995, Nayak and Raheja 1996, Sahana 1996, Panja 1997, Sivakumar 1998, Sahana and Gurnani 2000, Bhattacharya *et al.* 2002, PDC AR 2003–04, Mukherjee 2005, Kumar *et al*. 2008, Nehra 2011, Dash 2014) reported highly significant effect of period of calving on FLL in different HF crossbred cattle; while Sinha (1999), Saha (2001) and Akhtar *et al.* (2003) reported nonsignificant influence of period of calving on this trait.

The effect of service period was highly significant (P<0.01) on FLL. The least squares means of FLL was minimum for animals having lower service and vice versa. It was inferred that the FLL consistently increased as the service period increased and it seemed that the animals conceived earlier had dried earlier due to the physiological changes during pregnancy as compared to the animals conceived later having longer service period.

The effect of AFC groups on the FLL was found to be statistically nonsignificant (Table1). It was apparent from the results that there was not much variation in FLL among different AFC Groups. The nonsignificant effect of AFC on FLL in different HF crossbred cattle was also reported by Biradar *et al.* (1993), Panja (1997), Sinha (1999), Saha (2001), PDC AR (2003–04) and Nehra *et al*. (2011). However, Jadhav (1993), Singh (1995), Sahana (1996), Sivakumar (1998), Sahana and Gurnani (2000) and Mukherjee (2005) reported statistically significant (P<0.05) effect of AFC on FLL in HF crosses.

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