Genetic Studies and Development of Prediction Equations in Jersey×Sahiwal and Holstein-Friesian×Sahiwal Half Breds

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ABSTRACT : First lactation records (174) of Jersey×Sahiwal and Holstein Friesian×Sahiwal half breds under 9 sires maintained at Chandra Shekher Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India from 1975-1983, were used to estimate the genetic parameters and to predict herd life milk yield and average milk yield per day of herd life from first lactation traits. The traits included were: age at first calving, first service period, first lactation period, first calving interval, first lactation milk yield, milk yield per day of first calving interval, herd life milk yield, herd life and average milk yield per day of herd life. Most of the production and reproduction traits were found to have positive and significant correlations between them on genetic as well as phenotypic scales. Total twelve regression equations were fitted. The prediction equation of herd life milk yield in both the genetic groups showed linear relationship with AFC, FSP, FLP, FLMY and MY/DCI and was apparent and significant. Similarly, polynomials for milk yield per day of herd life for J×S and HF×S half breds also showed linear trend, which was found highly significant. The highest and lowest R^2 values were found for FCI and AFC, respectively. ***(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 2 : 179-184)***

Key Words : Genetic Study, Prediction Equations, Jersey, Holstein-friesian, Sahiwal

INTRODUCTION

Milk production of a dairy farm can be increased either by increasing the number of lactating animals or by exploiting the production potential of the milking animals by cross breeding of native breeds with high quality bulls of exotic breeds under standard managemental conditions provided to them. The second preposition is best suited to the present day needs and resources available.

The Holstein Friesian and Jersey are the best dairy cattle breeds of temperate region and Sahiwal is the best dairy cattle breed of tropical region of world, particularly in the Indian sub-continent. Holstein Friesian and Jersey breeds are well known for very high genetic potential for milk production but in spite of higher production potential, they are prone to some fatal diseases like Foot and Mouth Disease, Foot Rot etc. Sahiwal cattle has also well recognized for their high production potential and in addition to this they are having comparatively higher degree of heat tolerance, disease resistance and resistance to internal and external parasites. Therefore, it was thought better to combine genes for these two good qualities by making crosses between them.

Current milk production alone may not be a reliable criterion of selecting the animals for higher economic return as factors may significantly affect the further milk production. Attempts have been made by various workers for production of lifetime milk yield in indigenous and exotic pure bred and crossbred animals. Major emphasis should, therefore, be laid on production as a criterion of selection of dairy cattle. Therefore, it appears essential to predict the herd life milk yield on the basis of reproduction and production traits for judicious culling of inferior stock, which will result in profitable dairy. In view of the above, present study was undertaken to evaluate and compare first lactation traits and to predict the herd life milk yield and average milk yield per day of herd life based on production and reproduction traits in Holstein Friesian×Sahiwal and Jersey×Sahiwal cross breds.

MATERIALS AND METHODS

Data collected for age at first calving (AFC), first service period (FSP), first lactation period (FLP), first calving interval (FCI), first lactation milk yield (FLMY), milk yield per day of first calving interval (MY/DCI), herd life milk yield (HLMY), herd life (HL) and average milk yield per day of herd life (MY/DHL) on 174 Jersey×Sahiwal and Holstein Friesian×Sahiwal half breds sired by 9 sires maintained at Chandra Shekher Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India during 1975-1983 were analyzed for the present investigation. The animals that have not completed at least three lactations were not included in this study. Some of animals were also excluded as suspected outliers by subjective judgment based on histogram of various traits.

Least squares technique described by Harvey (1979) was applied to estimate the effect of non-genetic factors.

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Received August 7, 2003; Accepted October 4, 2004

Table 1. Means with their standard errors and coefficients of variation for reproductive and productive traits in Jersey×Sahiwal and Holstein Friesian×Sahiwal half breds

S.N.	Traits	Jersey×Sahiwal (99)*			Holstein Friesian×Sahiwal (75)*		
		Mean	S.E.	C.V.	Mean	S.E.	C.V.
A.	Reproductive traits						
1	Age at first calving (days)	947.36	17.05	17.82	983.65	19.47	17.14
2	First service period (days)	170.05	11.22	65.36	166.54	12.44	64.70
3	First lactation period (days)	333.66	7.69	22.82	346.41	7.74	19.36
4	First calving interval (days)	444.28	10.21	22.75	444.69	13.04	25.39
B	Productive traits						
5	First lactation milk yield (liters)	2,810.28	68.97	24.29	3,030.34	92.97	26.56
6	Milk yield per day of first calving interval (liters)	6.45	0.14	22.14	6.83	0.20	26.05
7	Herd life milk yield (liters) (up to 3rd lactations)	8129.06	129.05	15.71	8,598.78	269.34	27.13
8	Herd life (days) (up to 3rd lactations)	1,269.53	20.06	15.64	1,325.84	41.67	27.22
9	Average milk yield per day of herd life (days) (up to 3rd lactations)	6.49	0.11	18.13	6.68	0.17	22.83

* Figures within parentheses are No. of observations in the respective genetic group.

The year of calving make the first source of variation for all traits except age at first calving, which was analyzed according to year of birth of the animals. A calendar year was also divided into four seasons, winter (S_1)-December to February; summer (S_2)-March to May; rainy (S_3)-June to August and Autumn (S_4)-September to November depending upon the agro climatic conditions and availability of green fodder at dairy farms.

The following linear mathematical model was used to estimate the environmental effects.

$$Y_{ijk} = \mu+P_i+S_j+e_{ijk}$$

where,

Y_{ijk} = k^{th} observation belonging to j^{th} season and i^{th} year

μ=over all mean

P_i = effect of i^{th} year of calving (i=1,2, ------9)

S_j = effect of j^{th} season of calving (j=1----4)

e_{ijk} = random error assumed to be NID with mean zero and variance σ^2.

To remove the fixed effects, data were adjusted for each significant item of source of variation as follows: CF=P_i+S_j, CF is the correction factor for the observation under i^{th} year and j^{th} season. Data were adjusted as per Gocula et al. (1968) using additive correction factor with sign changed. Then adjusted records will be as follows:

$$Y_{ijk} = Y_{ijk}-[P_i+S_j]$$

Where,

Y_{ijk} = the actual record of k^{th} animal under P^{th} year and S^{th} season

P_i = i^{th} year constant

S_j = j^{th} season constant

Genetic and phenotypic variances and covariances were estimated according to Harvey (1979) applying paternal half sib correlation method. Heritability estimates (h^2) were computed using formula given by Falconer (1960) and the standard errors of the heritabilities were calculated as per Swiger et al. (1964). Genetic correlations and their standard errors were computed as outlined by Hazel et al. (1943) and Robertson (1959) whereas formula designed by Searle (1961) and Panse and Sukhatme (1967) was used to compute phenotypic correlations and their standard errors, respectively.

Third degree polynomial regression analysis of productive and reproductive traits on herd life milk yield and average milk yield per day of herd life was made as per following mathematical expression:

$$Y = h_1X+h_2X^2+h_3X^3 + \text{--------------} h_nX^n$$

where,

Y = dependent variable ie. Productive and reproductive traits

X = independent variable (herd life milk yield and average milk yield per day of herd life)

h_1,h_2,h_3 ---- h_n = regression coefficients

Total twelve third degree polynomial regression equations of herd life milk yield and average milk yield per day of herd life on productive and reproductive traits were fitted. The importance of independent variable in predicting dependent variable was judged by means of R^2 values (coefficient of determination). R^2 was estimated as follows:

$$R^2 = \frac{b_1\left(XY-\frac{XY}{n}\right)+b_2\left(X^2Y-\frac{X^2Y}{n}\right)+b_3\left(X^3Y-\frac{X^3Y}{n}\right)}{Y^2-\frac{((Y)^2)}{n}}$$

First and second order derivatives were marked out and equated to zero respectively and the maximum and minimum levels of traits were determined.

Table 2. Heritabilities, genetic, phenotypic and environmental correlations between reproductive and productive traits in Jersey× Sahiwal half breds

Trait		AFC	FSP	FLP	FCI	FLMY	FLMY/DCI	HLMY	HL	FLMY/HL
AFC		0.15±0.18								
FSP	r_g	1.06±0.01*								
	r_p	0.59±0.07*	0.93±0.11							
	r_e	-3.68								
FLP	r_g	1.08±0.01*	1.07±0.01*							
	r_p	0.36±0.09*	0.56±0.06*	0.11±0.14						
	r_e	-4.11	6.18							
FCI	r_g	1.09±0.01*	1.01±0.01*	1.10±0.01*						
	r_p	0.50±0.07*	0.94±0.01*	0.51±0.07*	0.77±0.03					
	r_e	-1.20	1.16	0.39						
FLMY	r_g	1.27±0.02*	1.23±0.01*	1.11±0.01*	1.24±0.01*					
	r_p	0.15±0.09*	0.43±0.08*	0.77±0.03*	0.41±0.08*	0.31±0.09				
	r_e	-1.98	0.66	-3.09	-0.53					
FLMY/DCI	r_g	-0.01±0.01	-0.03±0.01	-0.33±0.01*	0.02±0.01	-0.71±0.01*				
	r_p	-0.24±0.09*	-0.35±0.08*	0.28±0.09*	-0.42±0.08*	0.61±0.06*	0.17±0.01			
	r_e	-0.21	1.25	1.13	-0.84	0.87				
HLMY	r_g	0.46±0.01*	0.39±0.01*	0.29±0.01*	0.41±0.01*	0.02±0.01	-0.62±0.01*			
	r_p	0.01±0.10	0.18±0.09*	0.41±0.08*	0.17±0.09*	0.65±0.05*	0.47±0.07*	0.16±0.01		
	r_e	-0.27	0.12	0.77	0.05	0.72	0.49			
HL	r_g	1.01±0.01*	1.02±0.01*	1.05±0.01*	1.02±0.01*	1.24±0.01*	-0.02±0.01	0.35±0.01*		
	r_p	0.34±0.08*	0.54±0.07*	0.42±0.08*	0.58±0.06*	0.32±0.09*	-0.14±0.09*	0.25±0.09*	0.76±0.09	
	r_e	-2.24	-2.81	-3.46	-1.07	-0.77	-0.28	0.25		
FLMY/HL	r_g	-1.17±0.11*	-1.23±0.12*	-1.34±0.13*	-1.24±0.12*	-1.82±0.15*	-0.41±0.01*	-1.20±0.02*	-1.23±0.13*	
	r_p	-0.25±0.09*	0.26±0.09*	-0.01±0.10	-0.29±0.09*	0.27±0.09*	0.51±0.07*	0.61±0.06*	-0.59±0.06*	0.22±0.06
	r_e	0.68	1.36	2.18	0.55	1.06	0.62	0.89	-0.16	

Correlations of 0.062 and above are significant at 5% level and of 0.081 or above are significant at 1% level of significance.
Values exactly on diagonal are heritabilities.

RESULTS AND DISCUSSION

Mean

The means along with their standard errors and coefficient of variation for production and reproduction traits in Jersey×Sahiwal and Holstein Friesian×Sahiwal half breds are presented in Table 1. Average age of first calving was found quite higher for HF×Sahiwal (983.65±90.47 days) than J×Sahiwal (947.39±17.05 days) cross indicating that the crossbred of Sahiwal were able to deliver the calf earlier than that of purebred Sahiwal. However, Singh et al. (1996), Tomar et al. (1996) and Ahmad and Javed (2001) have observed higher age at first calving in HF×S cross. Bharti et al. (1996) computed quite lower AFC whereas Singh et al. (1996) have estimated higher values than the present study in Jersey and Sahiwal crosses.

The observed FSP was fairly comparable with the reports of Prasad (1983), Roy (1983) and Singh (1988) while longer service period than the present investigation was observed by Ahmad and Javed (2001). As far as FLP is concerned, Prasad (1983), Singh (1983) and Tomar et al. (1997) have strongly supported our results in HF×S crosses but Tomar et al. (1996), Thakur and Singh (2000) and Ahmad and Javed (2001) have estimated somewhat longer lactation period in the same genetic group. The present observations were in accordance with the reports of Bharti et al. (1996) and Singh et al. (1996) in Jersey and Sahiwal cross. First Calving Interval in J×S as well as HF×S was computed exactly similar (444 days) and confirmed by Gandhi and Gurnani (1987). However, longer calving interval was estimated by Tomar et al. (1996), Tomar et al. (1997) but fairly comparable with the reports of Singh et al. (1996) in HF×S cross. Singh et al. (1996) have observed higher value (467.32±23.93 days) whereas Bharti et al. (1996) have computed lower estimates for the trait in J×S cross. The differences in the mean performances of the trait may be attributed to environmental reasons. Average first lactation milk yield was found to be 2,810.28±68.67 and 3,030.34±92.97 liters in J×S and HF×S crosses, respectively. Mean phenotypic values observed in this study was in close agreement with the reports of Hegde and Bhatnagar (1986) and Singh et al. (1986). However, higher FLMY was reported by Bharti et al. (1996) in J×S whereas lower values were studied by Singh et al. (1996) in the same genetic group. Tomar et al. (1996), Thakur and Singh (2000) and Ahmad et al. (2001) worked out lower lactation milk yield as compared to present investigation in HF×S cross.

Milk yield per day of first calving interval was obtained

Table 3. Heritabilities, genetic, phenotypic and environmental correlations between reproductive and productive traits in Holstein Friesian×Sahiwal half breds

Trait		AFC	FSP	FLP	FCI	FLMY	FLMY/DCI	HLMY	HL	FLMY/HL
AFC										
		0.84±0.09								
FSP	r_g	-0.73±0.09*								
	r_p	0.05±0.11	0.12±0.13							
	r_e	3.83								
FLP	r_g	-0.70±0.09*	0.93±0.01*							
	r_p	0.46±0.12*	0.53±0.08*	0.86±0.10						
	r_e	4.54	-2.60							
FCI	r_g	-1.08±0.13*	1.28±0.01*	1.15±0.01*						
	r_p	0.03±0.11	0.82±0.03*	0.45±0.09*	0.19±0.03					
	r_e	4.33	-3.91	-0.16						
FLMY	r_g	-0.72±0.09*	0.95±0.01*	1.24±0.02*	1.24±0.01*					
	r_p	0.08±0.12*	0.46±0.09*	0.54±0.08*	0.42±0.09*	0.11±0.13				
	r_e	1.30	0.50	-4.58	-0.45					
FLMY/DCI	r_g	-0.49±0.08*	0.82±0.01*	1.17±0.01*	1.06±0.01*	1.32±0.02*				
	r_p	0.04±0.11	0.11±0.11*	0.39±0.09*	0.56±0.07*	0.25±0.10*	0.46±0.06			
	r_e	1.10	-2.15	-1.29	-0.96	-0.71				
HLMY	r_g	-0.45±0.07*	0.65±0.02*	1.04±0.01*	1.00±0.01*	0.90±0.01*	1.19±0.01*			
	r_p	0.10±0.11	0.37±0.09*	0.64±0.06*	0.67±0.06*	0.32±0.10*	0.50±0.08*	0.14±0.14		
	r_e	1.59	-1.65	-2.22	-0.24	-2.55	-0.99			
HL	r_g	0.02±0.03	0.10±0.03*	0.75±0.01*	0.72±0.01*	0.012±0.03	1.20±0.01*	0.90±0.01*		
	r_p	0.02±0.11	0.32±0.01*	0.25±0.10*	0.17±0.11*	0.34±0.10*	0.04±0.11	0.33±0.10*	0.13±0.01	
	r_e	-0.07	0.58	-0.01	0.35	-0.28	-0.42	-0.08		
FLMY/HL	r_g	-0.84±0.10*	0.88±0.01*	1.23±0.01*	1.16±0.01*	1.25±0.02*	1.22±0.01*	1.01±0.01*	1.34±0.01*	
	r_p	0.09±0.11*	0.12±0.11*	0.38±0.09*	0.53±0.08*	0.04±0.11	0.56±0.07*	0.73±0.05*	0.23±0.11*	0.51±0.10
	r_e	1.66	-1.81	-1.73	0.55	-1.41	-0.06	-0.40	-0.78	

Correlations of 0.062 and above are significant at 5% level and of 0.081 or above are significant at 1% level of significance.
Values exactly on diagonal are heritabilities.

by dividing FLMY by FCI. The MY/DCI in both groups was in agreement with the reports of Prasad (1983) and Reddy and Basu (1985). However, very low estimate for this trait was reported by Ahmad et al. (2001). Herd life milk yield (Cumulative milk yield of three lactations) was observed to be 8,129.06±129.09 and 8,598.78±269.34 liters in J×Sahiwal and HF×Sahiwal crosses, respectively and confirmed with those reported by Prasad (1983) and Singh (1988). The coefficient of variation was more (27.22%) in HF×S cross than that of J×S (15.64%). Our results were in close agreement with the findings of Singh (1988). Herd life (up to 3 lactations) was observed little higher for HF×S cross (1,325.84±41.67) as compared to J×S (1,269.53±20.06). Similarly, average MY/HL was in close agreement with other traits reported in the literature.

Heritability

Heritability estimates and their standard errors were summarized in Table 2 and 3 for J×S and HF×S crosses, respectively. Heritability of FLMY in first cross was found to be 0.31±0.09 but incase HF×S cross, surprisingly it was observed as 0.11±0.13 having no meaning. The reason for the trend was may be less number of sires and progenies. However, considerable amount of heritability for the same trait in HF×S cross-indicated that cow having better FLMY could be selected to alter the trait. The results were fairy comparable with the reports of Deshmukh et al. (1995) and Banerjee and Banerjee (2002). Much higher estimate of heritability for FLMY was computed by Tomar et al. (1996) in HF×S and by Singh et al. (1988) J×S crossbred. Despande and Bonde (1983) agreed with the heritability observed in the present research for MY/DCI in Jersey× Sahiwal cross. Heritabilities for HLMY in J×S and HF×S half-breds (Tables 2 and 3) were observed almost similar (0.16±0.01 and 0.14±0.14), respectively and supported by Singh (1988). Heritability estimates computed for FLP (0.11±0.14 and 0.86±0.10) in J×S and HF×S crosses, respectively were fairly comparable with these reported by Deshmukh et al. (1995) and Banerjee and Banerjee (2002).

Observed herd life heritability was much higher in J×S cross than HF×S and closely agreed with the reports of Singh (1988). Heritability of MY/HL was in agreement with Varma (1987) for J×S cross whereas it was much higher than reported by Sandhu (1986) and Varma (1987) for HF× S cross. Heritability for AFC was fairly comparable with the reports of Singh (1988) whereas Singh et al. (1989)

Table 4. Third degree polynomial regression equation of herd life milk yield on some reproduction and production traits in Jersey×Sahiwal and Holstein Friesian×Sahiwal half breds

S.N.	Traits	Constant (a)	Linear (b_1)	Quadratic (b_2)	Cubic (b_3)	R^2 (%)
Jersey×Sahiwal						
1.	Age at first calving	6.413	19.918	-0.0156	0.0000031	0.347
2.	First service period	557.981	31.128	-0.0994	0.000097	0.125
3.	First lactation period	352.071	50.473	-0.1129	0.000099	0.375
4.	First calving interval	546.319	5.482	-0.00413	0.000016	0.569
5.	First lactation milk yield	0.784	45.115	-0.0691	0.000037	0.351
6.	Milk yield per day of first caving interval	130.689	3,832.614	-610.602	34.964	0.642
Holstein Friesian×Sahiwal						
1.	Age at first calving	12.616	11.563	-0.00571	0.00000216	0.710
2.	First service period	3,688.68	11.732	-0.0068	-0.00000651	0.411
3.	First lactation period	1,653.94	8.963	0.0112	-0.0000295	0.433
4.	First calving interval	1,941.96	3.320	-0.000219	0.000000057	0.533
5.	First lactation milk yield	1.901	17.802	-0.015	0.00000217	0.361
6.	Milk yield per day of first caving interval	2,775.536	1,201.75	-56.238	3.37968	0.942

Table 5. Third degree polynomial regression equation of some reproduction and production traits on average milk yield per day of herd life in Jersey×Sahiwal and Holstein Friesian×Sahiwal half breds

S.N.	Traits	Constant (a)	Linear (b_1)	Quadratic (b_2)	Cubic (b_3)	R^2 (%)
Jersey×Sahiwal						
1.	Age at first calving	-0.132	0.0546	-0.000012	0.0000000021	0.33
2.	First service period	4.532	0.0274	-0.000098	0.000000078	0.16
3.	First lactation period	0.112	0.0397	-0.000068	0.000000036	0.27
4.	First calving interval	0.232	0.0036	0.00000055	0.000000000028	0.43
5.	First lactation milk yield	0.138	0.0382	0.000062	0.000000037	0.33
6.	Milk yield per day of first caving interval	-0.019	0.2434	0.3114	0.01549	0.4635
Holstein Friesian×Sahiwal						
1.	Age at first calving	-0.295	0.00934	-0.0000045	0.0000000031	0.074
2.	First service period	3.382	0.0143	-0.0000479	0.000000038	0.156
3.	First lactation period	1.442	0.0266	-0.0000125	0.0000000125	0.481
4.	First calving interval	1.456	0.0035	-0.000000335	0.0000000003	0.632
5.	First lactation milk yield	0.297	0.0326	0.0000773	0.000000056	0.571
6.	Milk yield per day of first caving interval	2.016	0.567	-0.2966	0.00235	0.294

reported higher estimate in J×S and much lower heritability in HF×S crosses while for FSP it was observed to be high in J×S than HF×S cross. Similar trend was found for first calving interval.

High heritability value for FSP and FCI in J×S cross- indicated that the proportion of additive genetic variance was high as compared to error variance. However, lower heritability for the same traits in HF×S cross was indicated wide genetic variation suggesting that the traits could be improved by proper manage mental approaches.

Correlations

Genetic and phenotypic correlations between production and reproduction traits for J×S and HF×S crosses are present in Table 2 and 3, respectively. Most of the phenotypic correlations between production and reproduction traits were found to be positive and highly significant ranging from low to high in magnitude in both groups.

Age of first calving was found to have highly positive and significant correlation with other reproductive traits in first cross indicating that increasing AFC might bring positive change in FCI at genetic level. These correlations were supported by Singh et al. (1988), Singh et al. (1990) and Banerjee et al. (2000) in both the crosses. First service period was also found to be positively and significantly correlated with other reproductive traits on phenotypic scale in both genetic groups. The similar trend was also observed by Singh et al. (1989). FSP and FLP was observed to be have positively and significantly correlated on genetic as well as phenotypic levels reflecting that directional change in FLP could be obtained after getting change in FSP. The present findings were supported by Singh (1988). Positive correlation among FCI and other productive traits was seen on genetic and phenotypic scales indicating the importance of the trait, as far as improvement in herd life milk yield and FLMY was concerned but less improvement occurred when the interest of breeder shifted towards milk yield per day herd life. Ahmad et al. (2002) have also observed strong genetic and phenotypic association between productive and reproductive traits in Sahiwal, HF and Jersey half-breds and also support our findings.

Prediction of herd life milk yield on the basis of reproduction and production traits

The polynomial regression equation for herd life milk yield in J×S and HF×S crosses showed that linear relationship of herd life milk yield with AFC, FSP, FLP, FCI, FLMY and MY/DCI was apparent and significant. The amount of variability shown by equation (R^2 values ranged from 12.57 to 94.20%), the highest being for milk yield for first calving interval. Thus, inference can be drawn that MY/DCI could better explain the variation in herd life milk yield.

Prediction of average milk yield per day herd life on the basis of reproduction and production traits

The polynomials for milk yield per day of herd life for both the groups on various traits also showed a linear trend, which was found highly significant. The highest and lowest R^2 values (63.2 and 7.4%) were observed for FCI and AFC, respectively. Some of them showed significant quadratic and cubic effects indicating non-linear relationship in both the groups.

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