Replacement and Lifetime Production Traits: Effect of Non-genetic Factors and Sire Evaluation

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ABSTRACT : The present investigation was undertaken to study the effects of non-genetic factors and association among replacement and lifetime production traits. The data on 542 Holstein Friesian cows maintained during 1975-98 at State Cattle Breeding Project, Sector III, Hisar, were utilized. The average sex-ratio, abnormal births, mortality, culling and replacement rates on total calf born and total female calf born basis were 51.62, 8.50, 17.52, 31.05, 22.78 and 51.41 per cent, respectively. The study revealed that a minimum of 4 to 5 progenies are required per cow over its lifetime to replace itself. It indicated that each cow should produce a minimum of 2 female calves during its life so as to replace herself before being lost. The least-squares means for productive herd life, longevity and lifetime production were 1439.32±87.64 and 2419.18±8.25 days and 11317.95±913.15 kg, respectively. The heritability estimates for all replacement traits were very low indicating that sire selection may bring no desirable change in these traits. Heritability estimates were 0.178±0.157, 0.288±0.184 and 0.096±0.195 for corresponding lifetime production traits. Breeding values and ranking of sires were generated for replacement and lifetime production traits to estimate the rank correlations between these traits. Moderate desirable rank correlations were obtained between replacement rate and lifetime production traits indicating that sires proven on the basis of milk production are also expected to have better replacement rate. ***(Asian-Aust. J. Anim. Sci. 2002. Vol 15, No. 1 : 11-15)***

Key Words : Dietary Xylitol, Nitrogen Retention, Immunological Stimulation, Broiler Chicks

INTRODUCTION

The effectiveness of selection depends on herd size, selection differential and selection intensity, which determine the rate of genetic improvement. Therefore, efforts should be made to increase the intensity of selection, which becomes possible by increasing the herd size and the number of offspring reaching the milking herd in the next generation. Genetic improvement is a long and expensive process, which becomes futile if the genetically superior germplasm fails to replace itself. This in turn depends upon reproductive efficiency and survival rate.

An individual has better fitness if it produces more surviving progeny in the same environment. The continuous use of highly selected sires to produce replacements virtually ensures an increase in the average genetic merit for milk producing ability as well as birth rate. An economic analysis indicated that ranking sires on stayability of daughters from birth to 48 months may increase profit for a broad range of replacement costs and returns from milk production. Thus, information on replacement rate is required for planning, operating and evaluating the breeding programmes for genetic improvement of the herd. Keeping this in view the present investigation was carried out to study the effects of non-genetic factors and association among herd replacement and lifetime production traits.

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MATERIALS AND METHODS

The data for the present investigation were collected on 542 Holstein Friesian cattle maintained at the State Cattle Breeding Project, Sector III, Hisar, over a period of 24 years from 1975-98. Replacement traits were recorded as all-or-none traits (1 versus 0) on individual basis, while on population basis these were defined as follows :

Sex-ratio: Percentage of male calves born.
Abnormal births: Percentage of prenatal calf mortality.
Mortality rate: Percentage of female calves died from birth to age at first calving.
Culling rate: Percentage of female calves culled from birth to age at first calving.
Replacement rate: Percentage of female calves reaching the milking herd over the total number of calves born.

Lifetime production traits included in the study were:

Longevity: The number of days from birth till disposal of the cow either due to culling or death.
Herd productive life: The number of days from first calving till disposal of the cow from the herd.
Life-time milk production: The total milk produced by the cow during its productive herd life.

The data for the present study were classified into seven periods of calving each with three consecutive years, four seasons of calving as Winter (December-February), Summer (March-June), Rainy (July-September) and Autumn (October); parity as order of lactation from first till the last completed lactation; and six age at first calving (AFC) groups (below 751, 751-850, 851-950, 951-1,050, 1,051-1,150 and above 1,150 days).

Replacement traits were analysed for studying the effect of various non-genetic factors according to Robertson and Learner (1949) procedure for all-or-none traits.

Analysis of lifetime production traits was carried out using the following

mixed model least-squares technique (model-2) of Harvey (1980):

$$Y_{ijklm}=\mu+G_i+P_j+S_k+A_l+e_{ijklm}$$

Where, Y_{ijklm} is the observation on the traits with various effects;

μ is the overall population mean;

G_i is the random effect of i^{th} sire NID (0, σ_s^2);

P_j is the fixed effect of j^{th} period of first calving (j=1,2,...,7);

S_k is the fixed effect of k^{th} season of first calving (k=1,2,...,4);

A_l is the fixed effect of l^{th} age of first calving group (l=1,2,...,6); and,

e_{ijklm} is the random error NID (0, σ_e^2).

The heritability estimates were worked out by the paternal half-sib correlation method. Sire evaluation was done by estimating the breeding value of the traits studied as deviation from the population mean using the formula as below:

$$\text{Breeding value} = \frac{2n_i\,h^2}{4+(n_i-1)\,h^2}(X_{oi}-X_p)$$

where, X_{oi} is the average of the progenies of the i^{th} sire,

X_p is the herd average,

h^2 is the heritability of the trait, and

n_i is the number of daughters of i^{th} sire.

The association between breeding value of sires for replacement and lifetime production traits was estimated as rank correlation.

RESULTS AND DISCUSSION

Effect of non-genetic factors

The period, season and parity of calving wise analysis of variance and average percentages of various replacement traits are presented in tables 1 and 2, respectively. The overall average incidence of sex ratio, abnormal births, culling, mortality and replacement rate was 51.62, 8.50, 31.05, 17.52 and 22.78 per cent, respectively. The non-significant effects of period, season and parity on sex ratio were in conformity with the results of Sethi and Rao (1981) and Khanna et al. (1983). The proportion of abnormal births was minimum in the third period (6.0%) and maximum in the last period (12.24%) but, the differences were non-significant (table 2). Similar results have been reported by Sharma and Jain (1984). A significantly higher proportion of abnormal births was observed in cows calving in the rainy season when compared to those calving in other seasons. This was in conformity with the results of Lathwal et al. (1993), while Khanna et al. (1983) observed non-significant differences among seasons. The incidence of abnormal births was not significantly different over parities, which was in line with the results of Lathwal et al. (1993) but contrary to those of Khanna et al. (1983).

Contrary to the report of Lathwal et al. (1993) culling rate was found to differ with the period of calving ($p<0.01$). The non-significant effect of season and parity on culling rate was in consonance with the results of Tomar and Verma (1988) and Lathwal et al. (1993). The mortality rate varied significantly among periods of calving, being highest during 1990-92 and lowest during 1993-95. These results are in conformity with those of Tomar and Verma (1988) and contrary to those of Lathwal et al. (1993). The results further revealed that season as well as parity were not significant sources of variations in female calf mortality.

The overall replacement rate was 22.78 and 51.41 per cent on the basis of the total calf born and the female calf born, respectively, which means that a very high proportion of calves born could not contribute to the future herd because of male births, abnormal births, culling and mortality of female calves up to the age at first calving. The study revealed that minimum 4 to 5 pregnancies were required per cow over its lifetime to replace itself. This was supported by the findings of Lathwal et al. (1993) in Red Sindhi cattle. It indicated that each cow should produce a minimum of two female calves during its herd life so as to replace itself or make genetic contribution to the future generation before being lost. Significant period differences in replacement rate indicated that the highest heifer replacements occured during 1984-86, and the lowest during 1981-83. The findings of Tomar and Verma (1988) were in conformity to the present results. The season of calving and the parity did not significantly influence both the replacement rates.

Analysis of variance and least-squares means for lifetime production traits depicting the effect of sire, AFC group, period and season of calving are given in tables 1b and 3, respectively. Longevity, productive herd life and lifetime production did not differ significantly among AFC groups, periods and seasons of first calving. These results

Table 1. Analysis of variance

a) Replacement traits

Source of variation	Degrees of freedom	Mean squares				
		Sex ratio	Abnormal births	Culling rate	Mortality rate	Replacement rate
Period	6	0.2712	0.0804	0.5796**	0.5580	1.3691
Season	3	0.5024	1.7331**	0.2950	0.2703	0.3638
Parity	10	0.4238	0.0492	0.1954	0.1874	0.0859
Error		0.2516	0.0754	0.1166	0.1219	0.1716
		(1898)	(1898)	(993)	(993)	(1898)

b) Lifetime production traits

Source of Variation	Degrees of freedom	Mean squares		
		Longevity (days)	Productive herd life (days)	Lifetime milk production (kg)
Sire	36	895356.17	872240.41	95018625.68
AFC[1] group	5	574049.30	967457.02	119117697.82
Period	5	1028921.09	1072526.52	81760424.87
Season	3	537865.81	487961.87	91928552.62
Error	310	833836.28	835783.79	91750864.02

** p<0.01.

Figures in parentheses are error degrees of freedom.

[1] Age at first calving.

Table 2. Period, season and parity of calving wise least-squares means of incidence (%) of various replacement traits

Effects	Total births	Sex ratio	Abnormal births	Culling rate	Mortality rate	Replacement rate	
						Total calf	Female calf
Overall	1918	51.62 (906)	8.50 (163)	31.05 (265)	17.52 (149)	22.78 (436)	51.41
Period of calving							
1975-77	401	47.68 (175)	8.71 (35)	15.79^{a} (30)	23.68^{b} (116)	28.86^{b} (116)	61.05
1978-80	490	55.43 (245)	9.80 (48)	41.91^{b} (83)	5.50^{a} (11)	21.22^{ab} (103)	52.52
1981-83	383	51.67 (245)	6.00 (23)	55.74^{b} (97)	14.36^{ab} (25)	13.58^{a} (52)	29.88
1984-86	239	46.40 (103)	7.11 (17)	12.60^{a} (15)	21.00b (25)	33.05^{b} (79)	66.33
1987-89	194	53.98 (95)	9.29 (18)	17.28^{a} (14)	20.98b (17)	25.77^{b} (50)	61.72
1990-92	162	52.41 (76)	9.94 (16)	24.28^{a} (17)	35.71b (25)	17.39^{a}	40.00
1993-95	49	60.47 (26)	12.24 (6)	47.00^{b} (8)	5.86a (1)	16.33^{a} (8)	47.00
Season of calving							
Winter	773	51.85 (379)	5.56^{a} (43)	34.75 (122)	19.37 (68)	20.88 (161)	45.00
Summer	159	54.00 (81)	5.66a (9)	28.33 (17)	33.33 (20)	20.13 (32)	46.38
Rainy	263	51.46 (106)	21.37^{b} (56)	30.69 (31)	20.79 (21)	18.70 (49)	48.51
Autumn	723	50.90 (340)	7.61a (55)	28.65 (94)	12.19 (40)	26.83 (194)	59.14
Parity							
1	543	52.83 (261)	8.86 (48)	26.49 (62)	20.51 (48)	22.88 (124)	52.99
2	420	49.36 (193)	6.90 (29)	33.16 (66)	15.07 (30)	24.52 (102)	51.75
3	332	47.47 (141)	10.54 (35)	35.25 (55)	17.30 (27)	22.29 (74)	47.43
4	244	57.78 (130)	8.16 (20)	28.72 (27)	12.76 (12)	22.45 (55)	58.51
5	163	55.63 (84)	7.36 (12)	35.82 (24)	10.44 (7)	22.09 (36)	53.73
6	102	46.15 (42)	10.78 (11)	32.65 (16)	18.36 (9)	23.53 (24)	48.97
7	53	53.06 (26)	7.55 (4)	34.78 (8)	34.78 (8)	12.21 (7)	30.43
8	29	62.91 (17)	6.90 (2)	6.90 (2)	30.00 (3)	17.24 (5)	50.00
9	17	56.25 (9)	5.88 (1)	14.28 (1)	14.28 (1)	29.41 (5)	71.42
10	10	10.00 (1)	0.00 (0)	22.22 (2)	44.44 (4)	30.00 (3)	33.33
11	5	0.00 (2)	30.0 (1)	50.00 (1)	0.00 (0)	20.00 (1)	50.00

Figures in parentheses are the number of observations in corresponding class.

Percentages bearing different superscripts differ significantly (p<0.01) from each other.

were contrary to those of Durocq et al. (1991) and Rogers et al. (1988) for longevity and Hegde and Bhatnager (1985) and Reddy and Basu (1985) for productive herd life. The overall least-square means for longevity, productive herd

Table 3. Least-squares means and standard errors of various lifetime production traits in different periods, seasons and age at first calving groups

Effects	Longevity (days)	Productive herd life (days)	Life-time milk production (kg)
Overall	2419.18±89.25	1439.00±87.64	11317.95±913.15
AFC[1] group (days)			
Below 751	2316.5±196.21	1609.00±195.19	13546.08±2043.00
751-850	2444.99±157.12	1633.88±124.56	13422.17±1301.51
851-950	2299.48±157.12	1380.91±156.01	10942.72±1631.83
951-1050	2423.62±138.26	1413.80±137.08	10915.94±1433.03
1051-1150	2671.56±178.94	1570.28±177.90	12610.71±1861.49
Above 1150	2349.27±288.82	1027.19±287.83	6470.07±3014.40
Period of calving			
1975-77	3056.69±358.60	2091.09±357.57	18283.89±3745.42
1978-80	2430.55±256.92	1460.55±255.94	12314.11±2680.03
1981-83	2434.46±269.77	1457.64±268.80	11293.84±2814.80
1984-86	2323.36±321.78	1348.20±320.78	11526.00±3065.05
1987-89	2441.61±293.65	1460.70±292.67	8769.72±3065.05
1990-92	1828.42±479.93	817.75±478.77	5719.21±5015.67
Season of calving			
Winter	2354.56±117.38	1383.59±116.07	10446.91±1212.33
Summer	2294.82±164.00	1318.78±162.91	9766.49±1704.25
Rainy	2534.22±160.21	1552.81±159.11	12987.41±1664.34
Autumn	2488.12±124.84	1502.11±123.58	12071.41±1291.27

[1] Age at first calving.

life and lifetime milk production were 2419.18±89.25 and 1439.00±87.64 days and 11317.95±913.15 kg, respectively. The lifetime milk production was higher in cows with lower age at first calving (up to 850 days) and those calving for the first time in the rainy season but the differences were non-significant ($p<0.05$).

Heritability estimates

Heritability estimates were calculated on sires having 9 or more progenies. The heritabilities for all the replacement traits were very low (between 0.041±0.010 and 0.069±0.001) indicating that selection is not likely to yield favourable response in improving any of the replacement traits. These results are in consonance with those of Tomar (1984) and Rawal and Tomar (1995, 1996). Heritability estimates for longevity, productive herd life and lifetime milk production were low to medium (0.288±0.184, 0.178±0.157 and 0.096±0.195, respectively), indicating that sire selection through progeny testing is expected to respond favourably.

Sire evaluation

Sires distribution in various classes of replacement traits is presented in table 4. The sex ratio varied from 33.37 to 69.56 per cent among progenies of different sires. About 85% of the sires used did not deviate from the expected sex ratio of 50:50. It was observed that only one sire had lower male births (33.37%). The incidence of female calf mortality varied from 5.26 to 40.00 per cent. Very low (5-10%) and very high (above 30%) mortalities were observed in only about 14% of the sires each, while the remaining 72% of the sires had medium mortality rates. The culling rate was almost evenly distributed with 6-8 sires falling in each of the below 20, 20-40 and the above 40% classes. The study revealed that about half of the sires had replacement rates above 50% on the basis of the total calves. This indicates that even though the heritability estimate is low, selecting sires with higher replacement rates may result in improvement of this trait.

Table 4. Sire distribution in classes of replacement traits

Class interval (%)	Number of sires	Per cent of sires
Sex ratio (males)		
30-40	1	4.76
40-50	7	33.33
50-60	11	52.38
60-70	2	9.50
Abnormal births		
Below 5	3	14.28
5-10	10	47.61
10-15	7	33.33
Above 15	1	4.76
Culling rate		
Below 10	1	4.76
10-20	5	23.78
20-30	5	23.78
30-40	3	14.28
40-50	6	28.54
Above 50	1	4.76
Mortality rate		
Below 10	3	14.28
10-20	11	52.37
20-30	4	19.04
Above 30	3	14.28
Replacement rate (on total calf basis)		
10-15	6	28.57
15-20	5	23.80
20-25	2	9.50
25-30	4	19.04
30-35	4	19.04
Replacement rate (on female calf basis)		
20-30	2	9.50
30-40	4	19.04
40-50	6	28.57
50-60	5	23.80
60-70	3	14.28
Above 70	1	4.76

The ranges of breeding values for sex ratio, abnormal births, culling, mortality and replacement rate were -0.184 to 0.321, -0.068 to 0.147, -0.103 to 0.165, -0.092 to 0.149 and -0.147 to 0.237, respectively. It was observed that 51.61, 62.90, 61.29, 54.83 and 50.00 per cent of the sires had their breeding values below the corresponding herd averages for

Table 5. Rank correlations among sire rankings on replacement and lifetime production traits

Traits	Sex ratio	Mortality rate	Culling rate	Replacement rate	Longevity	Productive herd life	Lifetime production
Abnormal births	0.136	-0.061	-0.044	0.211	0.250	0.128	0.023
Sex ratio		0.333	0.108	0.131	0.200	0.120	0.290
Mortality rate			-0.137	0.027	0.315	0.281	0.160
Culling rate				-0.136	-0.123	-0.264	0.066
Replacement rate					0.347	0.426	0.385

these traits.

The breeding value for lifetime production traits was estimated by the weighted least-squares method as a deviation from the herd average. The ranges of breeding values for different sires were from -382.92 to 878.00 days, -297.40 to 555.48 days and -3,946.73 to 4,954.53 kg for longevity, productive herd life and lifetime milk production, respectively. The rank correlations among sire rankings on replacement and lifetime production traits are presented in table 5. It was observed that the coefficients of rank correlations were positive and low to medium for sex ratio with all other replacement traits. It was negative and close to zero for abnormal birth with culling and mortality rates and positive and medium for abnormal birth with replacement rate (0.211). The rank correlation of culling rate with mortality and replacement rate was also low negative, while that between mortality and replacement rate was close to zero.

Moderately high and positive correlations between ranking of sires on sex ratio with all the lifetime production traits were obtained. These estimates for abnormal births with all the lifetime production traits were low to medium positive and were negative and close to zero for culling rate with various lifetime production traits.

Moderate desirable rank correlations were obtained only between replacement rate and lifetime production traits indicating that sires proven on the basis of milk production are also expected to have better replacement rate. Other replacement traits have no bearing on sire evaluation on lifetime production traits and vice versa.

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