

Effect of non-genetic factors and estimation of heritability of lifetime traits in Sahiwal cattle

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ABSTRACT

The present study aimed to evaluate the influence of non-genetic factors and to estimate heritability of lifetime traits in Sahiwal cattle. Lifetime lactation records of 901 Sahiwal cows spread over a period of 33 years from 1973 to 2005, maintained at National Dairy Research Institute, Karnal and Government Livestock Farm, Chakganjaria, Lucknow were utilized. The mean total milk yield was significantly higher ($P < 0.01$) in Karnal herd compared to that of Lucknow herd in the first five lactations. The effect of season of calving had significant influence on total milk yield in second and fourth lactations of Sahiwal cattle. The effect of different periods of calving was significant ($P < 0.01$) on the total milk yields of first and third lactations, whereas no significant effect of period was observed on total milk yields of second, fourth and fifth lactations. Among the interaction effects, the effect of herd X season interaction had significant influence on second and fifth lactation total milk yields, whereas the effect of herd X period interaction was significant on first and second lactation total milk yields. The overall mean lifetime milk yield in Sahiwal cattle was 6430.37 ± 72.57 kg with an average of Karnal and Lucknow herd being 7693.23 ± 106.45 and 5879.47 ± 67.84 kg respectively. The mean longevity was found to be significantly higher in Lucknow herd (3452.85 ± 70.83 days) as compared to that of Karnal herd (2959.13 ± 96.28 days). The effect of season of birth was not significant on longevity with a range of 3128.02 ± 135.14 days (autumn) to 3243.55 ± 99.63 days (rainy season). However, the period of birth was found to have significant effect on longevity. The heritability estimates of longevity and lifetime milk yield were found to be 0.276 ± 0.096 and 0.042 ± 0.066 respectively.

Key Words: Sahiwal, non-genetic effects, heritability, longevity, lifetime milk yield

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INTRODUCTION

Lifetime production of animals maintained at a farm determines the profitability of dairy enterprise. Higher profits come from high yielding cows that are able to remain in the herd for several lactations (Gill and Allaire, 1976; Allaire and Gibson, 1992). Longer productive life not only reduces rearing costs per year of productive life but also allows exploitation of maximum genetic potential of the cow. Selection goals for dairy cattle should reflect profit over lifetime of cows. Selection for lifetime production and longevity can increase profitability if these measures are estimated early in life when genetic variation is sufficient (Balaine et al., 1981 and Beaudry et al., 1988). The present study was undertaken to evaluate performance of Sahiwal cattle with respect to lifetime traits in two organized herds and to estimate the effects of different non-genetic factors and their interaction on lifetime milk yield and longevity in Sahiwal cattle.

MATERIALS AND METHODS

Two traits viz. longevity and lifetime milk yield were taken as measures to evaluate lifetime traits of Sahiwal cattle in the present study. Lifetime lactation records of 901 Sahiwal cows spread over a period of 33 years from 1973 to 2005, maintained at National Dairy Research Institute, Karnal and Government Livestock Farm, Chakganjaria, Lucknow were utilized. Only the sires having records on at least 3 daughters were included. The records of only those animals were considered which had known pedigree and normal lactation. The lactation records of less than 100 days were considered as abnormal and were not included in the analysis. Expression of different traits varies in different periods

due to change in managerial practices over time. The total duration of the present study was divided into ten equal periods of three years each. Each year was divided into four seasons namely winter (December-March), summer (April-June), rainy (July-September) and autumn (October-November). In order to classify the data for different periods and seasons, year and season of birth was considered for longevity, while year and season of each calving was considered for lifetime milk yield.

Longevity was defined as total number of days from the date of birth to the date of disposal or death. In order to define the lifetime milk yield in Sahiwal cattle, the percent contribution of each lactation to total milk yield in two herds for the period under study were estimated.

Statistical Analysis: The influence of non genetic factors on lifetime traits were studied by least squares analysis of variance for non orthogonal data using the technique described by Harvey (1987). In order to estimate the effects of non-genetic factors on lifetime milk yield in Sahiwal cattle, least squares analysis of variance was performed for different factors (herd, season, period and their interactions) in each of the first five lactations. The model for the least squares analysis of variance to estimate the influence of non-genetic factors on lifetime milk yield was:

$$Y_{ijklm} = m + H_i + S_j + P_k + L_l + IH_iS_j + IH_iP_k + e_{ijklm}$$

(where, Y_{ijklm} = observation of m th cow born in i th herd, j th season, k th period of calving and l th parity; H_i = Effect of i th herd; S_j = Effect of j th season of calving; P_k = Effect of k th period of calving; L_l = Effect of l th parity; IH_iS_j = Interaction between herd and season; IH_iP_k = Interaction between herd and period; e_{ijklm} =

Random error, NID (0, s_{2e}).

The model to estimate the effects of non-genetic factors on longevity was

$$Yijklm = m + Hi + Sj + Pk + Ll + IHiSj + IHiPk + eijklm$$

(Where, Yijklm = Dependent trait (Longevity) of mth cow born in ith herd, jth season, kth period and lth parity; m = Overall population mean; Hi = Effect of ith herd; Sj = Effect of jth season of birth; Pk = Effect of kth period of birth; Ll = Effect of lth parity; IHiSj = Interaction between herd and season; IHiPk = Interaction between herd and period; eijklm = Random error, NID (0, s_{2e})).

The data after adjustment for different significant non-genetic effects were utilized for estimation of heritability. The data on total milk yield was adjusted for significant non-genetic effects in each lactation and the adjusted values were summed up to arrive at adjusted lifetime milk yield. Paternal half-sib correlation (intra-sire correlation among daughters) method was used to estimate heritability of different traits (Becker, 1975). The standard error of heritability was estimated by the formula given by Swiger et al. (1964).

RESULTS AND DISCUSSION

The number of lactations required to achieve more than 80% of the total milk yield in both the herds of Sahiwal cattle was taken as the bench mark for defining the lifetime milk yield. There was a progressive decline in the total number of records and consequently the percent contribution to total milk yield for successive lactations (Figure 1a,b). The cumulative percent contribution of the first five lactations was 87.17% and 87.22% in Lucknow and Karnal herds with an overall percentage of 87.19% (Figure 1c). The lifetime milk yield in Sahiwal cattle was thus defined as the total milk produced by a cow in kilograms (kg) from the initiation of first lactation till the date of drying in the fifth lactation.

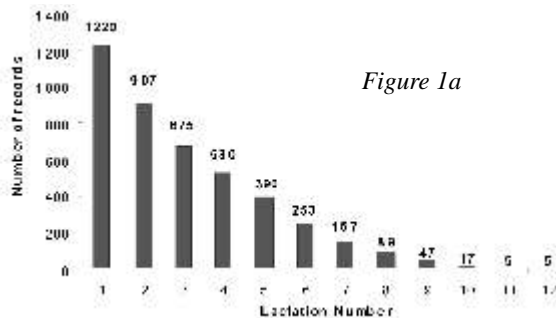


Figure 1a

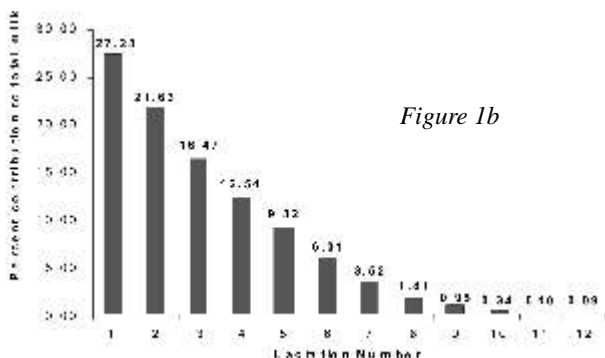


Figure 1b

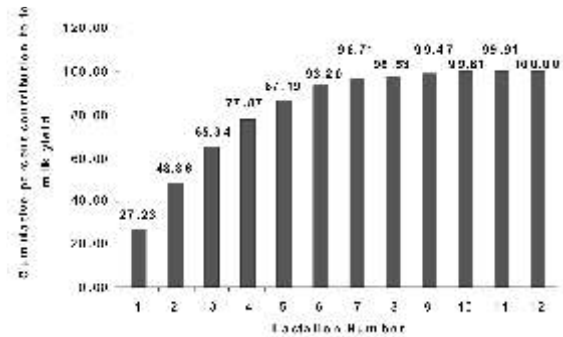


Figure 1c

Figure 1 (a-c). Overall data structure and percent contribution of each lactation to total milk yield in Sahiwal cattle

Lifetime milk yield: In order to estimate the effects of non-genetic factors on lifetime milk yield in Sahiwal cattle, least squares analysis of variance was performed for different factors (herd, season, period and their interaction) in each of the first five lactations (Table 1). The mean total milk yield was estimated to be 1805.5±42.6 kg, 1783.72±40.3 kg, 1954.4±42.9 kg, 1876.6±40.9 kg and 1900.5±54.7 kg in the first, second, third, fourth and fifth lactations respectively.

The effect of herd was highly significant on total lactation milk yield in all the five lactations. The mean lactation total milk yield was significantly higher (P < 0.01) in Karnal herd as compared to that of Lucknow herd in all the five lactations (Table 2). Significant influence of farms on lifetime milk yield has been reported earlier also (Reddy, 1983; Gandhi and Gurnani, 1988; Kumar, 2007). The effect of season of calving was significant on total milk yield in second and fourth lactations (P < 0.01). Cows that calved during winter in their second lactation had highest mean lactation milk yield (1941.6±46.9 kg) while those calved during summer season in their second lactation had lowest lactation milk yield (1683.4±60.2 kg). In the fourth lactation, the cows that calved during winter had the highest mean total lactation milk yield (2049.9±55.9 kg) while the cows that calved during summer had the lowest mean total lactation milk yield (1803.7±79.7 kg). However, the effect of season of calving was not found to have significant influence (P > 0.05) on total lactation milk yield in the first, third and fifth lactations. The effect of different periods of calving was found to exert significant influence (P < 0.01) on the total milk yields of first and third lactations, whereas no significant effect of period (P > 0.05) was observed on total milk yields of second, fourth and fifth lactations of Sahiwal cattle.

Gandhi and Gurnani (1990) reported significant influence of season of first calving on lifetime milk yield in Sahiwal cattle. Similarly significant influence of period of first calving on lifetime milk yield in Sahiwal cattle was reported by Acharya and Nagpal (1971), Reddy (1983), Hegde and Bhatnagar (1985), Gandhi and Gurnani (1995), Pundir and Raheja (1997), Kannan (2002) and Kumar (2003). Most of these studies reported the influence of season and period of first calving on lifetime milk yield. However, the milk yield in each lactation during the lifetime of a cow was affected by the season and period of respective calving. Hence, it

Table 1. Least squares ANOVA for effect of non-genetic factors and their interaction on total milk yields in different lactations of Sahiwal cattle

Source	df	Sum of Squares	Mean squares	F-value	P-value
I Lactation					
Herd	1	16260478.79	16260478.79	42.01**	0.000
Season	3	1343667.39	447889.13	1.16	0.325
Period	9	16016395.76	1779599.53	4.60**	0.000
Herd X Period	9	36109821.85	4012202.43	10.37**	0.000
Error	878	338660155.96	387040.18		
II Lactation					
Herd	1	16185249.25	16185249.25	34.45**	0.000
Season	3	9606053.99	3202018.00	6.82**	0.000
Period	9	7035287.55	781698.62	1.66	0.093
Herd X Season	3	5703173.16	1901057.72	4.05**	0.007
Herd X Period	9	26807529.97	2978614.44	6.34**	0.000
Error	875	411069204.60	469793.38		
III Lactation					
Herd	1	59246640.58	59246640.58	101.88**	0.000
Season	3	4336713.39	1445571.13	2.49	0.059
Period	9	12223796.77	1358199.64	2.34*	0.014
Herd X Period	9	498765.63	166255.21	0.29	0.837
Error	652	382658109.17	581547.28		
IV Lactation					
Herd	1	29434305.70	29434305.70	62.34**	0.000
Season	3	4743329.42	1581109.81	3.35*	0.019
Period	8	6349597.93	793699.74	1.68	0.100
Herd X Season	3	2759544.21	919848.07	1.95	0.119
Error	513	242212477.32	472149.08		
V Lactation					
Herd	1	24179541.67	24179541.67	45.44**	0.000
Season	3	3961271.97	1320423.99	2.48	0.060
Period	8	3050244.45	381280.56	0.72	0.677
Herd X Season	3	6215258.80	2071752.93	3.89**	0.009
Error	374	199030542.53	532167.23		

will be more appropriate to estimate the influence of non-genetic factors on total milk yield of each lactation separately rather than to study the influence of season and period of first calving on lifetime milk yield. In the present study, the effect of non-genetic factors and their interaction was calculated separately; data were adjusted for significant factors in each lactation and summed up to five lactations to arrive at adjusted lifetime milk yield. Among the interaction effects, the effect of herd X season interaction was significant on second and fifth lactation total milk yields, whereas the effect of herd X period interaction was significant on first and second lactation total milk yields. The effect of parity was found to have highly significant influence on lifetime milk yield. The significant effect of parity on lifetime traits is expected as the productive life varies among different animals depending on their time of disposal. The mean lifetime milk yield of cows up to second, third, fourth and fifth lactations were 3309.67 ± 134.57 kg, 5306.61 ± 162.16 kg, 7253.83 ± 171.85 kg and 9851.38 ± 101.59 kg respectively. The overall mean lifetime milk yield in Sahiwal cattle was estimated to be 6430.37 ± 72.57 kg. The mean lifetime milk yield in Karnal and Lucknow farms were estimated as 7693.23 ± 106.45 and 5879.47 ± 67.84 kg respectively.

Longevity: Longevity is relatively more reliable in assessing the lifetime of animals in a herd as it includes the variation that exists in the early life till the time of first calving. The least squares analysis of variance for the effects of different non-genetic factors and their interactions on longevity in Sahiwal cattle are presented in Table 3. The overall mean longevity was estimated as 3205.99 ± 59.76 days (Table 4). The effect of herd was significant ($P < 0.01$) on longevity. The mean longevity was found to be significantly higher in Lucknow herd (3452.85 ± 70.83 days) as compared to that of Karnal herd (2959.13 ± 96.28 days). The higher longevity of cows in Lucknow herd than Karnal herd, despite having lower estimates of mean lifetime milk, might be due to more stringent culling practices followed in the Karnal herd compared to that of Lucknow. The effect of season of birth was not found to have significant influence on longevity with a range of 3128.02 ± 135.14 days (autumn) to 3243.55 ± 99.63 days (rainy season). However, the effect of period of birth was significant on longevity. The mean longevity among different periods of birth varied between 2330.62 ± 283.81 days and 3941.15 ± 220.91 days. Similarly, the effect of interaction between herd and period was found to influence longevity significantly ($P < 0.05$) while the herd

Table 2. Least squares means of total milk yield in different lactations of Sahiwal cattle

Effects	I Lactation (kg)		II Lactation (kg)		III Lactation (kg)		IV Lactation (kg)		V Lactation (kg)	
	N	Mean ± SE	N	Mean ± SE	N	Mean ± SE	N	Mean ± SE	N	Mean ± SE
Overall	901	1805.5±42.6	901	1783.2±40.3	675	1954.4±42.9	529	1876.6±40.9	390	1900.5±54.7
Herd										
Lucknow	665	1529.5±42.1 ^a	665	1546.4±36.6 ^a	505	1566.6±44.1 ^a	411	1546.7±37.9 ^a	303	1557.6±49.2 ^a
Karnal	236	2081.5±74.1 ^b	236	2019.9±71.9 ^b	170	2342.2±68.5 ^b	118	2206.4±73.6 ^b	87	2243.5±93.5 ^b
Season										
Winter	508	1817.6±38.9	404	1941.6±46.9 ^a	284	2012.1±58.2	209	2049.9±55.9 ^a	164	2071.9±71.6
Summer	206	1735.3±49.4	199	1683.4±60.2 ^c	144	1873.5±76.1	115	1803.7±79.7 ^b	82	1806.2±101.9
Rainy	104	1752.2±68.6	189	1695.9±63.2 ^c	150	1837.7±77.4	126	1832.1±74.6 ^b	82	1813.9±103.2
Autumn	83	1916.7±125.8	109	1811.8±86.3 ^b	97	2094.3±89.6	79	1820.6±105.5 ^b	62	1910.1±121.3
Period										
1976-78	78	2253.6±125.2 ^a	35	1306.2±252.2	10	1957.4±244.6 ^c	-	-	-	-
1979-81	68	1951.6±148.9 ^{ab}	82	1874.9±136.6	58	2084.6±106.7 ^a	38	2030.8±118.2	10	1933.6±236.2
1982-84	115	1830.3±71.6 ^{ab}	98	1819.8±81.6	56	2019.7±106.4 ^b	45	1974.9±109.1	28	1920.1±147.0
1985-87	165	1863.4±76.1 ^{ab}	127	1964.0±82.4	87	1949.1±84.6 ^c	53	1819.1±97.7	42	1987.7±117.7
1988-90	139	1828.5±70.8 ^{ab}	160	1969.2±71.5	133	2081.1±72.9 ^a	106	1878.2±75.9	55	1889.0±107.5
1991-93	122	1849.9±71.7 ^{ab}	137	1737.8±70.7	78	2094.1±89.4 ^a	65	2022.3±89.7	72	1893.6±95.3
1994-96	59	1906.0±85.5 ^{ab}	80	1855.4±79.2	99	1717.2±79.8 ^c	85	1730.9±80.9	55	1859.6±102.8
1997-99	79	1620.3±75.5 ^{ab}	65	1813.4±88.8	43	2001.4±117.2 ^b	39	1938.2±111.5	53	2070.6±103.7
2000-02	52	1498.6±93.0 ^b	77	1726.4±82.8	71	1817.2±92.7 ^d	50	1772.2±98.4	31	1761.4±133.7
2003-05	24	1452.5±160.3 ^b	40	1764.8±125.6	40	1822.2±121.6 ^d	48	1722.3±104.3	44	1789.4±115.6

Table 3. Least squares ANOVA for effect of non-genetic factors and their interaction on longevity in Sahiwal cattle

Source	df	Sum of Squares	Mean squares	F-value	P-value
Herd	1	17655204.47	17655204.47	15.74**	0.000
Season	3	408864.21	136288.07	0.12	0.943
Period	9	30541190.44	3393465.60	3.02**	0.002
Herd X Season	3	878794.68	292931.56	0.26	0.854
Herd X Period	9	23140696.99	2571188.55	2.29*	0.015
Error	875	981762805.54	1122014.63		

Table 4 Least squares means of longevity in Sahiwal cattle

Effects	N	Longevity (days)
Overall	901	3205.99 ± 59.76
Herd		
Lucknow	665	3452.85 ± 70.83 ^a
Karnal	236	2959.13 ± 96.28 ^b
Season		
Winter	400	3221.52 ± 69.52
Summer	219	3230.87 ± 96.35
Rainy	164	3243.55 ± 99.63
Autumn	118	3128.02 ± 135.14
Period		
1973-75	82	2938.52 ± 217.91 ^{ab}
1976-78	79	3941.15 ± 220.91 ^a
1979-81	173	3213.45 ± 111.44 ^{ab}
1982-84	127	3266.06 ± 130.74 ^{ab}
1985-87	135	3326.21 ± 113.32 ^{ab}
1988-90	94	3319.79 ± 125.68 ^{ab}
1991-93	72	3514.29 ± 130.02 ^{ab}
1994-96	79	3245.41 ± 128.64 ^{ab}
1997-99	39	2964.39 ± 183.48 ^{ab}
2000-02	21	2330.62 ± 283.81 ^b

X season interaction had no significant effect on longevity. The effect of parity was significant on longevity.

Heritability of lifetime traits: The heritability estimates of longevity and lifetime milk yield were estimated as 0.276 ± 0.096 and 0.042 ± 0.066 respectively. The estimated heritability values for lifetime milk yield reported by previous workers in Sahiwal cattle ranged between zero (Reddy, 1983) to 0.84 (Kannan, 2002) while the estimates for herd life varied between 0.02 ± 0.18 (Kannan, 2002) to 0.61 ± 0.12 (Dubey, 2004). The heritability estimate of lifetime milk yield in the present study is much lower than the estimate of Kumar (2007) while the estimate for longevity was found to be relatively higher than the previous reports.

In conclusion, the present study attempted a new approach in defining and estimating the effects of non-genetic factors and their interaction on lifetime milk yield. This resulted in more appropriate adjustment of significant non-genetic factors and estimation of heritability of lifetime performance in Sahiwal cattle.

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