Indian J. Anim. Res., 51 (4) 2017 : 635-639
Print ISSN:0367-6722 / Online ISSN:0976-0555

AGRICULTURAL RESEARCH COMMUNICATION CENTRE
www.arccjournals.com/www.ijaronline.in

Effect of genetic and non-genetic factors on age at first calving in Sahiwal cattle

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Received: 05-09-2015 Accepted: 19-12-2015 DOI:10.18805/ijar.8425

ABSTRACT

The present study was conducted on Sahiwal cows maintained at Uttar Pradesh Livestock- cum- Agriculture Farm, Chak Ganjaria, Lucknow. A total of 1194 records on age at first calving (AFC) spanning over a period of 57 years (1949 to 2006) were subjected to least squares analysis using suitable statistical model considering sire as random while period and season as fixed effects. The least squares mean of AFC was estimated to be 1251.77± 22.15 days. The least squares analysis revealed significant effect ($P \leq 0.01$) of sire and period. However, the effect of season was found to be non-significant. The heritability estimate of age at first calving was found to be 0.159. The genetic, phenotypic and environmental trend for AFC were -3.31, 32.78 and 36.09 respectively. It was concluded from the present findings that selection of sire may be practiced for genetic improvement of this trait and ameliorative managemental practices should be employed to improve upon the trait i.e. age at first calving.

Key words: Age at first calving, Heritability, Genetic trend, Phenotypic trend, Sahiwal.

INTRODUCTION

Evaluation of an animal for the purpose of genetic improvement is based on several traits. Evaluation of important traits other than milk yield should provide dairy producers with more useful information upon which to base their genetic decisions (Mahoney *et al.*, 1986). Age at first calving (AFC) includes the period that a cow needs to reach maturity and to reproduce for the first time. It is a one of the many factors affecting farm profitability, through the direct cost of rearing heifers (Tozer and Heinrichs, 2001) as well as its potential effect on subsequent performance (Nilforooshan and Edriss, 2004). A younger age at first calving can potentially lead to a reduction in costs incurred on rearing leading to an earlier return on investment (Tozer and Heinrichs, 2001). Furthermore, a positive association between age at first calving and subsequent performance has been shown in previous studies (Dobos *et al.*, 2004) which may affect any potential benefits of earlier calving. Age at first calving has also been shown to influence calving performance (Ettema and Santos, 2004) and longevity (Ojango *et al.*, 2005; Sawa and Bogucki, 2010). Estimation of genetic trends is necessary to monitor and evaluate selection programs.

Currently efforts are being made to characterize, evaluate and conserve the breed in field conditions. Sahiwal is one of the best dairy cattle breed of tropical and subtropical region. The genetic analysis of economic traits of the Sahiwal cows may provide the background information for formulating the strategies for further genetic improvement of the breed. Keeping in view the above, the present investigation was undertaken to estimate the effect of genetic and non-genetic source of variation on age at first calving, to estimate the breeding values of Sahiwal sires for comparative ranking and genetic, phenotypic and environmental trends of age at first calving.

MATERIALS AND METHODS

The records of animals with known pedigree and normal lactation were considered for this study. A total of 1194 data spanned over a period of 57 years from 1949 to 2006 on age at first calving were obtained from the records of Sahiwal cows maintained at State Government Livestock farm, Chak Ganjaria, Lucknow (U.P.). The data were grouped under 15 periods with four years under each except first, fourteenth, and fifteenth period which consisted of five consecutive years. A calendar year was subdivided into three seasons, namely Summer (S_1): March –June, Rainy (S_2): July-October and Winter (S_3): November- February.

Statistical analysis of the data was done using mixed model Least Squares and Maximum Likelihood Computer Program PC – 1 (Harvey, 1990) to study the effect of genetic and non-genetic factors affecting the AFC using following statistical model:

$$Y_{ijkl} = \mu + s_i + a_j + b_k + e_{ijkl}$$

Where,

Y_{ijkl} is AFC of l^{th} cow belonging to i^{th} sire, j^{th} period and k^{th} season.

μ is overall mean of the population.

s_i is random effect of i^{th} sire.

a_j is the fixed effect of j^{th} season of birth.

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b_k is the fixed effect of k^{th} period of birth.
e_{ijkl} is random error associated with each observation assumed to be NID(0,σ^2e)

Breeding value was calculated by best linear unbiased prediction (BLUP) using mixed model methodology. The genetic trend was estimated by calculating the expected transmitting ability (ETA) of sires. The transmitting ability of sire is half of additive genetic value and therefore genetic trend was obtained as twice the regression of weighted average of sire transmitting abilities (WAETA) for each year as:

$$WAETA = n_{ik}\ i/n_k \text{(Hintz } et\ al.\text{, 1978)}$$

Where,
n_{ik} is the number of daughter of sire I (i= 1, 2, 3…………m) in k^{th} year
i is the estimated transmitting ability (EST) of i^{th} sire
n_k is the number of daughters of m sires in the k^{th} the year

The phenotypic trend for AFC was estimated by taking regression of performance of the population on the year as $b_{(PT)}$ (Smith, 1962).
Where,
b_{PT} is Linear regression of population performance (P) on time (year) of calving (T).
PT is corrected sum of products for trait (P) and time (T).

Environmental trend was obtained by subtracting the genetic trend (G) from the overall phenotypic trend (P) (Smith, 1962).

$$\Delta E = \Delta P - \Delta G$$

Table-1: Least squares analysis of variance for AFC

Source of variation	d.f.	Mean squares
Sire	127	228488.93**
Period	14	883313.90**
Season	2	76270.41
Error	1050	52317.50

** Significant (P ≤ 0.01)

RESULTS AND DISCUSSION

The overall population mean of age at first calving (AFC) in the present study was estimated as 1279.82 ± 6.25 days with 16.88% coefficient of variation (CV). The result of present finding is in close agreement with the finding of Rathi *et al.* (1992). However, higher values than the present finding were reported by Gandhi and Gurnani (1990) and Singh *et al.* (2001). On the contrary, the mean and CV for AFC obtained in the present study were lower than the values observed by Nandagawali *et al.* (1997). The least squares analysis of variance for age at first calving is presented in Table1. The corresponding least squares means for various factors are presented in Table 2.

In the present study, the effect of sire was found to be significant (P ≤ 0.01) on age at first calving. The present finding is in close agreement with the reports of Bhatnager *et al.* (1993) and Balasubramaniam *et al.* (2013) in Sahiwal breed of cattle. Contrary to the present finding, Singh and Dubey (2005) found this effect as non-significant in Sahiwal and cross-bred cows. The significant effect of sire indicates that selection of sire may be practiced for genetic improvement of this trait.

Table-2: Least square mean for age at first calving (AFC)

Factors	N	LS Mean	S.E	Rank
Overall	1194	1251.77	22.15	-
Period				
1944-1948	27	1333.80	48.80	9
1949-1952	47	1448.08	48.13	14
1953-1956	62	1129.23	47.93	5
1957-1960	76	1040.07	45.51	2
1961-1964	91	1068.60	38.54	3
1965-1968	76	1009.13	40.07	1
1969-1972	74	1101.72	38.66	4
1973-1976	88	1132.44	37.70	6
1977-1980	159	1212.48	37.15	7
1981-1984	124	1412.61	33.74	12
1985-1988	97	1346.53	37.36	11
1989-1992	46	1231.85	43.15	8
1993-1996	63	1339.00	40.11	10
1997-2001	71	1420.26	37.87	13
2001-2006	93	1549.84	37.65	15
Season				
Summer	419	1239.03	24.01	1
Rainy	310	1249.90	24.82	2
Winter	465	1266.38	23.36	3

Least squares analysis of variance revealed significant effect (P≤ 0.01) of period on age at first calving. Singh and Dubey (2005) and Balasubramaniam *et al.* (2013) also observed significant influence of period of birth on AFC in Sahiwal and crossbred cows. The significant effect of period might be due to variability in the feed and fodder availability during different periods influencing the growth rate and age at first calving in the heifers.

The least squares means of AFC obtained during different seasons did not differ significantly from one another. In consonance with the present findings, Singh and Dubey (2005) in Sahiwal and crossbred also reported non-significant effect of season of birth on AFC. The non-significant effect of season on AFC indicates that Sahiwal breed is adaptable to this area (Chak Ganjaria) and is not susceptible to the seasonal changes in temperature and humidity.

The heritability of age at first calving was estimated to be 0.159. Similar heritability estimates were also reported by Yadav *et al.* (1992), Khan *et al.*(1999) and Baniak and Gandhi (2007) while Ilatsia *et al.* (2007) reported lower i.e. 0.04 in Sahiwal cattle in semi arid Kenya while Balasubramaniam *et al.*(2013) reported moderate heritability of 0.45 in this breed.

The estimates of average breeding value of 128 sires for age at first calving with their ranks are presented in Table 3. The result revealed that out of 128 sires, the age at first calving decreased among daughters of 71 sires, while it increased among daughters of 57 sires. It indicated that replacement of sires was not done, which might have increased the inbreeding level among cows. The age at first calving of Sahiwal cows decreased from 1985 to 2001.

The phenotypic and genotypic values during different periods are presented in Table 4. The present findings of decreasing phenotypic and genetic values for AFC over different periods might be due to improper selection of sires and feeding and managemental practices. The genetic, phenotypic and environmental trends for AFC were -3.31, 32.78 and 36.09, respectively. The increasing phenotypic trend in AFC as observed in the present study was not in a desirable direction and needs to be reduced to the optimum level through both genetic and environmental paths. The genetic trend for AFC estimated as -3.31 days indicate desirable reduction in AFC on genetic scale, but due to environment trends being in the opposite direction, no significant change in AFC could be observed phenotypically. The genetic trend for AFC can further gain momentum with intensive selection and breeding programme.

Evidences indicate that the average performance of a group of animals is determined by its inherent genetic makeup, the environment in which it is kept and the interaction between genetotype and the environment (Cunningham and Syrstad, 1987; Falconer and Mackay,

Table-3: Estimates of breeding Value (B.V) of sires for AFC.

Sire no.	N	B.V	Rank	Sire no.	N	B.V	Rank
1	6	19.91	84	104	12	91.10	120
2	4	-26.67	45	105	13	169.66	126
3	4	.20	72	106	11	74.81	117
5	3	-53.32	24	107	9	182.3	128
6	4	-27.40	42	109	4	51.06	110
8	3	70.76	114	112	15	-2.79	66
9	3	1.66	74	113	6	-27.11	44
10	5	-58.10	19	114	11	55.91	111
11	4	-85.27	8	115	10	20.52	87
12	4	-131.99	1	116	15	29.92	99
13	1	-63.70	79	118	13	-9.09	58
14	21	151.56	125	119	7	-65.75	15
15	3	62.54	112	120	16	-6.75	60
16	34	29.19	98	121	6	-43.39	26
18	6	32.69	102	123	7	-130.43	2
20	76	34.13	104	124	18	-33.73	37
21	3	65.89	113	125	4	-28.01	41
23	3	-26.06	46	126	21	-14.15	55
24	22	-12.21	56	128	8	-2.61	68
25	11	-45.75	25	129	16	-33.55	38
28	6	33.11	33.11	130	11	-42.70	27
29	7	27.19	27.19	133	7	-17.09	52
30	4	-33.50	39	134	4	-1.59	70
31	3	-15.29	54	135	3	-17.69	51

contd...............

33	76	-16.39	53	137	5	-18.78	50
34	5	6.69	79	138	10	-38.43	31
35	25	-37.52	32	140	5	-39.62	29
36	5	-34.97	35	141	2	26.88	91
37	2	19.70	83	143	4	.19	71
39	3	-34.13	36	146	7	73.65	116
41	6	43.55	109	147	5	81.77	119
42	5	-8.08	59	148	7	5.02	78
43	1	-27.21	44	150	4	-4.71	62
47	3	42.77	108	151	11	-3.28	64
51	5	-21.85	49	153	8	-53.27	22
52	6	134.75	122	155	7	-48.23	24
58	10	32.29	101	156	4	-3.83	63
59	4	-2.38	69	157	3	28.54	96
61	3	-40.80	28	158	3	-52.71	23
64	6	19.06	82	159	13	-22.93	48
66	8	-76.52	11	163	6	-121.02	5
67	4	4.79	77	166	6	-62.25	17
69	5	-70.76	12	167	2	-98.74	6
70	11	-34.99	34	168	4	25.37	89
71	3	71.81	115	169	4	-60.73	18
72	16	-36.87	33	170	9	88.38	7
73	13	-4.73	61	171	9	28.90	97
74	7	27.29	93	172	7	21.91	88
75	5	26.16	90	173	10	142.25	124
78	13	-38.74	30	174	1	1.91	1.91
81	13	40.27	106	178	3	-10.87	57
83	12	19.94	86	180	1	-3.17	65
84	12	27.38	94	181	1	31.23	100
85	5	1.79	75	182	3	14.05	81
86	5	-75.11	11	185	3	.47	73
87	5	-2.71	67	186	15	28.40	95
90	53	40.98	106	188	10	109.25	121
92	3	-31.67	40	189	3	36.83	105
93	4	-70.32	13	192	5	182.02	127
94	10	-75.58	10	193	4	-54.49	20
96	21	-125.72	4	194	11	139.06	123
98	13	-67.32	14	195	6	7.73	80
99	9	-81.47	9	196	10	-129.36	3
101	47	75.81	118	198	14	-24.52	47

Table-4: Phenotypic and genetic value for age at first calving

Period	Phenotypic value	Genetic Value
1944-1948	1333.81	-3.65
1949-1952	1448.09	42.31
1953-1956	1129.24	40.43
1957-1960	1040.08	14.69
1961-1964	1068.60	0.92
1965-1968	1009.13	8.19
1969-1972	1101.73	-12.29
1973-1976	1132.45	2.64
1977-1980	1212.48	15.34
1981-1984	1412.61	26.00
1985-1988	1346.54	-20.92
1989-1992	1231.86	-11.14
1993-1996	1339.88	-8.04
1997-2001	1420.27	-24.69
2002-2006	1549.85	36.34

1996). Therefore, partial improvement in the environmental components alone may not guarantee improvements in the genetic merits unless all components of the genetic improvement programs are simultaneously considered. Thus, it may be concluded from the present findings that information about the genetic parameters for the AFC is of prime importance for making the appropriate selection and breeding programme of a breed in a particular environment and genetic and phenotypic changes in the performance traits of dairy cattle are the ultimate indicator of progress in a herd. The superior sires with high breeding value for the desired characters should be selected and semen of such sires be used for breed improvement under progeny testing programme and the progeny tested bulls having good merit should be used for breeding purposes along with ameliorative managemental practices in the farm.

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