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Genetic analysis of reproductive traits of Sahiwal cattle

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ABSTRACT

Data on first lactation reproduction traits of Sahiwal cattle maintained at an organized herd of the institute over a period of 29 years (1988–2016) were analyzed in the present study. Effect of various genetic and non–genetic factors on first lactation reproduction traits in addition to their genetic control was assessed by using mixed model least–square analysis. The overall least–square means for first lactation reproduction traits, viz. age at first service (AFS), age at first calving (AFC), number of services per conception (NSC), conception rate (CR), gestation period (GP), calving to first insemination interval (CFI), service period (SP), calving interval (CI) and pregnancy rate (PR) were 784.84±8.03 days, 1116.18±10.38 days, 1.86±0.11, 0.97±0.06, 287.73±0.60, 84.75±5.01, 119.86±8.31, 420.53±3.33 days and 0.27±0.02, respectively. Analysis of variance revealed that random effect of sire had non–significant influence on all the considered traits in present study. Period of birth significantly influenced AFS and AFC. Differences were statistically significant for effect of period of calving on NSC; season of calving on NSC, CR and PR; age group on NSC and CR. The effect of lactation length used as co–variable had significant influence on CFI, SP and PR. Service period as co–variable significantly affected CI. The magnitudes of heritability estimates were low to medium varying from 0.09 to 0.27 for different reproduction traits indicating large role of environment and management for improvement of these traits.

Key words: Genetic and non–genetic factors, Heritability, Reproduction traits, Sahiwal

India has 190.90 million cattle (Anonymous 2012) and out of total cattle population about 151.17 million are indigenous cattle which comprises of about 74.92% (113.25 million) non–descript cattle and 25.08% (37.91 million) descripted 43 cattle breeds. The population of Sahiwal cattle is about 4.88 million which is nearly 3.23% of total cattle and 12.87% of registered cattle breeds' population in India (Anon 2013). The decade wise trend of livestock population (1997 to 2012) shows a distinct shift in dynamics of dairy animals in favour of crossbred cattle, as their numbers increased by 20.18%, while that of indigenous cattle declined by about 8.94% (Anon 2012). Sahiwal is one of the most important milch breeds of cattle which originated in the Punjab region alongside Indian–Pakistan border. Sahiwal cattle is renowned for its higher milk production, remarkable power of endurance for hot climate of sub–tropics, relative resistance to diseases and low maintenance cost. The productivity of indigenous cattle is still low despite of having good genetic potential. It is important to improve production as well as reproduction potential of our indigenous stock in order to meet the increasing demand of milk and milk products in our country.

A large number of genetic and non–genetic factors affect production as well as reproduction traits of dairy animals. The female fertility is a complex set of traits related through genetic and environmental factors (Jamrozik *et al.* 2005). Fertility in dairy cows is highly related to the standard of reproduction management. Consequently, adjustment of effect of significant non–genetic factors is essential for accurate and unbiased estimates of genetic parameters. Therefore, the present study was undertaken to evaluate the effect of various genetic and non–genetic factors on reproduction traits and further to estimate their genetic parameters in Sahiwal cattle.

MATERIALS AND METHODS

In the present study, records on first lactation reproduction traits of Sahiwal cattle maintained at an organized herd of ICAR–National Dairy Research Institute, Karnal spread over a period of 29 years (1988–2016) were utilized. The animals having less than 100 days lactation length and less than 3 kg daily milk yield were considered as abnormal and were not included in the study. In order to study the effect of different non–genetic factors, viz. season of calving, period of caving and age group at first calving on traits under study, the data were classified into different groups. The year was classified into four seasons, i.e.

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Summer: April–June; Rainy: July–September, Autumn: October–November and Winter: December–March, based on prevalent conditions of the area. Total span was classified into ten periods comprising of three years each. Further, on the basis of age at first calving three groups were derived based on mean and standard deviation.

The least–square analysis as suggested by Harvey (1990) was applied to identify the significance of important genetic and non–genetic factors. In the present study, sire was considered as random source of variation. The following models were considered with assumptions that different components being fitted into the model were linear, independent and additive.

Model A: For AFS and AFC

$$Y_{ijkl} = \mu + S_i + P_j + (Sea)_k + e_{ijkl}$$

where Y_{ijkl}, observation of l^{th} individual cows which is progeny of i^{th} sire, calved in j^{th} period, k^{th} season; μ, overall mean; S_i, random effect of i^{th} sire; P_j, effect of j^{th} period of birth (N=1–10); Sea_k, effect of k^{th} season of birth (N=1–4).

Model B: For other considered traits

$Y_{ijklmn} = \mu + S_i + P_j + (Sea)_k + (AG)_l + b(X_m - \bar{X}) + e_{ijklmn}$

where, $\bar{Y}_{ijklmn}$, observation of n^{th}individual cows which is progeny of i^{th} sire, calved in j^{th} period, k^{th} season having l^{th} age group at calving; μ, overall mean; S_i, random effect of i^{th} sire; P_j, effect of j^{th} period of calving (N=1–10); Sea_k, effect of k^{th} season of calving (N=1–4); AG_l, effect of l^{th} age group in first calving (N=1–3); $b(X_m–X)$, effect of co–variable (X); e_{ijklmn}, random error associated with each observation assumed to be NID (0, σ^2).

Paternal half sib method was used for estimating heritability.

RESULTS AND DISCUSSION

The least–square means along with analysis of variance for different reproduction traits in Sahiwal cattle are presented in Table 1, 2, 3 and 4. The overall least–squares means for first lactation reproduction traits, viz. age at first service (AFS), age at first calving (AFC), number of services per conception (NSC), conception rate (CR), gestation period (GP), calving to first insemination interval (CFI), service period (SP), calving interval (CI) and pregnancy rate (PR) were 784.84±8.03 days, 1116.18±10.38 days, 1.86±0.11, 0.97±0.06, 287.73±0.60 days, 84.75±5.01 days, 119.86±8.31 days, 420.53±3.33 days and 0.27±0.02, respectively in Sahiwal cattle.

Effect of period of birth was found significant (P<0.01) on age at first service while effect of season of birth was observed as non–significant. Minimum (668.74±55.14 days) age at first service was observed during the period 1985–1987 and highest (1002.69±65.76 days) was observed during 2012–2013 period as shown in Table 1. Effect of period of birth was found to be significant (P<0.05) on AFC while effect of season of birth was non–significant (Table 2). Similar significant effect of period on AFC was reported by Raja (2010) but, Rehman *et al*. (2008) reported non–significant effect of period on AFC for the same breed.

Table 1. Least–squares means and standard errors of age at first service and age at first calving in Sahiwal cattle

Effect	AFS (days)	AFC (days)
Overall mean (μ)	784.84±8.03	1116.18±10.38
Period of birth		
1985–1987	668.74^{a}±55.14	974.01^{a}±55.16
1988–1990	694.78^{b}±36.58	1041.52^{b}±43.115
1991–1993	686.94^{ab}±37.31	1054.46^{bc} ±44.934
1994–1996	732.59^{c}±45.65	1054.90^{bc}±56.87
1997–1999	775.96^{d}± 49.62	1073.70^{c}±60.85
2000–2002	768.98^{d}± 53.16	1138.14^{d}±63.81
2003–2005	734.87^{c}±33.77	1059.48^{bc}±42.85
2006–2008	852.12^{e}±30.83	1204.40^{e}±36.97
2009–2011	930.77^{f}±41.97	1256.61^{f}±51.87
2012–2013	1002.69^{g}±65.76	1304.55^{g}±82.43
Season of birth		
Summer	777.44±13.29	1109.77±16.67
Rainy	765.74±16.82	1092.67±21.23
Autumn	802.51±15.82	1138.32±19.47
Winter	793.68±10.90	1123.95±13.74

Means with different superscripts differ significantly from each other.

Table 2. ANOVA (MS values) of age at first service and age at first calving in Sahiwal cattle

Source of variation	AFS	AFC
Sire	12823.40 (47)	23387.13 (49)
Period of birth (9)	28819.11**	35785.26*
Season of birth (3)	13474.32	18518.05
Error	10454.59 (275)	16409.18 (294)

Figures in parentheses represent number of degrees of freedom; ** and * represents significant at 1% and 5% level of significance.

Present study revealed that random effect of sire had no significant effect on NSC (Table 4) but period and season of calving significantly (P<0.05) affected NSC. No significant difference was observed in the number of services per conception in summer and autumn season. Significant (P<0.01) effect of age group at calving was also observed on NSC in Sahiwal cattle. The number of services per conception increased as the age of animal increased in the present study. Similar to present findings, Bolacali and Ozturk (2017) found significant effect of season of calving and age at calving in Simmental cows. Effect of season of calving and age group was found to be significant on conception rate in Sahiwal cattle. On perusal of Table 3, it is evident that there was decreasing trend in conception rate as age of animal increased.

There was no significant effect of genetic and non–genetic factors on gestation period in present study (Table 4). Kumar *et al*. (2016) reported significant effect of sire and season of calving on gestation period in Jersey crossbred cattle. Similar to present findings, they reported non–significant effect of period of calving on gestation length. Random effect of sire and fixed effect of period of calving

Table 3. Least–square means and standard errors of first lactation reproduction traits in Sahiwal cattle

Effect	NSC	CR	GP (days)	CFI (days)	SP (days)	CI (days)	PR
Overall mean (μ)	1.86±0.11	0.97±0.06	287.73±0.60	84.75±5.01	119.86±8.31	420.53±3.33	0.27±0.02
Period of calving							
1988–1990	1.52^{b}±0.40	1.23±0.25	289.03±2.24	103.56±20.58	85.76±27.84	425.55±13.08	0.44±0.11
1991–1993	$2.01^{d±}$0.31	0.84±0.19	290.77±1.83	64.51±15.19	93.97±22.70	422.50±10.62	0.34±0.09
1994–1996	1.72^{c}±0.33	1.09±0.21	289.17±1.97	78.67±16.75	84.13±26.72	421.52±11.82	0.32±0.09
1997–1999	$2.56^{f±}$0.37	0.63±0.23	289.95±2.10	80.78±18.66	114.03±30.94	427.16±13.76	0.23±0.10
2000–2002	1.27^{a}±0.41	1.08±0.26	288.14±2.21	67.29±21.87	100.19±29.50	419.65±13.92	0.34±0.12
2003–2005	2.27^{e}±0.38	0.58±0.23	289.43±2.13	50.59±22.30	124.30±28.77	416.72±12.18	0.29±0.09
2006–2008	2.03^{d}±0.25	0.87±0.15	286.07±1.50	100.39±13.23	127.73±19.70	420.90±9.25	0.23±0.07
2009–2011	1.50^{b}±0.25	1.17±0.15	287.62±1.45	106.27±13.28	146.26±19.26	415.90±8.67	0.14±0.07
2012–2014	1.93^{d}±0.36	1.17±0.22	282.20±2.17	110.68±23.12	202.39±37.41	414.89±16.25	0.10±0.11
2015–2016	1.77^{c}±0.49	1.02±0.31	284.98±2.97	–			
Season of calving							
Summer (Apr–Jun)	1.86^{b}±0.12	0.94^{b}±0.07	287.14±0.71	74.76±6.52	124.16±10.64	416.90±4.41	0.24^{b}±0.03
Rainy (Jul–Aug)	2.13^{c}±0.16	0.83^{a}±0.09	287.34±0.94	93.54±8.80	112.73±13.41	417.63±6.21	0.31^{c}±0.04
Autumn (Sep–Nov)	1.83^{b}±0.20	0.96^{b}±0.12	287.94±1.12	94.34±11.44	136.95±17.11	418.38±7.73	0.17^{a}±0.06
Winter (Dec–Mar)	1.61^{a}±0.12	1.13^{c}±0.07	288.53±0.69	76.36±5.82	105.60±9.98	429.22±4.13	0.36^{c}±0.03
Age group							
<32.56 months	1.37^{a}±0.19	1.26^{a}±0.11	287.40±1.07	–	106.94±15.00	–	0.30±0.05
32.57–42.84 months	1.61^{b}±0.10	1.08^{b}±0.06	287.82±0.59	–	129.03±8.69	–	0.26±0.02
>42.84 months	2.59^{c}±0.16	0.57^{c}±0.9	287.98±0.93	–	123.61±13.92	–	0.25±0.04
LL (Regression)	–	–	–	0.16**±0.03	0.46**±0.06	–	–.001±0.00
SP (Regression)					–	0.97±0.02	–

Means with different superscripts differ significantly from each other.

Table 4. ANOVA (MS values) of first lactation reproduction traits in Sahiwal cattle

Source of variation	NSC	CR	GP	CFI	SP	CI	PR
Sire	0.93 (29)	0.31 (29)	33.65 (32)	2055.15 (21)	3964.99 (22)	1006.28 (23)	0.04 (21)
Period of calving	1.34*(9)	0.42 (9)	35.31 (9)	1754.94 (8)	3707.96	88.12	0.03
Season of calving (3)	2.48*	0.94*	32.63	3195.72	5237.90	1704.18	0.13*
Age group (2)	12.47**	3.63**	2.27	–	3757.63	–	0.01
LL (Regression)	–	–	–	33841.22**	190757.36**	–	0.63**
SP (Regression)	–	–	–	–	–	1100771.35**	–
Error	0.64 (230)	0.25 (230)	23.78 (248)	1573.58 (156)	3193.78 (144)	790.09 (158)	0.03 (123)

Figures in parentheses represent number of degrees of freedom; ** and * represents significant at 1% and 5% level of significance.

and season of calving was found non–significant on CFI. Effect of lactation length taken as co–variable was found to be significant (P<0.01) on CFI in Sahiwal cattle. Similar non–significant effect of season and period of calving on CFI was observed by Meera (2017) in Karan Fries cattle, however, several workers (Hammound *et al*. 2010, Potgieter, 2012) reported significant effect of season and period of calving on CFI in HF and HF crossbred cattle.

Effect of period of calving, season of calving and age group at calving was found to be non–significant while lactation length as co–variable had significant (P<0.01) effect on first service period. On contrary, period of calving had significant effect on service period as reported by various researchers (Zafar *et al.* 2008, Raja, 2010) and Rehman and Khan (2012) reported significant effect of season of calving on service period in Sahiwal cattle. As evident from the Table 4, random effect of sire and fixed effect of season and period of calving had no significant effect on calving interval in the present study. Service period as a co–variable significantly (P<0.01) affected calving interval in Sahiwal cattle. Shinghare *et al.* (2015) reported non–significant influence of period and season of calving on calving interval however, Manoj *et al.* (2010) reported significant effect of period on calving interval in Sahiwal cattle.

Effect of season of calving and lactation length as co–variable was found to be significant (P<0.05 and P<0.01) on pregnancy rate while random effect of sire, fixed effect of period of calving and age group at first calving was found to be non–significant. Significant effect of season of calving on first lactation pregnancy rate was reported by Meera (2017) in Karan Fries cattle. Meera (2017) observed non–significant effect of period of calving on pregnancy rate in KF cattle which was in concordance with the present report.

Heritability estimate of age at first service was found to be 0.15 in Sahiwal cattle in present study. Vinothraj *et al*. (2016) reported heritability of age at first service as 0.29 in Jersey × Red Sindhi cattle. Heritability of AFC in present study was observed as 0.27 in Sahiwal cattle. Heritability estimates of age at first calving as reported by Rehman *et al*. (2008) and Banik and Gandhi (2010) in Sahiwal cattle were 0.02 and 0.19, respectively. These were lower than the estimated value of heritability obtained in present study.

The estimated heritability of number of services per conception was found to be medium (0.24) in Sahiwal cattle (Table 5). Vinothraj *et al*. (2016) observed heritability of number of services per conception as 0.04 in Jersey × Red Sindhi cattle. M'hamdi *et al*. (2011) reported heritability of same trait as 0.02 in Tunisian Holstein cows. Heritability of conception rate in Sahiwal cattle was found to be low (0.13) in present study. Bormann *et al*. (2006) reported comparatively lower heritability estimate of first–service conception rate in Angus cattle as 0.03. Heritability of gestation period in Sahiwal cattle was found to be medium (0.23). Azzam and Nielsen (1987) reported heritability of gestation period as 0.41 for first parity in beef cattle. Similar to present report, moderate estimates of heritability for gestation period were observed by Normann *et al*. (2009) in different dairy breeds.

Heritability estimates of calving to first insemination was 0.18 (Table 5) in this study. Several workers (Berry *et al*. 2003, Sun *et al*. 2010, Potgieter, 2012) reported comparatively lower estimates of heritability in HF cattle. Heritability of service period was also found to be low (0.17) in Sahiwal cattle. Similar estimate of heritability was reported by Banik and Gandhi (2010) although, Choudhary *et al*. (2003) reported higher estimates and Rehman *et al*. (2008) observed lower estimates in Sahiwal cattle. In the present study, heritability estimate of calving interval was found to be low (0.17). This was in concordance with heritability estimates reported by Singh *et al*. (1999). However, Rehman *et al*. (2008) and Banik and Gandhi (2010) observed comparatively lower heritability of calving interval in Sahiwal cattle. Heritability estimate of pregnancy rate was found to be low (0.09) in Sahiwal cattle. Almost similar low estimates of heritability was reported by VanRaden *et al*. (2004) in HF cattle. Borman *et al*. (2006) also reported low (0.13) heritability of pregnancy rate in Angus cattle.

Table 5. Heritability estimates of different first lactation reproduction traits in Sahiwal cattle

Trait	Heritability estimate
AFS	0.15
AFC	0.27
NSC	0.24
CR	0.13
GP	0.23
CFI	0.18
SP	0.17
CI	0.17
PR	0.09

In conclusion, our study revealed that variations in reproduction traits may be more of non–genetic origin as opposed to genetics and sampling of population. All the traits considered in the present study had no significant effect of sire. Period of birth had significant effect on age at first service (AFS) and age at first calving (AFC). Statistically significant ($P<0.05$) differences were found for effect of period of calving and season of calving on different reproduction traits. Differences in reproduction traits over different periods and seasons may be ascribed to differences in management and different environmental conditions. The magnitudes of heritability estimates were found to be low to medium varying from 0.09 to 0.27 for different reproduction traits.This suggests that there is great role of environment and management for improvement of these traits.

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