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Effect of different non-genetic factors on production and reproduction traits in Sahiwal cattle

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Abstract
The present study was conducted to evaluate the effect of non-genetic factors on production and reproduction traits of Sahiwal cattle. The effects of period of birth, season of birth, period of calving, season of calving, and parity on various production and reproduction traits were examined using data from 238 Sahiwal cows kept at the Cattle breeding farm, Department of Animal Genetics and Breeding, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar, Haryana. The overall least squares means of total milk yield (TMY), 300 days milk yield (300D MY), lactation length (LL), dry period (DP), service period (SP), calving interval (CI) and AI per conception (AI/conception) were 1765.08 ± 142.49 kg, 1730.08 ± 133.90 kg, 257.70 ± 14.76 days, 175.36 ± 23.33 days, 144.25 ± 23.29 days, 432.35 ± 23.63 days and 1.49 ± 0.18, respectively. Among the non-genetic factors, the period of birth had significant (p<0.05) effect on TMY, 300D MY, LL and DP and period of calving had highly significant (p<0.01) effect on all traits (TMY, 300D MY, LL, DP, SP, CI and AI/conception) taken into consideration. The season of birth and season of calving had no significant effect on these traits indicating the endurance of Sahiwal cattle to the hot tropical climatic conditions with respect to the above traits. It was therefore, concluded that, Sahiwal cattle performance was affected by non-genetic factors.

Keywords: Dry period, lactation length, milk yield, non-genetic factors, sahiwal

Introduction
Millions of rural households rely heavily on the money generated by dairying, which also plays a vital role in creating jobs and income. Cattle form the most important part of livestock and there are 53 registered breeds of cattle in India (NBAGR, 2023) [28]. India has 193.46 million (36.04%) total cattle population. Out of which, about 142.11 million are indigenous cattle and population of Sahiwal cattle is approximately 46 lacs (20th Livestock Census, 2019) [1]. The recent increase in cattle population (2012 to 2019) demonstrates a clear preference for crossbred dairy animals, while that of indigenous cattle declined by 6% (20th Livestock Census, 2019) [1]. Milk productivity in the country remains the lowest as compared to many leading countries of the world. In India, total milk production is 221.06 million tonnes (BAHS, 2022-23). Out of which, 20% milk is contributed by indigenous cattle breeds (BAHS, 2022-23). Average milk productivity of indigenous cows is about 4.07 kg/day (BAHS, 2022-23). India has historically been completely self-sufficient in milk, with annual total imports and exports of about 0.3 million tonnes; as a result, it can be said to be essentially isolated from the global dairy market (FAO, 2019) [20]. For a variety of reasons, including inadequate nutrition, low genetic potential, inadequate animal health services, harsh climatic conditions, and other management-related issues, cow productivity remains low in the country despite the presence of large and diverse cattle genetic resources. The native breeds of cattle produce ineffectively due to their late maturation, delayed conception, and lengthy calving intervals (Effa *et al*. 2011) [19]. One of the most significant milch cow breeds, the Sahiwal, has its home tract in the Montgomery district of the old Punjab (now a part of Pakistan). Sahiwal cattle can be found in the Punjab district of Ferozpur and Amritsar as well as the Rajasthani district of Sri Ganganagar under field circumstances. Several organised farms in India also have a few hundred animals available.

Sahiwal cattle are renowned for their superior milk production, extraordinary capacity for enduring the hot subtropical temperature, comparative diseases resistance, and inexpensive maintenance costs. In India, the Sahiwal breed of native cattle is the most significant. According to Bajwa *et al*. (2004) [4], the majority of indigenous cattle have an average lactation length (LL) of less than 305 days. Therefore, it is crucial to boost the native stock's production capacity in order to fulfil the rising demand for milk and milk products from our nation's rapidly expanding population. To meet the continuously rising demand for milk and milk products from our nation's ever-growing population, it is crucial to increase the production capability of our indigenous stock. The features of dairy cows that affect production and reproduction are influenced by a wide range of non-genetic factors. Thus, the present study was undertaken to assess the effect of various non-genetic factors on production and reproduction traits in Sahiwal cattle kept at Cattle breeding farm, Department of Animal Genetics and Breeding, LUVAS, Hisar, Haryana.

Materials and Methods

Data

In the present study, records on production and reproduction traits of Sahiwal cows kept at Department of Animal Genetics and Breeding, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar, Haryana maintained over a period of 10 years (2008-2018) were used. Animals with a lactation length of fewer than 100 days and a daily milk production of less than 3 kg were excluded from the study as they were taken to be abnormal. A total of seven different production and reproduction traits up to third parity were considered in this study. Production traits taken under consideration were total milk yield (TMY), 300 days milk yield (300D MY), lactation length (LL), dry period (DP) and reproduction traits as calving interval (CI), service period (SP), number of artificial insemination per conception (AI/Conception).

Statistical analyses

The following least-squares method of the General linear model was used to discern the influence of effect of period and season of birth, period and season of calving and parity order on traits related to production and reproduction in targeted population.

Model

$Y_{ijklmn} = \mu + P_i + Q_j + R_k + S_l + T_m + e_{ijklmn}$

Where,

Y_{ijklmn} = Observed value of reproduction and production traits;

μ = overall mean;

P_i = Effect of i^{th} period of birth;

Q_j = Effect of j^{th} season of birth;

R_k = Effect of k^{th} period of calving;

S_l = Effect of l^{th} season of calving;

T_m = Effect of m^{th} parity;

e_{ijklmn} = Random error associated with each observation assumed to be NID e $(0, \sigma^2)$.

where, i = 1, 2; j = 1, 2, 3; k = (1, 2, 3 for 1st parity) and (1, 2 for 2nd and 3rd parity); l = 1, 2, 3; m = 1, 2, 3.

Model was used for the analysis of production and reproduction traits *viz*. TMY, 300D MY, LL, DP, CI, SP and AI/Conception.

In order to study the effect of different non genetic factors on different traits, the data were classified according to period of birth, season of birth, period of calving and season of calving. Different non genetic factors were classified in various categories as two period of birth i.e. I (2008-2011) and II (2012- 2016); three season of birth: I -Winter (December to March), II- Summer (April to July), III - Rainy (August to November); three period of calving: - I (2011-2013), II (2014-2016), III (2017-2019); three season of Calving: I -Winter (December to March), II- Summer (April to July), III –Rainy (August to November) and three group in parities i.e. I (1st parity), II (2nd parity) and III (3rd parity).

Results and Discussion

The general least–squares means for production and reproduction traits, *viz*. total milk yield (TMY), 300 days milk yield (300D MY), lactation length (LL), dry period (DP), calving interval (CI), service period (SP) and artificial insemination per conception (AI/Conception) were 1765.08 ± 142.49 kg, 1730.08 ± 133.90 kg and 257.70 ± 14.76 days, 175.36 ± 23.33 days, 432.35 ± 23.63 days, 144.25 ± 23.29 days and 1.49 ± 0.18, respectively in Sahiwal cattle (Table 1 and 2).

Effect of non-genetic factors on different production traits

There was a significant association (p<0.05) of period of birth with TMY, 300D MY and LL. Animals born in period-2012-2016 were having significantly 357 kg higher TMY (1943.17± 176.95) kg, 329 kg higher 300D MY (1894.97 ± 166.29) kg and 26 days longer LL (270.41 ± 18.33) days than period- 2008-2011 TMY (1586.99 ± 133.06) kg, 300D MY (1565.19 ± 125.04) kg and LL (244.98 ± 13.78) days. Petrovic *et al.* (2009) [31] observed a significant effect of year of birth on all the lactation traits. On the contrary, Habib *et al.* (2010) [21] and Veraprasad *et al.* (2013) [42] reported non-significant effect of year of birth on lactation traits. There is no significant association of season of birth with TMY, 300D MY and LL in the targeted population (p>0.05). However, animals born in summer season produced higher TMY and 300D MY with longer LL than the animals born in winter and rainy season. The present findings were in agreement with the findings of Veraprasad *et al.* (2013) [42] who reported non-significant effect of season of birth on lactation traits. However, Petrovic *et al.* (2009) [31] observed significant effect of season of birth on all the lactation traits.

There was significant association (p<0.01) of period of calving with TMY, 300D MY and LL. Animals calved in period 2014-2016 were having significantly higher TMY (1939.05 ± 150.56) days, 300D MY (1881.83 ± 141.49) days and longer LL (272.17 ± 15.60) days than period 2011-2013 - TMY (1549.20 ± 196.93) kg, 300D MY (1522.81 ± 185.06) kg and LL (260.56 ± 20.40) days and period 2017-2019 - TMY (1807.00 ± 136.47) kg, 300D MY (1785.60± 128.25) kg and LL (240.36 ± 14.14) days. Animals calved in period 2014-2016 were having significantly 390 kg and 359 kg higher TMY and 300D MY respectively than period

2011-2013 and animals calved in period 2014-2016 were having significantly 133 kg and 96 kg higher TMY and 300D MY respectively than period 2017-2019 TMY and 300D MY. Similarly, significant influence of period of calving was reported in the literature on TMY by Shrivastava *et al.* (1985) [36] and Mishra and Prasad (1994) [26], 300D MY by Thakur and Singh (2000 and 2001) [38, 40], LL by Deshmukh *et al.* (1995b) [14]. In contrast, Tewari *et al.* (1995) in Jersey × Sahiwal cows and Singh and Nagarcenkar (1997) [27] in Sahiwal cows and Das *et al.* (2006) [11] in Holstein Friesian and Sahiwal cows observed no significant influence of period on various milk production traits. Season of calving had no significant effect on TMY and 300D MY and LL and cows calved in winter season were having higher least square mean values of TMY, 300D MY and LL than the cows calved in summer and rainy season which might be due to the variation in climate and quality of feeds and fodders available in different seasons. Deshpande *et al.* (1992) [15], Singh and Nagarcenkar (1997) [27], Das *et al.* (2001) [12] and Thakur and Singh (2000 and 2005) [38, 40] also noticed the influence of season of calving on various production traits of purebred and crossbred cows. While non-significant influence of season of calving was reported on TMY by Jadhav and Khan (1995) [22] and 300D MY by Das *et al.* (2006) [11]. The calving season had no significant effect on the LL. Chavan (2001) [10] reported similar outcomes. On the other hand, Auradkar (1999) [3] reported significant effect of season on lactation length. There was no significant association (p>0.05) found in different parities with TMY, 300D MY and LL of cows. On perusal of Table 1, it is evident that animals in parity III were having higher TMY, 300D MY and longer LL as compared to animals of parity I and II. This suggests that milk yield increases as parity proceeds because due to large body size and increased development of udder tissue, large cows produced more milk than cows of earlier parities. The studies carried out on LL by Topaloglu and Gunes (2010) [41] and Kumar *et al.* (2014) [25] also reported similar findings. On contrary, Wondifraw *et al.* (2013) [43] reported non-significant effect of parity on lactation length. Wondifraw *et al.* (2013) [43] and Japheth *et al.* (2015) [23] also observed significant effect of parity on 305DMY in cattle.

In the present study, there was significant association (p<0.05) of period of birth with DP. Animals born in period 2 (2012-2016) were having significantly shorter DP (167.03 ± 28.97) days than DP (183.69 ± 21.79) days in period 1(2008-2011). Habib *et al.* (2010) [21] reported non-significant effect of year and season of birth on dry period. There was no significant association between season of birth and DP in the targeted population (p>0.05) and cows born in summer season were having shorter DP than the cows born in winter and rainy season. Analysis revealed significant association (p<0.01) of period of calving with DP in Sahiwal cattle (Table 1). Animals calved in period 2 (2014-2016) were having significantly shorter DP (148.11 ± 24.65) days than period 1(2011-2013) DP (225.42 ± 32.24) days and period 3 (2017-2019) DP (152.55 ± 22.34) days and season of calving had no significant effect on DP. However, animals calved in winter season were having favourable mean values of DP than the animals calved in summer and rainy season. Similar to our findings, Bhutkar *et al.* (2014) [7], Dhawan *et al.* (2015) [16] and Sawant *et al.* (2016) [35] reported non-significant effect of season of calving on DP. Whereas, the significant effect of calving season on DP was observed in literature by Chaudhari *et al.* (2013) [9] and Raja and Gandhi (2015) [33]. There was no significant association (p>0.05) found in DP of cows with different parities in Sahiwal cattle. It was evident that animals in third parity were having shorter DP as compared to animals of parity I and II respectively. For crossbreed cattle, Ahmed *et al.* (2007) [2] observed significant effect of parity on DP; however, Poudel *et al.* (2017) [32] reported a non-significant effect of parity in Murrah buffalo.

Effect of non-genetic factors on different reproduction traits

Analysis showed that, there was no significant association of period and season of birth with SP and CI (p>0.05). However, animals born in period 2008-2011 and winter season were having shorter SP and CI than period 2012-2016, summer and rainy season.

Analysis revealed that there was no significant association (p>0.05) of period and season of calving with SP and CI in Sahiwal cattle taken under study (Table 2). In Sahiwal cattle, animals calved in period 2017-2019 were having shorter SP and CI than period 2011-2016 and cows calved in rainy season were having favourable mean values of SP and CI than the cows calved in winter and summer season. Saha *et al.* (2010) [34] showed similar non-significant effects of calving period on SP and CI in Karan-Fries cattle. Contrary to the above findings, Divya (2012) [18], Chaudhari *et al.* (2013) [9] and Dash *et al.* (2016) [13] reported significant effect of period of calving on SP and CI. Non-significant effect of season of calving on SP and CI was reported by Divya *et al.* (2014) [17] and Kumar (2015) [25] in crossbreed cattle and Basak and Das (2018) in Deoni. Whereas, Chaudhari *et al.* (2013) [9] and Dash *et al.* (2016) [13] reported the significant effect of season of calving on SP and CI in cattle. In the present study, there was no significant association (p>0.05) found between different parities of animals with their SP and CI. On perusal of Table 2, it is evident that animals in parity III were having shorter SP and CI as compared to animals of earlier parities. However, a significant effect of lactation parity on SP and CI was reported by Dash *et al.* (2016) [13] in crossbreed (Karan-Fries) and Basak and Das (2018) in Deoni cattle.

Analysis revealed that, there was no significant association (p>0.05) of period and season of birth with AI/conception (p>0.05) in Sahiwal cattle. However, animals born in period 2008-2011 and winter season were having lesser AI/conception than period 2012-2016, summer and rainy season in the targeted population. There was significant association (p<0.01) of period of calving with AI/conception. However, the mean value of AI/conception was found 0.5 and 0.8 lesser for animals calved during the period 2011-2013 in comparison to the later period 2014-2016 and period 2017-2019 respectively and there was significant association (p<0.01) of season of calving with AI/conception. Animals calved in winter season were having significantly 0.28 and 0.3 lesser AI/conception than summer and rainy season respectively. Bolacali and Ozturk (2017) [8] discovered a significant impact of calving season in Simmental cows, which is in accordance with the current findings. Lactation parity (Ozkan and Gunes, 2007) [29] were reported to have significant effects on the number of insemination per pregnancy, consistent with the findings of the current study. However, Ozkan and Gunes (2011) [30]

found that the effects of calving year, lactation parity, and calving season on the number of insemination per pregnancy were not significant and there was no significant association found in AI/conception of cows with different parities. On perusal of Table 2, it is evident that animals in parity I were having lesser AI/conception as compared to animals of later parities.

Table 1: Effect of non-genetic factors on production traits of Sahiwal cattle.

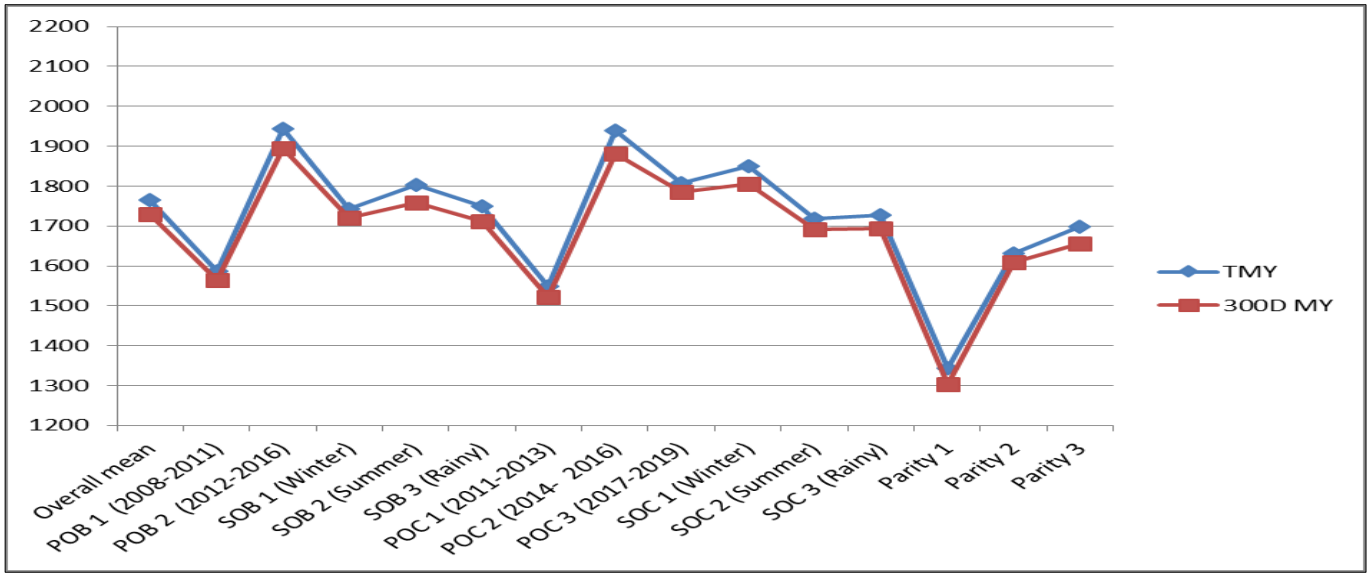
Effects	No. of animals	TMY	300D MY	LL	DP
Overall mean	238	1765.08 ± 142.49	1730.08 ± 133.90	257.70 ± 14.76	175.36 ± 23.33
Period of birth*					
2008-2011	160	1586.99b ± 133.06	1565.19 b± 125.04	244.98b ± 13.78	183.69b ± 21.79
2012-2016	78	1943.17a± 176.95	1894.97a ± 166.29	270.41a± 18.33	167.03a ± 28.97
Season of birth					
Winter	132	1742.10 ± 133.90	1719.51 ± 125.83	256.35 ± 13.87	155.88 ± 21.92
Summer	59	1803.30 ± 163.34	1758.17 ± 153.50	262.62 ± 16.92	134.19 ± 26.74
Rainy	47	1749.85 ± 170.31	1712.56 ± 160.04	254.13 ± 17.64	206.01 ± 27.88
Period of Calving **					
2011-2013	33	1549.20b ± 196.93	1522.81 b± 185.06	260.56b ± 20.40	225.43b ± 32.24
2014-2016	116	1939.05a ± 150.57	1881.83 a ± 141.49	272.17a ± 15.60	148.11 a ± 24.65
2017-2019	89	1806.99a± 136.47	1785.61a ± 128.25	240.36a ± 14.14	152.55 a ± 22.34
Season of calving					
Winter	91	1849.06 ± 159.00	1804.46 ± 149.42	268.42 ± 16.47	177.48 ± 26.03
Summer	84	1718.52 ± 148.04	1690.92 ± 139.12	252.26 ± 15.33	178.52 ± 24.24
Rainy	63	1727.66 ± 155.40	1694.86 ± 146.03	252.41 ± 16.10	179.07 ± 25.44
Parity *					
I	90	1343.13 ± 71.71	1304.25 ± 67.39	248.84 ± 7.43	242.20^{b} ± 11.74
II	64	1631.66 ± 87.85	1608.72 ± 82.56	251.80 ± 9.10	196.89^{a} ± 14.38
III	44	1697.27 ± 110.36	1656.85 ± 103.71	259.59 ± 11.43	193.43^{a} ± 18.07

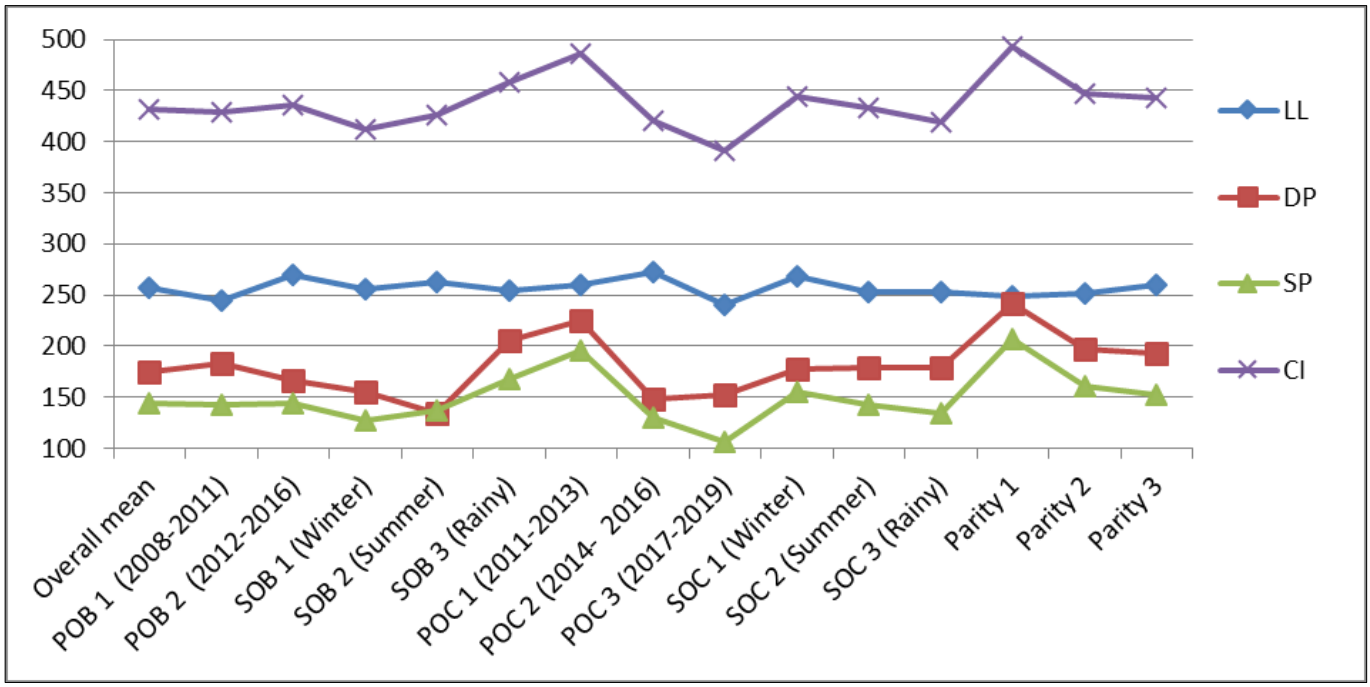
* Significant (p<0.05); ** Significant (p<0.01); Mean values with different superscripts differ significantly.

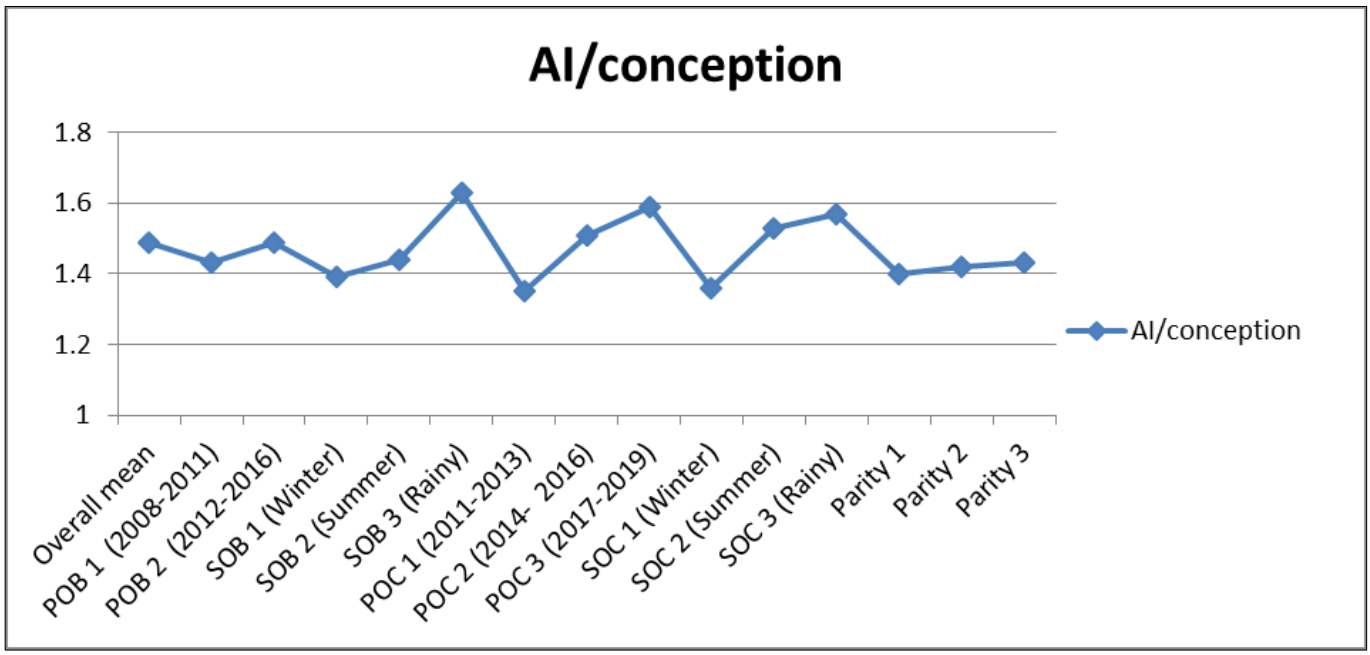
Table 2 Effect of non-genetic factors on reproduction traits of Sahiwal cattle

Effects	No. of animals (n)	SP	CI	AI/conception
Overall mean	238	144.25 ± 23.29	432.35 ± 23.63	1.49 ± 0.18
Period of birth				
2008-2011	160	142.36 ± 21.75	428.49 ± 22.06	1.43 ± 0.16
2012-2016	78	144.14 ± 28.92	436.21 ± 29.34	1.49 ± 0.22
Season of birth				
Winter	132	127.06 ± 21.88	412.50 ± 22.20	1.39 ± 0.17
Summer	59	137.62 ± 26.70	426.84 ± 27.09	1.44 ± 0.20
Rainy	47	168.07 ± 27.84	457.72 ± 28.24	1.63 ± 0.21
Period of Calving**				
2011-2013	33	195.57 ± 32.19	485.78 ± 32.65	1.35^{a} ± 0.24
2014-2016	116	130.62 ± 24.61	420.68 ± 24.97	1.51^{b} ± 0.19
2017-2019	89	106.56 ± 22.31	390.60 ± 22.63	1.59^{b} ± 0.17
Season of calving**				
Winter	91	155.47 ± 25.99	444.65 ± 26.37	1.36^{a} ± 0.20
Summer	84	142.38 ± 24.20	433.16 ± 24.55	1.53^{b} ± 0.18
Rainy	63	134.90 ± 25.40	419.24 ± 25.77	1.57^{b} ± 0.19
Parity				
I	90	206.81 ± 11.72	493.23 ± 11.89	1.40 ± 0.09
II	64	160.68 ± 14.36	447.65 ± 14.57	1.42 ± 0.11
III	44	152.22 ± 18.04	442.46 ± 18.30	1.43 ± 0.14

* Significant (p<0.05); ** Significant (p<0.01); Mean values with different superscripts differ significantly.


2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
Overall mean
POB 1 (2008-2011)
POB 2 (2012-2016)
SOB 1 (Winter)
SOB 2 (Summer)
SOB 3 (Rainy)
POC 1 (2011-2013)
POC 2 (2014- 2016)
POC 3 (2017-2019)
SOC 1 (Winter)
SOC 2 (Summer)
SOC 3 (Rainy)
Parity 1
Parity 2
Parity 3
TMY
300D MY


500
450
400
350
300
250
200
150
100
Overall mean
POB 1 (2008-2011)
POB 2 (2012-2016)
SOB 1 (Winter)
SOB 2 (Summer)
SOB 3 (Rainy)
POC 1 (2011-2013)
POC 2 (2014- 2016)
POC 3 (2017-2019)
SOC 1 (Winter)
SOC 2 (Summer)
SOC 3 (Rainy)
Parity 1
Parity 2
Parity 3
LL
DP
SP
CI


AI/conception
1.8
1.6
1.4
1.2
1
Overall mean
POB 1 (2008-2011)
POB 2 (2012-2016)
SOB 1 (Winter)
SOB 2 (Summer)
SOB 3 (Rainy)
POC 1 (2011-2013)
POC 2 (2014- 2016)
POC 3 (2017-2019)
SOC 1 (Winter)
SOC 2 (Summer)
SOC 3 (Rainy)
Parity 1
Parity 2
Parity 3
AI/conception

Conclusion

In targeted cattle population, animals born in period - 2012-2016 and animals calved in period - 2014-2019 were having significantly (p<0.01) higher TMY, 300DMY, LL and shorter DP. All the production traits under study exhibit improved performance over periods that could be attributed to better selection, improved management and nutrition followed at the farm over time. The variations in the management techniques and feeding schedules used on the farm may be the cause of these variations in these traits.

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