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Reproductive Performance of Lactating Holstein Cows as Influenced by Season of Calving and Parity Under Subtropical Conditions

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ABSTRACT

Normal lactation records of 1717 Holstein cows belong to commercial dairy farm covered a period of 11 years from 1995 to 2005 were used in this study to evaluate the effects of calving season and parity on reproductive performance under subtropical desert conditions. The reproductive traits studied were age at first calving (AFC, month), first service period (FSP, day), number of services per conception (NSC, number), days open (DO, day), calving interval (CI, month), projected minimum calving interval (PMCI, month), breeding interval (BI, day) and conception rate (CR, %). NSC, DO, CI, and PMCI were enhanced significantly in winter compared to summer. Also, PMCI value in winter was lower compared to summer. The overall means of FSP, DO, PMCI, and BI were lower in multiparous cows compared to those in primiparous. No influences of interaction between season of calving and parity were detected on the reproductive traits of FSP, NSC, DO, CI and PMCI. CR had been influenced by season of calving as cows calved in winter exhibited higher CR (44%) than those calved in summer (39%). Heritability estimate of NSC, DO, CI and PMCI heritabilities were low and ranged from 0.07 to 0.19. In contrast, FSP and BI had medium heritabilities. Genetic correlations were low and positive between each of NSC, FSP or BI, between CI and each of NSC or FSP. In contrast, Genetic correlations were medium to high positive among other traits. The phenotypic correlations between NSC and each of FSP or BI were negatively low. Other phenotypic correlations were mostly similar in value and direction as the corresponding genetic correlations. Genetic trends of FSP, DO, CI and PMCI exhibited clear deterioration by time. They tended to decrease throughout the years of study. In contrast NSC and BI breeding values tended to increase during the same period.

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Introduction

The success of a cow production system from a dairy enterprise and high profitability vividly depend on the excellent reproductive performance (De Vries, 2006; Drackley and Cardoso, 2014). Reproductive and productive traits contribute to the evaluation and selection for animals' decisions made on breeding or production purposes. Moreover, reproductive performance could provide an objective description for animal milk production since it has an influence on the amount of milk synthesized by a cow per day of her life. In addition, its effects on profitability and longevity of dairy cows have indirect effects on the costs of replacement, breeding and veterinary services (Gilmore *et al.*, 2011).

It is worth noting that the low to medium values of heritability of the reproductive traits illustrate that the major part of the variation in this group of traits is regulated by environmental conditions (Radostits, 2001). Therefore, the management practices adopted in a dairy farm present a powerful tool to support high production levels (Thomas and Sastry, 2008).

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Parity, feeding protocol, and season of calving are principal environmental elements that have an influence on the reproductive performance of dairy cows (M'hamdi *et al.*, 2012) measured as calving interval, age at first calving, first service period, number of services per conception, days open, breeding interval, conception and pregnancy rates (Inchaisri *et al.*, 2010). In order to distinguish a sound management plan to enhance the dairy cows' reproductive efficiency, the awareness of the reproductive performance elements is, therefore, essential.

Days open period of 85 days, number of services per conception of 1.3 to 1.5, and calving interval of 12 to 13.5 months were declared as standard values (Radostits, 2001). However, for a long term study lasted for 20 years on 70 dairy herds, Silvia (1998) reported that days open were increased by 27 days, but services per conception performance were decreased by 80%. Similarly, under tropical conditions, the number of services per conception and calving interval increased from 1.92 and 463 (Negusie *et al.*, 2000) to 2.15 services and 490 days (Yohannes *et al.*, 2001), respectively, which necessitated a periodic evaluation of the dairy cows for appropriate corrective measures for reproductive performance.

The objective of present study was to evaluate the effects of calving season and parity on reproductive performance;

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first service period, number of services per conception, days open, calving interval, projected minimum calving and breeding interval of dairy cows under subtropical desert conditions.

Materials and methods

A total of 1717 normal lactation records of Holstein cows belong to El-Yoser commercial dairy farm located in Nubaria region K 51 Alex_Cairo desert road (temperature humidity indexes 80 & 83 and 94 & 95 in winter and summer, respectively according to NRC, 1971) were used in this study. The records covered a period of 11 years from 1995 to 2005. Heifers were first artificially inseminated at 18 months of age and 360 kg body weight. In subsequent lactations, cows were initially inseminated a 60–70 days postpartum. Cows were housed free in open yard with semi-open sheds all the year round and were fed corn silage mixed with concentrate ration (TMR) according to NRC (1989) requirements. After delivery, cows were machine milked three times daily at 5 am, 1 pm and 10 pm. Milk yield was recorded every two weeks. Cows were usually milked until two months before the next expected calving and then dried off.

All animals and sampling procedures in this experiment were supervised and approved by the Institutional Animal Care and Use Committee of Alexandria University. Also, all procedures and experimental protocols were in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments.

Factors and traits under Study

The reproductive traits studied were age at first calving (AFC, month), first service period (FSP, day), number of services per conception (NSC, number), days open (DO, day), calving interval (CI, month), projected minimum calving interval (PMCI, month) and breeding interval (BI, day). Also, conception rate (CR, %) was calculated as the number of cows conceived from first insemination by the total number of cows inseminated. Days open were the interval from calving to conception. The average DO was added to a standard 279-days gestation length of Holstein then divided by 30.25 days/month to calculate PMCI that was used for comparing days open to actual calving interval, and herd reproduction management according to Varner *et al*. (2010). PMCI and BI were calculated (Varner *et al*., 2010) as:

PMCI, mo = (DO, d + 279) / 30.25, BI, d = (DO, d – FSP, d) / (NSC – 1)

The effects of the environmental factors of parity, season of calving, year of calving and age at first calving on all performance traits were studied. The data were classified according to season of calving into; summer (from March to August)

Statistical analysis

Best linear unbiased estimation (BLUE) is the method most frequently used in animal production for estimation of fixed effects (Weigel *et al*., 1991). To derive BLUE of the fixed effects, least-squares procedures through the mixed model method, considering the parity effect as the repeated measurement, were used (SAS Inst. Inc., Cary, NC). To study the factors affecting reproductive performance traits, MIXED procedure of SAS (SAS, 2004) was used according to the following model:

$$Y_{ijklmno} = \mu + S_i + F_j + P_k + (FP)_{jk} + b_l (x_1 - \bar{x}1) + b_m (x_2 - \bar{x}2) + e_{ijklmn}$$

Where: $Y_{ijklmno}$ = the traits under study, μ = the overall mean, S_i = the random effect of ith sire, F_j = the fixed effect of j^{th} season of calving, P_k = the fixed effect of k^{th} parturition number, F_jP_k = the fixed effect of interaction between season and parturition number, b_l = a regression coefficient of the trait on year of calving, b_m = a regression coefficient of the trait on age at first calving (AFC), and e_{ijklmn}= the residual error.

Differences among means were tested using least significant difference ($LSD_{0.05}$). Conception rate was calculated and analyzed by odd ratio procedure. Heritability and genetic and phenotypic correlations were estimated using Multiple Traits Derivative Free Restricted Maximum Likelihood (MTDFREML) according to Boldman *et al*. (1995) using Animal Model. Besides, the genetic trend was performed for all studied traits using years of birth for cows.

Results

Overview of herd performance

Means standard deviation and coefficient of variation of reproductive performance traits of Holstein dairy cows in this study are presented in Table 1. AFC had the smallest coefficient of variation (8.54) indicating a close proximity between cows to reach puberty and achieve conception. In contrast NSC and BI had the largest coefficient of variation declaring lack of similarity among cows for number of services per conception.

Factors affecting reproductive performance

The reproductive performance of Holstein dairy cows in the current study was significantly influenced by season of calving (Table 2). NSC, DO, CI, and PMCI were enhanced significantly in winter (2.67 services; 168.85 days; 14.48 months and 14.80 months, respectively) compared to summer (2.98 services; 184.14 days; 15.73 months and 15.31 months, respectively), while no differences were observed between seasons

Table 1. Means, standard deviations (S.D.) and coefficients of variation (C.V., %) for some reproductive traits of Holstein dairy cows under Egyptian desert conditions (no. = 1717).

Traits	Mean	S.D.	C.V.
AFC	27.18	2.32	8.54
FSP	116.03	88.22	76.03
NSC	2.77	2.54	91.49
DO	173.17	114.13	65.9
CI	15.01	7.84	52.24
PMCI	14.95	3.77	25.24
BI	32.21	29.2	90.65
CRFI	41.8	49.3	117.82

Age at first calving: AFC (Month); FSP: First service period (Days); NSC: Number of services per conception (Number); DO; Days open (Days); CI; Calving interval (Month); PMCI: Projected minimum calving interval (Month); BI: Breeding interval (Days); CRFI: Conception rate from first insemination (%).

in FSP or BI. Also, PMCI value in winter was lower (P<0.019) compared to summer (14.80±0.20 vs15.31±0.23 mo.).

The FSP, DO, PMCI, and BI reproductive traits were influenced (P < 0.05) by parity, but both of NSC and CI were not (Table 2). The overall means of FSP, DO, PMCI, and BI were lower (P < 0.05) in multiparous cows (114.41 days; 159.69 days; 14.50 mo.; and 26.47 days respectively) compared to those in primiparous (129.27 days; 193.30 days; 15.61 mo.; and 32.82, respectively; Table 2). The long period of DO for primiparous cows was reflected on the overall mean of PMCI, the primiparous cows exhibited similarly longer PMCI and BI compared to multiparous cows.

No influences of interaction between season of calving and parity were detected on the reproductive traits of FSP, NSC, DO, CI and PMCI (Table 3). However, BI was affected (P<0.033) by that interaction. Generally, BI was lower in multiparous cows calving in winter then those summers calving, while primiparous cows calving in both seasons had long BI.

The present results showed that regardless of parity, CR had been influenced (P<0.01) by season of calving (Table 4). Cows calved in winter exhibited higher CR (44%) than those calved in summer (39%).

Heritability estimates and phenotypic and genetic correlations among reproductive traits under study are presented in Table 5. Heritability estimate of NSC was very low (0.07). Also, DO, CI and PMCI heritabilities were low and ranged from

Table 2. Least squares means (±SE) of reproductive traits of Holstein dairy cows as influenced by season of calving and parity under Egyptian desert conditions.

Traits*	Season		*P*-Value	Parturition		*P*-Value
	Winter	Summer		Primiparous	Multiparous	
	(n = 1088)	(n = 629)		(n = 690)	(n = 1027)	
FSP	120.68±3.98	122.99±4.59	0.603	129.27±4.60[a]	114.41±4.54[b]	0.006
NSC	2.67±0.11[b]	2.98±0.13[a]	0.015	2.95±0.13	2.70±0.12	0.109
DO	168.85±6.13[b]	184.14±7.01[a]	0.018	193.30±6.92[a]	159.69±7.01[b]	< 0.001
CI	14.48±0.44[b]	15.73±0.51[a]	0.012	15.57±0.45	14.64±0.56	0.126
PMCI	14.80±0.20[b]	15.31±0.23[a]	0.019	15.61±0.23[a]	14.50±0.23[b]	< 0.001
BI	28.74±3.93	31.13±3.96	0.373	32.82±4.03[a]	26.47±4.00[b]	< 0.001

[a-b] Least squares means with different letters in the same row within the same factor are significantly different (P < 0.05). * FSP: First service period (Days); NSC: Number of services per conception (Number); DO; Days open (Days); CI; Calving interval (Month); PMCI: Projected minimum calving interval (Month); BI: Breeding interval (Days).

Table 3. Least squares means (±SE) of some reproductive traits of Holstein dairy cows as affected by the interaction between season of calving and parity under Egyptian desert conditions.

Traits*	Winter		Summer		*P*-Value
	Primiparous	Multiparous	Primiparous	Multiparous	
FSP	127.34±5.24	113.72±4.95	131.77±6.38	114.66±5.79	0.696
NSC	2.80±0.15	2.55±0.14	3.11±0.18	2.86±0.16	0.968
DO	185.48±7.82	152.16±7.55	201.22±9.23	167.13±8.86	0.952
CI	14.92±0.53	14.03±0.61	16.24±0.65	15.24±0.70	0.907
PMCI	15.35±0.25	14.25±0.24	15.87±0.31	14.72±0.29	0.388
BI	32.22±4.41[a]	25.16±4.17[c]	33.17±4.52[a]	28.49±4.34[b]	0.033

[a-c] Least squares means with different letters in the same row are significantly difference (P < 0.05). * FSP: First service period (Days); NSC: Number of services per conception (Number); DO; Days open (Days); CI; Calving interval (Month); PMCI: Projected minimum calving interval (Month); BI: Breeding interval (Days)

Table 4. Conception rates after first insemination (CR, %) in lactating Holstein dairy cows in different calving seasons and parities.

Item	CR, %	Odds ratio[1]	95% confidence interval	*P*-value
Calving season:				
Winter	44[a]	Referent	-	-
Summer	39[b]	0.826	0.673 - 1.014	0.01
Parturition:				
Primiparous	50[a]	Referent	-	-
Multiparous	36[b]	0.573	0.471 - 0.697	0.01

[a-b] Values with different letters in the same column within the same factor are significantly different. [1]Odds ratio is the estimated probability of conception. Ratios exceeding 1 indicate increased probability of conception, whereas ratios less than 1 indicate decreased probability of conception.

Table 5. Heritability estimates (on diagonal), phenotypic correlation (above diagonal) and genetic correlation (below diagonal) among reproductive traits under study.

Traits[1]	NSC	FSP	DO	CI	PMCI	BI
NSC	0.07	-0.11	0.59	0.25	0.59	-0.09
FSP	0.01	0.35	0.61	0.27	0.61	0.01
DO	0.44	0.47	0.16	0.43	1	0.37
CI	0.13	0.19	0.38	0.19	0.43	0.34
PMCI	0.44	0.47	1	0.38	0.16	0.37
BI	0.01	0.01	0.25	0.31	0.25	22

[1]FSP: First service period (Days); NSC: Number of services per conception (Number); DO; Days open (Days); CI; Calving interval (Month); PMCI: Projected minimum calving interval (Month); BI: Breeding interval (Days)

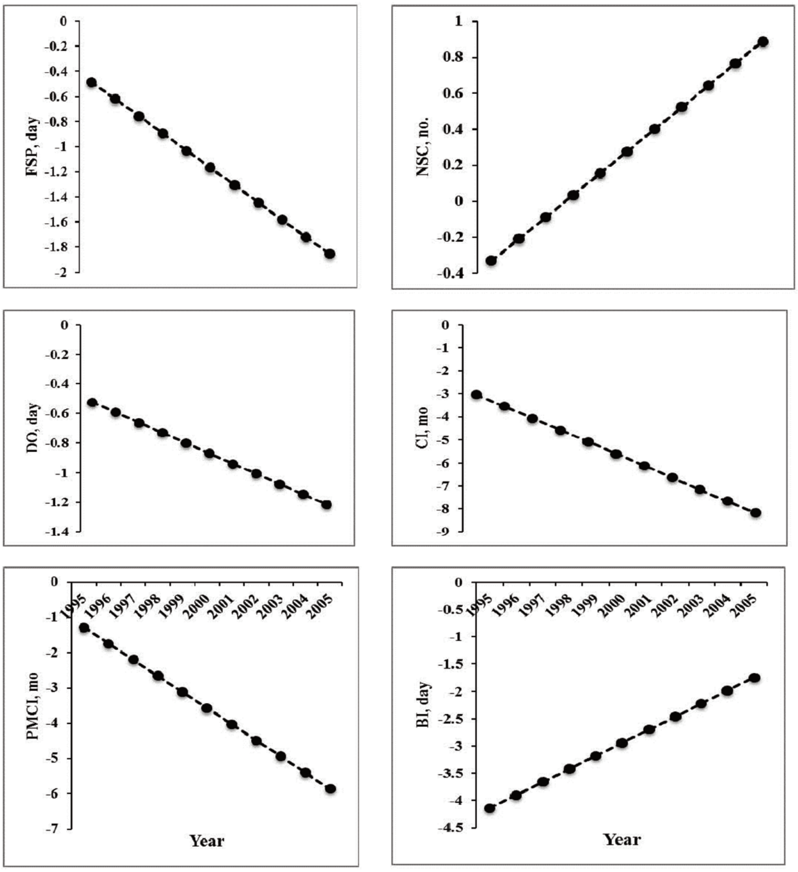

Fig. 1. Genetic trends of first service period (FSP), number of services per conception (NSC), days open (DO), calving interval (CI), projected minimum calving interval (PMCI) and breeding interval (BI) for cow.

0.16 to 0.19. In contrast, FSP and BI had medium heritabilities (0.35 and 0.22, respectively).

Genetic correlations were very low (0.01) between each of NSC, FSP or BI. Also, were low and positive between CI and each of NSC or FSP (0.13 and 0.19, respectively). In contrast, correlations were medium to high positive among other traits and ranged from 0.25 to 0.47. Besides, the genetic correlation between PMCI and DO was equal to unity. These results indicated that DO can be used successfully for early prediction of selection progress. These results also suggested that genes associated with short DO might be associated with those favorable for reproduction performance and, therefore, selection for short DO is also expected to improve reproduction performance.

The phenotypic correlations between NSC and each of FSP or BI were negatively low (-0.11 and -0.09, respectively). Similar to the genetic correlation, the phenotypic correlation be- tween DO and PMCI was equal unity. Other phenotypic correlations were mostly similar in value and direction as the corresponding genetic correlations. Medium to high positive phenotypic correlations found between DO, CI, PMCI and FSP indicated that any of the four traits can be used alternatively for evaluating reproductive performance of cows.

Genetic trends for FSP, NSC, DO, CI, PMCI and BI for cow are shown in Fig. 1. Traits of FSP, DO, CI and PMCI exhibited clear deterioration by time. They had a tendency to decrease throughout the years of study. In contrast NSC and BI breeding values tended to increase during the same period.

Discussion

The present DO, NSC and CI of the studied herd were lower than those recorded as standard values (Radostits, 2001) being 85 days, 1.3 to 1.5 services / conception and 12 to 13.5 months, respectively. Also, of the effect of season on reproductive performance are in partial agreement with those of Apori and Hagan (2014) who reported that all major determinants of reproductive performance traits were significantly influenced by year of birth and season of calving. However, Ansari-Lari *et al*. (2010) noted no influence of calving season on reproductive efficiency as described by NSC, DO, and CI.

The present mean of CI (15.01 months, Table 1) was larger than that estimated by Shalaby *et al*. (2001) and Hammoud *et al*. (2010). However, the lower CI of cows calved in winter compared to those calving in summer were consistent with those reported by Hammoud *et al*. (2010) and Motlagh *et al*. (2013), who reported that calving season had an influence on reproductive performance of dairy cows with cows calving in winter having shorter CI than those calving in summer. Similarly, Ansari-Lari *et al*. (2009) reported that during cold months, cows performed shorter CI than warm months. Likewise, Kunbhar *et al*. (2017) reported that cows calving in winter had shorter CI than those calving in summer followed by those calving in spring then autumn seasons. However, other reports showed CI did not differ among seasons (Ansari-Lari *et al*., 2010). The long CI of summer calvers could be attributed to the adverse effect of heat stress, disappearance of heat signs and low conception rate. Because CI present the best reproductive efficiency index (Mukasa-Mugerwa, 1989), long CI leads to direct economic losses. Moreover, it is associated with long DO, high NSC and low efficiency of heat detection.

In the present study, NSC (2.77) and DO (173.17 d) were higher than those reported by Hammoud *et al*. (2010) probably be due to conception failure or early embryonic losses. The decreased NSC during winter was reflected on the length of DO which was subsequently longer (184.14 days) during summer compared to winter (168.85 days). Similar to the current results, Motlagh *et al.* (2013) reported that season of calving had significant effect on the NSC and DO. Low (P<0.05) NSC was recorded in winter and in accordance the fewest DO compared to the summer season (Motlagh *et al.*, 2013). Also, Ghavi Hossein-Zadeh *et al.* (2013) noted that summer heat stress negatively affected reproductive performance of dairy cows. Summer-calved cows had greater NSC (P<0.05) than those calved in other seasons, also, DO of cows that calved during spring had longer (P<0.05) DO than those calved in other seasons (Ghavi Hossein-Zadeh *et al.*, 2013). On the other hand, Silvia *et al.* (2002) noted that the fewest number of DO was recorded for summer-calved cows compared to others. Moreover, cows calving in the summer had fewer DO than those calved in the spring (Hammoud *et al.*, 2010). Nonetheless, Mekuriaw *et al.* (2009) and Ansari-Lari *et al.* (2010) reported that the season of calving had no significant influenced on DO and NSC.

The discrepancies between different reports may be due to differences in management protocols and production levels. High producing cows calving in summer had longer DO than those calving in winter, while no significant differences were observed in the case of low producing cows in either season (Soydan and Kuran, 2017). Furthermore, regardless of season of calving, increased DO was associated with increasing in milk production, DO in high producing cows was 63 days longer than in low producing cows (Soydan and Kuran, 2017).

The present results of the effect of parity on reproductive performance disagree with those of Ansari-Lari *et al.* (2010) and Ghavi Hossein-Zadeh *et al.* (2013) who reported that NSC tended to increase significantly with parity number. Also, some reports declared that CI was affected in a decline trend (P < 0.05) with the advancement of parity (Ansari-Lari *et al.*, 2010; Hammoud *et al.*, 2010; Apori and Hagan, 2014). This was suggested to be due to lower fertility of cows in early parities. Previously, Bulman and Wood (1980) reported that the primiparous cows had high incidence of silent heat that was decline with the advancement of lactation number. Also, it has been reported that primiparous cows had lower energy balance than multiparous cows as a result of reduced appetite and consequently low feed intake and available only energy for growth (Stahl *et al.*, 1999). Negative energy balance associates with the incidence of postpartum anestrus, as a result of inadequate LH pulse frequency and low concentration of insulin hormone which prevents liver's insulin-like growth factor-I (IGF-I) secretion causing hinder once of the follicular growth which reduces the chance of ovulation (Lucy, 2008). However, the current results were in agreement with those of Habib *et al.* (2010) and Guinguina *et al.* (2011), who noted a lack of influence of parity on CI. While Ray *et al.* (1992) accentuated that the primiparous cows had the longest (P<0.05) CI and the highest NSC compared to other parities.-

The present results showed that FSP and DO were longer in primiparous than in multiparous cows. This was in agreement with Hammoud *et al.* (2010) for FSP and with Hammoud *et al.* (2010) and Ghavi Hossein-Zadeh *et al.* (2013) for DO which were recorded to be the longest in primiparous cows then declined (P<0.05) with the advancement of parity. Long FSP and DO are essentially concomitant with decreased reproductive performance highly for the producing dairy cows (Lucy, 2001). In contrast, Kefena and Kumsa (2006) and Ansari-Lari *et al.* (2010) reported that DO did not differ among cows in different parities. The shortest period of DO was obtained with the advancement of parity could be attributed to physiological maturity of cows.

The differences among present groups according to the interaction effect between season and parity could be attributed to lower energy balance of primiparous cows that led to delayed resumption of ovarian cyclicity and therefore delayed onset of postpartum estrus (Mekuriaw *et al.*, 2009). Also, Zhang *et al.* (2010) identified a negative relationship between parity and first ovulation postpartum. Multiparous cows ovulate during the first and second follicular waves but primiparous cows ovulate during the third follicular waves. It has been reported that with the advancement of parities in dairy cows the length of period from calving to first ovulation decreased significantly (Tanaka *et al.*, 2008), and the longer interval from calving to first ovulation in primiparous cows may be due to repetitious follicular waves of nonovulatory follicles (Tanaka *et al.*, 2008).

The present results of CR agree with those of Shehab-El-Deen *et al.* (2010), and Ghavi Hossein-Zadeh *et al.* (2013) who reported that CR of dairy cows decreased significantly during the summer season. It has been reported that fertility of dairy cows during the summer season was reduced because of heat stress. The negative effect of heat stress on fertility of dairy cows may be due to changing the follicular microenvironment of highly yielding dairy cows (Shehab-El-Deen *et al.*, 2010), as a result of the high metabolic clearance of steroid hormones (Sangsritavong *et al.*, 2002), thus reduction of estradiol secretion from the dominant follicle (De Rensis and Scaramuzzi, 2003), compromises the oocyte's developmental competence and granulosa cell quality (Shehab-El-Deen *et al.*, 2010). Therefore, low concentration of estradiol hormone resulted in poor estrus expression, consequently, reduced conception rates. Moreover, when Holstein dairy cows were exposed to high temperature (> 30°C) and high relative humidity, not only the estrus expression was reduced, but also estrus period (Hansen and Areéchiga, 1999), estrus intensity (De Rensis and Scaramuzzi, 2003), and conception rate (Morton *et al.*, 2007). Therefore, the reduction of conception rate in the summer season may be due to an elevation of body temperature during maturation of oocytes (Shehab-El-Deen *et al.*, 2010).

Present results showed, also, that CR was influenced by parity, primiparous cows had higher (P<0.01) CR (50%) compared to multiparous cows (36%). these results consent with those of Chebel *et al.* (2004); Ghavi Hossein-Zadeh *et al.* (2013), and Liu *et al.* (2018) who reported that multiparous cows had lower (P<0.05) CR compared to primiparous cows. There are many factors affecting CR, including uterine involution, uterus health, resumption of ovarian cyclicity and production level. It was reported that primiparous cows were less than multiparous cows in endometritis occurrence (Kim and Kang, 2003), which due to faster uterine involution in primiparous compared to multiparous cows. Also, multiparous cows have a risk factor of postpartum clinical endometritis (Gautam *et al.*, 2009), that influence them less likely to be conceived compared to primiparous cows (Chebel *et al.*, 2004). Lower CR in multiparous cows may be due to early embryonic loss or difficulty of embryo implantation after multiple pregnancies (Ferreira *et al.*, 2011). Moreover, multiparous cows are usually high yielders, which have high level of prolactin hormone. Higher concentration of prolactin in high producing dairy cows suppresses secretion of GnRH, consequently, reduces FSH and LH, resulting anestrus. Also, high producing dairy cows may suffer from an imbalance of nutrients or diets not matched to production (Pryce *et al.*, 2004), negative energy balance, metabolic heat increment and global warming. For these reasons, it is rational that multiparous cows display lower conception rates because they could be at a higher risk for postpartum problems known to affect fertility.

Low heritability estimates for DO, CI and NSC were reported also by Haile-Mariam *et al.* (2013) and that indicated that these traits are affected mainly by environmental factors. Therefore, improvement of feeding, management, detection of heat and insemination at proper time with good quality semen would help in improving NSC, DO and CI. Khattab and Atil (1999) found that heritability of DO and CI for Friesian cows in Egypt were 0.05 and concluded that a major part of variation in these traits were of environmental origin and recommended that selection for these traits would not be effective to bring about significant genetic improvement. Alternatively, good management practices can play an effective role in improving these traits. Solemani *et al*. (2014) reported lower heritability estimates of DO and CI to be 0.041 and 0.019. Similarly, Rehman *et al*. (2008) reported lower heritability estimate of 0.04 and 0.02 for DO and CI of Sahiwal cattle in Pakistan. DO is an excellent indicator of the reproductive performance of the herd. Long DO periods adversely affect CI and ultimately reproductive performance of the cows, as the number of DO increase markedly increases CI. Increase in DO decrease lactation milk yield and therefore the productive performance of cows decrease (Rehman *et al*., 2008).

Significant positive genetic correlation between DO and CI ($r = 0.77$; $p < 0.01$) was reported by Ali *et al*. (2019). Also, Birhanu *et al*. (2015) reported strong positive genetic correlation between CI and DO (0. 97 and 0.998) in Ethiopian Boran and Boran x Holstein Friesian cows, respectively. Moderate (0.36) genetic correlation was observed between CI and DO of Holstein cows (Getahun *et al*., 2020). However, Toghiani (2012) reported a weak positive genetic correlation of 0.11 between DO and CI.

Estimation of the average genetic merit of cows by year of birth proved to be a useful approach to quantify genetic trends and thus determine the impact of past or current breeding goals on performance (Berry *et al*., 2014). Genetic merit for CI deteriorates primarily due to aggressive selection for improved milk yield which is known to be antagonistically correlated with reproductive performance in dairy cattle (Berry *et al*., 2007). Lindhé and Philipsson (2001) obtained a clear unfavorable genetic trend in female fertility for Swedish Holsteins and a slightly favorable genetic trend for the Swedish Red breed. In the Norwegian Red breed no trend or a slightly favorable genetic trend for fertility traits was found (Chang *et al*., 2006). This illustrated apparent breed variation in fertility concomitant with variation in milk production.

Conclusion

The present results showed that heritability estimates are very low for NSC and moderate for DO, CI, PMCI and BI reproductive traits. which indicated that low proportion of additive genetic variance relative to phenotypic variance are available for the studied reproductive traits. Regardless of the low heritability estimates, considerable proportions of the genetic variations among dairy cows in that population were certainly accessible and provide room for genetic improvement. However, high proportion of phenotypic variance in these traits indicated that altering the unfavorable environmental conditions through improving management and feeding system of the herd should improve herd fertility. The high positive genetic correlations between all reproductive traits in this study imply that they are probably controlled by the same set of genes and selection of one trait should improve the other correlated traits in the same desired direction which may improve the whole breeding process.

Conflict of interest

The authors declare that they have no conflicts of interest

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