Spanish Journal of Agricultural Research
13(2), e0605, 7 pages (2015)
eISSN: 2171-9292
http://dx.doi.org/10.5424/sjar/2015132-6320
Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA)

RESEARCH ARTICLE

OPEN ACCESS

Effect of calf sex on some productive, reproductive and health traits in Holstein cows

Arash Chegini, Navid Ghavi Hossein-Zadeh and Hossein Hosseini-Moghadam
University of Guilan, Faculty of Agricultural Sciences, Department of Animal Science. P. O. Box: 41635-1314, Rasht, Iran

Abstract

Records of Holstein cows from March 1992 to April 2008 from 194 large herds and comprising from 402,716 records for productive traits to 178,344 records of somatic cell count were used to study the effect of calf sex in different parities and calving season on the subsequent productive, reproductive and health traits in Holstein cows. T-test procedure of SAS software was used to investigate the effect of calf sex and season of calving on aforementioned traits. Cows with female calves had higher milk and fat yield, persistency of milk and fat yield and longer lactation length, while cows that gave birth to male calves had shorter calving interval and longer productive life. Also, cows with female calves had higher milk yield per day of lactation in the first two parities, but there was no difference in milk yield per day of lactation for parities ≥ 3. There was no relationship among mean somatic cell count and sex of born calf. Fall calves had the highest adjusted milk yield and milk yield per day of lactation, however, winter calves had the longest lactation lengthand productive life and the highest somatic cell count. Results from this study demonstrate that it seems necessary to consider the effect of calf sex on aforementioned traits when making decision to use sexed semen or conventional semen.

Additional key words: persistency; lactation length; calving interval; productive life.

Abbreviations used: CI (calving interval); DM (milk yield per day of lactation); F2:1 (fat yield second 100 days/fat yield first 100 days); F3:1 (fat yield third 100 days/fat yield first 100 days); Fat100 (first 100-day fat yield); Fat200 (second 100-day fat yield); Fat300 (third 100-day fat yield); Fat305 (305-day fat yield); LL (lactation length); LMY (lactation milk yield); Milk2x (adjusted milk yield); Milk100 (first 100-day milk yield); Milk200 (second 100-day milk yield); Milk300 (third 100-day milk yield); P2:1 (milk yield second 100 days/milk yield first 100 days); P3:1 (milk yield third 100 days/milk yield first 100 days); PL (productive life); SCC (mean somatic cell count)

Received: 26 May 2014. **Accepted:** 23 Mar 2015

Citation: Chegini, A.; Ghavi Hossein-Zadeh, N.; Hosseini-Moghadam, H. (2015). Effect of calf sex on some productive, reproductive and health traits in Holstein cows. Spanish Journal of Agricultural Research, Volume 13, Issue 2, e0605, 7 pages. http://dx.doi.org/10.5424/sjar/2015132-6320.

Funding: The author(s) received no specific funding for this work

Competing interests: The authors have declared that no competing interests exist.

Correspondence should be addressed to Arash Chegini: cheginiarash@phd.guilan.ac.ir; cheginiarash@yahoo.com.

Introduction

Milk sale is the primary source of income for dairy producers and profitability of dairy farming is highly affected by reproductive performance of dairy cows. Maximization of profit can be achieved by reducing costs of rearing, feeding and management through increasing annual milk yield of cows. Milk yield and composition is affected by many factors that can be grouped into two categories: inheritance and non-inheritance (or environmental) factors (Chegini, 2010).

Non-inheritance factors can be classified as internal factors (such as age, lactation number, pregnancy status, etc) and external factors (such as feeding, temperature, humidity, etc). Regarding the effect of calf sex on dystocia and development of udder system, calf sex can be considered as an internal factor. The understanding of the effect of calf sex on economically important traits in cattle is financially attractive. Results regarding the effect of calf sex on milk production traits are inconsistent. Some studies have reported an effect of calf sex on milk yield (Fabrice *et al.,* 1995; Gaafar *et al.,* 2011; Yudin *et al.,* 2013; Hinde *et al.,* 2014), whereas other studies have reported no such association (Afzal *et al.,* 2007; Atashi *et al.,* 2012). Hinde *et al.* (2014) reported that the sex of fetus can influence milk yield through manipulating the capacity of mammary gland. On the other hand, Ghavi Hossein-Zadeh *et al.* (2010) and Khalajzadeh *et al.*(2012) investigated the effect of widespread and limited use of sexed semen on the genetic progress.

Berry *et al.* (2007) and Gaafar *et al.* (2011) investigated the effect of different factors on dystocia and subsequently effect of dystocia on performance of dairy cows. They indicated that dystocia significantly reduced whole lactation milk yield. Colburn *et al.* (1997), Bareille *et al.* (2003), Berry *et al.* (2007), Alphonsus *et al.* (2011), Eaglen *et al.* (2011) and Ghavi Hossein-Zadeh (2013) studied the effect of many factors on productive and reproductive traits of dairy cows, but the effect of sex of born calf on economically important traits has been less investigated. Therefore, the objectives of this study were to investigate: 1) the effect of calf sex and season of calving on some productive, reproductive and health traits, and 2) the difference between first lactation performances of cows with different calf sex within different calving seasons.

Material and methods

Calving records of Holstein cows from March 1992 to April 2008 and comprising from 402,716 records for productive traits to 178,344 records of somatic cell count from 194 large herds were included in the data set. The majority of the Iranian dairy cattle population consists of several domestic breeds and their crosses with Holstein. Only about 800,000 head are purebred Holsteins. These are either descendants of the cows originally imported from North America and Europe or Holstein upgrades of domestic breeds over 50 years. The herds used in this study are among the purebred Holsteins managed under conditions similar to those in most other developed countries. The herds are under official performance and pedigree recording. Artificial insemination is used almost exclusively; and 60 to 80% of semen is from US and Canadian proven sires (Ghavi Hossein-Zadeh *et al.,* 2008).

The data included animal registration number, herd, calving date, parity, adjusted milk yield (Milk2x), lactation milk yield (LMY), first 100-day milk yield (Milk100), second 100-day milk yield (Milk200), third 100-day milk yield (Milk300), ratios of milk yield in the second and third 100-days to the first 100-days of lactation (P2:1 and P3:1, respectively), 305-d fat yield (Fat305), fat percentage (Fat%), first 100-day fat yield (Fat100), second 100-day fat yield (Fat200), third 100-day fat yield (Fat300), ratios of fat yield in the second and third 100-days to the first 100-days of lactation (F2:1 and F3:1, respectively), lactation length (LL), milk yield per day of lactation (DM), calving interval (CI), productive life (PL) and mean somatic cell count (SCC). Milk2x were actual yields of dairy cows which were corrected based on days in milk and twice daily milking. LMY was actual lactation milk yield, not standardized to 305 d. Months of calving were grouped into four seasons: April through June (season 1 = spring), July through September (season 2 = summer), October through December (season 3 = fall), and January through March (season 4 = winter). Calving interval between 290 and 650 days and lactation lengths between 180 and 650 days were included. Cows with less than 5 test-day records for SCC were excluded. DM was calculated as LMY divided by LL, and also PL was the range of time between date of first calving to date of death or culling from herd. Table 1 shows the records used for different traits in different parities.

A multiple linear regression model was used to analyse the effect of parity, calving season and calf sex on studied traits using the GLM procedure of SAS (SAS, 2002). The general equation of multiple linear regression model was defined as follows:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_{p-1} x_{p-1} + \varepsilon$$

where y = dependent variable (Milk2x, LMY, Milk100, Milk200, Milk300, P2:1, P3:1, Fat305, Fat%, Fat100, Fat200, Fat300, F2:1, F3:1, LL, DM, CI, PL, SCC); x_1, x_2,..., x_{p-1} = independent variables (parity, calving season and calf sex); β_0, β_1, β_2,..., β_{p-1} = regression parameters; ε= random error. Then, in order to quantify the effect of calf sex and calving season within lactations, statistical analyses were performed using the student's t-test (procTTEST) of SAS. Also, sex of calf in the first three calvings was coded "3" if all of first three calves were male, "2" if

Table 1. Number of records used for the analyses

Trait[§]	1st Parity		2nd Parity		3rd Parity		≥ 4th Parity	
	♂	♀	♂	♀	♂	♀	♂	♀
Productive traits	41745	39167	43765	44937	44445	47828	66396	74433
CI	45799	44097	49544	51642	33624	35191	42724	45758
PL	31573	28159	30428	30614	30035	32331	38282	43053
SCC	28921	30679	21758	24527	14414	16441	19077	22527

[§] CI: calving interval; PL: productive life; SCC: mean somatic cell count.

two out of three calves were male, "1" if one out of three calves were male and "0" when all of first three calves were female. Regression coefficient of PL per sex of each calf in the first three calvings was estimated using REG procedure of SAS.

Results

The effect of parity, calving season and calf sex on studied traits assessed with multiple linear regression models is shown in Table 2. The parity, month of calving and calf sex significantly affected all the traits, except for the SCC. Third lactation cows had the highest Milk2x, but the highest LMY was observed in second lactation (see Table 3). First lactation cows had the lowest Milk100, Milk200, Fat305, Fat%, Fat100, Fat200 and DM but they had the highest Milk300, P2:1, P3:1, F2:1, F3:1 and LL. Also, first lactation cows had the lowest SCC. The effects of calf sex on productive, reproductive and health traits in Holstein cows in different parities are shown in Table 3. Cows with female calves had higher Milk2x relative to cows with male calves. Milk100 was not affected by the sex of born calf, except for Milk100 in second parity. Also, cows with female calves had higher Fat305, Fat%, P2:1 and P3:1, F2:1 and F3:1, and DM (although DM was non-significant in parity ≥ 3) and longer LL, while cows that gave birth to male calves had shorter CI and longer PL. Sex of calf had no effect on SCC (except for third parity). Fig. 1 shows a diagram of the effect of calf sex on milk yield and persistency, CI and PL. Also, the effect of calf sex in the first three calvings on PL is shown in Table 4. Sex of calf in the first three calvings was coded based on the number of born male calves. Using REG procedure of SAS it was shown that birth of each male calf in the first three calvings lead to increase in PL to an amount of 19.5 days (R^2 = 0.948). Table 5 shows the effect of season of first calving on Milk2x, DM, CI, PL and SCC. The highest Milk2x and DM corresponded to cows that calved in fall and cows that calved in winter had the longest PL and LL. Also, winter calves had the longest CI and highest SCC. In addition, the difference between first lactation performances of cows with different calf sex within different calving seasons is shown in Table 6.

Table 2. Effect (p-values are shown) of parity, calving season and calf sex on studied traits assessed with multiple linear regression model

Traits[§]	Parity	Calving season	Calf sex
Milk2x (kg)	<0.0001	<0.0001	0.0130
LMY (kg)	<0.0001	<0.0001	0.0001
Milk100 (kg)	<0.0001	<0.0001	0.0056
Milk200 (kg)	<0.0001	<0.0001	<0.0001
Milk300 (kg)	<0.0001	<0.0001	<0.0001
P2:1 (%)	<0.0001	<0.0001	<0.0001
P3:1 (%)	<0.0001	<0.0001	<0.0001
Fat305 (kg)	<0.0001	<0.0001	0.0571
Fat%	<0.0001	0.0027	0.0197
Fat100 (kg)	<0.0001	<0.0001	<0.0001
Fat200 (kg)	<0.0001	<0.0001	<0.0001
Fat300 (kg)	<0.0001	<0.0001	<0.0001
F2:1 (%)	<0.0001	<0.0001	0.0005
F3:1 (%)	<0.0001	<0.0001	0.0016
LL (days)	<0.0001	<0.0001	<0.0001
DM (kg)	<0.0001	<0.0001	<0.0001
CI (days)	<0.0001	0.0050	<0.0001
PL (months)	<0.0001	<0.0001	<0.0001
SCC (×1000)	<0.0001	0.0002	0.3588

[§] Milk2x: adjusted milk yield; LMY: lactation milk yield; Milk100: first 100-day milk yield; Milk200: second 100-day milk yield; Milk300: third 100-day milk yield; P2:1: [(milk yield second 100 days)/(milk yield first 100 days)]; P3:1: [(milk yield third 100 days)/(milk yield first 100 days)]; Fat305: 305-d fat yield; Fat%: fat percentage; Fat100: first 100-day fat yield; Fat200: second 100-day fat yield; Fat300: third 100-day fat yield; F2:1: [(fat yield second 100 days)/(fat yield first 100 days)]; F3:1: [(fat yield third 100 days)/(fat yield first 100 days)]; LL: lactation length; DM: milk yield per day of lactation; CI: calving interval; PL: productive life; SCC: mean somatic cell count.

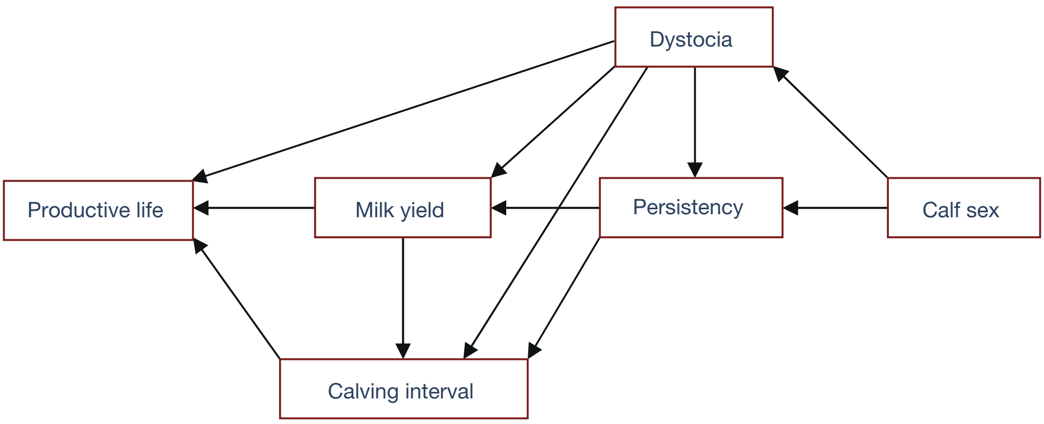

Figure 1. Effect of calf sex on milk yield and persistency, calving interval and productive life.

Table 3. Effect of calf sex on studied traits in different parities

Trait§	1st Parity		2nd Parity		3rd Parity		≥ 4th Parity	
	♂	♀	♂	♀	♂	♀	♂	♀
Milk2x (kg)	6662.3^{a}	6706.5	7432.0^{a}	7508.2	7699.6^{a}	7735.6	7376.7^{c}	7398.2
LMY (kg)	8316.2^{a}	8453.7	8881.2^{a}	9053.9	8660.9^{b}	8717.4	8118.0^{a}	8196.7
Milk100 (kg)	2313.8^{ns}	2316.2	2893.6^{a}	2910.8	3079.9^{ns}	3083.6	2984.0^{ns}	2980.5
Milk200 (kg)	2302.7^{a}	2319.0	2564.0^{a}	2589.5	2694.5^{a}	2716.1	2614.1^{a}	2630.0
Milk300 (kg)	2099.6^{a}	2123.7	2017.2^{a}	2051.7	2034.3^{a}	2064.6	1943.0^{a}	1963.2
P2:1 (%)	0.998^{a}	1.004	0.886^{a}	0.890	0.873^{a}	0.878	0.870^{a}	0.876
P3:1 (%)	0.905^{a}	0.915	0.700^{a}	0.707	0.660^{a}	0.668	0.649^{a}	0.656
Fat305 (kg)	205.22^{a}	207.94	229.31^{a}	233.13	241.67^{a}	244.14	233.81^{a}	235.40
Fat%	3.091^{a}	3.111	3.100^{a}	3.120	3.163^{a}	3.184	3.205^{a}	3.218
Fat100 (kg)	69.89^{a}	70.48	85.50^{a}	86.75	93.45^{a}	94.20	91.49^{a}	91.70
Fat200 (kg)	68.81^{a}	69.83	77.74^{a}	78.97	82.91^{a}	83.98	80.87^{a}	81.74
Fat300 (kg)	67.26^{a}	68.40	67.13^{a}	68.53	68.06^{a}	69.26	65.24^{a}	66.05
F2:1 (%)	1.007^{b}	1.013	0.931^{ns}	0.932	0.909^{d}	0.912	0.902^{a}	0.909
F3:1 (%)	0.994^{b}	1.001	0.814^{b}	0.819	0.754^{b}	0.760	0.735^{a}	0.742
LL (days)	344.38^{a}	348.59	334.78^{a}	338.62	327.76^{a}	330.84	322.83^{a}	325.65
DM (kg)	24.38^{a}	24.52	26.67^{a}	26.91	27.73^{ns}	27.82	27.06^{ns}	27.08
CI (days)	401.2^{a}	404.3	401.0^{a}	404.2	400.2^{a}	403.1	402.7^{a}	407.0
PL (months)	58.34^{a}	57.23	58.52^{a}	57.27	58.73^{a}	57.60	78.59^{c}	78.28

§ For traits, see Table 2.^{a,b,c,d}: $p < 0.001$, $p < 0.01$, $p < 0.05$, $p < 0.10$, respectively; ^{ns}: non-significant ($p > 0.10$).

Table 4. Effect of calf sex in first three parities on productive life

Class§	Code	No. of records	Productive life (months)
MMM	3	6273	58.10^{a}
MMF	2	6732	57.50^{a}
MFM	2	6264	57.40^{ab}
MFF	1	7327	56.58^{c}
FMM	2	5622	57.69^{a}
FMF	1	6430	56.79^{bc}
FFM	1	6241	56.77^{bc}
FFF	0	7036	56.32^{c}

§ MMM: first three calves were male; MMF: first two calves were male and third calf was female; MFM: only the second calf was female; MFF: only the first calf was male; FMM: only the first calf was female; FMF: only the second calf was male; FFM: first two calves were female and third calf was male; FFF: first three calves were female. ^{a,b,c} Means with different superscripts differ significantly ($p < 0.05$).

Table 5. Effect of season of first calving on first lactation Milk2x, LL, DM, CI, PL and SCC. In parentheses, number of records

Trait§	Winter	Spring	Summer	Fall
Milk2x (kg)	6748.9^{b} (20211)	6581.7^{c} (20611)	6597.2^{c} (19686)	6805.5^{a} (20404)
LL (days)	352.0^{a} (20211)	349.3^{b} (20611)	340.4^{d} (19686)	343.7^{c} (20404)
DM (kg)	24.55^{b} (20211)	24.17^{c} (20611)	24.19^{c} (19868)	24.86^{a} (20404)
CI (days)	407.9^{a} (22555)	408.2^{a} (22873)	396.4^{c} (21754)	398.0^{b}(22714)
PL (months)	58.47^{a} (14760)	57.93^{b} (15418)	57.20^{c} (14621)	57.66^{bc} (14933)
SCC (×1000)	296.1^{a} (15186)	277.2^{b} (14232)	278.6^{b} (14936)	282.5^{b} (15246)

§ For traits, see Table 2.^{a,b,c,d} Means with different superscripts within traits differ significantly ($p < 0.05$).

The highest difference between male and female calves for Milk2x, DM and PL was observed in summer and fall; the highest difference for LL and CI between male and female calves was observed in winter and spring. However, there was no difference for SCC in cows with different calf sex within seasons.

Discussion

Effect of calf sex on Milk2x, LMY and DM was significant and cows with female calves had higher levels of aforementioned traits. Probably, born of a male calf causes more dystocia that influences the milk

Table 6. Effect of season of first calving on first lactation Milk2x, LL, DM, CI, PL and SCC in cows with different calf sex

Trait[§]	Winter		Spring		Summer		Fall	
	♂	♀	♂	♀	♂	♀	♂	♀
Milk2x (kg)	6730.6^{c}	6768.5	6563.4^{c}	6601.4	6572.0^{b}	6623.9	6781.8^{b}	6830.7
LL (days)	349.33^{a}	354.97	346.67^{a}	352.05	339.00^{c}	342.00	342.34^{c}	345.18
DM (kg)	24.51^{ns}	24.58	24.12^{ns}	24.24	24.10^{c}	24.30	24.77^{c}	24.97
CI (days)	405.8^{a}	410.1	406.1^{a}	410.5	395.5^{d}	397.2	396.8^{b}	399.3
PL (months)	59.04^{a}	57.83	58.28^{c}	57.54	57.77^{a}	56.56	58.27^{a}	56.98
SCC (×1000)	297.6^{ns}	294.7	273.7^{ns}	280.4	278.4^{ns}	278.9	279.2^{ns}	285.4

[§] For traits, see Table 2.[a,b,c,d]: $p < 0.001$, $p < 0.01$, $p < 0.05$, $p < 0.10$, respectively; [ns]: non-significant ($p > 0.10$).

yield of their dam. Similar to the results of this study Gaafar *et al.* (2011) and Ghavi Hossein-Zadeh (2013), investigating the effect of dystocia on performance of Holstein cows, reported that cows with male calves had higher incidence of dystocia compared with cows with female calves, and dystocia had significant effect on milk production. Fabrice *et al.* (1995) found a significant difference for milk yield between cows with female or male calves (female calves produced 117 kg more milk during a 23-year period in that study). Working on association of polymorphism of a gene and sex of calf with lactation performance, Yudin *et al.* (2013) found that cows with a given genotype had higher milk yield in case of a male calf than a heifer calf. Also, a recent study in USA (Hinde *et al.,* 2014) using a large dataset (2.39 million lactation records) showed that gestation of a female calf in first parity increased milk production by 445 kg over the first two lactations. Contrary to the result of this study, Atashi *et al.* (2012) reported that calf sex had no effect on 305-day milk yield in Holstein cows. Also, Afzal *et al.* (2007) mentioned that sex of calf did not affect milk yield in buffaloes. Sex of calf in parity ≥ 3 had no effect on DM, probably due to that older cows have larger pelvic dimensions and lower incidence of dystocia that could mitigate the subsequent consequences of dystocia. Colburn *et al.* (1997) found that heifers with smaller pelvic area had higher requirements of caesarean section. Since cows with female calf had higher Milk200, Milk300, P2:1 and P3:1, F2:1 and F3:1 and LL, it can be concluded that giving birth to a female calf increase milk and fat yield through increasing persistency (*i.e.,* dystocia has higher effects on production in later parts of lactation). There is limited published research on the effect of calf sex on persistency. Eaglen *et al.* (2011) reported a reduction in milk yield between 10 and 90 DIM in veterinary-assisted dams compared with non-assisted dam and stated that non-assisted dams had flatter lactation curve after peak yield. Atashi *et al.* (2012) observed no difference for persistency of milk yield between cows with male calves and cows with female calves. Also, Fat305, Fat%, Fat100, Fat200 and Fat300 of cows with female calf was higher. To our knowledge, there are no studies on the effect of calf sex on fat yield. Probably, during pregnancy, male calves affect more on the performance of digestive system through occupation of more abdominal space and reduction of digestive system volume. Bareille *et al.* (2003) showed that cows experiencing dystocia had lower dry matter intake in the months postpartum compared to cows that calved normally.

No significant effect of calf sex on SCC was observed in this study, in accordance with Berry *et al.* (2007) and Eaglen *et al.* (2011). Effect of calf sex in first three calvings on PL is shown in Table 4. Obviously, the higher the number of male calves, the longer PL. According to the findings in this study, it can be concluded that calf sex influence on PL by affecting milk yield, persistency and CI. Although cows that give birth to female calves have lower percentage of dystocia and better reproductive performance (Eaglen *et al.,* 2011; Gaafar *et al.,* 2011), born of a female calf lead to higher milk and fat production, presumably because of bearing less stress and pain during calving in comparison with born of a male calf, and experience of more energy imbalance that can cause more metabolic disorders and consequently shortened PL.

The highest Milk2x and DM were observed in cows that calved during fall. The reported data on the effects of calving season on subsequent performance are inconsistent. Lateef *et al.* (2008) reported that Holstein cows calved in fall had the highest milk yield whereas spring calves had the lowest milk yield. Syrstad (1965) found that season of calving influenced milk yield, and fall and early winter appeared to be optimal times for calving. Tadesse & Dessie (2003) reported no effect of calving season on the total milk yield. However, Chaudhry (1992) and Afzal *et al.* (2007) found that buffaloes calved in spring and winter had the highest total lactation yield and those calved in fall had the lowest. Such discrepancies may be the result of differences in management. Season can affect milk production by deficiency of fodder in a particular season. It has been shown that there are discrepancies between ration in different seasons (Afzal *et al.,* 2007; Gaafar *et al.,* 2011). In addition, seasonal stress due to extreme temperatures and humidity may suppress production. Uneven reports on effect of season on milk production indicate that these stress factors may be overcome through better feeding and management (Afzal *et al.,* 2007). The pattern of LL and CI was similar and the shortest LL and CI was observed in cows that calved during summer. This can be due to that cows calved in summer conceive earlier because of optimum temperature and environmental conditions in the next 7 to 8 weeks (*i.e.,* fall). Studies reported a high correlation between LL and CI (Haile-Mariam *et al.,* 2003; Chegini, 2010). Also, Gaafar *et al.* (2011) found that percentage of dystocia was significantly lower with feeding summer ration compared with winter ration. Probably, summer calves can recover earlier and would have shorter calving to first service and consequently shorter days open and CI. Older cows had higher level of SCC and the highest SCC observed in cows that calved in winter. It has been shown that parity has a significant effect on SCC (Olde Riekerink *et al*., 2007; Chegini, 2010). Effect of season of calving on SCC is rare in literature. Olde Riekerink *et al.* (2007) observed the highest bulk milk SCC and individual cow SCC in summer months. One reason can be due to that the majority of cows in their dataset calved in fall and they were at the end of their lactation in summer and milk of cows later in lactation has higher SCC (Schutz *et al.,* 1990; Olde Riekerink *et al.,* 2007; Chegini, 2010). On the other hand, our criterion was SCC throughout lactation but they used test day records. The highest difference in Milk2x and DM between cows with different calf sex was observed in summer and fall. Adversely, the highest difference inLL and CI between cows with different calf sex was observed in winter and spring. These results are hard to interpret, but it can be concluded that season affects milk production through difference in feed quality and incidence of dystocia. The less difference in Milk2x (and no difference in DM) between cows with different calf sex in winter and spring could be due to that there was no large difference in incidence and severity of dystocia between cows with female calf and cows with male calf in winter and spring, or cows with female calf could not show their potential better in comparison with cows with male calf, because of lower quality of winter ration.

As final conclusions, cows with female calf had higher milk and fat yield, milk and fat persistency and longer lactation length, while cows with male calf had shorter calving interval and longer productive life. Also, cows with female calf in the first two parities had higher milk yield per day of lactation, but there was no difference in milk yield per day of lactation in parities ≥ 3. There was no relationship between mean somatic cell count and sex of born calf. Fall calves had the highest adjusted milk yield and milk yield per day of lactation, however, winter calves had the longest LL and PL and the highest SCC. According to these results, the economic weights of traits should take into consideration in each country (or region), when making decision about time (*i.e.,* season) and usage amount of sexed and conventional semen. Also, it seems necessary to include calf sex and season of calving in model when analyzing aforementioned traits in order to predicting animals' breeding values.

Acknowledgements

Authors wish to acknowledge the Animal Breeding Center of Iran for providing the data used in this study.

References

Afzal M, Anwar M, Mirza MA, 2007. Some factors affecting milk yield and lactation length in Nili Ravi buffaloes. Pakistan Vet J 27(3): 113-117.

Alphonsus C, Essien IC, Akpa GN, Barje PP, 2011. Factors influencing milk yield characteristics in Bunaji and Friesian ×Bunaji cows in northern Nigeria. Anim Prod 13(3): 143-149.

Atashi H, Zamiri MJ, Sayyadnejad MB, 2012. Effect of twinning and stillbirth on the shape of lactation curve in Holstein dairy cows of Iran. Arch Tierz 55(3): 226-233.

Bareille N, Beaudeau F, Billon S, Robert A, Faverdin P, 2003. Effects of health disorders on feed intake and milk production in dairy cows. Livest Prod Sci 83(1): 53-62. http://dx.doi.org/10.1016/S0301-6226(03)00040-X

Berry DP, Lee JM, Macdonald KA, Roche JR, 2007. Body condition score and body weight effects on dystocia and stillbirths and consequent effects on postcalving performance. J Dairy Sci 90: 4201-4211. http://dx.doi.org/10.3168/jds.2007-0023

Chaudhry MA, 1992. Factors affecting the lactation length and milk yield in Nili-Ravi buffaloes. Asian-Australas J AnimSci 5: 375-382. http://dx.doi.org/10.5713/ajas.1992.375

Chegini A, 2010. Genetic and environmental relationship among milk yield, persistency of milk yield, somatic cell count and calving interval of Holstein cows in Iran. Master's thesis. University of Guilan, Iran.

Colburn DJ, Deutscher GH, Nielsen MK, Adams DC, 1997. Effects of sire, dam traits, calf traits, and environment on dystocia and subsequent reproduction of two-year-old heifers. J Anim Sci 75: 1452-1460.

Eaglen SAE, Coffey MP, Woolliams JA, Mrode R, Wall E, 2011. Phenotypic effects of calving ease on the subsequent fertility and milk production of dam and calf in UK Holstein-Friesian heifers. J Dairy Sci 94: 5413-5423. http://dx.doi.org/10.3168/jds.2010-4040

Fabrice NQ, Wilcox CJ, Simerl NA, Sharma AK, Thatcher WW, 1995. Effects of fetal sex and sire and other factors on periparturient and postpartum performance of dairy cattle. Braz J Genet 18(4): 541-545.

Gaafar HMA, Shamiah ShM, Abu El-Hamd MA, Shitta AA, Tag El-Din MA, 2011. Dystocia in Friesian cows and its effects on postpartum reproductive performance and milk production. Trop Anim Heal Prod 43(1): 229-234. http://dx.doi.org/10.1007/s11250-010-9682-3

Ghavi Hossein-Zadeh N, 2013. Effects of main reproductive and health problems on the performance of dairy cows: a review. Span J Agric Res 11(3): 718-735. http://dx.doi.org/10.5424/sjar/2013113-4140

Ghavi Hossein-Zadeh N, Nejati-Javaremi A, Miraei-Ashtiani SR, Kohram H, 2008. An observational analysis of twin births, calf stillbirth, calf sex ratio, and abortion in Iranian Holsteins. J Dairy Sci 91: 4198-4205. http://dx.doi.org/10.3168/jds.2008-1079

Ghavi Hossein-Zadeh N, Nejati-Javaremi A, Miraei-Ashtiani SR, Kohram H, 2010. Bioeconomic evaluation of the use of sexed semen at different conception rates and herd sizes in Holstein populations. Anim Reprod Sci 121: 17-23. http://dx.doi.org/10.1016/j.anireprosci.2010.05.012

Haile-Mariam M, Bowman PJ, Goddard ME, 2003. Genetic and environmental relationship among calving interval, survival, persistency of milk yield and somatic cell count in dairy cattle. Livest Prod Sci 80: 189-200. http://dx.doi.org/10.1016/S0301-6226(02)00188-4

Hinde K, Carpenter AJ, Clay JS, Bradford BJ, 2014. Holsteins favor heifers, not bulls: biased milk production programmed during pregnancy as a function of fetal sex. Plos One 9(2): e86169. http://dx.doi.org/10.1371/journal.pone.0086169

Khalajzadeh S, Nejati-Javaremi A, Mehrbani Yeganeh H, 2012. Effect of widespread and limited use of sexed semen on genetic progress and reproductive performance of dairy cows. Anim 6: 1398-1406. http://dx.doi.org/10.1017/S1751731112000651

Lateef M, Gondal KZ, Younas M, Sarwar M, Mustafa MI, Bashir MK, 2008. Milk production potential of pure bred Holstein Friesian and Jersey cows in subtropical environment of Pakistan. Pakistan Vet J 28(1): 9-12.

Olde Riekerink RGM, Barkema HW, Stryhn H, 2007. The effect of season on somatic cell count and the incidence of clinical mastitis. J Dairy Sci 90: 1704-1715. http://dx.doi.org/10.3168/jds.2006-567

SAS, 2002. SAS User's guide v. 9.1: Statistics. SAS Inst. Inc., Cary, NC, USA.

Schutz MM, Hansen LB, Steuernagel GR, 1990. Variation of milk, fat, protein, and somatic cells for dairy cattle. J Dairy Sci 73: 484-493. http://dx.doi.org/10.3168/jds.S0022-0302(90)78696-1

Syrstad O, 1965. Studies on herd records. II. Effect of age and season of calving. Acta Agric Scand 15: 31. http://dx.doi.org/10.1080/00015126509433110

Tadesse M, Dessie T, 2003. Milk production performance of Zebu, Holstein Friesian and their crosses in Ethiopia. Livest Res Rural Dev 15 (3). Available in http://www.lrrd.org/lrrd15/3/Tade153.htm.

Yudin NS, Aitnazarov RB, Voevoda MI, Gerlinskaya LA, Moshkin MP, 2013. Association of polymorphism harbored by tumor necrosis factor alpha gene and sex of calf with lactation performance in cattle. Asian-Australas J Anim Sci 26: 1379-1387 http://dx.doi.org/10.5713/ajas.2013.13114