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

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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 length 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); 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)

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 the 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 (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:

\[ y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_{p-1} x_{p-1} + \epsilon \]

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); \( x_1, x_2, \ldots, x_{p-1} \) = independent variables (parity, calving season and calf sex); \( \beta_0, \beta_1, \beta_2, \ldots, \beta_{p-1} \) = regression parameters; \( \epsilon \) = 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

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

![Figure 1](image_url). 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 |
|-------|------------|------------|------------|-------------|
|       | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ | ♂ | ♀ |

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 ab                 |
| FMM  | 2    | 5622           | 57.69 a                  |
| FMF  | 1    | 6430           | 56.79 ab                 |
| FFM  | 1    | 6241           | 56.77 ab                 |
| FFF  | 0    | 7036           | 56.32 ab                 |

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 (20211) | 6581.7 (20611) | 6597.2 (19686) | 6805.5 (20404) |
| LL (days) | 352.0 (20211) | 349.3 (20611) | 340.4 (19686) | 343.7 (20404) |
| DM (kg) | 24.55 (20211) | 24.17 (20611) | 24.19 (19686) | 24.86 (20404) |
| CI (days) | 407.9 (22555) | 408.2 (22873) | 396.4 (21754) | 398.0 (22714) |
| PL (months) | 58.47 (14760) | 57.93 (15418) | 57.20 (14621) | 57.66 (14933) |
| SCC (×1000) | 296.1 (15186) | 277.2 (14232) | 278.6 (14936) | 282.5 (15246) |

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 production.
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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) | ♂ 6730.6c ♀ 6768.5 | ♂ 6563.4c ♀ 6601.4 | ♂ 6572.0c ♀ 6623.9 | ♂ 6781.8c ♀ 6830.7 |
| LL (days) | ♂ 349.33c ♀ 354.97 | ♂ 346.67c ♀ 352.05 | ♂ 339.00c ♀ 342.00 | ♂ 342.34c ♀ 345.18 |
| DM (kg) | ♂ 24.51ac ♀ 24.58 | ♂ 24.12ac ♀ 24.24 | ♂ 24.10ac ♀ 24.30 | ♂ 24.77ac ♀ 24.97 |
| CI (days) | ♂ 406.10 ♀ 406.10 | ♂ 406.10 ♀ 406.10 | ♂ 395.50 ♀ 397.20 | ♂ 396.80 ♀ 399.30 |
| PL (months) | ♂ 59.04c ♀ 57.83 | ♂ 58.28c ♀ 57.54 | ♂ 57.77c ♀ 56.56 | ♂ 58.27c ♀ 56.98 |
| SCC (×1000) | ♂ 297.6ac ♀ 294.7 | ♂ 273.7ac ♀ 280.4 | ♂ 278.4ac ♀ 278.9 | ♂ 279.2ac ♀ 285.4 |

1 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).
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 in LL 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.

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