The Influence of Calf's Sex on Total Milk Yield and its Constituents of Dairy Cows

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Abstract. *The objective of the present work was to evaluate the influence of the sex of the calf on total milk yield and its constituents of Holstein-Friesian dairy cows. The Holstein Livestock Breeders Association of Minas Gerais provided data collected over the years from 2000 to 2016 from 127 dairy farms located in the state of Minas Gerais – Brazil. The data set analyzed contained 61747 observations of Holstein-Friesian animals that calved female (n = 28903) or male (n = 32844) calf. Fat, protein, lactose, and total of solids were the components evaluated. The t test was used to evaluate milk yield and its components according to calf's sex at an error level α < 0.05. Lactose was higher (P < 0.001) on the milk of cows that calved female calves (366.19 kg) than those who calved male calves (360.50 kg). Statistically significant difference (P < 0.001) was also observed for total solids content of milk among those cows that calved female calves (952.48 kg) than on those who calved males (938,1 kg). No statistical differences (P > 0.05) were observed for the other variables evaluated in the study. We, therefore, concluded that there was an impact of the sex of the calf on total lactose and total solid content yield of dairy milk. Cows that calves female calves yielded more lactose and total solids than those that calved male calves.*

Keywords. *Dairy, Holstein-Friesian, milk yield, precision dairy farming.*

Introduction

The study of factors that affect milk production is relevant to strategically allocate genetic resources, to plan breeding programs, and to choose more appropriate management practices regarding different production systems in Brazil. For some time, it has been recognized the necessity of more studies aiming at discovering environmental and genetic factors that affect milk production (Naufel 1965; Freitas et al. 1983).

Cow milk production is influenced by environmental and physiological factors. Environmental factors may include feeding, milking frequency, water intake, season of the year, and heat stress among others. Physiological factors can be animal's genetics, lactation stage, age, body condition, nutritional level, animal health, offspring sex, among others (Radostits et al. 2001).

The influence of calf sex on cow milk production has been highlighted in several studies. However, there are conflicting results. Thus, we have accumulated questions and doubts about how the sex of the calf influences on the milk yield of cows (Oliveira et al. 2007).

It should be noted, however, that the gestation period usually overlaps with the lactation period. Therefore, the milk synthesis would not be only affected by the sex of the offspring that started lactation, but also by the sex of the gestating animal. Also in this context, considering the breeding characteristic focused on milk production where calves are separated shortly after birth, it is relevant to study the influence of calf sex on milk production.

Thus, the objective of this study was to evaluate the influence of the offspring sex on milk production and its constituents on Holstein dairy cows.

Materials and Methods

The data used in this study were part of a pre-existing data set; therefore, approval was not required from the Animal Ethics Committee of the Federal University of Jequitinhonha and Mucuri Valleys in order to carry out this study.

The Holstein Livestock Breeders Association of Minas Gerais provided data collected over the years from 2000 to 2016 from 127 dairy farms located in the state of Minas Gerais – Brazil. Outliers were identified and excluded according to methodology proposed by Leys et al. (2013). The data set analyzed contained 61747 observations of Holstein-Friesian animals. Out of that, 28903 represented milk production and its constituents within 305 days of lactation from animals that calved female calves and 32844 from cows that calved male calves.

Statistical analyzes were performed in the statistical program R (R Core Team 2017). Fat, protein, lactose, and total of solids were the components evaluated. The data followed a normal distribution upon visual inspection of frequency histograms. Thus, t test was used to evaluate milk yield and its components according to calf's sex at an error level $\alpha < 0.05$ or lower

Results and Discussion

Milk yield in 305-day lactation did not differ ($P > 0.05$) between cows that calved females or male calves (Table 1).

Table 1. Milk yield and its constituents in 305-day lactation of Holstein dairy cows according to calf sex.

Item (Mean ± Standard deviation)	Offspring sex		*P-value*
	Female (n = 28903)	Male (n = 32844)	
Milk(kg)	7992,4 ± 2931,53	7977,6 ± 2912,55	0,52
Fat (kg)	262,8 ± 103,87	261,6 ± 102,58	0,11
Protein (kg)	243,9 ± 90,60	243,8 ± 90,22	0,82
Lactose (kg)	366,2 ± 138,97	360,5 ± 140,08	< 0,001
Total solids(kg)	952,5 ± 355,66	938,1 ± 357,11	< 0,001

Contradictions have been reported in the literature regarding the calf sex interference on milk yield of dairy cows. For instance, Hinde et al. (2014) found higher milk yield in cows that calved females. According to them, dairy cows that calved a female calf on their first lactation tend to have high milk production in the next gestation reducing the negative effect of calving a male on next lactation, which was not observed in our study. Other authors have reported different results. Oliveira et al. (2007), Fagundes et al. (2004), and Pope et al. (1963) found that it is possible to have higher milk production in cows that calved male compared to cows that calved female. However, Robison et al. (1978) observed 1,319 lactations of 528 cows and verified a higher production of cows that called females compared to male. They also suggested that milk production would be more influenced by the size of the calf than by its sex. Thus, the relationship between calf sex and milk yield is not perfectly elucidated.

In most of published studies, Holstein dairy cows showed a tendency to adjust milk yield according to the sex of the calf, although this fact was not observed in our study. The offspring is separated from the mother as soon as they are born and milking is mechanically done. Therefore, the postnatal influence on milk yield does not seems to be of great importance. Thus, the variation in milk yield depends on the sex of the fetus. According to Hinde et al. (2014), the energy value of milk was higher when gestating a female calf and a female in the first calving of the cow would increase the production in the two subsequent pregnancies and reduce the negative effects of gestating a male. These results disagree with the work done by Rodrigues (2017) that found higher milk yield when the calf was male under the conditions of the São Joaquim Valley, California, USA.

Many studies have been carried out with the purpose of verifying the alteration of milk production and composition as a function of calf sex in different mammals. Roe deer and rhesus monkeys produce milk with higher protein content when calved a male compared to calving female, regardless of the mother's body condition score (Landete-Castillejos et al. 2005).

The use of recombinant bovine somatotropin (rBST) has been an option in order to increase milk production. According to Hinde et al. (2014), rBST enhances the effect of calf sex on milk production, although these analyzes have not been addressed in our work. The rBST is naturally produced by the bovine organism and plays a role in stimulating protein and glucose synthesis, fat oxidation, and inhibition of glucose utilization by peripheral cow tissues, thus increasing milk production (Akers 2006).

The biological adaptive pathway by which an adjustment in the development of the mammary gland as a function of calf sex is not known. It is known, however, that hormones of gestational origin transcolate in the bloodstream of the mother and bind to receptors of the mammary gland, influencing development and consequently milk production (Hinde et al. 2014).

Although there was no significant difference ($P > 0.05$) in milk production between cows that calved female or male calves, studies that did find an effect of calf sex on milk yield argued that the high milk production could be related to environmental factors, maternal effect, and their interaction. Even in works where there is a greater milk production in favor of the daughters, the natural proportion of births without the use of reproductive biotechnologies would be slightly high for male calf (54%) (Del Río et al. 2007). In general, these results do not agree with the Trivers-Willard's theory, which postulates that depending on the biological condition, mothers can "adjust" the proportion of genders. This adjustment would be made towards male calves when environmental conditions were unfavorable. In this situation, a slightly greater number of male calves compared to female is observed (Del Río et al. 2007). However, according to Hinde et al. (2014), the cow's production is higher when the calf is female. This fact may be related to the biological interest of females to reach sexual maturity earlier, generate descendants earlier, and favor the perpetuation of the species. However, higher milk production would be inversely related to the production of fat and protein in milk, reduced fertility, and increased propensity to diseases (Carvalho et al. 2002).

In beef cattle, male calves are born larger than females and they grow faster as well (Hinde et al. 2014). Few studies agree with these results, but there is no documented relationship of a possible differentiated behavior of the mother to the offspring when they are kept together.

As shown in Table 1, the values of protein and fat did not present statistically significant differences ($P > 0.05$). The production of fat and protein in milk is inversely related to milk production, which justifies the results of the protein and fat contents found. Hinde et al. (2014), when evaluating 2.39 million lactations of 1.49 million cows, found that the male calves received milk with a higher percentage of protein and fat in their composition them female (thus able to generate more energy). On the other hand, female calves received higher volume of milk than male. However, these results are not yet proven by science, but could be related to the adaptability of the calf, since in the case of females receiving more milk from their mothers allowed them to reach reproductive stage at a young age (Hinde et al. 2014).

Lactose as well as total solids was higher ($P < 0.05$) in the milk of cows that calved females (Table 1). Lactose is the main carbohydrate available to the calf (Cerdótes et al. 2004). Milk and lactose production are directly related, since it is the main osmotically active component (Auldist et al. 1995). The secretion of lactose in the alveolar lumen in the mammary complex causes the ingress of water and exert an essential role in the quantity of milk. The lactose content may vary according to the endocrine regulation and because it is the fundamental osmotic agent involved in the expulsion of milk (Lindorfer et al. 2016).

According to Buckley et al. (2003) the high lactose content in the milk of cows raised in Irish pastures was shown to be related to reproductive factors and was linked to great difficulty in pregnancy at first calving. As lactose is derived almost entirely from plasma glucose, this indicates that the concentration of lactose in milk can be used as a possible indicator of reproductive performance.

Conclusion

It was concluded that cows that calved males produced higher amounts of lactose and total solids than those that calved females.

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