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THE EFFECTS OF BIRTH AND CALVING SESON AND BIRTH YEAR ON MILK PRODUCTION AND COMPOSITION IN FIRST LACTATING COWS

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Summary

The aim of this study was to investigate the effects of birth and calving season (spring, summer, autumn, and winter (astronomical)) and birth year on milk production and composition (content of lactose, fat, protein, and total fat and protein (kg, %)) of Holstein first lactating cows. The analysed data based on milk production records of the first lactation Holstein cows (n=158 and n=246 on farm 1 and farm 2, resp.) recorded within the years of 2013 to 2017 on two farms in west part of Slovakia. The birth season of heifers had no significant effect on the milk composition and production. The significant effect of birth year was observed on all parameters evaluated, except on total fat and protein content (%). Milk yield, depending on the birth year, increased from 7793.31±1629.31 kg (in cows born in year 2013) to 9628.76±1386.45 kg (in cows born in year 2017). Similarly, the content (kg) of all components evaluated was higher in cows born in year 2017 than in cows born in year 2013. The influence of the farm was evident in all parameters evaluated, except for total fat and protein and lactose content (%). Milk production and milk composition of first-lactation cows appear to be influenced by factors other than calving and birth season. The management practices implemented on the evaluated farms could be one of the influencing factors.

Key words: first lactating cows, milk production and composition, birth season, calving season, birth year

Introduction

The milk production of dairy cows is affected not only by their genetic disposition and direct environmental effects they are exposed to, but also by the genetic constitution of the dam and non-genetic factors (maternal effect) (Susanto et al., 2019). Environmental factors affecting animals during prenatal and early postnatal period play an important role for the animals to express their performance during adult age (Hanson et al., 2011). Environmental stressors include heat and cold stress. These stressors can dramatically affect the dairy industry. These negative effects have an influence on the milk yield, milk composition, and milk quality of dairy animals (Collier et al., 2006; Mbuthia et al., 2021). Moreover, milk from heat-stressed animals may have altered coagulation properties, which could have an important impact on the cheese process (Salama et al., 2014).

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Cold stress at birth caused a decrease in preweaning weight gain and has a negative effect on the milk production of first-lactation cows (Soberon et al., 2012). The increased requirements of the cow during cold stress can be attributed primarily to increased maintenance functions. Pregnancy, calf development, and calf weight at birth were not negatively affected by cold stress, provided that the animal had a sufficient supply of nutrition (Young, 1981). However, if the animal has to use its body's energy reserves too much (insufficient nutrition or lack of protein), complications such as weak calf syndrome, reduced lactation potential, and even delayed reintroduction into breeding can occur (Young, 1981, 1983). Angrecka and Herbut (2015) in their study stated that the lower milk production appeared when the temperature was much lower than 0°C. They found out that animals suffering mild cold stress (calculated average operative temperature was -12.3°C) had lower milk yield by approximately 9.3%.

While the impact of heat stress on lactating cows is better understood and documented (i.e. its impact on milk yield, feed intake, composition of milk and colostrum, disease incidence (mammary gland health), and reproduction), recent literature has demonstrated that heat stress during late gestation can lead to a range of negative effects in both the dam and offspring (Nardone et al., 1997; Tao et al., 2019; Dado-Senn et al., 2020; Salama et al., 2020), with long-lasting multigenerational consequences on herd performance and longevity (Laporta et al., 2020).

Several researchers have revealed that heat stress during late gestation affects the birth weight, calf grain intake, weaning weight, standing behaviour (standing time, standing bound), and immune function (Tao et al., 2012; Monteiro et al., 2016a; Laporta et al., 2017). Heifers born to heat-stressed dry cows also had a greater number of services per conception confirmed 30 days after insemination and lower milk production in the first lactation compared to those born to cooled cows (Monteiro et al., 2013; 2016a).

Therefore, it is important to evaluate environmental factors that affect animals' performance under practical conditions. The aim of this study was to analyse the effect of year birth, as well as the birth and calving season, on the milk yield and composition of first lactating Holstein dairy cows on two dairy farms.

Material and Methods

Data were obtained from the Breeding services of the Slovak Republic from two dairy farms (farm 1 and farm 2) in west part of Slovakia located 5 km apart. The data were collected in years 2013 to 2017 from 404 animals (246 animals on farm 1 and 158 animals on farm 2). The animals included in the study were cows of Holstein breed with completed first lactation. Lactation duration of cows varied, therefore the animal's milk yield was standardized to 305 days milk yields. There were evaluated productive traits (milk yield (kg) and milk composition (fat, protein, total fat and protein, lactose in kg and %, resp.)) according to birth and calving season (each in four categories, Winter – December 21 to March 20, Spring –March 21 to June 20, Summer –June 21 to September 22, Autumn –September 23 to December 20) and birth year (from 2013 to 2017) of heifers.

Statistical data evaluation was performed with ANOVA and Tukey post hoc test by multiple comparison using proc mixed procedure of SAS®9.4. The effect of birth season, calving season, birth year, and farm on tested parameters was evaluated. The level of significance was set up at $p<0.05$.

Results and Discussion

The effects of the birth season on milk production and composition are shown in Table 1. According to Toledo et al. (2020), cows that were born in summer (from July to September) produced more milk and more protein than cows born in winter (from January to March). In our study, no significant effect of the birth season was observed on the evaluated parameters, similarly to the results of the studies by Mikláš et al. (2020a,b). Barash et al. (1996) evaluated the effects of birth month and observed a significant effect of birth month on the production of milk, fat, and protein in first-lactation cows. Milk production was the lowest in firstlactation cows born in early spring and the highest in those born in autumn (Barash et al., 1996). On the other hand, the results of Skiebiel et al. (2018) and Monteiro et al. (2016b) indicate that heifers exposed to heat stress conditions in the intrauterine environment can have lower milk yield during the first lactation.

Table 1 The effect of birth season on milk yield and milk composition

Parameters	Birth season				P
	Spring (n=68)	**Summer** (n=120)	**Autumn** (n=116)	**Winter** (n=100)	
Milk yield, kg	8642.28±1443.00	8768.19±1323.46	9011.59±1255.91	8962.37±1381.60	0.9361
Fat, kg	306.15±54.11	324.23±50.78	331.22±52.24	323.57±58.95	0.5243
Fat, %	3.58±0.54	3.73±0.49	3.69±0.45	3.62±0.43	0.1428
Protein, kg	286.84±41.59	295.45±40.48	300.00±38.49	297.63±41.01	0.9541
Protein, %	3.34±0.27	3.38±0.23	3.34±0.21	3.34±0.21	0.4962
Fat+Protein, kg	592.97±89.22	619.68±83.64	631.26±83.11	621.20±94.43	0.7858
Fat+Protein, %	6.92±0.73	7.11±0.63	7.03±0.55	6.96±0.54	0.1656
Lactose, kg	422.81±73.13	432.76±66.34	446.03±62.30	442.35±68.22	0.9591
Lactose, %	4.89±0.19	4.94±0.14	4.95±0.11	4.94±0.14	0.2492

As expected, and in accordance with other studies (Susanto et al., 2019; Soberon et al., 2012), the birth year of heifers had a significant effect (P<0.0001) on their milk yield during the first lactation and on the content of all components tested, except on total fat and protein content (%) (Table 2). The highest milk yield was observed in cows born in the year 2017 (9628.76 kg), and the lowest in cows born in the year 2013 (7793.31 kg). Similarly, the content (in kg) of all evaluated components was higher in cows born in the year 2017 than in cows born in the year 2013. However, while the milk yield varied from year to year on farm 1 (ranging from 8858,67±935,41 kg in cows born in the year 2016 to 9720,27±1316,23 kg in cows born in the year 2017), an increase in milk yield was observed on farm 2 (from 6859,10±1028,29 kg in cows born in 2013 to 9238,63±1635,31 kg in cows born in 2017) (data not shown). Since the influence of the birth season was not evident, the differences in milk production and milk composition (fat, protein, lactose) observed among the evaluated birth years could be attributed to the management practices (including genetic progress) implemented on the evaluated farms.

Table 2 The effect of birth year on milk yield and milk composition

Parameters	Birth year					P
	2013 (n=32)	**2014** (n=53)	**2015** (n=100)	**2016** (n=119)	**2017** (n=100)	
Milk yield, kg	7793.31±1629.31[a]	8390.32±1324.72[ab]	8720.90±1141.46[b]	8843.70±1026.14[b]	9628.76±1386.45[c]	<0.0001
Fat, kg	280.28±49.64[a]	290.30±43.19[a]	323.78±47.84[b]	327.34±52.68[b]	348.18±53.19[b]	<0.0001
Fat, %	3.65±0.49[ab]	3.49±0.47[a]	3.74±0.48[b]	3.71±0.50[b]	3.64±0.42[ab]	0.0059
Protein, kg	258.69±38.59[a]	277.11±35.35[ab]	292.84±30.29[b]	292.45±30.74[b]	324.71±44.13[c]	<0.0001
Protein, %	3.37±0.33[ab]	3.33±0.24[ab]	3.38±0.23[ab]	3.32±0.21[a]	3.38±0.18[b]	0.0193
Fat+Protein, kg	539.03±82.25[ab]	567.51±72.32[b]	616.62±72.30[c]	619.78±75.47[c]	672.86±89.88[d]	<0.0001
Fat+Protein, %	7.02±0.74	6.82±0.63	7.11±0.64	7.03±0.61	7.02±0.50	0.0556
Lactose, kg	381.78±84.56[a]	417.81±69.78[a]	432.84±57.50[a]	435.09±53.24[a]	472.35±66.40[b]	<0.0001
Lactose, %	4.89±0.13[ab]	4.97±0.11[a]	4.97±0.14[a]	4.92±0.18[ab]	4.91±0.10[b]	0.0020

a,b,c,d The means in the same line without same letter were significantly different at $p \leq 0.05$.

High air temperature can reduce the milk yield and the content of some milk component. According to Brasil et al. (2000) and Hamzaoui et al. (2013), dairy animals during heat stress produced less milk with lower protein and lactose contents. Moreover, according to Tao et al. (2012), cows exposed to heat stress before calving produced less milk. However, Barash et al. (1996) found out that the effect of calving month and birth month were not similar in heifers, but birth month had similar effects for the production traits as milk, fat, and protein. In cows in the second or higher lactation, the factor of birth month was less important than calving month. Heifers calved in spring had lower milk production than heifers calved in winter (Ray et al., 1992). In this study, there were not significant differences observed in milk yield and composition among the calving seasons of heifers (Table 3). The highest milk production was numerically observed in heifers calved in autumn, while the lowest was observed in spring-calved heifers (8956.54 kg and 8680.41 kg, resp.). Though several combinations of temperature, relative humidity, and radiant energy impact heat load in the cow, it is apparent that given sufficient night cooling, cows can tolerate relatively high daytime air temperatures (West, 2003). Igono et al. (1992) reported that despite high ambient temperatures during the day, a cool period of less than 21°C for 3 to 6 h will minimize the decline in milk yield.

The farm has a significant effect on all evaluated parameters, except for total fat and protein content (%) and lactose content (%) (Table 4). Higher milk production, fat content (%, kg), protein content (%, kg) and lactose (kg) content were observed on farm 2. According to Bateki et al. (2020), the use of improved cattle breeds and improved feeding is responsible for at least 50% of the average daily milk yield. Both evaluated farms reared the same breed under the similar environmental conditions (the distance between both farms was 5 km). However, the difference in genetical material or climate condition could have existed. Nevertheless, when the data were evaluated separately for each farm, no significant effects of birth and calving season were observed on all evaluated parameters, except for effect of calving season on fat content (%) on farm 2 (data not shown). However, also management strategies or the quality of

Table 3 The effect of calving season on milk yield and milk composition

Parameters	Calving season				P
	Spring (n=68)	**Summer** (n=104)	**Autumn** (n=113)	**Winter** (n=119)	
Milk yield, kg	8680.41±1398.61	8870.01±1340.11	8956.54±1319.41	8885.55±1338.80	0.7320
Fat, kg	316.87±54.28	323.61±50.88	327.47±53.32	322.12±59.24	0.4850
Fat, %	3.67±0.43	3.68±0.48	3.68±0.48	3.64±0.48	0.7684
Protein, kg	288.88±41.81	299.68±40.57	297.63±39.15	294.63±40.21	0.9157
Protein, %	3.35±0.25	3.39±0.21	3.34±0.24	3.33±0.21	0.2233
Fat+Protein, kg	605.79±91.19	623.24±84.01	625.13±84.02	616.77±92.69	0.7899
Fat+Protein, %	7.02±0.60	7.07±0.61	7.02±0.64	6.97±0.58	0.8741
Lactose, kg	424.41±71.62	437.06±66.33	443.21±65.87	439.61±66.28	0.5554
Lactose, %	4.87±0.19	4.92±0.16	4.95±0.13	4.95±0.12	0.1446

management practices could also influence milk production and composition. Unfortunately, the management strategies or quality of applied management could not be evaluated in this study. However, it seems that management practices applied on the evaluated farms could be one of influencing factors affecting milk production and composition. Nevertheless, dairy management should not be considered as stand-alone solutions but rather should be considered as a set of options that should be combined depending on the resources available to the farmer in order to achieve balance between the use of dairy cattle genetics, proper husbandry, and appropriate feeding practices to ensure higher milk yield.

Table 4 The effect of farm on milk yield and milk composition

Parameters	Farm		P
	Farm 1 (n=158)	**Farm 2** (n=246)	
Milk yield, kg	8270.52±1433.35	9246.74±1128.49	<0.0001
Fat, kg	292.10±48,47	342.89±48.29	<0.0001
Fat, %	3.57±0.50	3.73±0.45	0.0008
Protein, kg	284.03±43.04	303.44±36.62	0.0132
Protein, %	3.46±0.25	3.29±0.18	<0.0001
Fat+Protein, kg	576.16±85.60	646.33±77.80	<0.0001
Fat+Protein, %	7.03±0.68	7.01±0.56	0.6808
Lactose, kg	407.38±73.20	456.47±55.11	<0.0001
Lactose, %	4.92±0.18	4.94±0.11	0.2677

a,b The means in the same line without same letter were significantly different at $p \leq 0.05$.

Conclusions

In contrast to results of several previous studies, the milk production and composition were not affected by birth and calving season in first-lactation cows on the evaluated farms. In addition to possible variations in genetical material (even though the same breeds were bred on both farms), the applied management could influence milk production and composition on the evaluated farms. However, understanding the negative environmental effects (such as heat stress) on dairy animals, not only after birth but also already during intrauterine development, seems to be crucial for the development and selection of management practices aimed at enhancing the productivity, health, and well-being of dairy animals.

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