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Seasonality in milk performance and reproduction of dairy cows in low-input farms depending on feeding system*

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ABSTRACT

Seasonality in milk performance and reproduction was analysed in low-input mountain farms in the Czech Republic. Two different feeding regimes were distinguished: seasonal pasture and all-year silage feeding in confinement. Seventeen pastured herds and sixteen confined herds of Czech Pied and Holstein breeds (total 12 158 cows) were included in the seven-year study. Seasonal variation of milk, fat and protein yields per lactation according to the month of calving was found in both groups of herds. The highest yields were achieved by autumn-calved, and the lowest yields, by summer-calved cows (difference of 542 kg and 474 kg of milk on average in pastured and in confined herds, respectively). Higher individual daily yields (up to 2.9 kg on average) were recorded in the period between May and July than in the rest of a year. No effect of month of calving on days-to-first-service and on days-open period was identified.

KEY WORDS: cows, mountain region, feeding system, production, reproduction

INTRODUCTION

Cattle husbandry aimed at milk and beef production is the prevailing way of farm management in the mountain areas of the Czech Republic. The management effectiveness of these farms is lower than in lowland areas and compensatory state

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subsidies have not improved it (Štolbová et al., 2008). The farms have thus become increasingly dependent on state financial support. The effective utilization of seasonal pastures and the application of seasonal calving could be a way forward to reduce the expenses connected with milk production on low-input farms. Milk produced from pastured cows is better quality (fatty acid composition) and is generally better viewed by consumers than milk from permanently confined cows (Abrahamsen et al., 2007; Anderson, 2007; Refsholt et al., 2007; Węglarz et al., 2007; Król et al., 2008). Seasonal calving is becoming an attractive option in view of the approaching lifting of the milk quota regulation system in Europe. It offers a new opportunity to farmers to enhance farm milk production. The effect of month of calving on production and reproduction traits of Czech Fleckvieh cows was analysed by Kučera et al. (1999) and Brouček et al. (2004). In Holstein cows it was described by Schei et al. (2007). In both breeds the highest milk yields were achieved in cows calved in autumn and winter, whereas the lowest milk yields were found in cows calved in summer. The qualitative changes in feed rations can generally be identified as the reason for seasonal changes in milk production. The aim of this study was to analyse the seasonal variation in milk production and reproduction of cows offered seasonal pasture or silage feeding in confinement, i.e. in cows with substantially different summer feed rations.

MATERIAL AND METHODS

Herd management

Seventeen herds with access to a pasture during the vegetation period (May - October) and sixteen herds confined all year in stalls were selected for this study in the southern and western part of the Czech Republic. The pastured herds were located at an altitude from 500 to 896 m above sea level (mean 684 m) and the permanently confined herds from 411 to 826 meters above sea level (mean 566 m). Herd size was between 12 and 314 cows (mean 72) in pastured herds and between 47 and 308 cows (mean 170) in confined herds in 2006. The feed ration of pastured herds was based on grazed herbage *ad libitum* in the period between May and October and on grain supplements in the amount of 4-7 kg per cow per day offered in stalls during two milkings a day. The vegetation of the pastures appertained to the *Lolio-Cynosuretum* association (Klimeš, 1999; Frelich et al., 2006). The cows were supplied with water *ad libitum* from water tanks located in the pasture. Depending on the farm, supplements of hay, straw, fresh cut herbage, maize silage, grass silage, brewery draff, or rapeseed were offered to cows in stalls during milking in the amount of 1-10 kg per cow per day. The all- year feed ration for confined herds and the winter feed ration for pastured herds was based on a grass silage and/or maize silage in the amount of 20-35 kg and grain supplements, 4-7 kg per cow per day.

Depending on the farm, supplements of hay, straw, molasses, rapeseed, wheat bran or brewery draff were additionally offered to cows in the amount of 1-10 kg per cow per day. Mineral supplements were added to the feed ration in all surveyed farms. Eight of seventeen pastured herds were stabled in a freestall barn, the others were bonded in stalls. In confined herds, two of sixteen herds were bonded in stalls, the rest was kept in a freestall barn. The feeding technology was generally based on a total mixed ration (TMR) in confined herds, whereas in many of the pastured herds the components of feed were put into a manger separately.

The data on milk performance and reproduction recorded by the Czech Moravian Breeder's Corporation within the framework of breeding-value monitoring surveys were used in this study. In total, data on 5 468 cows in pastured herds and 6 690 cows in permanently confined herds were included. The cows belonged to Czech Fleckvieh and Holstein breeds and their crossbreeds, and calved in the period from January 2000 to December 2006. Except for three pastured herds and one confined herd, all the herds contained both breeds in different ratios. The average parity of cows was 3.0 in pastured herds and 2.7 in confined herds, 29 and 32% of lactations being the first lactations (pastured and confined herds, respectively), 23 and 25% of them were second lactations (pastured and confined herds, respectively), and the remainder were the third and later lactations. The average milk yield per standard (305-day) lactation in pastured herds was 5 798 kg (minimum, mean and maximum values: 4 152, 5 250, and 6 052 kg of Czech Fleckvieh cows and 5 063, 6 383 and 10 297, of Holstein cows). In permanently confined herds the average milk yield was 6 104 kg (minimum, mean and maximum values: 4 467, 5 401 and 6 112 kg of Czech Fleckvieh cows and 5 266, 6 763, and 7 860 kg of Holstein cows).

Statistical analysis

The effect of month of calving on milk, fat and protein yield per lactation and its effect on days-to-first-service and on days-open period was evaluated for each herd group (pastured, confined) separately, using the following linear model of the GLM procedure of SAS statistical software (SAS, 2001):

$$y_{ijklm} = \mu + H_i + B_j + P_k + Y_l + M_m + \beta\upsilon + e_{ijklm}$$

where: y_{ijklm} - value of measured trait, i.e. milk, fat and protein yield per lactation, days to first service and days open; H_i - fixed effects of the i^{th} herd; B_j - fixed effects of the j^{th} breed; P_k - fixed effects of the k^{th} parity; Y_l - fixed effects of the l^{th} year of calving; M_m - fixed effects of the m^{th} month of calving, $\beta\upsilon$ - fixed linear regression on the age at 1st calving; e_{ijklm} - the residuum.

Six levels were distinguished for effect of the breed: Holstein breed and crossbreds with proportions of H-breed: 50-62, 63-88 and 100%; and Czech Fleckvieh breed with proportions of C-breed: 51-74, 75-88 and 100%. Three levels of effect of parity were used: first lactation, second lactation, third or later lactations. Only lactations with a duration of 240 days and more were used. In total, data on 8 853 lactations in pastured herds and 11 664 lactations in confined herds were analysed.

The analysis of seasonal changes in milk performance was conducted using 24-h milk performance (test-day) data recorded from January 2000 to December 2006. The pastured and confined herds were analysed separately. In total, 103 444 test-day records in pastured herds and 131 599 test-day records in confined herds were used in analysis using the following model of analysis of covariable of statistical software StatSoft, Inc. (2005):

$$y_{ijk} = \mu + B_i + P_j + M_k + co + e_{ijk}$$

where: y_{ijk} - value of measured trait, i.e. 24-h milk yield, fat and protein milk content and 24-h milk yield transformed on a standard content of milk fat and protein: Milk = 24-h milk yield (fat content + protein content)/(3.8 + 3.2); B_i - fixed effects of the ith breed; P_j - fixed effects of the jth parity; M_k - fixed effects of the kth month of test-day; co - days in milk as a covariable; e_{ijk} - the residuum.

Two levels were used for the effect of the breed: Czech Fleckvieh breed with proportion of C-breed: 51-100%, and Holstein breed and its crossbreds with proportion of H-breed: 50-100%. Three levels of effect of parity were used: first lactation, second lactation, third or later lactations.

In order to distinguish the seasonal variation in daily milk yields in herds differed by achieved milk production (by breeding effectiveness), three herds with the highest and three herds with the lowest milk yield per standard lactation (least squares means given by GLM analysis described above) were selected from each group of herds (pastured and confined) and analysed separately. The model of analysis of covariance described above was applied to the following data sub-samples: Pasture 1: three pastured herds with a high milk production (5 943-6 052 kg per lactation in Czech Fleckvieh and 6 729-10 297 kg in Holstein cows, an average of a herd); Pasture 2: three pastured herds with a low milk production (4 152-4 928 kg in Czech Fleckvieh and 5 063-5 612 kg in Hostein cows, an average of a herd); Confined 1: three confined herds with a high milk production (5 690-6 112 kg in Czech Fleckvieh and 6 977-7 860 kg in Holstein cows, an average of a herd); Confined 2: three confined herds with a low milk production (4 467-5 143 kg in Czech Fleckvieh and 5 266-6 277 kg in Holstein cows, an average of a herd).

RESULTS

Significant effects of month of calving on milk, fat and protein yields per lactation were found in both pastured and permanently confined herds (Table 1). The highest yields were achieved by autumn- and winter-calved cows, whereas the lowest yields were recorded by summer-calved cows (Figures 1-3). On

Table 1. Statistical significance of an effect on analysed parameters of milk performance and reproduction in seasonally pastured (P) and permanently confined (C) herds

Analysed parameter	Category of herds	Herd	Breed	Parity	Year of calving	Age at 1st calving	Month of calving
Milk yield	P	***	***	***	***	***	***
Fat yield	P	***	***	***	***	***	***
Protein yield	P	***	***	***	***	***	***
Days to first service	P	***	***	**	***	n.s.	n.s.
Open days	P	***	***	n.s.	**	n.s.	n.s.
Milk yield	C	***	***	***	***	***	***
Fat yield	C	***	***	***	***	***	***
Protein yield	C	***	***	***	***	***	***
Days to first service	C	***	***	**	***	***	n.s.
Open days	C	***	***	n.s.	n.s.	**	n.s.

*** P<0.001; ** P<0.01; n.s. - not significant (P>0.05)

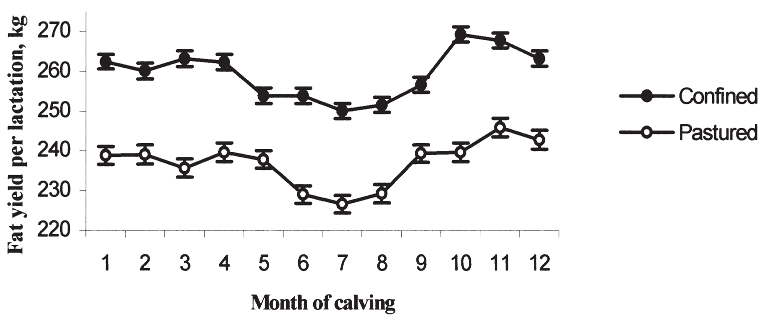

Figure 1. Least squares means of milk yield per lactation and standard errors of means in permanently confined (Confined) and in seasonally pastured (Pastured) herds according to the month of calving

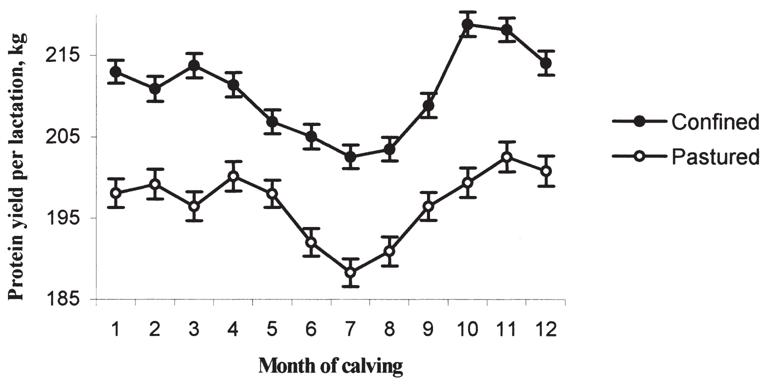

Figure 2. Least squares means of fat yield per lactation and standard errors of means in permanently confined (Confined) and in seasonally pastured (Pastured) herds according to the month of calving

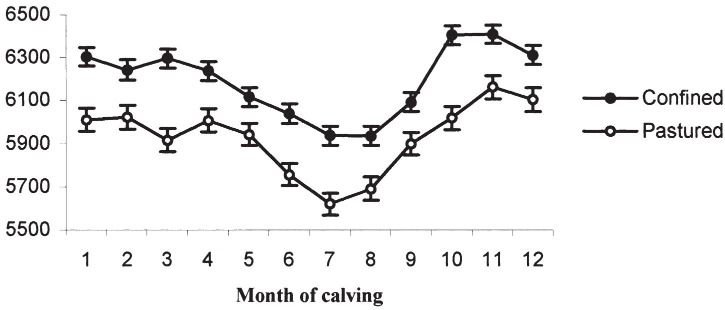

Figure 3. Least squares means of protein yield per lactation and standard errors of means in permanently confined (Confined) and seasonally pastured (Pastured) herds according to the month of calving

average, the highest milk production per lactation was in cows calved in November (least squares means: 6 162 and 6 409 kg in pastured and confined herds, respectively), and the lowest milk production by cows calved in July in pastured herds (least squares mean 5 620 kg) and in August in confined herds (least squares mean 5 935 kg). The effect of month of calving on days-to-first-service and on days-open period was not significant (Table 1). The least squares means of days-to-first service were between 72 and 78 in pastured herds and between 73 and 76 days in confined herds, depending on the month of calving (Figure 4). Days open were between 116 and 126, on average, in pastured herds and between 115 and 123 days in confined herds (Figure 5). Analysis of test-day data revealed significant seasonal variation in daily milk yields and in milk fat and protein contents in both groups of herds (Table 2). The highest milk yields were recorded in spring and in early summer (from May to July) in pastured as

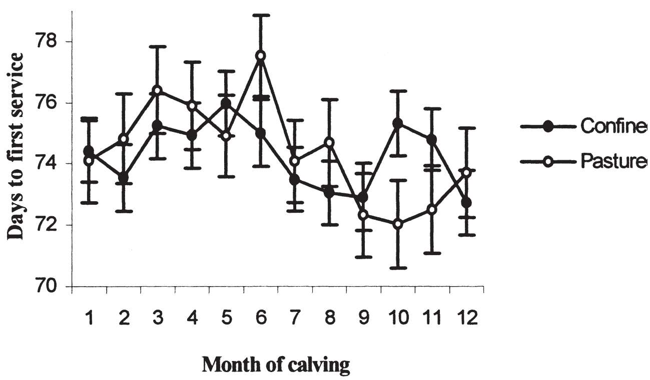

Figure 4. Least squares means of days-to-first-service period and standard errors of means in permanently confined (Confined) and seasonally pastured (Pastured) herds according to the month of calving

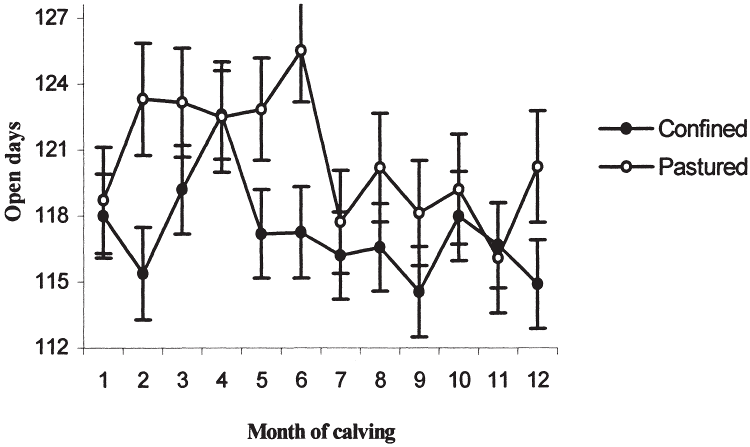

Figure 5. Least squares means of days-open period and standard errors of means in permanently confined (Confined) and seasonally pastured (Pastured) herds according to the month of calving

Table 2. Statistical significance of an effect on analysed parameters of test-day milk performance. Milk = 24 h milk yield (fat content + protein content)/(3.8 + 3.2); P - seasonally pastured herds, C - permanently confined herds

Analysed parameter of milk performance	Category of herds	Breed	Parity	Days in milk	Month of test-day
24-h milk yield, kg	P	***	***	***	***
Fat content in milk, %	P	***	***	***	***
Protein content in milk, %	P	***	***	***	***
Milk, kg	P	***	***	***	***
24-h milk yield, kg	C	***	***	***	***
Fat content in milk, %	C	***	***	***	***
Protein content in milk, %	C	***	***	***	***
Milk, kg	C	***	***	***	***

*** P<0.001

well as in confined herds (Figure 6). June-August milk had the lowest fat and protein contents in comparison with the rest of the year (Figures 7 and 8). The maximum difference in daily milk yields between months was 2.9 kg in pastured and 2.2 kg in confined herds, on average (least squares means given by analysis of covariance). After correction of milk yields by standard fat and protein content (Figure 9) there is evident enhancement of milk productivity in confined cows during April-July. In pastured herds, the milk yield peaked in May and gradually declined to November. Similar seasonal trends in milk yields were found in high-production as well as in low-production herds (Table 3, Figures 10 and 11). The May peak in milk yields was evident in both the high- and low-productive pastured herds, while the seasonal variation was not so distinct in confined herds.

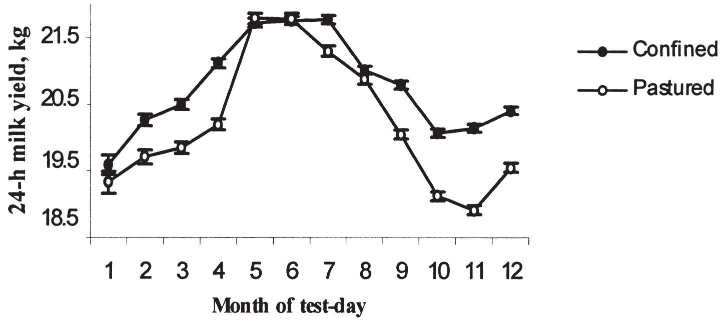

Figure 6. Least squares means of 24-h milk yield and standard errors of means in permanently confined (Confined) and seasonally pastured (pastured) herds according to the month of test-day

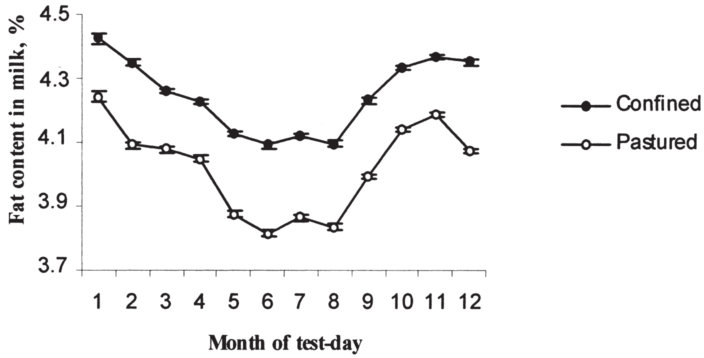

Figure 7. Least squares means of fat content in milk and standard errors of means in permanently confined (Confined) and seasonally pastured (Pastured) herds according to the month of test-day

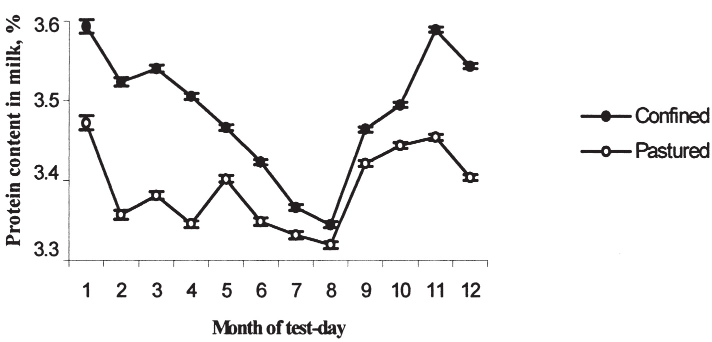

Figure 8. Least squares means of protein content in milk and standard errors of means in permanently confined (Confined) and seasonally pastured (Pastured) herds according to the month of test-day

Table 3. Statistical significance of an effect on analysed parameters of test-day milk performance in selected pastured and confined herds with a high (Pastured 1, Confined 1) or low (Pastured 2, Confined 2) average milk production per lactation. Milk = 24 h milk yield (fat content + protein content) / (3.8 + 3.2)

Analysed parameter of milk performance	Category of herds	Breed	Parity	Days in milk	Month of test-day
24-h milk yield, kg	Pastured 1	***	***	***	***
Milk, kg	Pastured 1	***	***	***	***
24-h milk yield, kg	Pastured 2	***	***	***	***
Milk, kg	Pastured 2	***	***	***	***
24-h milk yield, kg	Confined 1	***	***	***	***
Milk, kg	Confined 1	***	***	***	***
24-h milk yield, kg	Confined 2	***	***	***	***
Milk, kg	Confined 2	***	***	***	***

*** P<0.001

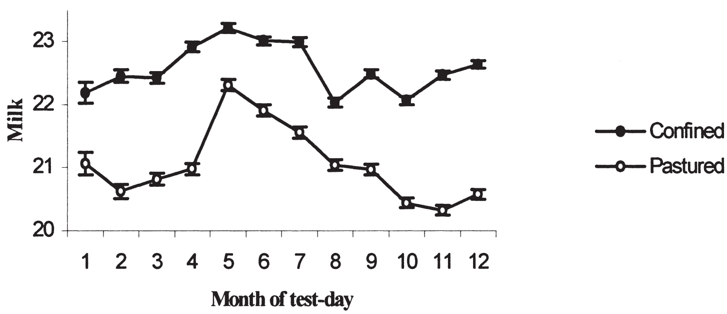

Figure 9. Least squares means of 24-h milk yield transformed into milk yield with standardized fat and protein content: Milk = 24 h milk yield (fat content + protein content) / (3.8 + 3.2) in permanently confined (Confined) and in seasonally pastured (Pastured) herds according to the month of test-day

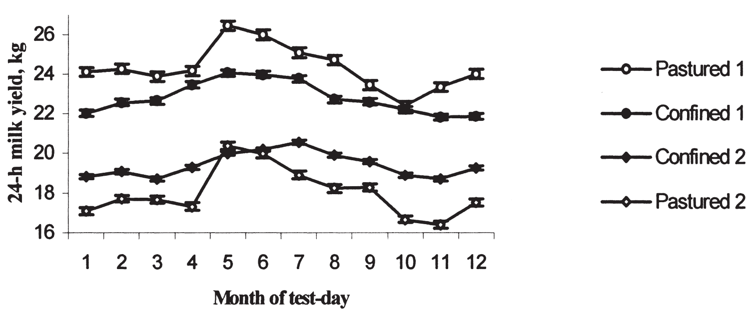

Figure 10. Least squares means of 24-h milk yield and standard errors of means according to the month of test-day in selected seasonally pastured and permanently confined herds with a high (Pastured 1, Confined 1) or low (Pastured 2, Confined 2) average milk production per lactation

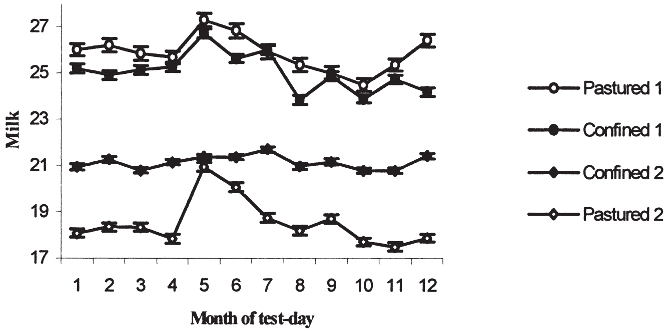

Figure 11. Least squares means and standard errors means of 24-h milk yield transformed into milk yield with standardized fat and protein content: Milk = 24 h milk yield (fat content + protein content) / (3.8 + 3.2), according to the month of test-day in selected seasonally pastured and permanently confined herds with a high (Pastured 1, Confined 1) or low (Pastured 2, Confined 2) average milk production per lactation according to the month of test-day

DISCUSSION

The seasonal changes in milk performance recorded in this study correspond well with findings of other authors on Czech Fleckvieh or Holstein cows (Kučera et al., 1999; Brouček et al., 2004; Schei et al., 2007). The month of calving significantly influenced milk production per lactation, the highest yields being achieved in autumn-calved and winter-calved cows and the lowest yields in summer-calved cows. Similar seasonal trends in milk production were revealed in herds subjected to different summer feeding regimes (grazed vs conserved forage). The timing of the late lactation phase on the spring-summer period, when individual milk yield were the highest, was probably the reason for the high milk production per lactation achieved in autumn-calved cows. The pastured cows had more evident peaks in milk yields in May, which were followed by a gradual depression of yields until November. The change of feeding regime from silage feeding to pasture grazing could be the reason for such enhancement in milk production in May. Grazing generally has a positive influence on dry matter intake and milk production of cows (Romney and Gill, 2000). Enhanced milk and protein yields were found in cows already offered two-hour access to pasture in early spring (Sayers and Mayne, 2001). A similar positive effect of early spring pasture was also found by Kennedy et al. (2006). Król et al. (2008) observed that cows maintained in the conventional system (pasture feeding) showed a significantly higher level of functional whey proteins in milk. However, feeding according to the TMR system resulted in higher total contents of milk protein, casein and fat. The gradual depression of milk yield observed from May to November could be connected with the lowering of the nutritional quality of the pasture herbage. The reduction of crude protein content and enhancement of fibre content in pasture herbage was found during a grazing season in two farms included in this study (Frelich et al., 2008). Such changes of forage quality cause lower dry matter intake leading to lower milk yields. Although the supplementation of fresh cut herbage was applied in summer, it did not prevent the decline in milk yields (Frelich et al., 2008). The physiological response of cows to a change in photoperiod plays a substantial role in the seasonal variation of milk production (Dahl et al., 2000) and could be responsible for the seasonality in milk production in both the pastured and the confined cows. No seasonality in day to first service and in open days according to the month of calving was found. The date of calving thus determines rather the production than the reproduction of cows. Seasonal calving thus seems to offer a possibility further to enhance the efficiency of dairy management. The difference in milk production could reach 542 or 474 kg per lactation, on average, according to month of calving and summer feeding regime applied (least squares means given by GLM analysis, pastured and confined herds, respectively). Similar seasonal variation in milk yields was recorded in herds differed substantially by achieved milk production, i.e. by different breeding management efficiency. This is a positive conclusion as regards low-input farming, where updating breeding technologies (milking parlour, mixed feed ration, freestall barn) or pasture sward resowing and nitrogen fertilization are largely neglected due to financial constraints. According to the presented data, a good level of milk production can be achieved by application of seasonal pasture. However, the most productive herds achieved their milk productivity due to supplementation of pastured cows with some additional feed components, like maize silage, rapeseed or wheat bran, while sward renovation and mineral fertilization were omitted there. The productivity of pasture swards thus remained low and varied between 3 and 5 tons of dry matter per hectar and year (Klimeš, 1999; Klimeš et al., 2008). Better sward management would improve pasture utilization and mik yields of cows. This offers another opportunity for enhancing low-input farming effectivity in the surveyed regions.

CONCLUSIONS

In a sample of 33 low-input mountain herds, a significant effect of month of calving on milk, milk fat, and protein yields per lactation was found. The highest yields were achieved in autumn-calved and the lowest yields in summer-calved cows. Higher individual milk productivity of cows in the late spring - summer period was identified as a reason for seasonal variation in milk yields according to the month of calving. No seasonality was found in the analysed reproduction traits (days to first service and open days). Similar seasonal trends in individual milk yields were observed in herds differed substantially by their summer feed ration (based on grazed or conserved forage) or by achieved milk production. The application of seasonal calving is suggested as a way of enhancing milk production in low-input farms.

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