Monitoring of physical activity for management of cow reproduction

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ABSTRACT: The objective of this paper was to assess by means of pedometers the period of anoestrus in a herd where the calving interval was 400 days and to detect the influence of some factors (breed, year, season, parity) on the length of anoestrus and the intensity of increased physical activity during oestrus. It was also monitored whether the intensity of increased physical activity would influence the conception rate. The observations were performed in a herd of 243 cows, 80 of them Czech Pied cows (C) and 163 of them Holstein cows (H) during 4 years. The cows were housed together in a free cubicle housing system. The cows of H breed produced 3 790 kg and those of C breed 3 087 kg of milk on average during the first 100 days of lactation. The mean calving interval was 400 days, and the mean number of services per pregnancy was 2.1. The cows were fed a total mixed ration. This ration has a low energy content (NEL) and excessive content of crude protein according to the official evaluation used in the Czech Republic. The intake of NEL ensured the production of 30.9 l of milk and the intake of crude protein in 45 l of milk in these cows. The cows of both breeds significantly differed in the length of postpartal anoestrus, which is probably related to the negative energetic balance of H cows. The effect of parity, year of calving, and season of calving on the length of postpartum anoestrus was not demonstrated as statistically significant. A comparison of the walking activity over the oestrus period in the individual breeds demonstrated that the cows of the Czech Pied breed exhibited significantly higher activity. The highest walking activity was observed in first-calvers of both breeds, and the lowest walking activity during oestrus was recorded in winter. The cows with higher walking activity had a higher conception rate than those with lower walking activity.

Keywords: cow; physical activity; pedometers; anoestrus

Reproductive performance of dairy cows has decreased in the last two decades, simultaneously with a high increase in milk production per cow. High reproductive performance in a dairy herd requires each cow to calve during a pre-planned calving season, with a calving interval that maximizes the economic output of milk production within the herd. To this end, a disease-free transition period, high submission rate to artificial insemination (AI), and high pregnancy rates are necessary (Roche *et al*., 2000). The submission rate to AI depends on the length of anovulatory anoestrus and the efficiency of oestrus detection.

Economically, anoestrus is of main importance because it prolongs the calving interval. The prolongation of anoestrus is due to a failure of dominant follicles (DFs) to ovulate rather than to their absence (Roche *et al*., 1998). The inability of DF to produce an elevated concentration of oestradiol in cows during anoestrus is related to the degree of negative energetic balance (NEB) in the early postpartum period. This causes a decrease in LH pulse frequency, in the diameter of DF with low oestradiol production, in the systemic insulin-like growth factor-I (IGF-I), and perhaps intrafollicular IGF-I availability, as well as an increase in the interval to the first oestrus (Beam

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and Butler, 1997; Stagg *et al*., 1998; Roche *et al*., 2000). Because most dairy cows ovulate for the first time between the second and fourth weeks, Stewenson and Call (1988) defined any delay beyond the fourth week as a delayed ovulation or anovulation. In the experiments of these authors, the average anovulation rate was 5.5% (ranging from 2.3% to 22.5%) in 1 518 cows from 130 herds under study.

The increased interval to the first oestrus is a common problem. For effective management of reproduction, the breeder must know whether anoestrus or failure of oestrus detection are involved in problematic animals. Pedometric monitoring of the physical activity of cows is a simple and available method providing sufficiently exact data. Pennigton *et al*. (1986) reported 78–96% efficiency and 88–100% accuracy, Liu and Spahr (1993) 74% efficiency of this method. According to Peter and Bosu (1986), the first, second, and third postpartal ovulations were recorded in 57%, 91%, and 92%, respectively. Nebel *et al*. (2000) detected oestrus in 70% to 80% by means of pedometer measurements.

The objective of this paper was to assess by means of pedometers the period of anoestrus in a herd where the calving interval was 400 days and to detect the influence of selected factors (breed, year, season, parity) on the length of anoestrus and the intensity of increased physical activity during oestrus. It was also observed whether the intensity of increased physical activity would influence the conception rate.

MATERIAL AND METHODS

Our studies were performed in 1999–2002. A herd of 243 cows, 80 of them Czech Pied cows (C) and 163 of them Holstein cows (H), were housed together in a free cubicle housing system. Cows in the 1st to 8th lactations with the total number of 468 lactations were included in the experiment. The cows of H breed produced 3 790 kg and those of C breed 3 087 kg of milk on average during the first 100 days of lactation. The mean calving interval was 400 days and the mean number of services per pregnancy was 2.1. The cows were fed a total mixed ration. This ration has a low energy content (NEL) and excessive content of crude protein according to the official evaluation used in the Czech Republic. The intake of NEL ensured the production of 30.9 l of milk and the intake of crude protein in 45 l of milk in these cows.

Oestrus detection was performed on the basis of increased physical activity. The number of steps recorded by pedometers strapped on the cow's hind leg was recorded at morning and afternoon milking using AFI 2000 program (version 1.26) and then evaluated. The detected mean number of steps was compared with that recorded during the whole postpartum period. The criterion for determination of a cow in the first oestrus was at least 100% increase in activity. These data served for the assessment of the length of postpartal anoestrus.

A total of 1 228 records of oestrous events were used to assess the number of steps per hour in the oestrus. The relation between the conception rate and the intensity of increased physical activity rate was studied on the basis of the records of 744 insemination events carried out in oestrus and detected by pedometers in all the cows under study.

In order to determine the effect of the studied criteria, the cows were classified into two groups according to their breeds (C and H) and into four groups according to the year of calving. The first group consisted of cows in the first lactation, the second group of cows in the second lactation, and the third group in the third-plus lactation. For analysis of the studied criteria the cows were categorized into four groups according to the season of calving: spring – March, April, June; summer – June, July, August; autumn – September, October, November, and winter – December, January, February.

The least squares method utilizing the SAS 6.12 procedure was applied for the analysis. The following effects were included in the model:

$$y_{ijklm} = \mu_i + A_i + B_j + C_k + D_l + e_{ijklm}$$

where: y_{ijklm} = observation of trait
μ = overall mean
A_i = fixed effect of breed
B_j = fixed effect of parity
C_k = fixed effect of year of calving
D_l = season of calving
e_{ijklm} = random error

The E_m fixed effects characterizing the successful or unsuccessful insemination and fixed regression on lactation stage during insemination (days) were included in the basic model of the analysis of the relation between the intensity of increased physical activity and level of pregnancy. For the evaluation of the duration of postpartal anoestrus, the

cows were categorized into the following categories according to days-postpartum (DPP): < 30; 30–60; 61–90; > 90.

RESULTS AND DISCUSSION

Factors affecting the length of postpartum anoestrus

The length of postpartum anoestrus and effect of breed. The cows of both breeds significantly differed in the length of postpartal anoestrus. The postpartum in Holstein cows was 11 days longer (Table 1). There was also a statistically significant difference between these two breeds in the number of cows in individual classes classified according to the length of anoestrus (Table 2). In the Czech Pied cows, oestrus occurred within 30 days postpartum in double the number of cows compared to the Holstein breed, in which the highest number of oestrous events was recorded between 30 and 60 days postpartum. At the first ovulation the oestrus is usually silent. Peter and Bosu (1986) found that only 57% of first postpartum ovulations were associated with an increase in activity (pedometer readings), and only 19% of first postpartum ovulations were associated with behavioural signs of oestrus. Considering anoestrus as the lack of oestrus, Cavestany and Galina (2001), Fonseca *et al*. (1983), and Schopper *et al*. (1993) reported that about 50% of ovulations were never observed. According to Cavestany and Galina (2001), 85% of the cows with normal ovarian activity as indicated by the progesterone test were never detected in oestrus during the 80 days of the experimental period. With regard to these facts it can be said that the first ovulation was recorded within 30 days postpartum in almost all of the Czech Pied cows, and the prolonged anovulation reported by Roche *et al*. (1998) was not observed in them. The results obtained with Holstein cows were markedly different. Ovulation within 30 days occurred in 50% of the cows only, and a much longer postpartal anoestrus was recorded in them.

Cavestany and Galina (2001) studied the length of postpartal anoestrus in various breeds and found a significant effect of farming (feeding and management of breeding). Postpartal anoestrus occurred

Table 1. Overall mean ($\mu + a_i$) of the length of postpartum anoestrus according to breed

Trait		Breed	
		Holstein	Czech Pied
	N^1	318	150
Length of postpartum	$\mu + a_i$	48[a]	37[b]
anoestrus (days)	$s_{\mu + ai}$	1.58	2.04

N^1 = No. of postpartal anoestrus events
Statistically significant difference ($P < 0.05$) is indicated by different superscripts [a, b]

Table 2. Length of postpartum anoestrus in cows of Holstein and Czech Pied breeds

Days	Breed			
	Holstein[a]		Czech Pied[b]	
	N^1	%	N^1	%
< 30	71	22.3	69	46.0
30–60	185	58.2	65	43.3
61–90	51	16.0	12	8.0
> 90	11	3.5	4	2.7

N^1 = No. of postpartal anoestrus events
Statistically significant differences ($P < 0.05$) were determined by Chi-square analysis and are indicated by different superscripts [a, b]

in 12.5% of cows. In the authors' opinion, this was due to unsuitable feeding at some farms. Many authors observed a linear increase in days to the first oestrus with increasing milk yield (Spalding *et al*., 1975; Tong *et al*., 1979; Berger *et al*., 1981; Vaněk, 2004). Malnutrition seems to be the reason for these results. Nevertheless, this hypothesis was not confirmed by Fonseca *et al*. (1983), who found that fertility traits measured for Holstein cows that produced more than 1 500 kg below their herd mates were similar to those for cows that produced more than 1 000 kg above herd mates. The authors assume that the linear relationship between yield and fertility traits in field studies may be the result of selective culling of low-producing, less fertile cows from the population sampled. Jersey cows according to their characteristics, producing more milk ovulated sooner post partum than lower producing herd mates, but days open were longer.

However, Staples *et al*. (1990) demonstrated that anoestrus is related to energy deficiency. This corresponds to our results, since the energy in Czech Pied cows was 100%, whereas that in Holstein cows only 82%.

Effect of parity on the length of postpartum anoestrus. The effect of parity on the length of postpartum anoestrus (Table 3) was not demonstrated as statistically significant. The assessed length of anoestrus was almost the same in the groups of cows in 2nd and 3rd-plus lactations and reached the values of 42 and 79 or 42 and 68 days, respectively. The shortest postpartal anoestrus was detected in first-calvers (41 and 21 days), but the difference from the other groups was not statistically significant. These results absolutely differ from the observations by Cavestany and Galina (2001), who found 82.1% of first-calvers and 17.9% of mature cows to be in anoestrus 80 days postpartum. It is difficult to comment on the differences in these results because the conditions of observations cannot be compared. However, it is evident that the statement that first-calvers use a part of nutrients consumed for the termination of their own growth and are therefore in a nutrient deficit resulting in lower reproductive performance, is not generally valid.

Effect of year of calving on the length of postpartum anoestrus. Analysis of the effect of the year of calving (Table 4) shows that there was no statistically significant difference between the years of calving in all the experimental animals. The length of anoestrus tended to shorten slowly from 1999 to

Table 3. Overall mean ($\mu + a_i$) of the length of postpartum anoestrus according to parity

Trait		Parity in the		
		first lactation	second lactation	third-plus lactation
	N^1	158	148	162
Length of postpartum	$\mu + a_i$	41	42	42
anoestrus (days)	$s_{\mu + ai}$	2.02	2.08	1.95

N^1 = No. of postpartal anoestrus events
The differences are not statistically significant

Table 4. Overall mean ($\mu + a_i$) of the length of postpartum anoestrus according to year of calving

Trait		Year of calving			
		1999	2000	2001	2002
	N^1	36	154	159	119
Length of postpartum	$\mu + a_i$	44	43	40	41
anoestrus (days)	$s_{\mu + ai}$	3.63	1.95	1.97	2.14

N^1 = No. of postpartal anoestrus events
The differences are not statistically significant

2001 and became somewhat longer in 2002. This fact suggests that the management of herd breeding was the same during the experiment.

Effect of season on the length of postpartum anoestrus. The length of anoestrus did not significantly differ in the spring, summer, and autumn periods (Table 5). The highest estimated values were 44 or 45 days in spring and summer. In autumn the length of anoestrus was shorter, 43 days, but in winter, the shortening to 36.5 days was already statistically significant. These results do not correspond to those obtained by Boyd (1977), who emphasized the negative effect of winter and early spring on the length of postpartum anoestrus due to the change of photoperiod. Fonseca *et al*. (1983) also observed that cows calving during the period from December to February had 6.5 ± 2.9 ($P < 0.05$) more days to their first ovulation than cows calving during the period from September to November. Concerning the effect of season in general, two factors are involved: the effect of seasonal ration and extreme climatic conditions. In our experiments, the cows were fed a total mixed ration during the whole year, and no extreme prolonged conditions were recorded. Therefore, the shortening of anoestrus in winter must have been influenced by other factors that cannot be determined from our studies.

Factors affecting the walking activity of cows over the oestrus period. The walking activity of cows as measured by pedometers increased 2× to 8× over the oestrus period. The mean number of steps per hour increased by 400% in this period. The same results were reported by Kiddy (1977).

Effect of breed on walking activity over the oestrus period. A comparison of the walking activity over the oestrus period in individual breeds (Table 6) revealed that the cows of the Czech Pied breed exhibited significantly higher activity. The mean value of $\mu + a_i$ was 426 steps per hour in Czech Pied cows, while that in Holstein cows was 367 steps. Data on similar differences between individual breeds are missing in the literature, but Boyd (1977) assumes that they exist. A demonstration of the effect of negative energy balance on oestrus expression requires further experiments.

Effect of parity on walking activity over the oestrus period. Analysis of the effect of parity on walking activity (Table 7) showed marked differences in the walking activity between individual parities. The highest walking activity was observed in first-calvers, cows in 2nd lactation exhibited lower activity; and the greatest decrease was observed in cows in 3rd-plus lactation. Quite contrary results were reported by Cavestany and Galina (2001). Only 3.3% of the ovulated first-calvers were detected in oestrus

Table 5. Overall mean ($\mu + a_i$) of the length of postpartum anoestrus according to season of calving

Trait		Season of calving			
		1	2	3	4
	N^1	130	116	96	126
Length of postpartum anoestrus (days)	$\mu + a_i$	44[a]	45[a]	43[a]	37[b]
	$s_{\mu + ai}$	2.27	2.13	2.30	2.24

N^1 = No. of postpartal anoestrus events

Statistically significant differences ($P < 0.05$) were determined by *t*-test and are indicated by different superscripts [a, b]

Table 6. Overall mean ($\mu + a_i$) of No. of steps per hour over the oestrus period according to breed

Trait		Breed	
		Holstein	Czech Pied
	N^1	877	351
No. of steps per hour	$\mu + a_i$	367[a]	425[b]
	$s_{\mu + ai}$	7.31	10.41

Statistically significant differences ($P < 0.05$) were determined by *t*-test and are indicated by different superscripts [a, b]

compared with 67.7% of the mature cows, which was in accordance with Fagan *et al*. (1988).

Effect of year of calving on walking activity over the oestrus period. There were some differences in walking activity in relation to the year of calving (Table 8). Walking activity decreased between 1999 and 2000, and then gradually increased until 2002, when it reached a maximum. The increase in walking activity during the last years might have been caused by culling of old

Table 7. Overall mean ($\mu + a_i$) of No. of steps per hour over the oestrus period according to parity

Trait		Parity in the		
		first lactation	second lactation	third-plus lactation
	N[1]	442	418	368
No. of steps per hour	$\mu + a_i$	431[a]	405[b]	353[c]
	$s_{\mu + ai}$	9.55	9.53	10.31

Statistically significant differences ($P < 0.05$) were determined by *t*-test and are indicated by different superscripts [a, b, c]

Table 8. Overall mean ($\mu + a_i$) of No. of steps per hour over the oestrus period according to year of calving

Trait		Year of calving			
		1999	2000	2001	2002
	N[1]	61	309	446	412
No. of steps per hour	$\mu + a_i$	404[bc]	354[a]	398[b]	430[c]
	$s_{\mu + ai}$	21.94	9.79	8.28	8.85

Statistically significant differences ($P < 0.05$) were determined by *t*-test and are indicated by different superscripts [a, b, c]

Table 9. Overall mean ($\mu + a_i$) of No. of steps per hour over the oestrus period according to season of calving

Trait		Season of calving			
		1	2	3	4
	N[1]	337	286	226	379
No. of steps per hour	$\mu + a_i$	378[a]	422[b]	422[b]	364[a]
	$s_{\mu + ai}$	11.03	10.48	12.12	10.63

Statistically significant differences ($P < 0.05$) were determined by *t*-test and are indicated by different superscripts [a, b]

Table 10. Overall mean ($\mu + a_i$) of No. of steps per hour over the oestrus period according to conception after insemination

		Insemination with conception	Insemination without conception
	N[1]	324	420
No. of steps per hour	$\mu + a_i$	427[a]	377[b]
	$s_{\mu + ai}$	10.49	9.75

Statistically significant differences ($P < 0.05$) were determined by *t*-test and are indicated by different superscripts [a, b]

cows from the herd and including first-calvers with higher walking activity.

Effect of season of calving on walking activity over the oestrus period. The season of calving markedly affected the walking activity of cows (Table 9). The lowest walking activity during oestrus was recorded in winter. In early spring, walking activity started to increase and reached a peak in summer and autumn. The lack of increased activity during oestrus may be due to the effects of ambient temperature (Etherington *et al*., 1985). Peter and Bosu (1986) reported that 94% of postpartum ovulations not predicted by pedometer occurred during the winter. Similarly, Boyd (1977) assumes that anoestrus is a problem of winter and early spring, with possible recurrence in late summer.

Rate of conception after insemination. Analysis of the relation between the rate of walking activity and successful insemination (Table 10) showed significant differences. The cows with higher walking activity had higher a conception rate than those with lower walking activity.

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ABSTRAKT

Využití sledování pohybové aktivity v managementu reprodukce krav

Cílem práce bylo odhadnout pomocí pedometrů délku postpartálního anestru v chovu, kde je mezidobí 400 dnů a zjistit vliv vybraných faktorů (plemeno, rok sezona a parita) na délku anestru a intenzitu zvýšené pohybové aktivity během říje. Dále bylo sledováno, zda existuje vztah mezi intenzitou zvýšené pohybové aktivity a zabřezáváním po inseminaci. V jednom chovu bylo sledováno 80 krav českého strakatého skotu (C) a 163 krav holštýnského skotu (H) po dobu čtyř let, které byly ustájeny společně ve volné boxové stáji. Krávy plemene H produkovaly 3 790 kg mléka za prvních 100 dnů laktace a krávy C 3 087 kg. Krmná dávka měla nízký obsah energie (NEL) a nadměrný obsah N-látek. Příjem NEL zajišťoval produkci 30,9 l mléka a příjem N-látek 45 l mléka denně. Bylo zjištěno, že se krávy jednotlivých plemen významně liší v délce postpartálního anestru, což pravděpodobně souvisí s negativní energetickou bilancí krav plemene H. Vliv parity, roku otelení a sezony při otelení na délku postpartálního anestru nebyl prokázán. Při srovnání pohybové aktivity během říje bylo zjištěno, že krávy C vykazují významně vyšší aktivitu než krávy H, prvotelky obou plemen mají vyšší aktivitu než krávy na dalších laktacích a v ročních obdobích, kdy se krávy zapouštěly, byla nejnižší aktivita v zimě. Krávy s vyšší pohybovou aktivitou během říje zabřezávaly významně lépe, než krávy s nižší aktivitou.

Klíčová slova: kráva; pohybová aktivita; pedometry; anestrus

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