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EFFECTIVENESS OF USING ACTIVITY TAGS IN MANAGEMENT OF HIGH-PRODUCING DAIRY HERD

EFEKTYWNOŚĆ WYKORZYSTANIA AKTYWATORÓW RUCHU W ZARZĄDZANIU WYSOKOWYDAJNYM STADEM BYDŁA MLECZNEGO

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Streszczenie. W badaniach wykorzystano dwie grupy krów (jałówki oraz krowy) rasy HF, którym zamocowano pedometry typu AfiAct oraz Gyuho na 65 dni. Analizowano aktywność dobową i miesięczną krów, uwzględniając wiek, laktację, wielkość produkcji mleka, fazę laktacji oraz termin wystąpienia rui. Określono efektywność wykorzystania obu modeli pedometrów w wykrywaniu rui u krów i jałówek. Stwierdzono duże zróżnicowanie w dobowej aktywności, w zależności od badanych czynników oraz wysoką skuteczność urządzeń w wykrywaniu rui u krów (93–95%) i jałówek (89%). Stwierdzono, że najczęściej odpoczywają krowy w II laktacji; najdłuższy czas odpoczynku charakteryzuje krowy do 100 dni laktacji, natomiast najwięcej czasu na odpoczynek w ciągu doby potrzebują krowy o wydajności dziennej powyżej 40 kg.

Key words: 24-hour activity, dairy cattle, pedometers.
Słowa kluczowe: aktywność dobowa, bydło mleczne, pedometry.

INTRODUCTION

The increasing number of farms with loose-housed cows and the intensification of livestock production make it more difficult to identify reproductive, health and behavioural problems in high-yielding cows. To counteract these unfavourable developments, various devices have been used for many years to monitor animals and record their daily activity. Of particular importance is the decrease in estrus detection efficiency in high-producing cattle, which has led to a search for other methods than the common observation (Nebel et al. 2000; Dochi et al. 2006; Mosaferi et al. 2012). One such method are electronic activity tags or pedometers attached to the cows' legs (Roelofs et al. 2005; Peter 1986). Research has shown pedometers to be highly effective in improving fertility in dairy herds and in detecting lameness and leg disorders (Liu and Spahr 1993; Roelofs et al. 2005).

The aim of the study was to analyse changes in the activity of cows depending on age and production level, and to determine the effectiveness of different activity tag systems in improving estrus detection rates.

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MATERIALS AND METHODS

The study used two groups of Polish Holstein-Friesian dairy cows (10 animals per group) from the Experimental Station of the National Research Institute of Animal Production in Chorzelów. The first group consisted of 10 heifers and the second group was comprised of first, second and third lactation cows with a mean lactation yield of 10 006 kg milk. Feeding and housing conditions were the same for both groups (free-stall barn, milking in a milking parlour). Prior to the experiment, animals selected for particular groups were examined by a veterinarian to determine their health, stage of the estrous cycle, and structural correctness of legs and feet. Activity tags (Israeli AfiAct and Japanese Gyuho) were attached to the front legs of each animal. Pedometer readings were taken over 3 complete estrous cycles of each cow at 06.00,12.00 and 19.00 hours. The experiment accounted for the age of animals (first, second and third lactation), lactation stage (1–100, 101–200, 201–300 and > 301–day groups) and milk production level (1–20, 21–30, 31–40 and > 41 kg). Depending on lactation stage, activity was measured for up to 200 days of lactation (Japanese system) and throughout the study period (Israeli system). Production data were collected for date of last recorded estrus, motor activity, and daily milk yield (milk, fat, protein). These data were used to analyse the 24–hour activity of animals, resting frequency, average time spent resting per lying bout, and total resting time. Average resting time in relation to total resting time, and the indicator of distress were estimated. Activity data were compared to the milk production level of the cows. Two complete cycles were analysed for each animal, and in the third estrus the cows and heifers from the analysed groups were mated. Statistical analyses were performed using the SAS package based on one-way analysis of variance. In addition, Pearson's correlations were estomated between curves for daily activity of the cows based on AfiAct and Gyuho systems.

RESULTS AND DISCUSSION

Analysis of hourly activity of the cows depending on their age (lactation) is presented in Fig. 1. The data showed the highest daily activity in second lactation cows (around 120 steps per hour on average) and the lowest activity in third lactation cows (100 steps per hour on average). The higher activity in second compared to third lactation cows is also confirmed by Gatius et al. (2005). In the analysed lactation groups, after night cows were considerably more active (distressed) at milking time, i.e. at 6.00 ($P \leq 0.01$), than before the same activity at noon and in the afternoon. The lowest average hourly activity was at 3.00 in first lactation cows (64 steps per hour) and at 4.00 in second and third lactation cows (72 and 51 steps per hour, respectively, $P \leq 0.05$). During the day, lowest activity of the cows occurred between 2.00 and 4.00, between 8.00 and 9.00, and between 13.00 and 15.00 hours. Apart from milking at 6.00, 12.00 and 19.00, the highest activity was observed in first lactation cows at 16.00, in second lactation cows at 5.00, and in third lactation cows at 16.00. In each of these periods between milkings, animals showed similar shorter periods of lower activity between 2.00 and 3.00 (first lactation cows) and between 3.00 and 4.00 (second and third lactation cows). The lowest minimal activity of first, second and third lactation cows was 10 steps per hour. Analysis of hourly activity of the cows depending on lactation stage is presented in Fig. 2.

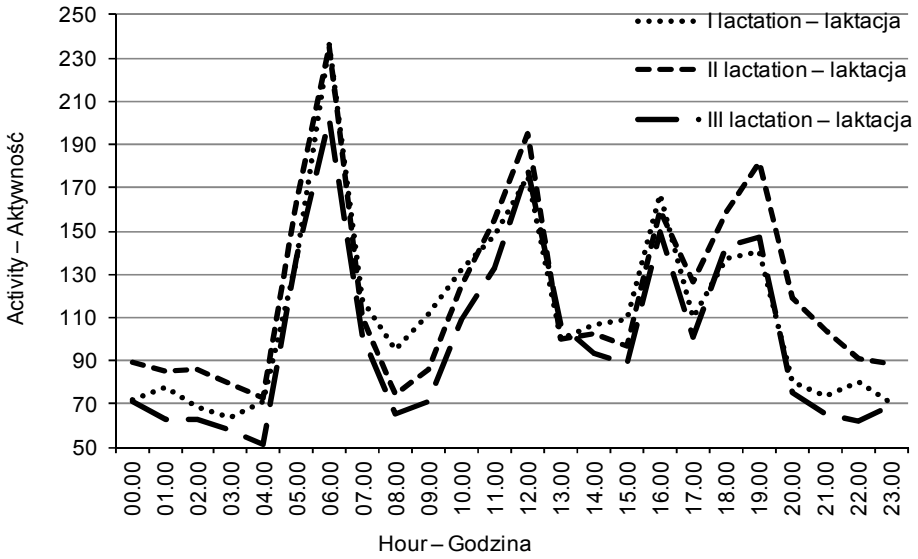

Fig. 1. Hourly activity of cows depending on their age in the Japanese Gyuho device
Ryc. 1. Aktywność krów w zależności od ich wieku, wg systemu japońskiego Gyuho

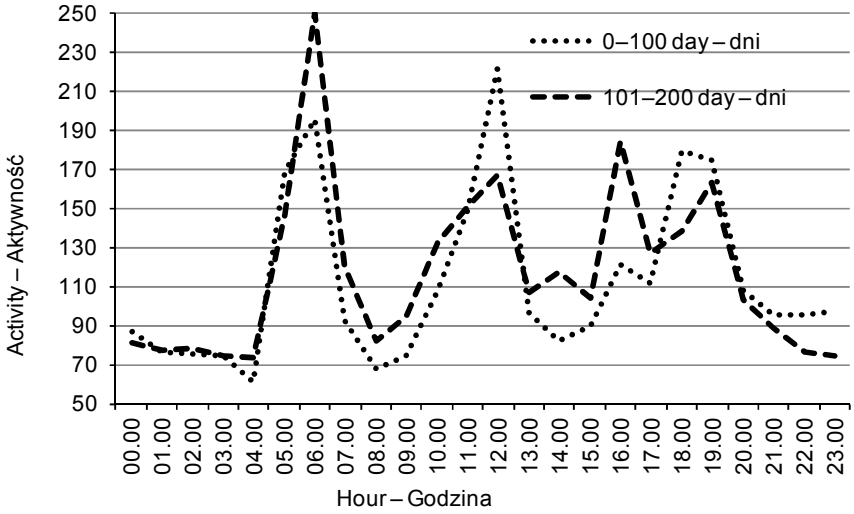

Fig. 2. Hourly activity of cows depending on lactation stage in the Japanese Gyuho device
Ryc. 2. Aktywność krów w zależności od fazy laktacji, wg systemu japońskiego Gyuho

The lowest cow activity was found between 3.00 and 4.00 regardless of the lactation stage. The highest cow activity occurred between 12.00 and 18.00 when barn work is most intensive. Differences between the groups were confirmed statistically for 14.00, 16.00 and 18.00 hours at $P \leq 0.01$. With activity of 61–73 steps per hour, the lowest cow activity occurred in the first days of lactation (1–100 days) at the level of 112 steps. The highest temperament was characteristic of second lactation cows at 16.00 (184 steps per hour), with average activity of 117 cows. Compared to the other groups, cows with average daily milk yield of 31–40 kg (Fig. 3) were characterized by the highest daily activity (121 steps per hour); this mainly concerned the 5.00–7:00 and 10.00–15.00 periods, which was confirmed statistically at $P \leq 0.01$. A study by Gatius et al. (2005) supports the above observations concerning the low-yielding groups of cows.

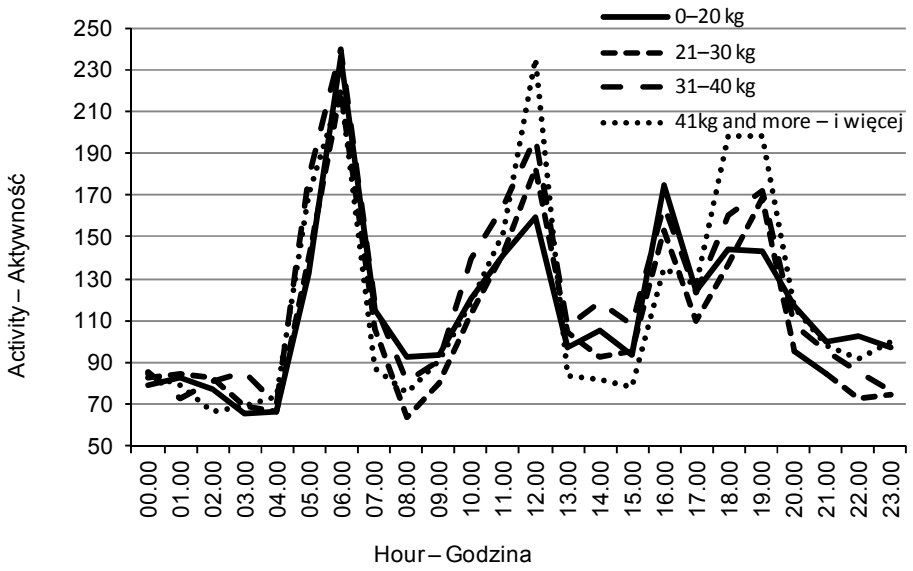

Fig. 3. Hourly activity of cows depending on milk production level in the Japanese Gyuho device
Ryc. 3. Aktywność krów w zależności od wielkości produkcji mleka w laktacji, wg systemu japońskiego Gyuho

The groups of cows with production levels of up to 20 kg and more than 40 kg milk showed lower activity (114–117 steps per hour), and in relation to the other groups increased activity occurred between 20.00 and 22.00 for the first group and between 17.00 and 20.00 for the second. Statistically significant differences were only found (P≤0.05) between the < 20 kg and 21–30 kg groups. Within each production group, highest activity (122 to 135 steps per hour) was noted between 13.00 and 19.00. It is worth noting that cow activity increases sharply in all the groups an hour before milking.

Detailed analysis of daily activity in the investigated barn (Table 1) revealed that dairy cows needed different amounts of rest depending on their age (lactation). Second lactation cows rested most often (9.8 times per day) and third lactation cow the least often (6.49 times per day), with statistically significant differences (P ≤ 0.01). Thus, total resting time was longest in the second lactation cows with concurrently the shortest average time spent resting per lying bout. First lactation cows showed the longest resting time (63 min) per lying bout (P ≤ 0.01). Third lactation cows were characterized by the highest indicator of distress and the highest daily milk yield (P ≤ 0.01). In first and second lactation cows, distress was at the same level with milk yield of 18–26 kg. Although the longest resting time per bout (Table 2) was noted in cows during the first 100 days of lactation (P ≤ 0.01), these animals showed highest distress levels in the herd under study (2.6). Cows in the last stage of lactation (beyond 300 days) demonstrated the highest resting frequency, but at the same time were characterized by shortest time spent resting per lying bout (P ≤ 0.01). A study with beef cattle and their crossbreds (Anderson 1986) showed that stage of pregnancy caused no significant differences in the activity of the cows compared to dry cows or those in early pregnancy. As a result, this group had the longest resting time of all the cows studied (P ≤ 0.01). Cows beyond 100 days of lactation were characterized (up until 300 days) by a total resting time of 417–440 minutes per day.

Table 1. Daily activity of cows depending on their age in the AfiAct system
Tabela 1. Aktywność dobowa krów w zależności od ich wieku w systemie AfiAct

Traits – Cecha	I lactation – laktacja n = 346		II lactation – laktacja n = 1024		III lactation – laktacja n = 346	
	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd
Resting frequency Częstotliwość odpoczynku [n/24h]	7.17 A	3.25	9.87 A	4.03	6.49 A	2.61
Average time spent resting per lying bout Średni czas odpoczynku na leżenie	63.93 A	19.54	56.44 AB	21.40	62.01 B	22.15
Total resting time Łączny czas odpoczynku [min/24h]	426.43 A	149.16	510.77 A	177.24	377.77 A	142.29
Indicator of distress Wskaźnik niepokoju	1.99 A	1.13	1.99 B	1.27	2.23 AB	1.23
Average daily productivity Średnia wydajność dzienna [kg]	18.25 A	4.79	26.74 A	9.05	30.61 A	7.20

Statistically significiant difference between columns at AA – P ≤ 0.01; aa – P ≤ 0.05.
Istotność różnic między kolumnami dla AA – P ≤ 0,01; aa – P ≤ 0,05.

Table 2. Daily activity of cows depending on lactation stage in the AfiAct system
Tabela 2. Aktywność dobowa krów w zależności od fazy laktacji w systemie AfiAct

Traits – Cecha	0–100 day dni n = 292		101–200 day dni n = 787		201–300 day dni n = 306		301- more day więcej dni n = 332	
	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd
Resting frequency Częstotliwość odpoczynku [n/24h]	8.15 A	3.68	8.01 a	3.85	8.51 a	3.01	10.73 ABC	4.03
Average time spent resting per lying bout Średni czas odpoczynku na leżenie	68.69 AB	23.69	60.05 AC	21.87	53.48 A	19.43	52.54 Bc	15.38
Total resting time Łączny czas odpoczynku [min/24h]	508.54 AB	192.03	440.26 ACa	174.48	417.42 BDa	126.01	532.91 CD	162.30
Indicator of distress Wskaźnik niepokoju	2.67 ABC	1.57	1.96 Aa	1.19	1.76 Ba	1.11	1.91 C	0.96
Średnia wydajność dzienna Average daily productivity [kg]	32.71 A	8.90	28.28 A	6.77	24.14 A	6.08	15.42 A	6.16

Statistically significiant difference between columns at AA – P ≤ 0.01; aa – P ≤ 0.05.
Istotność różnic między kolumnami dla AA – P ≤ 0,01; aa – P ≤ 0,05.

Table 3. Daily activity of cows depending on milk production level during lactation in the AfiAct system
Tabela 3. Aktywność dobowa krów w zależności od wielości produkcji mleka w laktacji w systemie AfiAct

Traits – Cecha	0–20 kg n = 436		21–30 kg n = 705		31–40 kg n = 484		41 i więcej and more n = 92	
	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd	$\bar{x}$	sd
Resting frequency Częstotliwość odpoczynku [n/24h]	8.73 AB	4.24	8.07 ACD	3.60	8.99 CE	3.94	10.64 BDE	3.95
Average time spent resting per lying bout Średni czas odpoczynku na leżenie	61.66 A	20.46	61.07 B	23.68	54.22 ABa	18.57	58.36 a	17.45
Total resting time Łączny czas odpoczynku [min/24h]	486.17 AB	170.03	447.95 AC	163.51	455.44 B	186.53	577.58 ABC	155.75
Indicator of distress Wskaźnik niepokoju	1.72 A	0.90	1.99 A	1.30	2.27 A	1.32	2.62 A	1.27

Statistically significiant difference between columns at AA – P ≤ 0.01; aa – P ≤ 0.05.
Istotność różnic między kolumnami dla AA – P ≤ 0,01; aa – P ≤ 0,05.

Analysis of daily activity of the cows depending on their production level showed that cows with the highest daily milk production (40 kg) needed many more resting bouts (10.6) and thus much more total resting time (577 minutes), which was confirmed statistically ($P \leq 0.01$). This group was characterized by the highest indicator of distress, as reflected in the average resting time per lying bout. In relation to the lowest yielding group, the difference in total resting time was 91 minutes per day, and the frequency was higher by 1.91 ($P \leq 0.01$).

During the experiment, veterinary examination of the studied cows and heifers revealed 62 estruses, which gives an average of 3 estrous cycles per cow. Twenty-nine estruses were noted among heifers. The Japanese system gave 65 alerts (of which 60 were confirmed by estrus) and the Israeli system gave 60 alerts, of which 58 were confirmed by estrus. The consistency of both heat detection systems averaged 70% (80% for heifers and 60% for cows). In the studies by Roelofs et al. (2005), Holman et al. (2011) and Liu and Spahr (1993), this value was higher and ranged from 74% to 87%, but estrus detection "sensitivity" of 60% reported by the authors was the same as for cows in our study. In turn, in a study by Peter and Bosu (1986) 75% of ovulations were confirmed by pedometer readings, with only 35% of the cows showing the external signs.

Because the systems signaled 7 instances of undetermined higher activity, the overall efficiency of both systems was concluded to be 93–95% (compared to 95% reported by Roelofs et al. 2005), and 89% for heifers. Both systems failed to detect 6 estruses. Gatius et al. (2005) clearly demonstrated that cow activity and fertility are significantly correlated, and that cows in estrus show much higher activity compared to the rest of the herd. However, Anderson (1986) reported that age and pregnancy had no significant effect on the activity expressed as distance traveled by the cows. Gatius et al. (2005) also suggested that the results are influenced by lactation number, age of cows, insemination number, and the bull. Depending estimated Pearson's correlations were determined between the cow activity curves determined by both systems to range from $r = 0.62$ to $r = 0.89$ ($P \leq 0.01$). In a similar study (Higginson et al. 2010) that used AfiAct and IceTag systems, the correlation was $r = 0.73$ ($P \leq 0.01$).

CONCLUSIONS

In summing up the results it is concluded that in both cows and heifers, the two systems ensured high efficiency of behaviour monitoring as well as the possibility of heat detection, including a decrease in the number of undetected estruses.

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Abstract. The study used four groups of Holstein-Friesian cows (2 heifers and 2 cows), which were fitted with pedometers (AfiAct and Gyuho) for a period of 65 days. Daily and monthly activity of the cows was analysed with regard to age, lactation, production level, lactation stage and the time of estrus onset. Efficiency of both pedometry systems in the detection of estrus in cows and heifers was determined. Large variations were found in daily activity depending on the treatment factors. Pedometers ensured high heat detection rates of 93–95% for cows and 89% for heifers. It was found that second lactation cows were the group that rested most often, the longest time spent resting per lying bout was characteristic of cows up to 100 days of lactation, and cows with a daily milk yield of more than 40 kg showed the longest resting time over a 24–hour period.