

Effect of lactation number on feeding behaviour and motor activity of dairy cows

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The aim of the study was to determine the effect of lactation number on the overall duration and circadian rhythm of feed intake by cows milked three times a day, taking into account their motor activity. The analysis included two equal groups of primiparous and multiparous cows (n = 220) kept in a free-stall barn. Ethological studies of cow feeding behaviour, motor activity, daily milk yield and microclimate of the barn were carried out. It was proven that the lactation number had a significant effect on the overall duration and circadian rhythm of feed intake, and also on the motor activity of the cows. Primiparous cows fed themselves longer over the day, and their motor activity was greater than of multiparous cows.

Key words: cows, lactation number, feeding behaviour, cow motor activity

Overall duration and circadian rhythm of feed intake, the number of meals and duration of a single meal are core indicators of cow feeding patterns. The meal is the period of single stay of cows in a feeding stall at the feed bunk. The duration of feed intake in the barn ranges from 201 to 420 minutes within 24 hours (Hoy, 2009; Kaufman et al., 2007; DeVries et al., 2003). Both the time and circadian rhythm of feed intake can have a significant impact on total daily feed intake (Grant and Albright, 2000). The nutritional behaviour of cows is influenced by the level of daily milk yield (Huzzey et al., 2006; Benz et al., 2014). Circadian rhythm determines animal behaviour at particular hours a day, as well as an increase of specific behaviors at different parts of day and night. In general, it is presented as a percentage of animals performing relevant activities (e.g. eating fodder or resting). Cattle belongs to “diurnally active” animals,

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and its behaviour is regulated by a circadian clock. In conditions of twenty-four-hour grazing and during *ad libitum* feeding in the cowshed, two peaks of activities are observed: at dawn and before nightfall (Sambras, 1991; Shabi et al., 2005). However, the circadian rhythm and the remaining indicators of feeding patterns at particular hours of a day are formed differently for cows kept in barns and those grazing on pasture. Above all, it is dependent on time and frequency of feeding. Niu et al. (2014) stated that feeding time decides about a daily rhythm of feed consumption and resting behaviour of cows. Nudging of feed also motivates cows to walk up to the feed bunk (DeVries and Keyserlingk, 2009). DeVries et al. (2005) revealed that the change of times total mixed ration is given can influence cow behaviour. The increase of feeding from 2 to 4 times a day caused the change of the distribution of daily feed consumption phases and enhanced their duration. Milking schedule is another factor, which impacts nutritional habits of cows (Tolkamp et al., 2000). The frequency cows approach the feed bunk increases after milking. The ratio between the number of cows and the number of feeding stalls at the feed bunk influences not only eating but also social behaviour e.g. acts of aggression among cows (DeVries et al., 2004). Thermal stress can also affect cow behaviour (Frazzi et al., 2000). In addition to the availability of feed at the feed bunk, motor activity of cows plays a decisive role in their eating behaviour (Benz et al., 2014).

In the available literature there is lack of information about the connection between feeding patterns and motor activity of cows. Lactation number directly related to the age of cows can also have particular significance in consumption patterns.

The aim of the research was to determine the impact of the lactation number on the overall duration and circadian rhythm of feed intake in cows taking motor activity into account, using three-fold milking system.

Material and methods

The experiment was conducted on 220 Polish Holstein-Friesian Black-and-White lactating cows in the third stage of lactation in the Institute's Kołbacz Experimental Station. The cows were kept in two identical sectors of open-type free stall barn with box stalls (curtain-sided barn). The control group K consisted of primiparous cows, $n=110$ ($\bar{x}=227$ th day of milking), whereas experimental group D T of multiparous cows, $n=110$ ($\bar{x}=222$ nd day of milking – Table 2). Lactation number for multiparous cows amounted to 2.7. The cows were milked three times a day in side-by-side milking parlour, 2 x 16 with fast exit (group K – at 6:00 a.m., 1:30 p.m. and 9:30 p.m.; group D – at 7:00 a.m., 2:30 p.m. and 10:30 p.m.). Milking of one group lasted about 40 minutes. The average milk yield from a cow was about 11,000 kg/lactation. Between 6:00 and 7:00 a.m. uneaten feed was swept away from the feed bunk, manure was removed from manure corridors and the cubicles were lined. The animals from groups K and D were fed on total mix ration twice a day at 7:00 a.m. and 2:00 p.m.

A horizontal feed barrier was used in the barn and the width of a feeding stall was 67 cm per cow (Photo 1). The cows from each group had 64 feeding stalls at the feed bunk at their disposal.



Photo 1. Feed bunk equipped with a horizontal feed barrier

The ratio of the number of animals to the number of feeding stalls was 1.7:1. Average food consumption over the day amounted to 47.8 kg/cow with 48.5% content of dry matter. The intake of the ration of dry matter was 23.2 kg. The energy content of dry matter amounted to 6.95 MJ NEL/kg and 16.5% of crude protein. Lactation number directly related to the age of cows was an experimental factor. The research was carried out for two days in the autumn period (November) and it included such aspects as:

- Ethological research: feeding behavior and motor activity of the cows. Two activities of the cows were taken into account in their feeding patterns, i.e. real feed intake at a feeding stall at the feed bunk (a cow eats fodder) and solely standing at the feeding stall without feed intake (a cow stands at the feed bunk). Circadian rhythm of feed intake was presented, which specified the percentage of cows eating fodder and standing at the feed bunk in particular times of the day. Industrial cameras (Hikvision, China) were used to perform 24-hour ethological observations. The readout of the recorded images from the observations took place in ten-minute intervals. Motor activity was determined on the basis of the number of steps taken by the cows within one hour during ethological observations. The results of the research were obtained from Afifarm herd management system by means of AfiAct device equipped with Pedometers Plus (management system and devices, SAE Afikim Kibbutz, Israel);
- A study of daily milk yield of the cows. Daily milk production per cow was taken into consideration during conducted ethological research. The data was obtained from Afimilk system (subsystem of Afifarm) using electronic milk meters installed in the system (SAE Afikim Kibbutz, Israel);

- The study of microclimate. During ethological observations, temperature and relative air humidity in the barn were continuously measured and registered by means of Datalogger S3121 electronic devices (Comet, Czech Republic).

The results of the research were developed using Statistica v.12 software package (StatSoft, 2013). Student's t-test was used for independent samples.

The results

The results of ethological research were presented in Table 1. Ethological research revealed that more primiparous cows from group K than multiparous cows from group D were eating in particular times of the day. The average number of cows from group K consuming feed over the day was greater by three (16.5%) than in case of multiparous cows from group D ($P \leq 0.01$). However, the average number of cows from group K standing at the feed bunk, but not consuming feed was lower by 1 (40.5%) over the day than in case of multiparous cows from group D.

Table 1. Feed intake and motor activity of the cows ($\bar{x} \pm SE$)

Czynności krów Cow activities	Grupy Groups			
	K (krowy pierwsiastki) (primiparous cows)		D (krowy wieloródki) (multiparous cows)	
	\bar{x}	SE	\bar{x}	SE
Pobieranie paszy (n/grupa/doba) Feed intake (n/group/day)	21.85 A	2.28	18.74 B	2.23
Stanie przy stole paszowym, niepobieranie paszy (n/grupa/doba) Standing at the feed bunk, not eating (n/group/day)	1.23	0.21	2.10	0.81
Ogólny czas pobierania paszy (min/doba) Total duration of feeding (min/day)	286.01 A	7.11	243.49 B	6.43
Ogólny czas stania przy stole paszowym bez pobierania paszy (min/doba) Total duration of standing at the feed bunk without eating (min/day)	16.49	0.42	18.08	0.29
Aktywność ruchowa (liczba kroków/godz.) Motor activity (number of steps/hour)	101.06 A	2.21	86.05 B	1.83

A, B – wartości średnie w wierszach oznaczone różnymi literami różnią się przy $P \leq 0,01$.

A, B – mean values in rows with different letters differ at $P \leq 0.01$.

Table 2. Daily milk yield and days in lactation ($\bar{x} \pm SE$)

Parametry krów Parameters of cows	Grupy Groups			
	K (krowy pierwiałki) (primiparous cows)		D (krowy wieloródki) (multiparous cows)	
	\bar{x}	SE	\bar{x}	SE
Dzienna wydajność mleczna Daily milk yield (kg)	32.71	0.55	33.36	0.51
Dni laktacji Days in lactation (n)	227.31	6.15	221.82	6.96

Primiparous cows (K) were staying at the feed bunk for 362.5 minutes, out of which they were consuming feed for 286.01 minutes (94.6%) in the feeding stalls. For the remaining 16.49 minutes (5.4%), they were merely standing. In case of the group of multiparous cows (D), the activities lasted respectively 243.49 minutes (93.1%) and 18.08 minutes (6.9%) of the overall time of staying at the bunk, which was 261.57 minutes. The total duration of feed intake within 24 hours was 42.5 minutes (17.5%) longer for cows from group K than for cows from group D ($P \leq 0.01$). However, the overall time of cows from group K standing at the feed bunk without feeding was 1.6 minutes (9.6%) shorter than for cows from group D.

Motor activity of primiparous cows was higher than of multiparous cows (Table 1). The cows were taking 15 steps (17.4%) more within an hour than the cows from group D ($P \leq 0.01$).

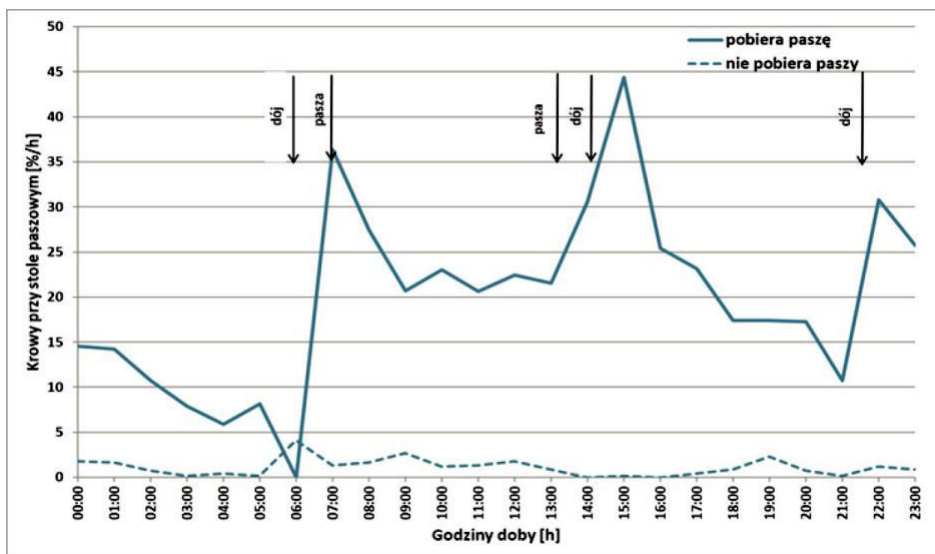


Fig. 1. Circadian rhythm of feeding and standing at the feed bunk in cows from group K

The circadian rhythm of consuming total mixed ration and only standing in the feeding stall by primiparous (K) and multiparous cows (D) were presented in Figures 1 and 2. The diagrams of circadian rhythm of feed intake and

standing at the feed bunk of cows from groups K and D differed with the percentage of animals performing the activities in particular times of the day. The average percentage of cows eating fodder within an hour amounted to 19.86% in group K, with fluctuations from 0 to 44.39%, whereas 17.11% in group D (ranging from 0 to 41.21%).

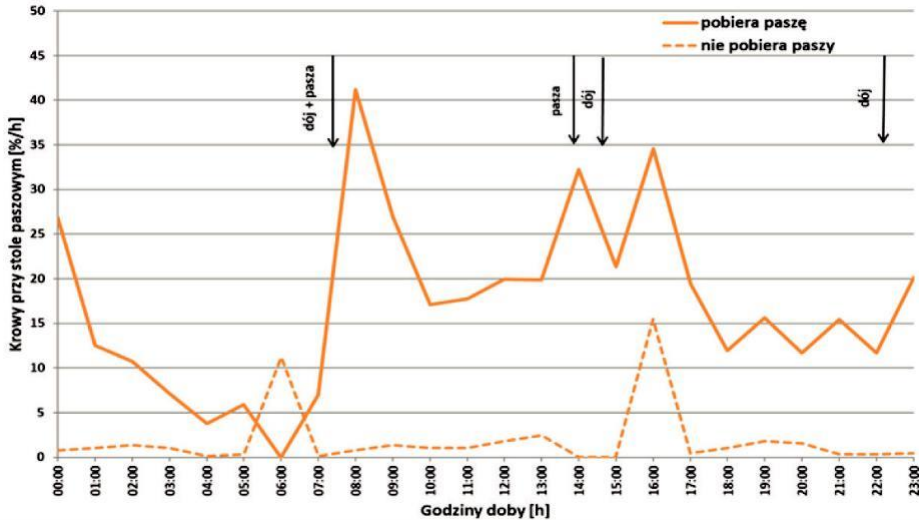


Fig. 2. Circadian rhythm of feeding and standing at the feed bunk in cows from group D

In group K an increase (peaks) of activities, characterized by a high percentage of cows consuming fodder were recorded between the following hours: 7:00–8:00 a.m. (36.36%), 2:00–3:00 p.m. (44.39%) and 10:00–11:00 p.m. (30.79%). However, in group D, four peaks of feed intake activity were observed, i.e. between hours: 8:00–9:00 a.m. (41.21%), 2:00–3:00 p.m. (32.21%), 4:00–5:00 p.m. (34.55%) and 11:00 p.m.–00:00 a.m. (26.81%). The cows rarely approached the feed bunk from 1:00 to 6:00 a.m. The percentage of the cows consuming fodder in this period ranged from 5.9 to 14.25% in group K, whereas 3.79 to 12.54% in group D. In both group K and D, the cows did not eat fodder between 6:00 and 7:00 a.m., since uneaten feed was removed at that time and there was no feed at the feed bunk.

The percentage of cows standing at the feed bunk, but not consuming feed was slight and amounted to 1.11% (from 0 to 4.09%) in the group of primiparous cows (K), whereas 1.91 (from 0 to 15.45%) in the group of multiparous cows (D). The activity of cows standing at the feed bunk without feed intake increased between 6:00 and 7:00 a.m. In group K it amounted to 4.09%, whereas in group D – 11.21%. At that time, the cows were awaiting fodder. In group D, feed intake additionally increased between 4:00 and 5:00 p.m., when 15.45% of cows were consuming feed.

The average daily milk yield of the cows from group K (32.71 kg) was close to milk yield of cows from group D (33.36 kg) – Table 2.

The average daily air temperature in the experimental barn (sector of group K and D) amounted to 20.4°C with fluctuations from 19.1 to 21°C. However, relative humidity was at an average level of 50.2%, fluctuating between 47.1 and 52.7%.

Discussion

The results of the ethological studies have revealed the differences in feeding patterns of the tested groups of cows, taking account of such activities as feed intake and standing in feeding stalls. The number of past lactations had statistically significant influence on indicators of the nutritional behavior of cows. First of them is the average number of cows feeding themselves during the day. The number of cows consuming feed over the day in a group of primiparous cows exceeded the number of multiparous cows (19.86% of the herd versus 17.04%). The ratio of animals to the number of feeding stalls, both in a group of primiparous and multiparous cows was 1.7:1. According to Georg and Bockisch (2000), the number of cows feeding themselves depends on the number of feeding stalls at the feed bunk. At a ratio of number of cows/number of feeding stalls amounting to 1:1, the percentage of cows feeding themselves over the day was 13.1% of the herd, whereas at a ratio of 2.6:1, it increased to 33.7% of the herd. The cows staying at the feed bunk in feeding stalls mainly dealt with feed intake and they seldom stood idle, i.e. with their mouth raised above the feed. The percentage of cows at the feed bunk and not feeding themselves over the day was 1.12% in group K and 1.9% in group D.

The overall time of feed intake within 24 hours was longer for primiparous cows from group K (286.01 minutes) than for multiparous cows from group D (243.49 minutes). The influence of the lactation number on the time of feed intake by cows was indicated by Tölle et al. (2002), who stated that the time of feed intake in multiparous cows over the day is shorter than in case of primiparous cows. Shorter time of feed intake in multiparous cows in this research resulted from speed higher by 57 g/min of eating it than in case of primiparous cows. However, Benz et al. (2014) proved that the lactation number did not have an influence on the overall duration of feed intake within 24 hours, since first- and second-lactation cows were feeding themselves for 328 minutes, whereas multiparous cows for 305 minutes. Lower values of feed intake in cows were presented by Dollinger and Kaufman (2013), demonstrating that time of feed intake ranged from 177.8 to 189.4 min/day.

The circadian rhythm of feed intake depended on two factors, i.e. time of feeding and milking schedule. The feed intake of cows increased both after they received fresh feed and when they left the milking parlour. The findings confirm the results of research, which proved that time of feed distribution decides about the daily rhythm of feed intake (Niu et al., 2014; Nikkha et al., 2008). The presented differences in the development of circadian rhythm of feed intake in groups of primiparous (K) and multiparous (D) cows resulted not only from the differences in the overall time of feed intake, but first and foremost from milking schedule, which is confirmed by the research of Dollinger and Kaufmann (2013). The influence of milking time was highlighted especially after milking in the afternoon and evening, since there was a one hour delay in the milking schedule between groups K and D for technological reasons. Group K was the first one to be milked (time: 6:00 a.m., 1:30 p.m., 9:30 p.m.) and was followed by group D (7:00 a.m., 2:30 p.m. and 10:30 p.m.). The majority of animals in group K (44.39%) fed themselves between 2:00 and 3:00 p.m., when feed was distributed and cows left milking parlour at the same time (at about 2:00 p.m.). The results are similar to the research where the maximum percentage of cows feeding themselves over the day amounted to 47% (Oberschätzl-Kopp et al., 2016). In a group of multiparous cows the greatest intensity of feed intake (41.21%) took place between 8:00 and 09:00 a.m., when feed was distributed (at 7:00 a.m.) and cows were leaving the milking parlour (at about 7:30 a.m.) at a similar time. However, when the time difference between giving feed and leaving the milking parlour was longer than one hour, the peaks of activities occurred one after another. Such a situation took place in the afternoon between 2:00 and 4:00 p.m. in a group of multiparous cows. At that time, two peaks of activities of feed intake

took place – one caused by giving feed, another by milking. The distinctive feature of circadian rhythm with threefold milking system was an additional nocturnal increase of feed intake. The incentive to this was the third milking which began at 9:30 p.m. in a group of primiparous cows and at 10:30 p.m. in a group of multiparous cows.

The results of the conducted research indicate that as the lactation number increased, motor activity of cows decreased. Primiparous cows took 15 more steps/hour. Similar values of motor activity of cows with threefold milking system were obtained in prior authors' own research (Kaczor and Kaczor, 2017). The number of steps taken within an hour by multiparous cows in the third stage of lactation was 96. However, according to Choromańska et al. (2014), the number of steps taken by cows over the day was lower but also dependent on lactation number. Using twofold milking system, primiparous cows took 72 steps/hour and multiparous cows of third and higher lactation – 59 steps/hour. It could be suggested that higher motor activity of cows with threefold milking system was caused by an additional walk of cows to the milking parlour.

Cow feeding patterns can also change with the occurrence of thermal stress (Frazzi et al., 2000). In the presented research, microclimate conditions in the barn were standard for dairy cows and amounted to 20.4°C with relative humidity of 50.2%. According to the Information Sheet of the Institute of Animal Production (Karta Informacyjna, 1977), air temperature in tying stalls and traditional free-stall barns should range from 6 to 25°C, whereas relative humidity – from 50 to 85%. It should also be emphasized that both primiparous and multiparous cows had a similar number of lactation days (227.31 and 221.82) and daily milk yield (32.71 and 33.36 kg of milk). It can be presumed that both microclimate factor, day of lactation and milk yield did not influence cow feeding patterns.

On the basis of the obtained research results it could be concluded that lactation number significantly influenced the indicators of feeding patterns and motor activity of the cows. The number of the cows feeding themselves over the day was higher in group of primiparous cows than in group of multiparous cows. Cows staying at the feed bunk in feeding stalls dealt mainly with feed intake, they seldom merely stood. The overall time of feed intake within 24 hours was longer for primiparous than for multiparous cows. Shorter time of feed intake in multiparous cows probably resulted from higher rate of consumption. The circadian rhythm of feed intake depended on two factors, i.e. time of feed distribution and milking schedule. The additional nocturnal increase in feed intake was a distinctive feature of circadian rhythm using threefold milking system. The factor of lactation number influenced the motor activity of the cows. As the number of lactation increased, motor activity of the cows decreased. The presented analysis of the indicators of feeding patterns and motor activity of the cows indicates that primiparous cows should be kept in a separate sector of the barn.

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SUMMARY

The aim of the study was to determine the effect of lactation number on the overall duration and circadian rhythm of feeding in cows milked three times daily, taking into account their motor activity. The analysis included two equal groups of primiparous (n = 110) and multiparous cows (n = 110) kept in a free-stall barn. Ethological studies of cow feeding behaviour, motor activity, daily milk yield and barn microclimate were performed. The number of lactation had a significant effect on the overall duration and circadian rhythm of feeding, and also on the motor activity of the cows. Primiparous cows were on feed longer during the day, and their motor activity was greater than in multiparous cows.

Key words: cows, lactation number, feeding behaviour, motor activity