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The effect of the number of feed pushing-ups on animal behavior, dry matter intake and milk yield of dairy cows

Vliv četnosti přihrnování na chování zvířat, příjem sušiny a dojivost dojnic

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ABSTRACT

This study evaluated the effect of different feed pushing-up frequencies on the behavior, dry matter intake and milk production of dairy cows in the first lactation. In each monitoring, 32 - 37 dairy cows of Czech spotted cattle at the peak of lactation were represented. After the feed was delivered to cows, the feed was pushed-up 2, 3, 4, 5, or 6 times in 5 different frequencies within 12 hours. Each frequency was monitored for 1 month in four repetitions. The behavior of dairy cows during feeding was monitored for 15 minutes after the feed delivery and after each food pushing-up. We evaluated how often the dairy cows came to the feeding table, how they used mixed ration and milk production. The frequency of feed pushing-ups has shown an effect on the dairy cow's milk yield. As a result of the 2, 3, 4, 5 and 6 feed pushing-up frequencies, the average milk production per cow per day was 24.52; 25.84; 25.48; 25.78; 26.03 kg. Also feed conversion increased with the frequency of feed pushing-ups to 1.22; 1.29; 1.25; 1.30 aand nd 1.30 kg of milk from 1 kg of received dry matter. TMR dry matter utilization increased by 1% on average.

Keywords: cow, push-up, dairy cow, TMR, milk yield

ABSTRAKT

Tato studie hodnotila vliv různých četností přihrnutí krmiva na chování dojnic, příjem sušiny a mléčnou produkci dojnic na první laktaci. V každém sledování bylo zastoupeno 32 - 37 dojnic českého strakatého skotu na vrcholu laktace. Bylo zvoleno 5 frekvencí přihrnutí krmiva během 12 hodin od jeho založení. Počet přihrnutí byl 2, 3, 4, 5, 6. Doba sledování každé frekvence byla 1 měsíc ve čtyřech opakováních. Chování dojnic během krmení bylo sledováno po dobu 15 minut od založení krmiva a každého přihrnutí. Hodnocena byla návštěvnost dojnic u krmného stolu, využití směsné krmné dávky dojnicí a produkce mléka. Frekvence přihrnování krmiva prokázala vliv na mléčnou užitkovost dojnice. Průměrná produkce mléka na kus a den činila 24,52; 25,84; 25,48; 25,78; 26,03 kg pro frekvence přihrnutí 2, 3, 4, 5 a 6. Konverze krmiva se zvýšila s četností přihrnutí na 1,22; 1,29; 1,25; 1,30; 1,30 kg mléka z 1 kg přijaté sušiny. Využití sušiny TMR se v průměru zvýšilo o 1%.

Klíčová slova: push-up, výživa, TMR, mléčná užitkovost

INTRODUCTION

The correct feeding system is one of the important aspects influencing the dry matter intake of dairy cows and their subsequent milk production (Metz, 1975; Mašek, 2010; Miller-Cushon and DeVries, 2017a). Nutrient conversion affects the condition and body condition of lactating dairy cows (DeVries et al., 2003). The strategy of group feeding depending on the daily feed intake has a great influence on the productivity of the dairy cows, their well-being, the welfare of the dairy cows in the herd, and business management. Daily patterns of feeding affect the lying behavior of dairy cattle, because dairy cows are stimulated to get up and feed themselves when fresh feed is delivered (DeVries and von Keyserlingk, 2005a). The feed ration must be compiled taking into account the needs of dairy cows in the individual stages of lactation, where milk production is governed by the total intake of dry matter and the amount of utilized nutrients (Sniffen et al., 1993; Veerkamp, 1998). There is evidence that feed manipulation, in general, including delivery of fresh feed and feed push-up, around the time when cows are milked increases latency to lie down after milking compared with feed manipulation hours after milking time (Miller-Cushon and DeVries, 2017b).

Milk productivity is also determined by the dairy cow's own behavior during the rest and the length of rumination (Dado and Allen, 1994; Grant and Albright, 1995; Nielsen, 1999). Milk production is affected by a number of external influences, such as housing system, number of waterers per cow, feedbunk space per cow, feedbunk management, milking time, settings and routine (Bach et al., 2018). Feedbunk restrictions and push-up frequency affect not only animal behavior (feed intake, rest), but also productivity (Mattachini et al., 2019; Coblentz et al., 2020). Teshome et al. (2017), states that the ventilation of the barn as one of the external influence is of fundamental importance for feed intake (Teshome et al., 2017).

When feeding high-yielding dairy cows, the total mixed ration (TMR) feeding method is commonly used, which is characterized by the fact that everything that is included in the feed ration is mixed in the feed truck until it is in its final form (Mašek, 2010; Lammers et al., 2012; Teshome et al., 2017). As cows sort their TMR, the NDF content of the feed remaining in the bunk increases throughout the day, and the extent of this sorting is reduced by increasing the frequency of feed delivery beyond once per day (DeVries et al., 2005). The total mixed ration is designed as a homogeneous mixture that will satiate dairy cows according to their actual needs. The stable composition of the feed ration minimizes the selective consumption of individual feeds and ensures sufficient fiber intake (Coppcok et al., 1981; Mašek, 2010; Třináctý, 2013). TMR feeding affects the body weight feed intake and feed efficiency, milk yield. A balanced diet contributes to reducing feed wastage and saves labor costs and time (Karunanayaka et al., 2022). Dairy cows housed in a free-stall barn are commonly fed a TMR once or twice daily (DeVries et al., 2005). When feeding TMR, dairy cows have a natural tendency to constantly sort the feed, preferring energetically valuable or tasty components. (Miller-Cushon and DeVries, 2017b). A significant part of the feed is pushed away and reaches places beyond the reach of the animals (Leonardi and Armentano, 2003). This becomes a particular problem when feed is delivered via a feed alley (DeVries et al., 2003). In practice, continuous access of the dairy cow to the feed is ensured by bringing it back to the feed trough. The extent of feed sorting is reduced by increasing the frequency of feed delivery (DeVries et al., 2005). Putting fresh feed on the trough, scooping, but also the return of animals from the milking parlor stimulates feeding activity in free housing (Grant and Albright, 2001; DeVries et al., 2003). Feed availability can often be more important than the actual amount of nutrients provided (Grant and Albright, 2001). Studies have shown that pushing-up feed at a frequency equaling three or more times a day increases the interest of animals and the number of approaches to the feed table for feed consumption, which leads to an increase in the productivity of dairy cows (Mattachini et al., 2019; Pavkin et al., 2021). The constant possibility of receiving feed also has a social aspect; it reduces the risks of animal clashes within the social hierarchy (DeVries et al., 2003; Pavkin et al., 2021).

More frequent pushing-up of feed and unlimited access to the feeding trough throughout the day positively affect the health of the dairy cows. A reduction in the risk of subclinical acidosis is confirmed (DeVries and Chevaux, 2014). Husbandry management errors that cause limited access of dairy cows to the trough and too quick feeding are connected with an increased incidence of metabolic indigestion (Krause and Oetzel, 2006; Illek, 2009).

The study is based on the hypothesis that the greater the frequency of feed pushing-up, the greater the animals' interest in food intake. A higher intake of dry matter is also reflected in the milk production of animals. The aim of the experiment was to verify the influence of different frequencies of feed pushing-up on the visitation of the feeding table by animals and the use of the feed ration by dairy cows. The factor for determining the feed conversion was the average daily milk production per 1 kg of dry matter TMR.

MATERIALS AND METHODS

The influence of the number of pushing-ups on the production of dairy cows was monitored in the years 2017-2021 during the morning feeding. In sub-experiments for the selected frequency of pushing-ups, 32-37 dairy cows of Czech spotted cattle during the first lactation were monitored. We selected animals two months after calving, i.e. at the peak of lactation. Within each year, one frequency of pushing-up was observed for 30 days from the middle of one month to the middle of the second month. Monitoring of a total of five frequencies (2, 3, 4, 5, 6) was conducted from March 15 to September 15. There were 30 days of normal feeding routine between the individual experimental periods during the year.

Monitoring within a day started with the delivery of feed at 6:00 in the morning.

The time schedule for the individual sub-experiments of pushing-up feed was as follows: (2) 2 x daily (at 12.00 and 18.00 p.m.), (3) 3 x daily (at 10.00, 14.00 and 18.00), (4) 4 x daily (at 9.00, 12.00, 15.00 and 18.00), (5) 5 times a day (at 8.25, 10.50, 13.15, 15.40 and 18.00), (6) 6 times a day (at 8.00, 10.00, 12.00, 14.00, 16.00 and 18.00).

After the feed was delivered and after it was pushed-up, the feed intake activity of the selected dairy cows was monitored for 15 minutes.

Dairy cows housed in a free-stall barn are commonly fed a TMR once or twice daily. The bedding consisted of wheat straw. Cow manure was removed twice a day with an arrow plow and litter (wheat straw) was added. The capacity of the experimental barn was 45 dairy cows. The size of the feeding trough was 45 cm at the height of the cock barrier, and its length from the standing level of the chest limbs was 125 cm. Cows were milked twice daily, at 4:30 and 16:30 in a rotary tandem milking parlor with 15 places. Leading software for dairy farm management was used for milk monitoring (AfiFarm MILKPLAN S.A., Greece). The TMR met the nutrient requirements of cows in late lactation producing 30 kg of milk/day. Vertical feed mixer wagons with Model H9 Cernin were used for preparing mixed ration. This universal car has three weighing gauges and its own onboard hydraulic systems.

A front-mount push-up blade sections tractor was used for feeding. Feed analyses were evaluated by the laboratory of Mikrob Čebín a.s. (the Czech Republic). Ethological observation of dairy cows in the group was monitored individually by a dairy cow caretaker.

During the experiments, the actual consumption of TMR was determined each day. Furthermore, the daily amount of milk produced by each dairy cow was monitored. Feed conversion was determined as the amount of milk per 1 kg of TMR dry matter used. During the last day of each experimental period, milk samples were taken from each dairy cow from the morning and afternoon milkings to determine the fat, protein and lactose content. The analyses were carried out by the Czech-Moravian Society of Breeders a.s., Milk Analysis Laboratory. The chemical composition of a diet is shown in Table 1.

Statistical analysis

The statistical software R was used to evaluate the results. All dependencies during the experiment were tested on these fixed effects: number of pushing-ups, year of the experiment and number of cows.

Table 1. Composition of TMR

	2018	2019	2020	2021
DM intake, kg/day/cow				
Corn silage	5,1	6,2	4,9	4,7
Alfalfa silage	5,8	6,0	4,9	4,7
Bean silage	1,6	1,7	1,8	1,7
Grass hay	0,9	0,8	0,9	0,9
Molasses	0,6	0,6	0,6	0,6
Brewer's spent grain	1,0	1,0	1,0	1,0
Supplemental mixture	7,2	7,2	7,2	7,2
Nutrient Composition g/kg DM				
Dry matter, g/kg	467,5	492,3	468,1	454,6
Crude protein	166,9	173,7	171,9	183,4
NDF	315,9	280,9	326,9	319,3
ADF	167,3	159,7	180,9	178,4
Starch	235,9	314,2	281,6	267,1
Ether extract	34,6	35,2	35,4	34,1
Ash	73,3	74,3	81,0	67,2

The random effects were the season in which the experiment took place and temperature measured during the experiment and an interaction of these two random effects.

The statistical evaluation is based on the fact that each frequency of pushing-up was tested during four years in the same season. First of all, the relationship between pushing-ups and feeding behavior was analyzed in the study. Furthermore, the effect of the number of pushing-ups on feed intake and milk yield was verified. Data were analyzed with a general linear model. The tested parameters were compared with the fixed effect of push-up frequency, year, and the other effects affecting the given observed parameter.

Each frequency of pushing-ups was tested at the same time of the year, therefore the season, the average daily temperature and also the interaction between two parameters were added as a random effect. Season and temperature can integrate together and independently. To verify the influence of feed pushing-ups on milk yield, a fixed effect of the average amount of dry matter of feed per dairy cow and the average amount of dry matter of feed actually eaten by a dairy cow was added to the linear model. When the interaction effect was significant ($P \leq 0.05$), pair-wise differences between means were explored using Tukey's test. A significant amount of data was analyzed, therefore, the results are marked with letters that indicate the order. The first letter of the alphabet represents the lowest value. If the variants have the same letter, it means that there is no demonstrable difference between them.

RESULTS

Feeding behavior

In the study, the effect of feed pushing-up on the visitation of the feeding place by dairy cows was

monitored. The reaction of the animals was determined by visual observation of the animals for 15 minutes after pushing-up feed. After the delivery of feed and after each pushing-up, the total number of dairy cows that were at the feedlot was counted. Testing and monitoring always took place from 6:00 to 18:00 p.m. (12-hour intervals according to the determined frequency of feed pushing-up). The number of dairy cows at the feed trough was not evaluated after the morning milking. The feed was available for dairy cows at all times, and the feed trough was cleaned of residues before each delivery. The residues were evaluated by weighing and new feed was delivered. Table 2. shows the percentage of animals that responded within 15 minutes of the feed delivery or its pushing-up to the feed trough from the total number of dairy cows. The experimental group did not always consist of the same number of animals, which was taken into account in the statistical processing of the results. The number of animals tested in a pushing-up 2; 3; 4; 5; 6 is 146; 132; 143; 149; 129 espectively. The amount of dairy cows that responded to the delivery of feed within 15 minutes was from 82.63 to 88.53%. For each additional feed pushing-up the percentage of attendance decreased (Table 2).

In this study, the attendance of dairy cows at the feed trough was evaluated by 3 parameters (Table 3). First of all, the influence of pushing-up was verified on the number of cows that came at least once within 15 minutes of all pushing-ups (parameter A). This parameter was significantly influenced by the number of pushing-ups [F (3;642) = 13.11; $P = 2.26 \times 10^{-8}$], also by a year [F (3;642) = 4.60; $P = 3.42 \times 10^{-3}$] and by the number of dairy cows in the experiment [F (1;642) = 14.04; $P = 1.95 \times 10^{-4}$]. The table shows the average percentage value for each frequency. The other parameter was the average number of dairy cows coming to the trough during all pushing-ups (parameter B). This parameter was also significantly influenced by the number of feedings [F (3;642) = 1544.72; $P < 2 \times 10^{-16}$], then by year [F (3;642) = 6.60; $P = 2.15 \times 10^{-4}$]. The effect of the number of dairy cows in the experiment was not statistically significant [F (1;642) = 0.13; $P = 0.72$]. The number of visits to the feeding area increased with the frequency of pushing-ups.

Figure 1 shows the attendance for all frequencies. The last parameter, representing the percentage of cows that came within 15 minutes after pushing-up (parameter C), was also statistically significant.

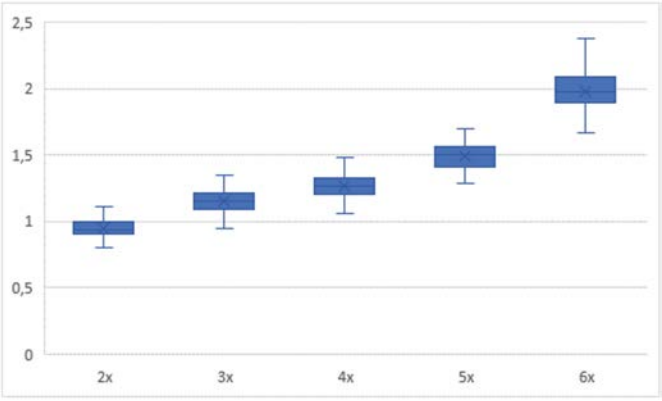

Figure 1. Frequency of visits to the feedlot by the dairy cow for individual pushing-up frequencies

Table 2. Percentage representation of dairy cows on the feed trough when the feed is delivered and after the next pushing-up

Push-up	[n]	Feed delivery	Push-up order					
				2	3	4	5	6
2	146	88,53	48,09	47,11				
3	132	85,52	45,58	38,69	30,59			
4	143	85,35	38,84	31,55	28,94	27,04		
5	149	82,63	37,42	33,48	29,61	25,18	23,43	
6	129	85,63	44,71	37,70	32,19	29,79	28,06	25,38

Table 3. Statistical evaluation of trough attendance by dairy cows

Visitation	Push-up frequency				
	2	3	4	5	6
Parameter					
A	33,30	17,65	17,14	16,22	14,29
B	1,0	1,2	1,3	1,5	2,0
C	47,60	38,28	31,59	29,82	32,97

This parameter was significantly influenced by the number of pushing-ups [F (3;642) = 1544.72; $P < 2 \times 10^{-16}$], by the year [F (3;642) = 3.16; $P = 2.43 \times 10^{-2}$] and also by the number of dairy cows in the experiment [F (1;642) = 4.27; $P = 3.92 \times 10^{-2}$].

DMI and the use of TMR

In the study, the influence of the frequency of pushing-ups on the use of feed by animals was monitored. For evaluation, the average dry matter intake of TMR per dairy cow and day of each experimental period was calculated (Table 4).

We demonstrated the influence of feed utilization by dairy cows at higher frequencies of pushing-ups feed into the trough. TMR consumption was significantly affected by pushing-up feed into the trough [F (3;642) = 75.36; $P = 0.001$] and by the year [F (3;642) = 512.38; $P < 2 \times 10^{-16}$]. The number of dairy cows included in the experiment had no effect on feed consumption [F (1;642) = 0.058; $P = 0.809$]. A post hoc test showed a statistical difference between the 4th and 5th pushing-up ($P = 7.7 \times 10^{-4}$). Table 5 shows how many percent of the TMR dry matter delivered was used in individual experimental periods.

DMI and the use of TMR

Daily productivity of dairy cows was recorded every day during the monitored period. The resulting values demonstrate an increasing daily average productivity of dairy cows at a higher frequency of feed pushing-ups. For evaluating daily productivity, we determined a parameter - the average amount of milk produced by one dairy cow per day (in kg). The average milk yield is shown in Table 6. The last row of the table evaluates the total average daily yield for individual pushing-ups. To calculate this value, the test model was supplemented with a fixed effect of the dry matter of the feed ration, the amount of dry matter actually eaten by the dairy cow, and also the interaction of both effects. This parameter was significantly influenced by the number of pushing-ups [F (3;639) = 115.54; $P < 2 \times 10^{-16}$], by the experimental year [F (3;639) = 300.12; $P < 2 \times 10^{-16}$], by the amount of added dry matter to cows [F (1;639) = 22.80; $P = 2.22 \times 10^{-6}$], by the percentage of dry matter intake per cow [F (1;639) = 22.81; $P = 67.16 \times 10^{-5}$] and also by the interaction between the last two mentioned effects [F (1;639) = 3.92; $P = 4.81 \times 10^{-2}$].

Table 4. Mean dry matter intake of dairy cows

	Push-up frequency									
	2		3		4		5		6	
Year	Ø	SE	Ø	SE	Ø	SE	Ø	SE	Ø	SE
2018	20,40	0,10	20,45	0,12	20,34	0,11	19,17	0,08	20,60	0,09
2019	22,29	0,20	22,20	0,44	22,96	0,23	20,15	0,38	20,06	0,14
2020	19,16	0,11	18,83	0,13	18,57	0,16	20,69	0,25	21,00	0,15
2021	18,69	0,10	18,93	0,08	19,03	0,11	19,09	0,09	18,87	0,11
Ø	20,13	1,40	20,11	1,40	20,31	1,72	19,78	0,71	20,15	0,82

Ø - the average of the values of the observed periods; SE - the standard deviation

Table 5. The percentage of dry matter used from the delivered TMR in different frequencies of pushing-ups and periods of experiments

	Push-up frequency									
	2		3		4		5		6	
Year	Ø	SE	Ø	SE	Ø	SE	Ø	SE	Ø	SE
2018	96,18	0,2	96,26	0,27	95,89	0,24	95,97	0,19	96,18	0,18
2019	93,23	0,49	93,14	0,41	93,82	0,58	95,83	0,2	95,64	0,22
2020	95,84	0,17	96,05	0,11	95,84	0,15	96,39	0,15	96,29	0,18
2021	95,14	1,2	95,81	0,33	95,92	0,24	96,22	0,23	95,82	0,24
Ø	95,14	1,2	95,22	1,3	95,26	0,97	96,1	0,29	96,15	0,49

Ø - the average of the values of the observed periods; SE - the standard deviation

Table 6. Average daily milk production

	Push-up frequency									
	2		3		4		5		6	
Year	Ø	SE	Ø	SE	Ø	SE	Ø	SE	Ø	SE
2018	23,06	3,04	26,08	4,52	25,65	4,28	24,66	4,08	25,73	3,60
2019	24,21	4,75	26,11	4,53	25,07	5,68	23,95	4,07	24,62	3,26
2020	25,30	4,32	24,87	3,11	25,23	4,27	26,93	4,65	27,79	4,19
2021	25,52	2,90	26,30	3,40	25,96	3,48	27,59	3,35	25,97	3,83
Ø	24,54	1,06	25,82	0,76	25,48	0,50	25,81	1,55	26,12	1,30

Ø - the average of the values of the observed periods; SE - the standard deviation

The study did not show any effect of the number of dairy cows in the experiment on the average daily yield of a dairy cow. [F (1;639) = 0.35; P = 0.55].

The feed conversion efficiency [FCE, milk kg/kg dry matter intake (DMI)] is shown in Table 7. FCE was affected by the frequency of feeding at the feed trough. The amount of dry matter fed TMR and the total daily intake of the experimental group was used to evaluate the data. The monitored parameter was significantly influenced by the number of feedings [F (3;642) = 279.56; $P < 2 \times 10^{-16}$], year of trial [F (3;642) = 1042.86; $P < 2 \times 10^{-16}$] and also by the number of dairy cows [F (1;642) = 13.88; $P = 2.12 \times 10^{-4}$].

Milk samples from each experimental dairy cow were analyzed during each experimental period. The content of fat, protein and lactose was determined. The results are shown in Table 8.

The frequency of pushing-ups had no statistical significance on milk fat content [F (3;669) = 0.11; P = 0.95]. Neither the effect of the experimental year on the content of this component in milk was not confirmed [F (3;669) = 3.42; P = 0.02]. A statistically significant effect of the frequency of feeding on the protein content of the milk was not confirmed either, although we can speak of a tendency to influence [F (3;669) = 2.44; P = 0.06].

Table 7. Feed conversion efficiency, milk kg/kg dry matter intake

	Push-up frequency									
	2		3		4		5		6	
Year	Ø	SE	Ø	SE	Ø	SE	Ø	SE	Ø	SE
2018	1,13	0,02	1,27	0,03	1,26	0,02	1,29	0,02	1,25	0,01
2019	1,09	0,02	1,18	0,03	1,09	0,01	1,19	0,02	1,23	0,02
2020	1,32	0,02	1,32	0,02	1,36	0,02	1,30	0,02	1,32	0,04
2021	1,37	0,02	1,39	0,02	1,36	0,03	1,44	0,02	1,38	0,02
Ø	1,22	0,12	1,29	0,09	1,25	0,11	1,30	0,09	1,30	0,06

Ø - the average of the values of the observed periods; SE - the standard deviation

Table 8. Qualitative indicators of milk

		Push-up frequency									
		2		3		4		5		6	
	Year	Ø	SE	Ø	SE	Ø	SE	Ø	SE	Ø	SE
Fat	2018	4,04	0,64	4,05	0,68	4,05	0,67	4,08	0,64	4,03	0,39
	2019	3,98	0,70	4,29	0,51	4,13	0,62	4,06	0,64	4,12	0,62
	2020	3,95	0,48	3,84	0,40	3,87	0,49	3,91	0,44	3,98	0,58
	2021	3,97	0,57	4,04	0,41	4,05	0,53	4,08	0,41	3,91	0,31
	Ø	3,99	0,60	4,05	0,53	4,03	0,58	4,03	0,54	4,00	0,49
Protein	2018	3,45	0,24	3,44	0,25	3,41	0,35	3,48	0,31	3,37	0,21
	2019	3,45	0,37	3,50	0,35	3,38	0,37	3,39	0,37	3,47	0,38
	2020	3,47	0,27	3,43	0,28	3,43	0,23	3,43	0,35	3,52	0,25
	2021	3,49	0,37	3,46	0,38	3,44	0,23	3,58	0,28	3,57	0,23
	Ø	3,47	0,32	3,46	0,32	3,41	0,30	3,47	0,33	3,48	0,28
Lactose	2018	4,94	0,20	5,07	0,10	5,00	0,14	5,02	0,11	4,93	0,22
	2019	4,76	0,27	4,85	0,23	4,86	0,22	4,89	0,24	4,90	0,17
	2020	4,89	0,19	4,88	0,24	5,02	0,17	4,86	0,17	4,93	0,24
	2021	4,91	0,15	4,90	0,14	4,94	0,17	4,97	0,11	4,99	0,19
	Ø	4,88	0,22	4,92	0,21	4,96	0,19	4,93	0,18	4,94	0,20

Ø - the average of the values of the observed periods; SE - the standard deviation

The protein content was not affected by the year of monitoring either [F (3;669) = 0.48; P = 0.69]. The frequency of pushing-ups affected the lactose content in the milk [F (3;669) = 4.21; P = 0.005]. The Tukey Test showed a significant difference between pushing-up 3 and 4. The tested parameter was significantly influenced by the year of monitoring [F (3;669) = 4.21; $P = 2 \times 10^{-9}$].

DISCUSSION

The stable environment is significantly different from natural grazing conditions. There are a number of external factors affecting the productivity of dairy cows. These include nutrition, environment and husbandry management. Changing physical and social factors, such as artificial lighting or limited space during housing, substantially changes the behavior of dairy cows not only in terms of the level but also in terms of the layout of behavioral activities. For more than 5 years, it has been a common trend to feed high-producing dairy cows twice a day and only once a day to late-lactation dairy cows to keep running costs at an acceptable minimum (Leonardi and Armentano, 2003; Mattachini et al., 2016; Siewert et al., 2018). In this study, dairy cows were kept without the possibility of grazing, dependent only on feed management. During the observation period, feed was delivered only once, after the morning milking. When fresh feed was placed in the trough, each dairy cow had enough space for feed intake. The number of places at the feeding table was 45, and the maximum number of dairy cows in the experiment did not exceed 37. Factors that appear to limit access to feed include not only the amount of bunk space but also social factors, such as the rate of aggressive displacements (Mentink and Cook, 2006). In terms of feeding space, no dairy cow was exposed to stress. No signs of aggression were observed during contact with dairy cows at the feed trough. A once-a-day feeding system could cause health problems due to large daily fluctuations in rumen pH (Shabi et al., 1999; Kudrna, 2003). Animal health problems associated with metabolic disorders were not confirmed in any monitored period.

Feeding behavior

Feeding behavior patterns differed and were more variable for parlor cows than for robot cows (Wagner-Storch and Palmer, 2003). In our case, the behavior of dairy cows housed in a free-stall barn milked in a rotary tandem milking parlor was monitored. The time between 6:00 and 18:00 p.m. was chosen for monitoring animal behavior because according to the results of the study by DeVries et al. (2005) from electronic monitoring, the activity of dairy cows is highest at this time (DeVries et al., 200). Groups of dairy cows were fed once a day during the observed period of 12 hours with a more frequent feeding frequency (2, 3, 4, 5, 6). The results of monitoring the behavior of dairy cows were not affected by competition for access to feed. According to Hosseinkhani et al. (2008), competition at the feed bunk essentially determines the behavior of animals in group housing (Hosseinkhani et al., 2008). While the timing and frequency of feed delivery clearly influence the behavior of dairy cows, the effect of feed pushing-ups on behavioral patterns is less clear. According to DeVries et al. (2005), the largest percentage representation of dairy cows in the feed aisle is after the introduction of fresh feed (DeVries et al., 2005). If dairy cows are fed only once a day, the time period immediately after feeding is significant according to the activity of the dairy cows, compared to dairy cows fed twice a day, where the feed dose is divided (Hosseinkhani et al., 2008; Mašek, 2010).

The percentage representation of dairy cows at the feedlot within 15 minutes after the feed delivery at 6:00 ranged from 82.63 to 88.53. According to the results of the electronic monitoring of the dairy cows, the highest activity was found after the delivery of the feed in the morning, the reaction to the pushing-up was not so dramatic.

In this study, a decrease in the percentage of dairy cows at the feedlot was noted with each feed pushing-up. The same results are confirmed by the study by DeVries et al. (2003) (DeVries et al., 2003). The feeding behavior pattern can be different for each dairy cow. Mattachini et al. (2019), monitored the behavior of dairy cows for 3

hours (Mattachini et al., 2019). Each of the observed dairy cows visited the feeding place at a different time, with a different frequency. Also, total feeding time varied (4.40 to 11.3 minutes) when monitoring 13 dairy cows. Cyclic handling with feed at the feeding table increases interest in feed intake (Pavkin et al., 2021). This corresponds with the results of our study. The average number of visits to the feeding place by one dairy cow increased with the frequency of feed pushing-up. When the number of pushing-ups was increased from 2 to 6, the average attendance at the feeding place increased twice. A study by DeVries et al. (2003) however, does not confirm the positive effect of the number of pushing-ups on feedlot attendance (DeVries et al., 2003). According to a study by DeVries et al. (2005; 2005) the increased frequency of pushing-ups feed into the trough significantly affects feeding behavior and can also affect the health and productivity of dairy cows (DeVries et al., 2005; DeVries et al., 2005b). Our study did not confirm changes in behavior due to pushing-up feed in the trough even at different frequencies (2, 3, 4, 5, 6).

DMI and the use of TMR

During the study, dairy cows were fed TMR, which was delivered at 6 o'clock in the morning and it was pushed-up 2x to 6x according to the schedule. As the frequency of pushing-ups increased, the use of TMR increased. Comparing the average results for 2x and 6x pushing-ups rates, the increase in TMR utilization was 1.01%. Miller-Cushon and DeVries (2017b) compared 2 frequencies of pushing-ups 3 and 5 times per day (Miller-Cushon and DeVries, 2017b). The frequency had no effect on dry matter consumption. The process of delivery and pushing-up feed affects the resting time of dairy cows. The animals are stimulated by the new action to break the lying period and approach the feeding trough (DeVries and Chevaux, 2014).

The Doležal study (2006) monitored the testing of different pushing-ups frequencies and observed a difference already from the feed pushing-up frequency of 4x to 12x per day (Doležal, 2006). An increase in feed dry matter consumption was observed with an increasing frequency of pushing-ups by 4.92 kg per day at a 12x frequency versus a 4x frequency. Feeding strategies with low feeding frequency can result in feed sorting (Miller-Cushon and DeVries, 2017a) and lower feed ration utilization. Coblentz et al. (2020) tested pushing-up in 90 min and 180 min intervals (Coblentz et al., 2020). Dry matter, NDF intakes were not affected by push-up frequency. DeVries et al. (2005) in their study tested different frequencies of feed delivery on cow behavior and feed sorting (DeVries et al., 2005). In the frame of each frequency, he tested even 2 and 3 pushing-ups. The frequency of feed delivery or its pushing-up did not affect the intake of the dry matter in the feed.

Milk production and quality

The average daily milk yield varied with the number of pushing-ups. It was the lowest at 2 pushing-ups (24.54 kg/pc/day). With 3 pushing-ups, it increased up to 25.82 kg/pc/day. The highest average daily milk yield was at 6 pushing-ups (26.12 kg/head/day. Statistically, the higher productivity of dairy cows at 6 pushing-ups within 12 hours was statistically proven. A study by Phillip and Rind (2001) recorded increased milk production in dairy cows associated with higher feed intake and lower frequency of pushing-ups (Phillip and Rind, 2001). The average daily milk production was lowest at the lowest frequency and reached the maximum at 6 pushing-ups within 12 hours. In the study by Sloth et al. (2017), feed pushing-ups were observed at ten frequencies per 12 hours, but the hypothesis of improvement in milk production was not confirmed compared to the interval (5.6) of pushing-ups to the feeding trough as observed in this study (Sloth et al., 2017). It is generally assumed that changing the pushing-up frequency from 3 times a day to 5 times a day increases the milk yield of dairy cows (DeVries et al., 2005; Bazeley and Hayton, 2013). Also according to Doležal (2006), milk production increases with the number of pushing-ups. The increase can be up to 4.24 kg of milk/piece/day for a frequency of 12x (Doležal, 2006).

On the contrary, Miller-Cushon and DeVries (2017a) do not confirm that the frequency of pushing-up feed would have an effect on the daily productivity of dairy

cows (40.3 vs. 40.1 kg/d) (Miller-Cushon and DeVries, 2017b). However, in their presented study, the animals were fed individually. The type of animal housing is related to the sorting of feed by dairy cows. Individually housed animals have a high consumption of feed particles rich in easily fermentable hydrocarbons, which unfortunately limits energy intake and subsequent production (DeVries et al., 2005). A study by Sova et al. (2013) confirms that the increase in milk production is related to herd-level management practices supporting the animals' access to feed (Sova et al., 2013). Bach et al. (2018) studied the association between non-alimentary influences and dairy herd performance in 47 herds (Bach et al., 2018). Producers pushed-up 2 to 4 times during the day. His evaluation did not show a statistically significant influence of the frequency of pushing-ups on milk yield. There was a statistically significant difference between the average daily milk yield of the herds whose feed was pushed-up compared to the others. The difference was 3.9 kg/day. According to Siewert et al. (2018) when using a robot for pushing-up feed, the increase in milk production can be up to 4.9 kg/piece/day (Siewert et al., 2018). Our study compared different pushing-ups frequencies, zero pushing-up was not tested. The difference between the lowest and highest frequency was 1.58 kg/pc/day. The fact is that the greater the number of pushing-ups feed, also the longer particles of fodder previously sorted by dairy cows are fed in practice. In a study by Deming et al. (2013), the content of NDF in TMR changed during pushing-ups (Deming et al., 2013). A lower intake of effective fiber is associated with a decrease in pH in the rumen and it affects negatively performance (Miller-Cushon and DeVries, 2017b; Rabelo et al., 2003). A dairy cow's milk production can decrease by up to 1 kg (Sova et al., 2013).

Feed conversion efficiency is measured as kg of milk per kg of dry matter intake TMR. Highly productive groups of dairy cows can thus achieve values of 1.7-1.8 kg of milk per 1 kg of dry matter of feed delivered in quality feed, as reported in a study by Hutjens, (2017) (Hutjens, 2017). When compared to the results in our study, the actual feed conversion [FCE, milk kg/kg dry matter intake (DMI)] in the case of 3 pushing-ups was higher than with 4 ones (1.29 vs. 1.25).

While monitoring the quality of milk indicators, the contents of fat, protein and lactose were determined. The average contents of fat, protein and lactose varied between 3.84 - 4.29% (fat), 3.37 — 3.58% (protein), and 4.76 - 5.07% (lactose). Only the lactose content was statistically significantly affected by the frequency of pushing-ups. Studies by Miller-Cushon and DeVries (2017a; 2017b) (Miller-Cushon and DeVries, 2017a; Miller-Cushon and DeVries, 2017b) did not find a difference in the content of milk fat or milk protein depending on the frequency of pushing-ups. Lactose content was not monitored.

CONCLUSIONS

Delivery of fresh feed and feed push-ups are two main factors for feed-stimulating behavior. The influence of totally 5 different pushing-up frequencies on the utilization of feed ration, milk production and quality was monitored during the years 2017-2021. The behavior of the dairy cows as a reaction to feed pushing was also monitored. Increasing the frequency from 2 to 6 increased TMR dry matter intake recovery by 1.01%. The highest feed conversion (1.30 kg/pc/day) was at 5 and 6 frequency (pushing-up up after two hours). The average daily yield of milk increased by 1.58 kg/pc/day. The results of the milk quality analyses prove that a higher frequency of milking had a significant effect on lactose content (increasing from 4.88 to 4.94%). Fat and protein content were not affected. From the point of view of ethology, the right feed management is very important. The percentage of cows on the feed trough was the highest after fresh feed delivery and the lowest after the last pushing up. In the average rating of all observations, the visitation of the feeding place by cows increased twice. Also, the difference between the number of pushing-ups and the use of the delivered feed ration was demonstrated. More frequent pushing-up of the delivered feed ration has a positive effect on has a positive effect not only on feed intake but also on the production of dairy cows. Pushing feed is perhaps the simplest and least expensive strategy for dairy cow management.

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