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Changes in the behaviour of Czech Fleckvieh dairy cows during the day under optimal ambient temperature conditions in the barn

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Abstract: In the experimental section of the barn (which made up 25% of the barn), 103 cubicles in free stall barn were selected in three rows, housing 98 dairy cows of Czech Fleckvieh cattle. Monitoring was done for one calendar year, once a week. From this period, 16 days with temperatures from 0.5–15.0 °C were selected for quantification. Observations were continuously recorded at 10:00 am (one hour after the coming of the last cow from the milking parlour), at hourly intervals until 7:00 pm. Ten observations were carried out every day of the monitoring period. In total, 15 680 individual observations were recorded. The microclimatic parameters (temperature, relative humidity) were monitored within the barns continuously at 15-minute intervals using three data logger sensors. Changes in the proportion of lying to standing dairy cows were observed during the day. A steady trend of a reduced ratio of lying dairy cows during the day (from 70% to 40%) in favour of standing dairy cows was observed. The optimal value of the cow comfort index – CCI (85%) was not reached in any monitored part of the day. The number of dairy cows lying on their left sides increased from 50.4% to 56%, especially after feeding (at 4:00 pm). Differences were found in the proportion of lying and standing cows ($P < 0.05$) at an optimal microclimate during the day. A significant preference for the left side when lying down was also found.

Keywords: lying; standing; laterality; cow comfort index; microclimate

A highly complex system of environmental factors influences the behaviour of reared animals. When removing animals from their natural environment into conditions inadequate to satisfy their natural demands and requirements, these conditions are very often significantly different from the demands and needs of humans. Usually, the breeder has to remove many factors that force reared animals to build up defensive mechanisms in their extreme values or certain combinations, thereby limiting production potential (Hulsen 2011).

An important element, which usually affects the barn microclimate, is the ambient air temperature in the barn. It is essential to react immediately to ambient air temperature changes since, in the case of animals with constant body temperature, this can affect the yield or health of the animal. The thermal equilibrium area is the barn air's tem-

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perature range that allows the highest production efficiency to optimise feed utilisation.

According to Roenfeldt (1998), dairy cattle resist low ambient temperatures. Roenfeldt (1998) also stated that a thermoneutral zone for cattle is in the temperature range from 5 °C to 25 °C, and Hulsen (2011) states optimum ambient temperature is between –5 °C to 20 °C.

Other climatic conditions, such as airflow, air humidity, etc., also play a significant role (Silanikove 2000). The temperature-humidity index (THI), as West (2003) reported, involves a combination of temperature and relative humidity effects. Currently, THI detection is used in many countries because meteorological stations in most countries commonly provide this information (Silanikove 2000). Dairy cows rest in standing (increasingly so on hot days, thus increasing the body's surface to cool down) and lying down positions. Standing rest is considered a transition to lying (Hulsen 2011). The time cows spend lying down can be used to assess the barn and the comfort of the lying down areas, which is one of the most important design criteria for housing dairy cows (Ito et al. 2009). Cow comfort index (CCI) can be used to evaluate the number of lying cows compared to standing ones; this value should be above 85% (Grant 2009).

Lying down is important for dairy cows because of the rumination process's importance in optimising feed digestion. According to Wagnon and Rolins (1972), side lying preference is influenced by the time of day. The authors report that dairy cows are recorded to prefer lying down predominantly on the left side (left laterality) in the afternoon (up to 56%) as opposed to in the morning (50%). Left laterality is also confirmed by Tucker et al. (2009).

Wagnon and Rolins (1972) explain that left laterality is due to the increased weight of the rumen after feeding, but according to Tucker et al. (2009), this fact does not impact the lateral effect. Other factors that influence laterality may be the gestation phase (Forsberg et al. 2008; Zejdova et al. 2011), lactation order (Zejdova et al. 2011) and, last but not least, the individuality of dairy cows (Gustafson and Lund-Magnussen 1995). The issues above are usually monitored daily (usually at 10:00 am).

The issue of thermal or cold stress and their influence on laterality behaviour is addressed by several authors (Zejdova et al. 2011; Velecka et al. 2014), but it is also necessary to evaluate laterality behaviour in optimal conditions.

MATERIAL AND METHODS

Experimental design and observations were done at the farm of a prominent dairy breeder, GenAgro Ricany a.s. (GPS: 49°12'31.494"N, 16°23'43.197"E) at an altitude of 349 m, near the village of Ricany. The average annual temperature of the area is around 6.5 °C. The object of the observation was one section of the barn (25% of the barn) with 103 vacant cubicles arranged in three rows (see Figures 1 and 2). In section 98, Czech Fleckvieh dairy cows were placed.

A separate biogas plant was used with limestone bedding in the box beds. Throughout the year, the side walls of the barn are permanently open. In the monitored section, animals were fed the same feed in the same quantities (total mix ratio) at 4:00 am and 4:00 pm throughout the experiment. Cows were milked twice a day, at 8:00 am and 8:00 pm.

Monitoring was carried out for one calendar year (from June to May). In the observed section, only dairy cows were housed in the second or higher lactation periods (average 3.02 order of lactation) or up to 30 days from calving (average 152.0 DIM) during the monitoring period. Data on actual milk yields were collected during milking sessions on monitoring days using the FASTOS 2000 program, which is part of the milking parlour's equipment. The following climate parameters were recorded inside the barn: temperature (°C), relative humidity (%) and THI.

These parameters were also monitored inside the barn. Temperature and relative humidity were continuously measured during the year at 15-minute intervals using three data logger sensors placed in the monitored section (i.e., uniformly at cow height) – to eliminate the impact of one site (see Figure 2). THI values were calculated according to the following equation reported by Hahn (1999):

$$THI = 0.8\ t_{db} + (t_{db} - 14.4) \times RH/100 + 46.4 \quad (1)$$

where:

THI – temperature-humidity index;

t_{db} – temperature in the barn (°C);

RH – relative humidity in the barn (%).

THI values also serve as the basis for the livestock weather safety index: normal (≤ 74), alert (75–78), danger (79–83), emergency (≥ 84).

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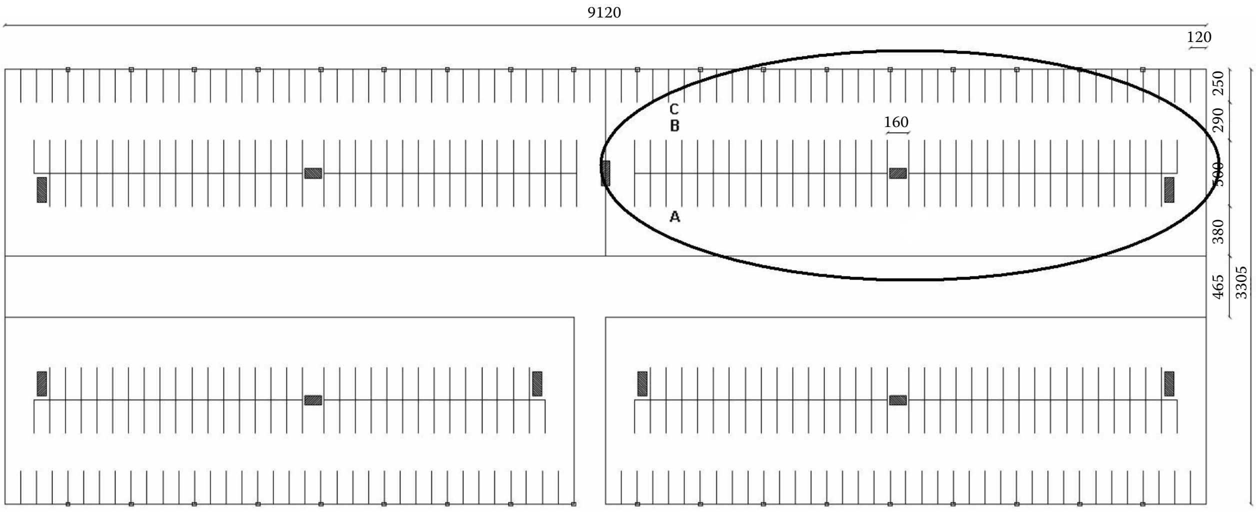

Figure1. Scheme of the barn with marked monitored section

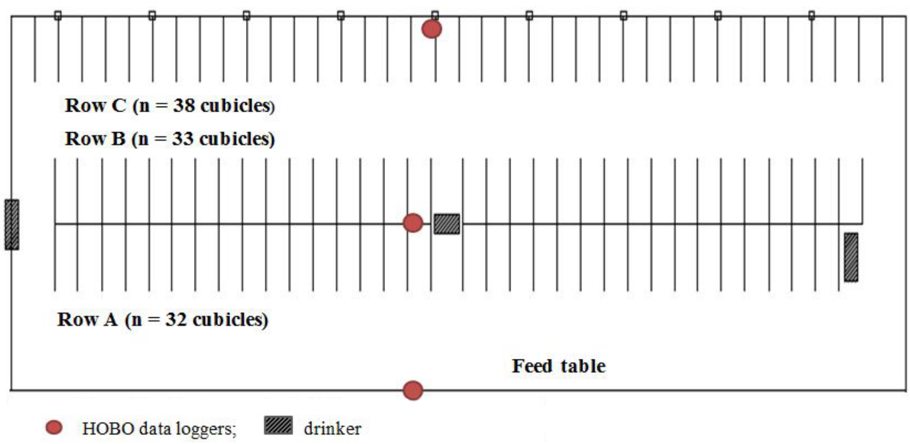

Figure 2. Ground plan of the monitored section indicating the location of the sensors (marked by red colour)

The observed air temperature, relative humidity and the calculated THI values were averaged over all three daily sensors. A number of 16 days (observed days) selected from the whole observation year according to the temperature from 5.0 to 15.0 °C (so-called thermo-neutral zone) was chosen for the experiment, during which the behavioural activity of the dairy cows was monitored using group image method (see following Formula 2). There was no case where dairy cows occupied all the boxes for the monitored period. Observations commenced at 10:00 am (one hour after the last dairy cow came from the milking parlour) and at hourly intervals until 7:00 pm (an hour before the first dairy cow left for the milking parlour). In total, up to 10 observations per day were recorded. In total, 15 680 individual observations were evaluated.

Schematic observation of activities of dairy cows (A) lying (on the left or right side), (B) standing:

$$\text{CCI} = (\text{number of lying cows/total number of cows}) \times 100 \quad (2)$$

where:

CCI – cow comfort index (%) (Grant 2009).

All obtained observation values of behavioural activities (frequencies of standing or lying) were divided into ten groups (after hourly observation intervals, factor = hour of observation) and statistically evaluated differences of mean frequencies among these groups using the GLM method (the effect was tested using ANOVA table Type I, F-test, P < 0.05). Laterality was tested using the Chi-square test goodness of fit (expected ver-

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sus observed frequencies between lateralities were tested, $P < 0.05$). All analyses were provided using Statistica v14.0 program (TIBCO Software Inc., Palo Alto, CA, USA).

RESULTS

Barn climatic characteristics during the observed 16 days

The descriptive statistics of the climatic (ambient) characteristics measured inside the barn (temperature in the barn, relative humidity, and THI) are indicated in Table 1. It is evident from the table that the average daily temperature in the monitored period was 10.1 °C, ranging between 5.1 °C and 14.9 °C. This indicated that, during the experimental period, the ambient temperature did not exceed the border values of the thermo-neutral zone (from 5.0 to 15.0 °C), as most of the referenced authors agreed upon. The average relative humidity (RH) reached 67.8%, and the average calculated THI was 51.1.

Changes in the behaviour of dairy cows during the observation periods

Changes in the behaviour of dairy cows during the observation periods are shown in Table 2. From the total of 15 680 observations, it is clear that the dairy cows were either lying down (9 094 cases, equivalent to 58.0%) or standing (6 586 cases, equal to 42.0%). In addition, the table shows a change in the proportion of lying down and standing dairy cows during the course of the day. A steady trend emerged in reducing the proportion of dairy cows lying down (from 70% to 40%) in favour of those standing.

Table 1. Barn climatic characteristics in the observed days (for 16 days)

Climatic characteristics	Mean	SEM	Min.	Max.
Temperature (°C)	10.1	2.8	5.1	14.9
Relative humidity (%)	67.8	15.6	42.9	93.1
THI	51.1	4.4	42.9	58.1

SEM = standard error of the mean; THI = temperature-humidity index

Table 2. Changes in the behaviour and laterality of dairy cows during the day

Observed activity		Σ^1 % (n)	Mean^2 % (n)	Time of monitoring % (n)										Significance
				10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	
TNL		58.0 (9 094)	58.0 (56.8)	74.0 (1 159)	69.8 (1 158)	70.4 (1 104)	65.2 (1 023)	66.8 (1 047)	63.8 (1 001)	45.3 (710)	39.4 (617)	41.1 (645)	40.2 (630)	**
TNS		42.0 (6 586)	42.0 (41.2)	26.0 (409)	30.2 (410)	29.6 (464)	34.8 (545)	33.2 (521)	36.2 (567)	54.7 (858)	60.6 (951)	58.9 (923)	59.8 (938)	**
CCI (%)		58.0	–	73.9	73.9	70.4	65.2	66.8	63.8	45.3	39.4	41.1	40.2	**
Lying down	left side	52.0 (4 739)	52.1 (29.6)	53.3^a (618)	51.5 (597)	49.0 (541)	50.1 (513)	50.3 (527)	50.3 (504)	56.2^A (399)	56.6^A (349)	54.0^a (348)	54.3^a (343)	NS
	right side	48.0 (4 355)	47.9 (27.2)	46.7^b (541)	48.5 (561)	51.0 (563)	49.9 (510)	49.7 (520)	49.7 (497)	43.8^B (311)	43.4^B (268)	46.0^b (297)	45.7^b (287)	NS
Sum of lying		100 (9 094)	100 (56.8)	100 (1 159)	100 (1 158)	100 (1 104)	100 (1 023)	100 (1 047)	100 (1 001)	100 (710)	100 (617)	100 (645)	100 (630)	–

CCI = cow comfort index; NS = not significant; TNL = total number of cows lying down; TNS = total number of cows standing

**Values in rows are significant on the level of $P < 0.01$

^{A,B}Values in columns, signed by different letters are significant on the level of $P < 0.01$; $^{a,b}P < 0.05$

^{1}Sum of observed activities in the monitored period for 16 days (number of observations)

^{2}Average numbers of cases per one observation (per 1 h of monitoring)

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It is also evident from the table that the number of dairy cows lying down reduced to 40%, especially after feeding (at 4:00 pm). The influence of observation time (time of day) on the proportion of dairy cows lying down was different ($P < 0.01$) when compared to cows standing by dairy cows. In this regard, it must be noted that no dairy cows were found lying outside the box throughout the monitoring period, i.e., all dairy cows were lying in the box.

During the day, the highest CCI value was observed one hour after returning from the milking parlour (73.9%) and the lowest at 5:00 pm (39.4%). In no case was the optimal CCI value of 85% achieved (Nelson 1996; Grant 2009).

Concerning the laterality behaviour of the observed cows, Table 2 shows that the total number of dairy cows lying down on the left side was recorded in 4 739 cases (52.1%) and on the right side in 4 355 cases (48.0%). As is further evident from Table 2, the number of dairy cows recorded lying down on the left side was consistently higher (except for the observation at noon when the ratio was up to 49.0% on the left side and up to 51.0% on the right side) with a marked increase, especially after feeding at 4:00 pm (when the ratio was up to 56.6% on the left side and up to 43.4% on the right side). These differences were statistically significant.

Average milk yield of dairy cows recorded during the 16-day observation period

Differences in the frequency of standing, lying down, and laterality depending on the milk yield are shown in Table 3. The observed differences were not statistically significant. The table shows that dairy cows preferred the left side when lying down ($P > 0.05$). The estimation of milk yield in 305 days was 7 381 kg of milk, using the methodology of Kopec et al. (2013).

DISCUSSION

Our study observed changes in the proportion of lying to standing dairy cows during the day. A steady trend of a reduced ratio of lying dairy cows during the day (from 70% to 40%) in favour of standing dairy cows was observed. The optimal value of the cow comfort index – CCI (85%) was not reached in any monitored part of the day. The number of dairy cows lying on their left sides increased from 50.4% to 56%, especially after feeding (at 4:00 pm).

A similar trend in the increased number of dairy cows standing after the afternoon feeding was also recorded by Velecka et al. (2014), who further states that this fact could have been caused by keeping cows in the passageway near the milking parlour, where they were waiting for the evening milking.

Many studies confirmed that the lying down of dairy cows is very important for rest and regeneration of the mammary gland (Lomb et al. 2018; Thompson et al. 2019). The time that cows spend lying down can be used to assess the quality of the barn (Ito et al. 2009). On the other hand, the currently observed results showing a lower rate of dairy cows lying down before milking was confirmed by Norring et al. (2012). These authors further reported that dairy cows were resting in the lying down position for up to 22% of the time before evening milking, but after milking, it was up to 50% of their time. As Houpt (2011) reported, dairy cows spend up to 13 h daily lying under normal conditions. This fact is also confirmed by Tucker et al.

Table 3. Differences in behaviour depending on milk yield

Group of milk yield (kg)	Σ^1 % (n)	Order of lactation (n)	DIM (days)	Total number of cows standing	Total number of cows lying down	Total number of cows lying down	
						left side	right side
< 20.0	12.3 (1 930)	3.12	188.6	43.7 (844)	56.3 (1 086)	50.6 (549)	49.4 (537)
20.1–30.0	54.8 (8 590)	3.03	157.8	40.7 (3 496)	59.3 (5 094)	52.1 (2 652)	47.9 (2 442)
< 30.1	32.9 (5 160)	2.97	128.8	43.5 (2 246)	56.5 (2 914)	52.7 (1 536)	47.3 (1 378)
Sum of cases	100 (15 680)	3.02	152.0	42.0 (6 586)	58.0 (9 094)	52.1 (4 737)	47.9 (4 357)

DIM = days in milk

[1]Sum of observed activities in the monitoring period for 16 days

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(2004), who reported an average time of lying dairy cows from 9.4 to 14.7 h per day with an approximate duration ranging from 0.9 to 1.4 h per lying period. Dairy cows are less lying and more standing in uncomfortable conditions, making them more susceptible to health complications and less productive (Hulsen 2011).

When increasing the values of THI over 68, the number of lying cows is reduced, but the number of ones standing in the stalls does not increase significantly. Authors Kulaz and Ser (2022) stated that higher THI causes an increase in the respiratory rate and decreases the milk yield. Cows prefer to stay in other building areas where they conceivably feel better in a cooler place (Dimov et al. 2017). According to Angrecka and Herbut (2015), monitoring the barn's temperature, humidity, and air velocity conditions in characteristic points of the living zones of cows is necessary.

Lying down time is considered an indicator of welfare (Haley et al. 2001; Fisher et al. 2003) and production (Bewley et al. 2009). The findings in this study are consistent with the pattern within the literature: some studies report that cows spend more time on the left side, while others report no difference. Tucker et al. (2009) recorded that dairy cows spent equal time lying on their left and right sides in three experimental animal groups. One group of non-lactating pregnant dairy cows housed in accessible stalls spent more time on their left side than expected. This was indicated to be by coincidence.

On the other hand, Gibbons et al. (2012) reported that dairy cows, as a breed, do not favour a particular side for lying down. Still, individual animals showed a marked preference for lying down on a specific side. The choice of lying down on the left side is also confirmed by Vecera et al. (2016). Similar observations were recorded by Zejdova et al. (2011): i.e., older dairy cows (4th and higher lactation) prefer the left side more than the younger dairy cows (2nd and 3rd lactation) for lying down.

Vecera et al. (2012) also reported that higher milk yields were found more frequently in dairy cows lying down on the left side. It can be associated with the different anatomical arrangements of cattle's left and right livers. The larger respiratory capacity of the right lung provides better air ventilation during breathing to dairy cows lying down on the left side. The effects influencing laterality behaviour may be far more, but the main cause can probably be ruminants' anatomical specificity, as confirmed by Phillips (2002). According to Phillips (2002), the calves do not have a particular side preference (laterality) because they do not have developed proventriculi and are not forced to rest in the sternal position.

CONCLUSION

The changes in the proportion of lying down and standing of dairy cows during the day were observed during optimum temperature conditions in the barn. While the proportion of dairy cows lying down was predominantly in the morning, in the afternoon, especially after feeding and milking, an increase in the proportion of standing dairy cows was recorded. Compared to the expectations created by other studies, dairy cows lying down more often did not show to give higher milk yields than standing cows. The optimal value of CCI (85%) was not reached in any monitored part of the day. Furthermore, the results show a higher left-side preference for dairy cows lying down almost daily. These cows, lying on the left side, showed a slightly higher yield. The differences found were not statistically significant.

Conflict of interest

The authors declare no conflict of interest.

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