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THE EFFECT OF LOW AND HIGH COWSHED TEMPERATURES ON THE BEHAVIOUR AND MILK PERFORMANCE OF CZECH FLECKVIEH COWS

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Abstract

A group of 98 Czech Fleckvieh cows (one section) was observed over the period of one year with the aim to determine the variation in their milk performance and behaviour at different cowshed temperatures. Behaviour and milk yield were recorded once a week (on the same day) at 10:00. Periods of 8 weeks with the highest temperature (hot period – H) and of 8 weeks with the lowest temperature (cold period – L) were then compared. The cows were housed in one section (1/4 of the total capacity) of the free-stall cubicle shed and where the cubicles were distributed into three rows. Row A (32 cubicles) was close to the feeding plateau, row B (33 cubicles) was in the centre and row C (38 cubicles) was peripheral, close to the side wall. The cowshed temperature was monitored on a daily basis and the mean temperature was 23.2°C in the hot period and –1.7°C in the cold period, relative humidity 60.2% (H) and 74.6% (L), and THI 69.4 (H) and 33.4 (L). The behaviour of the cows was recorded 1568 times, showing them mostly lying down (1037) or standing (531). The cows tended to prefer lying down on their left sides (594 observations) as opposed to their right sides (443). Row A was favoured by the cows (418) and row B was the least popular (377). The cows produced significantly more milk in H period than in L period (0.3 kg per day). The cows lying down were older (3.18 lactations) than the standing cows (2.99 lactations) and they tended to produce more milk per day (by 0.6 kg) but the difference was found to be insignificant. The cows lying resting on their left side produced more milk per day (0.9 kg) and were older (0.02 lactations). The cows in row C were the youngest (2.94 lactations) and the cows in row B were in the last days in milk (144.1 days).

Key words: Czech Fleckvieh, temperature, behaviour, cows

Although the process of domestication brought about a number of important, even essential, changes in farm animal performance, the environmental requirements

of animals remained relatively invariable throughout their phylogenesis. The impact of environmental factors on domesticated animals is extremely complex and difficult to define. The more the original environmental conditions change, the greater the responsibility of the breeder to provide adequately for animals' needs (Chládek, 2004).

Cowshed microclimate is, together with nutrition, type of housing and animal handling, one of the main factors affecting the animal. It affects cows' well-being and performance and subsequently herd performance and profitability. Cowshed microclimate is defined in terms of air temperature, relative humidity, air velocity and the presence of various components – gases, dust, microorganisms, etc. (Matějka, 1995).

According to Bílek (2002) cowshed temperature is the most important factor. The negative impact of high temperature is heightened by air humidity (Koukal, 2001). With increasing relative humidity, heat tolerance and stress resistance of cows decrease (Doležal et al., 2003). The Temperature-Humidity Index (THI) is used to describe the combined effects of temperature and relative humidity (West, 2003).

The time spent lying down is an indicator of the housing quality and a comfortable lying-down area is therefore one of the most important housing design criteria for dairy cows (Ito et al., 2009). The amount of time spent comfortably lying down is fundamental for cows' welfare (Thorne, 2008). It can be extended by various means, e.g. through the provision of additional bedding (Colam-Ainsworth, 1989; Drissler, 2005). The quality of cubicle surface, the number of cubicles and the area available for each cow are important characteristics affecting lying behaviour (Fregonesi et al., 2007). In order to maintain a good level of welfare of cows it is essential to analyse and understand their behavioural responses to cowshed microclimate changes, including the impact of low and high temperatures on the general behaviour and performance of cows.

Material and methods

The primary objective of the experiment was to assess the effects of low and high cowshed temperatures on the behaviour and milk performance of Czech Fleckvieh cows. Observations were recorded on a private farm GenAgro Ricany a.s. (Czech Republic; geographic coordinates 49°12´30.370´´N, 16°23´43.092´´E). The observed section (1/4 of the cowshed) included 103 comfortable cubicles arranged into three rows (Figure 1). Row A (32 cubicles) was the closest to the feeding plateau, row B (33 cubicles) was in the middle of the section and row C (38 cubicles) was situated peripherally, close to the side wall. Some other experiments described by Erbez et al. (2012) and Javorová et al. (2014) were carried out in this cowshed.

The average number of cows housed in the observed section was 98 in various days in milk (30 d and more) and lactation numbers (1st to 8th). The average milk yield was about 28.9 kg per cow per day. There were no dry cows. The data on milk yield consistency and days of milk were recorded on the test days using the milking parlour software FASTOS 2000.

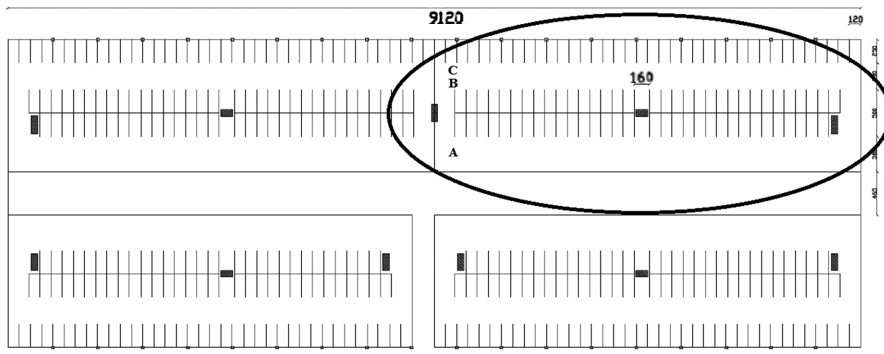

Figure 1. The scheme of the observed section

Data were collected over a period of one year (from 1st June to 31st May). Behaviour and milk production were monitored once a week, always on the same day, at 10:00. Then data from the 8 hottest (H) and 8 coldest (L) weeks were compared. The behaviour was described as the number of cows standing or lying down, the number of cows lying down on their left or right side, and row preference (A, B,C) in the resting area. The microclimate characteristics (air temperature and relative humidity) were recorded by HOBO data loggers which were distributed throughout the cowshed. Their detailed placement and function were described in Erbez et al. (2012). THI values were calculated using the following equation (Hahn, 1999):

$$THI = 0.8\ tdb + (tdb - 14.4) * RH/100 + 46.4$$

where:

tdb = cowshed temperature (°C),

RH = relative humidity (%).

The milk yield per lactation was assessed using Wood's mathematical model as presented in Kopec (2013):

$$y = at^b e^{-ct}$$

where:

a, b, c = assessed parameters of the function (*a* = 16,023, *b* = 0,158, *c* = 0,004),

y = daily milk yield in kg,

t = test day when the milk yield was recorded,

e = base of natural logarithm.

The calculated values were statistically evaluated by GLM procedure (to test for mean) and chi-square test (Statistica 10.0).

Results

Differences in the frequency of lying down and standing

The cowshed microclimatic characteristics (temperature, relative humidity and THI) are presented in Table 1. Mean values of the characteristics were +23.2ºC, 60.2% and 69.4 in H period (high temperature) and –1.7ºC, 74.6% and 33.4 in L period (low temperature). The differences between H and L periods were statistically highly significant. According to Erbez et al. (2012) heat stress develops at temperatures of +21ºC and higher. The upper temperature limit recorded in this study was +2.2ºC (+23.2ºC) higher than this threshold temperature value indicated in literature.

Table 1. Average climatic characteristics measured inside the cowshed

Period and climatic characteristics	$\sum$ (n = 16)	Period		
		High (n = 8)	Low (n = 8)	Sig.
Temperature (°C)	10.8	23.2	–1.7	**
Relative humidity (%)	67.1	60.2	74.6	**
THI	51.4	69.4	33.4	**

Within the column (Sig.), values marked with * and ** differ (P<0.05) and (P<0.01), respectively or the difference is not significant (NS).

The milk yield, lactation number and days in milk in H and L periods and the differences in the frequency of lying down and standing behaviour of the cows are presented in Table 2.

The database contained information on 1568 observations of cows. The estimated milk yield was 7 805 kg (using the methodology of Kopec et al., 2013). The number of observations recorded in hot and cold periods (H and L) was equal – 784 observations in each group. The recorded cow behaviour shows that cows were lying down (1037 observations) or standing (531 observations). The cows produced more milk (on average 3 kg per cow per day) during hot days than in cold days. The cows with greater milk yield in the hot period were of higher lactation number compared to the cold period (3.21 in H period vs. 3.02 in L period). This difference was significant (P<0.01). The differences between the days in lactation among the two groups were not significant. The cows preferred lying down (1037 observations which makes up 66% of the total number) to standing and the milk yield of the cows lying down was non-significantly higher (by 0.6 kg milk) compared to the standing cows (531 observations). The lactation number was greater in the cows lying down but no statistical differences were found in days in milk and milk yield between the lying and standing cows.

Table 2. Milk production, lactation number and days in milk of cows during H and L periods; differences in lying and standing

Period and row	n/avg.	Period			Lying × standing			Period × lying and standing				
Number and parameter	(sx)	High	Low	Sign.	Lying	Standing	Sig.	High × Lying	High × Standing	Low × Lying	Low × Standing	Sign.
Number	1568	784	784		1037	531		518	266	519	265	
Milk production (kg/cow/day)	28.9 (7.9)	30.4	27.4	**	29.1	28.5	NS	30.6	30.0	27.6	27.0	NS
Lactation number (l/cow)	3.12 (1.36)	3.21	3.02	**	3.18	2.99	*	3.25	3.15	3.12	2.84	NS
Days in milk (days/cow)	129.2 (76.9)	131.5	126.9	NS	130.4	126.9	NS	133.1	128.4	127.7	125.3	NS

Within the column, values marked with * and ** differ (P<0.05) and (P<0.01), respectively or the difference is not significant (NS).
Within the row, values marked with different letters a, b, c, differ significantly.

Table 3. Milk production, lactation number and days in milk of cows during H and L periods; lying laterality

Period and row	n/avg.	Period			Side			Period × lying laterality				
Number and parameter	(sx)	High	Low	Sign.	Left	Right	Sign.	High × Left	High × Right	Low × Left	Low × Right	Sign.
Number	1037	518	519		594	443		293	225	301	218	
Milk production (kg/cow/day)	29.1 (7.8)	30.6	27.5	**	29.5	28.6	*	31.1	30.0	27.8	27.0	NS
Lactation number (l/cow)	3.18 (1.37)	3.26	3.10	**	3.19	3.17	*	3.16 b	3.37 b	3.22 b	2.97 a	*
Days in milk (day/cow)	130.4 (78.5)	133.5	126.8	NS	131.5	128.9	NS	130.6	136.4	132.4	121.3	NS

Within the column, values marked with * and ** differ (P<0.05) and (P<0.01), respectively or the difference is not significant (NS).
Within the row, values marked with different letters a, b, c, differ significantly.

Table 4. Milk production, lactation number and days in milk of cows during H and L periods; occupation of cubicles and rows of cubicles

Period and line	n/avg.	Period			Line				Period × line						
Number and parameter	(sx)	High	Low	Sign.	A	B	C	Sign.	High × A	High × B	High × C	Low × A	Low × B	Low × C	Sign.
Number	1185	594	591		418	377	390		221	220	153	197	157	237	
Milk production (kg/cow/day)	28.9 (7.7)	30.5	27.2	**	29.2	28.5	29.0	NS	30.8 a	30.6 a	30.1 a	27.6 b	25.6 b	28.3 b	*
Lactation number (l/cow)	3.19 (1.39)	3.26	3.13	*	3.33 a	3.30 a	2.94 b	**	3.32	3.36	3.09	3.34	3.21	2.85	NS
Days in milk (days/cow)	132.0 (77.8)	132.3	131.7	NS	126.7a	144.1b	121.6a	**	122.9 bc	138.9 b	135.2 b	131.0 b	151.2 a	112.9 c	**

Within the column, values marked with * and ** differ ($P<0.05$) and ($P<0.01$), respectively or the difference is not significant (NS).
Within the row, values marked with different letters a, b, c, differ significantly.

Laterality of lying behaviour

The effect of temperature on laterality (preference of one side of the body over another) of cows' lying down behaviour, milk yield, lactation number and days in milk are described in Table 3. The total number of observations was 1 037. The estimated milk yield was 7 910 kg milk (using the methodology of estimation by Kopec et al., 2013). The cows again produced significantly more milk in the hot period (by 3.1 kg) than in the cold period. The cows preferring lying on their left sides produced significantly more milk (by 0.9 kg) and were of higher lactation number than the cows showing preference for lying on their right sides. There was no difference among the stages of lactation. Cows showed preference for lying down on their left sides in both hot and cold periods. The combination of laterality and cowshed temperature showed that cows showing preference for lying on their left sides produced more milk in both periods. The interaction between temperature and laterality proved significant when compared to lactation number. Lactation number of cows showing preference for lying on their right sides was the greatest in H period and smallest in L period.

Row preference

Findings comparing milk yield, lactation number and days in milk in H and L periods and their row preference are shown in Table 4. Out of the total 1185 observations 594 were monitored in H period and 591 in L period. The milk yield per lactation was estimated (following the methodology by Kopec et al., 2013) to be 8 024 kg. Table 4 shows 418 cows standing or lying down in the cubicles in row A (closest to the feeding plateau), 377 cows in row B (the middle of the section) and 390 cows in row C (the peripheral row).

The tendencies were similar to those found in Tables 2 and 3. Milk yield was significantly greater during hot days (by 3.3 kg per cow) compared to cold days. The cows in rows A and B were older (greater consistency of production) than the cows in row C. The cows in row B were in later days in milk compared to the cows in rows A and C. There was no significant difference in milk yield per cow between the rows.

Interaction of both factors with row selection was greatest in row C – milk yield was the lowest in H period and highest in L period. The interaction between the two factors was also significant for lactation number and implied that in row C there were high-lactation number cows in H period and low-lactation number cows in L period.

Discussion

The findings of this study do not conclusively prove the anticipated negative impact of high temperatures on milk yield with Czech Fleckvieh cows. Findings do, however, suggest that high temperatures negatively affected milk yield in Holstein dairy cows, due to their greater sensitivity to heat stress (e.g. in Zejdová et al., 2011).

Increasing air temperature and humidity negatively affects dry matter intake (DMI) and subsequently milk yield declines (West, 2003). Igono et al. (1992) also

found that milk yield decreased with increasing temperatures and heat stress (above 21°C) compared to thermo-neutral conditions. This was in contrast with the findings of this study – that cows in the hot period (the average temperature 23.2°C) produced more milk. A similar trend was described by Zejdová et al. (2010) who claim that summer temperatures stimulate cows' metabolism and subsequently also milk yield, despite the fact that the cows might experience heat stress for some period of time (even for several days).

Cows spend on average 13 hours per day (h/d) lying down (Houpt, 1998). Tucker et al. (2004) specified the range between 9.4 and 14.7 h/d. In adverse conditions cows tend to spend more time standing than lying down, are more susceptible to health problems and produce less milk (Thorne, 2008). According to O'Driscoll et al. (2009) cows spend more time lying down in winter than in summer in any kind of housing arrangement. Vecera et al. (2012 a) also found greater numbers of cows lying down in colder periods compared to cows standing.

A non-significant tendency regarding the preference of left side corresponds with the results of Hrouz et al. (2007), who found that 53–70% of the observed cows preferred to rest on their left sides. Tucker et al. (2009) also observed left-side laterality in loose-housed dry cows; however, the authors admitted that cows in pens or on pasture may exhibit no laterality when lying down. Although the cows show no overall preference of side as a group, there might be strong individual preferences (Gibbons et al., 2012). Zejdová et al. (2011) reported that older cows (4th lactation and older) lay on the left side more often than younger cows (2nd and 3rd lactation).

A greater milk yield in cows preferring the left side (Večeřa et al., 2012 a) might be due to the anatomical differences in the left and right lung. A greater respiration capacity of the right lung allows better lung ventilation in cows lying on their left side. Presumably, there are more factors affecting laterality but the specific anatomy of adult ruminants is likely to be the main cause. This presumption was supported by Phillips (2002) who claimed that calves show no laterality because their rumen has not been developed and they are not forced to rest in the sternal position.

Večeřa et al. (2012b) reported that cows preferred row B (in the middle of the section) during cold days but during hot days they did not. This is contrary to the findings recorded in this study. In this study cows preferred the row B during hot days and during cold days the preference was for the row C (close to the side wall). Doležal (2003) observed the preference of the first row of cubicles close to the feeding plateau over the peripheral row close to the side wall. This tendency was also reported in the study of Gaworski et al. (2003).

To the contrary, Wagner-Storch et al. (2003) claimed that cows preferred the peripheral row presumably because the ventilation was better in that part of the cowshed. Natzke et al. (1982) observed that the central rows were preferred over the peripheral ones. Večeřa et al. (2011) noticed that the cows coming from the milking parlour, when given a choice, will choose the row closest to the feeding plateau and then the central row. Older cows preferred the central row close to the feeding plateau and then the central row (Večeřa et al., 2012 b).

Conclusions

The findings reported in this study suggest important variations in behaviour and milk yields of cows associated with high and low cowshed temperatures. Cows with a tendency to lying down were older (greater consistency) than the cows with a preference for standing and tended to produce more milk (a non-significant difference). Cows showing preference for lying down on their left sides produced more milk and were older than the cows lying down on their right sides. The cows resting in the peripheral row far from the feeding plateau were younger and produced the same amount of milk as the cows resting in other rows.

References

Bilek M. (2002). Welfare in barns for cattle (in Czech). Praha, Czech Republic, Ústav zemědělských a potravinářských informací, 1st ed., 32 pp.

Chládek G. (2004). Milk composition as a cheap and efficient tool for evaluation of housing facilities for dairy cows (in Czech). In Aktuální problémy řízení v chovu skotu, HANUŠ, O., Rapotín, Czech Republic, pp. 56–60.

Colam-Ainsworth P., Lunn G.A., Thomas R.C., Eddy R.G. (1989). Behaviour of cows in cubicles and its possible relationship with laminitis in replacement dairy heifers. Vet. Rec., 125: 573–575.

Doležal O. (2003). Evaluation of a four-row disposition of lying boxes using the method of preference testing (in Czech) [online], Available from: www.mze-vyzkum-infobanka.cz/Download-File/41757.aspx. (cit. 03/01/2012)

Drissler M., Gaworski M., Tucker C.B., Weary D.M. (2005). Freestall maintenance: Effects on lying behaviour of dairy cattle. J. Dairy Sci., 88: 2381–2387.

Erbez M., Boe K.E., Falta D., Chládek G. (2012). Crowding of dairy cows in a cubicle barn during the hot summer months. Arch. Tierzucht, 55: 325–331.

Fregonesi J.A., Tucker C.B., Weary D.M. (2007). Overstocking reduces lying time in dairy cows. J. Dairy Sci., 90: 3349–3354.

Gaworski M.A., Tucker C.B., Weary D.M. (2003). Effects of two free-stall designs on dairy cattle behavior. In International Dairy Housing Conference, American Society of Agricultural Engineers, St. Joseph, pp. 139–146.

Gibbons J., Medrano-Galarza C., Passille A.M., Rushen J. (2012). Lying laterality and the effect of Ice Tag data loggers on lying behaviour of dairy cows. Appl. Anim. Behav. Sci., 136: 104–107.

Hahn G.L. (1999). Dynamic response of cattle to thermal heat loads. J. Anim. Sci., 77: 10–20.

Houpt K.A. (1998). Domestic Animal Behaviour for Veterinarians and Animal SDcientists. 3rd ed. Ames: Iowa State University Press, 495 pp.

Hrouz J., Mácha J., Klecker D., Veselý P. (2007). Etologie hospodářských zvířat. Brno, Czech Republic, Mendel University in Brno, 1st ed., 185 pp.

Igono M.O., Bjotvedt G., Sanford-Crane H.T. (1992). Environmental profile and critical temperature effects on milk production of Holstein cows in desert climate. Int. J. Biometeorol., 36: 77–87.

Ito K., Weary D.M., Keyserling M.A.G. (2009). Lying behavior: Assessing within- and between-herd variation in free-stall-housed dairy cows. J. Dairy Sci., 92: 4412–4420.

Javorová J., Velecká M., Falta D., Večeřa M., Andrýsek J., Studený S., Chládek G. (2014). The effect of temperature and time of day on distribution of Czech Fleckvieh cows within the cowshed. Acta U. Agr. Fac. Silvi., 62: 117–124.

Kopec T., Chládek G., Kučera J., Falta D., Hanuš O., Roubal P. (2013). The effect of the calving season on the Wood's model parameters and characteristics of the lactation curve in Czech Fleckvieh cows. Arch. Tierzucht, 56: 808–815.

Koukal P. (2001). Nutrition of dairy cows during periods of hot weather, experiences from the summer of 2000 (in Czech). Farmář, 9: 75–76.
Matějka J. (1995). Temperature and humidity conditions for cattle stables in winter (in Czech). Náš chov, 12: 22–23.
Natzke R.P., Bray D.R., Everett R.W. (1982). Cow preference for free stall surface material. J. Dairy Sci., 65: 146–153.
O'Driscoll K., Boyle L., Hanlon A. (2009). The effect of breed and housing system on dairy cow feeding and lying behaviour. Appl. Anim. Behav. Sci., 116: 156–162.
Phillips C.J.C. (2002). Cattle Behaviour and Welfare. University of Cambridge, United Kingdom, Blackwell Science, 2nd ed., 264 pp.
Thorne M. (2008). Busy cows need comfort when they take a rest. Farmers Weekly (10/2008).
Tucker C.B., Weary D.M., Rushen J., Passillé A.M. (2004). Designing better environments for dairy cattle to rest. Adv. Dairy Technol., 16, p. 39.
Tucker C.B., Cox N.R., Weary D.M., Spinka M. (2009). Laterality of lying behaviour in dairy cattle. Appl. Anim. Behav. Sci., 120: 125–131.
Večeřa M., Falta D., Zejdová P., Polák O., Studený S., Chládek G. (2011). Selection of box row by dairy cows after the return from the morning milking (in Czech). In: MendelNet 2011 – Proceedings of International Ph.D. Students Conference, Škarpa P. (ed.), Brno, Czech Republic, 56 pp.
Večeřa M., Falta D., Chládek G., Máchal L. (2012 a). The effect of low and high barn temperatures on behaviour and performance of Holstein dairy cows. Acta Univ. Agric. et Silvic. Mendel. Brun., 6: 343–350.
Večeřa M., Studený S., Polák O., Zejdová P., Falta D., Chládek G. (2012 b). Effect of rank of lactation on the all-day preference of box row in dairy cows of the Czech Red Pied breed (in Czech). In: Animal Breeding, International Conference, Filipčík R., Lichovníková M., Falta D. (eds), Brno, Czech Republic, pp. 62–66.
Wagner-Storch A.M., Palmer R.W., Kammel D.W. (2003). Factors affecting stall use for different freestall bases. J. Dairy Sci., 86: 2253–2266.
West J.W. (2003). Effects of heat-stress on production in dairy cattle. J. Dairy Sci., 86: 2131–2144.
Zejdová P., Walterová L., Falta D., Chládek G. (2010). Summer temperatures of barn air and their effect on milk performance of dairy cows (in Czech). In: MendelNet 2010 – Proceedings of International Ph.D. Students Conference, Škarpa P. (ed.), Brno, Czech Republic, pp. 68.
Zejdová P., Falta D., Chládek G., Máchal L. (2011). Effect of lactation stage, its number, current milk performance and barn air temperature on laterality of Holstein dairy cows laying behaviour. Acta Univ. Agric. Silvic. Mendel. Brun., 5: 315–321.

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