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THE EFFECT OF TEMPERATURE AND TIME OF DAY ON WELFARE INDICES IN LOOSE-HOUSED HOLSTEIN COWS

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Abstract

VELECKÁ MILENA, JAVOROVÁ JANA, FALTA DANIEL, VEČEŘA MILAN, ANDRÝSEK JIŘÍ, CHLÁDEK GUSTAV. 2014. The Effect of Temperature and Time of Day on Welfare Indices in Loose-housed Holstein Cows. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis,* 62(3): 565–570.

This study was carried out with the aim to assess the effect of temperature and time of day on the values of welfare indices in Holstein dairy cows. The observation continued for one year and included 77 Holstein cows. The cows were loose-housed in one of the four sections of the barn with straw-bedded stalls. The cows were milked three times a day (at 4.00, 8.00 and 17.00). The barn is situated on Mendel University farm in Žabčice (the Czech Republic: GPS 49°0′51.786″N, 16°36′14.809″E). The air temperature was monitored with three sensors fitted at the level of the animals' whithers in 15-minute intervals. The following welfare indices were evaluated: CCI (the Cow Comfort Index), CCI* (the modified Cow Comfort Index which reflects the motivation to lie down), SSI (the Stall Standing Index) and PEL (the Proportion Eligible Lying). The maximal CCI values (above 90%) and the minimal SSI values (below 10%) were found (in the barn in Zabcice) at temperatures up to 30 °C. The maximal CCI* values (above 70%) only occurred at temperatures up to 20 °C. The maximal PEL values (above 80%) were detected at temperatures up to 25 °C. The maximal CCI values (above 90%) as well as the minimal SSI values (below 10%) were found in the period between 9.00 and 12.00 (+1 to +3 hours after milking). The maximal PEL values (above 80%) occurred in the period between 9.00 and 16.00 (+1 to +8 hours after milking). The maximal CCI* values (above 70%) were detected between 14.00 and 15.00 (+6 to +7 hours after milking). CCI* index appears to be more eligible for welfare assessment compared to CCI index. This study could have a practical impact on cattle husbandry because it may help the farmers secure adequate husbandry conditions for the animals and thus positively affect milk production.

Keywords: Cow Comfort Index, Stall Standing Index, Proportion Eligible Lying, temperature, Holstein cows

INTRODUCTION

Welfare of an animal is its state as regards its attempts to cope with its environment. Welfare is defined as a state of an organism when all the material and non-material needs, which underlie good health, are fulfilled, and the animal is in harmony with the environment (Doležal, Bečková, 2008). Cow's well-being is an emotional state; in other words, it reflects how the cow feels (Ito, 2009). Good comfort makes milk. Cows that are comfortable will experience less stress, eat more, have less health problems, and be injured less. Cows should be eating, drinking, milking, or lying down. If the stall comfort is a problem, cows spend more time standing (de Ondarza, 2000). Cow welfare is one of the basic prerequisites of success on large-scale dairy farms. One of the most important factors influencing the cows' welfare is the microclimate in the barn (Knížková *et al.*, 1999). Cattle, being homoiothermic animals, keep constant body

temperature, therefore their physiological functions are independent of changes of the environmental temperature. However, the body temperature is only relatively constant. Extreme temperature changes may cause hypo- or hyperthermia (Brestenský, Mihina, 2006). Adult cattle tolerate low temperatures quite well but have difficulties tolerating high environmental temperatures (Illek *et al.*, 2007). High temperatures decrease energy intake in feed, leading to its deficiency in an organism and milk production declines (Brestenský, Mihina, 2006). Research has shown that milk production generally drops at temperatures above 24 °C by 10–35% compared to the annual average (Doležal, 2009).

Welfare of animals is difficult to assess because it is not measurable by a single apparatus. Therefore, various indices have been developed, based on microclimatic characteristics or incidence of particular behaviour to describe welfare of animals. We used the following indices to assess cows' welfare:

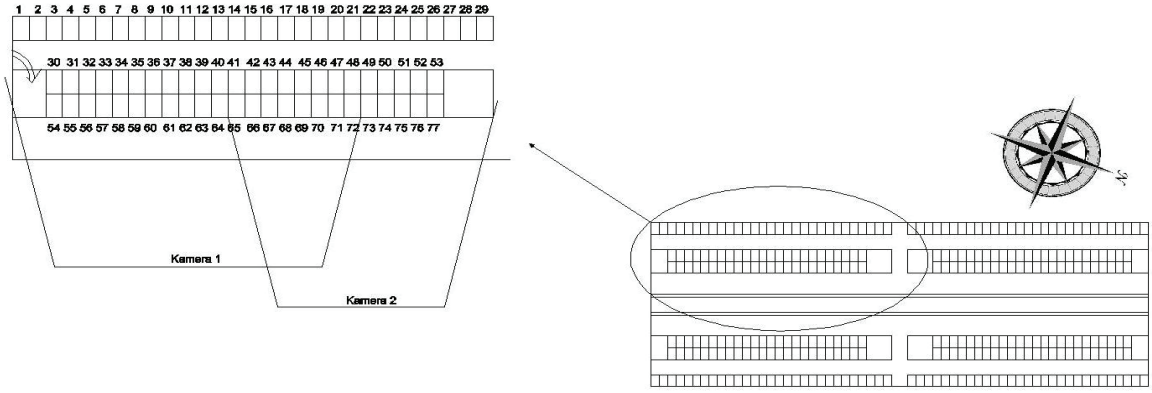
- Cow Comfort Quotient (CCQ) (now more commonly called the Cow Comfort Index (CCI)) was developed in the '90s but, throughout the last 10 to 20 years, people have used it quite extensively (Grant, 2009). CCI is defined as cows lying properly / cows either lying or standing in stall (Nelson, 1996). The advantage of the CCI is that it estimates motivation to enter a free-stall and lie down and is useful for both free-stall and tie-stall barns. On the other hand, the disadvantage of the index is that it does not measure the amount of time the cow spends lying down. Well managed free-stall systems should have a CCI greater than 85 percent. It remains useful as a simple index of stall comfort but we must understand that is it not related to actual lying down time (Grant, 2009).
- Modified Cow Comfort Index (CCI*), unlike CCI, specifies the number of cows motivated to lie down out of the total number of cows in the section (not only those lying down in boxes, as it is in CCI). CCI* is only applicable in free-stall housing systems.
- Stall Standing Index (SSI) was developed a few years ago at the University of Wisconsin in an effort to improve upon the CCI (Grant, 2009). The author used the Index of Stall Usage, now called the Stall Standing Index (cows standing with two or four feet in a stall / number of cows touching a stall) which is essentially the inverse of the CCI or CCQ (Cook *et al.*, 2004). Unlike the CCI, the SSI is actually associated with increased standing time. Knowing when cows are spending too much time standing is important because of the strong positive relationship between standing and greater incidence of lameness. In well managed herds, the SSI should be less than 15 to 20 percent and an SSI greater than 20 percent is associated with standing time in excess of two hours per day and lameness problems (Grant, 2009).
- Proportion Eligible Lying (PEL) = Stall Usage Index (SUI) was developed by California researchers to assess the proportion of cows within a pen that are lying down divided by the cows within a pen who are not actively feeding. The PEL accurately reflects cow comfort within an overcrowded pen and reflects cows that are "wasting time" idling in alleys waiting for a stall to become available. Well managed herds should have a PEL of greater than 75 percent (Grant, 2009).

Use of these simple tools does not replace more in-depth analysis of comfort and stall design on a dairy operation (Grant, 2009). Practical experience have revealed that high temperatures induce changes in behaviour of cows (Doležal *et al.*, 2010). All indices of cow comfort are measured when cows are most motivated to lie down, typically one to two hours after milking or approximately two hours before milking (Grant, 2009). It is likely, that the values of indices do not stay constant throughout the day but vary with the time of day or changing temperature. The aim of this work was to assess the effect of temperature and time of day on the values of welfare indices in Holstein dairy cows.

MATERIALS AND METHOD

The observation was carried out on the University farm in Žabčice (49° 0′ 43″ N, 16° 36′ 8″ W; 182 m.a.s.l.). The experimental group included Holstein dairy cows with milk performance of 9 500 kg of milk per lactation. They were housed in one of the four sections of a new free-stall barn with bedded stalls. The total capacity of the new barn was 308 cows. The barn was rectangular, with longer walls equipped with blinds which were only drawn in extreme weather. They were fully open most of the days of year. A gabled roof was equipped with transparent panels and a ridge ventilation slit. The barn was divided into four identical sections, each of which could house up to 77 cows. The stalls formed three rows. The longest row (29 stalls) was located next to the side wall. The medium row consisted of 24 stalls; the third row (24 stalls) was positioned most centrally, opposite the feeding passage which ran through the centre of the barn.

The cows housed in the experimental section produced a minimum of 25 l milk per day and were in their second or later lactation. The housing conditions and diet (TMR – total mixed ration) were identical for all cows. The feed was provided on the feeding table twice a day (8.00 and 17.00). If it got out of reach of the cows, it was shovelled back. The cows left the barn for milking only (at 4.00, 8.00 and 17.00). Manure was scraped and the stalls were bedded once a day (at about 2.00). Straw was used as a bedding material. The observation continued for the period of one year in seven-day intervals – the cows were monitored once in seven days (from 7th June 2011 to 26th June 2012). The images were captured in 60-minute intervals. There were two IP cameras fitted at the ceiling of the barn and each of them monitored more than a half of the section,



1: *Layout of the housing facilities – the experimental section*

so their scopes overlapped. The observed activities were as follows:

→ lying down → in the stall
→ in the alley

→ standing → in the stall
→ in the feeding area
→ in the alley

The cow "lying down in the stall" was a cow whose body, either whole or the greater part of it, was present in the stall. All other lying cows fell into the category "lying down in the alley". The incidence of such cases was very low. Feeding cows were included into the category "standing in the feeding area". If the cows were standing with the whole body or a greater part of it in the stall, they fell into the category "standing in the stall". The cows standing in the alley, either fully or with the greater part of the body, were included into the category "standing in the alley". The data were analysed using Microsoft Excel 2010 programme and the statistical analyses was carried out using STATISTICA 8.0. programme.

Welfare indices were calculated as:

- Cow comfort index:

$$CCI\ (\%) = \frac{\text{cows lying}}{\text{cows either lying or standing in stall}} \times 100.$$

- Cow comfort index*:

$$CCI^*\ (\%) = \frac{\text{cows lying}}{\text{cows either lying or standing in barn}} \times 100.$$

- Stall standing index:

$$SSI\ (\%) = \frac{\text{cows standing}}{\text{cows either lying or standing in stall}} \times 100.$$

- Proportion eligible lying:

$$PEL\ (\%) = \frac{\text{cows lying}}{\text{cows in stall – cows in feeding area}} \times 100.$$

RESULTS AND DISCUSSION

The effect of temperature and time of day on the values of Cow Comfort Index (CCI) is described in Tab. I. The mean CCI values mostly exceeded 90% which is by 10% higher than optimal,

I: *The effect of temperature and time of day on values of the Cow Comfort Index*

Cow comfort index (%)								
Hour after milking	Barn airspace temperature (°C)							
	Hour of day	less than 4.99	5–9.99	10–14.99	15–19.99	20–24.99	25–29.99	above 30
0	8	90.62	**92.71**	89.5	89.39	90.35	-	-
1	9	94.35	**96.33**	92.55	92.32	93.46	90.74	-
2	10	90.03	89.65	**92.91**	84.73	92.04	92.58	-
3	11	**96.43**	93.55	93.3	89.56	90.95	88.14	68.75
4	12	90.28	91.46	**95.33**	89.67	88.57	89.68	79.25
5	13	89.09	**92.81**	92.69	89.72	88.95	87.4	66.25
6	14	90.03	87.77	88.43	**91.72**	75.8	73.4	57.05
7	15	**92.53**	92.05	90.54	86.07	86.51	84.46	71.35
8	16	**92.51**	94.01	90.68	73.94	89.26	80.04	66.23
9	17	91.67	91.26	90.31	**91.77**	88.42	81.92	55.95

Underlined – maximum value in the column, bold – maximum value in the line, shaded – optimal value of CCI

according to Grant (2009). The data in Tab. I also show that such high CCI values were found at all temperatures up to 30 °C including temperature above 25 °C which are considered to be too high by Knížková and Knížek (1995). At such temperatures, a cow starts using the energy for cooling (Hulsen, 2005). Voigt *et al.* (2007) claim that the optimum value can only be considered if measured one to two hours after milking. At this time, the cows are the most strongly motivated to enter the stall and lie down (Grant, 2009). We found the maximum CCI values in the period between 9.00 and 12.00 (+1 to +3 hours after milking) which corresponds with the results of Voigt *et al.* (2007). We can conclude that our results backed up the argument of Cook *et al.* (2005) that the timing of measurement is important.

The effect of temperature and time of day on values of the modified Cow Comfort Index (CCI*) is described in Tab. II. According to Nehasilová (2006), the optimal values at resting time are greater than 80%. However, Doležal (2013) considers values exceeding 90% to be optimal. Our maximum CCI* values exceeded 70% but only at temperatures up to 20 °C. These temperatures fall within the thermoneutral zone which stretches between 13 and 16 °C, according to Toufar and Dolejš (1996). Behavioural changes caused by exceeding of the thermoneutral limits were described by Igono *et al.* (1987) who found out that the cows spent a considerable part of the day standing rather than lying down. Only about 55% of stalls were occupied on hot days which is by 20% less compared to cold days (Michal, 2006). Zejdová and Chládek (2012) studied this issue in detail and came to the conclusion that the cows reduced their lying down time by 25% and prolonged their standing time by 70%. A dairy cattle keeper should monitor the lying-down time in the stalls throughout the day (Doležal, 2013). Our maximum CCI* values were found between 14.00 and 15.00 (+6 to +7 hours after milking), similarly to Doležal (2013) who extended the time range up to 10.30–14.30.

The effect of temperature and time of day on the Stall Standing Index (SSI) is described in Tab. III. Most SSI values did not exceed 10%. According to Grant (2009) the optimal value is by

II: *The effect of temperature and time of day on values of the modified Cow Comfort Index*

Cow comfort index* (%)								
Hours after milking		Barn airspace temperature (°C)						
	Hour of day	less than 4.99	5–9.99	10–14.99	15–19.99	20–24.99	25–29.99	above 30
0	8	25.54	**58.6**	38.1	35.79	25.97	-	-
1	9	64.34	59.85	67.97	**70.72**	65.37	63.64	-
2	10	**61.04**	60.39	58.59	53.43	**61.04**	57.14	-
3	11	53.1	56.85	**62.34**	60.39	57.94	53.25	31.12
4	12	59.09	59.42	**64.68**	64.01	60.23	62.99	49.35
5	13	61.04	62.5	**66.49**	61.04	57.95	59.03	37.66
6	14	66.23	65.32	64.65	**72.51**	49.51	46.75	22.73
7	15	70.13	71.56	**72.29**	55.66	53.25	52.49	33.12
8	16	**50.22**	46.1	37.45	27.27	38.03	32.68	21.21
0	17	3.68	9.48	**37.11**	33.77	9.09	9.09	22.08

Underlined – maximum value in the column, bold – maximum value in the line

III: *The effect of temperature and time of day on values of the Stall Standing Index*

Stall standing index (%)								
Hour after milking		Barn air temperature (°C)						
	Hour of day	less than 4.99	5–9.99	10–14.99	15–19.99	20–24.99	25–29.99	above 30
0	8	9.38	**7.29**	10.5	10.61	9.65	-	-
1	9	5.65	**3.67**	7.45	7.68	6.54	9.26	-
2	10	9.97	10.35	**7.09**	15.27	7.96	7.42	-
3	11	**3.57**	6.45	6.7	10.44	9.05	11.86	31.25
4	12	9.72	8.54	**4.67**	10.33	11.43	10.32	20.75
5	13	10.91	**7.19**	7.31	10.28	11.05	12.6	33.75
6	14	9.97	12.23	11.57	**8.28**	24.2	26.6	42.95
7	15	**7.47**	7.95	9.46	13.93	13.49	15.54	28.65
8	16	7.49	**5.99**	9.32	26.06	10.74	19.96	33.77
9	17	8.33	8.74	9.69	**8.23**	11.58	18.08	44.05

Underlined – minimum value in the column, bold – minimum value in the line, shaded – optimum value of SSI

IV: *The effect of temperature and time of day on values of the Proportion Eligible Lying*

Proportion Eligible Lying (%)								
Hours after milking	Hour of day	Barn air temperature (°C)						
		less than 4.99	5–9.99	10–14.99	15–19.99	20–24.99	25–29.99	above 30
0	8	69.2	**76.77**	70.57	72.38	69.65	-	-
1	9	74	82.14	79.74	78.48	**85.86**	72.32	-
2	10	71.77	63.3	**79.93**	62.77	70.58	73.96	-
3	11	83.82	61.04	81.13	**84**	78.46	72.93	57.89
4	12	81.11	83.44	**86.24**	81.54	78.95	70.56	53.28
5	13	81.26	**84.5**	83.54	81.7	76.09	72.51	40.52
6	14	79.67	78.83	73.36	**84.17**	59.25	59.02	30.14
7	15	**85.86**	84.2	82.05	75.26	68.95	60.5	48.23
8	16	**84.5**	83.95	76.14	60.74	54.4	42.99	36.03
9	17	**65.22**	41.56	60.87	57.33	33.56	31.25	35.83

Underlined – minimum value in the column, bold – minimum value in the line, shaded – optimum value of PEL

5% greater. However, SSI values exceeding 24% are undesirable because they are often associated with lameness (Cook *et al.*, 2004). Our SSI values fell within the optimal range, until the temperature in the barn rose to 30 °C. On hot days cows frequently rest standing. Zahrádková *et al.* (2009) explains this behaviour by a theory that a cow's body surface is greater while standing compared to lying down which facilitates cooling. Doležal (2010) identified this behaviour as one of the typical signs of heat stress. Minimum SSI values were found between 9.00 and 12.00 (+1 to +3 hours after milking) which corresponds with the results of Stone (2006).

The effect of temperature and time of day on the Proportion Eligible Lying (PEL) is described in Tab. IV. Our PEL values were mostly greater than 80% which is by 5% more than the optimum defined by Grant (2009). Such high PEL values were found at all temperatures up to 25 °C which corresponds with the results of Zejdová and Chládek (2012). With growing temperature (above 25.1 °C) the proportion of cows lying down decreased and cows standing up increased which diminished PEL values (down to 58.5%, measured one hour after milking). This indicates that the cows experienced discomfort at that time. The maximal values were found in the period between 9.00 and 16.00 (+1 to +8 hours after milking) which corresponds with the results of Lendelová *et al.* (2012). They found out that PEL values were lower two hours before the evening milking than the values detected one hour before milking which was likely due to the fact that the cows were standing in the alleys closer to the milking time waiting for milking.

CONCLUSION

The observation, which continued for one year, was designed with the aim to analyse the effect of temperature and time of day on welfare indices in Holstein cows. The evaluated welfare indices were the Cow Comfort Index (CCI), the modified Cow Comfort Index (CCI*), the Stall Standing Index (SSI) and the Proportion Eligible Lying (PEL). The research has shown that the heat stress (temperatures above 20 °C) negatively affected cows' behaviour and consequently the values of the welfare indices in Holstein cows. The optimal values of the welfare indices were found at times of day which mostly agreed with, but some also differed from the times suggested by the authors of these indices. Therefore it is important to consider the time of observation when assessing welfare indices. This study could have a practical impact on cattle husbandry because it may help the farmers secure adequate husbandry conditions for the animals and thus positively affect milk production.

SUMMARY

The aim of this work was to assess the effect of temperature and time of day on the values of welfare indices in Holstein dairy cows. The observation was carried out on the University farm in Žabčice (49° 0′ 43″ N, 16° 36′ 8″ W; 182 m.a.s.l.) in the course of one year. The experimental group consisted of 77 Holstein dairy cows in various lactations which were loose-housed in a barn with straw-bedded stalls. The cows were monitored using IP cameras which captured images every 60 minutes for the whole day once a week. The data on cows' behaviour (lying down, standing) and their position (stall, feeding area, and alley) were collected throughout the test day and were used for calculation of the welfare indices. The evaluated welfare indices were the Cow Comfort Index (CCI), the modified Cow Comfort Index (CCI*), the Stall Standing Index (SSI) and the Proportion Eligible Lying (PEL). The maximal CCI values (above 90%) and the minimal SSI values (below 10%) were found (in the barn in Žabčice) at temperatures up to 30 °C. The maximal CCI* values (above 70%) occurred at all temperatures up to 20 °C. The maximal PEL values (above 80%) were detected at temperatures up to

25 °C. The maximal CCI values (above 90%) as well as the minimal SSI values (below 10%) were found in the period between 9.00 and 12.00 (+1 to +3 hours after milking). The maximal PEL values (above 80%) occurred in the period between 9.00 and 16.00 (+1 to +8 hours after milking). The maximal CCI* values (above 70%) were detected between 14.00 and 15.00 (+6 to +7 hours after milking). It seems that CCI* index is more eligible for welfare assessment compared to CCI index. The welfare indices are affected by temperature and time of day, therefore it is advisable to keep records of time and air temperature when assessing the indices (except the PEL). In our study, the optimal values of welfare indices were found at times of day which mostly agreed with, but some also differed from, the times suggested by the authors of the indices.

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