

**Pest flies on dairy farms affect behaviour and welfare of dairy cows during summer season**

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Department of Animal Protection and Welfare and Veterinary Public Health, Brno, Czech Republic*Received January 13, 2021**Accepted August 31, 2021***Abstract**

Monitoring of changes in the behaviour of dairy cows related to the occurrence of insects in the stable and in the milking parlour was carried out on a selected dairy farm during the summer season. The effect of the number of insects on the occurrence of huddling of dairy cows in the stable was proved. Huddling occurred significantly ( $P = 0.003$ ) more often when the number of insects captured by fly glue traps exceeded 500 individuals. The occurrence of pest flies affected also the behaviour of dairy cows during milking. With the increasing number of insects captured by glue traps in the milking parlour, the cows more frequently kicked off the milking units ( $r = 0.944$ ,  $P < 0.001$ ) and defecated ( $r = 0.940$ ,  $P < 0.001$ ) during milking. In addition, the increasing number of captured insects correlated with a significantly lower milk yield in cows ( $r = -0.709$ ,  $P < 0.001$ ). The number of insects in the stable also correlated with the incidence of mastitis in dairy cows on the monitored farm ( $r = 0.681$ ,  $P < 0.001$ ) during the summer season. The study shows that pest flies affect the behaviour of cows which is further reflected in their health, milk production and thus the overall farm performance.

*Cattle, milk production, fly infestation, huddling, bunching, stress*

Exposing animals to stress compromises their welfare. Various studies have focused on the assessment of stress and welfare in farm animals (Nečasová et al. 2019; Píšířková et al. 2019; Večerková et al. 2019; Večerek et al. 2020, 2021). Increasing summer temperatures present one of the stressors for livestock (Autukaite et al. 2020). During the summer months, however, cattle is also exposed to another stress factor which is insect pests. The occurrence of insects on dairy farms is a recurring problem for cattle farmers every year. The most common nuisance insects in dairy stables are flies. They annoy livestock and have an impact on their behaviour; moreover, they can also transmit diseases and reduce production performance (Mullens et al. 2006; Taylor et al. 2012).

The most common insect species annoying cattle in stables include representatives of the order Diptera, namely houseflies (*Musca domestica*) and stable flies (*Stomoxys calcitrans*). The stable fly is one of the biting flies that feed on blood causing high stress and elevated cortisol levels in host animals, which can affect the health, performance, and welfare of cattle (Vitela-Mendoza et al. 2016). Taylor et al. (2012) found that high activity of adult stable flies causes lower feed intake, weight loss, increased stress and lower milk production. The reduced feed intake and increased stress or cortisol levels can reduce milk production by 20 to 30 percent (Choudhary et al. 2019). The decrease in production continues for weeks or months after the end of the fly season. Control during the four months of the fly season can therefore positively affect a period of six months or even longer (Bruce and Decker 1958). As stable flies mechanically and chemically damage the skin surface due to enzymatic activity, they cause pain in the infested area, local infections and reduce the host's immunity (Baldacchino et al. 2013). Lesions on the teat may be a predisposing factor for the development of a disease (Bramley et al. 1985). In animals attacked by flies, it is possible to observe attempts to get rid of the flies by specific

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behaviour including head tossing, skin twitching, ear trembling, tail flicking, leg lifting and kicking into the abdomen (Schmidtman and Valla 1982; Wall and Shearer 1997; Cortinas and Jones 2006; Mullens et al. 2006; Gerry et al. 2007; Williams 2010). Furthermore, animals group together to avoid being bitten by insects (Schmidtman and Valla 1982; Hart 1992; Wieman et al. 1992; Cornitas and Jones 2006).

The presence of flies has a negative effect on the health and overall well-being of animals but also their caregivers. Large numbers of flies make it difficult to work on farms. Stress caused by the presence of insects makes handling difficult during milking and thus also affects the quality of milking, which may be related to the occurrence of mammary gland diseases. Vitela-Mendoza et al. (2016) found that plasma cortisol concentrations are linearly related to fly numbers and defense behaviour (fly-dislodging). Since dairy cows tend to group together as a reaction to stinging and biting insects, the effect of heat stress increases (Mullens and Meyer 1987; Campbell et al. 1993; Erbez et al. 2012). Lactating dairy cows are particularly sensitive to heat stress due to milk production elevating metabolism (Polsky and von Keyserlingk 2017). Therefore, it is important to deal not only with heat stress caused by rising temperatures during the day but also with the issue of insect pests whose activity typically increases with a higher ambient temperature (Taylor 1963).

The aim of the study was to assess changes in the behaviour of dairy cows related to the number of insects captured by fly glue traps in the stable and in the milking parlour. Furthermore, the effect of the presence of insect pests on the milk production and incidence of mastitis was evaluated.

### Materials and Methods

The monitoring was carried out on a selected dairy farm in the Czech Republic in the summer season. The number of dairy cows (Czech Spotted cattle) on the farm was approximately 120. The stable was brick and provided litterless housing with elevated lying boxes with automatic removal of manure from manure corridors with the frequency of removal every 2 h. The stable was divided into three sections, each of which had up to 40 dairy cows. The milking parlour was herringbone with a capacity of 2 × 5 milking stalls. The waiting area was directly connected to the stable. Cow milking took place twice a day and was carried out by two workers, one of whom was milking and the other was moving cows. Dairy cows were fed a mixed feed ration twice a day in a feeding trough. Water was provided by waterers with float drinkers located in the outer passages. The cows were supplied with mineral lick *ad libitum*. Cow scratching brushes with vertically and horizontally placed brushes were available in the stable, one in each section.

The effect of the number of insects on the behaviour of dairy cows in the stable was evaluated on the basis of the occurrence of huddling, i.e. cows grouping together in a characteristic position with their heads to the centre of the group and their tails to the outside. The occurrence of huddling was monitored in one of the three sections of the stable, which was divided into three equally large sectors (A, B, C – marked in the direction from the stable entrance; Fig. 1). The behaviour was monitored in a group of 40 dairy cows, which were observed every day for 14 days, always two hours after the end of morning milking (from 10 am to 12 am) and two hours before the start of afternoon milking (from 1:30 pm to 3:30 pm). The monitoring was carried out at the turn of July and August. The presence or absence of huddling behaviour was recorded for each day of observation. The insect infestation in the stable was evaluated on the basis of the number of insects captured by fly glue traps. Every day, during the period of monitoring the behaviour of dairy cows in the stable, three fly glue traps (Muskaset fly glue trap 11 × 32 cm) were installed in the stable, namely one at each end (sectors A and C) of the stable section and one into its centre (sector B). The fly glue traps were placed above the feeding trough to a height of 2 m. Removal and counting the number of insects on fly glue traps took place every 24 hours. A total of 42 fly glue traps were used (3 fly glue traps every day for 14 days).

Section 1			Section 2	Section 3
Sector A	Sector B	Sector C		
Feeding trough				

Fig. 1. Scheme of the stable floor plan.

The effect of the number of insects on the behaviour of dairy cows in the milking parlour was evaluated during milking. In the milking parlour, at the beginning of milking a Muskaset fly glue trap of 11 × 32 cm was always installed to the height of two metres from the floor on the milk pipeline transferring milk to a bulk tank and then removed after milking. During 14 observations (7 during morning milking and 7 during afternoon milking), the number of insects captured by the fly glue trap was determined and at the same time the number of cases of cows kicking off the milking units during milking and the incidences of defecation in the milking parlour were recorded as signs of stress during milking.

The data on the performance of dairy cows and the incidence of mammary gland inflammation during the summer season (May to September) were obtained from the farmer's records and compared with the insect infestation in this period. The number of insects in the stable was counted at weekly intervals. Muskaset fly glue traps of 11 × 32 cm were installed at the entrance (Section 1), in the middle area (Section 2) and in the back of the stable (Section 3) to a height of 2 m above the feeding trough. After 24 h, the fly glue traps were removed and the number of insects on the traps were counted. During the monitored period, a chemical insecticide was applied by spraying at monthly intervals for insect control.

The results were statistically analyzed using the statistical package Unistat 6.5. (Unistat Ltd., United Kingdom). The differences in the frequency of the categorical variables of interest (the number of insects in the sectors, the frequency of huddling of cows and the incidence of mastitis) were tested on the basis of a chi-square test within the  $k \times m$  and  $2 \times 2$  contingency table procedures (Zar 1999). When the frequencies in the contingency table were lower than 5, Fisher's exact test was used instead of a Chi-square test. The dependencies between the continuous variables monitored (the number of insects, the frequency of kicking off the milking unit, the frequency of defecation, mean daily milk production, the incidence of mastitis) were analyzed using Pearson's (for normal data) and Spearman's (for non-normal data) correlation coefficients along with their significance. A  $P$ -value  $< 0.05$  was considered significant.

## Results

Huddling was observed 9 times during the monitoring of cow behaviour in the stable, occurring always in the afternoon and only in sector C. Huddling was never observed during the morning observation periods. Huddling of dairy cows correlated with the number of insects. Huddling of dairy cows occurred significantly ( $P = 0.003$ ) more often when the number of insects captured by fly glue traps exceeded 500 individuals. The numbers of insects captured by fly glue traps varied in the individual sectors of the monitored stable section (Fig. 2). The highest numbers of insects were captured in Sector A, i.e. at the beginning of the stable and the lowest in Sector C, which was at the end of this section of the stable. A significant ( $P < 0.001$ ) difference in the number of captured insects was found between all sectors (A, B, C). Dairy cows huddled in Sector C, where the fewest insects were captured. Dairy cows moved from Sectors A and B, where there were more ( $P < 0.001$ ) insects, to Sector C where they huddled together.

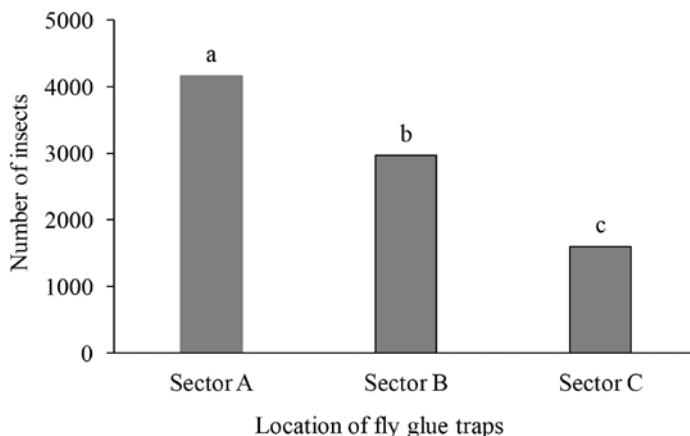


Fig. 2. Total number of insects captured in individual sectors of the monitored stable section. a,b,c - values in columns with different superscripts differ ( $P < 0.001$ ).

The occurrence of pest flies affected also the behaviour of dairy cows during milking. With the increasing number of insects captured by the fly glue traps in the milking parlour, cows more frequently kicked off the milking units ( $r = 0.944$ ,  $P < 0.001$ ) and defecated ( $r = 0.940$ ,  $P < 0.001$ ) during milking.

A comparison of the number of insects captured by fly glue traps in the stable, daily milk production and the incidence of mastitis during the summer season is given in Table 1. A negative correlation between the number of insects in the stable and cow performance was found. The increasing number of captured insects correlated with a significantly lower milk yield in cows ( $r = -0.709$ ,  $P < 0.001$ ). The number of insects in the stable also correlated ( $r = 0.681$ ,  $P < 0.001$ ) with the incidence of mastitis in dairy cows on the monitored farm during the summer season.

Table 1. Number of insects captured by fly glue traps in the stable and the milk production and incidence of mastitis during the summer season.

Date	Number of insects captured	Mean daily milk production per cow (l)	Number of cows with mastitis (%)
06 May	0	24.4	0.94
13 May	2	24.6	0.00
20 May	12	25.0	2.27
27 May	13	24.5	2.17
03 June	7	24.6	0.62
10 June	5	25.1	0.99
17 June	10	26.2	1.61
24 June	18	24.7	1.57
01 July	49	24.7	1.63
08 July	54	25.2	1.94
15 July	86	24.9	1.62
22 July	111	24.7	1.30
29 July	127	24.0	2.59
05 August	177	24.2	0.99
12 August	307	23.2	2.86
19 August	533	23.7	1.91
26 August	618	24.0	2.18
02 September	324	23.8	3.15
09 September	348	22.9	2.14
16 September	654	23.6	2.45
23 September	804	23.3	2.54

## Discussion

In the spring and early summer, flies maximize their numbers which leads to serious problems with welfare and productivity of cattle (Taylor et al. 2012). Our results show that the behaviour of dairy cows in the stable and in the milking parlour is significantly affected by the occurrence of pest flies. With a higher number of insects in the stable, the cows huddle into a specific formation which allows them to drive away insects more efficiently. Duncan and Vigne (1979) and Mooring and Hart (1992) found that animals in larger groups have fewer flies around than individuals in smaller groups. King and Gurnell (2010) suggested that flies may be responsible for social grouping in several species, such as feral horses (*Equus ferus caballus*), caribou (*Rangifer tarandus*), and red

deer (*Cervus elaphus*). According to Wall and Shearer (1997) and Williams (2010), occasional attacks by a small number of individuals are not an issue that significantly affects the welfare of animals but the problem occurs when animals are infested with tens to hundreds of ectoparasites. In such cases, animals tend to group together to help one another to drive away insects (Schmidtman and Valla 1982; Hart 1992; Wieman et al. 1992; Cortinas and Jones 2006). In our study, there was a significantly higher frequency of huddling when the numbers of insects captured by fly glue traps exceeded 500 individuals.

Erbez et al. (2012) monitored the crowding of dairy cows in a cubicle barn during hot summer months. They found that while dairy cows were distributed quite evenly among sectors when air temperatures inside the barn ranged from 5 °C to 11 °C, crowding began to appear when the average daily temperatures increased to 20 °C. On hot days, dairy cows moved into one section of the cubicle barn and the crowding apparently became more intense as temperatures increased. The authors could not explain why the cows preferred to huddle together in sector A and not in sectors B or C. However, they reported that this behaviour was observed on a number of farms. The results of our study suggest that this behaviour may be related to varying numbers of insects in different parts of the stable. According to our observations, dairy cows move from places with a higher number of insects to places where there are fewer of them and they huddle together there. Thus, the defense against insects is primarily moving to places where there are fewer annoying insects but if cows are still being bothered by insects there, they will huddle together. Mullens and Meyer (1987) reported that insect activity depends on environmental conditions with a maximum at temperatures of 24–30 °C. This is also in accordance with our results as huddling was observed exclusively in the afternoon, probably in connection with an increase in temperature and thus higher insect activity.

Huddling of dairy cows in the stable occurred during the period when daily temperatures exceeded 25 °C, which is in conflict with the natural need for behavioural thermoregulation. Huddling together is one of thermoregulatory behaviours that allows the body to reduce heat loss at low ambient temperatures; it was observed e.g. in pigs (Boon 1981) and in sheep (Bøe 1990). Conversely, huddling increases heat stress and the risk of injury as animals jockey for position (Campbell et al. 1993). To maximize heat loss, cattle increase the surface area of their body for heat dissipation by standing (Igono et al. 1987; Anderson et al. 2013; Smith et al. 2016). In contrast, in the presence of annoying insects, they huddle together to reduce the surface of the body accessible to insects. It is therefore disadvantageous for cattle to huddle together under high temperatures. The results of our study suggest that cattle perceive insect nuisance as an issue that has a more significant effect on their welfare than heat stress.

Another example of natural thermoregulatory strategies is the reduction of feed intake, as heat is produced during digestive microbial processes in the rumen (Beatty et al. 2008). Cows under heat stress, on the other hand, try to increase the fluid (water) content in the rumen which is due to the acceleration of water metabolism (Silanikove 1992). In our study, as a result of huddling the cows could neither feed nor drink. The reduction in water intake was also caused by blocking access to the drinking troughs in Sector C by huddled cows. The drinking troughs in Sector A were used minimally as the cows did not stay there likely due to the higher numbers of insects in this part as shown by our results. Thus, huddling can significantly contribute to the increase of heat stress not only due to the body heat of huddled cows but also due to the limitation of other thermoregulatory strategies (individual standing, water intake).

Our results show that increasing numbers of insect pests affect also the behaviour of dairy cows in the milking parlour, i.e. cows more frequently kick off the milking units and defecate during milking. Defecation is a specific sign of stress during milking (Friend 1991).

Acute stress during milking reduces milk production through central inhibition of oxytocin secretion and subsequently inhibits milk ejection and increases residual milk (Rushen et al. 2001; Tančín and Bruckmaier 2001). Kicking off the milking unit during milking can lead to incomplete milking. When observing the work of the milkers, we noticed that the cows that had kicked off the milking unit had not been put back on and milking was not completed. Incomplete udder emptying can lead to pathological changes (Borell 2001). Stress caused by the presence of insect pests during the summer season leads to inhibition of milk ejection and, together with incomplete milking due to the defensive behaviour of dairy cows, may affect the increase in the number of cases of mastitis detected during the summer months.

However, the presence of insects itself and the absence of their control contribute to the infection of the mammary gland of dairy cows (Oliver et al. 2005). Ryman et al. (2013) found a relationship between the number of insects and prevalence of intramammary infections in cows. Nickerson et al. (1995) found that there were fewer cases of mastitis on farms where some kind of insect control was provided compared to farms without this measure. Foster et al. (2007) pointed out that flies are important vectors of infectious pathogens predisposing to mastitis through immediate teat contact or through teat injury. Thus, insect infestation can affect the number of cases of mastitis directly by contact, but also indirectly, as it makes milking difficult for milkers and it is often not possible for them to milk nervous cows completely. Our results also confirm the increased incidence of clinical mastitis during the summer season in connection with the increase in the number of insects in the stable. Concurrently, the increased number of insects correlated with the decrease in average milk yield in dairy cows. Accordingly, Gerry et al. (2007) reported a decrease in milk production by cows of up to 1.49 kg per day when attacked by stable flies.

In conclusion, the welfare of dairy cows is significantly affected by the presence and number of insect pests in the stable and in the milking parlour during the summer season. The presence of insect pests affects not only the welfare of cows but also their behaviour which is further reflected in their health, milk production and thus the farm performance. It is important not only to monitor the number of insects in the stable, but also to perform timely disinsection aimed at the developmental stages of flies, which can significantly reduce the number of insects during the summer months. Preventive measures adopted to control insect pests can positively affect the behaviour of dairy cows in the stable and prevent their huddling, which increases heat stress, but also their behaviour in the milking parlour, and thus minimize economic losses due to lower milk production and higher incidence of mastitis caused either directly by blood-sucking insects spreading pathogens among dairy cows, but also indirectly as a result of incomplete milking of dairy cows due to stress and their defensive behaviour directed towards annoying insects.

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