Original Paper

Influence of estrus on changes of locomotion activity and rumination time in cattle dams

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The study is focused on the evaluation of the changes in locomotion activity and rumination time in heifers and dairy cows of Holstein breed during estrus. We analysed the locomotion activity and rumination time using the Heatime RuminAct device on 110 dams (78 dairy cows and 32 heifers). We evaluated a total of 298 estrus cycles during the reference period of 3 days before estrus, 3 days after estrus and on the day of the estrus occurrence. The locomotion of cows was expressed in units of locomotion activity in 24 hours (u/24 h). Rumination time was expressed in minutes in 24 hours (min/24 h). Based on the results of the study, we established that during estrus, the locomotion activity of dams increases to 888 u 24/h (P <0.001), which represents an increase of +305 u/24 h (+38%). Rumination time of dams was considerably affected by estrus as well and decreased from 582 min/24 h (1 day before estrus) to 482 min/24 in estrus time (-43 min/24 h).

Keywords: cattle dams, estrus, locomotion activity, rumination time, Heatime RuminAct

1 Introduction

The estrus is defined as a complex of physiological signs and changes of behavior occurring immediately before the ovulation (Mičiaková et al., 2018). Behavior around estrus is according to Forde et al. (2011) induced predominantly by the action of estrogens (17β estradiol), which transmit stimuli to the brain from pre-ovulation follicles.

To improve the effectiveness of heat detection, a number of new electronic technologies have recently been developed (Rorie et al., 2002) as well as other additional devices measuring the behavior of dairy cows at the time of estrus (Firk et al., 2002). These technologies measure the time that the cow spends moving (Rorie et al., 2002), lying (Brehme et al., 2006), standing (Rorie et al., 2002), and also how much time a cow spends eating and drinking (Reith et al., 2014a).

By exploring locomotion activity and rumination time, devices have been developed that identify dams in heat in real time anywhere on the farm, 24 hours a day and 7 days a week. The sensing system allows radio communication to detect estrus even at greater distances (up to 50 meters) from the installed radio antenna. According to the available data, this device shows up to 90% of heat detection reliability based on the evaluation of increased locomotion activity (Mičiaková et al., 2018).

Roelofs et al. (2005a) and Arney et al. (1994) confirmed by the use of monitoring devices, that the locomotion activity of dairy cows increases during estrus. Arney et al. (1994) observed a gradual increase in locomotion activity 3 days

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before estrus. The increase in locomotion activity was linear 72 to 16 hours before the estrus, followed by a sharp increase in activity up to estrus. It has been proven, that regular treatment of claws has several demonstrable and positive effects, but we still record diseases of claws even when regularly treated, because the health of claws is also affected by many other factors (Stoddard and Cramer, 2017).

Authors observed an opposite tendency in assessing the frequency and rumination rate at the time of estrus, with the beginning of a significant decrease in rumination 2 days before the onset of estrus (Hurnik et al., 1975). In the assessment of rumination by De Ondarza (2015), the dairy cows spend an average of 400–600 minutes of rumination per day (about 10 hours) on the average. The impact of rumination on heat is different from each author. Lukas et al. (2008) reported increased dry matter intake during estrus, Maltz et al. (1997) and Reith et al. (2014a) found a decrease in daily intake of dry matter and De Silva et al. (1981) didn´t detect effect of rumination on daily dry matter intake.

2 Material and methods

2.1 Cows and housing

Basic measurements of locomotion activity and rumination were carried out on dairy farm in University of Bologna, Italy. In order to assess the impact of estrus on changes in locomotion activity and rumination time we have analyzed data from 110 dams (78 cows and 32 heifers) of the Holstein breed. Cows were fed with dry TMR *ad libitum*, mixture of grass hay, corn ground fine, sorghum grain meal, molasses, concentrate mix, vitamins and minerals. Heifers were fed an *ad libitum* mixture of grass hay, corn flakes and concentrate mix like cows but in smaller doses. Cows were milked twice a day (08.00 and 19.00 h) in a double-5 milking parlor and were separated from feed.

2.2 Data collection

Locomotion activity (LA) and rumination time (RT) were recorded using the Heatime RuminAct (HR) monitoring system (SCR Engineers Ltd., Netanya, Israel). HR tag was fixed on a collar and placed on the left side of the dam's neck. Locomotion activity is measured on the base of accelerometers that send data wirelessly every 2 h to a receiving unit connected to a computer. A cow's activity is translated into an index value that represents weighted standard deviations from each cow's own basal activity. The rumination sensor includes a microphone that detects rumination sounds, a motion sensor, a microprocessor, a storage unit, and a battery. The collected data from the sensors were sent to a PC. The software (Data Flow™ II. software, SCR Engineers Ltd.) analysed the locomotion activity and rumination time in 2 h intervals as minutes of 2 h (Schirmann et al., 2009) and calculated the rumination time of the last 24 h.

Data were analysed using SAS 9.4 software. Changes in locomotion activity and rumination time in the reference period and during estrus were calculated by variance analysis (ANOVA), and differences of the mean values were tested by the Scheffe test.

3 Results and discussion

When assessing the estrus effect on changes in the locomotion activity of dams, we found, that in the reference period 3 days before estrus the average locomotion activity was 589 ±132 u/24 h. The LA values gradually increased from 553 (d -3) to 558 u/24 h (d -2). One day before estrus there was a significant increase in LA to u 24/h, which was +14% increase in LA compared to the previous day. During estrus, there was a statistically significant increase (P <0.001) in the LA of dams to 888 u/24 h, which represents an increase of +305 u/24 h (+38%) from average in reference period (from d -3 to d -1) and +28% compared with activity 1 day before estrus. We noticed an immediate and significant decrease of activity to 561 u/24 h (d 1). In the reference period, 3 days after heat, the values of the locomotion activity gained a fairly balanced level (549 to 561 u/24 h), similar to the activity level in the reference period 2 days before heat (556 u/24 h) (Figure 1).

In connection with the increase in locomotion activity of dams, our results confirmed the findings of Arney et al. (1994), who recorded a gradual and linear increase in the locomotion activity of dairy cows 3 days before the estrus followed by a more pronounced increase in activity up to the occurrence of estrus. Reith et al. (2014b) recorded an increase in locomotion activity already 2 days before the heat. Similarly, Reith et al. (2014a) confirmed the rise in activity of the Holstein dairy cows in estrus, which was on average 4% more than our results. In the evaluation of the decline in locomotion activity of dairy cows, Reith et al. (2014b) report a prominent decline in this indicator on the first day after the end of estrus, which according to the authors, is closely related to the decrease in the concentration

of estradiol in the blood of dairy cows. Roelofs et al. (2005) recorded the highest increase in LA during estrus. Similar findings were confirmed by Yaniz et al. (2006) and Madureira et al. (2013).

Rumination time of dairy cows was considerably affected by the day of estrus (Figure 1). In the reference period before estrus, cows spent 543 (±85) min/24 h ruminating. The duration of RT was significantly reduced on the day of estrus compared with all other days. The minimum level of daily RT was found on d 0 with 482 min/24 h, and RT decreased from 554 min/24 h (d -3) to 551 min/24 h (d -2) and 525 min/24 h (d -1). The decrease of RT from d -1 to the day of estrus was 43 min. After estrus, daily RT duration increased to 65 min from the day of estrus to *d* 1 (538 and 547 min/24 h in d 1 and d 2). On average, RT during estrus was shortened by 11% (61 min) compared to the reference period before estrus.

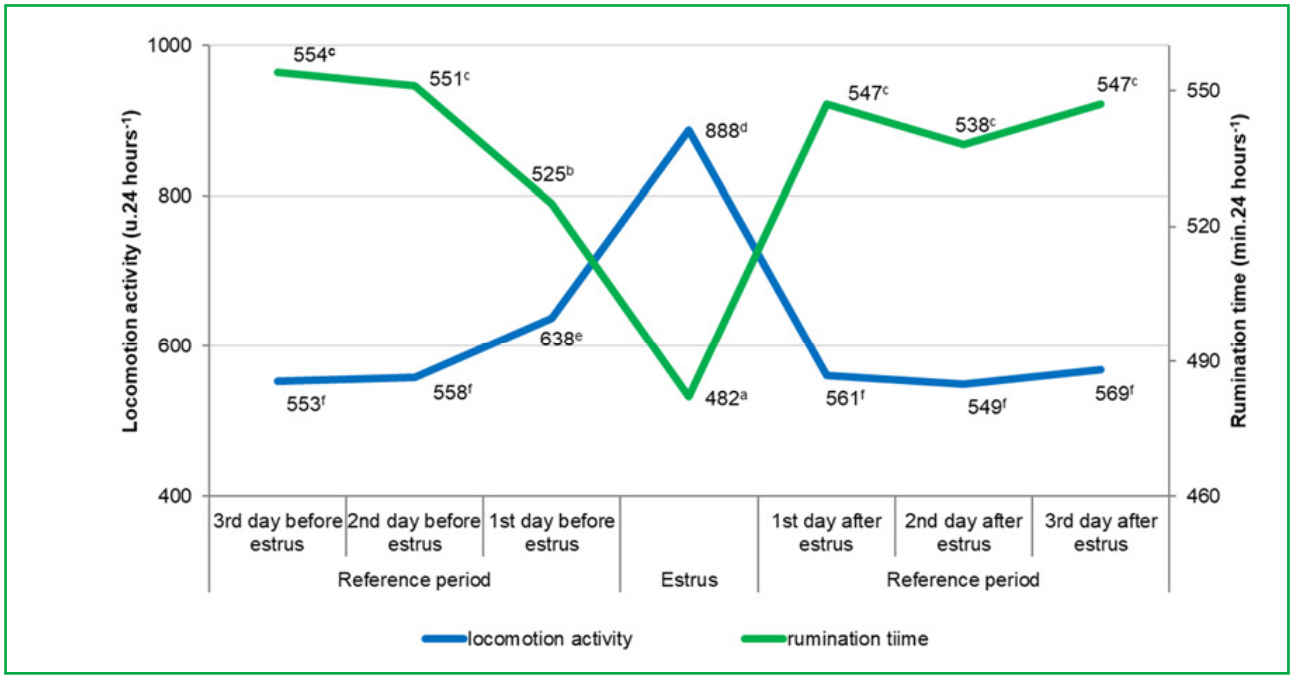

Figure 1 The changes of locomotion activity and rumination time of Holstein dams (n = 298)
a, b, c – different letters represent significance (P <0.05) for rumination time; d, e, f – different letters represent significance (P <0.05) for locomotion activity.

Brehme et al. (2006) reported that animal discomfort reduces the total lying time during estrus time. The authors recorded the average time spent lying down from 6 to 17 hours, while cows in estrus spent much less time lying down, due to the fact, that most of their time was spent ruminating in boxes (Schirmann et al., 2012). Reith and Hoy (2012a) found a relation between the total time of lying down and shorter time of rumination during estrus as significant. Compared with the results of our work Adin et al. (2009) recorded a lower average rumination time of dairy cows from 428 to 482 minutes. The results of our work confirmed the influence of estrus on rumination time with the findings of Phillips and Schofield (1990), who noted a 5% to 20% reduction in rumination time. Reith et al. (2014b) found a shorter RT of -61 min/24 h (-19.6%) on the day of the estrus, which is an intensive decrease in 24-hour RT compared to the evaluated Holstein dams in our work (-8.6%). A more pronounced decrease in the level of rumination time of the dams at the time of estrus (-74 min in 24 hours or -17%) compared to the results of our work is also shown by Adin et al. (2009), who justify this situation by the fact that the reduced RT is closely related to increased locomotion activity, which we consider to be one of the first external signs in relation to the behaviour of animals in estrus. These statements were also confirmed by Reith and Hoy (2012b), who also reported significantly reduced time of rumination in dairy cows during estrus compared with reference period, with the lowest value being 335 min/24 h (-74%).

4 Conclusions

In recent times farmers are using devices, which measured locomotion activity and rumination time regularly. Reliability of heat detection can be enhanced by a combination of LA and RT evaluation system like the Heatime

RuminAct technical device. The system evaluates the peak of the heat and the optimum insemination time. Our work has confirmed the practical use of the system Heatime RuminAct in practice and can be considered a reliable tool for heat detection.

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