Journal of Applied Animal Welfare Science

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/haaw20

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Published online: 25 Sep 2012.


To link to this article: http://dx.doi.org/10.1080/10888705.2012.709137

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Dairy Cow Behavior and Welfare
Implications of Time Waiting Before
Entry Into the Milking Parlor

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The objective of this study was to investigate dairy cows’ time spent in the possibly stressful waiting area (WA) of the milking parlor (MP) and their behavioral patterns while there and thereby investigate comparative effects on their welfare. The experiments were carried out in 3 loose-housing cowsheds. The study consisted of a total of 3,522 observations of individual dairy cows. Depending on the group size and the number of places in the MP, cows’ waiting times in the WA were as high as 1:42:22 (h:mm:ss). In Cowsheds I and II, only one third of cows were observed ruminating in the WA, and up to 52% of cows were observed ruminating in the WA of Cowshed III where the feeding group size was the smallest, waiting time the shortest, and space per cow the largest. Cows spending more time in the WA have limited opportunities to behave normally; therefore, the welfare of these cows in particular is poor.

Current trends in intensive cattle production are toward higher milk production, larger dairy herds, the introduction of advanced and automated technical solutions, and a more business-oriented farm management style (Hultgren, 2003; Noordhuizen & Cannas da Silvia, 2007). These trends are extant in Estonia. The development of the loose housing of large dairy cattle herds has increased rapidly.

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in Estonia since the 1990s (Veermäe, Poikalainen, & Praks, 2001). The first large cowshed was introduced in 2002, and by 2010 one third of all dairy cows were kept in cowsheds with more than 300 dairy cows. There are several studies that examine the impacts on the welfare of the dairy cows under different housing types (Fregonesi & Leaver, 2001; Haley, Rushen, & de Passillé, 2000), but the effect of enforced waiting times before entering the milking parlor (MP) has been neglected. In these large loose-housing systems, cows often have to wait, standing for long periods of time in confined areas before entering the MP. This is likely to be a stressful environment for them; feeding and drinking behaviors are excluded, cows cannot lie down, and locomotion activity is severely restricted. The environment is likely to be socially disruptive; the cows are forced into close proximity with each other, and there are no possibilities for low-ranking cows to avoid aggressive conspecifics or to leave the area. Indeed, Lexer, Hagen, Palme, Troxler, and Waiblinger (2009) surmised from their work that herding and standing in the waiting area (WA) were responsible for the higher fecal cortisol levels collected in parlor-milked nonhuman animals than in robotic-milked animals. This waiting period can be in excess of 1 hr at each milking. If cows are being milked twice or even three times a day, this has a significant negative impact on their daily budget of behavior; some behaviors (that the cows would ordinarily express) may therefore be sacrificed from their daily repertoire. The frustration implicit in their inability to carry out these desired behaviors may be considered a source of stress and therefore an impairment to their welfare (Veermäe, Kaihilahti, Praks, & Poikalainen, 2003), and it has been noted by Cooper, Arney, and Phillips (2007) that cows experience discomfort when they are forced to stand for long periods. The time that cows spend lying, as opposed to standing, is of interest both from the cow’s and the dairy farmer’s points of view (Österman & Redbo, 2001). High-producing dairy cows spend about 40% to 50% of the day lying down, and adequate rest is necessary to ensure high production (Rushen & Passillé, 1999). Blood flow to the udder doubles when cows are lying down, and because cows tend to ruminate for longer periods when lying down compared with when they are standing up, maximizing the time spent lying down is important for optimizing rumination time (Rushen & Passillé, 1999). The time spent lying is normally approximately 7 to 10 hr a day for lactating dairy cows, in approximately five periods of 1.5 hr each (Arave & Walters, 1980). The preferred lying time for cattle is 10 hr per day (Cooper et al., 2007).

Extended periods without access to feed may reduce intakes and possibly production. Housed cattle will typically eat forage (silage or hay) in bouts of 6 to 12 meals per day for a total of 4 to 7 hr per day. However, providing only this amount of time for the cows to eat will reduce the intake by up to 20%, demonstrating the requirement to spread feeding bouts throughout the day for cattle (Campling & Morgan, 1981).
A prominent feature of the social system of dairy cattle is the consistency of order of entry into the MP (Grasso, De Rosa, Napolitano, Di Francia, & Bordi, 2007; Rathore, 1982). High-dominance animals tend to walk at the front of the herd and get milked first, whereas more submissive animals tend to walk at the rear of the herd and get milked last. The dominance structure of dairy cows has been shown to remain stable throughout the course of a lactation (Polikarpus, Kaart, Kokin, Veermäe, & Poikalainen, 2011; Sauter-Louis, Chesterton, & Pfeiffer, 2004). Submissive cows are therefore forced to spend more time waiting for milking. An uncharacteristically late entry into the parlor can also be related to health problems. Rathore (1982) reported that cows entering the MP earlier had lower somatic cell counts than cows coming later. Grasso et al. (2007) observed a significant correlation between entrance order and milk yield in primiparous animals. This result was attributed to the higher somatic cell counts observed in more productive subjects, which may determine stress during farming routines (Grasso et al., 2007). Juarez, Robinson, DePeters, and Price (2003) found that return time from MP (i.e., time after the first cow returned from the MP) tended to increase linearly as the locomotion scores of cows increased (a higher locomotion score represented increased severity of lameness). Based on the multivariate model, Sauter-Louis et al. (2004) found an increased likelihood of lameness for cows who walked or were milked among the last quarter of the individuals of the herd (odds ratios = 1.8 and 1.5, respectively).

Individual cows may find milking either a positive or negative experience, but overall the motivation to be milked may be weak. Food is significantly more rewarding than milking (Melin, Hermans, Pettersson, & Wiktorsson, 2006; Prescott, Mottram, & Webster, 1998). Gere and Hamar (2003) compared the behaviors of Holstein-Friesian cows when entering the MP and at the feeding trough; there was no correlation between the entrance order to the MP and the dominance order at the feeding trough, but there is no reason to suppose that these two resources result in the same social hierarchical arrangement. Indeed, the competitiveness of individual cows in a herd will depend upon their individual motivation for a resource as well as their social position (Val-Laillet, Guesdon, von Keyserlingk, de Passillé, & Rushen, 2009; Val-Laillet, Veira, & von Keyserlingk, 2008).

This study was designed to observe the behavior of cows waiting to enter the MP and consider its implications for the welfare of the animals, particularly for those cows who entered the parlor later than their herdmates and therefore spent the longest time in enforced restrictive conditions in the WA. This study focused on the time schedule of cows in the WA and MP, their behavioral patterns, and their actual and potential propensity to behave naturally, with the hypothesis being that dairy cows in the WA of the MP are likely to engage in abnormal behavior.
METHODS

Cowsheds and Animals

The experiments were carried out on three relatively newly constructed large loose-housing cubicle cowsheds located in northern and central Estonia during the early winter period in October, November, and December 2004.

There were 519 dairy cows in Cowshed I, with a mean annual milk production of 6,374 kg per cow. The lactating cows (Estonian Holstein breed) were divided into four feeding groups according to milk yield and milked in a 2 × 12 DeLaval tandem MP twice per day (milking periods from 05:00–12:00 and 17:00–24:00). The size of the WA for the MP was 172 m², a mean initial space per cow of 1.5 m². The WA flooring was made of grooved concrete.

There were 561 dairy cows in Cowshed II, with a mean annual milk production of 7,916 kg per cow. Lactating cows (including individuals from both Estonian Holstein and Estonian Red breeds) were divided into two feeding groups (according to milk yields) and milked in a 2 × 20 Strankgo tandem MP three times per day (milking periods from 02:00–07:00, 11:00–16:00, and 18:00–22:00). The size of the WA for the MP was 196 m², a mean initial space per cow of 1.1 m². The WA flooring was made of grooved concrete.

There were 693 dairy cows in Cowshed III (including individuals from both Estonian Holstein and Estonian Red breeds) divided into five feeding groups (according to milk yield), with a mean annual milk production for the whole herd of 7,675 kg per cow. Cows were milked in a 2 × 12 DeLaval tandem MP three times per day (milking periods from 03:00–09:00, 11:00–17:00, and 19:00–24:00). The size of the WA for the MP was 140 m², an initial mean space per cow of 1.9 m². The WA flooring was made of grooved concrete.

An automated crowd gate was used to encourage cows to enter the MP from the WA in all farms.

Experiment Layout

In each cowshed, behavioral observations were carried out in the WA over three milking periods on three consecutive days (Cowshed I during the morning milking from 05:00–midday; Cowsheds II and III during the midday milking from 11:00–16:00 and from 11:00–17:00, respectively; Table 1).

Cow groups were defined as follows (Figure 1):

Feeding group (FG)—this group has a fixed size and is housed and fed separately in the cowshed. All of the members of an FG enter the waiting area (WA) at the same time.
**TABLE 1**
Experimental Layout

<table>
<thead>
<tr>
<th>Cowshed</th>
<th>Cows</th>
<th>FGs</th>
<th>Mean FG Size</th>
<th>MP Size</th>
<th>FGs</th>
<th>WGs</th>
<th>MGs</th>
<th>Cows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cowshed I</td>
<td>519</td>
<td>4</td>
<td>115</td>
<td>24</td>
<td>12</td>
<td>52</td>
<td>121</td>
<td>1,388</td>
</tr>
<tr>
<td>Cowshed II</td>
<td>561</td>
<td>2</td>
<td>177</td>
<td>40</td>
<td>6</td>
<td>31</td>
<td>54</td>
<td>1,062</td>
</tr>
<tr>
<td>Cowshed III</td>
<td>693</td>
<td>5</td>
<td>70</td>
<td>24</td>
<td>15</td>
<td>49</td>
<td>91</td>
<td>1,072</td>
</tr>
<tr>
<td>Total</td>
<td>33</td>
<td>132</td>
<td>266</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3,522</td>
</tr>
</tbody>
</table>

*Note.* FG = feeding group; MP = milking parlor; WG = waiting group; MG = milking group.

Milking group (MG)—a group of cows on either the left or right side of the milking parlor (MP) during one milking session.

Milking session—time of milking each left and right MG in the MP in min, numbered consecutively.

**FIGURE 1** Gray animals are from a single feeding group: waiting for milking (W), milking (M), and returning from the parlor to the feeding area (F). Black animals represent the following feeding groups, entering the waiting area (WA): (1) milking parlor, (2) WA, (3) alley to the cowshed, (4) alley to the WA, (5) area of WA left by movable barrier, (6) alley to the waiting area, part II after turnout.
Data Collection

Data collection took place during the daily milking management routine. The following data were recorded during investigation of the cows’ milking schedules:

Waiting group (WG)—a group of cows in the WA during each milking. The number of cows in the WA decreases at a regular time interval while the cows enter the MP from the WA. Different-size WGs are indicated by order numbers (Figure 2).
• Time when the first cow of each FG entered the WA (h:mm:ss);
• Time when the last cow of each FG entered the WA (h:mm:ss);
• Time when the first cow of the MG entered the MP, left and right side separately (h:mm:ss);
• Time when the last cow of the MG entered the MP, left and right side separately (h:mm:ss);
• Time when the cows left the MP, left and right side separately (h:mm:ss);
• Number of cows in the WA during each milking session (size of WG); and
• Number of cows in the MG.

Cow activities were defined as follows (according to Hurnik, Webster, & Siegel, 1995):

Aggression: Any purposive action of an organism toward another organism with the actual or potential result of harming, limiting, or depriving it.

Curiosity: A tendency to approach and investigate novel stimuli or situations and become familiar with their attributes or implications.

Grooming: An act of integumentary care (e.g., licking, scratching) to remove parasites, smooth ruffled fur, remove dirt, and so on. Grooming is subdivided into self-grooming (an animal grooming himself or herself) and allogrooming (an animal grooming another animal).

Mounting: The act of an animal raising the anterior part of his or her body generally onto the posterior part of another animal.

Rumination: The process of digestion of ruminants whereby the animal swallows food quickly and then regurgitates and chews it more thoroughly at a later time until digestion is completed (Morris, 1992).

Vocalization: Production of sounds by the vibration of vocal cords in the larynx.

Cows’ activities (aggression, curiosity, grooming and allogrooming, mounting, vocalizing, and falling over) were registered continuously from the time the first cow entered the WA. The number of ruminating cows was recorded every 10 min. All observations were made by a single observer, observing the WA from a raised platform on the far side of the WA of the MP.

Statistical Analysis

The following data were collected for statistical analysis:

• WA entering time of the FG: (time when the last cow of the FG entered the WA) – (time when the first cow of the FG entered the WA), mm:ss;
Waiting time in the WA of the WG: \([\text{time when the first cow of the left side MG entered the MP}) + (\text{time when the first cow of the right side MG entered the MP})/2 - (\text{time when the first cow of the FG entered the WA}), \text{h:mm:ss};\]  
MP entering time of the MG: (time when the last cow of the MG entered the MP) – (time when the first cow of MG entered the MP), mm:ss;  
MP time of the MG: (time when cows leave the MP) – (time when the last cow of MG entered the MP), mm:ss;  
Cows’ behaviors were calculated as a percentage of each behavior engaged in by all of the animals in each WG and FG; and  
Rumination was assessed as the percentage of ruminating animals in the WG.

Data were managed and descriptive statistics calculated with MS Excel and statistical package SAS 9.1 for multiple comparison analysis. Behavioral data were calculated for each WG—the cow group in the WA during a milking session. To compare different WG cows’ behaviors (percentages of cows engaged in a specific behavior), multiple comparisons were used. The reference method used was the Wilcoxon test, two-sided with a \(t\) distribution approximation.

**RESULTS**

As expected, the number of cows in the WA decreased with time in relation to MP size, whereas the waiting time increased according to the MP size (Figure 2). Statistical data on the cow groups’ time schedules are shown in Table 2.

The time schedule depended both on the FG and MG sizes. However, there were also differences between the cowsheds. Mean WA entering time depended on the group size and the distance between the FG location in the cowshed and the WA. FG entering time to the WA varied from 2:13 to 21:15 (mm:ss). The extent of the difference in waiting time varied greatly—from 01:01 (mm:ss) to 1:58:45 (h:mm:ss), depending on the milking session. MG entering time to the MP ranged from 3 s (2 cows in the last MP group, Cowshed I) to 07:02 (mm:ss)—for the first MG in Cowshed I.

The percentage of cows ruminating in the WA increased in all cowsheds as milking proceeded. About one third of all cows were observed ruminating in the WA in Cowsheds I (32.1%; Figure 3) and II (36.7%) and 52.8% in Cowshed III. There were significant differences between rumination observations in different WGs in all three cowsheds (\(p\) value of multiple comparisons of rumination means <.05).
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
<td>III</td>
<td>I</td>
</tr>
<tr>
<td><strong>M</strong></td>
<td>0:03:29</td>
<td>0:17:10</td>
<td>0:05:03</td>
<td>0:44:02</td>
</tr>
<tr>
<td><strong>Max.</strong></td>
<td>0:08:25</td>
<td>0:21:15</td>
<td>0:08:50</td>
<td>1:42:22</td>
</tr>
<tr>
<td><strong>Min.</strong></td>
<td>0:02:13</td>
<td>0:13:47</td>
<td>0:02:36</td>
<td>0:01:01</td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td>0:01:40</td>
<td>0:02:34</td>
<td>0:01:33</td>
<td>0:29:14</td>
</tr>
</tbody>
</table>

*Note.* WA = waiting area; FG = feeding group; WG = waiting group; MP = milking parlor; MG = milking group.
The activity of cows in the WA was low in all cowsheds. Less than 2% of all cows were engaged in any of the recorded activities except for curiosity, which was 8% in Cowshed III (Figure 4).

The mean numbers of cows in the WA and activities according to the WG number are shown in Table 3.

The number of aggressions was highest in Cowshed I where 1.4% of the cows in the second WG acted aggressively toward another cow. Allogrooming was not observed in the last WG in each cowshed, and aggression was not observed in these final WGs. During the observation period, the only few incidents of
individuals falling over were observed in Cowshed III where the cows had been housed together for only 1 month.

The cows in the last WGs performed more curiosity ($p = .02$) and grooming ($p = .04$) activities. Mounting ($p = .13$) and vocalization ($p = .13$) activities had a tendency to decrease with time in the WA.

**DISCUSSION**

Being among the first cows to be milked gave certain advantages to the cows: In addition to spending less standing time in the WA, after returning to the empty cowshed, all cubicles and access to the feeding barrier were freely available. Cows in the WA did not have opportunities to lie down, drink, or eat. Limited space per cow (at the beginning of milking a maximum of 3 m$^2$ in the WA) inhibited locomotion and social activity, as has been reported elsewhere (Dijkstra, Veermäe, Praks, & Poikalainen, 2007).

The cows’ opportunities for normal behavior in the WA were limited in all cowsheds (Table 3 and Figure 4). The most prevalent activity was rumination (Table 3 and Figure 3). According to Lidfors (1996), rumination accounts for a substantial part of a cow’s daily activities, altogether for about 6 to 8 hr performed in about eight bouts of about 45 min each day. Rumination is often associated with reduced alertness and its rhythmic action may induce a soporific
<table>
<thead>
<tr>
<th>Group Number</th>
<th>No. of Cows</th>
<th>Ruminating</th>
<th>Falling Over</th>
<th>Grooming</th>
<th>Allogrooming</th>
<th>Mounting</th>
<th>Curiosity</th>
<th>Vocalization</th>
<th>Aggressions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cowshed Ia</td>
<td>1 116</td>
<td>9.3</td>
<td>0.0</td>
<td>1.0</td>
<td>0.7</td>
<td>1.1</td>
<td>3.1</td>
<td>0.5</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>2 92</td>
<td>29.3</td>
<td>0.0</td>
<td>0.9</td>
<td>1.0</td>
<td>0.7</td>
<td>2.0</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>3 68</td>
<td>28.0</td>
<td>0.0</td>
<td>0.5</td>
<td>0.9</td>
<td>0.8</td>
<td>1.6</td>
<td>0.0</td>
<td>0.9</td>
</tr>
<tr>
<td></td>
<td>4 45</td>
<td>25.1</td>
<td>0.0</td>
<td>1.6</td>
<td>0.8</td>
<td>0.0</td>
<td>2.6</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>5 26</td>
<td>1116</td>
<td>0.0</td>
<td>8.3</td>
<td>0.0</td>
<td>0.0</td>
<td>10.7</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>6 11</td>
<td>32.1</td>
<td>0.0</td>
<td>3.0</td>
<td>0.2</td>
<td>0.2</td>
<td>3.0</td>
<td>0.0</td>
<td>1.4</td>
</tr>
</tbody>
</table>

| Cowshed II   | 1 177      | 5.3        | 0.0          | 0.0      | 0.2          | 0.6      | 0.6       | 0.5         | 0.0         |
|              | 2 137      | 17.4       | 0.0          | 0.0      | 0.1          | 0.7      | 1.2       | 0.1         | 0.4         |
|              | 3 97       | 26.6       | 0.0          | 0.0      | 0.2          | 0.3      | 2.1       | 0.0         | 0.2         |
|              | 4 57       | 20.7       | 0.0          | 0.0      | 0.3          | 0.6      | 2.0       | 0.9         | 0.0         |
|              | 5 20       | 36.7       | 0.0          | 1.7      | 0.0          | 2.5      | 3.3       | 0.9         | 0.0         |

| Cowshed III  | 1 75       | 5.0        | 0.1          | 0.5      | 0.7          | 0.9      | 3.0       | 0.1         | 0.2         |
|              | 2 51       | 13.3       | 0.0          | 0.9      | 1.1          | 0.5      | 3.2       | 0.1         | 0.1         |
|              | 3 27       | 30.7       | 0.2          | 1.0      | 1.0          | 0.3      | 5.6       | 0.6         | 0.0         |
|              | 4 10       | 52.8       | 0.0          | 0.0      | 0.0          | 0.0      | 12.0      | 0.0         | 0.0         |

*Note. WG = waiting group; MG = milking group; MP = milking parlor.
*aIn Cowshed I, the cows of the first MG entered the MP directly without any waiting time.*
or even hypnotic effect on the animal. Only healthy and unstressed cattle will ruminate normally (Dado & Allen, 1994; Lidfors, 1996). In the current study, up to 52% of cows were observed ruminating in the WA of Cowshed III where the FG size was the smallest, waiting time the shortest, and space per cow the largest. In Cowsheds I and II, only one third of cows ruminated in the WA. This low proportion of ruminating cows in the WA perhaps indicated an environment that was found to be stressful. The percentage of cows ruminating in the WA increased in all cowsheds as milking proceeded. As the WG became depleted over time, the social environment changed, and it might therefore be the case that as the WG becomes smaller, there are fewer stressor animals and the remaining animals become less stressed. Indeed, the reduced number of aggression events in the WA over time support this. Nevertheless, rumination remained suboptimal, and having an extended period of time where the cows remain in the constrictive and restrictive environment of the WA remains a concern for good welfare. In this study, the cows were not identified individually. Therefore, it is not possible to say whether more cows started to ruminate in the WA as time progressed or if the cows who ruminated were ruminating throughout the waiting period and were among those cows who happened to remain in the last MGs.

It is also not possible to distinguish between the cows from different MGs in the WA prior to the MG separating itself from the rest in the WA. We could not know which cows were leaving the WA for the MP until they actually did so. Therefore, the results of these observations represent a “substructured” image: the influence of an MG could only be estimated by observing the change in behavior of the remaining cows once the MG had left the WA.

Despite some increase in space per cow (from 2–3 m² to 4–5 m²), the cows’ activities remained low. The same behaviors and pattern of changes in behaviors were observed in all cowsheds. The cows’ social activity (when two cows were involved) decreased. The number of aggressions and allogroomings (submissive cows’ behavior toward dominant cows) was reduced; there were no allogroomings or aggressions among the final WGs. The same trend was observed for mounting and vocalization activities (except for mounting activity in Cowshed II, which remained unchanged). At the same time, curiosity and grooming activities increased. Curiosity, or seeking behavior, has been identified previously from substantial neurological studies of mammals with a positive emotional state (Panksepp, 2005). Grooming is a social behavior. It may be that the first MGs were comprised of more socially extroverted animals and that they were individuals who communicated more and also expressed more of the other social behaviors. The last WA cows, who regularly had to wait for milking for several hours each day, were more introverted animals. They engaged in less social behavior; rumination, curiosity, and self-grooming activities were dominant.
In a previous study (Veermäe et al., 2003), cows entering the MP later spent less time throughout the day feeding and less time lying. The cows who spend longer in the WA before milking therefore spend less time exhibiting normal behavior. Production and welfare are impaired if they are sacrificing some of their feeding time. The current study is limited in that behavior without the MP was not considered. The experiment was designed with studying the milking parlor waiting area as the main objective, so predictions about consequences for intake and lying times upon returning to the cubicle areas are largely surmise.

Haskell, Rennie, Bowell, Wemelsfelder, & Lawrence (2003) developed a welfare evaluation project that focused on younger cows: “Our main hypothesis is that the behavioral and physical responses of ‘at-risk’ younger cows provide a sensitive indication of farm-level ‘stress’” (p. 554). However, our proposal is that, in the evaluation of welfare, it is better to focus on the idea that the cows in the last MGs are more at risk of suffering and are therefore more sensitive indicators of farm-level stress for the following reasons:

- Milking order stability selects these cows into the last MG,
- The last cows in the WA are often submissive cows,
- Cows with health problems (lameness and udder diseases) tend to move (or be forced) into later entry groups than their usual groups,
- The cows’ possibilities to express normal behavior in the WA are very limited,
- Time in the WA is related to fewer possibilities for eating and lying in the cowshed, and
- Submissive cows are unable to avoid the stressful situation by rapidly removing themselves from it.

It may therefore be concluded that cows in large groups perform “self-evaluation,” which occurs in the WA and is reflected in the milking order. From the viewpoint of welfare, the WA is a critical factor in the management of large loose-housing cowsheds. Cows who are more or less voluntarily joining the last MG can be considered among the lowest social rank in the group. Their opportunities to perform normal behavior are the most limited, and therefore it may be better to focus welfare evaluations on this group of animals. Assessing the welfare of the herd as a whole may discount the suffering of a significant portion of the herd. In the context of developments in the management of the milking process, and perhaps with particular reference to precision livestock farming, efforts should be concentrated on the assessment of the welfare of these animals in particular and on reducing the period of waiting that cows must endure prior to milking.
CONCLUSIONS

Some cows spend long periods, up to 100 min at each milking, in the WA before entering the MP. The dairy cows’ time schedule in the WA depends on the management of the milking process as well as the FG and MG sizes. Cows were observed ruminating most frequently in the WA of Cowshed III where the FG size was the smallest, waiting time the shortest, and space per cow the largest. The percentage of cows ruminating in the WA increased in accordance with the decrease in the WG size, whereas the percentages of vocalization, mounting, allogrooming, and aggression decreased, suggesting that as the WA lost some cows, the social environment became less of a source of stress for the remaining cows. Cows in the last MGs have fewer opportunities to express normal behavior and are confined for longer periods each day, spending more of their time in a stressful environment. It is therefore reasonable to focus on these cows in welfare evaluations of dairy cows in general but also in light of the introduction of new technologies in the milking process. If we assess the welfare of this vulnerable group in a dairy management system positively, it may be sufficient to make an accurate positive assessment of the well-being of the whole herd and likewise with a negative welfare assessment. If we make assessments on the observations of the whole herd and use mean values for our assessments, we may miss the hidden suffering of an overlooked portion of the herd.

ACKNOWLEDGMENTS

This research was supported by the Estonian Science Foundation Grant 7518 and Interreg project Energy Positive Farm (ENPOS). We are most grateful for the collaboration with owners and staff of the farms, who kindly permitted us to carry out the experiments for this study. We also thank Mirjam Vallas for help with statistical analysis.

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