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Changes in amount and length of periods of stereotypic behavior in Jersey cows with and without access to pasture

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The aim of the present study was to investigate whether the access to pasture affects the stereotypic behavior of Jersey cows kept in loose housing systems. Therefore, a total of 21 randomly selected Jersey cows housed in two different investigation farms were observed once a week for four weeks in winter and summer, respectively, using the focal sampling method. On every examination day, each cow was observed for 15 min and the amount (AP) and length (LP) of periods, in which the cows showed stereotypic behavior within this observation time, were counted. Wilcoxon signed rank tests were carried out to estimate differences between pasture access and no pasture access regarding AP and LP. Welch two sample t-tests were performed to detect differences in AP and LP between both investigation farms. The results of the study show significant differences between the option of pasture access and no pasture access regarding the values of AP and LP. The values of AP ($p = 0.001$) as well as the values of LP ($p = 0.006$) were lower when the cows had access to the pasture. No differences could be found between the investigation farms. It could be concluded that the access to pasture has a significant influence on the stereotypic behavior of Jersey cows. Further studies are needed to intensively analyze the causes of stereotypic behavior in Jersey cows.

KEYWORDS

oral stereotypes, behavior, pasture access, dairy cattle, animal welfare, Jersey cows

1 Introduction

Stereotypies are defined as a repetitive, invariant behavior with no obvious goal or function (Mason, 1991). According to Mostard (2011), stereotypies are abnormal, repetitive, unvarying, and functionless behaviors. Stereotypic behavior is often associated with suboptimal environmental conditions (Mason, 1991) as well as poor welfare (Mostard, 2011). According to Döpjan and Puppe (2016), abnormal behavior could be an indicator of suffering, pain, and injury. Stereotypic behavior, especially oral stereotypies such as tongue rolling, bar biting and sucking on barn equipment, can be caused by various factors, such as

genetics of Holstein cattle (Mostard, 2011; Prodanović et al., 2013; Webb et al., 2017), stimulus transmission (Sato et al., 1994b; Ishiwata et al., 2008), age (Binev, 2022), and low concentration of minerals in the blood (Prodanović et al., 2013; Kirmizigul et al., 2019). However, feeding and feeding management is one of the main contributing factors to oral stereotypies. The proportion of roughage in the ration is the most important factor. According to Redbo and Nordblad (1997), a restrictive feeding of roughage significantly increase the formation and the frequency of oral stereotypies in cattle. The feeding of straw increases the feeding duration and the rumination activity and leads to a decrease of oral stereotypies (Tuytens, 2005). Devant et al. (2016) found a decrease in the occurrence of oral stereotypies caused by the supplementation of straw. Already Holstein, Montbeliard, and Polish Friesian calves show oral stereotypies like tongue rolling or object manipulation when there is not enough roughage in the ration (Veissier et al., 1998; Mattiello et al., 2002; Faleiro et al., 2011; Webb et al., 2017). In contrast, Rotger et al. (2006) did not detect stereotypies in Holstein heifers fed high-concentrate diets. In addition to the proportion of roughage in the ration, feeding duration plays a role in the formation of oral stereotypies as well. Swedish Red and White cows with longer eating times show less oral stereotypic behavior (Redbo et al., 1996). Lindström and Redbo (2000) found out that Swedish Red and White cows with a short feeding duration show stereotypic behavior for longer time and with a higher frequency than cows with a long feeding duration. According to Phillips et al. (1999), an increased salt content in the diet of British Friesian and Estonian Red calves or cows in restricted housing conditions can decrease the formation of oral stereotypies. Frustration and stress have also been highlighted as an important factor in the occurrence of stereotypies (Mason, 1991). Sato et al. (1994a) suggested that feeding frustration, such as feed intake disturbances, stimulates the formation of stereotypic behavior in Japanese Blacks. Álvarez-Rodríguez et al. (2020) could confirm this suggestion by finding out that feeding frustration caused by a short feeding duration resulted in abnormal behavior such as oral stereotypies in Parda de Montaña and Pirenaica cows. Seo et al. (1998a) found out that the heart rate of Japanese Black calves decreased while tongue rolling and significantly increased after performing tongue rolling. The authors assume that tongue rolling has a calming function that reduces the activity of the sympathetic nervous system in stressful situations. In contrast, Binev (2022) found increased values of vital parameters (body temperature, heart rate, respiratory rate, ruminal motility rate) in cows performing oral stereotypies compared with a control group, but these findings were not significant. Changes in animal routine, such as avoiding milking by an induced power cut in the automatic milking system, resulted in a significant increase in tongue rolling in dairy cows (Graeff et al., 2017). According to Redbo (1993), there is a correlation between increased levels of stereotypic behavior and high cortisol contents in urine. The housing system and the housing environment play an important rule regarding the formation of stereotypic behavior as well. Even the housing system of calves can influence the occurrence of oral stereotypies. Thus, calves in individual housing showed significantly more oral stereotypies than calves in group housing systems (Veissier et al., 1998; Seo

et al., 1998b; Bokkers and Koene, 2001). The housing system has a significant effect on stereotypic behavior of dairy cows as well. Redbo (1990) compared the occurrence of oral stereotypies in heifers before, during, and after the grazing period. The author found out that the heifers showed no stereotypic behavior during the grazing period and the oral stereotypies significantly increased after the grazing period compared with before. These findings were confirmed by Corazzin et al. (2010). They investigated the effect of summer grazing on tongue playing in cows, which are kept in tie-stall barns. The authors found out that tongue playing decreased during the summer grazing but this effect was temporary. Redbo (1992) investigated the influence of different housing treatments (Group A: tie-stall housing after a four-months grazing period; Group B: tie-stall housing before, during, and after the grazing period; Group C: tie-stall housing for eight months, then loose housing for one months, then pasture access) on the stereotypic behavior of dairy cows. The results of this study showed that the access to pasture as well as a loose housing system decreased the influence of stereotypic behavior in dairy cows. These findings were confirmed by Krohn (1994) who found a 2-3 times higher exploratory behavior in cows housed in a tie-stall compared with cows kept in a loose housing system. The enrichment of the housing environment could be helpful to reduce the occurrence of stereotypic behavior in cattle. The studies of Park et al. (2020) and Meneses et al. (2021) showed that the installation of cattle brushes resulted in a decrease of the stereotypic behavior in bulls.

Since previous studies mainly focused on the difference between tie-stall housing systems and pasture access regarding the occurrence of oral stereotypies, the aim of the present study was to investigate whether there are differences in the stereotypic behavior of Jersey cows, which are kept in loose housing systems, when they have access to the pasture.

2 Materials and methods

2.1 Farms and animals

Observations were conducted on two commercial dairy farms in Mecklenburg Western Pomerania (Farm 1) and Brandenburg (Farm 2), Germany. Both farms keep Jersey cows for milk production.

2.1.1 Farm 1

Farm 1 is an organic producing farm where the cows are kept in a loose housing system. At the beginning of the investigations in March 2021, the herd consists of 525 lactating cows with an average milk yield of 37.8 ± 10.85 kg per cow and day, a mean fat content of $5.72 \pm 0.86\%$ and an average protein content of $4.32 \pm 0.42\%$. The mean somatic cell count of the herd was 236,000 cells/mL. The cows were milked twice a day in rotary milking parlor.

The barn is divided into four compartments, two on each side of the food table and it is equipped with high lying cubicles with rubber mats and sawdust as bedding materials. The cubicles were cleaned twice a day and interspersed with fresh sawdust once a week. In the walking and feeding alleys, the barn is equipped with slatted flooring,

which is regularly cleaned by a slatted robot. The cows were fed once a day with a total mixed ration (TMR) consisting of corn and grass silage, straw, rapeseed, molasses, lupines, beans and peas (CP = 163 g/kg DM; CF = 157 g/kg DM; CL = 45 g/kg DM; Ca = 6.9 g/kg DM; P = 4.7 g/kg DM; Na = 2.3 g/kg DM; Mg = 3.4 g/kg DM; 30% concentrate in the TMR) and it was pushed five times a day. In summer, the proportion of grass silage in the ration is reduced and replaced by fresh grass. Lactating cows are divided into the following four groups: primiparous cows to be inseminated, pregnant primiparous cows, multiparous cows to be inseminated, and pregnant multiparous cows. The group size was between 100 and 140 cows per group and the animal:feeding place ratio in the investigated groups was 1.94:1, 1.79:1, and 1.44:1, respectively.

From May to October, all lactating cows have access to the pasture (6 ha per group) for around 8 hours a day. During this time, the animals can move freely between the barn and the pasture. Due to the structural conditions of the farm, two groups have access to pasture during the day and two groups overnight.

2.1.2 Farm 2

Farm 2 is a conventional producing farm where the cows are kept in a loose housing system as well. In total, the herd includes 401 lactating dairy cows with an average milk yield of 21.9 ± 6.23 kg per cow and day, a mean fat content of $5.61 \pm 0.94\%$ and an average protein content of $4.35 \pm 0.43\%$. The herd has an average somatic cell count of 222,000 cells/mL. Twice a day, the cows were milked in a herring bone milking parlor.

The barn is divided into two compartments, one on each side of the milking parlor. It is equipped with deep bedded cubicles with straw as bedding material. The cubicles were cleaned twice a day and daily interspersed with fresh straw. The barn is completely mucked out every three to four weeks. In the walking and feeding alleys, the barn is equipped with concrete flooring, which is cleaned by an employee with a tractor once a day. Due to the construction of the barn, there are four dead ends within each of the groups. The cows were fed twice a day with a TMR consisting of corn- and grass silage, straw or hay, pea pulp, canola meal, grain maize and triticale (CP = 157 g/kg DM; CA = 71 g/kg DM; CF = 175 g/kg DM; CL = 31 g/kg DM; Ca = 7.4 g/kg DM; P = 4.5 g/kg DM; Na = 2.4 g/kg DM; Mg = 3.5 g/kg DM; 33% concentrate in the TMR). The proportion of grass silage in the ration is reduced and replaced by fresh grass and wilted silage in summer. The group size was approximately 160 cows per group and the animal:feeding place ratio in the investigated groups was 1.5:1.

All lactating cows have daily access to the pasture (11 ha per group) for at least 5 hours from April to October. The cows cannot

move between the barn and the pasture and are driven back into the barn by an employee before milking. Due to the workload, one group has access to the pasture during the day and one group overnight.

Both farms could not provide information about the grass species in the pasture because they were not determined. The feed intake during grazing was not considered in the composition of the TMR. The pastures of both farms were in poor condition as they were grazed very short.

2.2 Study design and data collection

In total, 21 Jersey cows (Farm 1 = 11 cows, Farm 2 = 10 cows) between their first and sixth parity were examined. The cows were selected randomly out of these cows in the herd, which showed oral stereotypes like tongue playing, bar biting and licking of equipment with a high frequency using the scan sampling method. Then, these cows were observed using the focal sampling method as described by [Altmann \(1974\)](#) once a week for four weeks in winter and summer, respectively. On every examination day, each cow was observed for 15 min around the individual feed intake, because the occurrence of oral stereotypes is highest around the feeding behavior ([Sato et al., 1994a](#)). The amount (AP) and length (LP) of periods, in which the cows showed stereotypic behavior within this observation time, were counted. In this context, AP indicates the frequency within the 15 min observation time in which the cows show stereotypic behavior. A period was registered as one if the break between two periods was less than 20 s. The trait AP means the length of each period within the 15 min observation time in which the cows show stereotypic behavior. Thereby, the investigated oral stereotypes were defined as shown in [Table 1](#).

2.3 Statistical analysis

Data were analyzed using the R 4.1.2 software package (The R Foundation for Statistical Computing, Vienna, Austria). The described `By-function` of the `psych` package was used to calculate the descriptive statistics for AP and LP. Wilcoxon signed rank tests were carried out to estimate differences between pasture access and no pasture access regarding AP and LP. The null hypotheses were that there are no differences in AP and LP between the possibility of the cows having access to the pasture or not. Welch two sample t-tests were performed to detect differences in AP and LP between both investigation farms. The null hypotheses for AP and LP were that the difference in means between both tested groups is equal to zero and it was assumed that there were no differences between the

TABLE 1 Definition of the investigated oral stereotypes.

Tongue playing	Bar biting	Licking of equipment
Repeated form (more than twice) of abnormal, stereotyped tongue movement, such as swinging the tongue outside the mouth from side to side, twisting or rolling the tongue inside the mouth, sticking the tongue, or intermediate forms (Sato et al., 1994a).	A cow repeatedly clamps her jaws around a bar and moves her head back and forth while chewing on the bar.	A cow repeatedly licks a clearly defined and distinct part of an object, e.g. barn gates, walls, cubicle bars.

investigation farms regarding the tested traits. All tests were performed at a significance level of 0.05.

3 Results

On Farm 1, eight of the investigated cows showed tongue playing, one cow showed licking of the barn equipment, and two cows showed both tongue playing and licking of the barn equipment. None of the examined cows showed bar biting. During the 15 min of observation, all cows showed at least in one period stereotypic behavior when they had no access to the pasture while stereotypic behavior was shown on all, three, and two investigation days by four, five, and one cow, respectively, when the cows had pasture access. One cow showed no stereotypic behavior at all when the herd had access to the pasture. During winter, when the cows had no access to the pasture, AP ranged between 1 and 16 periods, and LP was between 2 s and 687 s. In the summer period, when the cows had pasture access, AP was between 0 and 15 periods and LP ranged between 0 s and 503 s.

On Farm 2, from a total of ten examined cows, seven cows showed tongue playing, two cows showed licking of the barn equipment, and one cow showed both tongue playing and licking of the barn equipment. None of the investigated cows in Farm 2 showed bar biting as well. All cows showed at least in one period oral stereotypes when they had no access to the pasture in winter. During the summer period, when the cows had pasture access, stereotypic behavior was shown on all, two, and one investigation day by two, one, and four cows, respectively. No stereotypic behavior was shown by the three cows when they had access to the pasture. When the cows had no access to the pasture, AP ranged between 1 and 8 periods, and LP was between 8 s and 630 s. When the cows had pasture access, AP was between 0 and 9 periods and LP ranged between 0 s and 575 s.

The median, minimum, 25% quantile, 75% quantile, and maximum values of AP and LP for both farms and housing systems are given in Table 2.

The results of the Wilcoxon signed rank tests show significant differences between the housing system regarding the values of AP (Figure 1) and LP (Figure 2). The values of AP ($p = 0.001$) as well as

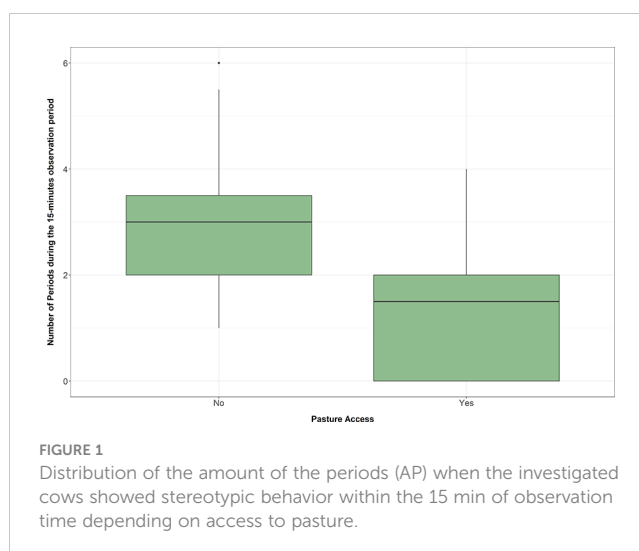


FIGURE 1 Distribution of the amount of the periods (AP) when the investigated cows showed stereotypic behavior within the 15 min of observation time depending on access to pasture.

the values of LP ($p = 0.006$) were lower when the cows had access to the pasture.

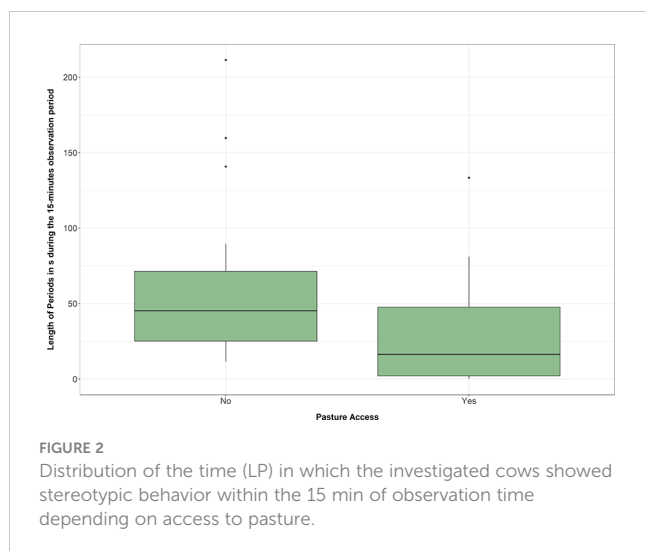
No differences could be found between the investigation farms regarding the values of AP ($p = 0.184$) and LP ($p = 0.078$).

4 Discussion

In the present investigation the examined cows showed tongue rolling (71.4%), licking of the barn equipment (14.3%), and a combination of these both stereotypes (14.3%) as stereotypic behavior. Thus, tongue rolling could be identified as the main stereotype in the investigated Jersey herds. These results agree with the findings of Sato et al. (1994a) who found 470 (92%) out of 510 cows performing tongue rolling (31%) or para tongue rolling (61%). Schneider et al. (2020) detect tongue rolling with an occurrence between 81.8% and 95.5% as the main stereotypic behavior in fattening Simmental bulls. As in the present study, licking of the barn equipment was second most common stereotype in the investigation of (Schneider et al., 2020). More than half of the examined Japanese Black x Holstein steers (56.34%) showed tongue rolling in the study of Ishiwata et al. (2008) as well. In the present

TABLE 2 Median, minimum, 25% quantile (Q1), 75% quantile (Q3), and maximum values of the amount (AP) and the length (LP in s) of the periods in which the cows showed stereotypic behavior for both farms and housing systems.

Farm	Housing	Variable	Median	Minimum	Q1	Q3	Maximum
1	Barn	AP	3	1	2	5	16
		LP	25	2	12	58	687
1	Pasture	AP	2	0	1	4	15
		LP	14	0	5	39	503
2	Barn	AP	3	1	2	5	8
		LP	20	2	8	50	630
2	Pasture	AP	1	0	0	2	9
		LP	3	0	0	13	575



investigation 3 out of 21 observed cows showed a combination of two stereotypic behaviors. This does not seem to be unusual, because Binev (2022) found in 6 out of 48 cows a combination of stereotypic behavior as well. Independent of whether the cows had access to the pasture or not the average LP ranged between 6.15 s and 110.15 s. Eleven of the 21 observed cows (52.4%) had an average LP of more than 30 s. These findings disagree with the results of Binev (2022) who found 92% of the examined cows performing stereotypic behavior less than 30 s.

In this study, the cows of both investigated farms showed stereotypic behaviors consisting of tongue playing, licking of the barn equipment, and a combination of both behaviors. This stereotypic behavior could be observed in both when the cows had access to the pasture and when they had not. There are different reasons for this in the both farms. With an average animal:feeding place ratio of 1.7:1 (Farm 1) and 1.5:1 (Farm 2) the barns in both farms were overcrowded (optimal - 1:1), which could increase the social stress by competition for resources in Holstein cattle (Proudfoot et al., 2009) and result in an increased occurrence of oral stereotypic behavior due to feeding frustration (Álvarez-Rodríguez et al., 2020). In contrast, Telezhenko et al. (2012) and Wang et al. (2016) did not find behavioral changes with an increasing stocking density. A lack of environmental enrichment could be a reason for the occurrence of oral stereotypies in the investigation farms as well. Redbo (1990) assumed that the stereotypies of their investigated Jersey and Swedish Red and White heifers most of the time depended on their immediate environment. This leads to the assumption that the housing environment of the cows influences their behavior. According to Wilson et al. (2002), a scratching/rubbing device like a cattle brush is a good tool to enrich the environment of cattle. These findings could be confirmed by Park et al. (2020) and Meneses et al. (2021) who found a decrease in the stereotypic behavior of British and British-Continental crossbreed bulls after the installation of cattle brushes. In order to obtain a positive effect on the stereotypic behavior, sufficient devices, such as brushes, have to be available to the cows. In the present investigation, there was one cattle brush for 100-140 cows (Farm 1) and two fixed cattle brushes for around 160

cows (Farm 2). The installation of more brushes could be helpful to reduce the stereotypic behavior of the cows. The group size in the investigated farms could be a reason for the stereotypic behavior of the cows as well. Kondo et al. (1989) found an increasing occurrence of stereotypic behavior with an increasing group size. According to Arave and Albright (1981), the optimal group size is from 50 to 60 cows per group. Thus, it could be assumed that the group size from 100 to 160 cows per group in the investigation farms could be a reason for the occurrence of stereotypic behavior. This assumption is supported by the results of Rind and Phillips (1999) as well as Jensen and Proudfoot (2017) who found out that larger group sizes resulted in more stress for the cows.

In the present investigation a significant effect of pasture access on the occurrence of stereotypic behavior could be detected. Thereby, the observed cows showed less stereotypes when they had pasture access. These findings agree with Redbo (1990); Redbo (1992), and Corazzin et al. (2010) who found a decreased occurrence of oral stereotypies during the grazing period in Swedish Red and White, Italian Simmental, and Italian Brown as well. Various reasons could be responsible for this. One of these reasons seems to be the increased space available for the animals due to access to pasture. Previous studies show that increased space allowance reduces the restlessness of cows as well as the incidence of aggressive behavior in cows (Kondo et al., 1989; O'Connell et al., 1989; Miller and Wood-Gush, 1991; Huzzey et al., 2006). Haskell et al. (2013) found out that lower-ranking cows used the available outdoor space to keep out of the way of higher-ranking animals. The authors were able to show that increased space reduces the occurrence of rank fights and the resulting stress. According to Smid et al. (2020), pasture grazing of cows reduces negative social interactions as cows have fewer social interactions on the pasture than in the barn due to the more available space per cow. The results of Higashiyama et al. (2007), that urinary cortisol content in cows was lower during the grazing period, confirm that grazing had a positive effect on stress reduction. In addition to the place allowance, competition for resources access affects the stress level of the cows as well. Restrictive feeding during housing combined with a too low animal:feeding place ratio, resulted in a competition for feed which increased the number of displacements at the feed table (Proudfoot et al., 2009). This led to frustration and consequently to the occurrence of oral stereotypies (Sato et al., 1994a). As grazing is the most common behavior on pasture (Kilgour, 2012) and restrictive feeding resulted in a significant increase of stereotypic behavior (Redbo et al., 1996), cows should have free access to feed at all times to reduce the incidence of stereotypies. Although the occurrence of stereotypic behavior decreased when the cows had pasture access, in the present study in both investigation farms stereotypes could be observed during the grazing period. These results are contrary to the results mentioned by Redbo (1990); Redbo (1992) and Corazzin et al. (2010) who found no stereotypic behavior in the cows during the grazing period. This could be explained by the fact that these studies investigated the differences in stereotypic behavior between tie stall housing and full day grazing. Thus, the contrast between both housing systems was much higher than in the investigation farms of the present study where the cows can move freely in the loose

housing system throughout the year and have additionally access to the pasture from spring to fall. Phillips et al. (2013) and Arnott et al. (2017) concluded that the integration of pasture access has significant advantages regarding the behavior and the welfare of dairy cows.

In the present investigation cows were observed using the focal sampling method described by Altmann (1974). According to Mitlöchner et al. (2001), this method is only acceptable to observe behaviors of a long duration like feeding or lying. Since the stereotypic behaviors of the cows on both farms were such long behaviors, the focal sampling method seems appropriate for studies of this design. However, this method is well suited if no social interaction between the animals is observed, but as soon as a social interaction between individual cows causes a specific behavior, this method is less suitable because the observer concentrates on the focal animal and thus overlooks possible triggers (Altmann, 1974). The use of cameras to observe the stereotypic behavior of dairy cows and the influence of social interaction on such behavior should be investigated in further studies although Tosi et al. (2006) found video recording not suitable to observe the oral stereotypes in calves. However, video technology has improved since their study, so that the recording of oral stereotypes should now work very well *via* video recordings.

5 Conclusions

It could be concluded that the access to pasture has a significant influence on the stereotypic behavior of Jersey cows. The values of AP and LP decreased when the cows had pasture access from spring to fall. Thus, pasture access could improve the animal welfare in dairy farming systems. Although the occurrence of stereotypic behavior decreased when the cows had pasture access, in both investigation farms stereotypes could be observed during the grazing period. Therefore, further studies are needed to determine in which situations the cows show stereotypic behavior and to analyze the causes of stereotypic behavior in Jersey cows.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval were not required for the animal study because the cows were exclusively observed from the feeding table and the observer did not come into direct contact with them

and none of the animals was handled or restricted at any time for this study.

Author contributions

Conceptualization: SD and SR. Methodology: SD. Formal analysis: SD. Investigation: SD and SR. Data curation: SD. Writing—original draft preparation: SD. Writing—review and editing: SR. Supervision: SR. Project administration: SD and SR. Funding acquisition: SR. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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