ABSTRACT

Holsteins and Jerseys, the 2 most prominent dairy breeds in the US, differ in many regards. They have not been evaluated for differences in oral behavior performance, despite anecdotal evidence that Jerseys perform more abnormal behaviors than Holsteins. As abnormal behaviors can indicate compromised welfare, we evaluated whether breed differences existed in 1-year-old heifers. Since many oral behaviors could be expressed in abnormal ways, we also sought to describe performance of a wide range of behaviors and whether these varied among individuals. We studied 42 pair-housed heifers (33 Holstein, 9 Jersey) at 12.8 ± 1.1 mo of age (mean ± SD) that were restricted to 50% of their ad-libitum TMR intake for 2 d as part of a short-term feed challenge. Using continuous video recording from 0800 to 2000 h on the 2nd d of feed restriction, we scored time spent performing tongue rolling, tongue flicking, self-grooming, allogrooming, intersucking, drinking urine, drinking water, and nonnutritive oral manipulation (NNOM) of rice hull bedding, the feed bin, or other pen fixtures. Eating TMR was recorded at 5-min intervals. We found that Jerseys spent more time tongue rolling (3.3% vs. 0.2% proportion of 12-h observations) and performing all types of NNOM than Holsteins (feed bin: 3.8% vs. 2.4%, bedding: 7.7% vs. 5.4%, other: 7.5 vs. 4.2%, total: 19.0% vs. 12.0%), and tended to spend more time tongue flicking (1.4% vs. 1.1%). Jerseys spent less time allogrooming than Holsteins (1.3% vs. 3.4%). There was no evidence of an effect of breed on self-grooming (2.0%), water drinking (1.0%), eating TMR (16.0%), or intersucking (0.06%). Urine drinking was performed by 9 total heifers and was not compared between breeds. All behaviors were highly variable across individuals, particularly tongue rolling and intersucking. Allogrooming was more variable than self-grooming, and each subcategory of NNOM was more variable than total NNOM. Outliers, or extreme performance of oral behaviors relative to the rest of our population, were present in most behaviors. Heifers who were outliers in one behavior were not consistently outliers in all. Overall, there are breed differences in many oral behaviors in a feed-restricted environment. Despite no difference in proportion of time spent eating, Jerseys often performed higher levels of potentially abnormal behaviors than Holsteins, though both breeds performed many oral behaviors, sometimes at extreme levels, that may indicate a concern.

Key words: Jersey, Holstein, abnormal behavior

INTRODUCTION

Dairy breeds vary in many ways, some of which may be connected to differences in welfare outcomes. Holsteins and Jerseys, the 2 most common breeds in the US (86% and 8%, respectively, of all dairy cows, USDA, 2016), differ in some of these metrics. Holsteins are more likely to be lame than Jerseys (Hoffman et al., 2013) and can be more prone to mastitis (Washburn et al., 2002), both of which are related to pain and culling risk. Indeed, Jerseys are more likely to survive longer on farms than Holsteins (Garcia-Peniche et al., 2006). Jerseys also appear to be more heat tolerant, withstanding higher temperatures before dropping or altering milk production (Smith et al., 2013), though are more susceptible to cold stress as calves compared with Holsteins (Scibilia et al., 1987) due to their smaller size. Quantifying breed differences can provide important insights into identifying and mediating welfare risks.

One area that has received less attention is breed differences in oral behaviors, which can provide valuable insight into how animals are interacting with their environment and each other. Feeding is the most-studied oral behavior. Jerseys naturally spend more time grazing and eating per unit of BW compared with Holsteins (ad libitum pasture: Prendiville et al., 2010; ad libitum PMR: Munksgaard et al., 2020). This apparent motivation to spend more time eating and using their mouth could lead to differences in other oral behaviors, such as ones that seem abnormal, like tongue rolling and nonnutritive oral manipulation (NNOM). These
behaviors appear inappropriate and sometimes repetitive in goal or motor pattern (e.g., abnormal repetitive behaviors, ARBs; Garner, 2005). ARBs can indicate compromised welfare (Mason and Latham, 2004) as they are often performed in sub-optimal environments. For example, when kept in environments that restrict motivated feeding behaviors, cattle increase performance of NNOM (Redbo and Nordblad, 1997; Horvath and Miller-Cushon, 2019; Downey et al., 2022). Both Jerseys and Holsteins are known to perform behaviors commonly considered ARBs, like NNOM and tongue rolling (e.g., Pempek et al., 2016; Robbins et al., 2023; Downey et al., 2022), and while Jerseys are anecdotally considered to engage in more ARBs, breed differences have not yet been directly compared.

In addition to feeding and ARBs, other oral behaviors that cattle perform can be expressed in ways that suggest abnormality. Some oral behaviors are performed at high levels under restrictive environments despite otherwise being considered normal behaviors, and these include grooming, tongue flicking (performed, at least in part, to clear the nostrils; Meltzer and Githens, 1919), and water drinking (e.g., Ishiwata et al., 2008; Faleiro et al., 2011; Downey et al., 2022). Other behaviors may be considered abnormal, and thus reflect concern, depending on the target: sucking is a normal behavior for neonates, but intersuckling, or manipulating the teats or udder of conspecifics, and urine drinking are both considered abnormal (e.g., Wiepkema, 1987; Lidfors and Isberg, 2003). Similarly, while eating is normal, eating non-nutritive bedding may reflect pica (Samaha et al., 1990). While both high level of performance and redirected targets can be concerning, extreme individual expression or wide variability within a group may also suggest abnormality. We have previously used outliers to describe excessive self-grooming performance in calves (Downey and Tucker, 2023a), while abnormal behaviors are found to have higher CVs than more normal behaviors in broilers (Kostal et al., 1992). Breed differences may exist in these other possibly abnormal oral behaviors, but to date, none of these have been evaluated.

Our objective was to evaluate whether Jerseys and Holsteins differed in oral behavior performance. We investigated this under a feed-restricted environment, as heifers often experience limit feeding (Zanton and Miller-Cushon, 2019), and abnormal behaviors in this age group are often documented under feed-limited conditions (Faleiro et al., 2011; Madruga et al., 2017; Bruno et al., 2020), suggesting the behaviors of interest were likely to occur in this setting. We expected that both breeds would spend similar amounts of time eating TMR, as this was restricted, but Jerseys would perform more abnormal (NNOM, tongue rolling) or possibly abnormal behaviors (allogrooming, self-grooming, tongue flicks, drinking water, drinking urine, intersuckling) than Holsteins. We expected to see variability in all behaviors, regardless of breed, evidenced by the presence of outliers and high CVs, both of which could indicate excessive performance of behaviors relative to the rest of the population.

**MATERIALS AND METHODS**

The following procedures were approved by the UC Davis Institutional Animal Care and Use Committee (protocol #21801). This study was conducted from July to September 2020 at the University of California, Davis Dairy Teaching and Research Facility.

**Experimental Design**

We enrolled 9 Jersey and 33 Holstein heifers (12.8 ± 1.1 mo, 358 ± 48 kg, mean ± SD) representing all healthy females born between May and September 2019 (between 11 and 15 mo of age). As per farm protocol, heifers were originally housed in groups between 19 and 23 animals, which included both experimental and similarly aged non-experimental heifers. For this experiment, heifers were paired and run in 5 total cohorts of 4 or 5 pens of 2 heifers each. Heifers were initially classified according to rearing environment from 0 to 7 wk of age (fed hay in a bucket, hay in a PVC pipe feeder, no hay, see Downey and Tucker, 2023a, for more details; sand or rice hull bedding) and breed (Jersey or Holstein) as part of a separate experiment, leading to 5 classifications (Jersey/sand/no hay, Jersey/rice hulls/no hay, Holsteins/rice hulls/no hay, Holsteins/sand/no hay, Holsteins/sand/no hay). This led to 10 possible unique pairings within a pen. In each cohort, there were thus 40–50 possible combinations of pairing and pen location. Heifers were sorted by age and allocated to pens and pairs randomly, starting with oldest first. We made replacements based on priori rules to balance pair combinations across all cohorts and to ensure that each classification was represented within each one. A priori rules also were in place to replace heifers that would come into heat during the experiment, based on visual and automated heat detection before pairing. We collected information about estrus from the farm management 2 d before each cohort began and applied these rules consistently throughout the experiment. Due to the sample size and early life classifications, Holsteins could be paired with other Holsteins or Jerseys, but Jerseys were only paired with Holsteins.

Pens were outside but partially covered by a roof for shade. Each pen had an “outside” (3.7 × 6.2 m; 3.7 × 3.4 m covered by the roof) and “inside” (3.7 × 3.4 m covered by the roof) and...
After adjustment to pair housing, heifers were fed the same TMR at ad-libitum levels for 2 d to calculate baseline feed intake. Feed was weighed before delivery at 0800 and 1600, and refusals were determined the next morning at 0700. Heifers thus did not have access to feed from 0700 to 0800. Across the adjustment and baseline days, heifers were fed to 110% of the previous day’s intake. Baseline intake by pen was averaged across the 2 d. Individual intake was not possible to measure during the ad libitum-fed days for ethical reasons, as this would have required 24-h isolation. Instead, we calculated the proportion of overall BW each heifer made up in their pair. We then multiplied this proportion by the pen level average feed intake to obtain a proxy for how much TMR each heifer had consumed, as higher body weight is correlated with higher intake (e.g., Frisch and Vercoe, 1977; Taylor et al., 1986).

After the baseline days, feed allowance was reduced by 50% for the following 2 d. Restriction was imposed at the individual heifer level, based on the proxy intake calculated across the baseline period, using the same TMR fed during the previous days. This is similar to the level of feed restriction used for limit feeding on farms (approximately 1.5–2% BW for heifers 4–22 mo old, Zanton and Heinrichs, 2008), but for ethical reasons, we imposed a duration of feed restriction less severe than farm and research settings (2 d vs. 26 d – 6 mo, Hoffman et al., 2007; Kruse et al., 2010; Kitts et al., 2011; Greter et al., 2015) as feed restriction is likely to cause hunger. Heifers were never restricted in water intake. The restricted TMR allowance (5.27 ± 0.8 kg/heifer/d, mean ± SD) was fed to heifers across 2 daily feedings. Heifers were separated at feeding by locking the gate in each pen so 1 individual would have exclusive access to the inside feed bin and the other would have exclusive access to the outside bin. Heifers were consistently fed either inside or outside during this phase, with feeding location balanced by initial heifer classification across cohorts. Heifers were separated until individuals across all pens ceased eating and did not return to the feed bin for at least 5 min, leading to a separation of approximately 1.5 h per feeding on both days. At this point, feed bins were swept out and heifers were reunited. Refusals per heifer were calculated. Any remaining feed from the 0800 feeding was added back for the 1600 feeding, but the 1600 refusals were not added to the next day’s intake.

**Behavioral observations.** Video was recorded from 0800 to 2000 on the 2nd d of feed restriction (GV-BL4713 Pro IR Bullet IP Cameras and GV-POE2411-V2 NVR, Geovision Inc., 24 fps, H.264 codec recording). On d 1 of feed restriction, heifers would still be adjusting to the 50% reduction in food and would likely still have had rumen content from the previous ad libitum-fed day, so only d 2 was observed. Evaluating oral behavior over daylight hours is common in this age class (e.g., Špinka, 1992; Ishiwata et al., 2008; Bourguet et al., 2011). Each pen was visible via 3 camera angles covering the inside portion, outside portion, and full pen. The cameras covering either the inside or outside portion of the pens were positioned 2–2.3 m above the ground, while the cameras covering the full pen were 3–4 m. Videos were scored using behavior sampling for oral behaviors (Table 1; Supplemental Videos S1-S16 https://doi.org/10.25338/B8PD3Z, Downey and Tucker, 2023b, 2023c) with a continuous recording rule (Bateson and Martin, 2021) for all behaviors except eating, which was quantified with a scan sampling rule and instantaneous recording at 5-min intervals (demonstrated to be accurate for eating behaviors in cattle in Chen et al., 2016). Videos were analyzed using BORIS (Behavioral Observation Research Interactive Software; Friard and Gamba, 2016). A total of 18 observers watched 1 heifer at a time and were not blind to breed as coat color could not be masked. Observers were first trained to identify tongue rolling and intersucking using 30-question video tests (15 yes, 15 no) to reliability ≥ 80% (Cohen's kappa, irr package version 0.84.1, Gamer et al., 2019). Observers then scored 21 videos (5-min duration/video) continu-
Heifers were always in view while scoring eating at 5-min intervals. For all other behaviors, proportion of time engaged in oral behavior on the second day of feed restriction was calculated relative to total time in view [duration of behavior/(12 h – time spent out of view)] for each heifer. All relevant results are presented using this calculation. Heifers were in view for 93.5 ± 3.5% (mean ± SD) of the 12-h observation period. The most common way “out of view” was scored was that their muzzles were obscured by the other heifer and the camera angle.

A betaregression (betareg package version 3.1–4, Cribari-Neto and Zeileis, 2010) was fitted with breed as a fixed effect to analyze proportion of visible time tongue rolling, performing tongue flicks, manipulating bedding (NNOM: Bedding), performing other oral manipulation (NNOM: Other), all oral manipulation (NNOM: Total; Bedding + Feed bin + Other), drinking water, eating TMR, self-grooming (Groom: Self), and allogrooming (Groom: Allo). Models were assessed with a type II ANOVA (car package version 3.0–10, Fox and Weisberg, 2019) to obtain P-values. Time spent intersuckling and manipulating the feed bin (NNOM: 

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Table 1. Behaviors recorded from video using behavior sampling and continuous recording over 12 h

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eating TMR</td>
<td>Muzzle is below the top edge of the feed bin or within 1 head length above the feed bin. If head is above the feed bin but turned away, eating can be identified if there are jaw movements within 1 s. Heifer is not licking/chewing/sucking on the feed bin or bars, and mouth/tongue is not in contact with heifer’s own body or the body of penmate.</td>
</tr>
<tr>
<td>Drinking urine</td>
<td>Mouth or tongue visibly touch urine stream from neighboring animal. If mouth or tongue are not visible, muzzle is oriented against the rear of the neighboring animal while urinating (as indicated by urinating posture of arched back and wide stance, or visual confirmation of a urine stream) or toward the urine stream and jaw is moving.</td>
</tr>
<tr>
<td>Drinking water</td>
<td>Mouth or tongue visibly touch water; if not visible, any part of the muzzle is in water trough for at least 1 s</td>
</tr>
<tr>
<td>Groom: Allo</td>
<td>Touching hair on a neighboring animal with the tongue or mouth; includes if mouth is not visible but directed toward neighbor’s body and the head moves in a vertical (up or down) motion</td>
</tr>
<tr>
<td>Groom: Self</td>
<td>Touching tongue with the tongue or mouth on heifer’s own body; includes if mouth is not visible but directed toward body and the head moves in a vertical (up or down) motion</td>
</tr>
<tr>
<td>Intersucking</td>
<td>Mouth or tongue is touching the teats or udder of another animal; if mouth is not visible, can be identified by the muzzle oriented between the hind legs of another animal or underneath the back third of other animal’s abdomen. In this case, the muzzle should be angled up to access the udder</td>
</tr>
<tr>
<td>NNOM: Feed</td>
<td>Licking or chewing directed toward feeding; tongue must be touching feeding, or jaw moving as the lips touch feeding or while mouth is directed at the feeding, or jaw movements while feeding is visible inside the mouth, or jaw movements continuing within 3 s after any of the preceding actions</td>
</tr>
<tr>
<td>NNOM: Bedding</td>
<td>Licking, chewing, or sucking directed toward the feed bin. Includes if mouth is not visible but directed toward feed bin and the head moves in a vertical (up or down motion). When feed bin is empty (whenever heifers are not separated), includes if muzzle is below the top edge of the feed bin for at least 1 s</td>
</tr>
<tr>
<td>NNOM: Other</td>
<td>Licking, chewing, or sucking directed toward any non-nutritive item except beddinng or feed bin (includes bars, water trough, hose); tongue or lips must be touching a non-nutritive item, or such item must be held inside the mouth; Includes if mouth is not visible but directed toward non-nutritive items and the head or jaw move in a vertical (up or down) motion</td>
</tr>
<tr>
<td>Out of view</td>
<td>The heifer’s muzzle and/or body are not visible, preventing classification of other behaviors</td>
</tr>
<tr>
<td>Tongue flicks</td>
<td>The tongue extends out of the mouth without touching other objects or forming a full or partial circular motion, or extends up to the nose before retracting back into mouth and repeating at least once more within 1 s; does not count during eating and ruminating</td>
</tr>
<tr>
<td>Tongue rolling</td>
<td>Tongue is held in a full or partial circular position or moves in a full or partial circular motion; this can occur when the tongue is held within the border of the lips inside the mouth and/or extended outside the border of the lips. This cannot occur while any other behaviors are being performed (the tongue is not touching any feed/nonnutritive items), and does not need to repeat.</td>
</tr>
</tbody>
</table>

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1For all relevant definitions, muzzle is defined as from the bottom of the eyes to the end of the mouth. See Supplemental Videos S1–S16 in https://doi.org/10.25338/B8PD3Z (Downey and Tucker, 2023b, 2023c) examples.

2As defined in Downey et al. (2022).
Feed bin) were evaluated using an unpaired Wilcoxon signed-rank test (stats package in base R), as data did not meet the assumptions of normality. All oral behaviors are reported as percentages hereafter in the text to facilitate readability. Time spent drinking urine was rare, and not evaluated with a model.

Coefficients of variation (CV) and outliers and were calculated for all behaviors that were fitted with a model. Outliers were considered those that fell more than 1.5x below or above the 1st and 3rd quartiles, respectively (boxplot function in base R; interquartile range criteria). Outliers in this case were used to identify and describe extreme performances of oral behavior within the population, not as criteria for discarding rare, and not evaluated with a model. Outliers were considered those that fell more than 1.5x below or above the 1st and 3rd quartiles, respectively (boxplot function in base R; interquartile range criteria). Outliers in this case were used to identify and describe extreme performances of oral behavior within the population, not as criteria for discarding data. We used a similar method to describe excessive grooming bouts in Downey and Tucker (2023a).

RESULTS

All data (https://doi.org/10.25338/B81D19), Rmarkdown files for analyses and figures (https://doi.org/10.5281/zenodo.7308642), and a supplemental table containing means, SE, CI, test statistics, df, and P-values for all analyses (https://doi.org/10.5281/zenodo.7308644) are available in the Dryad repository (Downey and Tucker, 2023d).

Jersey heifers spent more time performing all NNOM (bedding, feeding, allogrooming, NNOM: Feed bin, bedding, all other, and total, P ≤ 0.013; Figure 1) than Holsteins. There was no evidence of breed differences in time spent self-grooming, drinking water, or eating TMR (P ≥ 0.264; Figure 2). Intersucking was performed by 30 of the 42 heifers (71%), representing 70% of Jerseys and 78% of Holsteins, but there was no evidence of an effect of breed (P = 0.877; Figure 2). Nine heifers drank urine from a penmate (18% of Holsteins, 33% of Jerseys) for a total of 1–15 s/12 h.

Regardless of breed, all heifers varied in their performance of oral behaviors. Outliers were present in most behaviors (Figures 1–2). Four heifers (3 Holstein, 1 Jersey) were outliers for intersucking, spending 0.2–0.4% of the 12-h period engaged in this. There were also 4 outliers in tongue rolling (3 Jersey, 1 Holstein) for 1.4–18.9% of time. Drinking water had 1 outlier (Holstein; 4.1% of time), as did self-grooming (Jersey; 4.4%) and tongue flicks (Holstein; 2.7%). There were no outliers in eating, allogrooming, NNOM: Feed bin, or NNOM: Bedding. Most outliers represented unique heifers; no heifer performed outlier levels of more than one behavior except for a heifer that was an outlier for both NNOM: Other (Jersey; 15.2%) and NNOM: Total (30.1%). Across all individuals, tongue rolling had the highest CV, and was the most variable (367%), followed by intersucking (152%). Allogrooming was more variable than self-grooming (61 vs. 36%). Subcategories of NNOM varied more than total NNOM (bin: 51, bedding: 56, all other: 61, total: 36%). Drinking water (46%) and tongue flicks (50%) also varied. Eating TMR was the least variable behavior (13%).

DISCUSSION

Jerseys engaged in more tongue rolling and all NNOM (feed bin, bedding, other, total) than Holsteins, but all heifers performed these behaviors. To our knowledge, this is the first documented comparison of abnormal behaviors in these breeds, which together make up 94% of all US dairy cows (Holsteins outnumber Jerseys 9:1; USDA, 2016). While Holsteins spent similar amounts of time tongue rolling (0.2%) as other steers and heifers in farm settings (0.1–1.1%, Ishiwata et al., 2008; Iraira et al., 2013; Madruga et al., 2017), Jerseys tongue rolled at much higher levels (3.3%). Both breeds performed NNOM at higher levels than typically reported (e.g., 12–19% vs. 1.3–3.5%, Robles et al., 2007; Ishiwata et al., 2008; Devant et al., 2015), with Jerseys consistently doing more NNOM in each category, possibly due to sampling differences, as instantaneous recording rules used by many others are noted to be inaccurate above 5-min intervals for heifers (Madruga et al., 2017). Tongue rolling is reported to be twice as prevalent in Jersey cows compared with Jersey-Holstein crosses (Robbins et al., 2023), suggesting there may be a genetic component to the behavior. This is true of abnormal behaviors in other species. In mice, for example, C58/J strains show consistently high ARBs like back flipping and jumping while C57BL/6J perform almost none (Ryan et al., 2010). Species of captive primates and carnivores also vary in ARB severity, and this variation correlates with their natural home range and group size (e.g., Clubb and Mason, 2007; Pomerantz et al., 2013). Jerseys may similarly be more prone to ARBs in confined dairy settings because they naturally spend more time grazing and eating in confined settings per kg BW than Holsteins (Prendiville et al., 2010; Munksgaard et al., 2020), and may be motivated to engage in these behaviors more. Restricting this ability by limiting feed could thus affect Jerseys more severely than Holsteins.

Jerseys also tended to spend more time tongue flicking than Holsteins. This behavior has normal motivations, i.e., to clear the nostrils (Meltzer and Githens, 1919), but is also increased under restrictive conditions,
such as in calves not provided hay (Downey et al., 2022), suggesting it may have abnormal underpinnings. The behavior itself appears similar to tongue rolling, though less extreme in form, further suggesting a possible abnormal connection. Tongue movements are typically involved in natural feeding motions on pasture (Sambraus, 1985), and both tongue flicks and rolls may relate to motivation to express this behavior.

We did not find evidence that breed affected intersucking. Conspecific sucking (intersucking and cross-sucking combined) has been found to be heritable within a breed (Austrian Fleckvieh, $h^2 = 0.04$, Fuerst-Waltl et al., 2010), and Jerseys have sometimes been reported to perform more intersucking than other European dairy breeds (e.g., reviewed by Lidfors and Isberg, 2003). Others have found no significant breed differences (Keil et al., 2001). Intersucking is typically reported to occur in 1–57% of heifers on farms (Śpinka, 1992; Keil et al., 2001), though we found it was more prevalent, occurring in 70–78% of heifers in both breeds. This higher prevalence could be, in part, because heifers were evaluated in a limit-fed environment. Decreased solid feed has been suggested as a risk factor for intersucking previously (Keil and Langhans, 2001, Goeller et al., submitted), and both breeds may have performed this behavior as a response to hunger. Intersucking was performed for short overall durations (0.06%), which could reflect the willingness, or lack thereof, of the recipient to be sucked. Partner willingness also is likely to influence the expression of this behavior, and could play a role in the overall lack of evidence of a breed difference in these pair-housed heifers.

Jerseys and Holsteins spent similar amounts of time eating, self-grooming, and drinking water. Feed was limited for all heifers based on BW-approximated individual feed intake, and was not expected to differ. All heifers spent approximately 2% of time self-grooming, similar to findings in other confined heifers (2.5–4%, Ishiwata et al., 2008; Faleiro et al., 2011; Madruga et al., 2017), and 1.5% of time drinking water, which also mirrored findings in similar age classes (1.2–2.5%; Robles et al., 2007; González et al., 2008; Madruga et al., 2017). The lack of evidence of a difference in these 2 parameters could suggest that these behaviors

Figure 1. Mean percentage of time engaged in nonnutritive oral behaviors across 12 h in year-old feed-restricted Jersey ($n = 9$) and Holstein ($n = 33$) heifers. Data were collected using behavior sampling and continuous recording on the 2nd day of feed restriction (50% of ad-libitum intake). Boxplots represent the median (black line within box) and first and third quartiles (25 and 75% of data). Whiskers extend to the lowest and highest values that are not outliers (values that are 1.5x the interquartile range); outliers (o) and means (x) are also presented.

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are normal, as commonly thought, and thus expressed similarly across breeds. However, total time engaged in these behaviors may not exclusively indicate abnormal performance. We have previously found evidence of seemingly abnormal expression in dairy calves by tracking bout length (grooming for up to 30 min in a single bout; Downey and Tucker, 2023a) and consumption (polydipsia, Downey et al., 2022), while cattle in tie stalls have also been reported to “lap” at water (Mattielo et al., 2005; Corazzin et al., 2010). Future work should consider using more robust ways of measuring abnormal expression to evaluate whether breeds differ under more nuanced approaches.

Holsteins spent over twice as much time allogrooming as Jerseys. A similar pattern was reported under mixed breed pasture settings, with Holsteins grooming 1.2 times longer than Jerseys, though this included time spent self-grooming and object rubbing as well (Guimarães-Yamada et al., 2022). Despite the breed difference, both Jerseys and Holsteins spent a similar amount of time allogrooming as others have reported in this age class under restrictive settings (e.g., limited forage and individual stalls) for both dairy (e.g., 4%, Holsteins: Rotger et al., 2006) and dual-purpose breeds (e.g., 1.8–3.3%, Holsteins: González et al., 2008; Simmental: Iaira et al., 2013; Madruga et al., 2017). Familiarity with the receiver, such as through previous interactions, could be a factor in eliciting allogrooming (e.g., Sato et al., 1993, Val-Laillet et al., 2009, Pinheiro Machado et al., 2020). Similar physical appearance (e.g., coat color) may also play a role, as it can affect social preferences in environments of otherwise unfamiliar animals (e.g., Murphey and de Moura Duarte, 1990). Our pairing decisions, particularly the lack of same-breed Jersey pairs due to sample size constraints, may have influenced these results.

Across breeds, heifers showed wide variability in each behavior except eating. Variability was expressed through number of heifers performing each behavior, presence of outliers, and CVs. Behaviors were performed by all or most heifers except urine drinking, which is also reported to be rare in calves (de Wilt, 1985; Lidfors, 1993), but is otherwise not often scored in cattle. Individuals performed many behaviors at outlier levels, which described extreme performance relative to the rest of our population. The most extreme outliers were found in tongue rolling, where 1 Jersey performed this behavior for 19% of the daylight period, or approximately 4.5 h, and total NNOM, where a different Jersey spent 30% of the period, or 7 h manipulating the
environment. However, heifers were not usually outliers in multiple behaviors, suggesting there may be individual variability in response to restrictive farm conditions. Variability was also seen through CVs. Tongue rolling and intersucking had the highest CVs, but all behaviors scored were more variable than more normal behaviors like eating (13%, this study; 16%; Dado and Allen, 1994), ruminating (18%, Dado and Allen, 1994), and sucking milk from a bottle (26%, Downey et al., 2021). This mirrors work in chickens that found ARBs like feather pecking had much higher CVs than more normal behaviors like feeding and resting (Kostal et al., 1992). Interestingly, total NNOM was less variable than the sum of its parts (36% vs. 51–61%). This may suggest that individuals have preferred outlets for how they express abnormal behaviors, but that the behaviors may have similar underlying motivations. Taken together, these indicators of variability suggest that cattle may respond to farm environments in different ways.

All heifers faced a welfare challenge in this study and both individuals and breeds responded to this in different ways. These patterns are not straightforward. While we have found evidence of breed differences in some behaviors, the underlying mechanism behind these, and resultant implications, are not yet known. Differences could stem from genetics or preferences in expressing abnormal behaviors. Differences may also relate to challenges in adapting to restrictive farm settings more broadly: cattle in confined settings, where feed requires minimal searching and processing, spend less time eating than those in pasture-based ones (e.g., 3–5 h/d vs. 7–13 h/d, DeVries and von Keyserlingk, 2009; Kilgour, 2012). Both breeds may have performed abnormal behaviors due to this limitation. There may also be behaviors of concern that we did not score here, like inactivity (e.g., Hintze et al., 2020) or leaning (e.g., Krohn, 1994; Nielsen et al., 1997). Further, while abnormal behaviors indicate a concern, it is not known if Jerseys are inherently more likely to experience poor normal behaviors like feeding and resting (Kostal et al., 1994; Nielsen et al., 1997). Further, while abnormal behaviors may have similar underlying motivations. Taken together, these indicators of variability suggest that cattle may respond to farm environments in different ways.

To the authors’ knowledge, this is the first study quantifying abnormal oral behavior differences between Holsteins and Jerseys. We found that Jerseys spend more time tongue rolling and NNOM compared with Holsteins and tended to perform more tongue flicks. Holsteins spent more time allogrooming. There was no evidence of differences in eating TMR, self-grooming, drinking water, or intersucking. Regardless of breed, behaviors were highly variable, and some, including those commonly considered “normal,” were performed at extreme levels, raising questions about what we consider to be “abnormal.”

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**REFERENCES**


Madurga, A., E. Mainau, L. A. González, M. Rodríguez-Prado, J. L. Ruiz de la Torre, X. Manteca, and A. Ferret. 2017. Technical note: Recording rules for behavioral studies in growing heifers fed high-
Downey and Tucker. Jerseys and Holsteins differ in oral behavior


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