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Short communication: Automatic detection of social competition using an electronic feeding system

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ABSTRACT

The objective of this study was to determine if data derived from a system that electronically monitors feeding behavior could be used to identify competitive interactions of dairy cows at the feed bunk. A short interval between successive feeding events of 2 cows at 1 feed bin was predicted to be associated with a competitive replacement: when one cow displaced a feeding cow and then took her position at the bin. To identify the interval between feeding events that best predicted these replacement events, the feeding activity of 5 Holstein dairy cows was monitored using an electronic feeding system and video recordings. The number of times a cow was replaced at the feed bunk over 3 consecutive 24-h periods was determined using video analysis and these events were paired with the corresponding feeding events recorded by an electronic feeding system (Roughage Intake Control system; Insentec B.V., Marknesse, the Netherlands). A pooled analysis of all 5 cows showed that the optimal interval for predicting replacements at the feed bunk was 26 s (sensitivity = 86% and specificity = 82%); this interval was termed the replacement criterion. This criterion was then applied to feeding data from a sample of 24 independent Holstein dairy cows, each observed for 3 d during the week following calving. Video had previously been used to measure the number of times each cow was an actor and reactor of a displacement (when one cow displaced a feeding cow but did not necessarily take her position at the bin). Despite the differences in measures, the number of replacements (as estimated by our algorithm) was positively correlated with the number of displacements [as measured using video; correlation coefficient (r) = 0.63 as actor, r = 0.69 as reactor]. Estimates of an index of success in competitive interactions (number of times actor/number of times actor + number of times reactor) generated using the 2 methods were highly correlated (r = 0.94). These results suggest that competitive behavior at the feed bunk can be automatically quantified using data derived from an electronic feeding system.

Key words: animal welfare, feeding behavior, displacement

Short Communication

Social competition at the feed bunk (for example, when one cow makes contact or threatens a feeding cow such that a feeding cow leaves the bunk) is common among group-housed dairy cattle. This competition is known to increase in response to overstocking (Huzzey et al., 2006; Proudfoot et al., 2009) and during the first few days after regrouping (von Keyserlingk et al., 2008). Increased competition among cattle at the feed bunk is also associated with increased physiological stress (Friend et al., 1979; Huzzey et al., 2012), decreased feeding time (Olofsson 1999; Huzzey et al., 2006), and decreased DMI (Proudfoot et al., 2009).

Conventional techniques used to record competition involve live observation or retrospective observation using video recordings (e.g., Phillips and Rind, 2001; Færevik et al., 2010; Huzzey et al., 2012). These methods are time consuming and can be subject to poor intra- and interobserver reliability if the behavioral definition is poor or observer training insufficient. Identifying faster and more objective ways to measure competitive behavior at the feed bunk would be useful.

Technology has proven useful for monitoring the feeding behavior of cattle (Sowell et al., 1998; DeVries et al., 2003; Chapinal et al., 2007). For example, the Insentec Roughage Intake Control system (Insentec B.V., Marknesse, the Netherlands; validated by Chapinal et al., 2007) records intake, time, and location of feeding events for group-housed dairy cows. These data can be used in several innovative ways. For example, cows at risk for disease can be identified weeks before clinical symptoms become evident based on changes in daily feeding time and DMI (Huzzey et al. 2007; Goldhawk et al. 2009). However, no attempt has been made to use this type of data to quantify competitive behavior.

We hypothesized that competitive replacements at the feed bunk, defined as occurring when one cow (the actor) makes physical contact with a feeding cow (the

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reactor), such that reactor leaves the feed bunk and the actor takes her position, can be assessed using data derived from a system that electronically monitors feeding behavior. If the replacement is motivated by hunger, it is expected that an actor will quickly occupy the feeding location that the reactor just left. We predicted that a short interval between the feeding events of 2 different cows at 1 feed location (i.e., a short period of time during which the bin is empty between feeding events) would be linked to a replacement. The objectives of this study were (1) to determine the interval between feeding events of 2 cows at 1 bin (replacement criterion) that best predicts replacement events as identified by video analysis and (2) validate the use of this replacement criterion by correlating estimates of competitive behavior obtained using video analysis and the electronic feeding system from a larger sample of animals.

To achieve our first objective, the feeding and competitive behavior of 5 pregnant, nonlactating, Holstein dairy cattle [heifers (n = 2), first lactation (n = 2), second lactation (n = 1)] were observed concurrently during 3 consecutive 24-h periods at The University of British Columbia Dairy Education and Research Center (Agassiz, British Columbia, Canada). The selected sample size was limited to 5 cows during this initial analysis because of the time investment required to record competitive behavior from video recordings. These cows were part of a group of 20 cows housed in a pen containing 12 electronic feed bins (Insentec B.V.). Each feed bin measured 1.00 m wide, 0.75 m high, and 0.84 m deep. All 20 cows in the pen had access to all feed bins and ad libitum access to 2 water bins. Cows were fed a TMR formulated for nonlactating cows, consisting of 21.3% corn silage, 42.8% alfalfa hay, and 35.9% concentrate and mineral mix on a DM basis.

Cows were fitted with an ear tag transponder (High-Performance ISO Half Duplex Electronic ID Tag; Allflex Canada, Saint-Hyacinthe, Quebec, Canada). When a cow approached a feed bin, an antenna detected the cow's transponder, allowing a gate to drop, providing the cow access to the feed. The electronic feeding system recorded the time the cow entered the bin and the initial weight of the feed bin at the time of entry and then the time the cow left the feed bin and the weight of the bin at the time of exit; thus, for each visit to a feed bin, the system would record the duration of the visit and the amount of feed consumed.

Competitive behavior of the focal cows was monitored using video cameras [closed-circuit television (CCTV) camera, model WV-BP330; Panasonic Corp., Osaka, Japan] fitted with an F1.4/2.5–6-mm varifocal lens. Cameras were connected to a video multiplexer (Panasonic Video Multiplexer, WJ FS 416) and a time-lapse videocassette recorder (Panasonic Time-Lapse VCR, AG-6540). Two cameras were spaced evenly and directly above the feed bunk. Red lights (100 W) were hung adjacent to the cameras to facilitate video recording at night. Individual cows were identified on the video recordings by unique alphanumeric symbols located on their back and sides. A displacement from the feed bunk was noted when a cow's head (actor) came in contact with a cow who was feeding (reactor), such that the feeding cow withdrew its head from the feed bunk. A displacement was identified as a replacement when the actor was the next cow to begin a feeding event at the bin that the reactor was displaced from.

For each feeding event, the elapsed time where the bin was unoccupied immediately following the event was noted. Each interval was then coded as being associated with a replacement (1) or not (0) based on the video analysis.

The logistic procedure of SAS (version 9.3; SAS Institute Inc., Cary, NC) was used to determine the predicative value of the interval between feeding events of 2 cows at 1 bin for identifying a replacement event. Replacement outcome (0 vs. 1) was considered the dependent variable and interval between feed events as the independent variable in the model. A receiver operating characteristic (**ROC**) curve was constructed and area under the curve (**AUC**) was determined as a measure of accuracy in predicting replacements. An ROC curve is a plot of the true-positive rate (sensitivity) versus the false-positive rate (1 − specificity), for a binary classifier (i.e., replacement outcome) for all possible discrimination thresholds (i.e., intervals between feed events). Sensitivity (**Se**) is the proportion of intervals at or below a given threshold that are associated with true replacement events, whereas specificity (**Sp**) is the proportion of intervals above a given threshold that are not associated with true replacement events. The point on an ROC curve that is closest to the upper left corner has the highest combined Se and Sp, and was considered the optimal threshold (Akobeng, 2007; Dohoo et al., 2009) and was termed the replacement criterion. Because this analysis requires that the interval be used as the experimental unit, replacement criteria were determined for each cow individually (n = 5) and then for all cows together.

Based on the video analysis, the 5 focal cows were replaced at the feed bunk a total of 160 times over the 3-d observation period and had a total of 627 feeding events. Table 1 presents the replacement criteria and associated statistics using data from individual cows and from all the cows combined. Estimates of the individual replacement criteria varied (range of 15 to 47 s); however, these estimates were generally associated with high Se and Sp. In all cases, the exact 2-sided