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Probabilities of cattle participating in eating and drinking behavior when located at feeding and watering locations by a real time location system

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ABSTRACT

Introduction: Animal location can be monitored and described through remote, real-time location systems (RTLS) that locate animals within a defined housing area on a continuous basis using an X, Y coordinate system. These systems only collect locational data and do not measure participation in behaviors of interest. Video recording is a method for documenting animal behavior but analysis of the data is time consuming and prone to error. The objective of this research was to determine the probability of calves participating in eating or drinking behavior as classified by video when located by RTLS within 0.3 m of the hay, grain, or water.
Results: Two, separate 24 h trials monitored two independent groups of cattle in a dry lot pen. Trial 1 monitored 2- to 3-month old Holstein steer calves (n = 16) and Trial 2 monitored 4- to 5-month old beef heifer calves (n = 9). Video observers categorized each calf according to target behaviors as 0 (no behavior) or 1 (behavior observed) and video data was compared to RTLS data classifying calves as in-the-zone of interest. Analysis accounted for lack of independence of samples due to observer, repeated measures of calves, and period of the day (6 h block). Significant differences in the probability of engaging in a behavior of interest were observed between calves and periods of the day. When located in the zone of interest categorized as "in-the-water" by RTLS, individual calves displayed a model-estimated median (min, max) probability of drinking as categorized by video observation of 42.09% (26.58, 60.05) in Trial 1 and 54.49% (40.15, 75.01) in Trial 2. The model-estimated median probability of eating while located in the zone categorized as "in-the-hay" was 88.27% (65.10, 99.26) and 67.87% (22.63, 84.13) in Trials 1 and 2, respectively. The model-estimated median probability of eating when in-the-grain in Trial 1 was 59.59% (9.87, 88.07) and was 51.97% (36.86, 77.51) in Trial 2.
Conclusions: The data from this trial provide an estimate of the median probability of participating in eating and drinking behavior when located at feeding and watering locations as categorized by RTLS. The observed data also highlights the significant variability in the probability of participating in a behavior of interest when at a location of interest between calves. This trial provides an improved understanding of the association between RTLS data and some of the behaviors of interest to researchers.

1. Introduction

Researchers use various direct and indirect methods of observation to assess health status (Theurer et al., 2013a, 2013b). These methods are also used to monitor and quantify behaviors of interest, such as eating and drinking, when investigating the effects of a variable of interest. Direct observation methods such as assigning subjective clinical illness scores by trained observers have been used as a method to assess and describe health and wellness in cattle (Hanzlicek et al., 2010). Radio frequency transmitters have been used to determine presence and duration at feeding and watering locations, with this data being correlated to health status (Sowell et al., 1998; Quimby et al., 2001). Accelerometer technology and data logger technology utilizing electrical circuits have been validated and used to analyse postural behavior patterns of cattle (O'Driscoll et al., 2008; White et al.,

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2008; Robért et al., 2011). Walking activity and grazing bite activity have been successfully monitored through the use of pedometers (Devant et al., 2012; Umemura, 2013).

Technologies that integrate data from multiple measuring devices into one system may provide a benefit for investigating cattle behavior. Remote, real time locating systems (RTLS) have been used to analyse the amount of time cattle spend at locations of interest, as well as distance traveled (White et al., 2012; Theurer et al., 2013a, 2013b). These systems have been shown to have high precision regarding locational data of cattle in confined areas (Porto et al., 2014). RTLS can be used to detect differences or changes in cattle behavior associated with animal health and wellness and have many benefits over other systems for assessing behavioral differences (White et al., 2012, 2015; Theurer et al., 2013a, 2013b). Unfortunately, the technology does not indicate the amount of time participating in various behaviors of interest, only whether or not cattle are located where they could participate in the activity. Thus, RTLS data must be interpreted knowing this limitation (Theurer et al., 2013a, 2013b). Since feeding and watering behavior are associated with health status it would be beneficial to provide estimates for these behaviors of interest when using a RTLS system.

Direct observation of video recordings is a method that is frequently used to monitor and analyse cattle behaviors. Various behaviors such as eating, drinking, and lying down have been successfully monitored and assessed through the use of video recording (Szyszka et al., 2012; Huzzey et al., 2013; Uzal Seyfi, 2013). Though analysis of video data is difficult, time consuming, and often accompanied with error (Mitlöhner et al., 2001), it is frequently the most accurate method to assess cattle behavior. To address limitations of RTLS behavioral monitoring, the objective of this trial is to determine the probability of calves participating in eating or drinking behavior as classified by video when located within 0.3 m of the hay, grain, or water as indicated by RTLS. Comparison of video data to the RTLS data will provide a better understanding of the data gathered from RTLS technology.

2. Methods

2.1. Cattle and husbandry

The research was conducted at the Large Animal Research Center at Kansas State University in Manhattan, Kansas. There were two individual trials conducted on separate groups of cattle. Animals used in Trial 1 were Holstein steer calves (n = 16) with an estimated age of 2- to 3-months. Trial 2 was conducted on beef heifers (n = 9) with an estimated age of 4- to 5-months. Observation periods were 24 h in duration with records being taken each second. Trial 1 was conducted from 12:00:00 PM on June 6, 2012 until 11:59:59 AM on June 7, 2012. Trial 2 took place from 12:00:00 PM on August 13, 2012 until 11:59:59 on August 14, 2012. The Animal Care and Use Committee at Kansas State University approved the study under protocol number 3178.

2.2. Housing and weather conditions

Calves were housed in a standard livestock dry lot pen that was 12.2 m wide and 24.4 m long. Hay was fed ad libitum in a double sided 3.7 m bunk. A wood barrier was placed at the end of the hay bunk to ensure that feeding could not occur at the end of the bunk where video identification would be difficult. The water tank was a standard automatic ball fill tank with adequate space for a single calf to consume water at a time. Three feed bunks totaling 8.5 m in length place along one side of the pen were used to feed grain. Calves were fed grain daily at 08:30:00 AM and 04:00:00 PM. The layout of the pen is represented in Fig. 1.

Weather data were collected using the National Climatic Data Centre. The high and low temperatures recorded during Trial 1 were 31 °C and 16 °C, respectively. The maximum temperature during Trial 2 was 27 °C and the minimum temperature was 16 °C. Precipitation occurred during Trial 2 from 06:30:00 to 09:30:00 with a total 7.62 mm of measurable precipitation (Center, 2012).

2.3. Cattle identification

Calves in both trials were identified with a numbered ear tag and Ubisense Series 7000 compact tag RTLS tracking device (Ubisense, Denver, CO, USA). Numbered ear tags in Trial 1 were on the right ear, with the RTLS transmitters on the left ear. Calves in Trial 1 were identified in video using natural color pattern and by unique markings made with spray paint over the dorsal portion of the animal.

In Trial 2, beef heifers were given a numbered tag on their left ear, with the RTLS transmitter on the right ear. These calves were all black and were given unique markings with white spray paint in order to make identification on video possible. In both trials the Ubisense tag serial number was matched to the identification number on the ear tag.

2.4. Animal health monitoring

Cattle were observed twice daily for evidence of disease. Subjective clinical illness scores were assigned by a trained observer and the scores were utilized to evaluate wellness status (1 = clinically normal, 2 = slight illness, 3 = moderate illness, 4 = severely ill). Clinical indicators of health status included respiratory rate, visualization of cud chewing, tightness of the flank, willingness to move, coat condition, and others. Disease events were not expected in either trial. Clinical illness scores were used as part of standard animal husbandry procedures and were not used as data for this trial.

2.5. Remote, real-time locating system

Real-time location systems (RTLS) technology utilizes sensors and radio signals from transmitters to triangulate a location within a coordinate system designed for an area of interest. Ubisense Series 7000 compact tags (Ubisense, Denver, CO, USA) served as the transmitter and were attached to the ear of each calf using a modified ear tag and plastic cable zip tie.

The system interprets two pieces of information from the transmitter: The angle-of-arrival and the time-difference-of-arrival. The angle of arrival is the angle of the transmitter relative to the sensors. The time-difference-of-arrival is the difference in the amount of time it takes a signal from a transmitter to reach the different sensors. These measures are used to position the transmitter within the coordinate system. The system can then calculate the difference between time of arrival at one set of coordinates and the previous triangulation time point and calculate the amount of time spent at a respective coordinate. These coordinated data are then used to match and classify animals as present or absent in locations of interest using data mining software (MySQL, Oracle Corporation Redwood City, CA). The system included four RTLS sensors in close proximity to the pen of interest (Fig. 1). The coordinate system was programmed and validated for the pen used in the trial. Validation was completed by investigators placing tags at various locations in the pen and examining the locational data for agreement. Locational data were collected every second for each calf. The data matched by the mining software binomially classified the cattle as "in-the-zone" (1) or "not-in-the-zone" (0) for each location.