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# *Technical note:* Validation of data loggers for recording lying behavior in dairy goats

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## ABSTRACT

Changes in standing and lying behavior are frequently used in farm animals as indictors of comfort and health. In dairy goats, these behaviors have primarily been measured using labor-intensive video and live observation methodologies. The aim of this study was to validate accelerometer-based data loggers for use in goats. Two commercial dairy goat farms in Ontario were enrolled; goats were fitted with data loggers on their rear left legs and the pens were equipped with video. Data loggers compared well with video in identifying lying and standing events on both farms (farm 1 and 2, respectively: sensitivity = 99.7 and 99.8%, specificity = 99.5 and 99.4%, false readings = 0.43 and 0.36%). The loggers were also able to record if the goat was lying on her left or right side (farm 1 only: sensitivity = 99.9%, specificity = 99.3%, false readings = 0.38%), but these measures were only accurate if the loggers were attached with sufficient tension to prevent logger rotation. The mature does enrolled on farm 1 spent 14.5 ± 1.0 h/d lying down and frequently changed lying side even within a single lying bout (24 ± 5 shifts/d between left and right sides and 16 ± 5 lying bouts/d). The young goats on the second farm averaged just 8.5 ± 3.2 h/d in lying time, and spread this time over 8 ± 4 bouts/d. Data loggers accurately measured lying time and lying bouts in mature does and younger goats on both farms, and lying laterality (e.g., left and right lying sides) in mature does on farm 1.
**Key words:** accelerometer, activity, does, welfare

## Technical Note

Measures of standing and lying behavior have been used in the assessment of welfare of farm animals in many applications. For instance, in dairy cattle, links have been found between increased standing and mastitis (Medrano-Galarza et al., 2012), claw horn lesions (Proudfoot et al., 2010), overall lameness (Ito et al., 2010), and bedding, cleanliness, and flooring (Ito et al., 2014). Less work has been done on dairy goats, but studies to date have used changes in lying behavior to assess how goats respond to separation and reintegration within groups (Patt et al., 2013), to determine the effects of different stocking densities (Loretz et al., 2004; Andersen and Bøe, 2007), and to evaluate the positive effects of environmental enrichment (Aschwanden et al., 2009). In the majority of goat studies to date, video and direct observation were used to assess lying and standing time and bouts. Unfortunately, video can be difficult to install in some commercial farms and video recordings are labor intensive to analyze. Live observations may disturb the goats' behavior (due to presence of the observer) and, again, are labor intensive, especially if many animals are followed over an extended period. Data loggers can automate recordings and provide more detailed coverage over a long period than is typically practical for video or live observations. Although one study has utilized data loggers (different from those being validated in this study), it was not indicated whether these loggers were validated for use in goats (Patt et al., 2012).

Data loggers, specifically accelerometers (e.g., devices that record $g$-force acceleration values), have been readily adopted into research. Several devices are commercially available for use on dairy cows. For instance, the IceTag Sensor (IceRobotics Ltd., Edinburgh, UK) has been successfully used to monitor lying behavior (Gibbons et al., 2012), but the size of these products makes them unsuitable for use on goats. The Hobo Pendant G data logger (Onset Computer Corporation, Bourne, MA) is smaller and can be used on goats, but to date this device has only been validated for use on dairy cows (Ledgerwood et al., 2010) and dairy calves (Bonk et al., 2013). The aim of the current study was to validate the use of these data loggers for goats.

Our 3 objectives were to (1) determine appropriate cut-off points for coding lying and standing, as well as lying side, in the raw $g$-force data collected by Hobo

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data loggers; (2) determine a suitable correction factor for dealing with data abnormalities caused by other activities (e.g., perching, scratching, and urination); and (3) assess the validity of using the data loggers on both mature, pregnant does, as well as younger, nonmilking goats.

Two commercial farms in southern Ontario, Canada, were enrolled. The Hobo Pendant G data loggers were attached vertically (with the rounded base closest to the ground), on the inside of the rear left leg (above the metatarsophalangeal joint) of a subset of goats on each farm. This orientation resulted in the data logger's x-axis pointing upwards and the z-axis pointing inwards toward the animal's leg, with the logger label showing. Attachment was done with veterinary self-adherent bandage (Vetrap, 3M, St. Paul, MN) and pieces of foam to minimize any chafing. Loggers were set to record in 1-min intervals; this allows for more than 3 wk of continuous data collection. Due to the vertical placement of the logger, only the *g*-forces for the x- and z-axes were recorded (the y-axis does not change when the logger is vertically oriented). Logger data were downloaded via HoboWare Pro V3 (Onset Computer Corporation) and raw *g*-force values were exported as CSV files, which were then imported into SAS (SAS Institute Inc., Cary, NC) for further analyses.

On farm 1, 4 mature, multiparous Saanen × Alpine crossbred does were monitored using video. Prior to monitoring, these does were housed in a group with 30 other late gestation does (approximately 120–130 d); all does were fitted with data loggers. The video-monitored does were selected based on differences in color and ear characteristics (e.g., black, white, gray, and La Mancha). During the monitoring period, these 4 does were moved to a smaller pen (3 × 4 m) immediately adjacent to the home pen. All management remained the same as in the home pen. All goats had ad libitum access to water and a chopped hay and silage mixture. Approximately 100 g of corn and commercial supplement per goat was top dressed 3 times daily. Does were not milking at the time of observation. Two cameras were placed above the monitored pen (Panasonic HDC TM-900, Taiwan) and recorded video continuously for 3 d. All instances of lying and standing behavior were coded from the 72 h of video (Observer XT, Noldus Information Technology, Leesburg, VA). Additionally, all other behaviors with potential to affect the data logger orientation (e.g., perching on back legs, urination, and lifting rear legs for scratching) were noted. For comparison to logger data, daily values (for each goat on each of the 3 d) were calculated for lying time, lying bouts, as well as shifts in lying position between the left and the right sides. Standing behavior (i.e., time, bouts, bout duration) was calculated for descriptive statistics only. One 3-h block of video was rewatched to determine intraobserver reliability for distinguishing between lying and standing events (Cohen's kappa, $\kappa = 0.84$). Lying and standing behaviors were also measured using loggers (but not video) for the 30 does remaining in the home pen; these results from the home pen does are provided for descriptive purposes only.

On farm 2, 5 Saanen crossbred doelings (nonbred) and 1 Saanen crossbred wether (neutered male) were housed in a single 3- × 6-m pen bedded with straw. All goats were between 8 and 12 mo old. These animals were approximately half the size of the mature, late gestation does on farm 1. All 6 animals had data loggers attached as described above. Individual animals were marked with hair dye to facilitate identification on video. Hay was fed twice a day and ad libitum water access was provided. One camera (Panasonic HDC TM-900) recorded video continuously for 3 d. Lying and standing behavior was continuously coded from the video. The full 72 h of video was used to calculate 3-d values for lying time and lying bouts for each goat. Differences in lying side (between left and right), as well as perching, scratching, and urination behaviors, could not be reliably coded on this farm due to the camera's view angle (constrained by a low ceiling). One 3-h block of video was rewatched to determine intraobserver reliability for discerning between lying and standing events (Cohen's kappa, $\kappa = 0.88$).

### *Objective 1*

The raw data on the x- and z-axes ranged from −3.2 to 3.15 *g*. To avoid any data-handling issues caused by negative data points, a value of 3.2 was first added to the raw data collected by the data loggers (Ledgerwood et al., 2010), resulting in an adjusted range of 0 to 6.35. To determine appropriate cut-off points, PROC UNIVARIATE (SAS 9.2) was used to generate separate frequency distributions of the adjusted x- and z-axis values for the data from farm 1. Cut-off points established by Ledgerwood et al. (2010) for dairy cattle were first plotted onto these distributions and used to assist in the visual identification of 6 potentially feasible cut-off points for use in goats. Next, the adjusted x- and z- axis values were converted to binary values, using the potential cut-off points to associate 1 for standing and 0 for lying (x-axis) and 1 for lying on the right side and 0 for lying on the left side (z-axis). This created a 3-d, minute-by-minute data set for each goat, which were then combined into data sets for each axis. A rotated logger resulted in the z-axis data of 1 goat being discarded from the data for the group of does monitored by video. Video data was also converted into a minute-by-minute binary data set and merged with