Our objective was to evaluate how prevalence estimates for health conditions are affected by the number of cows sampled and the selection method used. On 10 California dairy farms, we assessed all cows in the high-producing pen (DIM < 100; range 81–241 cows) using measures from the Welfare Quality Protocol for Dairy Cattle. Cows were evaluated for body condition, hygiene, skin alterations (hairless patches, lesions, or swelling), discharge (ocular, nasal, vulvar), diarrhea, and impaired respiration while restrained in headlocks. Lameness was scored upon release from the feed bunk. Prevalence for each condition was calculated as a percentage of cows in the pen. The most common conditions were dirty hindquarters (33.5 ± 10.7%, mean ± SD) and lesions or swelling on the knee (34.4 ± 17.0%) and hock (26.4 ± 16.7%). Diarrhea (8.0 ± 5.8%), lameness (mild: 7.3 ± 4.7%, severe: 2.2 ± 2.2%), and neck (5.8 ± 12.6%), flank (4.5 ± 5.0%), or hindquarter alterations (5.5 ± 3.9%) were less common. Very fat cows, vulvar discharge, and impaired respiration were excluded from further analysis (prevalence ≤ 1%). To evaluate how many cows are needed to accurately estimate prevalence, 7 subsets of data were created by selecting every 10th, 5th, 4th, 3rd, 2nd, 2 of 3, or 3 of 4 cows using their position at the bunk. In addition, 7 matching proportions of the pen were randomly computer-selected (14 subsets total). Estimates were compared with true values using regression analysis and were considered accurate if they met 3 criteria: R^2 > 0.9 and the slope and intercept did not significantly differ (P > 0.05) from 1 and 0, respectively. All estimates met the slope and intercept criteria, whereas R^2 increased when more cows were sampled.

Regardless of how many cows were used, both selection methods were accurate for ocular discharge (22.2 ± 27.4%), neck alterations (5.8 ± 12.6%), and knee hairless patches (14.1 ± 17.4%). For the other conditions, all estimates based on feed bunk position were accurate when ≥ 2/3 of the pen was used, and all but severe lameness were accurately estimated when sampling randomly. Selecting cows using feed bunk position did not differ systematically from computer-selecting random ear tag numbers, suggesting the former may be an appropriate method for welfare assessments.

Key Words: cow welfare indicators, farm profitability, productivity
3% of cows in both the MW and NE. Hock injury prevalence averaged 12.0 ± 7.8% in CA, 20.3 ± 22.5% in MW, and 33.3 ± 21.9% in NE. Severe hock lesions were almost nonexistent in CA (0.3 ± 0.6%), but higher in MW (1.6 ± 2.8%) and NE (2.6 ± 3.6%). These results indicate that lameness and leg injuries remain prevalent, and underscore the importance of efforts to reduce these problems.

Key Words: lesions, gait, cow comfort


Lameness is a serious welfare issue facing the dairy industry. To date, the majority of studies have focused on its effect on health and behavior at the herd-level. The aim of this study was to identify cow-level changes in lying behavior associated with lameness. A total of 201 dairy cows from 6 pasture-based farms in southern Brazil were gait scored weekly to assess lameness using a 5-point scale (≥3 as lame) for 4 consecutive weeks. During this time, lying behavior (daily lying time, lying bouts, and mean lying bout duration) was recorded continuously using leg-mounted accelerometers. Lying data from the 3 d following each gait score were averaged. Cow-level variables included days in milk (DIM), parity, and BCS. Regional precipitation was recorded daily and categorized as positive if rainfall was recorded on at least 2 of these 3 d. DIM was categorized as early (DIM <100d), mid (100d ≤ DIM ≤200d), and late lactation (DIM >200d). Linear mixed models (cow nested within farm as random effect) were used to test the effect of lameness on lying behavior, accounting for precipitation and DIM. The incidence and recovery rate were 15% and 10% respectively. When lame, cows increased the duration of each lying bout by 6 min (95% CI: 0 to 10; P = 0.03) compared with when non-lame. We also found an interaction between lameness and precipitation on lying time; during periods of rainfall, cows that were lame spent an extra 44 min/d (95% CI: 6 to 83; P = 0.02) lying compared with when they were not lame, but without rainfall cows showed no difference in lying time between lame and non-lame status (−7 min/d; 95% CI: −34 to 21; P = 0.64). Rainfall decreased the number of lying bouts by 0.9 bouts/d (95% CI: 0.8 to 0.9; P < 0.01), but increased the average duration of bouts by 6 min/bout (95% CI: 1 to 11; P = 0.02). Late lactation cows spent an extra 17 min/bout (95% CI: 7 to 27; P < 0.01) and an extra 57 min/d (95% CI: 7 to 105; P = 0.03) lying compared with early lactation cows. Cows alter their lying behavior in response to changes in lameness status and rainfall. The results of this work may be used to better identify cows that are developing or recovering from lameness in pasture-based systems.

Key Words: infrared thermography (IRT), sole ulcers, dairy cows

M58 Early non-invasive clinical diagnosis of hoof ulcers by infrared thermographic images (IRT) in milking dairy cows. S. Vázquez-Flores* and C. Lucio-Rodriguez, Tecnologico de Monterrey Campus Queretaro, Queretaro, Mexico.

Clinical assessment during hoof trimming implies restrictive methods and many hours of keeping cows waiting for their turn. The intention of this study was to characterize temperature emission in punctual areas of the hoof by capturing images with an infrared thermography camera (IRT) comparing them to other hoof conditions. The trial took place on a commercial dairy in Central México. Punctual temperature emission was used by tracking 14 specific areas in the sole. Mapping was related to the external/internal middle axis: Sp1/Sp9 (white line axial wall); Sp2/Sp10 (white line); Sp3/Sp11 (abaxial wall); Sp4/Sp12 (caudal claw); Sp5/Sp13 (cranial claw); Sp6/Sp14 (heel bulb); Sp7 (interdigital hind claw); Sp8 (interdigital medial claw). The study included a convenience sampling of 37 milking cows (<150 DIM), in an ambient temperature of 23°C. Cows were restrained in the hydraulic chute for hoof trimming, clinical analysis and IRT image capturing. Hoof analysis was characterized as sole ulcers, digital dermatitis, white line disease and normal cases. Two multiple statistical comparison tests (Snu’s MCB test/Wilcoxon pairwise contrast) showed differences in temperature between heel bulb with ulceration and the other areas (JMP 11.1). The hind-left hoof showed an average temperature of 29.5°C in area Sp14 in cows with sole ulcer (P = 0.0003). For the hind-right hoof, sole ulcer cases were different from the normal in 3 instances: area Sp3 with a temperature of 22.9°C (P = 0.03); and areas Sp6 and 14 with average temperatures of 21.2 and 18.8°C respectively (P = 0.05; P = 0.0027). The most common cases overall were slight dermatitis in both hind limbs (49%); and sole ulcers in the left hoof (73%). Areas Sp6 and 14 are easily reached without causing distress in cows during milking, currently under investigation. The diagnostic approach is a non-invasive system that identifies elevated emission of temperature of the heel bulb related to ulcers when taking an IRT image.

Key Words: infrared thermography (IRT), sole ulcers, dairy cows

M59 Evaluation of the relationship between prepartal ruminal and mammary gland temperature and calving day in dairy cows. F. Batistel*, E. Gonzalez-Angulo, C. I. M. Garces, and J. J. Loor, University of Illinois at Urbana-Champaign, Urbana, IL.

Monitoring parturition is fundamental to avoid mortality of newborn calves. Physiological conditions such as pregnancy and lactation influence the diurnal temperature pattern of dairy cows. However, information on changes in body temperature and their association with calving time in dairy cows is lacking. Therefore, our objective was to evaluate the use of external ruminal and mammary gland temperature as predictors of calving day. Thirty Holstein cows were used and measurements were taken from 15 d before the expected calving day until the actual calving day. The ruminal temperature was recorded approximately 2 h post-feeding after an area of 0.4 × 0.4 m on the left side of the animal (including the paralumbar fossa) was shaved and cleaned. Measurements were made at a distance of 1.0 m using a hand-held portable infrared camera (E4 Box, FLIR Systems, Wilsonville, OR). The mammary gland temperature was assessed around 4 p.m. from the posterior side following the same approach used for rumen. The average temperature was calculated by tracing the shaved area using ThermalCAM Researcher Pro 2.7 software (FLIR Systems). The statistical model included the random effect of block and fixed effect of treatment, time and interactions. Ruminal temperature and DMI were not correlated (P = 0.08; r = 0.08). Ruminal temperature and calving day were negatively correlated (P < 0.01; r = 0.19). Compared with 5 d before parturition, ruminal temperature was 1.8°C (P < 0.01), 1.2°C (P = 0.02), 0.5°C (P = 0.15), 0.2°C (P = 0.22), and 0.0°C (P = 0.32) lower at calving, −1, −2, −3 and −4 d, respectively. Mammary gland temperature and calving day were positively correlated (P = 0.04; r = 0.11). Compared with 15 d before parturition, mammary temperature was 1.4°C (P = 0.02), 1.1°C (P = 0.03), 1.2°C (P = 0.02), 1.0°C (P = 0.05), 1.1°C (P = 0.04) and 0.7°C (P = 0.09) greater at calving, −1, −2, −3, −4 and −10 d, respectively. Overall, dairy cows exhibit a distinct change in ruminal and mammary gland temperature commencing approximately 8 and 1 d before partu-
tion. Thus, monitoring the ruminal temperature externally could be a practical tool to predict calving.

**Key Words:** monitoring parturition, temperature

### M60 Effect of ketosis on behavioral activity in transition dairy cows

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The objective of this study was to assess the effect of ketosis status on behavioral activity in transition dairy cows. A behavioral activity index (BAI) was computed for every animal taking into account the number of steps (no./d), standing time (min/d), lying time (min/d), and lying bout (LB, no./d). A total of 387 Holstein dairy cows (110 primiparous and 277 multiparous) in 3 commercial dairy herds were enrolled at 7 d before calving until 14 d post-calving. Weekly, a cohort of 10 to 15 cows was enrolled at each farm and electronic data loggers (IceQube, IceRobotics, Edinburgh, UK) were fitted to the hind leg of individual cows to assess their behavioral activity. Postpartum heifers and cows were moved into prepartum pens 21 d before the expected calving date. All heifers and cows were housed in similar prepartum free-stall barns and moved into a contiguous individual maternity pen for parturition. Stillbirth was defined as a calf born dead or died within 24 h after birth, and with normal gestation length. The BAI was computed for the last 7 d before parturition to assess differences among primiparous and multiparous cows. Data were analyzed using MIXED procedure of SAS. Primiparous cows (P < 0.05) had greater BAI compared with multiparous cows, and as cows mature (multiparous), they become less active around parturition. Regardless of parity, cows with a stillborn calf had less pre-partum lying time (10.5 h/d; P < 0.05) at calving compared with cows with a calf born alive (12.15 h/d). Primiparous cows with a stillborn calf at calving had a greater prepartum BAI (P < 0.05) with similar lying time before calving compared with primiparous cows with calves born alive. Multiparous cows that had a stillborn calf at calving had reduced lying time (P < 0.05) with similar BAI before calving compared with multiparous cows with calves born alive. These results suggest that monitoring a combination of pre-partum behavioral metrics, such as lying time and BAI, could be used to predict stillborn calves in transition heifers and cows.

**Key Words:** stillbirth, behavior, dairy cattle

### M61 Effect of prepartum behavioral activity on stillbirth in transition dairy heifers and cows

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The objective of this study was to assess the effect of pre-partum behavioral activity on stillbirth in transition dairy heifers and cows. A behavioral activity index (BAI) was computed for every animal taking into account the number of steps (no./d), standing time (min/d), lying time (min/d), and lying bouts (LB, no./d). A total of 387 Holstein dairy cows (110 primiparous and 277 multiparous) in 3 commercial dairy herds were enrolled at 7 d before calving until 14 d post-calving. Weekly, a cohort of 10 to 15 heifers and cows were enrolled at each farm, and electronic data loggers (IceQube, IceRobotics, Edinburgh, UK) were fitted to the hind leg of individual animals to assess their behavioral activity. Prepartum heifers and cows were moved into prepartum pens 21 d before the expected calving date. All heifers and cows were housed in similar prepartum free-stall barns and moved into a contiguous individual maternity pen for parturition. Stillbirth was defined as a calf born dead or died within 24 h after birth, and with normal gestation length. The BAI was computed for the last 7 d before parturition to assess differences among primiparous and multiparous cows. Data were analyzed using MIXED procedure of SAS. Primiparous cows (P < 0.05) had greater BAI compared with multiparous cows, and as cows mature (multiparous), they become less active around parturition. Regardless of parity, cows with a stillborn calf had less pre-partum lying time (10.5 h/d; P < 0.05) at calving compared with cows with a calf born alive (12.15 h/d). Primiparous cows with a stillborn calf at calving had a greater prepartum BAI (P < 0.05) with similar lying time before calving compared with primiparous cows with calves born alive. Multiparous cows that had a stillborn calf at calving had reduced lying time (P < 0.05) with similar BAI before calving compared with multiparous cows with calves born alive. These results suggest that monitoring a combination of pre-partum behavioral metrics, such as lying time and BAI, could be used to predict stillborn calves in transition heifers and cows.

**Key Words:** dairy cow, mammary biopsy, lying behavior

### M62 Effects of mammary biopsy on behavior of dairy cows


In dairy cattle, mammary biopsies are commonly used to study mammary development and function. The objective of this study was to investigate the behavioral changes following mammary biopsy. Pregnant, nonlactating Holstein dairy cows (n = 9; treatment; 20 d before expected calving date) were exposed to either: 1) a biopsy procedure, in which mammary tissue samples (60 × 4 mm in diameter) were obtained using a biopsy tool from the rear left quarter, following administration of a sedative (xylazine, 20 µg/kg of BW) and local anesthesia (3 mL lidocaine), or 2) a sham procedure, in which cows were removed from the pen and restrained for a similar duration of time as for the biopsy procedure. Cows were fitted with accelerometers to record daily standing time, standing bout frequency, and lying side. Dry matter intake (DMI) was recorded daily using the Calan gate system. Daily activity data and DMI were recorded for 1 wk following the biopsy or sham procedure, and analyzed in a general linear mixed model with day as a repeated measure. The biopsy procedure had no effect on DMI (11.2 kg/d; SE = 0.67; P = 0.88) or total daily standing time (10.0 h/d; SE = 0.44, P = 0.44). However, relative to control cows, biopsied cows had more frequent standing bouts (11.8 vs. 9.9 bouts/d; SE = 0.59; P = 0.04) of shorter duration (52.2 vs. 64.8 min/bout; SE = 4.4, P = 0.05) with no interaction of treatment and day (P > 0.33). On d 1 following the procedure, biopsied cows also showed greater laterality in their lying behavior (P = 0.021), having longer lying bouts on their right side than left (97.8 vs. 70.0 min/bout; SE = 8.6; P = 0.015) whereas control cows showed no lying side preference (P = 0.56). These results suggest that mammary biopsy does not affect overall activity and feeding behavior, but has subtle effects on activity, which may be indicative of increased restlessness or short-term discomfort in the biopsied quarter. These effects, however, dissipate rapidly following biopsy.

**Key Words:** behavior, health, dairy cattle
Relationship between the clinical and behavioral response to a mastitis challenge with *Streptococcus uberis* from Holstein dairy cows. V. L. Couture*, P. D. Krawczel, G. M. Pighetti, R. A. Almeida, and S. P. Oliver, Department of Animal Science, The University of Tennessee, Knoxville, TN.

Treatment of mastitis may be improved by earlier detection through use of sickness behaviors. The objective was to determine the relationship between clinical signs of mastitis, induced by a *Streptococcus uberis* challenge, and resting behavior of early lactation dairy cows. Holstein cows in their second (n = 21) and third (n = 7) lactation were enrolled and intramammary challenges were conducted with *S. uberis* (10,560 ± 1,855 cfu) within 1.2 ± 0.7 d after calving. Somatic cell count, milk score (MS), and udder inflammation score (US) were collected 24 h and 0 h before challenge, every 12 h for 3 d post-challenge, and daily on d 4–7. MS and US were assessed from appearance of the milk and udder, respectively, with a score of 0 = normal and 3 = severe. Accelerometers attached to the hind leg recorded lying duration (h/d) and mean bout duration (min/bout). Data were summarized by 24-h period starting at 0900 h using the mean SCC, MS, and US for each d 0–3 d post-challenge and the recorded daily score from d 4–7. Data were analyzed using a regression model in SAS (v9.4) to determine the relationship between the independent variables of SCC, MS, and US and the dependent variables of daily lying duration and mean bout duration. MS was positively associated with mean bout duration (P = 0.005; R² = 0.04; y = 6.4x+72.6), but SCC (P = 0.74) and US (P = 0.26) were not. SCC (P = 0.74), MS (P = 0.73), and US (P = 0.94) were not associated with daily lying time. Of the 3 severity measures, MS was the most sensitive (or most closely associated) with sickness-related behavior and offers the greatest potential to predict clinical mastitis caused by *S. uberis*. The positive relationship between MS and mean bout duration most likely is driven by the strength of the acute inflammatory response, which results in a more systemic response best represented by these 2 measures. Closer examination of the timing of these events relative to each other within and across cows can potentially improve the ability to predict future cases of clinical mastitis through changes in lying behavior.

**Key Words:** mastitis, behavior, *S. uberis*