Animal Behavior and Well-Being: Focus on Physiological Response

151 Utilizing a multidisciplinary approach to assess livestock welfare. J. Johnson*, USDA-ARS Livestock Behavior Research Unit, West Lafayette, IN.

Animal agriculture sustainability is being challenged by a rapidly increasing global human population, environmental pressures such as climate change, and a push toward reducing or eliminating antibiotic use. As a result, livestock producers are tasked with producing more animal products with less inputs and technologies while ensuring that appropriate animal welfare standards are maintained. The belief that distress should be limited for livestock to improve welfare is widely accepted by producers, scientists, and the public, and as such, farm animal welfare is an important societal issue. However, the correct way to assess the welfare state of livestock is often debated and using sound science to define what constitutes “good” animal welfare is a key component of developing animal husbandry practices and mitigation strategies to improve animal welfare while maintaining economic sustainability. The study of animal welfare is unique in that it often incorporates multiple scientific disciplines (i.e., stress physiology, behavior, immunology, nutrition) to evaluate the impact of various stressors on animal welfare and understand the interactions between differing biological systems under stressful conditions. Therefore, a multidisciplinary assessment of livestock welfare allows scientists to determine the relationships between animal behavior and physiology that can affect welfare states and ultimately influence animal performance and production efficiency.

Key Words: animal welfare, livestock, multidisciplinary

152 Using drool as an indicator of heat load in dairy cattle. A. M. Drwencke*, G. Tresoldi, and C. B. Tucker, Center for Animal Welfare, Department of Animal Science, University of California, Davis, Davis, CA, 2College of Agriculture, California State University, Chico, Chico, CA.

Heat stress is a prominent issue in the dairy industry that results in approximately $800 million in production losses each year. Signs of heat stress include higher respiration rates and body temperature as well as panting, a combination of drooling and breathing through an open mouth. Identification of early signs of heat stress is important for effective abatement, but the thresholds of when onset occurs are not well defined. Drooling could be a way to identify early signs of increasing heat load. Our objective was to identify the respiration rate and body temperature of cattle at 3 time points: 1) when cows initially began drooling in a day (ID), 2) during other drooling events following the first occurrence in a day (OD) and 3) when they were not drooling (ND). Twenty-four Holstein cows averaging (±SD) 37.5 ± 4.5 kg/d of milk were observed over the course of a summer (12 d/cow; 6 cows at a time; total of 48 d of observation). Respiration rate and signs of drooling, breathing with their mouth open and tongue extended past the teeth were taken every 30 min from 1000 to 1900 h. Body temperature was recorded every 3 min 24 h/d using vaginal loggers. To evaluate body temperature alongside drooling, all readings of vaginal temperature within 10 min of a respiration rate and panting data collection event were averaged and assigned to that time point. During the time period of observation, air temperature averaged 33.3 ± 4.0°C or THI 79 ± 3.2.

Least squares means within a mixed model were used to obtain average values. Respiration rates in breaths/min were: ID = 73 ± 2; OD = 76 ± 2; ND = 60 ± 2 ($P < 0.001$). Body temperature averaged: ID = 38.8 ± 0.05; OD = 39.0 ± 0.05; ND = 38.7 ± 0.05°C ($P < 0.001$). Taken together, these results indicate that the first occurrence of drool in a day is an early indicator of increased heat load. Drooling occurs at higher respiration rates and body temperature than when no drool is present. Finally, within this data set, any occurrence of drooling could have been utilized by producers as an indicator of increased heat load in cattle.

Key Words: heat stress, drooling, panting

153 Efficacy of pain control for caustic paste disbudding in very young calves. C. N. Reedman*, T. F. Duffield, T. J. DeVries, K. D. Lissemore, N. Karrow, Z. Li, and C. B. Winder, Department of Population Medicine, University of Guelph, Guelph, ON, Canada, 2Department of Animal Biosciences, University of Guelph, Guelph, ON, Canada.

Dairy producers disbudding calves with caustic paste are less likely to provide pain control than those using cautery. Little research has been conducted on pain control for this method and no studies have specifically examined calves under a week of age although producers will commonly apply this product at this time. The objective of this study was to evaluate the efficacy of local anesthesia and nonsteroidal anti-inflammatory drug (NSAID) analgesia in very young dairy calves. 140 heifer calves aged 1–9 d were enrolled into 28 blocks and randomly allocated to 1 of 5 interventions: sham control; positive control (no pain control); lidocaine corneal block; meloxicam; and lidocaine corneal block and meloxicam. Data were analyzed using mixed models with a fixed effect for baseline values and a random effect for trial block. Compared with no local anesthetic, lidocaine reduced serum cortisol at 15, 30, 45, and 60 min post-disbudding (60 min; −138 pg/mL, 95% CI: −200 to −76 pg/mL). Cortisol values were not different between lidocaine treated calves and sham controls at these time points. At 60, 90, 120, and 180 min post-disbudding, calves treated with lidocaine and meloxicam had reduced cortisol compared with lidocaine alone (180 min post-disbudding, −61 pg/mL, 95% CI −112 to −10 pg/mL), and values did not differ between lidocaine/meloxicam treated calves and sham controls at these time points. At 3–4 d post-disbudding, treatment with lidocaine and meloxicam tended to reduce haptoglobin (0.16 mg/mL, 95% CI 0.00 to 0.32), but no differences were found between groups at 3 h and 6–7 d post-disbudding. At 60, 90, and 120 min post-disbudding, lidocaine treated calves had decreased pressure sensitivity (90 min, −2.26 kgf, 95% CI −3.15 to −1.37). No differences were seen in pressure sensitivity between groups at 180 min, 3–4 or 6–7 d post-disbudding. These findings suggest that the combination of local anesthesia with NSAID analgesia are beneficial at reducing pain indicators and inflammation in very young calves disbudded with caustic paste.

Key Words: welfare, anesthesia, analgesia


The objective of this study is to determine if the addition of environmental enrichment will prevent the negative behaviors exhibited by limit-fed heifers. Twenty-four Holstein heifers (161.9 ± 33d of age) were randomly assigned to a split-plot design and housed in 2 sets of 3 pens containing a brush (BR), ball (BA) or no enrichment (NO).
Within each pen, 4 Calan gates were used to individually feed heifers with control (CON, n = 2) or limit-fed (LIM, n = 2) diet. LIM heifers were fed 85% of the NRC (2001) DM% recommendation and the CON was fed 100% of NRC (2001) DM% recommendations. Both diets were balanced to provide the same nutritional content. Weekly rumen samples, blood samples, and body measures were taken. Ruminating events were recorded every 5 min over 6 h after feeding. Individual heifer behaviors such as feed aggression, feeding, use of enrichment, and social play behavior were recorded for 24 h each week. Lying time was recorded every hour for 6 weeks using an accelerometer. A linear regression in MIXED procedure of SAS was used to analyze the effects of treatment, date, and all 2-way interactions for all models on social play, object interactions, ruminating events, and lying time. Pen was included in the random statement. Enrichment or diet did not affect the average daily gain. LIM heifers consumed less (0.68 kg/d DM, \( P = 0.003 \)). CON heifers with a BR or NO had 4 and 2.8 more ruminating events than the LIM in those groups (respectively, \( P < 0.001 \)). Providing a BA increased social play by 8 min per day (\( P = 0.01 \)). Heifers, regardless of diet, spent 30 min more using the BR than heifers using the BA (\( P = 0.03 \)). Treatment did not affect feed aggression or visits to the feed bunk. When the pen was enriched with a BA, LIM heifers laid 72 more mins/day compared with CON (\( P = 0.01 \)). BR did not affect lying time. Enrichment use in limited feed heifers shows some improvement in lying times and social play.

**Key Words:** limit feeding, environmental enrichment

### 155 Integration of productive, reproductive, and health variables with activity behavior data as welfare indicators in dairy cows

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This study aimed to investigate the associations between activity behavior data and 2 proposed welfare categories (WC) based on productive performance, cyclicity, and absence of clinical disease. A single cohort of 202 Holstein dairy cows (Parity 1; \( n = 55 \); Parity \( \geq 2; n = 147 \)) was followed from 10 d pre-calving to 150 DIM. All cows were ear-tagged with a device measuring activity (AT), rumination (RT), and eating (ET) time (min/h). Daily milk yield and health data were retrieved from on-farm software. Ovarian cyclicity was evaluated by transrectal ultrasonography at 35 DIM. Upon completion of the follow-up period, study cows were classified into one of 2 WC: (1) WC1 = milk yield \( \geq \) group study mean, absence of clinical disease, and cyclic at d35; and (2) WC2 = cows that failed in at least one of the WC1 conditions. Differences in behavior data between WC were determined by repeated measures analysis, including, parity, DIM and the interaction term WC \( \times \) DIM in the models. Subsequently, odds ratios were calculated using 5 min increments in behavioral variables to evaluate their ability on predicting WC categorization. Overall, 59 cows were classified in WC1 and 141 in WC2. A significant effect on AT was found for WC \( \times \) DIM (\( P < 0.0001 \)), but no differences were found in AT between WC. A significant effect on RT was determined for WC \( \times \) DIM (\( P < 0.0001 \)) and the effect of WC showed a tendency for significance (\( P = 0.08 \)), where RT was greater in WC1 (20.0 ± 0.4 vs. WC2: 19.2 ± 0.23 min/h; \( P = 0.25 \)). As interaction terms were significant, multiple comparison analysis resulted in significant differences within the first 21 DIM, where WC1 had greater RT and ET. RT and ET were adequate predictors for WC; increases by 5 min in RT and ET increased by 2.2 (1.3 – 4.2; \( P < 0.001 \)) and 1.6 (1.1 – 2.5; \( P = 0.02 \)) times the odds of being classified as WC1. These associations could be used to implement welfare evaluations based on this behavioral parameters.

**Key Words:** activity, rumination, health

### 156 The impact of heat stress on individual cows in a Pennsylvania dairy herd

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The objective of this study was to estimate the impact of heat stress on milk and component yields at the Penn State University research farm. Data included 703,106 daily records from 1156 Holstein cows that calved from 2004 to 2016. Temperature-humidity index (THI) was calculated with daily average temperature (°C) and average relative humidity (%) retrieved from the nearest weather station. Milk, fat, protein, and energy corrected milk (ECM) yields were evaluated with a model that included the fixed effects of lactation, year-month of calving, biweekly days in milk (DIM), age at calving; random effects included cow, date, and random regression on THI within cow. This model assumes that, in the same herd, cows respond differently to the same severity of heat stress, which was termed the heat-resistance coefficient (HRC). For every THI unit above 72, there was a significant (\( P < 0.05 \)) reduction of 0.282 kg, 0.011 kg, 0.009 kg, and 0.301 kg for milk, fat, protein, and ECM yields, respectively. Production for the least heat resistant quartile of cows and the most heat resistant quartile of cows based on HRC for ECM was compared. The heat tolerant group did not decline in production as THI rose, whereas it declined steadily for the least heat tolerant group. Production in the most extreme THI groups (not heat stressed = THI <72; highly heat stressed = THI >78) are shown in Table 1. Production for intermediate THI levels were in-between the extremes presented in the table. Cow HRC for milk yield was positively correlated with HRC for ECM (0.95), fat (0.15), and protein (0.59) yields. The HRC of fat yield was positively correlated with ECM (0.38) and protein (0.36) yields. In conclusion, there is significant variation among cows within the same herd for reaction to heat stress.

**Table 1 (Abstr. 156).** Production for the top and bottom quartiles of heat-resistant cows for ECM

<table>
<thead>
<tr>
<th></th>
<th>Least heat resistant group (n=132)</th>
<th>Most heat resistant group (n=132)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not heat stressed (THI &gt;78)</td>
<td>Heat-stressed (THI &gt;78)</td>
</tr>
<tr>
<td>Milk, kg</td>
<td>37.08a</td>
<td>31.86b</td>
</tr>
<tr>
<td>Fat, kg</td>
<td>1.40ac</td>
<td>1.34ad</td>
</tr>
<tr>
<td>Protein, kg</td>
<td>1.15a</td>
<td>1.07bc</td>
</tr>
<tr>
<td>ECM, kg</td>
<td>39.17ac</td>
<td>36.02b</td>
</tr>
</tbody>
</table>

\( ^\text{a-d} \)Different letters within the same row indicate a significant difference (\( P < 0.05 \)).

**Key Words:** heat stress, temperature-humidity index, milk yield

### 157 Hot weather increases competition between dairy cows at the drinker


Heat stressed dairy cows on pasture will compete for resources that aid cooling, but it is not known how heat stress affects the competition for water by indoor housed cows. The objective of this study was to evaluate how heat stress affects the behavior of indoor, loose-housed dairy cows at the drinker. For 3 wk after calving, cows were housed in a
dynamic group (n = 20) in a pen equipped with 12 electronic feed bins, 2 electronic water bins, and 24 freestalls. A total of 68 lactating, Holstein dairy cows were enrolled over a 59-d period. The electronic water bins recorded time spent at the drinker, frequency of visits, water intake, and competitive events for 24 h/d. Competitive events were quantified using the number of replacements (when one cow displaced another cow from the drinker and took her place). Heat stress was defined as a temperature humidity index (THI) ≥ 72. THI parameters examined were daily mean, minimum, maximum, and number of h ≥68 or 72. To determine if there was a lag effect of heat stress on drinking behavior, we examined the effects of this on the day of behavioral recordings and on the previous 1 to 3 d. For the analysis of time spent at the drinker, frequency of visits, and water intake, the measures from all cows in the pen (n = 20) were averaged to create one observation per day. For the analysis of competitive events, the number of replacements at the drinker was summed from all cows in the pen (n = 20) to create one observation per day. A linear regression analysis was performed to determine the relationship between heat stress and behavior at the drinker. We found that, with increasing numbers of hours in heat stress conditions (THI ≥72) over a 3-d period, cows drank more water, spent more time at the drinker, made more visits to the drinker, and engaged in more competition (P < 0.0001 for all). These results indicate that behavior at the drinker may provide a biomarker of heat stress. This measure may be of practical value, especially for farms where attendance at the drinker can be monitored electronically.

Key Words: heat stress, aggressive behavior, water intake

158 Provision of shelter during the prepartum period: Effects on behavior and non-esterified fatty acid concentrations of dairy cows in a pasture-based system. D. Cartes*,1, A. Strappini2, R. Held1, and P. Sepúlveda-Varas3,1 Escuela de Graduados, Facultad de Ciencias Veterinarias, Universidad Austral de Chile, Valdivia, Chile,2 Instituto de Ciencia Animal, Universidad Austral de Chile, Valdivia, Chile,3 Instituto de Ciencias Clinicas Veterinarias, Universidad Austral de Chile, Valdivia, Chile.

In pasture-based systems where seasonal calving predominates, many farmers use open dirt corrals to keep cows before calving. Our objective was to examine whether shelter provision under winter conditions influences behavior and body fat mobilization in outdoor-housed prepartum dairy cows. Two cohorts of 12 clinically healthy multiparous Holstein prepurum cows were housed in open dirt corrals at the Experimental Dairy Farm of the Universidad Austral de Chile (Valdivia, Chile) during the winter months (July and August). Twenty-one days before the expecting calving date, the cows in each cohort were paired. Each pair was randomly assigned to either a corral without shelter, or to a corral with access to an artificial shelter until calving. The use of shelter was measured by scan sampling every 10 min from video data (2 cameras/corral) during the 3 weeks study period. The lying time were measured with data loggers and rumination time was recorded using an automated monitoring system over the study period. A blood sample was taken from the coccygeal vein of each cow for measurement of nonesterified fatty acids (NEFA) the same day once a week. Daily lying and rumination time were summarized by week and comparisons were made between groups with and without access to shelter. Data were analyzed using mixed linear models (SAS v9.4). Cows spent 62% of their daily time in shelters and 75% of this time they were lying down. Furthermore, the cows that had access to shelter during the prepartum spent more time lying down during the wk 3(706 min/d vs. 559 min/d; P < 0.001) and wk 2 (742 min/d vs. 566 min/d; P < 0.001) before calving compared with cows without shelter access. They also had lower NEFA concentrations on wk 2 (272 µmol/L vs. 554 µmol/L; P < 0.001) and wk 1 (460 µmol/L vs. 646 µmol/L; P = 0.05) before calving. The daily rumination time was not different between groups. These results demonstrate the importance of granting a protected area for the welfare of prepartum dairy cows exposed to winter climate conditions. Project funded by FONDECYT #11170820.

Key Words: shelter, winter, dairy cow

159 Validation of a multiple accelerometer sensor system to estimate dry matter intake in lactating dairy cows. N. Carpinelli*, F. Rosa, R. C. B. Grazziotin, and J. Osorio, South Dakota State University, Brookings, SD.

Dry matter intake is a valuable parameter that can be used to evaluate health and milk efficiency in dairy cows. The objective was to evaluate the use of 3-dimensional accelerometer sensors to estimate DMI in lactating dairy cows. Twenty-four late-lactation Holstein dairy cows housed in a free-stall barn were fitted with 3 sensors that record acceleration in the 3-axis (i.e., x, y, and z), one sensor on the lateral side of the left hind leg and 2 attached to a halter directly superpose over the jaw and nose. Cows were assigned 2 groups, a data collection group (A; n = 12) and a validation group (B; n = 12). Cows were trained to use Calan gates during a 7-d period followed by 10 d of data collection of acceleration and individual intakes for both groups. Four cameras were used to continuously video record cows, then eating times for each cow were generated. Sensors were set to record the accelerations at 10-s intervals. Eating times and accelerometer data from group A was cross-reference based on date and time. Six new variables were derived from jaw and nose accelerations by measuring the change in acceleration between 2 consecutive time points (lag-time). The REG procedure of SAS was used to regress each acceleration against the DMI during 24h period in group A to select the highest R² data. In group B, DMI derived from acceleration combinations (DMIA) was compared against the actual DMI using the CORR and MIXED procedures of SAS. All 32,767 acceleration combinations were tested, and only 921 were deemed relevant (>80% data coverage). LagNoseZ+LagNoseX model had the strongest positive correlation (r = 0.42), but its DMIA was greater (P < 0.01) than the actual DMI (36.2 vs 21.4 kg/d). In contrast, LegY+JawZ+LagNoseY model had similar DMIA and actual DMI (P = 0.99) but a weaker correlation (r = −0.11). The LegX+JawX+LagNoseZ model had a weak correlation (r = 0.28), but an accurate (P = 0.77) estimation of actual DMI (21.8 vs 21.4 kg/d). Accelerometer sensors have a great potential to estimate actual DMI in dairy cows, but a superior correlation will be required to improved robustness and reliability in a commercial farm.

Key Words: accelerometer, intake, sensor technology

160 Nutrient intake, feeding patterns of growing bulls fed different concentrate levels and a single fiber source. A. u. R. Muhammad*,1,2, C. Q. Xia1, B. Cao1, and H. Su1,1 State Key Laboratory of Animal Nutrition, Beijing, China,2 Institute of Animal and Dairy Sciences, University of Agriculture, Faisalabad, Pakistan.

The objective of the study was to determine the effect of concentrate levels with corn stover silage (CSS) on the nutrient intake and feeding behaviors of growing Chinese Holstein bulls. Twenty-eight bulls (weighing 227 ± 6.8 kg) were selected and fed randomly 4 concentrate levels (1–1.5 kg (LC), 1.5–2 kg (MC), 2–2.5 kg (HC), and 2.5–3 kg (H’C)) and CSS ad libitum. The concentrate and CSS consumption were recorded daily. Video recordings were performed with an infrared anti-nozzle camera to record the feeding behavior. Three minutes scan
sampling method was used to measure eating time for concentrate, CSS and chewing time over 24-h time period. Alterations in DMI and nutrient intake between the concentrate levels for 3 mo were analyzed using the MIXED process in SAS, with the month as a repeated measure. For feeding behavior, data were averaged over 5 d (focal animal sampling; 4 calves/treatment). Differences among the concentrate levels according to intake time of concentrate, silage and chewing time for 24 h were analyzed using the MIXED process in SAS, while hour was considered as a repeated measure. After 3 mo, increases in the concentrate level resulted in increased ADF in LC (2.26 kg/d, SE = 0.07, \( P < 0.001 \)) and MC (2.81 kg/d, SE = 0.07, \( P < 0.001 \)) treatments. Similarly, NDF intake were also increased in LC (3.97 kg/d, SE = 0.09, \( P < 0.001 \)) and MC (4.43 kg/d, \( P < 0.001 \)) treatments. Whereas the ADF intake was decreased in HC (2.61 kg/d, \( P < 0.001 \)) and H+C (2.41 kg/d, \( P < 0.001 \)) treatment. Similar with ADF, NDF intake was decreased in HC (4.35 kg/d, \( P < 0.001 \)) and H+C (4.04 kg/d, \( P < 0.001 \)) treatment. The longest time required to consume the concentrate was observed in the H+C (29 min, \( P < 0.001 \)) treatment compare with LC treatment (23 min, \( P < 0.001 \)). The highest silage consumption was observed for the LC treatment at 16:00 (25 min, \( P < 0.001 \)). Chewing was highest at 04:00 (33 min, \( P = 0.03 \)) and 18:00 (36 min, \( P = 0.03 \)) for the H+C treatment. Overall, increasing the concentrate in the diet altered specific behaviors, which could compromise the calves’ welfare.

**Key Words:** corn stover, bull, behavior