# ENVIRONMENT AND BEHAVIOR

## 361 Dynamic responses of cattle to thermal heat loads.

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Persons concerned with providing adequate care of farm animals are generally aware that environmental stressors can harm animal performance, health and well-being. Specific impacts of adverse environments are less well known. Questions relevant to rational management include: 1) how much harm is associated with given environments?, and 2) is there a need for intervention to reduce the risk to the animals or to the enterprise? These key questions can be addressed at two levels of decision-making: strategic and tactical. For strategic decisions, integrative response functions can reflect how animals respond over an extended period of time (several days to several weeks or months) to accommodate potential adaptive and compensatory capabilities. These can be used, for example, to assess long-term animal performance losses in various thermal environments as a basis for selection among alternative environmental modification methods. Tactical decisions are more closely aligned with day-to-day environmental management, such as operation of sprinklers on hot days. Recent research at the USMARC has shown that knowledge of the short-term, dynamic responses (a few minutes to a few days) can enhance environmental management, particularly at the tactical level. For cattle, our results from short-interval measures (e.g., 15 sec to 5 min) of body temperature and feeding behavior have defined an upper threshold for *ad-lib*-fed *Bos taurus* cattle of 25°C at moderate humidity, above which the animal is subject to excessive heat loads resulting in feed intake declines. Observations of respiration rates (RR) for similar cattle have also shown a threshold for increased RR at 21.3°C, with RR increasing at a rate of 4.3 breaths/min-C above a baseline RR of 60 bpm. Such results provide guidelines for minimizing risk to animals and provide guidance for monitoring animals during exposure to environmental challenges. The purpose of this report is to set forth dynamic responses of cattle as appropriate criteria for proactive environmental management during hot weather.

**Key Words:** Environmental management, Physiological responses, Feeding behavior

## 362 Assessing swine thermal comfort by neural network analysis of their postural behavior images.

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Postural behavior is an *integral* response of animals to their environmental stimuli. Huddling, nearly touching one another, and spreading apart among group-housed animals are the *qualitative* stereotypes of postural patterns corresponding, respectively, to cold, comfortable, and warm/hot sensation. It is these postural patterns that have been routinely used by animal caretakers to assess thermal comfort state of the animals and to adjust the environment or management accordingly. This human observation and manual adjustment approach, however, has two inherent pitfalls. First, it is impossible for the caretakers to attend the animals around the clock despite the circadian thermal needs of the animals. Secondly, the interpretation of optimal animal comfort behavior may vary considerably from one caretaker to another.

fontsize58The goal of this project is to develop a machine vision system that automatically assesses thermal comfort state of swine and make according environmental adjustments. As the first step toward the goal achievement, this study examined the feasibility of classifying thermal comfort state of pigs by neural network (NN) analysis of their behavioral images. Specifically, pigs from 2 to 4 weeks of age were exposed in groups of 10 to cold, comfortable, and warm environments. Postural behaviors of the pigs were recorded and processed into binary images. Fourier coefficients (FC), moments (M), perimeter (P), area (A), and combination of M, P, and A were evaluated as the feature representations of the processed behavioral images. Using these features as inputs, a 3-layer NN was established and then used to classify each of the postural images into the cold, comfortable, or warm category. The combination of M, P, and A as inputs to the NN model produced the best classification rate. The results suggest that this approach has a good potential as a non-invasive assessment of the animal's thermal comfort and ultimately may provide a practical management tool for an enhanced animal well-being. Meanwhile, the results reveal the need for quantitative relations between physiological measurements of the pig comfort and the behavioral displays. This information is essential for *objectively* building the NN, particularly fuzzy-logic NN, and thus improving its correct classification rate.

**Key Words:** Postural Behavior, Image Processing, Neural Network

## 363 Nutritional strategies for managing the heat-stressed dairy cow.

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Heat stress negatively affects production and alters the physiologic state of the cow due to the upset of heat balance and the onset of thermoregulatory responses which disturb homeostasis. The most obvious effect of heat stress is a sharp decline in DMI, which reduces metabolic heat production but compromises nutrient intake. Mineral metabolism is altered by the obligatory loss of K through sweating, and by altered blood acid-base chemistry due to hyperventilation. Numerous hormones involved with the metabolism of minerals, water balance, partitioning of nutrients, and which affect rate of passage of digesta and digestion are altered in response to heat stress. Modification of the environment through cooling can moderate the severity of heat stress, but barring total environmental control, performance losses due to environmental heat stress will occur. Nutritional modifications during hot weather seek to improve DMI, increase dietary nutrient density, or attempt to compensate for the altered physiologic state of the cow. Formulating for adequate nutrient intake often becomes a competition between nutrient density (primarily energy) and adequate fiber in the diet. Theoretical heat increment favors feeding those feeds with a lower heat increment such as concentrates and fats, but may occur at the expense of forages, which have a higher heat increment. Rumen inert fats provide for greater dietary lipid content and may improve energy intake despite DMI limited by heat stress. Optimizing rumen undegraded protein has improved milk yield in hot climates, but feeding excessive degradable protein may be contraindicated because of energy costs associated with the metabolism and excretion of N as urea. Feed additives including sodium bicarbonate, microbial additives, fungal cultures, and vitamins such as niacin may stimulate intake during hot weather. A number of nutritional modifications can be used during periods of high environmental temperatures, but are best used in concert with an effective environmental cooling system.

**Key Words:** Dairy, Heat Stress, Nutrition

## 364 New strategies for managing reproduction in the heat-stressed dairy cow.

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Heat stress of lactating dairy cows causes a decline in estrous detection rate and the proportion of inseminated cows that maintain pregnancy. The most common approach to ameliorate heat stress has been to alter the cow's environment through provision of shade, fans, sprinklers, etc. Nonetheless, seasonal variation in reproductive function persists. Increased understanding of bovine reproductive biology and how that biology is altered by heat stress has led to new strategies for reducing deleterious consequences of heat stress on reproduction. Among these are timed artificial insemination, which can reduce losses in reproductive efficiency caused by poor estrous detection, and embryo transfer, which can increase pregnancy rate by allowing embryos to bypass the period when they are most sensitive to elevated temperature (i.e., in the first 1–2 days after breeding). Another approach has been to provide antioxidants. Glutathione, taurine and vitamin E can reduce adverse effects of elevated temperature on cultured embryos, presumably because they scavenge free radicals produced in response to elevated temperature. Acute administration of $\beta$-carotene or vitamin E did not improve pregnancy rates of lactating Holsteins during the summer but feeding $\beta$-carotene for $\geq$ 90 d during periods of heat stress increased the proportion of cows pregnant at 120 d postpartum. Thus, additional studies evaluating effectiveness of long-term administration of antioxidants are warranted. One future area of research for increasing embryonic survival will be manipulation of heat shock protein (HSP) synthesis. The bovine embryo can produce increased amounts of HSP70 in response to elevated temperature as early as the 2-cell stage. Future work will be directed towards determining whether manipulation of HSP synthesis can increase embryonic survival following exposure to maternal hyperthermia or other shocks (support: USDA-CBAG 95-34135-1860, USDA NRICGP 96-35205-3728 and Florida Dairy Checkoff).

**Key Words:** Reproduction, Heat stress, Cattle

**365 Energy and protein utilization for maintenance and growth in Omani sheep in hot climates. I. Estimates of energy and protein requirements.** O. Mahgoub, R. J. Early, and C. D. Lu*, *Sultan Qaboos University, Sultanate of Oman.*

Energy and protein requirements for maintenance and growth were estimated in Omani male lambs during the hot summer months (July to October; maximum temperature, 48°C). Weaned lambs (n=10 per diet) were fed one of three totally mixed, 16% CP diets that contained 60, 40 or 20% rhodesgrass hay for low, medium and high energy contents, respectively. Other than energy, diets met the minimum nutritional needs for maximum growth (NRC Sheep, 1985). The trial lasted for 114 d. The purpose of the three diets was to induce a broad spectrum of growth rates that could be used in regression analysis for determining energy and protein requirements for maintenance and growth. A digestibility trial indicated that these diets contained 9.98 ± 0.16, 10.3 ± 0.14 and 11.4 ± 0.06 MJ/kg of ME (DE × 0.82) and 70.6 ± 22, 70.1 ± 17, and 76.9 ± 11 g/kg metabolizable protein (MP; based on (Feed N - Fecal N - Urinary N) × 6.25). Regression analysis (tested for linear, quadratic and cubic effects) showed a significant ($p<0.001$) linear relationship of ME ($r^2=0.64$, $p<0.001$) or MP ($r^2=0.68$, $p<0.001$) versus lamb average daily gains (ADG), quadratic and cubic effects were not significant. ME at 0 ADG (maintenance energy requirement) was 494 ± 52 kJ / $kg^{0.75}$ BW and the regression coefficient, which describes the ME required for gain, was 33.6 ± 4.8 kJ / (g gain $kg^{0.75}$ BW). MP at 0 ADG (maintenance protein requirement) was 3.69 ± 0.29 g / $kg^{0.75}$ BW and the regression coefficient, which describes the MP required for gain, was 0.201 ± 0.027 g / (g gain $kg^{0.75}$ BW). These values indicate that ME energy requirements for Omani sheep in hot environments are approximately 20% greater than those reported for sheep in temperate climates.

**Key Words:** Heat Stress, Sheep, Requirements

**366 Energy and protein utilization for maintenance and growth in Omani sheep in hot climates. II. Estimates of the efficiency of energy and protein utilization for maintenance and growth.** R. J. Early*, O. Mahgoub, and C. D. Lu, *Sultan Qaboos University, Sultanate of Oman.*

Efficiency of energy and protein utilization for maintenance and growth were estimated in Omani male lambs during the hot summer months (July to October; maximum temperature 48°C). Weaned lambs (n=10 per diet) were fed one of three isonitrogeneous (16% CP) diets that contained low (9.98 ± 0.16 MJ/kg), medium (10.3 ± 0.14 MJ/kg) and high (11.4 ± 0.06 MJ/kg) energy contents. Diets were supplemented with appropriate minerals and a vitamin premix. An initial slaughter group of 10 animals was used to estimate the initial body composition of the animals. Treatment animals were slaughtered at 114 d. Rates of gain in body components and energy are given below.

| Composition Gain, g/d | Low | Medium | High | Pooled SE |
|---|---|---|---|---|
| Water | $29.3^a$ | $43.8^b$ | $56.1^c$ | 3.4 |
| Fat | $24.4^a$ | $35.9^b$ | $46.1^c$ | 3.5 |
| Crude protein | $12.0^a$ | $15.5^b$ | $21.0^c$ | 1.5 |
| Ash | $2.8^a$ | $4.8^b$ | $6.1^c$ | 0.9 |
| Energy Gain, MJ/d | | | | |
| Total energy | $1.23^a$ | $1.76^b$ | $2.28^c$ | 0.16 |
| Fat energy | $0.95^a$ | $1.40^b$ | $1.80^c$ | 0.13 |
| Protein energy | $0.28^a$ | $0.36^b$ | $0.48^c$ | 0.03 |

$^{a,b,c}$ Means with different superscripts are different ($p<0.01$)

Dietary treatments, however, did not affect the distribution of energy between protein and fat within the empty body, carcass or non-carcass tissues. Protein accounted for 27%, 24% and 31% of the energy gain in the empty body, carcass and non-carcass tissues, respectively. Fat accounted for 73%, 76% and 69% of the energy gain in the empty body, carcass and non-carcass tissues, respectively. The average efficiency of metabolizable energy (ME) and metabolizable protein (MP; based on (Feed N - Fecal N - Urinary N) x 6.25) used for weight gain was calculated from the nutrient gain in the tissue versus the nutrient available for gain in the feed. These efficiencies were 45% and 71% for ME and MP, respectively, and were not affected by the energy content of the diet.

**Key Words:** Heat Stress, Sheep, Efficiency

**367 Effects of recombinant growth promotants on lactating rats maintained at different ambient temperatures.** P. A. Eichen*[1], D. E. Spiers[1], K. E. Westhoff[1], J. C. Byatt[2], and A. Gertler[3], [1]*University of Missouri, Columbia,* [2]*Monsanto Agricultural Co., St. Louis, MO,* [3]*The Hebrew University, Rehovot, Israel.*

Recombinant bovine somatotropin (bGH) and placental lactogen (bPL) increase growth in juvenile and adult rats maintained in thermoneutral (TN; 21C) and heat challenge (HC; 31C) environments. This study was conducted to determine lactogenic properties of these hormones and bPL analogs at different ambient temperatures. In Study 1, pregnant, first-parity rats (n=91), maintained at TN, were randomly assigned to treatment with lactogenic hormone, bGH or bPL analog (73A, 73D or T188F) at 20mg/kg/d, recombinant bovine prolactin (bPRL) at 2mg/kg/d, or vehicle. Litters of 9 pups were maintained at TN until day 15. Daily ip injections of dams began on day 5. Dam body and organ mass, food intake, and litter mass were recorded. In Study 2, rats (n=48) received similar treatments (bGH, bPRL, bPL, T188F or vehicle) in an HC environment. A third study determined lactation-related dose-response to bGH at TN (n=47). Treatment with bGH increased rate of change in dam mass ($P\leq.04$) and relative mammary gland mass ($P\leq.07$) at TN. None of the other treatments altered rate of change in dam mass ($P\leq.74$-$.95$). However, relative mammary gland mass increased with all treatments but bPRL. Relative food intake decreased below control level with all treatments ($P\leq.002$-$.05$). Rate of change in litter weight only increased with T188F treatment ($P\leq.002$), to suggest increased milk production. Relative feed intake was the only parameter affected by HC, where treatment with bPL, bPRL and T188F produced a decrease ($P\leq.0001$-$.02$). The bGH dose study showed that treatment with 40mg/kg/d produced the greatest dam and litter responses. These results suggest that bPL analog T188F is the superior lactogenic compound at thermoneutrality. However, higher doses of all tested compounds may be needed to increase lactation during heat challenge. (Support: BARD-USDA Project No. US-2109-92R)

**Key Words:** Lactation, Heat Stress, Somatotropins

**368 Physiologic and productive responses of holstein dairy cows with access to shade constant or limited.** J. C. Damasceno*[1], F. Baccari Jr.[2], L. A. Targa[2], E. N. Martins[1], and G. T. Santos[1], [1]*Universidade Estadual de Maringá - Maringá - PR - Brazil,* [2]*Universidade Estadual Paulista.*

The work was carried out at Piracicaba, São Paulo, from January to February 1993, with the objective of evaluating the physiologic and productive responses of Holstein cows, kept in free stall barns, during the summer, with access to shade constant or limited. The experimental design utilized was completly randomized. Sixteen dairy cows were used, at different lactation stages and production levels, confined in two free stall barns, with or without protection against solar radiation in south-east and north-west edge. The physiological variables measured were respiratory frequency (morning and afternoon) and rectal temperature (morning and afternoon). The productive variables were milk production (morning, afternoon and total), dry matter (DM) intake (% body weight) and efficiency of milk production (kg of milk/kg DM intake). The animals with access constant shade had lower respiratory frequency (74.1 vs 81.0 breaths/min.) and rectal temperature (39.50C vs 39.70C) ($P<0.05$) and higher milk production (22.6 vs 20.9 kg/day) and efficiency of milk production (1.3 vs 1.2 kg of milk/kg DM ingested) ($P<0.05$) than animals with access to shade limited. There were no effects on the dry matter intake ($P>0.05$).

**Key Words:** Heat Stress, Milk Production, Rectal Temperature

**369 The responses of body surface temperature in dairy cows to microclimatic factors.** P. Kunc*[1], I. Knížková[1], M. Koubková[2], and J. Brouček[3], [1]*RIAP Prague,* [2]*CAU Prague (Czech Rep.)*[3]*RIAP Nitra (Slovakia).*

The objective of this experiment was to evaluate the influence of natural ventilation on the heat comfort of housed dairy cows. The measurement was carried out in a reconstructed barn (loose housing with free-stalls) for 300 dairy cows during May 1997. The barn was equipped with natural ventilation and an open-sided construction with plastic blinds. The measurements were carried out in two stages with cycles: I stage (ST)-cycles (CY):1/ 10.00–10.30 AM - open-sided construction fully opened, 2/ 10.30–11.30 AM open-sided construction closed by means of plastic blinds, 3/ 11.30–12.30 AM - open-sided construction fully opened. II. stage (ST) - cycles (CY): 1/ 8.00–8.30 PM - open-sided construction closed, 2/ 8.30–9.30 PM - open-sided construction fully opened. The air temperature (T), relative humidity (RH), air flow (AF) and cooling index (CI) were measured during every cycle. The changes of body surface temperatures were measured in 12 dairy cows (Czech Pied cattle) by thermovision set AGA 880 during each cycle. The changes of body surface temperatures were evaluated in 4 zones: body forepart (BF), barrel (B), hindpart (H) and udder (U). CM-SOFT computer program was used for data and thermograms analyses. Results are datailed in the following chart:

| ST | CY | T °C | RH % | AF m/s | CI W/m$^2$ | BF °C | B °C | H °C | U °C |
|---|---|---|---|---|---|---|---|---|---|
| I. | 1. | 21.7 | 49 | 1.75 | 336 | 31.38 | 31.11 | 31.04 | 33.03 |
| | 2. | 25.2 | 52 | 0.08 | 142 | 31.85 | 32.03 | 32.08 | 33.39 |
| differ. | | 3.5 | 3 | 1.67 | 194 | 0.47** | 0.92* | 1.03 | 0.37 |
| | 2. | 25.2 | 52 | 0.08 | 142 | 31.85 | 32.03 | 32.07 | 33.39 |
| | 3. | 24.4 | 46.5 | 2.00 | 432 | 31.37 | 31.36 | 31.22 | 33.32 |
| differ. | | 0.8 | 5.5 | 1.93 | 290 | 0.48 | 0.67 | 0.85** | 0.07 |
| II. | 1. | 22.7 | 68 | 0.10 | 156 | 33.42 | 33.34 | 33.18 | 34.28 |
| | 2. | 16.2 | 66.5 | 0.35 | 346 | 31.86 | 31.91 | 31.36 | 33.95 |
| differ. | | 6.5 | 1.5 | 0.25 | 190 | 1.56* | 1.43* | 1.82* | 0.34 |

* P< .01
** P< .05

In this case, natural ventilation ensured adequate heat comfort of housed animals. Closed open-sided construction caused undesirable changes in microclimate. The dairy cows responded promptly to these changes by the changes of body surface temperature. No significant differences were observed in udder. These responses manifest a very good adaptation to temperature differences.

**Key Words:** Dairy Cows, Body Surface Temperature, Thermography

**370 Spring temperature effects on milk production and composition in Argentinian grazing systems.** S. E. Valtorta, M. R. Gallardo, J. Maiztegui*, and H. C. Castro, *FAVE-UNL, Esperanza, Santa Fe (Argentina).*

An 85 milking cow herd in a rotational grazing system was utilized to estimate the effects of spring temperatures on milk production and composition from September to December during 1996 and 1997. Forage:concentrate ratio was 70:30, alfalfa being the only grazing forage source. The average values were:

| Variable | 1996 | 1997 |
|---|---|---|
| Mean Temp. (°C) | 21.4±5.3 | 21.0±4.6 |
| Min. Temp. (°C) | 13.0±5.1 | 14.3±4.4 |
| Max. Temp. (°C) | 26.6±5.5 | 26.2±5.2 |
| Milk (litres/cow/day) | 27.6±1.7 | 34.0±3.8 |
| Fat (%) | 3.14±0.17 | 3.18±0.31 |
| Protein (%) | 2.95±0.07 | 2.94±0.28 |

In 1996 the most important effects were produced by mean temperature (Mean), while during 1997 minimium temperature (Min)was the variable producing the greatest impact on milk production:
$Yield_{1996}$=30.86−0.15Med($R^2$=0.21;P<0.01; $ss_{resid}$=279.1)
$Yield_{1997}$=40.40−0.30Min($R^2$=0.27;P<0.01; $ss_{resid}$=600.8)
No effects were observed on fat. Protein contents was only affected by Min ($R^2$=0.50;P<0.01)during 1996.The hottest month for each period (December 1996 and October 1997)were analyzed separately. No effects were detected on either milk or fat or protein during 1997. In 1996, however, both Max ($R^2$=0.41;P<0.01)and Min ($R^2$=0.40;P<=0.01) temperatures affected milk production, while protein decreased in response to increased Min ($R^2$=0.50;P<=0.01). These data show that high spring temperature has a negative effect on milk output. The difference in milk during both years could be due to the fact that 1996 was an extremely dry year and that protected fat was added to the concentrate during 1997. It also appears that protein contents decreases as minimum temperature increases, thus suggesting that the night recovery period is important for protein yield.

**Key Words:** Spring Temperature, Milk Production, Grazing Systems

**371 A comparison of pasture-based and confinement rearing systems for immuno-deficient calves.** B. A. Reed*, C. Stull, and S. L. Berry, *Glenn County Cooperative Extension, Veterinary Medicine Extension, and Animal Science Extension, University of California, Davis.*

Failure of passive immune transfer compromises the calf's immune system. Although colostral substitutes offer some protection to the calf, modifying the calf's environment may improve health. This trial compared rearing system effects on growth and morbidity of unweaned calves. In spring, colostrum deprived newborn Holstein calves (n=38) were randomly assigned to one of two rearing treatments: group-reared on pasture (n=20) or individually housed in elevated metal pens (n=18). Portable data loggers recorded temperature and humidity in each environment. Rectal temperature and signs of morbidity were recorded at enrollment. Blood samples were collected to evaluate IgG status. Calves were weighed at enrollment, weaning, and 28 d post-weaning. Following enrollment, morbidity observations were made three times per week; rectal temperature, heart-girth and additional morbidity observations were measured bi-weekly. Mean IgG and rectal temperature were not significantly different between groups. IgG for both groups was less than 900 mg/$\mu$l. Pastured calves were subjected to larger daily variations in temperature and humidity (P<.01). Mortality was not significantly different between groups, although risk of calf mortality was 40% lower in the pastured group. Weight gains were not significantly different between groups from birth to weaning, but gains for 28 d following weaning were larger for pastured calves (P<.01). Morbidity was not significantly different between groups, except for injuries, which were more prevalent in the control group (P<.05). When analyzed in similar age groupings, control calves had a greater incidence of lameness and injury at 0.5 months and 2.5 months respectively, while pastured calves had a greater incidence of nasal discharge at 1.5 months (P<.05). Results suggest unweaned calves can be reared on pasture with morbidity and mortality similar to calves reared in individual pens.

**Key Words:** Unweaned Calves, Health, Pasture

**372 Semen quality of Holstein bulls throughout the year in the US Virgin Islands.** R. W. Godfrey and J. R. Collins*, *University of the Virgin Islands, Agricultural Experiment Station, St Croix.*

Dairy farms in the US Virgin Islands utilize natural breeding and a pasture-based management system in a semi-arid tropical environment. To determine if there were any seasonal fluctuations in semen quality of Holstein bulls throughout the year semen was collected from bulls (n = 9) on two farms on St Croix during a 13-mo period. Bulls were 3.2 ± .4 yr of age (range 1.9 to 4.7 yr) at the start of the data collection in April. Semen was collected by electroejaculation at monthly intervals and evaluated for percentage motile cells (MOT), percentage live cells (LIVE), sperm concentration (CONC) and sperm morphology. Scrotal circumference (SC) was also measured at this time and used, along with testes length, to determine paired testes volume (PTV). The bulls were being used for breeding at various times of the year and the status of the bull (exposed to cows or not exposed) at the time of semen collection was noted. The mean monthly high and low temperatures were 30.1 ± .06 and 23.4 ± .08 °C, respectively. Percentage of normal sperm was lowest (P < .01) during July (71.1 ± 3.1 %) which was due primarily to the high (P < .01) percentage of abnormal sperm tails at this time (20.1 ± 2.4 %). None of the other semen quality traits or testicular measures were affected by time of year (P > .10). Bulls that were not exposed to cows at the time of semen collection had lower (P < .05) MOT than bulls that were exposed to cows (57.0 ± 13 vs 69.1 ± 1.8 %, respectively). Mean high temperature 60 d prior to semen collection was negatively correlated (P < .03) with MOT (R = −.25), LIVE (R = −.24) and positively correlated (P < .02) with percentage abnormal sperm heads (R = .27). These results show that semen quality of Holstein bulls on St Croix does not vary significantly throughout the year, but there is a delayed effect of high environmental temperature on semen quality of bulls. Funded by USDA-CBAG project #9504784.

**Key Words:** Bull, Semen, Environment

**373 Effects of introduction of heifers to tie-stalls one or eight weeks before calving on behavior and subsequent production.** L. Munksgaard and L. Mogensen, *Danish Institute of Agricultural Science, Tjele, Denmark*.

Thirty-nine Danish Friesian heifers were randomly assigned to one of four treatments. Groups 1 and 2 were moved to tie-stalls 1 week before expected calving and groups 3 and 4 were moved 8 weeks before expected calving. All animals were kept in pens with straw bedding before tethering. Groups 1 and 3 were fed grass silage in both the pens and the tie-stalls. Groups 2 and 4 were fed grass silage for the first time when tethered. Behavior of the animals was observed during the first 24 hours after tethering and during 24 hours at 1 and 6 weeks after calving. Heifers which were moved 1 week before calving had a shorter lying time on the first day after tethering (554 min versus 723 min, $P < .01$) and were more restless (activity change 392 versus 293, $P < .01$) than heifers moved to tie-stalls 8 weeks before calving. Heifers which were accustomed to grass silage had a shorter eating time and longer lying time, when tethered 8 weeks before calving, but when tethered at 1 week before calving, only eating time was decreased while lying time was not affected. After calving there were no differences between groups in behavior, average feed intake and milk yield in the first 6 weeks of lactation. Restriction of movements in the tie-stalls may have led to decreased fitness of the pregnant heifers tethered long before calving, and hence offset the expected positive effects of the longer acclimatization period.

**Key Words:** Heifers, Behavior, Tethering

**374 Determination of sensitivity to endophyte-infected tall fescue for beef heifers in a controlled environment.** B. L. Snyder*[1], D. E. Spiers[1], E. J. Scholljegerdes[1], S. VanDyke[1], G. E. Rottinghaus[1], and E. L. Piper[2], [1]*University of Missouri, Columbia,* [2]*University of Arkansas, Fayetteville*.

Earlier field studies have shown it is possible to identify animal sensitivity to combined summer heat and endophyte-infected tall fescue (EIF) stress. The present study determined if the sensitivity is to heat, EIF, or both conditions. Angus heifers, identified in the previous study as sensitive (S; n=6) or insensitive (I; n=6), were placed in environmental chambers. Study I was to determine response to heat stress alone. Air temperature (Ta) was increased to 33C after 4d at 21C. At this point, Ta was cycled daily for 10d, with 5h at 33C and 5h at 25C. Following study I, animals were allowed 21d recovery. Study II tested response to EIF seed, (5$\mu$g ergovaline/kg bw/d), and heat stress. There were daily determinations of respiration rate (RR), skin (Ts) and rectal temperatures (Tr), with blood samples collected to determine prolactin (PRL). Overall Tr was higher in S compared to I heifers ($P \leq .02$), and in EIF compared to non-EIF conditions ($P \leq .0006$). Although there was no overall difference in RR based on animal sensitivity ($P \leq .46$), there was a higher RR response to heat stress alone in S heifers ($P \leq .0001$). In addition, EIF increased RR in both groups ($P \leq .0001$). EIF treatment decreased ($P \leq .001$) ear, rump and tail temperatures by .94, .51, and .46C, respectively, with S heifers displaying higher Ts. Serum PRL levels were lower by 5.7ng/ml in S compared to I heifers ($P \leq .02$), and by 14.7ng/ml in EIF compared to non-EIF treatments. Sensitivity to EIF-heat conditions is primarily due to differences in the heat stress response. It is possible to identify this sensitivity with thermal and hormonal markers. (Support: USDA-ARS 58-6227-5-032)

**Key Words:** Heat Stress, Endophyte, Sensitivity

**375 Time of cooling important for cattle heat load alleviation.** S. M. Holt[1]*, J. B. Gaughan[1], T. L. Mader[2], B. A. Young[1], and P. J. Goodwin[1], [1]*The University of Queensland, Gatton College, Qld. Australia,* [2]*University of Nebraska, Lincoln*.

Six *Bos taurus* (216 to 281kg) steers were used to study the physiological function of thermally challenged cattle prior to, during, and following a period of cooling. Steers were housed in individual stalls in 2 environmentally controlled rooms (3 stalls/room). A Latin-square design was used involving 2 days pretreatment, 5 day exposure to hot conditions, followed by 9 days rest in outside yards. Cooling treatments were (1 in each room); daytime cooling (DT), and night time cooling (NT). The DT steers were cooled using sprinklers and fans from 0800h to 1500h each day. The NT steers were cooled from 1500h to 0800h the following day. The sprinklers were set to turn on for 5 mins. every 20 mins. when ambient temperature $\geq 28^{\circ}$C. Ambient temperature ($T_a$), relative humidity (RH) and rectal temperatures (RT) were recorded to a data logger every 5.4 mins. Respiration rate (RR), heart rate (HR) were recorded hourly. Over the 5 day test period, mean daytime (0900h to 1600h) $T_a$ was 37.4$^{\circ}$C, mean RH was 57.3% and mean temperature humidity index value (THI) was 89.4. Mean night time (1700h to 0800h) $T_a$ was 28.8$^{\circ}$C, mean RH was 70.5 and mean THI was 79.6. Although there was no significant difference in total feed intake between treatments, the DT cattle ate predominantly during the day and NT ate at night. During the day, lag times behind ta for DT & NT steers respectively were: RT 0 hr and 1 hr; HR 0 hr both groups; RR between 0 hr and 2 hrs both groups. During the night lag times behind $t_a$ for physiological parametes tended to be 3 hrs or more, however correlations were small ($-.50 < r < .50$). These results suggest that time of cooling is important in the alleviation of high thermal load in cattle. The effect of cooling during the day had a greater impact on feed intake than cooling at night. RR was the most useful physiological parameter to assess heat load in beef cattle.

**Key Words:** Environmental Stress, Feedlot Cattle, Respiration Rate

**376 Effect of location and intensity of electrical shock on cattle movements.** S. Markus[1], D. Jensen*[1], D. W. Bailey[2], and M. Price[3], [1]*Alberta Agriculture Food and Rural Development,* [2]*Montana State University, Havre,* [3]*University of Alberta*.

Available electronic and Global Positioning System technology has the potential to replace traditional fencing with fenceless livestock control. A series of studies were conducted to evaluate behavioral responses of cattle to a simulated fenceless livestock control system. The specific objective of this study was to determine the most suitable location to deliver an electrical shock and to determine the optimum intensity of shock. Eighteen yearling Charolais steers were allocated randomly to 6 treatment groups consisting of 2 locations (neck and muzzle) and high (5800 V), medium (5600 V) and low (5000 V) intensities. Cattle were fitted with a Tri-Tronics Sportsman® remote trainer designed for dogs. For 4 d prior to the study, steers were individually trained to travel to the end of an alley and eat barley silage. During the 6 d study, individual cattle were again allowed access to the silage, but they were given an electric shock as they approached the feeding area. Electrical shocks were repeated every 3 s until the steer left the feeding area or until the 2 min test period ended. Behavioral responses were considered incorrect if steers remained in the feeding area after being shocked. Fewer ($P < .05$) incorrect responses were observed at the higher shock intensity ($0.29 \pm 0.09$) than at the moderate ($0.73 \pm 0.09$) or low ($0.83 \pm 0.09$) levels. Animals in the low voltage group often continued forward and entered the feeding area after receiving a shock, but cattle in the high voltage group usually stopped abruptly after the shock. No differences ($P > .10$) in incorrect behaviors were observed between the neck ($0.66 \pm 0.07$) and muzzle ($0.57 \pm 0.08$) locations. However, cattle appeared to learn faster when the shock was applied to the muzzle. The high intensity of shock applied to either the neck or muzzle was effective in preventing cattle from entering the designated area.

**Key Words:** Cattle, Behavior

**377 Predicting Ponderosa pine needle intake with near infrared reflectance spectroscopy and fecal samples.** S. L. Kronberg[1]*, J. W. Walker[2], and R. E. Short[3], [1]*South Dakota State University, Brookings,* [2]*Texas A&M University Agricultural Research Station, San Angelo, and* [3]*USDA-ARS, Miles City, MT.*

Study of ingestion of Ponderosa pine needles (PN) and other toxic plant materials by free-ranging ruminants is limited by a lack of fast and inexpensive methods to estimate individual intake of the materials. We tested the potential for using near infrared reflectance (NIR) analysis of fecal samples as a means of estimating PN intake of cattle. Mature cows were divided into three groups (n=10/group) and fed a diet equal to 2% of their BW (DM basis) once daily. For each group, dried and ground PN were added to their diets at 0, 2, 4, 8, and 16% (DM basis) of the total diet (two cows/level of PN). Each group was fed a different basal diet, which was either ground alfalfa hay, ground grass hay, or corn silage. After 7 d of feeding these diets, fecal samples were collected on d 8 and 9. Dried and ground fecal material was scanned by a monochromator that collected spectra from 400 to 2500 nm at 2 nm intervals. This information was used to develop calibration equations and evaluate their performance. When spectra from fecal samples of all cattle were combined, the best composite set of wavelengths produced a prediction equation with an $R^2$ of .86 and a SE of calibration (SEC) of 2.9. When separate calibration equations were developed from feces of cattle on each basal diet, $R^2$ and SEC for the equations for alfalfa hay, corn silage, and grass hay were .89, 1.93; .95, 1.29; and .99, .61, respectively. Evaluation of fecal samples with NIR technology has good potential as a fast, inexpensive, and accurate method for estimating the amount of PN ingested by cattle.

**Key Words:** Ponderosa pine needles, Cattle, Ingestion

**378 Using sentinal pens with performance testing equipment as a tactical management tool.** R. L. Korthals*, *Osborne Industries, Inc., Osborne, KS.*

An experiment was run to evaluate the effectiveness of Feed Intake Recording Equipment (FIRE®) performance testing stations as a sentinel tool for monitoring swine production. Animals in pens with conventional feeders were compared with animals fed using FIRE® feeding stations. A randomized complete block test design was used with a replication of treatments over time. Four groups of animals, two of barrows and two of gilts were used in each treatment replication. Average daily feed intake (ADFI), average daily gain (ADG), and feed conversion (FC) were compared. No significant difference in ADFI, ADG, or FC were noted between FIRE® feeders and conventional feeders. There was an interaction effect in ADFI for replication * treatment. Replication 1 with conventional feeders had higher ADFI ($P < 0.02$) than replication 2 (6.20 kg/day vs. 5.22 kg/day), but neither was significantly different from the FIRE® feeders (5.72 and 5.71kg/day). Differences in ADFI and ADG were noted for sex ($P < 0.02$), but no significant difference was noted in FC between barrows and gilts.

The amount and detail of data presented by sentinel testing enhances the understanding of animal production. For example, data from a FIRE® performance testing station during this test provided daily feed intakes and estimated average animal weights as shown in the table. Further analysis of day 18 data indicated that the standard deviation on animal weights for that pen was 3.5 kg. The overall ADG was also evaluated, and found to range from 0.80 to 1.11 kg/day with a mean and standard deviation of 0.94 and 0.08 kg/day respectively for the individual animals in this test. This level of "real-time" information creates new opportunities for improved tactical management, such as adjusting ration formulations for each subsequent batch of feed.

| Day | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|---|---|
| ADFI (kg/day) | 1.707 | 1.768 | 1.784 | 1.798 | 1.789 | 1.669 | 1.797 | 1.865 |
| Weight (kg) | 31.3 | 32.6 | 33.5 | 35.0 | 34.1 | 35.1 | 35.1 | 36.4 |

**Key Words:** Feed Intake, Electronic Identification

**379 Evaluation of municipal solid waste compost as a cattle feedlot bedding material.** C. M. Zehnder*[1], A. DiCostanzo[1], K. Thate[2], R. Gilland[3], M. J. Murphy[1], and T. R. Halbach[1], [1]*University of Minnesota, St. Paul,* [2]*Prairieland Solid Waste Management, Truman, MN,* [3]*Gilland Feedlot Inc., Morgan, MN.*

A trial was conducted to determine the safety and feasibility of using municipal solid waste compost (MSWC) as a bedding material for cattle feedlots. Two pens, bedded with either cornstalks or MSWC, were used in each feeding period. One-hundred sixty-eight heifers (398 kg) /pen were housed from 7/10/96 to 10/22/96 (104-d) during a summer feeding period; while 138 steers (412 kg) /pen were housed from 11/13/96 to 2/13/97 (92-d) during a winter feeding period. More MSWC than cornstalks was used ($P < 0.05$) resulting in bedding rates of .5 and 1.0, 1.7 and 5.0 kg/hd/d for cornstalks and MSWC each in the summer and winter, respectively. Manure (as-is) output was similar ($P > 0.05$) for both bedding systems; but was twice as high during the winter. When analyzed on a DM basis, more ($P < 0.05$) manure was removed from the MSWC lot in the winter. Manure DM output was 3.27 and 4.68, 3.86 and 7.59 kg/hd/d for cornstalks and MSWC each in the summer and winter, respectively. Total manure N and P removed from the lots were not affected by bedding system and averaged .12 and .03 kg/hd/d, respectively. Blood concentrations of macro-elements, electrolytes, glucose or liver and kidney enzymes were unaffected by bedding system. Concentrations of polychlorinated biphenyls in perirenal fat were not detectable in cattle bedded with either material. Kidney Cu, and kidney and liver Pb concentrations were greater ($P < 0.05$) for cattle bedded with MSWC (14.4 vs 17.0 mg Cu/kg kidney, .2 vs 2.2 mg Pb/kg kidney and .5 vs 2.1 mg Pb/ kg liver, respectively for cattle bedded with cornstalks or MSWC). However, concentrations of these elements were well within concentrations considered normal for healthy cattle. Cattle bedded on MSWC consistently had faster rates of gain ($P < 0.05$) than control cattle (1.4 and 1.5 kg/d for control and MSWC, respectively). Municipal solid waste compost can safely and effectively be used as a bedding material in yearling feeding programs (less than 120 d).

**Key Words:** Cattle, Bedding, Compost

**380 Use of the house fly larvae (Musca domestic L) for the degradation of pig manure.** I. Aubert[1], J. Ramos-Elorduy[2], J. Martinez[1], and G. Borbolla[1], [1]*Facultad de Medicina Veterinaria y Zootecnia &* [2]*Institudo de Biologia, Universidad Nacional Autónoma de México, México D.F., México City, México.*

The objective of this study was to evaluate the efficiency of the house fly larvae for the biodegradation of pig manure and the recuperation of some nutrients contained in it. Fresh manure from pigs weighing 30 kg was inoculated with eggs of house flies (1 g of eggs/kg manure). The eggs were obtained from adult flies breeding on an artificial environment at 280°C and 60% humidity. Crude protein (CP), Crude fiber (CF), Fat (F), Non-protein-Nitrogen (NPN), and Dry matter (DM) were evaluated before and after the inoculation of the fly eggs to the excreta. Larvaes were allowed to grow for 7 days after which they were removed by light. Excreta samples were taken five times before and after the inoculation. The data was analyzed using non-orthogonal contrast. After seven days larvae-digested pig manure had higher ($p>0.01$) protein content (CP) when compared to the pig manure before the larvae inoculation (25.8 vs 22.9%). The same trend ($p<0.01$) was observed with CF (8.4 vs 12.1%) and NPN (4.3 vs 6.4%). In contrast, the fat content of the larvae-digested pig manure was sharply decrease ($p<0.01$) as compared to the non-inoculated pig manure. Larvae produced and removed from the manure after 7 days were microbiologically analyzed for the presence of *Salmonellae* and *E. coli*. No presence of any of these bacteria was found, thus the larvae growing in pig manure represent no biological hazard. The inoculation of the house fly larvae in the manure of pigs can improve the usefulness of this by-product, and at the same time it is possible to produce a high protein ingredient (larvae).

**Key Words:** Pig manure, House fly larvae, Degradation

**381 A chemical free method for controlling flies in dairies.** C. N. Lee*, G. K. Fukumoto[1], and G. M. Toyama[2], [1]*University of Hawaii at Manoa and* [2]*Department of Health, State of Hawaii*.

The massive breeding by the fly *Musca sorben* Wiedemann in a dairy resulted in serious environmental and health concerns. Initial studies with commercial larvicide resulted in 85% effective kill rate. However, due to the possible development of insecticide resistance by the flies and chemical residues in milk, alternate and sustainable methods were investigated. Studies were designed to determine: 1) preferential selection of ovipositioning behavior of gravid flies and 2) feed ingredients that would elicit ovipositioning behavior. In objective 1, fecal materials were obtained per rectum from cows: a)on pasture, b) pasture and supplemented with commercial lactation concentrates and c) in dry lots fed commercial concentrates plus alfalfa. A minimum of 200 gravid females was placed in cages with paired feces for each diet. Egg clusters were collected and counted. Feces from cows supplemented with commercial concentrates attracted 147 eggs vs 10 eggs laid on grass diet (n=19, p<0.01). Flies would restrain from egg laying when exposed to feces from forage diet alone. Hence, feces from cows supplemented with concentrates are considered desirable for breeding. In objective 2, feed ingredients were fermented in rumen fluid obtained from fistulated steers fed a forage diet and these ingredients were exposed to flies (n=300) in cages (n=10). Ovipositional behavior was measured by the number of eggs laid by the gravid females. The feed ingredient that elicited the highest response in egg laid by the flies and subsequent pupae formation were: ground corn (2,210), ground barley (255), cottonseed meal (203), soybean meal (100) and guinea grass, *Panicum maximum* (1). The weights of the pupae (n=25) raised on ground corn diets (0.66g) were heavier than ground barley (0.53g) or grass alone (0.21g), (p<0.05) . These studies showed that it is possible to control ovipositional behavior of *Musca sorben* Wiedemann via alteration of feed ingredients in dairy diets.

**Key Words:** Flies, Dairy

**382 Loading techniques and their effect on behavioral and physiological responses of market weight pigs.** L. Brundige*, T. Oleas, M. Doumit, and A. J. Zanella, *Michigan State University, East Lansing*.

The excessive use of an electric prod during loading may be associated with an increase in stress responses that negatively affect pig welfare and could impair meat quality. Hurdles (H) or electric prods (EP) were used to load market weight, halothane negative pigs (n=48) into a trailer, which remained stationary for 15 minutes. Eight groups of 6 pigs (3H & 3EP) were tested over a 4 week period. The same stockperson loaded both H and EP treatments. Loading techniques were standardized and the stockperson's consistency was monitored using a video recorder. Pigs were videoed during the experiment and data were decoded using behavior observation software (The Observer, Noldus Information Technology). Heart rate (HR) was monitored continuously using a transmitter belted to the pig's body (Polar Sport Tester). Rectal temperature (RT) was taken prior to loading, immediately after loading and 15 minutes post-loading. Cortisol (C) was measured in salivary samples by RIA (Coat-A-Count, DPC) collected at the same intervals as RT. Behavior, HR, RT and cortisol control data were obtained at 24 or 48 hours prior to loading by monitoring pigs at the same time and intervals as used during the experimental day. Data were analyzed using SAS (GLM). Results were summarized as basal (B), post-loading (L) and 15 minutes post-loading (PL), for both control and experimental days. There was no difference among the two treatments when comparing measurements taken during control days and in basal levels. Levels of activity (rooting and investigative behavior) were higher during the 15 minutes PL in pigs subjected to EP (P<0.01). The EP loaded pigs had higher HR and RT 15 minutes PL (P<0.01), than H loaded pigs (mean 1 SD; HR: EP=135.04 ± 12.4 and H=120.16 ± 11.9; RT:EP=102.9 ± .58 and H=102.4 ± .87). No significant difference was observed in salivary cortisol levels between EP and H loaded pigs. The higher activity levels, HR and RT in the EP treatment suggests that the use of an electric prod to load pigs has a negative effect on pig welfare. The association of these measures with meat quality characteristics merits furthe investigation.

**Key Words:** pig loading, stress, welfare

**383 Danger to piglets due to crushing can be reduced by the use of a simulated udder.** M. F. Haussmann*, D. C. Lay, Jr., H. S. Buchanan, and M. J. Daniels, *Iowa State University, Ames*.

The occurrence of sows lying on their young, or piglet "crushing", is a significant cause of piglet mortality in current production systems. Although mortality rates of piglets in farrowing crates are lower than in pens, loss due to crushing is still estimated to be between 4.8% and 18%. During the first few days after parturition, piglets are highly attracted to the odor of their dam's udder. Thus, our research was designed to move the piglets away from the sow by competing with the sow's udder using a "simulated" udder. Fifteen Yorkshire sows and their litters (11.4 ± .78 pigs) were assigned to either the control group (C, n = 9) or the experimental group (SU, n = 6). The C piglets had access to a heat lamp whereas the SU piglets' crate had a simulated udder. Data was collected using time-lapse photography (1 frame/.4 s) for a 3-d duration at the initiation of farrowing. When the sow stood, data was recorded by 1-min scan samples to record the number of piglets using either the heat lamp or the simulated udder. In addition, stillborn piglets, piglet crushing, and death by other means were also recorded. Data was analyzed by 12-h periods using generalized estimating equations. Results indicate that from 12 to 72 h postpartum, excluding 24 to 36 h postpartum, the estimated probability that piglets were in a safe area (simulated udder or heat lamp) was .89 for SU piglets compared to only .72 for C piglets (P = .005). During the 24- to 36-h period, it was more probable to find piglets on a simulated udder (.45) than under only a heat lamp (.19) (P = .005). Stillborn piglets, piglet crushing, and death by other means were not different within treatments (mean = .87, .60, 1.2; P > .20). The simulated udder drew piglets away from the sow's udder better than heat lamps alone. Considering these findings, mortality of piglets due to crushing may be decreased substantially using a simulated udder. These results are promising, but further refinement should be done including: improved udder design and investigation on the attractiveness of various stimuli.

**Key Words:** Piglets, Mortality, Crushing

**384 Type of birth affects the function of the hypothalamic-pituitary-adrenal axis in the neonatal pig.** J. A. Daniel[1], D. H. Keisler[1], J. A. Sterle[1], R. L. Matteri[2], and J. A. Carroll[2], [1]*University of Missouri,* [2]*Animal Physiology Research Unit, Agricultural Research Service, USDA, Columbia, MO*.

A study was conducted to compare the development of the hypothalamic-pituitary-adrenal (HPA) axis in piglets born by natural birth or Cesarean-Section. Eight crossbred sows were selected for the study (n=4 natural birth and n=4 C-Section). Gestation length did not differ between natural birth and C-Section piglets (113.6 ± .14 and 113.2 ± .27 d, respectively; P>.16). Blood and tissue samples from 38 piglets were collected at birth. All remaining piglets were sustained with natural birth sows until 2 wks of age. Piglets were canulated for blood sample collection to assess pituitary-adrenal responses to an injection of corticotrophin-releasing hormone (CRH; 10 $\mu$g/kg). Blood samples were collected at −30, −15, 0, 5, 10, 20, 40, 60, and 90 min, piglets received CRH or saline at time 0, and tissue samples were collected immediately following the last blood sample. Serum adrenocorticotrophic-releasing hormone (ACTH) and cortisol (CS) were determined by RIA. Total RNA was isolated from the right adrenal and levels of ACTH receptor and 28S ribosomal RNA were determined by slot-blot hybridization. Basal concentration of ACTH was greater in C-Section than natural birth piglets at birth (P=.01) but did not differ at 2 wks of age (P=.42). Basal concentration of CS was not different at birth (P=.86) but was greater in C-Section piglets at 2 wks of age (P>.04). Serum ACTH was not different between C-Section and natural birth piglets following the CRH challenge (P>.99). However, serum concentration of CS was greater in C-Section than natural birth piglets following the CRH challenge (P<.05). Expression of ACTH receptor mRNA relative to 28S rRNA was greater in C-Section piglets (P=.04). These data indicate that the birth process plays an important role in post-natal function of the hypothalamic-pituitary-adrenal axis.

**Key Words:** Porcine, Stress, Birth

**385 The behavior and performance of piglets weaned at three ages.** E. K. Worobec, I. J. H. Duncan, and T.M. Widowski*, *University of Guelph, Canada*.

To determine the effects of weaning age on piglet behavior and performance, litters of piglets were randomly assigned to be weaned at 7, 14 and 28 d of age. In each of three trials, piglets from three litters were mixed into two pens of ten piglets per weaning age (N=180). Pens were video-taped for two d immediately post-weaning and periodically until piglets were six wks of age. A three phase feeding system was used, with feeding regimen dependent on weaning age. Feed intake, body weight and skin integrity scores were recorded weekly. Piglets weaned at 7 d spent more time belly-nosing and less time feeding than piglets weaned later. Piglets weaned at 14 d showed more belly-nosing and spent less time feeding than piglets weaned at 28 d. On the two d immediately post-weaning, piglets weaned at 7, 14 and 28 d spent 0.6±0.5, 2.7±1.0 and 4.6±0.4 % of the time at the feeder (P<.05). At 28 and 29 d of age, piglets weaned at 7, 14 and 28 d spent 6.4±0.9, 2.0±0.9 and 0.6±0.3 % of the time belly-nosing (P<.05). By six wks of age, belly-nosing had decreased, but was still higher in earlier weaned piglets (P<.05). Piglets weaned at 7 d consumed little feed, gained poorly and had higher mortality during the wk following weaning than piglets weaned later. Feed intake for piglets weaned at 7, 14 and 28 d was 78.1±7.9, 114.0±7.4 and 241.0±50.2 g/piglet/d during the first wk post-weaning (P<.05). Piglets weaned at 7 d had more skin markings from belly-nosing, fighting or sucking during the first wk post-weaning than did piglets weaned at 14 and 28d (P<.05). By six wk of age, piglets weaned at 7 d still weighed less than piglets weaned at 14 or 28 days (P<0.05), but feed:gain did not differ with weaning age over the last two wk of the trial (P>0.10). Early weaning without off-site segregation did not result in improved piglet performance. Piglets weaned at 7 d had greater difficulty starting to feed and developed higher frequencies of behavior problems than later weaned piglets.

**Key Words:** Early Weaning, Behavior, Performance

**386 The effect of genotype on behavior in segregated early-weaned pigs tested in an open-field.** M. Shea-Moore*, *USDA-ARS, West Lafayette, IN*.

Selection pressure in the meat industry continues to move towards a more lean and less fat product. Pigs have been selected to gain weight rapidly and deposit minimal amounts of fat. Combining genotype selection with segregated early weaning, raises questions about the behavior and well-being of the pig. Two groups of 44 d old pigs were compared using a completely randomized design. One treatment group was selected for high levels of lean gain (Hi-L)(N=12) and the other was selected for low levels of lean gain (Lo-L)(N=12). The effect of genotype on behavior was compared using an open-field arena (150cm X180 cm). Pigs were tested for 5 min and vocalization, defecation and activity level were recorded. Salivary cortisol samples were collected immediately after the open-field test and at 15, 30 and 45 min post-behavioral test. Results indicated higher levels of activity in the Lo-L treatment group compared to the Hi-L (P<.05). There was large variation in the number of vocalizations regardless of treatment. Due to this variability, no treatment differences were detected. Higher levels of activity usually suggest less anxiety and more interest in exploration of the environment. Defecation indicates an increase in anxiety in a novel situation. However, there was a trend toward a positive correlation between defecation and activity level (P=.09). Although baseline cortisol levels were higher in the LO-L compared to the Hi-L group(P<.05),a repeated measures analysis of cortisol did not suggest significant treatment differences in salivary cortisol over time. Pigs selected for a lower lean-gain showed higher activity level in the open-field test. It is possible that by selecting for high lean-gain, an animal's ability to cope with a novel situation is changed, thus affecting the well-being of the animal.

**Key Words:** Genotype, Open-field, Pig

**387 Biological and behavioral indicators of frustration and pleasure in the boar.** J. D. Bishop[1], P. V. Malven[1], W. L. Singleton[1], and G. D. Weesner*[2], [1]*Purdue University,* [2]*USDA-ARS, W. Lafayette, IN*.

The goal of this experiment was to compare biological and behavioral indices of stress between boars experiencing frustration and pleasure. Mature boars were trained to mount an artificial sow for semen collection purposes. Because all 11 trained boars in this study appeared eager to enter the collection arena, it seems likely that they were anticipating pleasure. Each boar was fitted with a jugular venous catheter to facilitate frequent blood sampling without stress. Two treatments were imposed upon each animal: 1) a control (CTRL) condition of presumed pleasure wherein the boar was allowed to proceed with normal copulatory behavior culminating in ejaculation; and, 2) a frustration (FRUS) treatment which allowed the boar to mount and display courtship behaviors toward the artificial sow but in which ejaculation was not allowed. Blood was sampled at frequent intervals for 30 min before, during, and for 30 min after exposure to the artificial sow. These samples were analyzed for three stress-related hormones: cortisol (C), beta-endorphin (BE), and testosterone (T). Behaviors were recorded with overhead video cameras. Compared to pre-exposure levels, T did not change during or following exposure to either treatment. However, BE concentrations measured in the arena increased (P< .05) during FRUS treatment but not during CTRL conditions. Following return to the housing pen, cortisol levels were elevated over pre-exposure concentrations for both treatments (CTRL, P< .04; FRUS, P< .06). Analysis of the post-exposure behaviors found that following FRUS, the boars spent less time lying down and more time standing and moving around their pen (P< .05) than following CTRL. In summary, these results indicate that increased BE levels and decreased time spent lying down may be associated with the stress of frustration in the boar. Furthermore, cortisol and testosterone changes were not useful for differentiating between CTRL conditions and frustration.

**Key Words:** Behavior, Swine, Well-Being

**388 Gilt physiology and behavior housed indoors or semi-outdoors in either pens or crates.** J. J. McGlone*[1], S. D. Fullwood[1], and R. L. Norman[2], [1]*Texas Tech University, Lubbock,* [2]*Texas Tech University, Lubbock*.

Sixty-four gilts were used to evaluate the effects of housing systems on behavior and physiology. Gilts were housed in social groups and then placed in either a gestation pen (2.44 X 4.1 m; with 4 gilts/pen) with feeding stalls or in a gestation crate (.61 X 2.1 m). Each pen type was represented in an indoor facility (mechanically ventilated, environmentally controlled) or a semi-outdoor facility (shaded concrete slab with .3 m fresh sand and straw bedding). Littermate gilts were randomly assigned to one of the four treatments in each of four blocks. Gilts had a 24-hour time-lapse video record collected for behavior data summary. A 20 mL blood sample was collected at 60 d of gestation for immune measures (white blood cell (WBC) number and differential counts, lymphocyte proliferation under mitogen, natural killer [NK] cell cytotoxicity and neutrophil chemokinesis and chemotaxis). For immune measures, the interaction between pen/crate and in/out was not significant. For WBC, lymphocyte proliferation, NK and neutrophil chemokinesis, gilts housed semi-outdoors had lower (P < .05) means than littermates housed indoors. Behavior data (Oral/nasal/facial [ONF], bar biting and lying down) showed interactions (P < .05) among time, in/out and pen/crate. Sows in crates (both indoors and outdoors) showed more (P < .05) ONF during four hours around feeding time than sows in pens. Likewise, crated sows spent less (P < .05) time lying during the post-feeding period than did penned sows. Bar biting was highly variable but was expressed for similar durations for sows in crates and pens indoors or out. In conclusion, gilts showed either immunosuppression when housed outdoors or immune activation when housed indoors. Behavior data in concert with immune data support the view that ONF behaviors are under homeostatic control, not related to stress.

**Key Words:** Pigs, Behavior, Welfare

**389 Preferred orientation and the effect of fixed orientation on the balance of horses during transport.** A. E. Gibbs* and T. H. Friend, *Texas A&M University, College Station*.

Preferred orientation of horses when hauled in a commercial open deck trailer was determined when horses were either: loose (L, n=4), tied to the left side of the trailer (TL, n=4), or tied to the right (TR, n=4). Each subject experienced all three treatments (L, TL, TR), each in a 3.7x 2.4 m compartment. Four horses at a time were transported four laps around a 3.6 km rectangular course, reversing direction each lap, for a total of 14.4 km. The course had artificial bumps, one 90° turn, one 45° turn, one 135° turn, five straight-aways, and a hard stop at the end of each lap. The orientation (angle) of each horse and the number of seconds spent in that angle were recorded using overhead video cameras. The loose horses spent the greatest percentage of time facing the direction of travel, between 22 degrees to the left of, and 67 degrees to the right of parallel (31.9 % and 25.7 % of the trip). The TL horses spent the greatest percentage of time (52.4%) facing away from the direction of travel at an angle of 45° ± 22.5°. The TR horses spent the greatest percentage of time (58.9 %) facing the direction of travel at an angle of 45° ± 22.5°. To investigate a horse's balancing ability when confined to different orientations within the trailer, four orientations were used with at least eight horses per orientation: slanted 45° forward (SF), slanted 45° backward (SB), parallel forward (PF), and parallel backward (PB). The PB treatment group slipped more than treatments PF, SB, SF (P=0.0004). There were no treatment effects for falling, contacting the front, back, and far barriers, and leaning on the barrier nearest the observer (P> 0.13). The mean number of near foreleg and hindleg movements per horse were 8.10 and 4.01 for unshod horses and 6.23 and 5.07 for shod horses. Mean slips and falls per horse were 0.54 and 0.01 for unshod horses and 0.66 and 0.00 for shod horses. There was a slight preference for a 45° orientation, and balancing ability was not significantly affected by orientation, with the exception of those horses in treatment PB.

**Key Words:** Horse, Transport, Orientation

**390 Stress responses of horses during commercial truck transport for 30 hours in hot weather.** T. H. Friend*, M. L. Parker, and N. S. Matthews, *Texas A&M University, College Station*.

Thirty adult mares and geldings were deprived of access to feed and water for 6 h, blocked by age, sex, and breed, and assigned to one of the following treatments: penned, offered water (PW, n=5); penned, no water (PN, n=5); transported, offered water (TW, two groups of n=5); transported, no water (TN, two groups of n=5). A commercial, single-deck, open-top, 15.8-m-long trailer was divided into four compartments to accommodate the two TW and two TN groups. Transport commenced at noon and stopped after 8, 8, 4, 4, and 2 h of transport for a 1-h period during which time the horses were unloaded and data collected. The horses were then reloaded, rotating compartments to help balance location effects, and the TW were given 10 min access to water prior to the next trip. The penned horses were maintained in a 15-m-diameter pen in full sun and were subjected to the same data collection as the TW and TN. The PW subjects were also given 10 min access to water. The weather was hot, peaking at 37 C. After 30 h, all of the PN and TN horses were judged unfit to go for another 2 h and were removed from the trial, while the PW and TW horses went for an additional 2 h. Mean weight loss after 30 h was greatest in the PN (127 kg) and TN (116 kg) when compared to the TW (46 kg) and PW (38 kg), P=.0001. Respiration, heart rate, sodium, chloride, total protein and osmolality were significantly elevated in the non-watered horses (P<.0001). Transport elevated cortisol values above concentrations in the PW horses, but the PN had the highest concentrations (P=.0001), but also the greatest hemoconcentration, as indicated by electrolytes, blood protein, and weight loss. The horses penned in full sun, with or without water, had a fatigue and dehydration response that was similar to the horses transported in the open-topped trailer, with or without water. Transporting healthy horses for more than 24 h without water will cause severe dehydration; transport for more than 28 h when they have periodic access to water will cause severe fatigue.

**Key Words:** Horse, Transport, Dehydration

**391 Changes in levels of dihydrotestosterone, testosterone and estradiol in response to ewe exposure in rams differing in sexual performance.** E. O. Price*[1], A. Orihuela[1], R. Borgwardt[1], M. R. Dally[1], and T. E. Adams[1], *University of California, Davis*.

Circulating levels of dihydrotestosterone (DHT) are a better predictor of sexual activity in human males than testosterone (T). The purpose of this investigation was to determine if levels of DHT, T and estradiol (E) were greater in rams known to exhibit higher levels of sexual performance (6 or more ejaculations per 30 min) than in low performance rams (3 or fewer ejaculations per 30 min). Six high performance (HP) rams and 6 low performance (LP) rams were exposed to 12 estrous ewes for 4 hr. A blood sample was drawn from each ram immediately prior to and immediately after ewe exposure. Levels of DHT, T and E did not differ between HP and LP rams either before or after ewe exposure. However, levels of DHT, T and E increased with ewe exposure for both HP and LP rams (DHT: combined means = 37.4 vs 71.9 pg/ml for before and after exposure, respectively, P<0.02; T: combined means = 1.9 vs 5.4 ng/ml, P<0.001; E: combined means = 3.3 vs 6.7 pg/ml, P<0.001). Absolute and percentage changes in DHT, T and E were not different for HP and LP rams. We concluded that circulating levels of DHT cannot be used to predict sexual performance levels in rams.

**Key Words:** Ram, Sexual Behavior, Dihydrotestosterone

**392 Physiological and behavioral changes of tail-docked cows during fly season.** S. D. Eicher*[1], J. L. Morrow-Tesch[1], J. L. Albright[2], and R. E. Williams[2], [1]*USDA-ARS, West Lafayette, IN*, [2]*Purdue University, West Lafayette, IN*.

Tail-docking arouses not only animal welfare issues regarding the docking procedures, but animal well-being concerns during fly season. To address the latter question, we selected 8 cows which had been tail-docked in a previous experiment and 8 non-docked cows matched by stage of lactation. Physiological, immunological, and behavioral measures were used to evaluate well-being of cows housed in tie-stall barns during fly season for 5 consecutive days. Behavior was observed with 5 minute scan samples for one hour each at 0800, 1200, and 1600 h. Flies were counted prior to behavior observations. Blood samples were taken daily for plasma and leukocyte separation. Cows were scored on d 5 for cleanliness on a 5 point scale. Lymphocyte CD4:CD8 tended to decrease for docked cows (P=.06), but WC1 (a $\gamma\delta$ T-cell subset marker), TcR1(a different $\gamma\delta$ population marker), CD4 and CD8 expression, and plasma IgG, haptoglobin, and $\alpha_1$-acid glycoprotein were not different. Fly counts of docked cows were greater for total fly counts (12.4 vs 15.4 flies per leg, P=.01) and rear leg counts (2.5 vs 4.9 flies per leg, P=.0001), but not for front leg counts. Docked cows were cleaner (3.4 vs 2.4, P=.03). Time of day effect was significant, so each time of day was analyzed separately. Behaviors are reported as a percentage of observations. Control cows were observed with more tail-swings (18.3 vs 9.2, P=.002) at 0800 h, but docked cows tended to ruminate more (32.7 vs 21.9, P=.06). Non-significant differences were detected for standing (38.9 vs 49.8, P=.10) at the 1200 h observation. The 1600 h observation detected more fly avoidance behaviors (skin flicks, tail-swings, foot stomps, and head tossing) for all cows. Although, tail-swings (42.1 vs 32.2, P=.10) were not significantly more frequent with docked cows, foot stomps occurred only in the docked cows (P=.04). In conclusion, although docked cows were cleaner, as the fly number increased throughout the day, fly avoidance behaviors also increased and foot stomping appeared as an alternative method for fly avoidance by docked cows.

**Key Words:** Behavior, Tail-docking, Immunity

**393 Behavior of feedlot cattle fed once or three times per day.** D. L. Wiggers*[1], J. J. McGlone[1], J. L. Morrow-Tesch[2], and J. W. Dailey[2], [1] *Texas Tech University, Lubbock,* [2] *USDA-ARS, Purdue University, West Lafayette, IN.*

A total of 2,042 crossbred steers in 22 pens (at a commercial feedlot) were observed from 30 min prior to sunrise until 30 min after sunset on 5 d over a 3 mo period to quantify their behavior. Half the pens were fed on a once-a-day feeding regime (1X) (at 1230 h) and the others were fed three-times-per-day (3X) (at 0600, 0900 and 1200 h). All groups were fed to as near to ad libitum as possible. One observer recorded the behavioral state of each animal every 15 min in each of four pens from a platform mounted on the top of a recreational vehicle. Behaviors recorded included: feeding, drinking, standing, lying, walking, agonistic, bulling and social behavior. The observer also noted any events that may have affected changes in behavior (i.e.; weather, cowboy penriding, feed truck arrival, etc.). The 1X animals spent more time lying ($P < .04$) and exhibited more displays of social behavior ($P < .02$) than the 3X animals. The percentage of time engaged in feeding behavior did not differ between treatments. However, the date by treatment by hour interaction was significant ($P < .001$) for all behaviors suggesting that cattle fed 1 vs 3 times per day have different behavior patterns. When undisturbed by humans or weather changes, cattle fed 1X were less active in the daylight hours before feeding, thus not expressing an early-morning increase in feeding behavior or other activities. Variation in cattle management (human behavior) on different days led to variable cattle behavior.

**Key Words:** Cattle, Feedlot, Behavior

**394 Doramectin causes significantly less discomfort during injection than Ivermectin.** T. Grandin[1], K. Maxwell[2], and J. Lanier[1], [1] *Colorado State University, Fort Collins and* [2] *Pfizer Animal Health, Lee's Summit, MO.*

This study was conducted to determine if there was a difference in the behavioral reaction of cattle during an injection of either doramectin 1% injectable solution or ivermectin 1% injectable solution. Sixty-one red Angus-cross, two year old heifers were used. Each animal was held in a squeeze chute and given a 9 ml subcutaneous injection of either doramectin, ivermectin or sterile saline. Two observers, who were blind to the treatment, rated the behavioral reactions to the injections. Each animal was scored on a four number rating scale, 1 = no reaction stood still, 2 = slight movement, 3 = shaking and 4 = vigorous shaking. The cattle were also scored for willingness to re-enter the squeeze chute. Animals in the doramectin group reacted significantly less to the injection compared to cattle injected with ivermectin. The results for observer 1 with a score of 1 were, doramectin 17 animals, ivermectin 6 animals, saline 14 animals. The results for observer 2 with a score of 1 were, doramectin 14 animals, ivermectin 4 animals, saline 12 animals. Differences between doramectin and ivermectin (p=.001) and ivermectin and saline (p=.002) were found. Re-entry scores into the chute were significantly different for one observer and not significantly different for the other observer. Doramectin caused significantly less discomfort during injection than ivermectin. Use of a product, which causes less discomfort during injection, may improve ease of handling in the future and reduce animal discomfort. From a behavioral standpoint, this experiment is of interest because it showed that small differences in animal discomfort can be detected with a simple technique.

**Key Words:** Anthelmintic, Cattle, Stress

**395 Chronobiological effects of different tree densities on the grazing behavior of Zebu cattle in the tropics.** F. M. Mitloehner*[1] and R.-B. Laube[2], [1] *Texas Tech University, Lubbock,* [2] *University of Leipzig, Germany.*

In tropical western Paraguay, general activity and grazing behavior in *Bos indicus* cattle were measured continuously during the hot rainy season. The objective of this study was to determine how rhythms in behavioral patterns were influenced by tree density. Twenty four steers were in four paddocks of 4 ha size each. Three paddocks differed in tree density (10 trees/ha, 20 trees/ha, bush-tree stripes) and the control which was completely cleared of bush and trees. Behavioral patterns based on time-series analyses were carried out using autocorrelation and power spectral analysis based on measures from datalogger-collars (IMF technology, Franfurt/O., Germany). These data show how animal biorhythms react to alternating environmental cues ("Zeitgeber") such as light or ambient temperatures. Rectal temperatures and body weights were measured every week. The general activity of the cattle from the three shaded paddocks was primarily grazing motivated. Rhythms typical of cattle can be ascertained respecting the two parallel mean curves of general activity and grazing ($r = .87$, $P < .05$). In this case, there were temporal well-ordered conditions which allowed behavior typical of cattle. The power spectrum exhibited, extremely strong harmonic oscillations. On the paddock without trees or shade, the mean curve of general activity contrasted sharply with the grazing curve ($r = -.41$, $P < .05$). Thus, the general activity of the unshaded cattle was not grazing-motivated; instead, they sought but could not obtain shade. From noon until sunset, grazing activity of unshaded cattle were at a very low level. The power spectrum for grazing showed definitive disorders in the time spectrum for cattle lacking shade during very warm ($> 40\ ^\circ C$) days. Unshaded cattle with disrupted behavior biorythyms also showed lower ($P < .05$) daily weight gains and higher ($P < .10$) body temperatures. In conclusion, *Bos indicus* cattle maintained on unshaded paddocks showed disrupted biorythms and suppressed growth compared to cattle with shade from trees.

**Key Words:** Bos indicus, Heat Stress, Behavior

**396 Effects of mirror-image exposure on heart rate and movement of isolated heifers.** J. M. Stookey*, C. A. K. Piller, and J. M. Watts, *University of Saskatchewan, Canada.*

Characteristics of a fear response in cattle include an elevated heart rate and behavioral signs of agitation. Cattle exhibit a similar response when visually isolated from herdmates. Two trials were conducted to determine whether exposure to a mirror reduces the stress of social isolation of heifers confined within a weigh scale (Trial 1, n=41), and whether the response differs with a frontal or side-view of their mirror image (Trial 2, n=38). Crossbred beef heifers ($383.3 \pm 3.9$ kg) were exposed to their designated treatments for 1 min each day for 10 and 5 consecutive days in Trials 1 and 2, respectively. During the exposure, heifers were confined in social isolation on a single-animal electronic scale. Remote telemetry was used to record heart rate in beats per minute (HR). The behavioral response (the amount of movement) was quantified by an electronic movement-measuring-device (MMD). The MMD monitors changes in voltage from the load cells of the electronic scale and records a peak when a trend in voltage is reversed. The greater the number of peaks the more the animal moved during exposure. Heifers exposed to a mirror in Trial 1 had overall lower average HR compared to the no-mirror group (91.5 and 98.5 bpm, respectively; $P < 0.05$), while the amount of movement recorded was no different. Heifers exposed to a front-view mirror image in Trial 2 had an overall lower average HR compared to the side-view mirror group (91.9 and 98.0 bpm, respectively; $P < 0.05$). The front-view group also displayed less movement compared to the side-view group (34.8 and 68.9 MMD peaks respectively; $P < 0.01$). In both Trials heifers habituated to the treatments (had lower HR and less movement) as the days of the trial advanced. The mirror image did reduce the isolation stress, but had a greater calming effect when viewed directly in front of the animal. The reflected side-view may simulate the threat posture of an unfamiliar animal more so than a frontal view and therefore be less effective at reducing isolation stress.

**Key Words:** Cattle, Visual Isolation, Stress

**397 Vocal responses to pain and visual isolation in cattle.** J. M. Watts, J. M. Stookey, K. S. Schwartzkopf-Genswein, and C. S. Waltz, *University of Saskatchewan, Canada*.

Vocal behaviour of beef calves during branding and visual isolation was analysed. Such analyses may reveal the severity of procedures as felt by the animal, and allow valid comparisons between the effects of physical and social stressors.
**Trial 1.** Calves (N=189) were hot-iron branded(B) or sham branded with a cold iron(C). Their vocalizations were recorded. More B(61%) than C calves(7%) vocalized during treatment($p<0.0001$). Analysis of 167 sound spectra showed that B calves called at a higher pitch($p=0.0109$) and louder($p=0.0432$) than C calves.
**Trial 2.** Calves (N=293) were hot branded(H), freeze branded(F) or given a painless control treatment(C). Previous studies suggest that freeze branding is less painful than hot branding at the time of application. More H calves vocalized(23%) than either F(5%) or C(2%)($p\leq0.0004$) Rates of calling (calls/min) were higher($p=0.023$) for H(1.158) than F(0.113), but F did not differ significantly from C(0.072).
**Trial 3.** Calves (N=140) were brought in turn along a chute and stood on a scale platform with high solid sides, for 1 min, during which they were unable to see another calf. The next 3 calves(C1, C2, C3) stood in line in the chute behind. They could see each other but not the isolated calf(I). Rate of calling was higher($p=0.0022$) by I calves(0.57 calls/min) than the average for C calves(0.23). Calves called more often at C1 (where there was no calf visible directly ahead) than at C2($p=0.0526$) or C3 positions($p=0.0098$).
**Conclusions.** Calves gave more frequent and acoustically different calls in response to pain compared to controls. Calling rates appear to vary with the degree of pain. During visual isolation calves called at a rate intermediate to those heard during hot-iron and freeze branding. If vocal behavior is an honest signal of the affective state of an animal, then it may indicate the degree of discomfort caused by both physical and psychological stressors. If so, then visual isolation should be viewed as at least as unpleasant to a calf as a moderately painful treatment.

**Key Words:** Pain, Visual Isolation, Vocalization

**398 Preliminary evaluation of a fenceless livestock control system.** S. Markus*[1], D. W. Bailey[2], D. Jensen[1], and M. Price[3], [1]*Alberta Agriculture Food and Rural Development,* [2]*Montana State University, Bozeman, and* [3]*University of Alberta, Canada*.

New technology may allow development of fenceless livestock control systems (FLCS). Two studies were conducted using a simulated FLCS consisting of Tri-Tronics® training units capable of emitting 5600 V to animals by remote control. In the first study, cattle responses to a FLCS were observed in a rotational grazing scenario. Two groups of 4 heifers grazed during 90 min sessions for 4 d in half of a .5 ha pasture. The FLCS effectively kept heifers within the designated area. Cattle returned to the appropriate area after receiving a shock. Overall, animals received 1.3 ± .3 shocks per session. Cattle used the available area evenly ($P>.1$) without avoiding locations near the invisible boundary. The FLCS was then deactivated, and cattle were released in the previously excluded area. Cattle crossed the previous boundary and grazed throughout the pasture. In the second study, electric fence and FLCS were compared. A barrier was erected in the center of a pen, requiring heifers to go around to consume silage. For the fence group (n=3), the barrier consisted of posts and twine. For the fenceless group (n=3), only posts were used. Cattle received a shock when they approached the enclosed area. All cattle approached the barrier on d 1 and received a shock. Only 1 animal approached the barrier during the next 3 d. For the following 4 d, heifers were tested without the barrier to determine if they could remember and avoid the previously excluded area. Travel paths to the feed bunk were measured as deviations from a direct route (0 $m^2$). The fenceless group (122 ± 7 $m^2$) deviated more ($P=.03$) than the fence group (18 ± 7 $m^2$). Deviations declined ($P<.05$) from 119 ± 11 (d 5) to 31 ± 11 $m^2$ (d 8) after dismantling the barrier. Cattle in the fenceless group avoided the previously excluded area for 4 d without apparent visual cues and without reinforcement. These preliminary evaluations suggest that cattle movements can be controlled without physical barriers.

**Key Words:** Behavior, Cattle

**399 Strategic night cooling of dairy cows during heat challenge reduces impact on thermal status.** D. E. Spiers*, J. N. Spain, and B. L. Snyder, *University of Missouri, Columbia*.

Mid-lactation cows were tested to compare use of fan cooling during nighttime low temperature period to day cooling at peak heat for reducing thermal stress. All animals were implanted ip with telemetric temperature transmitters prior to the study to constantly monitor core body temperature (Tcore) during the entire period. All animals were placed in environmental chambers and exposed to thermoneutral condition (TN,19.9C) for 7 days. Air temperature was then increased over 3 days to 33.3C, followed by daily temperature cycling between 33.3 and 24C (HS) for 11 days. During HS, animals were exposed to either continuous fan cooling (CC) at 11.3 km/h, day fan cooling (DC; 1100–1900h), or night fan cooling (NC; 2300–0700h). Both skin surface heat transfer (HT) and respiration rate (RR) were measured, in addition to Tcore, during the study. The increase in Ta from TN to HS reduced skin HT by 92 $W/m^2$. Fan cooling during morning hours at 24C was 3.3 times more effective in increasing skin HT than at 33.3C. Use of fans at 33.3C only increased skin HT to the level at 24C without fans. As expected, there was no difference in Tcore ($P\leq0.77$) between fan treatment groups prior to the start of heat exposure and fan use. Average low and high Tcore at TN was 38.4C at 0700–0800h and 38.7C at 2100–2300h, respectively. Effect of fan treatment on Tcore during HS was significant ($P=.0003–.02$), with little change over the entire HS period. Low Tcore was at 0700-0800h, with Tcore for night cooled animals being 0.55C below day-cooled level. High Tcore for these groups, which was 1.3C above the low Ta value, occurred at 1700-1900h, with the Tcore for night-cooled cows being only 0.1C above day-cooled level. An interactive effect of study day and treatment on morning RR ($P\leq.0058$) showed lower values for night- compared day-cooled cows. These results show that fan cooling during the night period is superior to day cooling in reducing heat load of dairy cows at elevated air temperatures.
(Support: USDA NRICGP 96-35209-3893)

**Key Words:** Dairy, Cooling, Heat Stress

**400 The effects of strategically cooling dairy cows on milk production.** J. N. Spain*, D. E. Spiers, and B. L. Snyder, *University of Missouri - Columbia*.

Mid-lactation cows were tested to compare use of fan cooling during nighttime low temperature period to day cooling at peak heat for reducing thermal stress. All animals were implanted ip with telemetric temperature transmitters prior to the study to constantly monitor core body temperature (Tcore) during the entire period. All animals were placed in environmental changers and exposed to thermoneutral condition (TN, 19.9C) for 7 days. Air temperature was then increased over 3 days to 33.3 C, followed by dairy temperature cycling between 33.3 and 24 C (HS) for 11 days. During HS, animals were exposed to either continuous fan cooling (CC) at 11.3 km/h, day fan cooling (DC; 1100–1900h), or night fan cooling (NC; 2300–0700h). Cows were fed ad libitum a total mixed diet twice per day and were allowed continuous access to water. Cows were milked twice daily. Feed and water intake and milk production were recorded daily. During the thermoneutral period, core body temperatures (Tcore) were similar across all treatments. On days 10 and 11 of heat challenge, DC and NC cows had similar Tcore at 2400 h. However, at 0700 h, NC had Tcore lower than DC (38.3 vs. 38.9). These differences in daily thermal balance were associated with significant changes in feed intake and milk production. Continuous cooled cows maintained milk production throughout the study. In contrast, NC cows decreased 2.3% and DC cows decreased 6.3% in daily milk production. Change in milk production was associated with changes in feed intake. Cows housed under CC conditions decreased feed intake 6.0% while NC cows and DC cows had a decline of 11.8% and 16.0%, respectively. These results illustrate the effect of change in daily thermal balance of lactating dairy cows on milk production and feed intake.

**Key Words:** Dairy, Cooling, Heat Stress

**401 Effect of social and physical environment on dairy calf behavior and performance.** J. Morrow-Tesch*, J. Dailey, and K. Scott, *USDA-ARS, W. Lafayette, IN*.

The environment that we raise livestock in is important to their well-being. Dairy calves are weaned from the dam within 3 d of birth. They are then housed in individual pens of varying design as this reduces cross suckling and disease transmission. Cattle are social animals however and may benefit from rearing in group pens. The objectives of this study were to quantify behavior and production of calves housed individually or in groups with or without an enrichment device. The enrichment device was a commercially available Braden Bottle with a nipple on one end and filled with calf starter ration. The Braden bottles were placed directly in front and above the feed and water buckets. Three calves were randomly allotted to the four treatments which were replicated twice (N=24). Pens were 4.42 × 2.89 m and crates were .76 × 1.5 m. Group-housed calves were tethered at feeding and bucket fed a completely balanced milk replacer twice daily for the first four wk. Individually housed calves were continuously tethered and fed similarly. A pelleted calf ration and water was available *ad libitum* for the entire six-wk study. Behavior was continuously video recorded on a time-lapse recorder. Behavior was then quantified for three separate 24-hr time periods when calves were 2, 3 and 6 weeks of age. Behaviors recorded were standing, lying, walking, and social/oral behaviors including use of the environmental enrichment device, sucking on other calves or chewing on the tether during feeding. Calves in group pens gained more weight ($P = .04$) than calves from individual pens. Group-housed calves spent more time ($P < .01$) on oral activities including sucking on the Braden bottle ($P < .01$), other calves ($P < .01$) and tethers ($P = .02$). All calves showed increased oral activity across the six-wk study ($P < .01$). These results suggest that young calves have a behavioral requirement for oral activity and that group housing with the provision of substrates suitable for the redirection of normal oral behaviors is beneficial to calf well-being and productivity.

**Key Words:** Calf, Behavior, Environmental enrichment

**402 Behavioral indicators of cow comfort.** D. B. Haley*, J. Rushen, and A. M. De Passillé, *Agriulture and Agri-Food Canada, Lennoxville*.

In order to validate measures of diary cows' rest or activity as behavioral indices of cow comfort, eight lactating Holstein cows were kept in two different types of housing presumed to represent different degrees of comfort: large pens with soft rubber mats (PEN) and narrow tie-stalls with concrete flooring (STALL). Using a crossover design, cows spent three weeks in each of the two housing situations. All management routines were identical. While in each type of housing, cows were videotaped during three 24 h periods (on days 10, 16, and 21) and behavior was continuously recorded. Continuous observation showed that STALL cows lay down for less time than PEN cows (STALL vs. PEN = 314.4 vs. 441.6 ± 14.4 min/24h, $P < 0.001$). This was due to a reduced frequency of lying bouts (8.88 vs 13.68 ± 14.4 freq/24h, $P < 0.001$) with no difference in mean bout duration (36.2 vs. 33.1 ± 1.63 min, $P > 0.10$). Scan sampling at 12 min intervals showed STALL cows spent less time lying on their sternum (43.9 vs. 60.5 ± 1.29%, $P < 0.01$) and more time standing idle (35.1 vs. 18.9 ± 1.32%, $P < 0.01$) than PEN cows. There was no difference in the time spent feeding (17.9 vs. 17.5 ± 0.76%, $P > 0.10$) or in time cows spent lying on their side ($P > 0.10$) which occurred only rarely (< 1% of observations). Time spent idle versus lying down may be a valid measure of cow comfort to examine the effects of more specific aspects of stall design such as floor hardness, spatial restriction and tethering.

**Key Words:** Cow Comfort, Behavior, Housing

**403 Identifying milk components that elicit non-nutritive sucking by calves.** A. M. de Passillé* and J. Rushen, *Agriculture and Agri-Food Canada, Lennoxville, Canada*.

Previous research shows that non-nutritive sucking by calves is elicited by the ingestion of milk, and increases with increasing concentration of milk replacer. To identify which components of milk are responsible for this effect, male dairy calves were allowed to suck a non-nutritive teat after being given small quantities of reconstituted milk in which the concentrations of each component were varied, following a latin square design. The amount of non-nutritive sucking and butting that occurred after was observed. Results are shown as mean ± pooled s.e. of % observations spent in each behavior. First, we compared sucking following normal concentrations (N), or where the concentration of each component was twice normal (2N) or four times normal (4N) (n=12). Increased concentrations of lactose elicited increased ($P<.05$) non-nutritive sucking (N vs 2N vs 4N = 42.5 vs 48.6 vs 63.9 ± 3.4 %) and butting (2.95 vs 2.98 vs 4.1 ± .3 %). Increased concentrations of casein, lactoserum proteins and butter fat had no significant effect. Second, we examined sucking when each component was removed. Removal of casein, lactoserum proteins and butter fat (n=12) had no significant effect. Compared to reconstituted milk (20.67 ± 2.55%), removal of the non-protein component of lactoserum (containing the lactose, minerals and other non-protein solids) reduced sucking (12.73 ± 2.55%)(n=16, $P<.05$), but sucking did not return to normal levels when only the lactose was replaced (13.27 ± 2.55%). Addition of lactase to reconstituted milk did not affect sucking. The concentration of sugars in the milk drunk is one factor affecting non-nutritive sucking, although the other non-protein solid components of lactoserum, such as minerals, may need to be present.

**Key Words:** Calves, Milk Composition, Sucking

**404 Can human contact reduce the effects of stress on cows at milking?** J. Rushen[1], A. M. De Passillé[1], L. Munksgaard[2], and P.-G. Marnet[3], [1]*Agriculture and Agri-Food Canada, Lennoxville,* [2]*Research Centre Foulum, Denmark,* [3]*INRA/ENSAR, Rennes, France*.

We examined effects of novelty/isolation stress on cows at milking and whether human contact reduced the stress. Holstein cows (n=18) received three treatments following a balanced order: Control (C)- milked in usual place, Novelty/isolation stress (S)- milked alone in an unfamiliar room, Human contact (HC)- milked in unfamiliar room and brushed by a familiar person. Behavior and heart rate during milking, milk yield and residual milk following oxytocin were recorded, and blood samples assayed for oxytocin and cortisol. Milk yield was lower (C vs S vs HC: = 20.2 vs 16.9 vs 16.6 ± .6 kg) and residual milk higher (C vs S vs HC= 2.5 vs 5.8 vs 5.7 ± .5 kg) in the unfamiliar room ($P<.01$); this was not changed by human contact. Oxytocin during milking was lower (C vs S vs HC: = 19.9 vs 8.4 vs 11.4 ± 4.7 pg/ml) and cortisol higher (C vs S vs HC = 7.87 vs 18.09 vs 17.06 ± 1.9 ng/ml) when cows were milked in the unfamiliar room ($P<.05$); this was not affected by human contact. Cows moved less in the unfamiliar room, and human contact reduced this further ($P<.05$) (C vs S vs HC = 3.2 vs 1.9 vs 0.7 ± .3 freq/min). Cows defecated and vocalized more in the unfamiliar room ($P<.05$) but human contact prevented this increase (C vs S vs HC = .44 vs 1.44 vs .28 ± .21freq /min). In the unfamiliar room, heart rate increased above baseline but this rise was lower with human contact (C vs S vs HC = −2.0 vs 9.4 vs 4.5 ± 1.2 b.p.m). Cows milked alone in an unfamiliar room show signs of stress and give less milk due to higher residual milk and reduced oxytocin, but, in their behavior, appear less agitated. Human contact reduces signs of agitation, but has no effect on milk yield or hormonal responses.

**Key Words:** Dairy, Stress, Milking