forestomach motility and might be beneficial to future management systems for cattle.

Key Words: Dairy Cow, Rumen, Data Sampling

501 Open-air windrows for winter disposal of large animal mortalities: effects of ambient temperature and windrow dimensions. K. Stanford*, V. Nelson, and B. Sexton, *Alberta Agriculture, Food and Rural Development, Lethbridge, AB, Canada*.

Three open-air mortality compost windrows were constructed in January 2004 (REP1). Windrow A included a base of barley straw (min. 46 cm), a layer of cattle mortalities (n=12) and a layer of stockpiled manure (min. 46 cm) covering the mortalities. Windrow B was similar in makeup to windrow A, although 2 layers of straw, mortalities and manure were constructed containing a total of 9 mortalities. After 1 mo, replicate windrows of each type were constructed using the same number of mortalities and organization of layers (REP2). Due to low ambient temperatures, cattle mortalities(n=66, 236-673 kg) were frozen before addition to windrows. Type 'T' thermocouples were embedded within the lower layers of B and C windrows, while temperatures within 1 m of the surface were measured on all windrows using a stainless steel dial probe (C.E. Franklin Ltd, Calgary AB). Windrows were turned 3 times at approx. 3 mo intervals and 10 1-kg samples were collected from initial compost amendments and at each turning for determination of DM, OM, N and C. Temperatures were measured daily for the first wk after windrow construction and weekly thereafter. Ambient temperature was higher ($P < 0.05$) during the heating of REP2 as compared to REP1 compost, as evidenced by the 13°C mean differential between replicates during the initial heating period. Accordingly, temperature decline of REP2 compost was more gradual ($P < 0.001$) than that of REP1. However the time spent at maximum temperature did not differ ($P > 0.74$) between replicates and all windrows heated in excess of 55°C. Temperature profiles were not affected by windrow type (A, B, or C). After 3 heating periods and 9 mo, flesh was not evident and only fragments of bones (max wt. 740 g) were found. Results of this study demonstrate that reduced ambient temperatures and frozen mortalities provide no barrier to the use of open-air windrows for disposal of cattle mortalities.

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Key Words: Mortality Disposal, Compost, Cattle

Production, Management and the Environment: Heat Stress

502 Evaluation of environmental conditions in 4 and 6 row freestall barns that are tunnel ventilated with evaporative pads and located in Indiana. J. F. Smith*[1], M. J. VanBaale[2], M. J. Brouk[1], B. Prokop[3], and J. P. Harner[1], [1]*Kansas State University, Manhattan*, [2]*The University of Arizona, Tucson*, [3]*Herrema Dairy, Fairoaks, IN*.

Throughout July and August of 2003, HOBO Pro RH/Temp/Data Loggers® were installed to collect temperature and % relative humidity (RH) in recently constructed 4 and 6 row freestall barns with tunnel ventilation and evaporative pads located in northern Indiana. The 4 row barn had evaporative pads located in the middle of the barn with fans located on the east and west ends. In the 4 row barn four loggers/pen were evenly spaced in 4 pens over the head to head stalls. The 6 row barn had evaporative pads located on the east end and fans on the west end. In the 6 row barn eight loggers/pen were evenly spaced in two rows over the head to head stalls and over the single row of stalls in two pens. Loggers were set to take measurements at 15 min intervals 24 h daily. Data was averaged by hour and analyzed using the mixed procedure in SAS. Average ambient high and low temperature was 30.3 and 17.7°C and average ambient high and low % RH was 100 and 63.2, respectively. Overall maximum afternoon temperature was 2.9°C cooler, THI was 4.9 points lower and % RH was 23.6 higher in the 4 row barn as compared to ambient conditions. During hours 0:00 - 7:59 and 21:00 to 23:59, the 4 row barn temperature (1.3± 0.9) and THI (2.2±1.2) were higher as compared to ambient conditions. Similar differences in temperature, and THI were observed in the 6 row barn. However, the magnitude of these differences was lower on the outside rows of freestalls in the 6 row barn compared to the inside row (head to head stalls). Temperature, THI, and % RH differed from air intake to air exhaust in both the 4 and 6 row barns. Specifically, temperature was 1.8°C higher, THI was 4.2 points higher and RH was 9% lower at the air exhaust as compared to the air intake. In summary afternoon temperature and THI were lower in both the 4 and 6 row freestall barns as compared to ambient conditions. Early morning temperature and THI were higher in both 4 and 6 row structures versus ambient conditions, respectively. Air moving through these buildings increased in temperature and THI and decreased in % RH.

Key Words: Tunnel Ventilation, Evaporative Cooling, Dairy Cattle

503 Impact of using feedline soakers in combination with tunnel ventilation and evaporative pads to minimize heat stress in lactating dairy cows located in Thailand. J. F. Smith*[1], D.V Armstrong[2], M. J. Brouk[1], V. Wuthironarith[3], and J. P. Harner[1], [1]*Kansas State University, Manhattan*, [2]*University of Arizona, Tucson*, [3]*Charoen Pokphanol Group Co., LTD, Bangkok, Thailand*.

Twenty four lactating Holstein cows housed in a two row tunnel ventilated free stall barn equipped with evaporative pads and a feedline soaker system were arranged in a 4 x 4 Latin square design. The free stall barn was 16 by 113 m with a ceiling height of 2.6 m. The structure had 55.7 sq m of evaporative pads on end and eleven 130 cm fans on the opposite end of the barn. Treatments included control, feed line soaking in the afternoon (12:00 to 21:00), feedline soaking at night (21:00 to 6:00), and feed line soaking afternoon and night (12:00 to 6:00). Treatments were rotated from pen to pen each day. Individual cows were fitted with vaginal temperature recorders that allowed temperature to be recorded every minute. Feedline soakers operated when the barn temperature exceeded 21°C. The soaker cycle was 0.5 minute on and 4.5 minutes off. The median ambient temperature (°C) was 29.8 ± 5.0, percent relative humidity of 69 ± 26 and a THI of 79.8 ± 4.7. The median barn temperature was 25.5 ± 2, percent relative humidity was 94 ± 7 and THI was 77 ± 3.4. On average, barn temperature was 4.2°C lower, percent relative humidity was 28 higher and THI was 3.1 lower than ambient conditions. The maximum differences occurred in the heat of the day and when barn temperature was 9.1 lower, percent relative humidity was 52 higher and THI was 6.0 lower in the barn. Feedline soaking both in the afternoon and night was more effective in reducing respiration rates than soaking only at night. Feedline soaking in the afternoon was as effective as feedline soaking both afternoon and night in lowering respiration rates. Vaginal temperatures were lower when cows had access to soaking both afternoon and night as compared to soaking the control. The results of this trial suggest that feed line soaking can be used in combination with tunnel ventilation and evaporative pads to reduce heat stress.

Treatments	Control	Afternoon	Night	Afternoon+ Night	SE
Vaginal Temperature, °C	39.29[a]	39.24[ab]	39.26[ab]	39.20[b]	0.03
Respiration Rate, Breaths/min	64.1[c]	62.3[cd]	65.4[c]	59.5[d]	1.94

[ab]Means in the same row with unlike superscripts differ P<0.01 [cd]Means in the same row with unlike superscripts differ P<0.05

Key Words: Evaporative Cooling, Heat Stress, Lactating Dairy Cattle

504 Combining air cooling and feedline soaking for heat abatement of lactating dairy cattle housed in north central Florida. M. Brouk*[1], J. Smith[1], D. Armstrong[2], M. VanBaale[2], D. Bray[3], and J. Harner[2], [1]*Kansas State University*, *Manhattan*, [2]*University of Arizona*, *Tucson*, [3]*University of Florida*, *Gainesville*.

The study was conducted in a 213m long four-row dairy barn equipped with tunnel ventilation (north to south airflow) and a high-pressure fogging system. The fogging system operated when the temperature exceeded 26.7°C between 11:00 to 22:00 and when temperature exceeded 28.3°C between 22:00 to 11:00 the next day and was used to evaluate a combination cow cooling system. A feedline soaking system was installed in the two pens. Sidewall height was 3.6m and the peak height was 4.0m with a 1/12-pitch roof. Curtain sidewalls were closed during the cooling study. Environmental conditions inside the barn were 23.8 ± 3.0°C, relative humidity 84.6 ± 15.4 percent and THI 74.7 ± 5.3. The evaporative cooling system lowered average barn temperature by 0.5°C and reduced afternoon temperatures by a maximum of 5.1°C. Eight lactating Holstein cows were selected from each of two pens and fitted with a vaginal temperature recorder. In a switch back design two soaking treatments were applied to the pens. Treatments were, soaking in the afternoon and at night (10:00 to 6:00 the following morning - A&N) or just at night (22:00 to 6:00 the following morning - N). Feedline soakers were activated when the barn temperature exceeded 22.2°C and the system soaked for 1.6 min (followed by 4.8 min off. Approximately 1.1L of water was applied to each cow standing area per soaking. Respiration rates of cattle fitted with the vaginal probes were observed and recorded at 16:00, 22:00 and 6:00 of each study day. Vaginal temperature was recorded every minute and averaged into 15-min periods. All individual cow data were averaged by pen, treatment and time of observation prior to statistical analysis. Average respiration rates were lower (58.5 vs 66.9 breaths/min) for A&N as compared to N. Differences were greatest at the 22:00 observation (55.0 vs 73.3 breaths/min). Average vaginal temperature was also lower (38.9 vs 39.2°C) for A&N. Data indicate that heat stress was reduced more by the combination of cooling the air and feedline soaking during both the afternoon and at night than night only.

Key Words: Cow Cooling, Heat Stress, Facilities

505 Utilizing data loggers and vaginal temperature data to evaluate heat stress of dairy cattle. M. Brouk*, B. Cvetkovic, J. Smith, and J. Harner, *Kansas State University*, *Manhattan*.

Body temperature rise may indicate heat input has exceeded the heat exchange capacity of the dairy cow. Previous studies show a strong positive correlation between vaginal temperature and respiration rate. This indicates the stress response of the cow to increased body temperature. The ability to measure body temperature over time could help producers operate and select heat abatement systems. Vaginal temperature data collected multiple times per hour would provide a more sensitive testing tool than periodic respiration rates. Utilization of data loggers may provide a means of obtaining body temperature data over an extended period for free-ranging cattle. Data loggers (models HOBO®U12 and HOBO® H08-031-08) from Onset Computer Corporation, Pocasset, MA have been utilized in several experiments evaluating heat stress of dairy cattle. The external probe of the H08-031-08 model was inserted into the vagina and held in place with foam and the logger body was secured to the thurl with tape. Data measurements were recorded during a 2 hr period. The U12 model was 17.5mm in diameter x 101.6mm and weighed 72g. It was held in the vagina with foam and a blank CIDR®. The U12 had a stainless steel housing and was utilized continuously in free-ranging cattle for 5-7 days. Data were collected and analyzed from four dairies to evaluate heat stress abatement systems. Vaginal temperature was recorded at 1-min intervals and then averaged into 5-min blocks. Data were then graphed over a 24-hr period of time. Vaginal temperature increased with activity and heat stress. Effective heat abatement systems were shown to reduce vaginal temperature. On commercial farms, data were utilized to identify where heat abatement needed to be improved. Heat stress issues with milking parlor holding pens were easily identified. Producers and industry personnel could utilize data loggers to evaluate heat stress and the effectiveness of heat abatement systems on free-ranging dairy cattle. Devices could also be utilized to validate the effectiveness of modifications to heat abatement systems identified by the initial evaluation.

Key Words: Heat Abatement, Facilities, Body Temperature

506 Assessment of heat increment in dairy cattle by monitoring heart rate. A. Arieli*[1], U. Moallem[2], I. Halachmi[2], and Y. Aharoni[2], [1]*Hebrew University of Jerusalem*, *Rehovot, Israel*, [2]*Agricultural Research Organization, The Volcani Center*, *Bet Dagan, Israel*.

A trial was conducted during summer in mid-lactating cows (145 DIM, BW 607 kg) to evaluate the effect of whole cottonseeds (WCS) on cow's energy expenditure (EE). Forty cows were blocked into 2 treatments. In TRT diet, 2 kg of WCS replaced similar amount from CON diet of wheat hay, barley grain and corn gluten meal, providing 15.7% CP and 33% NDF in both diets. Cow's intake was measured continuously by a computerized system. The heart rate (HR) was measured in 5 cows per group during a 6 d period, and EE was estimated by calibrating HR with oxygen consumption (VO2). The diurnal pattern of EE was calculated from the diurnal pattern of HR and VO2 per heart beat. The mean and maximal ambient temperature, relative humidity and thermal humidity index during the EE determination period were: 26 and 34°C, 67 and 88%, and 73 and 82, respectively. The DMI was 18.4 kg/d in both groups. Meal numbers in TRT cows (9.8 meals/d) were higher than in CON (8.5 meals/d, P=0.06). Meal size (2.2 kg) and overall eating time (233 min/d) were similar between groups. Average HR was lower in TRT (74 b/min) than in CON (79 b/min, P=0.032) but daily EE (805 kJ/kg $BW^{0.75}$-d) was similar among groups. The effect of intake on EE was estimated assuming delayed effect of feed ingestion, up to 8 hours postfeeding. The diurnal patterns of feed intake and EE data were analyzed using a linear mixed model including fixed effects on EE of treatment, hour of the day and feed ingested (g of DM/kg $BW^{0.75}$-d) 0,1,2,3,4,5,6,7,8 hrs prior to the hour of EE measurement, and a random factor of cow. In both treatments significant EE increases of 0.4 to 0.8 kJ/g DM were found for 0 to 8 hrs from meals, with a peak at 6 hrs postfeeding. The model adjusted r^2 was 26%, and the heat increment during 9 hrs postfeeding was 4 kJ/g DM intake. More data and larger between diets variability seem to be needed in order to elucidate the suitability of the HR method as a tool for quantifying heat increment in dairy cattle.

Key Words: Energy Expenditure, Heart Rate, Heat Increment

507 Use of physiological measures as predictors of heat dissipation during heat stress in dairy cattle. B. C. Pollard*, P. C. Gentry, and R. J. Collier, *University of Arizona*, *Tucson*.

The use of infared thermography to measure surface temperature is a very practical tool for dairy farmers to evaluate heat stress in dairy cattle. Data was compiled from three trials conducted in climatic rooms at the University of Arizona-Agricultural Research Complex. In these trials, Holstein dairy cattle (n=36) both lactating and dry were exposed to dry bulb temperatures (T_{db}) and relative

humidities (RH) varying from 20.4 to 40.5ºC and 12 to 39%RH, respectively, resulting in temperature-humidity indexes (THI) ranging from not stressful (50) to very stressful (84). Data was collected for four physiological parameters: rectal temperature (RT), surface temperature (ST), respiration rate (RR), and sweating rate (SR). Regression equations were created to quantify relationships between variables. The variability in RR and SR can be described by changes in T_{db}, 50.3% and 53.8%, respectively, and THI, 49.6% and 55.2%, respectively, as cattle need to increase heat loss during thermal stress. THI is used commonly to classify the potential stress of an environment, and 75% of the variability in ST can be explained by changes in THI. ST can also be used to accurately predict both RR ($R^2 = 0.557$) and SR ($R^2 = 0.435$) whereas RT is not precise for SR ($R^2 = 0.035$). Stepwise regression analysis yielded equations for SR with RH, bodyweight, presence or absence of solar radiation, T_{db}, RR, and RT as predictors (R^2=0.517) and for RR with ST and RT as predictors (R^2=0.429). Overall, surface temperature is a more predictive measure of heat dissipation through evaporative methods than rectal temperature and can be used as a tool to evaluate environments in order to prevent productive losses due to heat stress in dairy cattle.

Key Words: Heat Stress, Surface Temperature, Dairy Cattle

508 Evaporative heat loss from pigs at different temperature and relative humidity. T.T. Huynh[1,2], J. A. Aarnink*[2], W. A. Verstegen[3], J. J. Gerrits[3], M. J. Heetkamp[4], and B. Kemp[4], [1]*Department of Animal Health, Ho Chi Minh city, Viet Nam*, [2]*Livestock and Environment, Wageningen University and Research Center, the Netherlands*, [3]*Animal Nutrition Group, Wageningen University and Research Center, the Netherlands*, [4]*Adaptation Physiology, Wageningen University and Research Center, the Netherlands*.

The distribution of evaporative water from respiration and from the skin at high ambient temperature (T) and relative humidity (RH) was studied using twelve groups (10 gilts per group) in partially slatted pens (40%) inside respiration chambers. The climate chamber was programmed so that T remained constant within a day. Each day, T was increased by 2°C from low (16°C) to high (32°C). RH was kept constant at 50, 65 or 80 %. The pigs' initial BW was 61.7 kg (58.0 to 65.5 kg). Total water evaporation (WE) was determined by measuring RH in the incoming and outgoing air and the total air flow. WE per m^2 wet floor area was estimated by weighing water buckets and video observations. WE by respiration was estimated from the measured respiration rate, the volume per respiration stroke, and the RH of the exhausted air. Furthermore, skin temperature (ST) and total heat production was measured and wallowing observed. The animals had free access to feed and water. The T above which evaporative heat loss (EH) started to change was determined (inflection point temperature (IPt)).

On average IPt for WE was 20.3°C. Results showed no effect of RH on IPt. At 32°C and 80 %RH, most (67%) of the total EH from our pigs was achieved as heat loss by respiration. There were differences in regression coefficients of WE by respiration: 0.15, 0.11, and 0.08 for 50, 65, and 80 %RH ($p<0.05$), respectively. The findings show that at high RH the pigs depended on EH from the skin. They wetted their skin by wallowing. Wallowing was observed earlier in the 80 %RH group than in the 50 and 65 %RH groups ($p<0.05$). This resulted in lower ST of the pigs at 80 than at 50 and 65 %RH ($p < 0.05$).

It was concluded that at high T and RH pigs have less possibilities to lose heat by respiration. They compensated it by employing skin moisture evaporation. The implication is that pigs at high T, especially in combination with a high RH, should be able to wet themselves. For animal welfare and environmental reasons it is important that the pigs do not have to do so with their own excreta. Water should be available for the pigs, in a water bath or from sprinklers.

Key Words: Evaporation, Heat Stress, Pig

Ruminant Nutrition: Dairy—Feed Additives

509 'Rumen-up': New plants and plant extracts to decrease methane and nitrogenous emissions from ruminants and to alleviate nutritional stress. R. J. Wallace[1], R. Ningrat[1], K. Becker[2], E. Hoffman[2], S. Muetzel[2], N. Selje[2], S. Lopez[3], D. E. Beever[4], K. E. Kliem[4], R. Morgan[4], F. L. Mould[4], C. Duffy[5], M. Frehner[6], and R. Losa*[6], [1]*RRI, Aberdeen, UK*, [2]*Inst An Prod Un, Hohenhein, Germany*, [3]*Dept Prod An Un, Leon, Spain*, [4]*Dept Agric Un, Reading, UK*, [5]*Alltech Irland Ltd, Dunboyne, Irland*, [6]*CRINA SA, Gland, Switzerland*.

The aim of this EC FP5 project was to develop new plants (plant extracts) as dietary additives for ruminants. Five hundred plant materials were collected, based on criteria such as traditional uses and phytochemical content. They were evaluated for their ability to prevent lactic acidosis and bloat, to decrease formation of the greenhouse gas, methane, and to decrease nitrogen excretions by inhibiting ruminal proteolysis and protozoal activity. The samples were also investigated to ensure that potentially useful samples had no detrimental effect on the other basic functions of the fermentation, such as fiber digestion and volatile fatty acid production. A total of 23 samples were identified to have potential for development as feed additives which could manipulate fermentation in one or more of the target areas without having detrimental effects on overall fermentation. A smaller number of samples was then taken forward for more detailed experimentation on persistence and dose response. These included *Bellis perennis* (antiprotozoal), *Carduus pycnocephalus* (antimethane), *Gentiana asclepiadea* (antiprotozoal), *Knautia arvensis* (antiproteolytic), *Lactuca sativa* (antiacidosis), *Peltiphyllum peltatum* (antiproteolytic) and *Urtica dioica* (antiacidosis). None of the short-listed samples gave any indication of toxicity. Generally, the materials were not potent at low concentrations. Most would have to be included in the diet at 3-5%. Differential solvent extraction and HPLC are being used to identify the likely active phytochemical components. Antimicrobial effects of samples are being assessed using both cultural and molecular profiling. Production-type trials are being carried out with three of the most promising samples. http://www.rowett.ac.uk/rumen_up/.

Key Words: Plant Extracts, Ruminants, Methane and Nitrogen

510 Effect of a specific blend of essential oils on the colonization of starch-rich substrates by rumen microorganisms. S. Duval*[1], N. McEwan[2], R. Graham[2], R. Wallace[2], and C. Newbold[1], [1]*The Institute of Rural Science, Aberystwyth, Wales, UK*, [2]*Rowett Research Institute, Aberdeen, Scotland, UK*.

A number of studies have found that essential oils (EO) are able to manipulate ruminal fermentation. Our group has previously shown that a commercial blend of EO was able to decrease the rate of degradation of some starch-rich supplements in the rumen. It was suggested that this effect may have been due to the EO decreasing the colonization of the substrates by rumen bacteria, and particularly by *Ruminobacter amylophilus*. *R. amylophilus* is one of the major starch degraders in the rumen, and its growth in pure culture was inhibited by the EO blend to a greater extent than many other rumen bacteria. In the present study wheat, maize and barley were incubated for 6 h, in the rumen of sheep receiving a diet of grass silage plus a high or low protein concentrate, plus or minus a commercial EO mixture (CRINA RUMINANTS fed to supply 110 mg per sheep per day) fed in a 4 x 4 latin square. DNA was extracted from the samples using a commercial kit and was used as template for 16S rDNA PCR-DGGE and real time PCR. Cluster analysis of DGGE band polymorphism showed that the treatment (supplementation with EO and the protein content of the concentrate) explained most of the similarity in the attached bacteria. Real time PCR enabled precise quantification of *R. amylophilus* and its abundance relative to total bacteria. Colonization by *R. amylophilus* was significantly affected by the substrate but there was no effect of essential oils. These results support the observation that EO influence the attachment and colonization of starch rich substrates in the rumen but do not support the hypothesis that this effect was mediated via *R. amylophilus*.

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Key Words: Rumen, Essential Oils, Colonization