-ANNUAL REPORT-

1. WORK PROGRESS AND PRINCIPAL ACCOMPLISHMENTS

A. PROJECT OBJECTIVE 1 (HEIFERS)

Effects of milk replacer feeding frequency and meal timing on performance and energy metabolism in Holstein dairy calves:
Ongoing research at Louisiana State University is investigate the effects of feeding milk replacer 1, 2, or 3× daily on starter intake, performance, and health of newborn dairy calves. Labor costs for feeding 1, 2, or 3× daily will be also estimated. In a second study calves will be fed milk replacer at a regular meal time or an irregular meal time to determine the effect of feeding time on the secretion of metabolic hormones, energy metabolism, growth, and average daily intake.

Effects of milk replacer nutrient composition on mitigating heat stress in dairy calves:
Forty Holstein heifers at Mississippi State University were used to test the impact of milk replacer on reducing the impact of heat stress. Heifers were fed either a control milk replacer (28% CP; 20% fat) or low fat milk replacer (27% CP; 10% fat) from birth to weaning at 42 days of age. Measurements and samples collected included: dry matter intake (starter and milk replacer), body weight, withers height, hip width, heart girth, blood, and ruminal fluid. These measurements and samples were collected weekly with the exception of the ruminal fluid, which was collected at weeks 4, 6, and 8. Hematocrit, total protein, glucose and non-esterified fatty acids will be determined. Ruminal fluid samples will be analyzed for volatile fatty acids, as an indirect measurement of rumen development.

Impact of dry hay or baleage on performance and structural growth of dairy heifers:
Researchers at Purdue University are investigating the impact of dry hay or baleage on performance and structural growth of dairy heifers experimenting rapid dietary changes as they transition from the post-weaned phase to the growing period. The objective of this study was to determine whether feeding dry or ensiled forages during the transition period improved heifer performance and ruminal parameters. Sixty Holstein heifers (141.9 ± 1.2 kg body weight) were randomly assigned to 1 of 12 pens for a 4 week period. Individual pens were assigned to 1 of 2 treatments: dry hay (H) or baleage (B) and were fed diets containing 40% hay or baleage (on a dry matter basis). Average daily gain (ADG) was greater ($P = 0.04$) for H than for B (1.01 and 0.89 kg/d, respectively) but final body weight was similar ($P = 0.26$) across treatments. Heifers fed H had gain to feed ratios of 0.071 compared to 0.037 kg/kg for B during week 4 ($P = 0.03$) and dry matter intake was similar ($P = 0.44$) between treatments. Hip height, withers height, heart girth circumference, and body condition score were similar between treatments. Ruminal pH was greater for B than for H at week 2 (6.85 vs. 6.58, respectively; $P = 0.01$), and ruminal ammonia ($P < 0.01$) concentration was greater for H at week 2 with levels of 15.5 and 11.7 mg/dL for H and B, respectively. In vitro cellulose disappearance was similar between treatments ($P = 0.25$). Plasma urea N was greater for H at both week 2 and 4 ($P = 0.02$). Blood amylase was similar between treatments, but there was a trend ($P < 0.10$) for blood glucose levels to be greater in H at week 2. Heifers fed diets containing dry hay had greater average daily weight gain than those fed ensiled forage during the transition period.

Although ensiled forages are commonly included in diets of growing dairy heifers, little research has been conducted to evaluate feeding baleage as a primary forage source. In a second study, researchers from Purdue University evaluated the effects of feeding H or B to prepubertal dairy heifers on growth, feed efficiency, and ruminal parameters. Thirty-six Holstein heifers (age = 189.3 ± 9.3 days; body weight = 185.3 ± 1.3 kg) were randomly assigned to 1 of 12 pens and fed a 60:40 forage-to-concentrate diet (dry matter basis) containing either H or B as the only forage source. Heifers fed H were 6.7 kg heavier ($P < 0.01$) than heifers fed B at the conclusion of the study. Heifers fed H also gained 0.63 kg/day compared to 0.56 kg/day for heifers fed B ($P < 0.05$). Overall, heifers fed H consumed 0.30 kg more dry matter/day than B ($P < 0.01$), resulting in a tendency ($P < 0.10$) for a 5.4% improvement in gain to feed ratios for H compared to B. Hip and withers heights, heart girth circumference, and body condition score were similar ($P > 0.10$) between treatments. Plasma urea N and glucose concentrations were similar between treatments ($P > 0.10$), as was ruminal pH ($P > 0.10$). In vitro cellulose disappearance tended to be 9.4% greater for H compared to B ($P < 0.10$); however, total in vitro gas production was similar between treatments. Rumen ammonia concentrations were similar between H and B ($P > 0.10$), though ammonia concentrations declined significantly from 16.3 to 13.2 mg/dL over the entire study ($P < 0.05$). In summary, feeding baleage decreased body weight gain, but did not alter skeletal growth or ruminal parameters in prepubertal dairy heifers.

Effect of calf starter form and milk source on growth and intake of dairy calves:
A combination of texturized calf starter and milk replacer are commonly used feeds for dairy calves, but alternative feeds may offer improved growth and development. Researchers from Purdue University are investigating the effects of different forms of calf starter and sources of milk on growth, dry matter intake, and feed efficiency of dairy calves on a commercial dairy farm. In this randomized complete block design with a 2 × 2 factorial arrangement of treatments, 120 Holstein heifers (body weight = 39.6 ± 5.4 kg) were blocked in groups of 4 by hutch type and birth date. Heifers were assigned to either pasteurized whole milk (WM) or milk replacer (MR) and either texturized (T) or pelleted (P) starter. The MR fed was 24% CP and 18% fat. Samples of WM were collected at each feeding and analyzed for total solids, protein and fat. Calves were allowed ad libitum access to starter and received 3.8 L/d of milk for 14 days, 6.7 L/d from day 15 to 21, and 7.6 L/day from day 22 to 56. Calves were weaned on day 63. Calves were weighed at birth and measured every 2 weeks for body weight, hip and withers height, body length, and heart girth circumference for 10 weeks. Feed and refusal samples were collected weekly and starter intake was measured every 2 weeks. Heifers fed WM were 4.3 kg heavier at week 10 than heifers fed MR ($P < 0.01$). Heifers fed WM also had greater ADG than heifers fed MR (0.76 and 0.70 kg/day, respectively; $P < 0.01$). Additionally, heifers fed WM and T or MR and T had greater average daily weight gain than heifers fed MR and P (0.76, 0.72, and 0.68 kg/day, respectively; $P < 0.01$). Dry matter intake of starter did not differ between milk or starter source, resulting in heifers fed WM having improved feed:gain compared with heifers fed MR (0.65 and 0.78 kg/kg, respectively; $P < 0.05$). Heifers fed WM and P were taller at the hip than heifers fed MR and P ($P < 0.05$). Withers height and heart girth circumference were greater ($P < 0.04$) and hip height tended ($P < 0.09$) to be greater for heifers fed WM compared with MR. However, skeletal measurements were similar between starter sources. Feeding heifers WM as compared with MR resulted in improved body weight and average daily weight gain.

Evaluation of feed delivery methods for prepubertal dairy heifers during the growing period:

Researchers at Purdue University investigated effects of feed delivery method on growth, dry matter intake, feed efficiency, and ruminal fermentation characteristics of prepubertal dairy heifers during the growing period. Ninety Holstein heifers (179.1 ± 29.9 kg, 171 ± 26 days of age) were randomly assigned to 1 of 15 pens by body weight. Treatment diets contained 56% forage and 44% grain mix (dry matter basis) and were delivered using a hay feeder and grain bunk (HF), forage and grain fed side-by-side in a bunk (SBS), or a total mixed ration (TMR) for 98 days. Heifers were weighed every 2 weeks, and hip and withers heights and heart girth circumference were measured monthly. Blood and rumen fluid were collected at the beginning, middle, and end of the study to measure plasma urea N, plasma glucose, and concentrations of rumen ammonia and volatile fatty acids. Feed delivery method affected final body weight, as HF heifers were 11.1 kg and 9.7 kg heavier than SBS and TMR heifers ($P < 0.01$ and $P < 0.01$), respectively. Average daily weight gains were lower for SBS ($P < 0.05$) and tended to be lower for TMR ($P < 0.10$) compared with HF, averaging 0.75, 0.78, and 0.87 kg/day, respectively. Average dry matter intake was greater for HF compared with SBS and TMR (8.2, 7.7, and 7.7 kg/day, respectively; $P < 0.01$), resulting in similar gain:feed across delivery methods ($P > 0.10$). Heifers fed using HF had greater heart girth circumference than SBS ($P < 0.05$) and tended to have greater heart girth circumference than TMR ($P < 0.10$); however, hip and withers heights were not affected by delivery method ($P > 0.10$). Heifers fed using SBS had increased acetate and butyrate concentrations on day 42 ($P < 0.05$), resulting in increased total volatile fatty acids concentrations ($P < 0.05$). Acetate and butyrate concentrations were similar for HF and TMR throughout the study ($P > 0.10$). Blood metabolites, ruminal pH, and ruminal ammonia concentration were not affected by delivery method ($P > 0.10$). Results from this study showed that component feeding using a hay feeder increased average daily weight gain; however, the manner of feed delivery did not affect feed efficiency or growth in prepubertal dairy heifers.

Calf grouping strategies for Holstein veal calves:

Grouping calves is an issue common to the dairy heifer, dairy beef, and veal industries. From a welfare perspective group housing is in many ways preferable to single housing, it enables young calves to run and play, to have full social interactions with other calves, show less fear and allow for early social interactions that are important in the development of normal social behavior. Group rearing of milk-fed dairy calves is thought to provide advantages in terms of labor but it creates challenges in terms of calf management. For example, calves in groups may need to compete with group mates for access to milk, sanitation can be difficult with large groups and is more difficult to identify and control contagious diseases. The present study conducted at Purdue University aimed to investigate the effect of group size on behavior, health, immunity, growth, and welfare of Holstein veal calves. Eighty-four Holstein-Friesian bull calves, aged 6-weeks old, were randomly assigned to 3 treatments of group housing: 2, 4 and 8 calves per pen. Eleven replications of each treatment were completed. The total pen area per calf was kept constant at 1.82 m^2 per calf for all group sizes. Behaviors were recorded between 0700 and 1900 on days 0, 1, 14, 42, and 70 relative to day of grouping. Body weights were obtained by weighing the calves twice, once at the day of group formation, and the second time when calves moved out of the facility for slaughter at day 157±3 of age. Hip height and heart girth circumference were measured every 4 weeks for 2 focal calves per pen. Health status scores (fecal, eye, ear, cough, and nasal discharge) were measured every 4 weeks for all calves in each group. Blood samples

were collected at the day of group formation, then monthly thereafter. Blood samples collected from 2 selected calves from each pen, were used for 5-part differential leucocyte count, plasma cortisol concentration, and complete blood profile. From the preliminary results, we found that different group size had no adverse effect on productive parameters of calves (body weight, body weight gain, and average daily weight gain); group size did not affect growth indicators of calves (hip height and heart girth circumference). The health status of calves was similar among groups, except that cough score was higher in groups of 8 calves. No treatment differences were observed in hematological parameters (white blood cell counts, red blood cell counts, lymphocyte%, neutrophil%, monocyte%, eosinophil%, and basophil%), which were used as health indicators. Plasma cortisol concentrations were used as measures of stress and were found within the normal ranges (14-18 ng/dL) and not significantly different among treatments. We observed that mutual grooming was higher in groups of 4 and 8 than groups of 2 calves, which indicated more social interaction between calves in larger groups. However, we observed more self-grooming in groups of 2 than groups of 4 and 8 calves. Eating and drinking behavior (a single category) was greater with increasing group size. Aggression was infrequent indicating good welfare of calves.

Impact of pasture or conventional feeding regime on performance of dairy heifers:
Researchers from University of Maryland are comparing body growth rates and first lactation milk production of pregnant heifers reared on intensively grazed pasture to those fed conventional diets in a 2-year replicated study. Pregnant Holstein heifers based on date of pregnancy confirmation were assigned to pasture (year 1, n=15; year 2, n=16) or conventional (year 1, n=15; year 2, n = 16) in spring to summer seasons of 2010 and 2011. Heifers fed conventional TMR included corn and rye silage, grass hay, and a monensin supplemented grain mix. Pastured heifers were fed 0.454 kg/heifer per day of ground shelled corn with minerals and monensin. Pasture consisted primarily of endophyte-infected tall fescue. Pasture-fed heifers were rotated daily to a new paddock of 0.1 to 0.3 ha based on available dry matter. Measurements included body weight, withers height, and hip height taken every 2 weeks. Growth rates and projected first lactation 305 day actual milk, fat, protein, calving age, and somatic cell count from Dairy Herd Improvement records were analyzed using analysis of variance using treatment group within year as a replicate. No differences were found in least square treatment means of any variable averaged by year when comparing pasture and conventionally raised heifers. It is concluded that pregnant heifers can be reared on pasture without detrimental effects on skeletal development, milk production, or somatic cell count.

Transitioning to group housing from individual pens using differing grain mixes with or without hay:
Researchers at the University of Minnesota evaluated the impact of transitioning to group housing from individual pens using differing grain mixes with or without hay on performance and intake of fairy heifers. One-hundred twelve 57-60 days old Holstein heifers (82.6 ± 1.32 kg) were assigned to 1 of 4 treatments in 4 replicate pens (7 heifers/pen) for 112 days. Treatments were fed day 1-14 and included: 1) free choice (FC) 18% CP texturized grain mix (GM) without hay (TXT); 2) same as TXT but with FC hay (TXTH); 3) FC 16% crude protein whole corn/pellet GM without hay (WCP); 4) same as WCP but with FC hay (WCPH). Then from day 15-112 all heifers were fed a common diet of 16% CP GM (2.73 kg/day: day 15-56 and 2.27 kg/d: day 57-112) with FC hay. Intakes were taken daily from day 1-28 and then weekly from

day 29-112. Daily GM dry matter intake and gain/feed did not differ from day 1-14, 2.30 ± 0.05 kg and 0.38 ± 0.006 kg gain/kg feed, respectively. Hay dry matter intake for d 1-14 was 0.06 and 0.11 kg/d for TXTH and WCPH, respectively. There were significant GM × hay interactions for average daily weight gain ($P < 0.05$) and total dry matter intake ($P = 0.0003$) but no differences in gain to feed from day 1-112 (0.29 ± 0.002 kg gain/kg feed). No differences were observed in body condition score (112 day avg. 3.25) or hip height (112 day avg. 112.2 cm; $P > 0.05$) Under conditions of this study feeding differing grain mixes with or without hay for 14 days in group pens after moving from individual nursery pens had minimal affect on heifer performance.

Pre- and post weaning performance and health of dairy calves when sodium butyrate is fed in milk replacer and/or calf starter during the summer months:

Researchers at the University of Minnesota evaluated the impact of supplementing milk replacer and/or calf starter with sodium butyrate during the summer months in pre- and post weaning performance and health of dairy calves. One-hundred eight (2-4 days old) individually fed Holstein heifer calves (39.3 ± 0.64 kg) were randomly assigned to 1 of 4 treatments to evaluate pre- (day 1-42) and post weaning (day 43-56) calf performance and health when fed sodium butyrate in milk replacer and/or calf starter. All calves were fed a non- medicated 20% fat:20% protein milk replacer (MR) at 0.284 kg in 1.99 L water (12.5% solids) 2× daily for the first 35 days and 1× daily from day 36 to weaning at 42 days. Calf starter (CS; 18% CP) and water was fed free choice day 1 to 56. Day 1 to 14, 1:1 neomycin:oxytetracycline was added to the MR solution to provide 22 mg/kg body weight/day. Treatments were: 1) Control MR and CS with rumensin (R; 33 mg/kg); 2) MR with 0.3% sodium butyrate (NaB; Adimix-Pro®) and CS with R; 3) MR and CS with 0.33% NaB (Adimix-30C®); and 4) MR with 0.3% NaB and CS with 0.33% NaB. Ambient temperatures averaged a high of 27.2^{o}C (range 18.9 to 38.3^{o}C) and a low of 16.9^{o}C (range 10.6 to 26.1^{o}C) during the study (June, July, August, 2011). Calves fed MR with NaB (treatments 2 and 4) had higher pre-weaning average daily weight gain ($P = 0.02$) and gain/feed ratio than those fed MR without NaB (treatments 1 and 3). Similar trends ($P = 0.09$) were observed for day 1-56 average daily weight gain. Calves fed treatment 1 had reduced gain/feed ratio and tended to have lower pre-weaning and overall average daily weight gain ($P = 0.07$) vs. treatments 2, 3, and 4. The addition of NaB or R to starter did not affect starter intake pre- or post-weaning. There were also no differences in total dry matter intake between treatments averaging 0.78 kg/day and 1.76 kg/day during the pre- and post-weaning periods, respectively. There were no pre- or post weaning scouring days and treatment cost differences due to treatments. Under the conditions of this study there were benefits to calf performance of adding NaB to MR during the summer months. Using NaB in CS appeared to be an acceptable alternative to R.

Performance and health of pre- and post-weaning calves fed milk replacers containing various protein sources balanced for selected amino acids:

This ongoing research at the University of Minnesota is evaluating the impact of partially replacing milk protein with alternative protein sources for conventional milk replacer programs balanced for selected amino acids on pre- and post weaning performance and health of dairy calves. All calves were fed a non-medicated 20:20 milk replacer with an 18% CP texturized calf starter. Milk replacer was offered at 1.25 lb powder daily diluted with water to 12.5% solids split into two equal feedings of 0.625 lbs powder fed for 35 days and once a day from day 36 to weaning at 42 days. During the first 14 days of the study, neomycin (1600 g/ton) and

oxytetracycline (1600 g/ton) was mixed with the milk replacer to provide 10 mg/lb body weight to each calf to control diarrhea during this period. Calves were assigned 1 of 4 treatments: 1) Treatment 1 – Control calves were fed as described above; 2) Treatment 2 - calves were fed as in Treatment 1. Total protein was replaced by 33% hydrolyzed wheat protein isolate formulated with synthetic lysine and methionine to equal total sulfur amino acids (methionine + cystine); 3) Treatment 3 - calves were fed as in Treatments 1 and 2. Total protein was replaced by 33% peptide powder formulated with synthetic lysine and methionine to equal total sulfur amino acids (methinone + cystine) as in Treatments 1 and 2; and 4) Treatment 4 - calves were fed as in Treatments 1, 2 and 3. Total protein was replaced by 33% peptide powder formulated with synthetic lysine and methionine to equal total sulfur amino acids (methinone + cystine) as in Treatments 1, 2, and 3. In addition the formulation will include synthetic tryptophan and threonine equivalent to Treatment 1.

Evaluation of an automatic calf feeding system in a renovated calf room:
An Urban automatic calf feeding system at the University of Minnesota has been functional since September 2011 in a renovated calf room. The Urban feeder is capable of feeding the same or 2 different milk replacers independently to calves co-mingled in 2 pens of 23 (32 sq ft/calf). Four groups of 46 calves split among the 2 pens have been raised to date from 2 to 4 days of age to up to 60 days of age by feeding through the automatic feeder. Within each pen automatic grain feeders or bunks have been evaluated for calf starter intake. Calves have used the bunk feeder more readily for establishing good feed intake. Calves will adjust to the automatic grain feeders but total intake over the 56-day nursery period is lower than the bunk feeder although we obtain individual daily calf vs. group bunk intake with the automatic grain feeder. The initial goal has been to use a base conventional program similar to that fed in individual pens so comparisons can be assessed. The automatic feeder calf room is the 5^{th} room to be used in a rotation with 4 rooms of 40 calves housed in individual pens for an all-in all-out system. The use of this 5^{th} room will depend on the number of calves picked–up weekly from the dairies. Calves are manually coaxed into the feeder nipples over a couple of days. Calves are fed 3-4 times a day and staff checks calves at least 3 times daily. Calves using the automatic feeder on a conventional program tend to have lower overall gains than those fed in individual pens. Much of this is due to the adjustment to feeding amounts especially during the first 2 weeks. A number of calves miss feedings during this period. Intensive or moderately intensive milk feeding rates will be evaluated in the next calf rotation.

Addition of sodium bicarbonate to either one or two feedings of colostrum replacer, with or without milk replacer:
Research at the University of New Hampshire is determining the effects of sodium bicarbonate and colostrum replacer fed in 1 or 2 feedings with or without 2 L of milk replacer 6 h after the last feeding of colostrum replacer. Eighty newborn calves were used in the 2 × 2 × 2 factorial arrangement of treatments. Blood samples were taken at 0, 6, 12, 18, and 24 h postpartum. Data are currently being statistically analyzed.

Relationships between Dairy Herd Improvement data and colostral nutrients and immunoglobulin G:
Research at the University of New Hampshire is evaluating individual cow milk production and composition based on Dairy Herd Improvement data and respective colostral components with

the goal to develop a regression equation to calculate IgG concentration based on previous Dairy Herd Improvement data. Data are being analyzed.

Determining plasma volume in newborn calves at 6, 12, 18, and 24 h after birth fed either 1 or 2 doses of colostrum replacer:
Presently there are no data used to calculate plasma volumes at 6, 12, and 18 h after birth. Data are limited to 24 h based on an equation used by most researchers working in the area of colostrum feeding (Quigley et al. 1998). Eighteen calves at the University of New Hampshire were fed colostrum replacer at either one dose or a second dose 6 h later. Blood samples were taken and Evan's blue Dye was immediately injected, after 10 minutes a second blood sample was collected. Plasma volume was determined based on Evan's Blue Dye concentration in the second blood sample. Data are being analyzed.

Reducing weaning stress through social interactions with milk replacer fed calves:
The objectives of this experiment conducted at the University of New Hampshire are to evaluate 2 extra visits per day to evaluate growth and weaning stress. Forty Holstein heifer calves are being used in a 2 × 2 factorial arrangement of treatments in a randomized complete block design. Main effects are 2 additional visits (4×) vs. only visits during feedings (2×) and accelerated milk replacer vs. conventional milk replacer. Calves are being weaned during week 6 resulting in being fed 1×/day. Calves have blood samples taken preweaning (day 40) and every 2 days up to day 50 for analysis of glucose, cortisol, and nonesterified fatty acids. Fecal samples will be taken at the same time for cortisol analysis. Experiment is ongoing.

Further studies on pasteurized colostrum feeding for newborn dairy calves:
Research at Penn State and University of Minnesota has previously demonstrated the potential of improving IgG absorption from bovine colostrum with the process of heat treating (pasteurization). Our published papers and those from researchers from The University of Minnesota College of Veterinary Medicine have shown that heating colostrum at 60°C for 30 to 60 minutes successfully decreases bacteria numbers, does not affect viscosity or IgG level, yet improves the absorption of the active IgG molecule into the blood stream of the neonate bovine animal by an average of 26% more IgG absorption. To date 5 studies have been published, and all of them using high quality colostrum only. We are in the process of studying a broader range of acceptable colostrum quality (based on IgG level) to further delineate the effects of this heat treatment on the range of bovine colostrum samples commonly found on dairy farms. This research involves feeding 140 neonate bovine calves either heat treated or control colostrum (first feeding) to further delineate the impacts of this management practice on IgG absorption in the calf from first colostrum feeding.

Fiber effect on rumen development in pre-weaned calves - Whole oats effects on rumen and intestinal development in neonatal dairy calves:
This study at Penn State University will investigate the effects of whole oats vs. ground oats in starter grain on digestive system development and xylose absorption of neonatal dairy calves at weaning time. We hypothesize that whole oats in grain starter can meet the pre-weaned calf requirement for effective fiber, preventing abnormal development of rumen papillae, and may also affect intestinal villi development by changes in the timing and place of starch digestion.

Holstein bull calves will be used for this study, 1 calf will be used for a preliminary portion of the study where the cannulation method will be evaluated. For the main portion of the study, 10 calves (5 per treatment) will be used to evaluate 2 grain starters differing in oats processing only. Flooring will consist in large amounts of wood shavings covered with a synthetic porous mat (landscape fabric) that would allow moisture (urine) to pass through but impede shavings consumption; feces will be scraped from mat twice daily. To equalize starter intake, calves will be offered a fixed amount that will be adjusted with age, the amount of starter not ingested will be manually inserted into the rumen through the rumen cannula. Cannulation will allow to equalize intake and to sample ruminal contents. Ruminal contents will be sampled 4 h after morning feeding at day 28, 35, and 42 of age. Contents will be strained trough 2 layers of cheese cloth, pH will be determined, and 20 mL of the fluid will be saved for bacteria, protozoa, ammonia, and volatile fatty acids analysis, the remaining fluid and solid fractions will be returned to the rumen. At 6 weeks of age calves will be euthanized. Reticulorumen, omasum, abomasum, liver, and spleen will be harvested, evacuated (stomachs), rinsed, dried, weighted, and rumen papillae will be measured. Reticulorumen contents will be strained through 2 layers of cheese cloth, pH will be measured and the liquid fraction will be sampled for protozoa, bacteria, ammonia, and volatile fatty acids. Rumen papillae and intestinal villi measurements will tell if oats processing changes the place of digestion and nutrient absorption, and it that has an impact on the anatomy and development of the different parts of the digestive system.

Verification of weight tapes for dairy heifers:
Using data from several NC 1042 Stations, we are developing a revised Holstein Weight (Heart Girth) Tape for use by dairy farmers and advisors to estimate the weight of dairy heifers. Because these heart girth comparisons are based on body conformation, as genetics change (in addition to breed) the equations may need to be subtly revised. The current analysis is including other data in addition to actual weight and heart girth, which have the potential to make the weight tapes to be more accurate in estimating body weight of the growing heifer. This project is near completion.

Feeding high and low quality forage with different rumen-degradable protein levels on nutrient utilization by dairy heifers:
This study done at Penn State University investigated the effects of manipulating the degradability of the protein fractions in heifers diets containing 2 dietary fiber quality levels with 4 combinations of rumen degradable protein (RDP) and rumen undegradable protein (RUP). Our previous data suggest that forage utilization of the diet of heifers can be manipulated with different responses expected as the forage quality and degradability of the protein fraction of the diet changes. Therefore, it is necessary asses the level of RDP that maximize microbial protein synthesis and animal performance when dairy heifers are limit-fed an optimal N and metabolizable energy intake. Dairy heifers precision fed diets using higher quality forage had greater apparent total tract dry matter, N, and organic matter digestibility over low quality diets. Protozoa numbers tended to be higher in low quality diets and linearly increased consistently with RDP in both forage qualities. Increasing RDP on low quality and high quality had no effects in apparent digestibility of any measured parameter or N retention in dairy heifers. The substitution of corn and a slow-release urea source for canola and a by-pass amino acid source was an effective replacement that increased rumen protozoa numbers. This study indicates that

high quality roughage or high starch in heifer diets can include a high proportion of NPN sources that are slowly released to promote balanced rumen fermentation.

Identifying efficient dairy heifers operations in Pennsylvania using data development analysis:
The cost of raising dairy heifers is an important aspect to the profitability of dairy farms. In addition way those heifers are raised and rates of gain will have impacts on production and age at calving all of which impact the profitability of the farm. This study focuses on determining the actual costs of raising heifers as well as the outcome of those animals in first lactation. We have determined costs on 45 dairy farms of various sizes in the major dairy areas of the state, determined growth of the heifers at various stages, and age at calving and first lactation milk production. The final analysis is near completion and will include determining which heifer operations are most efficient at raising heifers by way of a data envelopment analysis technique.

B. PROJECT OBJECTIVE 2 (COWS)

Inoculation of corn silage:
Corn silage harvested in early August was packed into plastic silo bags at Mississippi State University. As silage was loaded into the bags, one bag was sprayed with Buchneri 500, a silage inoculant designed to improve fermentation rates and reduce dry matter losses during ensiling. Temperature sensors were placed throughout the bag to measure internal temperature during the ensiling process and later storage. Samples were taken every 4 hours for the first 24 hours, then every 24 hours for the first 7 days, then weekly for 60 days, then at 90 days and 120 days. Silage samples will be subjected to Proximate Analysis as well as analysis for molds, microbial analysis, and volatile fatty acids. Both bags of silage (treated and control) will be fed to lactating cows to determine the efficiency of fermentation with the inoculant. Twenty four cows (n = 12) will be fed total mixed ration based on either the control or treated silage for approximately 30 days. Dry matter intake and milk yield will be measured. Milk samples will be taken and analyzed for fat, protein, and somatic cells count.

Feeding electrolytes to dry cows alleviates heat stress during early lactation:
Twenty four Holstein cows at Mississippi State University were fed 6 oz/head/day of Bovine BluLite electrolyte pellets, top dressed on a corn silage based total mixed ration. Cows were fed 14 days prior to expected calving date and then remained on their diets until 30 days post calving. Dry matter intake, body growth, rectal temperature, respiration rates and scores, and blood samples were taken weekly prior to calving. Those same measures were taken post calving in addition to milk yields and components. Data are currently being analyzed.

Effects of rubber flooring during the first two lactations on production, locomotion, hoof health, immune functions, and stress:
Some housing systems on dairy farms can result in long-term chronic pain. Impact of acute pain effects on immunity have been explored, but chronic pain's influence on immune responses is still poorly understood. Therefore, the objective of this research done at Purdue University was to determine chronic effects of flooring on immune responses and production in free-stall housing for dairy cows. Thirty heifers were studied from prior to calving as first-calf heifers until day 180 of their second lactation. Treatments were rubber (Kraiburg) flooring or concrete with

diamond grooves in a free stall barn, each in 2 quadrants of the barn. Heifers entered the treatments after calving, so the system was dynamic and each cow was considered an experimental unit. At the end of the first lactation, cows were housed in a bedded pack barn with pasture access until calving was imminent. At that time they returned to their assigned treatment, but not necessarily into the same quadrant. Production, reproduction, cortisol, acute phase proteins, and health data were recorded throughout lactation 1, locomotion was scored weekly and hoof scoring and care was conducted on days 60 and 180 of lactations 1 and 2, and qRT-PCR of blood leukocytes was analyzed mid-lactation of lactation 1. Mature equivalent milk fat, milk protein, and protein % during the 1st lactation were greater for cows on the rubber flooring. Hoof and leg therapy treatments per cow were fewer for rubber floor housed cows. Locomotion scores were less for cows housed on rubber during the 2nd lactation. White blood cell counts were less for cows housed on rubber, and caused by greater lymphocytes counts for cows housed on concrete. The possibility of chronic inflammation was substantiated by less interleukin (IL)-1β and more IL-1 receptor antagonist for cows housed on rubber at day 150 in the second lactation. Cortisol and acute phase proteins did not differ between the treatments. Interferon-γ, IL-12, the modulator of tissue reconstruction (B-cell transforming growth factor 1), and pain modulating neurokinin (tachykinin 1) were not different at day 105. These data show indicators of chronic inflammation for cows housed on the concrete flooring compared with those housed on rubber. Implications for the use of rubber flooring in free-stall barns are broader than just lameness and affect many aspects of cow physiology and production.

Effect of dietary potassium on water intake and rumen dynamics:

Water is a critical nutrient for dairy cows, though little work has looked at the effects of water intake on rumen parameters. The objective of this study done at Purdue University was to evaluate the effect of water intake on rumen parameters and determine effects of increased dietary K on water intake in dairy cows. Potassium carbonate was added to the diets of 9 ruminally cannulated, late lactation Holstein cows (207 ± 12 days in milk) that were randomly assigned to 1 of 3 treatments in a replicated 3 × 3 Latin square design with 18-days periods. Dietary treatments (on a dry matter basis) were baseline dietary K levels of 0.94% dietary K (Control), 0.75% added dietary K (LowK), and 1.5% added dietary K (HighK). Cows were fed treatment diets for a 14-days adaption period followed by a 4-days collection period. Total rumen evacuations were conducted on day 4 of the collection period. Weights of rumen contents were recorded and subsamples were dried. Rumen fluid samples were collected to determine volatile fatty acids and ammonia-N concentrations. Milk samples were collected twice daily during the collection period. Milk, milk fat and protein yields showed quadratic responses (P = 0.001, 0.01 and 0.001, respectively) with greatest yields for LowK. Dry matter intake had a quadratic response ($P < 0.001$) with 21.8 kg/day for LowK and 20.4 and 20.5 kg/day for Control and HighK, respectively. Water intake showed a linear relationship with HighK being the greatest (102.4, 118.4 and 129.3 L/day, $P = 0.001$). Total and wet weight of rumen contents declined linearly ($P = 0.01$ and 0.01, respectively) and dry weight tended ($P = 0.09$) to decline linearly for LowK and HighK. There was a negative linear relationship for rumen ammonia-N concentrations for LowK and HighK ($P = 0.004$). Concentrations of acetate as a percentage of total volatile fatty acids linearly increased for LowK and HighK ($P = 0.002$), while concentrations of propionate declined ($P = 0.003$) as percentage of total volatile fatty acids. Increasing dietary K in the diets of lactating dairy cows increased water consumption and rumen ammonia-N concentrations, while decreasing total water weight in the rumen.

Effects of sudden additions of condensed distillers solubles to diets of lactating dairy cows on milk production and milk components:
Variability in the fat content of dried distillers grains with solubles (DDGS) in dairy diets make dairy producers hesitant to utilize this coproduct. The objective of this study conducted at Purdue University was to determine the effect of sudden additions of condensed distillers solubles (CDS) on milk production, milk components and rumen parameters. Eight ruminally cannulated Holstein cows (166 ± 12 DIM) were randomly assigned to treatments in a replicated 4 × 4 Latin square design with 21-day periods. The dietary treatments, on a dry matter basis, were CON (10% DDGS); DDGS (20% DDGS); CDS2.5 (17.5% DDGS plus 2.5% CDS); and CDS5 (15% DDGS plus 5% CDS). Cows were fed CON diets for a 14-day adaptation period and treatments diets for a 7-day treatment period with the last 3 days used for data collection. Milk samples were collected daily to determine milk components. Rumen samples were collected via rumen cannula for determination of pH, volatile fatty acids and ammonia. Milk yield and fat percentage were similar between treatments ($P = 0.66$ and 0.82, respectively). Cows fed CON had greater ($P < 0.01$) and DDGS tended ($P = 0.06$) to have greater milk protein concentrations than CDS2.5 and CDS5 (2.89, 2.83, 2.77, 2.81%, respectively). Dry matter intake was greater ($P < 0.05$) for CON than CDS2.5 or CDS5 (21.6, 20.1, 20.5 kg/d, respectively), but was similar ($P = 0.11$) to DDGS (20.7 kg/d). Rumen pH was lesser for CON than CDS5 (6.05 and 6.13, respectively; $P = 0.03$) and lesser for DDGS than for CDS2.5 and CDS5 (6.03, 6.10, 6.13, respectively; $P \leq 0.05$). Total VFA concentrations were similar among treatments ($P = 0.84$); however, CDS5 had greater butyrate concentrations than CON (11.1 and 9.7 μmol/mL; $P = 0.05$) and tended to have greater concentrations than DDGS (9.7 μmol/ml; $P = 0.08$). Rumen ammonia was greater for CON and DDGS ($P < 0.03$) and tended ($P = 0.08$) to be greater for CDS2.5 than for CDS5 (18.4, 17.5, 17.1, 15.0 mg/dL, respectively). Sudden additions of up to 5% added CDS in dairy cow diets decreased milk protein concentration and DMI without affecting milk yield or milk fat.

Processed corn stover as a corn silage replacement feed for lactating dairy cattle:
Corn silage represents almost half of the forage used in rations for dairy cattle in the Midwest region and increased value for corn grain has increased the costs of corn silage production. Our overall goal is to determine the potential for treated corn crop residues as replacement feeds for corn silage and corn grain. The objective of this initial study conducted at Purdue University was to determine the short-term impact of feeding increasing amounts of processed and chemically treated corn stover on feed intake, milk production and milk composition. Baled stover was tub-ground, hydrated to approximately 50% moisture and treated with either 5% CaO or a mixture of 3% CaO and 2% NaOH (dry matter basis) in a twin-screw extruder. Separately, baled stover from the same lot was chopped through a 10.2 cm screen using HayBuster, mixed with water to 50% moisture and CaO to 5% of DM. All stovers were stored in AgBags. Fifty-six Holstein cows were assigned to 1 of 7diets in which corn silage was replaced by treated stover. Diets were: CaOH extruded stover at 12.5 and 25% of ration dry matter, CaOH +NaOH extruded stover at 12.5 and 25% of ration dry matter, on-farm prepared stover containing 5% CaOH and fed at 12.5 or 25% of ration dry matter and a control diet consisting of 37.5% corn silage. Cows were fed diets for 21 days to assess initial acceptance of treated stover and impact on production parameters. Milk production averaged 28.9 ± 2.22 kg/day and dry matter intake was 22.3 ± 1.26 kg/day and did not differ ($P > 0.05$) between treatments. There were no differences ($P > 0.05$) in milk composition, body weight changes during the 21-day feeding period. There were treatment × day of experiment effects ($P < 0.05$) for feed intake and milk production with the greatest

difference with day observed for extruded stover containing NaOH. The data indicate that chemically treated corn stover can replace corn silage in diets for lactating dairy cows to at least 25% of the ration dry matter and potentially more for some compositions.

Dairy welfare assessment programs:
Dairy welfare assessment programs are becoming more common on U.S. farms. Outcome-based measurements such as locomotion, hock lesion, hygiene, and body condition scores are included in these assessments. A study conducted at the University of Minnesota described the prevalence of parameters, and investigated the proportion of cows on a farm needed to provide an accurate estimate of locomotion, body condition, hygiene, and hock lesion scores. Researchers found that recording 15% of the pen represented the percentage of clinically lame cows (score 3 or more) with high accuracy ($R^2 > 0.9$), although a higher percentage (30%) of the pen needed to be measured in order to accurately estimate severe lameness (score 4 or more). Only 15% of the pen needed to be sampled to accurately estimate ($R^2 > 0.9$) the percentage of the herd with hygiene score ≥ 3, whereas 30% needed to be scored to accurately estimate the prevalence of severe hock lesions. Estimating the portion of thin and fat cows required that 70 to 80% of the pen be measured in order to accurately describe this parameter. Thus, unsurprisingly, a higher percentage of the group must be sampled to generate accurate estimates for relatively rare parameters among lactating cattle (e.g. very thin cows).

Types of housing systems for dairy cows:
A project on assessment of 2 types of housing systems for dairy cows was completed at the University of Minnesota. Researchers found that lameness prevalence in compost bedded pack barns (4.4%) was lower than in naturally ventilated (15.9%) and cross ventilated (13.1%) freestall barns. Lameness prevalence was similar between cross ventilated and naturally ventilated barns. Hock lesion was lower in compost bedded pack barns (3.8%) than cross ventilated (31.2%) and naturally ventilated barns (23.9%). Hygiene scores were higher for compost bedded pack barns (3.18) than cross ventilated (2.83) and naturally ventilated (2.77) barns with no differences between cross ventilated and naturally ventilated barns. There were no differences in body condition scores, respiration rates, mastitis prevalence, culling, or mortality rates among housing systems. The cross ventilated barns tended to have greater cow comfort index (85.9%) than the naturally ventilated barns (81.4%). When comparing the 2 freestall housing options, cross ventilated barns had improved cow comfort indices than naturally ventilated barns. Although cows in compost bedded pack barns had better feet and leg health as indicated by the reduced lameness and hock lesion prevalences, ability of acquiring bedding and managing the bedded pack could limit their use.

Recycled manure solids for bedding freestalls:
Another study done at the University of Minnesota evaluated the use of recycled manure solids for bedding freestalls in the US Midwest and compared welfare between deep beds and mattresses. Lameness prevalence was lower in deep-bedded freestalls (14.4%) than freestalls with mattresses (19.8%). Severe lameness prevalence (locomotion score ≥ 4) was also lower for cows housed in deep-bedded freestalls (3.6%) than for cows housed in freestalls with mattresses (5.9%). In addition, the prevalence of hock lesions and severe hock lesions was lower in herds with deep-bedded freestalls (49.4%; 6.4%) than in herds with mattresses (67.3%; 13.2%). Herd turnover rates were not associated with stall surface; however, the percentage of removals due to

voluntary (low milk production, disposition and dairy) and involuntary (death, illness, injury, and reproductive) reasons was different between deep-bedded and mattress based freestalls. Voluntary removals averaged 16% of all herd removals in deep-bedded herds, whereas in mattress herds these removals were 8%. Other welfare measurements such as cow hygiene, mortality rate, mastitis incidence, and milk production were not associated with stall surface. It was also described herd management practices and milk quality.

Investigation of dry cow management strategies to improve health and welfare:
Investigation of dry cow management strategies to improve health and welfare is ongoing at the University of Minnesota with the first study that aimed to reduce social turmoil in the group being partially completed. No differences were found on health, production, or feeding behavior between a stable (no entry of new cows in the close-up group) and a conventional (weekly entrance of new cows in the close-up group) strategy.

Use of kelp meal and flaxseed for organic dairy cows:
Overall, researchers at the University of New Hampshire are enhancing the knowledge about supplements (e.g., kelp meal and ground flaxseed) with potential to improve animal performance and nutrient utilization in organic dairy cows. Kelp meal (*Ascophyllum nodosum*) is commercialized throughout the Northeast as a rich source of minerals, particularly iodine. Kelp meal dealers claim that their products increase feed efficiency and animal health because kelp's high-nutrient density combined with its antioxidant and antimicrobial properties boost the immunological system helping livestock fight bacterial infections and heat stress. However, there is limited scientific evidence to support these claims and to justify the remarkable popularity of kelp meal among organic dairy farmers. Two experiments were conducted to investigate the effects of kelp meal on nutrient intake and milk production and composition in organic dairy cows during the winter and summer/grazing seasons. In the first study 16 organic dairy cows were randomly assigned to different treatments (0, 2, 4 or 6 oz of kelp meal) in 4 replicated 4 × 4 Latin squares. Incremental dietary levels of kelp meal did not improve animal performance and milk production and composition. However, the concentration of milk iodine increased linearly in response to incremental dietary levels of kelp meal. In the second study 20 lactating organic dairy cows grazing legume-grass herbage were randomly assigned to 2 treatments (0 or 4 oz of kelp meal) in a completely randomized design from June to October. Similar to the winter study, kelp meal did not improve animal performance and milk production and composition but did significantly increase the concentration of milk iodine. In both studies milk iodine concentrations approached toxic levels to children.

A third study was conducted using 20 organic dairy cows randomly assigned to different treatments (0, 5, 10 or 15% of ground flaxseed) in five replicated 4 × 4 Latin squares. Incremental dietary levels of ground flaxseed linearly decreased dry matter intake, yields of milk and milk components, and methane emissions. Despite the positive response of ground flaxseed on mitigating methane emissions, milk yield also declined linearly which may prevent farmers to feed flaxseed particularly in high levels (i.e., 15% of diet dry matter). Additional in vivo and in vitro studies including supplementation with energy sources and use of forages with improved concentrations of nonstructural carbohydrates are also part of the multi-state NC-1042. In collaboration with Dr. Kathy Soder (ARS-USDA), 3 dual flow continuous culture fermentor studies supplementing herbage with oilseeds (e.g., flaxseed, sunflower, and canola) and total

mixed rations were conducted. Feeding incremental dietary levels (0, 5, 10, or 15%) of ground flaxseed to an herbage-based diet (experiment 1) linearly reduced both methane emissions and nutrient digestibility during continuous culture. In general, supplementing herbage-based diets with different oilseeds (experiment 2) or total mixed rations (experiment 3) had minor impact on fementation and bacterial protein synthesis during continuous culture.

Eating behavior, ruminal fermentation, and milk production in lactating dairy cows fed rations that varied in dry alfalfa hay and alfalfa silage content:
Studies at Penn State University were conducted with the objective to evaluate effects of various inclusion levels of dry chopped alfalfa hay and alfalfa silage in lactating dairy cow rations on eating behavior, rumen fermentation, milk yield and components. Eight multiparous Holstein cows (79 ± 11 dais in milk initially; 647 ± 36 kg body weight) were randomly assigned to replicated 4 × 4 Latin squares. During each of the 4 periods, cows were fed 1 of 4 diets that were chemically similar but varied in dry chopped alfalfa hay level. Forage dry matter content of each ration consisted of 50% corn silage and 5, 10, 20, or 40% dry chopped alfalfa hay. The remaining forage dry matter content was alfalfa silage (45, 40, 30, and 10% respectively). It was determined that sorting did not change with increasing alfalfa hay content and that dry alfalfa hay can be included in the ration up to 23.5% of ration dry matter with no negative effects on dry matter intake, milk yield, and ruminal fermentation. Small decreases in milk fat and protein content occurred with increasing dry hay inclusion. Despite changes in total mixed ration refusal particle size distribution throughout the day, by 24 h after feeding no significant ration sorting occurred when measured either by selection indices or actual consumption of various particle size fractions (> 19.0, > 8.0, > 1.18 mm, and pan).

Fates of medium-chain fatty acids fed to lactating dairy cows:
The digestive metabolic fates of dietary saturated medium-chain fatty acids (C8 through C14) were examined at Michigan State University and compared with long-chain saturated fatty acid. Eight lactating Holstein cows were fed a total mixed ration with either coconut oil (CNO) or Energy Booster (EB) supplemented at 3.35% of dietary dry matter for 28 days in a crossover design. Concentrations of fatty acids in rations were 0.6 or 0.0% C8:0, 1.8 or 0.1% C10:0, 13.9 or 0.3% C12:0, and 6.8 or 1.4% C14:0, for CNO or EB, respectively (total fatty acids basis). Cows were fed ad libitum once daily at 1000 h. Rumens were evacuated and contents sampled 4 h post-feeding (day 26) and 2 h pre-feeding (day 28). Blood samples were obtained (day 17 to 20) prior to feeding and hourly post-feeding for 6 h. CNO reduced dry matter intake 17% ($P < 0.001$), but did not affect weight or volume of ruminal contents. CNO resulted in reduced total fatty acids concentration in ruminal contents, increased plasma concentration of total fatty acids, and depressed milk fat yield (d 22 to 25) compared with EB ($P < 0.01$). CNO vs. EB increased ruminal concentrations of C8:0 and C10:0 post-feeding ($P < 0.001$), but not pre-feeding. Although apparent total tract digestibilities of these fatty acids were nearly complete (>98%), their respective yields in milk were reduced ($P < 0.001$) and plasma concentrations were very small in cows fed CON. Amounts of C12:0 and C14:0 in rumen contents were greater with CNO than with EB ($P < 0.01$). Ruminal turnover rates per h were >100% for C8, 58% for C10, 5.8% for C12, and 4.8% for C14 in CNO-fed cows. CNO increased C12:0 and C14:0 concentrations in plasma and in milk fat compared with EB. Yet, milk fat yield of C14 decreased with CNO. Apparent transfer from diet (CNO) to milk was 57% for C12 and 187% for C14. Disappearance of C8 and C10 (not accounted for in ruminal contents, plasma, feces, or milk) suggests rapid

absorption and oxidation. Ruminal turnover rate and apparent total tract digestibilities of fatty acids decreased with increased chain length from C8 to C14. Increased conversion of C14 vs. C12 into milk fatty acids and greater increase of C14 vs. C12 in plasma fatty acids indicate reduced uptake of C14 by extra-mammary tissue. Results suggest large differences in fate among various medium-chain fatty acids fed to lactating cows.

Effects of water iron concentration, valence and source on drinking water preference in lactating cows:

Drinking water can contain high concentrations of Fe, mainly of the ferrous (Fe^{2+}) valence. Current recommended upper tolerable concentration of Fe in drinking water for cattle (0.3 mg/L) comes from guidelines for human palatability, but cattle may be able to tolerate greater concentrations. Our objective of this study conducted at Michigan State University was to determine the effects of varying concentrations of ferrous (Fe^{2+}) or ferric (Fe^{3+}) iron and Fe-salt source on lactating Holstein cows' preferences for drinking water offered as choices ad libitum. In 4 separate experiments, cows were offered pairs of water treatments for 22-h periods and water intake and drinking behavior were recorded. In Experiment 1 treatments were: 0, 4, or 8 mg of Fe/L from ferrous lactate [$Fe(C_3H_5O_3)_2$]. Cows exhibited no preference between water with 0 or 4 mg Fe/L, but water intake tended to be less with 8 compared with 0 or 4 mg Fe/L ($P < 0.10$). Also, cows spent less time drinking water containing 8 mg Fe/L ($P = 0.01$). Total drinking duration ($r = 0.62$) and frequency ($r = 0.55$) correlated positively with water intake ($P < 0.05$) when pooled across treatments. In Experiment 2, treatments were: 0 or 8 mg Fe/L from either ferrous sulfate ($FeSO_4$) or ferric sulfate [$Fe_2(SO_4)_3$]. Water intake did not differ among treatments. Treatments in Experiment 3 were: 0 or 8 mg Fe/L from either ferrous chloride ($FeCl_2$) or ferric chloride ($FeCl_3$). Again, cows exhibited no preference among the treatments. Treatments in Experiment 4 were: 0 or 8 mg Fe/L from ferrous lactate, sulfate, or chloride. Cows preferred water without added Fe ($P < 0.05$), but did not exhibit a preference among waters containing the Fe sources with different anionic moieties. Total drinking duration and frequency were less ($P < 0.05$) when offered water containing 8 mg of Fe/L from ferrous chloride compared with ferrous lactate or sulfate. Overall, our results indicate that upon first exposure to drinking water, lactating dairy cows tolerate concentrations of Fe up to 4 mg/L without reducing water intake; however, water intake was reduced with 8 mg Fe/L. Preference was not dependent upon Fe valence or Fe source in our studies.

Potential utility of a parlor-based individual quarter milking system:

Overmilking may lead to teat end hyperkeratosis (HK). The objective of this study, conducted at the University of Kentucky Coldstream Dairy, was to examine changes in teat end HK in a herd transitioning from a standard pulsation system to an individual quarter pulsation milking system. Teat end HK was evaluated immediately after cluster removal using the scoring system outlined by Mein et al. (2001) where N signifies no ring; S signifies a smooth, raised ring; R signifies a rough ring; and VR signifies a very rough ring. Scorings were classified for 69 cows (48 Holstein, 12 Crossbred, and 9 Jersey) relative to installation (April 28, 2011) of the Milpro P4CTM (Milkline, Gariga di Podenzano, Italy) system as follows: PRE1-April 7; PRE2-April 21; POST1-May 12; POST2-May 26; POST3-June 9. The Milpro P4CTM system stops milking individual quarters using a unique individual quarter pulsation system with four pulsation channels instead of two. Hyperkeratosis scores were converted to numerical values as follows: N = 1; S = 2; R = 3; VR = 4. The effects of position and scoring × breed were significant ($P < 0.01$

and $P = 0.02$, respectively). Hyperkeratosis scores improved for Holsteins from PRE1 to POST3 (1.75 ± 0.09 and 1.41 ± 0.10, respectively, $P < 0.01$), PRE1 to POST2 (1.75 ± 0.09 and 1.54 ± 0.09, respectively, $P < 0.01$), PRE2 to POST3 (1.64 ± 0.09 and 1.41 ± 0.10, respectively, $P < 0.01$) and POST1 to POST3 (1.62 ± 0.10 and 1.41 ± 0.10, respectively, $P < 0.01$) whereas Jersey and crossbred scores did not change among scorings ($P > 0.05$). Right front HK scores varied significantly from right rear and left rear scores (1.58 ± 0.09, 1.37 ± 0.09, and 1.36 ± 0.09, respectively, $P < 0.01$) and left front teat end HK scores varied significantly from right rear and left rear scores (1.62 ± 0.09, 1.37 ± 0.09, and 1.36 ± 0.09, respectively, $P < 0.01$). Teat end HK scores improved for Holsteins after installation of the individual quarter pulsation milking system.

Detection of clinical and subclinical mastitis using reticulorumen temperatures:
The objective of this study, conducted at the University of Kentucky Coldstream Dairy from September 15, 2011 to February 1, 2012, was to examine the relationship between changes in reticulorumen temperature (RT) and subclinical and clinical mastitis. The DVM Systems, LLC (Boulder, CO) bolus system monitors RT using a passive RFID transponder (Phase IV Engineering, Inc., Boulder, CO) equipped with a temperature sensor queried twice daily by a panel reader placed in parlor entrances. A composite milk sample was obtained from each cow in the herd every 14 days for somatic cells count analysis (Fossomatic™ FC somatic cell counter, Foss, Hilleroed, Denmark). Subclinical mastitis events were established by somatic cells count > 200,000 cells/mL. Milkers recorded clinical mastitis events. Reticulorumen temperatures < 38.9º C were interpreted as erroneous reads, likely from water intake before entering the parlor, and were eliminated from the data set. Reticulorumen temperatures were adjusted for the change in herd RT at each milking to account for the effect of changing ambient conditions and diurnal variation. A 30-day rolling mean baseline RT was calculated along with the number of standard deviation from which each respective RT varied from this baseline. The maximum RT and number of standard deviation among all RT within the previous 10 days were used as a baseline to assess whether a RT alert was observed for mastitis and high somatic cells count events. Using alert levels of > 2 standard deviation and > 3 standard deviation within 10 days of a mastitis event, alerts occurred for 47% (n=7) and 33% (n=5) of clinical mastitis events, respectively (n=15). Using alert levels of > 2 standard deviation and > 3 standard deviation within 10 days of a high somatic cells count event, alerts occurred for 23% (n=10) and 5% (n=2), respectively. Across all RT (n=23,298), 11% (n=2491) were > 40ºC. Using alert levels of RT > 40ºC, alerts occurred for 80% (n=12) and 50% (n=22) of clinical mastitis and high somatic cells count events, respectively. Reticulorumen temperature may be an indication of subclinical and clinical mastitis, but natural variation may limit the utility of a RT monitoring system.

Influence of time of day, breed, and season on reticulorumen temperature in lactating dairy cows
The objective of this research conducted by researchers at the University of Kentucky was to characterize the influence of time of day, breed, and season on reticulorumen temperatures in lactating dairy cows. Reticulorumen temperatures (RT) were recorded every 15 minutes using SmartBolus® transponders (TenXsys Inc., Eagle, ID) for 103 cows (68 Holstein, 25 crossbred and 10 Jersey) from November 06, 2009 to July 24, 2011. Air temperatures (AT) were collected every 15 minutes on location with a SmartBolus® transponder. Raw RT (n=1,646,145) were edited to remove erroneous reads and temperatures potentially influenced by water intake by

removing any RT lower than 38.33°C. The mean (±SD) RT among the remaining 927,048 temperatures was 40.16 ± 0.52°C. Peak and nadir mean RT occurred at 23:45 (40.26°C) and 10:00 (39.92°C), respectively. Mean (±SD) AT was 14.75 ±10.55°C. The reticulorumen temperature was lowly correlated with AT (r=0.28, $P < 0.01$). Least squares mean Holstein RT (40.16 ± 0.01°C) were higher ($P < 0.01$) than crossbred RT (40.07±0.01°C) while Jersey RT (40.09 ± 0.03°C) were not significantly different from Holstein RT or crossbred RT. Summer RT (40.24 ± 0.02°C) were higher than spring RT (40.08 ± 0.01°C), fall RT (40.09 ± 0.03°C) and winter RT (40.03 ± 0.02°C) ($P < 0.01$). In the spring, Holstein RT were higher than Jersey RT ($P < 0.01$) and crossbred RT ($P < 0.01$), with no significant differences observed between Jersey RT and crossbred RT. In the summer, Holstein RT was higher than crossbred RT ($P < 0.01$) and crossbred RT and Holstein RT were higher than Jersey RT ($P < 0.01$). In the fall, crossbred RT was higher than Holstein RT ($P < 0.01$) with no other significant differences among breeds observed. In the winter, Jersey RT were higher than Holstein RT ($P < 0.01$) and crossbred RT (P = 0.02) and Holstein RT were higher than crossbred RT (P = 0.02). These results may be useful in interpreting differences in RT obtained across varying seasons and breeds.

Changes in cortisol levels with alternating access to rotating cow brushes:
Rotating cow brushes are an environmental enrichment device for dairy cows that may satisfy grooming behavior needs. The objective of this study was to quantify changes in cortisol with alternating access to rotating cow brushes. Twenty lactating (2 groups of 10) Holstein cows were provided alternating access to a rotating cow brush (Lely Luna, Maassluis, The Netherlands) in a crossover experiment at the University of Kentucky Coldstream Dairy. Addition or removal of the brush occurred on days 0, 10, 20, 30, 40, and 50. Blood samples were collected on study days -1, 1, 5, 9, 11, 15, 19, 21, 25, 29, 31, 35, 39, 41, 45, 49, 51, 55, and 59 to establish an immediate change, short-term change, and a baseline for the alternating brush access. Samples were collected between 0800 and 0900 h in the freestall, feedbunk, or holding pen with minimal added stress. Locomotion scores (Sprecher,1997; 1=normal, 5=severely lame) were evaluated by the lead author. Cortisol levels were normalized using a natural log transformation. All interactions were tested using backwards elimination ($P < 0.05$). No difference ($P > 0.05$) in cortisol between group 1 (0.32 ± 0.10 μg/mL) and group 2 (0.40 ± 0.10 μg/mL) was observed. Cortisol was not altered by changing brush access (0.40 ± 0.10 vs. 0.32 ± 0.09 μg/mL with and without brush access, respectively, $P > 0.05$). Cortisol was lower in group 1 (0.24 ± 0.13 μg/mL) than in group 2 (0.43 ± 0.13 μg/mL) when access to the brush was restricted; however, no difference in cortisol was observed when brush access was permitted (0.44 ± 0.14 μg/mL vs. 0.37 ± 0.14 μg/mL, $P > 0.05$). A brush access × group interaction was observed ($P < 0.05$) with higher cortisol for group 1 (0.24 ± 0.13 μg/mL) than group 2 (0.43 ± 0.13 μg/mL) when brush use was restricted and no differences in cortisol when brush use was permitted (0.44 ± 0.14 and 0.37 ± 0.13 μg/mL for groups 1 and 2, respectively). Other behavioral and physiological effects of rotating cow brush use should be examined.

Potential for a real-time location system for dynamic tracking of dairy cow location within dairy facilities:
The objective of this study was to evaluate the potential accuracy of real time location systems (RTLS), commonly used to track assets or people, within a roofed dairy facility. AiRISTA (Sparks, MD) developed a leg-based RTLS tag incorporating Wi-Fi and RFID to locate tags through received signal strength indication (RSSI). The RTLS was installed in a newly

constructed 120-cow compost bedded pack barn, measuring 59.1 long (Y plane) by 39.6m wide (X plane). Six locators, mounted around the perimeter of the barn to transmit a signal, and 6 access points, mounted throughout the barn interior to send and receive signals, were installed 4.3m high. X and Y coordinates of 43 evenly distributed locations throughout the barn were obtained with a total surveying station (Topcon GTT3000, Livermore, CA). Calibration was achieved using AirCalibrator software and tags and seven reference location (RL) poles. The total surveying station determined RL coordinates. To assess system accuracy, a tag was attached to the researcher's leg while the researcher rotated among each RL 5 times to obtain X and Y coordinates for 35 samples. The mean (±SD) difference from the RL for the X coordinate was -0.08 ± 0.85m, ranging from -1.49 to 1.12m, and 0.37 ± 0.55m for the Y-coordinate, ranging from -0.46 to 1.36m. The mean (±SD) root squared error of the mean (RSEM) was 0.91 ± 0.48m. The mean (±SD) of the X and Y coordinates and RSEM for each location are depicted in the table below. A RTLS system may be able to identify animal position within a few meters, though additional validation with multiple cows is needed.

A decision support tool for investment analysis of new dairy housing facility construction:
The objective of this research done at the University of Kentucky was to develop a decision support tool, in the form of a user-friendly dashboard, for investment analysis of new dairy housing facility construction. User inputs included milking herd size, daily milk yield per cow, long-term milk price, daily lactating cow feed cost, hourly labor cost, time to move cows, somatic cells count bonus structure, somatic cells count, and clinical mastitis and lameness incidence rate. New facility inputs included per cow barn cost, bedding cost and usage rate, tax rate, discount rate, interest rate, predicted daily increase in production per cow, predicted time to move cows, predicted time to stir the pack or rake stalls, and predicted reduction in somatic cells count, lameness incidence and clinical mastitis incidence. Investment analysis outputs included net present value, internal rate of return, breakeven barn cost, and payback period. Model assumptions were obtained from published literature and farm surveys. This dashboard did not account for manure handling or culling costs. To compare alternative facilities with all model assumptions held equal except cow barn costs, cow barn costs were set at $850 per cow space for a compost bedded pack barn, $1,306 for a freestall barn with mattresses, and $1,021 for a freestall barn with sand. The net present value, internal rate of return, and payback period for the alternative facilities were compost bedded pack barn: $5,042, 9%, and 6.1y, respectively; free stall barn with mattresses: $5,673, 9% and 6.8y, respectively; and free stall barn with sand: $27,844, 13%, and 5.1y, respectively. A breakeven analysis was conducted for each of the 3 systems that would return a net present value of zero by changing bedding costs, cow barn costs, milk price, production per cow, predicted reductions in somatic cells count, lameness, or clinical mastitis. Results are depicted in the table below.

Effect of a liquid acid footbath solution containing a cationic surfactant on digital dermatitis in dairy cattle:
Dairy producers use many different footbath solutions for control of digital dermatitis (DD); however, many of these compounds have adverse effects on cows, handlers, or the environment. The objective of this research, consisting of 3 studies, was to examine the effects of a liquid acid footbath solution containing a cationic surfactant (PediCuRx® Prevent A (PED), GEA Farm Technologies, Naperville, IL) on digital dermatitis size (DDS) and pain (DDP). For each study, treatment cows were exposed to a 2% PED solution 3× per week. The same observer evaluated

DDS and DDP scores using 0 to 3 scales with 0 assigned to hooves with no DD. For DDS, scores were assigned as follows: 0 = no DD; 1 = < 20 mm DD; 2 = ~ 20 mm DD; and 3 = > 20 mm DD. The pain caused by wart presence was determined by the cow's reaction to either water or finger pressure on the hoof. For DDP, scores were assigned as follows: 0 = no pain; 1 = minimal pain; 2 = moderate pain; and 3 = severe pain. Study 1 included 53 cows in a commercial dairy that were exposed to PED in a footbath for 4 months. Study 2 included 250 cows in 2 commercial dairy farms in a 4-month experiment comparing PED to a 10% copper sulfate (CS) solution. Study 3 was conducted at the University of Kentucky Coldstream Dairy with 53 cows assigned for 4 months to either a PED treatment or a 5% CS control. In study 1, mean responses for DDS and DDP were higher (P<0.05) before starting the study (0.37 and 0.39 for DDS and DDP, respectively) than for the 3 test months after the study started (December: 0.12 and 0.10; January: 0.09 and 0.08; February: 0.00 and 0.00 for DDS and DDP, respectively). In study 2, mean responses for DDS and DDP were not different (P <0.05) during PED periods and CS periods (PED: 0.42 and 0.40; CS: 0.40 and 0.39 for DDS and DDP, respectively). In study 3, mean responses for DDS and DDP were not different (P <0.05) between treatments (PED: 0.28 and 0.28; CS: 0.21 and 0.25 for DDS and DDP, respectively). Control of DD was similar for PED and CS footbath solutions.

Replacing corn and soybean meal in lactating dairy cow diets with field peas (pisum sativum) on milk production and nitrogen utilization:

Sixteen lactating Holstein cows at South Dakota State University were used in a multiple 4 × 4 Latin square design with 28 day periods to evaluate replacing corn and soybean meal (SBM) with field peas (FP) on milk production and N utilization. Cows were 122 ± 47 days in milk, producing 35.4 ± 6.7 kg of milk, and weighed 645 ± 82 kg at the start of the study. All diets contained 37.5% corn silage, 12.5% alfalfa hay, and a 50% concentrate mix. Diets were formulated to replace corn and SBM with FP at 0 (FP0), 12 (FP12), 24 (FP24) and 36% (FP36) (dry matter basis) of the diet. Milk and dry matter intake data were collected the last 2 weeks of each period and milk composition samples were collected on days 17, 18, 24 and 25. No changes in body weight or body condition score were observed. With increasing inclusion rate of FP in the diet dry matter, milk yield, protein%, fat yield, protein yield, and energy corrected milk all linearly ($P \leq 0.03$) decreased while milk urea N linearly ($P < 0.01$) increased. Feed efficiency (energy corrected milk/dry matter intake) responded quadratically ($P < 0.01$) to increased inclusion of FP. In the milk, total antioxidant capacity (238, 240, 263, and 252 µmol/L $FeSO_4 7H_2O$) tended (P=0.10) and non-protein N (0.166, 0.168, 0.170, and 0.175%) linearly increased (P=0.03) with the inclusion of FP. True protein (2.91, 2.85, 2.74, and 2.68%), casein (2.33, 2.29, 2.17, and 2.15%), and whey protein (0.57, 0.55, 0.56, and 0.53%) decreased linearly ($P \leq 0.01$) with the inclusion of FP. These results show that replacing corn and SBM with FP at 24% of the diet or higher negatively affects the percentage and yield of milk protein. A deficiency of methionine could have possibly occurred due to the low met content of FP.

Response of different concentrations and sources of dietary protein on lactating dairy cows:

A study was conducted at South Dakota State University to determine the response of feeding 2 different concentrations (15% and 17%) and sources of protein [canola meal (CM) and high protein dried distillers grain (DG)]. Sixteen lactating Holstein cows (4 primiparous and 12 multiparous) were fed in a 4 × 4 Latin square with 2 × 2 factorial arrangement of treatments.

Each period was 4 weeks and data were collected during week 3 and 4 of each period. Diets were formulated with 15% crude protein with CM (15CM), 15% crude protein with DG (15DG), 17% crude protein with CM (17CM) and 17% crude protein with DG (17DG). All diets contained 55% forage (50% alfalfa hay and 50% corn silage) and 45% concentrate and all with 4.08% ether extract. Dry matter intake (kg/day) was similar ($P > 0.33$) between sources (25.0 vs. 25.5 for CM and DG respectively) but different ($P = 0.03$) between concentrations (24.6 vs. 25.9 for 15 and 17% crude protein respectively). Milk yield (kg/day) was similar between sources (34.9 vs. 35.5) but greater ($P = 0.002$) for cows fed 17% crude protein (34.0 vs. 36.4). Milk fat % was greater ($P = 0.02$) for cows fed 17% crude protein (3.14) compared to 15% crude protein (2.97) diets but similar between sources (3.05 vs. 3.06). Milk protein % (3.11 vs. 3.09), somatic cell count (273 vs. 225), and lactose % (4.82 vs. 4.88) were different ($P < 0.05$) between sources but similar between concentrations. Milk urea N (mg/dL) was greater ($P < 0.01$) for cows fed 17% crude protein and DG (P = 0.01) as compared to 15% crude protein (10.7 vs. 7.1) and CM (9.3 vs. 8.6). Fat yield (1.01 vs. 1.14), protein yield (1.05 vs. 1.13), lactose yield (1.65 vs. 1.77), fat-corrected milk (28.8 vs. 31.7) and energy-corrected milk (31.8 vs. 34.8) in kg were higher ($P < 0.01$) with 17% crude protein diets but not different between protein sources. Fat-corrected milk feed efficency (1.18 vs. 1.25) and energy-corrected milk feed efficiency (1.30 vs. 1.37)) were greater in cows fed 17% crude protein ($P < 0.05$) than 15% crude protein but similar between sources ($P > 0.05$). Average body weight (683 kg) and body condition score (3.07) for the experiment were not affected ($P > 0.05$) by the treatments. We concluded that use of CM or DG for the lactating dairy cows had same effect on production but the concentration had great impact on production.

Effect of different forage and dried distillers grains with solubles concentrations on sorting behavior of lactating dairy cows:

The objective of this study done at the South Dakota State University was to evaluate the effect of different forage and dried distillers grains with soluble (DDGS) concentrations on sorting behavior of lactating dairy cows. Four Holstein cows were assigned to a 4 × 4 Latin square in a 2 × 2 factorial arrangement of treatments with 4-week periods. Diets contained low forage (LF; 41% of diet dry matter) or high forage (HF; 60% of diet dry matter) and DDGS at 0 or 18% of diet dry matter. Ground corn and soybean feeds were partially replaced by DDGS from 0% DDGS diets to formulate 18% DDGS diets. Fresh total mixed rations and orts were sampled for particle size analysis on the first 3 days of week 3 and 4 of each period. Particle size distribution of samples of total mixed rations and orts were determined using the 4 box Penn State particle size separator. The particle size separator had 3 screens (19, 8, and 1.18 mm) and a bottom pan, resulting in 4 fractions (long, medium, short, and fine). Feed sorting was calculated as the actual intake of each particle size fraction expressed as a percentage of the predicted intake of that fraction. Average dry matter intake was similar ($P > 0.05$) across diets (23.8 kg/d). Cows fed HF diets sorted against long (91.2 vs. 97.6%) and medium (96.6 vs. 97.8%) particles compared to LF diets. Feeding HF diets increased selective consumption of short (103 vs. 101%) and fine (104 vs. 100%) particles compared to the LF diets. These results suggest that, despite geometric mean diameter of the diet being affected by forage (LF vs. HF: 1.55 vs. 1.95 mm) and DDGS (0DDGS vs. 18DDGS: 1.81 vs. 1.69) concentrations, only forage concentration affected the sorting behavior of lactating dairy cows.

A comparison of methods to analyze physical effective factor and physically effective NDF in TMR and orts:
The objectives of this study done at South Dakota State University were to compare available methods to measure physical effective factor (pef) and physically effective neutral detergent fiber (peNDF) in total mixed rations and orts while using different forage and dried distillers grains with solubles (DDGS) concentrations. Four Holstein cows were assigned to a 4 × 4 Latin square in a 2 × 2 factorial arrangement of treatments. Diets contained either low forage (LF; 41% of diet dry matter) or high forage (HF; 60% of diet dry matter) with DDGS at 0 or 18% of diet dry matter. The pef and peNDF of total mixed rations and orts were measured using 3 methods: 1) Dry sieving method using 12 screens (DS), 2) Penn State shaker box using top 3 screens (PS), and 3) Z-box (Z). Average pef and peNDF for all total mixed rations differed ($P < 0.05$) between the 3 methods (55.5, 79.7, and 52.6% and 16.0, 22.9, and 15.2%, for DS, PS, and Z, respectively). Average pef and peNDF of the orts were greater ($P < 0.05$) for PS (65.4, 82.4, and 63.6% and 22.2, 27.8, and 21.6%) compared to other methods. There was a forage × DDGS effect on pef of total mixed ration and pef and peNDF of orts irrespective of the method. The peNDF of total mixed ration was affected by forage and DDGS concentrations irrespective of the method. The results suggest that PS method overestimates pef and peNDF of total mixed ration and orts and interpretation of data is different compared to the DS method. Estimates pef and peNDF values of total mixed rations and orts by the Z method are closer and interpretation of data similar to that of the DS method.

Use of milk fatty acids as a tool to investigate milk fat depression on dairy farms:
University of California-Davis continues the work to evaluate the use of milk fatty acids as a tool to investigate low milk fat situations on dairy farms. The objective is to look at the relationship of C18:1 *trans 10* concentration in milk lipids. The goal was to obtain funding from the dairy industry to support the research, but the current economic situation has put the project on hold by a dairy organization that was approached. This past year it was initiated a study to measure cow variation in milk composition. To use milk fatty acids, it must be known how variable milk composition is within cow that creates the bulk tank sample. It was sampled 24 lactating cows for 30 consecutive days. Individual a.m. and p.m. milk samples were collected from each cow and analyzed for fat, protein, solids-not-fat, and lactose using an infrared milk analyzer. The goal is to determine the within cow variation to know what type of sampling protocol would be necessary on farm to use milk fatty acids as a marker. Depending on the results, a follow up study will be conducted to measure within cow variation of milk fatty acids as well as dry matter intake.

Productive response of lactating cows fed low-fat dried distillers grains with solubles in combination with rumen-inert fat:
Twenty Holstein cows, 12 primiparous and 8 multiparous, with (mean ± SD) 91 ± 19 days in milk and 594 ± 81 kg were used in replicated 4 × 4 Latin squares at the University of Nebraska to compare the effects of feeding conventional dried distillers grains with solubles (DDGS) and low-fat DDGS (LF-DDGS) in combination with rumen-inert fat (RIF, as calcium salts of long chain fatty acids). In each 21-day periods cows were randomly assigned to 1 of 4 dietary treatments (values expressed on a dry matter basis): control diet (CONT) that contained 0% DDGS; a second diet (DG) that contained 30% DDGS; a third diet (LF-DG) that contained 30% LF-DDGS in substitution of DDGS; and a fourth diet (COMBO) that was similar to LF-DG with

the addition of 1.9% RIF. Dry matter intake was similar across treatments containing any form of DDGS, 26.0 ± 0.6 kg/day, and greater ($P < 0.01$) than CONT, 21.6 ± 0.6 kg/day. Milk yield was similar across treatments averaging 33.4 ± 0.94 kg/day. The COMBO treatment resulted in the greatest ($P = 0.05$) fat corrected milk, 35.0 ± 0.98 kg/day, and no differences were observed among the remaining treatments averaging 33.4 ± 0.98 kg/day. A reduction in milk fat percentage and yield was observed ($P < 0.01$)when cows consumed the DG diet, 3.27 ± 0.10% and 1.11 ± 0.04 kg/day, whereas these parameters were similar among CONT, LF-DG and COMBO which averaged 3.68 ± 0.10% and 1.22 ± 0.04 kg/day. Concentration of milk protein was highest ($P < 0.01$) for the DG and LF-DG treatments, intermediate for the COMBO treatment and lowest for the CONT diet, namely 3.21, 3.12 and 3.07 ± 0.05%. Milk protein yield for the CONT diet was 1.0 ± 0.03 kg/day and was lower ($P < 0.01$) compared to DG, LF-DG and COMBO which averaged 1.08 ± 0.03 kg/day. These results demonstrate that compared to typical dairy diets, feeding high proportions of LF-DDGS to lactating dairy cows results in greater dry matter intake with no risk for milk fat depression and that the addition of RIF supports greater yield of fat corrected milk.

Effect of reduced fat dried distillers grains with solubles on lactation performance, rumen parameters in Holstein cows:

Sixteen multiparous lactating Holstein cows were used in 2 experiments at the University of Nebraska to evaluate the effect of reduced fat dried distillers grains with solubles (RFDG) on milk production, rumen parameters, and nutrient digestibility. In experiment 1, RFDG was fed at 0, 10, 20 and 30% of the diet dry matter to 12 non-cannulated Holstein cows (mean and SD, 89 ± 11 days in milk and 674 ± 68.2 kg body weight) to determine effects on milk production. In experiment 2, the same diets were fed to 4 ruminally and duodenally cannulated Holstein cows (mean and SD, 112 ± 41 days in milk; 590 ± 61.14 kg body weight) to evaluate the effect on rumen parameters and nutrient digestibility. In both experiments, cows were randomly assigned in 4 × 4 Latin squares over 21-day periods. Treatments (dry matter basis) were 1) CONTROL, a diet containing 0% RFDG; 2) LOW RFDG, a diet containing 10% RFDG; 3) MEDIUM RFDG, a diet containing 20% RFDG and 4) HIGH RFDG, a diet containing 30% RFDG. Feed intake and milk yield was recorded daily. In experiment 1, milk samples were collected on days 19 to 21 of each period for analysis of milk components. In experiment 2, ruminal pH was measured; samples of rumen fluid, duodenal digesta and feces were collected on days 18 to 21. Milk yield was not affected by treatment and averaged 34.0 ± 1.29 kg/day and 31.43 ± 2.81 kg/day in experiment 1 and 2, respectively. Percent of milk protein tended to increase in experiment 1; estimates were 3.08, 3.18, 3.15 and 3.19 ± 0.06% when RFDG increased from 0 to 30% in diets. However, it was not affected in experiment 2 and averaged 3.02 ± 0.07%. Percent milk fat was not affected and averaged 3.66 ± 0.05% and 3.25 ± 0.14% in experiment 1 and 2, respectively. Total ruminal VFA and ammonia concentrations were not affected by treatment and averaged 135.18 ± 6.45 m*M* and 18.66 ± 2.32 mg/dL, respectively. Dry matter, organic matter, and neutral detergent fiber digestibilities tended to increase with RFDG inclusion. Results of these experiments indicate that dairy rations can be formulated to include up to 30% RFDG while maintaining lactation performance, and rumen parameters.

In vivo determination of rumen undegradable protein of dried distillers grains with solubles and evaluation of duodenal microbial crude protein flow:
The objectives of this trial done at the University of Nebraska were to determine the rumen undegradable protein (RUP) of dried distillers grains with solubles (DDGS), to compare the estimates of duodenal bacterial crude protein (BCP) flow using diaminopumelic acid (DAPA) or DNA as bacterial markers, and to estimate duodenal protozoal crude protein (PCP) and yeast crude protein (YCP) flow when DDGS are fed. Three crossbred steers fitted with ruminal and double L-shaped duodenal cannulae (average body weight 780 ± 137 kg) were used in a 3 treatment, 6 period cross-over design. Animals were housed in individual free stalls and fed twice daily at 0700 and 1900 h. Diets (dry matter basis) were 1) CONTROL, 0% DDGS, but with 19.5% corn bran, 20% sorghum silage, 60% brome hay, 0.5% trace minerals and 0.25% urea; 2) LOW DDGS, inclusion of 9.75% DDGS replacing equal percentage of corn bran; 3) HIGH DDGS, inclusion of 19.5% DDGS completely replacing corn bran. In addition, duodenal PCP and YCP flow were estimated using DNA markers. The value of DDGS RUP as a percent of CP was determined to be 63.0 ± 0.64%. Estimates of duodenal BCP flow using DAPA were 473, 393, 357 ± 78 g/day (P = 0.09) for CONTROL, LOW DDGS and HIGH DDGS, respectively. Estimates of duodenal BCP flow using DNA were 479, 397 and 368 ± 74 g/day (P = 0.14), respectively. Average BCP flow across treatments was unaffected (P = 0.71) by marker type and were 404 and 417 ± 83 g/day for DAPA and DNA markers, respectively. Estimates of duodenal PCP flow were 82, 80 and 78 ± 12 g/day (P = 0.64) for CONTROL, LOW DDGS and HIGH DDGS, respectively. Estimates of duodenal YCP flow were 0.15, 1.94 and 4.80 ± 0.66 g/day (P < 0.01) for CONTROL, LOW DDGS and HIGH DDGS, respectively. Duodenal BCP flow tended to decrease with DDGS inclusion, but estimates were not affected by marker type. In addition, DDGS did not affect duodenal PCP supply and provided small amounts of duodenal YCP. Overall, the value of DDGS RUP determined in this study will contribute to better understand the effect of this byproduct in ruminant nutrition.

Feeding brown midrib corn silage with a high dietary concentration of alfalfa hay during early and mid-lactation:
This experiment done at the Utah State University aimed to determine the long-term effects of feeding brown midrib corn silage (BMRCS) fed with a high dietary concentration (25% DM) of good quality alfalfa hay in high-forage lactation diets on productive performance of dairy cows. During early lactation (0 to 60 days in milk), milk yield was not different between dietary treatments, whereas milk yield during mid-lactation (61 to 200 days in milk) increased by feeding the BMRCS compared with the conventional corn silage treatment (39.8 vs. 36.2 kg/day; P = 0.05), resulting in increased overall milk yield by feeding the BMRCS throughout the experiment (40.9 vs. 37.6 kg/day; P = 0.05). While milk fat concentration did not differ during early lactation, it tended to decrease by feeding the BMRCS compared with the conventional corn silage during mid-lactation (3.51 vs. 3.82%; P = 0.08). During mid-lactation, yield of 3.5% fat-corrected milk tended to increase for cows fed the BMRCS compared with those fed the conventional corn silage (42.5 vs. 39.3 kg/day; P = 0.10), but it remained similar during 200 days in milk. Overall, milk protein concentration was similar between dietary treatments throughout the experiment (2.95% on average), but overall milk protein yield was higher for the BMRCS than the conventional corn silage (1.27 vs.1.14 kg/day; P = 0.01). Milk protein concentration and yield were similar between dietary treatments during early lactation; however,

during mid-lactation, milk protein yield was greater for cows fed the BMRCS than those fed the conventional corn silage (1.27 vs. 1.10 kg/day; $P < 0.01$).

Effects of corn silage hybrids and quality of alfalfa hay on nitrogen metabolism and ruminal fermentation of early lactating dairy cows:

This experiment done at the Utah State University aimed to determine the effects of corn silage hybrids and quality of alfalfa hay in high forage dairy diets on N metabolism and ruminal fermentation in early lactating dairy cows. Conventional corn silage or brown midrib corn silage was combined with low quality alfalfa hay (46.4% NDF and 18.7% CP) or high quality alfalfa hay (37.4% NDF and 21.8% CP) to yield 4 treatments. Diets were isonitrogenous across treatments averaging 15.8% CP. Intake of dry matter did not differ because of corn silage hybrids and alfalfa hay quality. While feeding BMR corn silage based diets decreased urinary N output by 32% ($P < 0.01$), it did not affect fecal N output. Feeding high quality alfalfa hay decreased urinary N output by 18% ($P = 0.01$), but increased fecal N output by 14.5% ($P = 0.01$). Nitrogen efficiency (milk N (g/d)/intake N (g/d)) was similar across treatments. Ruminal ammonia-N concentration was lower for cows fed BMR corn silage based diets than those fed conventional corn silage based diets ($P = 0.02$), but was not affected by quality of alfalfa hay. Feeding BMR corn silage based diets decreased milk urea N concentration and yield by 23% ($P < 0.01$), whereas feeding high quality alfalfa hay decreased milk urea N concentration and yield by 15% ($P < 0.02$). Milk yield did not differ due to corn silage hybrids, but it tended to decrease ($P = 0.08$) by feeding high quality alfalfa hay.

Effects of overstocking on glucocorticoid production and analytes associated with energy metabolism:

The objective of this study done at Cornel University was to determine if overstocking alters energy metabolism and glucocorticoid production. Four groups of 10 dry Holstein cows (~60 d prepartum) were exposed to 2 treatments: Control (1 lying stall/cow and 0.67 m linear feed bunk space/cow) and Overstocked (0.5 stalls/cow and 0.34m feed bunk/cow) in a replicated 2 × 2 crossover design with 14-days treatments. Plasma nonesterified fatty acids, glucose, and insulin were measured from blood sampled every 2 days of each treatment and during an intravenous glucose tolerance test (0.25g dextrose/kg body weight) performed on day 13. Feces, collected every 2 days, were analyzed for fecal cortisol metabolites. Plasma cortisol response to an intravenous ACTH challenge (0.125 IU ACTH/kg body weight) was measured on day 14. Data from individual cows were averaged to create a group mean and all statistical analyses used group as the experimental unit. Average dry matter intake per cow was greater during the overstocked treatment relative to the control period (15.9 vs. 14.9 kg/day, $P < 0.001$). Plasma nonesterified fatty acids and glucose concentrations were higher during the overstocked treatment (0.11 vs. 0.09 mEq/L and 65 vs. 64 mg/dL respectively, $P < 0.05$); however, when stratified by parity these responses were limited to heifers ($P < 0.01$). Overstocking had no effect on insulin concentration during the treatment period ($P > 0.20$) while fecal cortisol tended to be higher (19 vs. 16 ng/g fecal dry matter, $P \leq 0.14$) during overstocking. During the glucose tolerance test, cows took longer to return to basal glucose concentration (55.1 vs. 51.5 min, P=0.05), tended to have greater area under the curve estimates for glucose (2837 vs. 2630 mg/dL x 120 min, P=0.06), had lower peak insulin concentrations (201 vs. 260 μIU/L, P=0.02), and tended to have a reduced rate of nonesterified fatty acids decline from circulation (1.4 vs. 1.9 μEq/L per min, P=0.1) following the overstocked treatment. Cortisol production after

administration of ACTH was not affected by stocking density treatment ($P > 0.48$). Overstocking alters energy metabolism. These effects seem to be mediated through changes in insulin production rather than insulin resistance; the role of glucocorticoids in influencing these effects is still unclear.

Use of a competition index to describe differences in physiological parameters associated with energy metabolism and stress in overstocked Holstein dairy cattle:
The objective of this study done at Cornel University was to evaluate how behavioral and physiological parameters are affected based on a cow's level of success at displacing others at an overstocked feed bunk. Forty Holstein non-lactating, late gestation dairy cattle were housed in an overstocked pen (5 stalls/10 cows and 0.34 m linear feed bunk space/cow) in groups of 10 (4 heifers and 6 multiparous cows) for 14 days. Plasma nonesterified fatty acids, glucose, and fecal cortisol metabolites (11,17-dioxoandrostanes, 11,17-DOA) were measured in blood and feces sampled every 2 days. A glucose tolerance test and an ACTH challenge were conducted on all cows on days 13 and 14, respectively to further explore the effects of competitive success on energy metabolism and stress physiology. Feeding behavior and displacements at the feed bunk were recorded between days 7 to 10 of the observation period. A competition index (CI) was calculated for each cow by dividing the number of displacements the animal initiated at the feed bunk by the total number of displacements the animal was involved in, either as an initiator or receiver. Cows were then divided into 3 sub-groups based on their CI: High-success (HS: $CI \geq 0.6$), Medium-success (MS: $0.4 \leq CI < 0.6$), and Low-success (LS: $CI < 0.4$). Heifers accounted for 7%, 36% and 79% of the total number of animals in the HS (n=15), MS (n=11), and LS (n=14) groups, respectively. There were no differences in daily feeding time, total number of displacements, and time to approach the feed bunk following fresh feed delivery between the 3 CI groups; however, cows in the LS group had greater daily nonesterified fatty acids and 11,17-DOA concentrations relative to cows in the HS group. There were no differences in cortisol response to an ACTH stimulation test between CI categories. During the clucose tolerance test, glucose response curves were the same between all 3 CI categories; however, the peak insulin response of LS cows was 130 μIU/mL greater than the peak HS response indicating LS cows may have reduced tissue responses to insulin or increased pancreatic responses to glucose. In an overstocked environment, dairy cattle physiology is linked to a cow's level of success at displacing other individuals at the feed bunk.

Association of biomarkers of stress, inflammation, and negative energy balance with milk yield and reproductive performance in Holstein dairy cows:
Researchers at Cornel University aimed to investigate the association between peripartum concentrations of fecal cortisol metabolites (11,17-dioxoandrostane; 11,17-DOA), plasma haptoglobin, and nonesterified fatty acids, and milk yield and reproductive performance. Blood and fecal samples were collected weekly from 412 Holstein dairy cows from week −3 through week +1 relative to calving. Pregnancies by 150 days in milk and projected 305 metabolizable energy milk yield based on the 3rd Dairy Herd Improvement test day (102 days in milk) were measured. A range of concentration cutpoints were evaluated for each biomarker; associations of these cutpoints with 305 metabolizable energy milk yield or risk of conception were assessed using mixed effects or semiparametric proportional hazards models, respectively. Associations between the biomarkers and reproductive performance were strongest for primiparous cows during week −1 or +1 relative to calving. Among multiparous cows, no biomarker measured

during week −1 or +1 was associated with reproductive performance ($P \geq 0.2$). Primiparous cows with haptoglobin >0.4 g/L, 11–17-DOA >2300 ng/g fecal dry matter, or nonesterified fatty acids >0.40 mEq/L during week −1 had a 41%, 42%, or 42% decreased risk of conception, respectively ($P \leq 0.05$), compared with primiparous cows below these cutpoints. Primiparous cows with haptoglobin >1.3 g/L or >0.45 mEq/L during week +1 had a 41% or 39% decreased risk of conception, respectively ($P = 0.02$). Associations between haptoglobin and 11,17-DOA with 305metabolizable energy milk yield were strongest when these analytes were measured during wk +1; however, week −1 nonesterified fatty acids concentrations were a better predictor of milk yield than week +1 nonesterified fatty acids. Postpartum haptoglobin >1.1 g/L was associated with 947 kg lower 305 metabolizable energy milk yield for both primiparous and multiparous cows ($P = 0.001$). For multiparous cows only, 11,17-DOA >400 ng/g fecal dry matter during week +1 was associated with a 663 kg lower 305 metabolizable energy milk yield ($P = 0.03$). Primiparous and multiparous cows with nonesterified fatty acids >0.55 mEq/L during week −1 had a 1360 kg lower projected 305 metabolizable energy milk yield ($P = 0.002$). Biomarkers of stress, inflammation, and negative energy balance around calving can be used to identifying opportunities to improve milk yield and reproductive performance.

Effects of trace mineral source on oxidative metabolism, subclinical endometritis, and performance of transition dairy cows:
Researchers at Cornel University used multiparous Holstein cows (n = 60) to determine effects of trace mineral source on oxidative metabolism, subclinical endometritis, and performance of transition cows. After a 1-week preliminary period, cows were assigned randomly to 1 of 3 topdress treatments from 21 days before expected calving through 84 days post calving: 1) Inorganic sources based upon sulfates of Zn, Cu, and Mn (ITM); 2) a blend (75:25) of sulfates and chelated sources of Zn, Cu, and Mn (ITM/OTM); and 3) Hydroxy Trace Minerals (HTM) of Zn, Cu, and Mn (IntelliBond; Micronutrients, Inc., Indianapolis, IN). Final concentrations of Zn, Cu, and Mn were similar among treatments and averaged 40, 10, and 27 ppm before calving and 59, 15, and 40 ppm after calving. An interaction of treatment and week existed ($P = 0.02$) for milk yield such that cows fed HTM increased milk yield faster than cows fed the other 2 treatments; a similar interaction was also present for yields of fat-corrected milk ($P = 0.03$) and lactose ($P = 0.05$). Cows fed HTM during the prepartum period tended ($P = 0.08$) to have higher body weight and had higher body weight during the postpartum period ($P = 0.04$) than those fed the other 2 treatments. Plasma antioxidant capacity was lower in cows fed HTM than ITM during both prepartum (1.84 vs. 2.09 m*M*; $P = 0.03$) and postpartum (1.95 vs. 2.16 m*M*; $P = 0.04$) periods; cows fed ITM/OTM had intermediate values. Cows fed HTM tended to have lower concentrations of plasma thiobarbituric acid reactive substances than those fed ITM during whole study period (1.95 vs. 2.11 µ*M*; $P = 0.07$). Endometrial cytology as characterized by low volume uterine lavage at 7 d postcalving and on 1 day between 40 and 60 days post calving was not affected by treatment. In conclusion, supplementation with HTM sources of Zn, Cu, and Mn resulted in evidence of improved productive performance during early lactation along with modulation of plasma variables related to oxidative metabolism.

Effects of chromium propionate supplementation during the periparturient period and early lactation on metabolism, performance, and subclinical endometritis in dairy cows:
Researchers at Cornel University used multiparous Holstein cows (n = 61) to determine effects of chromium propionate (Cr-Pro) supplementation during the periparturient period and early

lactation on metabolism, performance, and subclinical endometritis. After a 1-week preliminary period, cows were assigned randomly to 1 of 2 treatments from 21 days before expected calving through 63 days post calving: 1) control (n = 31) and 2) chromium propionate (n = 30; Cr-Pro, KemTRACE Chromium Propionate, Kemin Industries, Des Moines, IA) administered by daily topdress at a rate of 8 mg/day of chromium. There was a tendency for increased dry matter intake during the prepartum period in cows fed Cr-Pro (16.5 vs. 15.8 kg/day; *P* = 0.07). Cows fed Cr-Pro tended to have lower plasma nonesterified fatty acids during the prepartum period (184 vs. 211 µEq/L; *P* = 0.08). Effects of Cr-Pro supplementation on postpartum dry matter and milk yield were not significant; however, cows fed Cr-Pro had higher somatic cell counts (275 vs. 160 x 1000/mL; *P* = 0.04) and tended to have higher urea N concentrations in milk (11.2 vs. 10.6 mg/dL; *P* = 0.08). An interaction (*P* = 0.05) of treatment and day existed during the postpartum period such that cows fed Cr-Pro had lower plasma glucose concentrations immediately postpartum than controls. Evaluation of endometrial cytology by low volume lavage was determined on all cows at 7 days postcalving (1st lavage) and on 1 day between 40 and 60 days (2nd lavage) post calving. Cows fed Cr-Pro had lower incidence of subclinical endometritis for 2nd lavage using a cut-point of 10% neutrophils (30% vs. 57% of cows; *P* = 0.04). In conclusion, supplementation with chromium propionate resulted in trends for increased dry matter inatke and lower nonesterified fatty acids prepartum. Postpartum milk yield and dry matter intake were not affected by treatment; however, Cr-Pro supplementation decreased the incidence of subclinical endometritis between day 40 and 60 postcalving, suggesting the potential for effects on subsequent reproductive performance.

C. PROJECT OBJECTIVE 3 (WHOLE FARM)

Survey of Genetic Selection Practices on Pasture-based Dairy Farms in the US:
A survey developed by researchers at Purdue University was mailed to dairy graziers across the country to ascertain their genetic selection practices, but included background information on feeding, production, and health. The overall aim was to collect data to allow eventual development of a genetic selection index. Mailing addresses were obtained from extension cooperators, NRCS advisors, and commercial companies. Producers were able to respond to the survey by mail or internet. Respondents to the survey included 77 farmers in 22 states. Producers were asked questions about the grazing history of their herd and average milk and component production. They were also asked questions about breeding practices to determine number utilizing seasonal grazing and to gain an understanding of breeds present in their herds. Producers were asked to rank genetic traits by the amount of selection pressure they felt should be applied to those commonly available. Traits were ranked from negative five to positive five with negative being selection against a trait and positive being selection for a trait. Respondents averaged 15.95 ±9.12 years of grazing history, 129.1 ± 128.52 milking head, and grazed 224.5 ±60.47 days a year. Production was 20.9 ± 4.89 kg of milk per cow per day, 4.0 ± 0.42% milk fat, and 3.6 ± 0.23% milk protein. Also, 46.7% of producers participated in seasonal calving, defined as 75% of cattle calving in any 3 month window. Further, 70% utilized crossbreeding to the extent that at least 10% of the herd was crossbred. Percentage of herds that included at least some genetics from major breeds were: 70% Jersey, 65% Holstein, 26.7% Ayrshire, 21.7% Swedish or Norwegian Red, and 20% Milking Shorthorn. The average rank of genetic traits were: productive life 3.87, udder composite 3.57, somatic cell count -3.15, feet and legs 3.08, daughter pregnancy rate 3.05, fat percentage 2.97, calving ability 2.95, protein percentage 2.83,

body size -2.73, fat yield 2.69, protein yield 2.56, and milk yield 2.27. It appears that pasture-based dairy producers place more emphasis on traits relating to longevity and fertility and less on production traits than the most widely used US selection indexes.

Development of a merit-based genetic selection index for dairy grazing systems:
Pasture-based dairy producers face different costs, revenues and management challenges from those with conventional production systems. These differences have led many graziers to question whether the US Lifetime Net Merit (NM$) index is appropriate to achieve maximum economic gain when selecting dairy cows and bulls for their breeding programs. A Grazing Merit index (GM$) parallel to the US NM$ index was constructed using costs, revenues, and management characteristics representative of grazing systems. Inputs were obtained from surveys, literature, and farm financial record summaries. Derived weights for GM$ were then multiplied by Predicted Transmitting Abilities of 584 active Artificial Insemination Holstein bulls to compare with NM$. Spearman rank correlation between GM$ and NM$ was 0.93 ($P <$ 0.0001). Traits included in GM$ (and their percentage of weight) include: milk volume (24%), fat yield (16%), protein yield (4%), productive life (7%), somatic cell count (−8%), Feet and Leg Composite (4%), Body Size Composite (−3%), Udder Composite (7%), daughter pregnancy rate (18%), calving ability (3%), and dairy form (6%). Weights in NM$ were 0, 19, 16, 22, 10, 4, 6, 7, 11, 5, and 0% for the same traits, respectively. Dairy form was added to GM$ to offset the decrease in strength that arises from selection to reduce stature by selecting against Body Size Composite. Relative importance of milk volume was greater due in part to a difference in the milk prices used and the increased marginal value of milk yield when production is less in grazing systems. There is a large decrease in the emphasis placed on productive life probably because grazing cattle tend to remain in the herd longer; therefore, the marginal value of increasing length of productive life is decreased. This trend is reflected in the relative weight for productive life in GM$ (18%) vs. NM$ (22%). It appears that NM$ may provide guidance for pasture-based dairy producers, however a GM$ index based upon appropriate costs and revenues, is more beneficial.

Using whole farm assessment tools to identify strategies for change to increase dairy farm profitability:
The objectives for this project were to use the Profitability Assessment Dairy Tool (PA Dairy Tool) and the Income Over Feed Cost (IOFC) Tool developed at the Pen State University to 1) identify bottlenecks that limited dairy farm profitability on Pennsylvania dairy farms and 2) to show dairy producers how to make improvements to both overall profitability and IOFC. The PA Dairy Tool data and IOFC Tool data were included previously. Follow up work in the final year of this project found that higher profit farms exhibited four common traits: (1) better young stock management, (2) above average milk production, (3) extensive use of data in decision making and (4) excellent interpersonal relationship (both with employees and with farm advisors). Top profit herds when compared to state industry averages had 73.3 vs. 62.4 pounds of milk per cow; 33% vs. 35% cull rate and 225,000 vs. 268,000 bulk tank somatic cell counts. Additionally, the top profit herds had greater that 75% tool use and use of data for decisions compared with low profit herds, and more frequent communication with off farm advisors and improved employee management (as measure by employee performance and turnover). Effective use of evaluation assessments like the PA Dairy Tool and IOFC Tool can be effective in helping producers to target the most economically beneficial areas for changes to improve their bottom

line, but use of the data that resulted in improved production and management was necessary in order to see the benefit of the evaluation in return on assets.

Use of a directional distance function model to measure the amount of pollution originating from New England dairy farms:

New England dairy farm data for 1980-2011, collected and summarized by the Farm Credit Bureau, has been assembled by researchers at the University of Connecticut. Njuki et al. (2011b, 2012a, 2012b) have estimated a directional distance function model to measure the amount of pollution originating from these dairy farms. The pollution emanating from methane, nitrous oxide, carbon dioxide and particulate matter was then converted to a carbon dioxide equivalent and aggregated in order to obtain the corresponding undesirable output. Then, in a desirable output-undesirable output framework, we evaluated environmental efficiency of these dairy farms using estimates of shadow prices, technical efficiency, and the Morishima elasticity of substitution. The rationale for this work is to determine the environmental performance of these farms, and hence their environmental sustainability. It was established that large dairy farms face lower shadow prices and even lower marginal costs of abatement than smaller farms. The implication is that in the presence of regulatory policies to reduce pollution, smaller farms would face higher compliance costs.

Regression meta-models to predict the value of pregnancy in dairy cows:

The value of a new pregnancy can be calculated with a complex dynamic programming model (DairyVIP) for a variety of input parameters, but the model needs to be installed on a computer and each calculation takes time. The objective of this study done at the University of Florida was to predict the values of pregnancy for 9 important input parameters using a regression meta-model. Meta-models provide instant predictions of the value of pregnancy for the fitted inputs and can be used in web-based dashboard tools for easy access by interested users. Nine input parameters were randomly varied over reasonable ranges using 265 design points. The value of pregnancy and profit per cow per year were calculated for each design point with DairyVIP. Mean ± SD of the 265 values of pregnancy was \$246 ± \$131. The procedure Glmselect in SAS was used to fit the meta-model. The Glmselect procedure included learning (n = 150 design points), validation (n = 50) and testing (n = 65). The 9 main effects included the prices of replacement heifers, milk, feed, cull cows, and calves, as well as the probabilities of insemination, conception, culling, and the level of milk yield. The main effects, logs of the main effects, and all two-way interactions were fitted. At most 10 effects were selected for the regression model. Stepwise selection with the Press criteria was used to select the best fitting meta-model. Statistics for the final meta-model were $R^2 = 0.987$ and AIC = 990. Mean ± SD of the prediction error was \$0 ± \$15 (range -\$30 to \$41). Prediction errors were independent of the profit per cow per year. In conclusion, regression meta-models were able to accurately predict the value of pregnancy in most cases. Meta-modeling may be a useful approach to make results from complex computer models widely available.

Accuracy of the AfiLab real time milk analyzer to predict DHIA fat, DHIA protein and lactose:

Objective of this study was to quantify the agreement between the AfiLab real time milk analyzer based on light scattering and test day DHIA fat, DHIA protein and lactose, all based on the Bentley 2000 analyzer (BA). AfiLab data were collected twice daily at 12h intervals from the

double 12 parlor at the University of Florida Dairy Unit in Hague, FL, from January 2010 to December 2011. Alternating AM/PM BA data for the 24 test days in 2010 and 2011 were also obtained. Approximately 450 cows were tested each month. AfiLab data were matched with DHIA fat and protein (n=10,273; 23 test days) and lactose (n=6,741; 16 test days). Means and SD of BA fat, protein and lactose were 3.76 ± 0.80%, 3.08 ± 0.37% and 4.72 ± 0.30% respectively. Mean and SD of average AfiLab minus BA observations of the test day milking were -0.077 ± 0.116% for fat (n=23), 0.024 ± 0.107% for protein (n=23) and -0.024 ± 0.083% for lactose (n=16). Mean and SD of within test day SD of AfiLab minus BA observations of the test day milking were 0.659 ± 0.110% for fat, 0.274 ± 0.031% for protein and 0.262 ± 0.025% for lactose. Mean and SD of the corresponding correlations were 0.59 ± 0.09 for fat, 0.74 ± 0.03 for protein and 0.46 ± 0.08 for lactose. The accuracy of various combinations of AfiLab observations from up to 6 milkings before and after the test day milking was also evaluated. The accuracy of fat predictions was not improved. The average of the 13 protein observations improved the average difference to 0.011 ± 0.095% and SD of the difference to 0.227 ± 0.029%. The correlation increased to 0.78 ± 0.04. The average of 13 lactose observations improved the SD of the difference to 0.229 ± 0.021% but the mean of the difference was -0.031 ± 0.089%. The correlation increased to 0.55 ± 0.05. In conclusion, the accuracy of protein prediction was better than the accuracy of lactose and fat prediction. Combination of AfiLab observations from various milkings may improve the accuracy of prediction.

Developement of v.calculator: a simple herd budget spreadsheet:
A simple spreadsheet has been developed at the University of Florida to simulate the daily technical and economic performance of younstock and cows in parities 1 to 4+. The results of two sets of inputs can be compared side by side. A Spanish version is available. There is a screen with a limited set of inputs and a screen with an extended set of inputs, depending on user preference. The spreadsheet has been used to evaluate the economics of sexed semen, stocking density, Herd Navigator, and genomic testing. Development is on-going.

The effect of reproductive performance on the dairy cattle herd value assessed by integrating a daily dynamic programming with a daily Markov chain model:
The objective of this study conducted at the University of Wisconsin-Madison was to determine the effect of reproductive performance on the dairy cattle herd value under optimal replacement policies. The herd value was defined as the herd's average retention payoff (RPO). Individual cow RPO is the expected profit from keeping the cow compared with immediate replacement. First, a daily dynamic programming model was developed to calculate the RPO of all cow states in a herd. Second, a daily Markov chain model was applied to estimate the herd demographics. Then, the herd value was calculated by aggregating the RPO of all cows in the herd. Cow states were described by 5 milk yield classes (76, 88, 100, 112 and 124% with respect to average), 9 lactations, 750 days in milk and 282 dais in pregnancy. Five different reproductive programs were studied (RP1 to RP5). The RP1 used 100% timed artificial insemination (TAI; 42% conception rate for 1st TAI and 30% for 2nd and later services) and the other programs combined TAI with estrus detection. The proportion of cows receiving AI after estrus detection ranged from 30 to 80% and conception rate ranged from 25 to 35%. These five reproductive programs were categorized according to their 21 days pregnancy rate (21d PR), which is an indication of the rate the eligible cows become pregnant every 21 days. The 21d PR was 17% for RP1, 14% for RP2, 16% for RP3, 18% for RP4, and 20% for RP5. Results showed a positive

relationship between 21d PR and the herd value. The most extreme herd value difference ($/cow per yr) between two reproductive programs was $77 for average milk yield (RP5 – RP2); $13 for lowest milk yield (RP5 – RP1); and $160 for highest milk yield (RP5 – RP2). Reproductive programs were ranked based on their calculated herd value. With exception of the best reproductive program (RP5), all other programs showed some level of ranking change according to milk yield. The most dramatic ranking change was observed in RP1, which moved from being the worst ranked for lowest milk yield to the second best ranked for highest milk yield. Within a reproductive program the RPO changed based on the stage of lactation at pregnancy. Cows getting pregnant in the early stage of the lactation had higher RPO compared to getting pregnant later in the lactation. However, the RPO at calving were similar for early and late lactation pregnancies.

A daily herd Markov-chain model to study the reproductive and economic impact of reproductive programs combining timed artificial insemination and estrous detection: The objective of this study conducted at the University of Wisconsin-Madison was to compare the economic and reproductive performance of programs combining timed artificial insemination (TAI) and different levels of AI after estrus detection (ED) using a daily Markov-chain model. A dairy herd was modeled with every cow following daily probabilistic events of aging, replacement, mortality, pregnancy, pregnancy loss, and calving. The probability of pregnancy depended on the combination of probability of insemination and conception rate (CR). All non-pregnant cows had a probability of pregnancy between the end of the voluntary waiting period and days in milk cutoff for AI. After the cutoff, cows were labeled as "do-not-breed" and replaced when milk production was below a minimum milk threshold. A similar model was created to represent a replacement heifer herd to simulate and adjust the supply and demand of replacements. The net value (NV) of a program was the sum of: milk income over feed cost (IOFC), replacement and mortality cost, income from newborns, and reproductive costs. The model was used to compare the NV of 19 programs. One program used 100% TAI (42% CR 1st TAI and 30% for 2nd and later services), whereas the other programs combined TAI with ED. The proportion of cows receiving AI after ED for the combined programs ranged from 30 to 80% with levels of CR of 25, 30, and 35%. As the proportion of cows receiving AI after ED increased, the CR of cows receiving TAI decreased. The combined programs with CR of 35% for cows receiving AI after ED had the greatest NV and reproductive performance at all levels of ED. The program using 100% TAI had greater NV and better reproductive performance than all programs with 25% CR after ED inseminations while it had very similar performance than combined programs with up to 60% of cows receiving AI after ED and 30% CR. The factor with the greatest relative contribution to the differences among programs was IOFC followed by replacement and reproductive costs. Adjusting the days in milk cutoff for AI to match the supply and demand of heifer replacements improved the NV of all programs except for those with 25% CR after ED which had either no change or a decrease in NV. In summary, the economic value of reproductive management programs combining TAI and ED depended on the proportion of cows receiving AI after ED and the resulting CR. Adjusting the heifer supply and demand increased the NV of programs with heifer surplus and decreased the NV of programs with heifer deficit.

A simple formulation and solution to the replacement problem: A practical tool to assess the economic cow value, the value of a new pregnancy, and the cost of a pregnancy loss:
This study conducted at the University of Wisconsin-Madison contributes to the research literature by providing a new formulation of the cow replacement problem and it also contributes to the Extension deliverables by providing a user-friendly decision support system tool that would more likely be adopted and applied for practical decision-making. The cow value, its related values of a new pregnancy and a pregnancy loss, as well as their associated replacement policies, determines profitability in dairy farming. One objective of this study was to present a simple, interactive, dynamic, and robust formulation of the cow value and the replacement problem including expectancy of cow's future production and replacement's genetic gain. The proven hypothesis of this study was that all of the above requirements could be achieved by using a Markov chain algorithm. The Markov chain model allowed to: 1) calculate a forward expected value of a studied cow and its replacement; 2) use a single model (the Markov chain) to calculate both the replacement policies and the herd statistics; 3) use a pre-defined, already established, farm reproductive replacement policy; 4) include farmer's assessment of a cow expected future performance; 5) include farmer's assessment of genetic gain with a replacement; and 6) use a simple spreadsheet or an online system to implement the decision support system. Results clearly demonstrated that the decision policies found with the Markov chain model were consistent with more complex dynamic programming models. The final user-friendly decision support tool is available at DairyMGT.info → Tools → The Economic Value of a Dairy Cow. This tool calculates the cow value instantaneously, is highly interactive, dynamic, and robust. Studying a Wisconsin dairy farm with the model, the solution policy called for replacing nonpregnant cows 11 months after calving or months in milk (MIM) if first lactation and 9 MIM if later lactations. The cow value for an average second lactation cow was: 1) when nonpregnant: a) $897 in MIM = 1 and b) $68 in MIM = 8; 2) when just became pregnant: a) $889 for a pregnancy in MIM = 3 and b) $298 for a pregnancy in MIM = 8; and 3) the value of a pregnancy loss when a cow became pregnant in MIM = 5 was: a) $221 when the loss was in first month in pregnancy and b) $897 when the loss was in the ninth month of pregnancy. The cow value indicated pregnant cows should be kept. The expected future production of a cow with respect to a similar average cow was an important determinant on the cow replacement decision. The expected production in the rest of the lactation was more important for nonpregnant cows and the expected production in successive lactation was more important for pregnant cows. A 120% expected milk production for a cow in MIM = 16 and 6 mo pregnant in the present lactation or in successive lactations determined between 1.52 and 6.48 times the cow value of an average production cow, respectively. The cow value decreased $211 for every 1 percentage point of expected genetic gain of the replacement. A breakeven analysis of the cow value with respect to expected milk production of an average second parity cow indicated that: 1) nonpregnant cows in MIM = 1 and 8 could still remain in the herd if they produce at least 84 and 98% in the present lactation or if they produce at least 78 and 97% in future lactations, respectively; and 2) cows becoming pregnant in MIM = 5 would require at least 64% of milk production in the rest of the lactation or 93% in successive lactations to remain in the herd.

Economics of resynchronization strategies including chemical tests to identify non-pregnant cows:
The objectives of this study conducted at the University of Wisconsin-Madison were to asses: 1) the economic value of decreasing the interval between timed AI (TAI) services when using a

pregnancy test that allows earlier identification of nonpregnant cows; and 2) the impact of pregnancy loss and inaccuracy of a chemical test (CT) on the economic value of a pregnancy test for dairy farms. Simulation experiments were performed using a spreadsheet-based decision support tool (UW-DairyRepro$). In Experiment 1, the impact of changing the interbreeding interval (IBI) for cows receiving TAI on the value of reproductive programs was assessed by simulating a 1,000-cow dairy herd using a combination of detection of estrus (30 to 80% of cows detected in estrus) and TAI. The IBI was incremented by 7 d from 28 to 56 d to reflect intervals either observed (35 to 56) or potentially observed (28 d) in dairy operations. In Experiment 2, the impact of accuracy of the CT and additional pregnancy loss due to earlier testing on the value of reproductive programs was evaluated. The first scenario compared the use of a CT 31 ± 3 d after a previous AI with rectal palpation (RP) 39 ± 3 d after AI. The second scenario used a CT 24 ± 3 d after AI or transrectal ultrasound (TU) 32 d after AI. Parameters evaluated included: sensitivity (Se), specificity (Sp), questionable diagnosis (Qd), cost of the CT, and expected pregnancy loss. Sensitivity analysis was performed for all possible combinations of parameter values to determine their relative importance on the value of the CT. In Experiment 1, programs with a shorter IBI had greater economic net returns at all levels of detection of estrus, and use of chemical tests available in the market today might be beneficial when compared to RP. In Experiment 2, the economic value of programs using a CT could be either greater or lower than that of RP and TU depending on the value for each of the parameters related to the CT evaluated. The value of the program using the CT was affected (in order) by the 1) Se, 2) Sp, 3) pregnancy loss, 4) proportion of Qd, 5) the percent of cows AI in estrus, and 6) the CT cost. A change of 1% in the Se of the CT was 1.8 times more important than a similar change in Sp and pregnancy loss, and 13.7, 55.0, and 305.8 times more important than a similar change in Qd, cows inseminated in estrus, and the CT cost. We conclude that the major impact of using a CT was the potential of decreasing the IBI. Moreover, inaccuracy of the CT and additional pregnancy loss due to earlier testing resulted in smaller economic differences than when using RP or TU 8 d later.

Impact of animal density on predicted greenhouse gas emission on selected conventional, organic, and grazing dairy farms in Wisconsin:

The objective of this study conducted at the University of Wisconsin-Madison was to test the impact of animal density (AD) on predicted greenhouse gas emission (PGE) in three Wisconsin farms with contrasting management systems. A combination of farm data and model-based predictions, using the Integrated Farm System Model, was used to derive PGE on 1 conventional (C), 1 organic (O) and 1 grazing (G) farm at 2 AD. The farms had a herd size of about 80 cows, 133 ha of forage land, and 0.6 cows/ha. At this low AD (LAD), the PGE were 0.53, 0.70 and 0.77 kg of PGE (CO2eq)/kg of milk for the C, O and G respectively and the main source of PGE was from housing facilities (47, 39, and 31% of total PGE on C, Oand G, respectively). The indirect emission sources (manufacture or production of fuel, electricity, machinery, fertilizer, pesticide, and plastic) accounted for 21, 12, and 30% of PGE on C, O and G, respectively. Other important PGE sources at LAD were feed production on C (19%), and grazing on O and G (35 and 14%, respectively). Doubling the AD (HAD, 1.2 cows/ha of forage land) increased PGE by 22.9% on C, mainly due to 48% increase from indirect sources. The emissions from feed production and indirect sources increased by 38 and 29%, respectively on O, but the emission from grazing and housing facilities decreased by 5 and 1.3%, respectively, which led to a 6.4% net increase. Finally, PGE decreased by 3.1% on G as the net result of a decrease in emissions

from manure storage and fuel consumption (41 and 20%, respectively) but 8% increase in indirect sources. These results demonstrated that the impact of AD on PGE was different on the 3 selected farms because of different farm management practices such as feeding, manure storage, and housing facilities. Although increasing AD might have a beneficial effect in reducing PGE per unit of milk on the selected G farm, results predicted a slight negative effect in the O farm and a more substantial negative effect on the C farm. Although the scope of the study is limited to the 3 selected farms, combining farm data with model-based predictions may be useful to study the changes in farm-level management practices on PGE.

A cluster analysis to describe profitability on Wisconsin dairy farms:
A survey was implemented on Wisconsin dairy farms to understand the impact of farm management on profitability. Farms were selected across 3 systems: conventional (C), grazing (G) and organic (O). The objective was to characterize main factors associated with profitability. A cluster analysis using complete linkage was conducted on 20 farms as preliminary analysis: 4 O, 4 G and 12 C. The analysis yielded 3 clusters. Cluster 1 included 1 O, 2 G and 6 C farms; cluster 2 included 4 C and 1 G farms; and cluster 3 included 3 O, 1 G and 2 C farms. Clusters 1 and 3 had the same income over feed cost (IOFC, $5.97 and $5.22/d per cow, respectively) whereas cluster 2 had an IOFC of $8.09/d per cow. Farms in cluster 2 had 71 cows and 95 ha and were managed by the youngest farmers (44 years old). They used a ration with 35% grass silage (GS), 1% hay, 18% corn silage (CS) and 46% concentrate (C). They had the greatest milk production (10,764 kg/cow per year) and the lowest percentage of milk withheld from sale (0.49%). They produced milk with 3.55% fat, 3.03% protein and 203,000 somatic cells (SCC), but received the lowest milk price (0.348$/kg). Farms in cluster 1 had 72 cows and 115 ha and were managed by 49 years old farmers. They used 20% GS, 32% hay, 12% CS and 36% C in the ration. They had a lower milk production (7,068 kg/cow per year) and more milk withheld (1.65%) than farms in cluster 2. Their milk had 3.78% fat and 2.99% protein with a price of 0.368$/kg. Farms in cluster 3 were the smallest farms with 48 cows and 54 ha and were managed by 49 years old farmers. They used 17% GS, 54% hay, 5% CS and 24% C in the ration. They produced the least amount of milk (4,146kg/cow per year) and withheld 3.08% of production. They had the greatest milk fat and protein content (4.36% and 3.25%, respectively), the greatest SCC (317,167) and the greatest milk price (0.480$/kg). The 3 clusters contained farms from different systems indicating that management system was not a major descriptor of IOFC. However, this study suggested that IOFC was associated with quantity and quality of milk, percentage of milk withheld, feeding strategy and age of the farmer.

2. USEFULNESS OF FINDINGS

<u>Objective 1 (Heifers)</u>:

- Results of projects investigating the effects of milk replacer feeding frequency and meal timing on performance and energy metabolism in Holstein dairy calves should provide useful information for dairy producers in the southeast United States. Feeding management strategies that can improve performance while reducing labor costs will be very beneficial to producers.

- Although ensiled forages are commonly included in diets of growing dairy heifers, little research has been conducted to evaluate feeding baleage as a primary forage source. Heifers

fed hay were 6.7 kg heavier than heifers fed baleage at the conclusion of the study. Heifers fed hay also gained 0.63 kg/day compared to 0.56 kg/day for heifers fed baleage. Overall, heifers fed hay consumed 0.30 kg more dry matter/day than baleage, resulting in a tendency for a 5.4% improvement in gain to feed ratios for hay compared to baleage. In summary, feeding baleage decreased body weight gain, but did not alter skeletal growth or rumen parameters in prepubertal dairy heifers. Grouping of veal calves after 6 weeks of age in groups of 4 or 8 improved social interaction and feeding/drinking behavior without compromising growth compared to smaller pens, despite some indication of greater exposure to respiratory disease.

- A common question of dairy producers is whether similar growth and first lactation milk production can be achieved using pasture as the primary source of nutrition as compared to conventional diet and rearing in confined facilities. Pregnant heifers on pasture had similar average dairy gain, body condition score and skeletal growth rates as measured by whither height and hip height, as conventionally fed heifers. Neither somatic cell counts nor projected milk, fat, or protein yields were different between pasture and conventionally fed heifers. Pasture can be used in rearing pregnant heifers without detrimental effects on skeletal development, milk production, or somatic cell counts.

- Increasing fiber levels in precision feeding heifer programs can be beneficial in increasing protein and dry matter digestibility. This can result in a 4 to 6% improvement in N utilization over traditional heifer diets. Improved newborn calf management can affect lifetime milk production in dairy cows.

Objective 2 (Cows):

- Rubber flooring in the feed alley for lactating cows may impact production, especially components, in first parity. Rubber flooring may affect cows surviving first lactation differently than those who do not. Future work with more cows is needed to ascertain results for traits like somatic cell count and days open that inherently have higher environmental variation. Cortisol did not indicate an acute stress at any time in the first lactation, when evaluated by treatment or by a treatment for a condition that may lead to lameness in that lactation. The number of times that cows were given therapy for hoof or leg conditions was greater for cows housed on concrete. Changes in lymphocyte and total white blood cell counts in cows housed on concrete indicated chronic inflammation, but acute phase proteins did not. Flooring tends to affect cow hoof health, alters immune cell counts and influences production and herdlife. However, cost of rubber flooring to enhance cow comfort, which was not directly measured in this work, may not be justified solely in terms of yields and herdlife.

- When lactating dairy cows are offered diets which allow sorting, they will eat to a relatively constant diet particle size when given the opportunity to sort for longer or shorter forage particles.

- Feeding dietary coconut oil (CNO; a natural source of mainly medium chain fatty acids) can result in significant reductions in enteric methane emissions in lactating dairy cattle. However, the predominant medium chain fatty acids in CNO also have marked negative influences on feed intake, milk yield, and the fat content of milk. It does not appear that CNO will be a

viable commercial candidate for dietary use to reduce enteric methane emissions because of major negative consequences on feed intake, milk yield and milk fat concentration.

- Drinking water of lactating dairy cows with concentrations of iron (Fe) of greater than 4 ppm reduced free water intake and affected the drinking behavior of cows. Overall, the ferrous form of Fe had more negative effects than the ferric form of water intake and consumption pattern. Significant numbers of dairy farms in the USA have drinking water with elevated iron.

- Inclusion of high level of field peas as a replacement for corn and soybean meal linearly decreased milk production and milk composition. Because rumen protein degradability of field peas is greater than soybean, protein utilization of diets with increasing concentrations of field peas was reduced resulting in lower milk production and milk protein percent.

- Canola meal can be substituted for distillers grains as a source of protein in high producing dairy cows diets without any significant effect on DMI, milk production, and milk composition. Increasing the concentration of protein from 15 to 17% resulted in greater milk yield, fat%, fat yield, and protein yield regardless of the source of protein.

- Overall, all cows sorted against long and medium feed particles while preferentially sorted for short and fine feed particles. Lactating dairy cows fed high forage diets sorted to a greater degree against long (91.2 vs. 97.6%) and medium (96.6 vs. 97.8%) particles compared to lactating cows fed the low forage diets. The addition of distillers grains did not affect sorting behavior by lactating dairy cows.

- The addition of distillers grains and changes in forage concentration alters the physically effective neutral detergent fiber of total mixed rations. Use of the Penn State method overestimates physically effective neutral detergent fiber of total mixed ration. Estimates of physically effective fiber by the Z-box method are similar to those by the dry sieving method.

- Producers will be able to trouble shoot low milk fat situations by analyzing bulk tank milk. Strategies will be developed to access management practices and diet formulations to correct the problem to increase milk fat concentration and improve overall farm profitability. Developing a management tool to assist producers with manure management related decision will help producers meet current regulations as well as develop mitigation strategies on the dairy farm.

- University of Nebraska research established that in cattle consuming 1.3% of body weight the rumen undergrable protein value of dried distillers grain and solubles is 63%.

- University of Nebraska research established that when dairy diets containing large concentrations of reduced fat dried distillers grain and soluble, a small portion (8.1 g) of the protein of yeast from the feed bypasses rumen degradation and reaches the small intestine.

- University of Nebraska research established that diets with reduced fat dried distillers grain and solubles will result in more milk when supplement with a rumen protected fat and milk fat depression may be avoided.

- Feeding MBR corn silage with a high dietary concentration of alfalfa hay did not affect milk production during early lactation; however, cows fed the BMR corn silage maintained longer peak milk yield, which resulted in increased milk production during mid-lactation, leading to greater overall milk production and milk protein yield.

- Significantly decreased milk urea nitrogen by feeding BMR corn silage or high quality alfalfa hay suggests improved whole-body N utilization efficiency.

- Results from these studies demonstrate that overstocking of dairy cows during the dry period results in physiological changes that are at least partially independent of feed intake. Furthermore, cows that rank lower in a competition index have evidence of increased stress and altered energy metabolism when housed in overstocked groups. This further reinforces the concept that not all cows are affected equally by management factors such as stocking density. Research at Cornel University also demonstrated that elevated concentrations of physiological biomarkers associated with energy metabolism, inflammation, and stress in postpartum cows are associated with decreased milk production and reproductive performance in the ensuing lactation. Researchers at Cornel University determined that varying trace mineral source fed to dairy cows during the transition period alters aspects of oxidative metabolism, suggesting links between dietary trace mineral supplementation and health in these animals. Finally, Cornel researchers demonstrated that supplementation of cows during the transition period and early lactation with specific trace nutrients alters uterine cytology such that incidence of subclinical endometritis was decreased – this has potential impact relative to the potential use of nutritional approaches to improve reproductive performance in dairy cows.

Objective 3 (Whole Farm):

- Although the Grazing Merit Preference Index (GM) was closely correlated to USDA Lifetime Net Merit Dollar (NM$) there was a change in rank among the bulls. This is further compounded by the fact that the weights placed upon each trait differ significantly from GM to NM$. This leads to a possible conclusion that while the current bulls that rank highest for NM$ index are also bulls that score high in GM, it is possibly a coincidence and a tendency that may or may not continue. While popular vote to select index weights may not be the best course of action, scientifically; responses indicate that there may be a need for modifications to NM$ to create a comparable index more appropriate for use by graziers. Work continues to determine appropriate economic weights for a grazing merit index.

- Use of evaluation tools and key farm data is a first step in improving profitability of PA dairy farms. Studying best management practices indicated that utilization of those tool outputs to improve production, milk quality or other management areas along with better communication with both employees and off farm advisors were needed to impact the bottom line of the business.

- Regression metamodeling of the value of pregnancy in dairy cows was reasonably accurate. Metamodels allow for approximate estimates that can be easily implemented in various applications, for example on-line. The Afilab system provides moderately accurate estimates of fat%, protein%, and lactose% for individual milkings. Multiple Afilab observations remain needed to provide a good estimate of these components for individual cows. The v.calculator spreadsheet is useful for instantaneous calculations of various changes in herd management, cow performance and prices.

3. PUBLICATIONS (Peer-reviewed Research and Extension)

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Cabrera, V. E. 2012. A simple formulation and solution to the replacement problem: A practical tool to assess the economic cow value, the value of a new pregnancy, and the cost of a pregnancy loss. J. Dairy Sci. 95:4683-4698.

Chapman, C.E., R.G. Cabral, S.P. Marston, A.F. Brito, and P.S. Erickson. 2012. Short Communication: Addition of sodium bicarbonate to maternal colostrum: Effects on immunoglobulin G absorption and hematocrit. J. Dairy Sci. 95:5331-5335.

Dennis, T. S., J. E. Tower, and T. D. Nennich. 2012. Effects of feeding hay and baleage on growth and rumen parameters in prepubertal Holstein heifers. Prof. Anim. Sci. *In Press.*

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Goodier, G.E., J.C. Williams, K.L. O'Reilly, T.G. Snider, C.C. Stanley, A.H. Dolejsiova, and C.C. Williams. 2012. Effects of supplemental vitamin E and lasalocid on growth and immune responses of calves challenged with *Eimeria bovis*. Prof. Anim. Sci. 28:97-107.
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Holden, L. A., J. A. Hyde, B. J. Hilty, and E. Cowan. 2011. Challenges and Opportunities for New and Beginning Dairy Producers: A Pennsylvania Perspective. Journal of Extension. Vol. 49. No. 3. (http://www.joe.org/joe/2011june/pdf/JOE_v49_3rb2.pdf).

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Husfeldt, A.W., M.I. Endres, K.A. Janni, and J.A. Salfer. 2012. Management and characteristics of recycled manure solids used for bedding in Midwest freestall dairy herds. J. Dairy Sci. 95:2195–2203.

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4. IMPACT STATEMENT

Objective 1 (Heifers):

- Continued emphasis on growth and development of heifers will ultimately add to improved production efficiency in dairy operations in Louisiana. These animals are the future milking cows, and research must continue to identify management strategies that can improve performance of these valuable animals.

- In the Deep South, animals are subjected to more than 100 days of heat stress per year which can contribute to high production losses. Though many producers calve seasonally, it is common to have large percentages of cows calve early and heifers born to dams in heat stress can be up to 20% lighter than those born to dams not under heat stress. Calf research at Mississippi State University was designed to test diets that would help calves developed during heat stress to increase growth rates before weaning. Improving growth rates and development of these calves would result in a large savings in production costs for dairy producers in the Deep South.

- The cost of raising dairy heifers is typically the second highest expense for dairy producers. Strategies that improve the feed efficiency and growth rates of heifers will improve the economic sustainability of dairy operations. A study done at Purdue University found that feeding dairy heifers dry hay as compared to baleage improved average daily gain of dairy heifers. In another study at Purdue University, the results demonstrated that component feeding using a hay feeder increased average daily weigh gain; however, the manner of feed delivery did not affect feed efficiency or growth in prepubertal dairy heifers.

- The heifer enterprise on dairy farms is usually considered to be approximately 20% of the cost of operating a dairy herd and 70% of heifer raising is made up of feed costs. Thus, research at University of Maryland is aimed at improving profitability of the dairy farm operation through reduced feeding costs.

- The use of commercial dairy calves for nutritional and management studies up to 6 months of age and the ability to follow these calves back to their respective dairy herds for first lactation performance provides a critical base towards attaining objective 1 of the NC-1042 project. In terms of application of the results to the field, benchmarks have been developed at the University of Minnesota for calf performance parameters that have been used for on-farm comparisons across the US. The addition of research data anticipated on organic production systems for dairy young stock will be an important diversification for the project revision.

- Fiber levels of dairy heifer rations can greatly impact digestibility and nutrient content of manure from precision fed dairy heifers. This could mean reducing manure production by 10 to 30% from heifer herds and could reduce N by 5 to 10% from traditional low quality high forage feeding systems.

Objective 2 (Cows):

- Reducing the loss of dry matter during ensiling allows dairy producers to increase the amount of silage they can feed from harvest. Inoculating silage can also improve the quality of the silage since pH and temperature are lowered quickly. This contributes to a greater profit for dairy farmers, allowing them to make better use of home grown feeds. Very little data exists on feeding inoculated corn silage to dairy cows and that data is conflicting where production numbers are concerned. Data from Mississippi State University will give farmers an indication of the ability to store corn silage in bag silos, with and without inoculants, as well as the impact on milk production when inoculated silage is fed to lactating cows.

- Reducing the impact of heat stress during the close up dry period can improve the transition time for cows, resulting in improved health and increased milk yield. Adding electrolytes to the water is typical on dairy farms, but not an accurate way to dose cows. Adding these electrolytes to the feed ensures that each cow received the appropriate dose and becomes an easy way to deliver the additives. Reducing the impact of heat stress on transitioning cows could increase milk yield, resulting in a greater profit for farmers in Mississippi and beyond.

- Water is a critical nutrient for dairy cows, though little work has looked at the effects of water intake on rumen parameters. A study conducted at Purdue University evaluated the effect of water intake on rumen parameters and determined the effects of increased dietary K on water intake in dairy cows. Increasing dietary K in the diets of lactating dairy cows increased water consumption, and milk production was increased when moderate amounts of K were fed. Even though water consumption increased, the total water weight in the rumen was decreased.

- Because on farm animal welfare assessments are becoming more common and expected by the consumer, knowing how to obtain accurate measurements of welfare is crucial. Other work performed at the University of Minnesota has helped dairy producers make housing and management decisions that can significantly impact profitability of their operations.

- Data from the Penn State and Ro-Tap particle separators produced different particle size distributions from the same sample. This indicates that data obtained from these 2 methods of particle separation are not directly comparable and that the method of particle separation should be considered when interpreting experimental or forage analysis results.

- Efforts focused on mitigation and measurement of enteric methane from lactating dairy cows. In one series of experiments at Michigan State University coconut oil, a source of predominantly medium chain (C-12 and C-14) fatty acids, was thoroughly evaluated characterizing the potential reduction of methane emissions and nutritional, ruminal and metabolic effects on lactational performance. Marked reduction in methane emissions was found, presumably due to effects on the rumen microbial ecosystem as well as reduced feed intake. However, lactational performance and milk fat concentration and yield were detrimentally affected to the degree that coconut oil is not likely a viable commercial feed ingredient unless revenue from the lost milk production could be recovered by new revenue generation for the amount of methane reduction.

- Drinking water of lactating cows with 4 ppm or greater iron concentration reduces preference for and consumption of water. Presumably feed intake and milk production also would be

reduced, but this has not been tested. It is not known if drinking water with iron concentrations between 2 and 4 ppm would be detrimental, as these concentrations have not been tested yet at Michigan State University.

- Technology research provides new insight into the utility of automated temperature monitoring. Decision support tools will help dairy farmers understand decision economics and make more informed decisions toward improved profitability.

- Research at South Dakota State University demonstrated: 1) Field peas can be fed up to 12% of the diet without negatively affecting production, but at higher levels of inclusion (24 and 36%), dry matter intake, milk production, and milk protein was decreased; 2) Canola meal can replace distillers grains as a source of protein in high producing dairy cows diets without any significant effect on dry matter intake, milk production, and milk composition; 3) The forage concentration of the ration explained the sorting behavior by lactating dairy cows. Feeding distillers grains had little effect on the sorting behavior by lactating dairy cows; 4) Estimates of physically effective fiber of the total mixed ration by the Z-box method are similar to that of the dry sieving method.

- Research data from University of California-Davis will be used to develop tools that will allow dairy producers to maintain overall sustainability by increasing profits and meeting environmental regulations.

- Dairy farms are under pressure to increase production, but reduce input costs. Feed costs are the single highest expense on a dairy and increasing. Feeding brown midrib corn silage, under western U.S. conditions, can be a viable way to improved milk production and nitrogen utilization while reducing amounts of high-cost concentrates.

- Management practices such as overstocking induce physiological changes in dairy cattle beyond those that can be described by alterations in feed intake. Furthermore, the degree of competitiveness of cows at the feedbunk in an overstocked pen is associated with these physiological changes. Physiological evidence for inflammation is present in 30 to 40% of dairy cows during the first week postcalving and is associated with markedly decreased milk yield and reproductive performance in these animals. Finally, dietary supplementation of specific trace elements to dairy cows during the transition period and early lactation appears to modulate oxidative metabolism and incidence of subclinical endometritis in early lactation.

Objective 3 (Whole Farm):

- Grazing dairy operations place emphasis on different traits for their cows than confinement dairy operations. Understanding the needs and preferences of grazing dairy operators will assist in the development of a New Merit Index for selecting sires for grazing operations. A Grazing Merit index (GM$) parallel to the US NM$ index was constructed using costs, revenues, and management characteristics representative of grazing systems. Inputs were obtained from surveys, literature, and farm financial record summaries. It appears that NM$ may provide guidance for pasture-based dairy producers, however a GM$ index based upon appropriate costs and revenues, is more beneficial.

- Improvements in dairy farm profitability can be made by increasing income over feed costs and by systematically identifying bottlenecks in production and financial management using benchmarking. Best management practices of higher profit herds included above average production and regular communication with off-farm advisors.

- Dairy producers in Wisconsin and elsewhere are always looking for cost-efficient and profitable management strategies to improve their bottom-line and guarantee their long-term economic and environmental sustainability. Dairy producers have indicated that they need support in making complex planning decisions to improve their efficiency of production, profitability, and for the dairy industry to remain sustainable. Management information systems are increasingly important for helping in the decision-making of dairy systems. Indeed, dairy farming is a decision-intensive enterprise where profitable decisions cannot be made without the use of decision aids. The dynamics of dairy farm systems warrants the utilization of sophisticated techniques to assess the impacts of management strategies to farm economics, which at the same time need to be user-friendly and ready to be applied at the farm level. Simulation techniques help to overcome these shortcomings assessing cost-efficiency and profitability even under highly uncertain scenarios. Wisconsin's applied research and extension programs are committed to provide relevant, up-to-date, research based, and field-tested decision aids to farmers, extension agents.

5. LEVERAGE

<u>Objective 1 (Heifers)</u>:

- The current work with SROC/University of Minnesota, allied industry and commercial dairy partnership has leveraged interest from non-partner collaborators to maintain the level of support needed to keep the project viable. The recent emphasis at WCROC/University of Minnesota on low input organic and conventionally dairy production will support a prevalent segment of the dairy sector.

- $14,500 + colostrum replacer and assays- Saskatoon Colostrum Co. for ongoing project evaluating IgG uptake with or without sodium bicarbonate, split into two feedings with or without milk replacer. (Erickson).

- Colostrum Replacer, milk replacer from Land O' Lakes for 40 calves for 9 weeks. Calf starter for 40 calves for 9 weeks from Blue Seal Feeds for behavior experiment. (Erickson).

- $25,000 for evaluating zero hour IgG in dairy calves- Saskatoon Colostrum Co. (Erickson).

- $10,000 Manual Manipulation of Calf Starter for Calves Fed Milk Replacer: Effects on, Growth, Starter Intake and Weaning. George Walker Milk Fund (Erickson).

Objective 2 (Cows):

- $20,000 Feeding sucrose to transition dairy cows to prevent metabolic disorders. Bernice Barbour Foundation (Cabral, Guindon, Erickson).

- $129,000 and niacin- Lonza for the evaluation of 48 g of niacin fed during the prepartum period in a large dairy field study. (Erickson).

- Nennich, T., J. Townsend, M. Schutz, and K. Ilelegi. 2011. Evaluation of factors limiting DDGS inclusion in dairy diets. Indiana Corn Marketing Council. $27,900.

- USDA/NIFA-Organic Research and Extension Initiative, "Assisting Organic Dairy Producers to Meet New and Emerging Milk Markets" – Brito et al., 2011-2015 ($2, 863,915).

- Multistate Hatch, "NC: 1042 Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises" – Brito et al., 2010-present ($9,000/year).

- Northeast SARE, "Integrating Grazing Research with Surveys to Assess and Advance the Current Knowledge about Kelp Meal Supplementation for Organic Dairy Farms in the Northeast" – Brito and Antaya, 2012-2013 ($14,963).

- Hatch Research Development, "Feeding High-Sugars Forage and Molasses to Organic Dairy Cows" – Brito, 2010-2013 ($36,000).

- USDA/NIFA-Organic Research and Extension Initiative, "Addressing the Research and Extension Needs of the Organic Dairy Industry in the Northeast – Brito and Townson, 2010-2012 ($31,300).

- Bewley, J.M. 2012-2013. Stochastic modeling of dairy investments. $50,000. Elanco Animal Health.

- Bewley, J.M. Evaluation of a novel milking pulsation system. $5,000. Milkline Research Support.

- Taraba, J.L., J.M. Bewley, G. B. Day, T. Missun. Compost bedded pack barn housing system for dairy manure storage/treatment. $132,941. NRCS-CIG Grant.

- Bewley, J.M., A.E. Sterrett, W.J. Silvia, L.M. Arnold. E. Aalseth, R.J. Harmon, M. Rossano. 2011-2014. Quantification of physiological and behavioral indicators of disease in dairy cattle using Precision Dairy Farming technologies. $139,472. Donations from IceRobotics, Milkline, SCR Engineers, and DVM Systems.

- Bewley, J.M., G. Heersche, and W.J. Silvia. Reproductive management programs that do not utilize visual detection of estrus: a comparison of a timed artificial insemination program

versus a program based on monitoring cow movement and activity. $87,500. SAE Afikim Research Support.

- Bewley, J.M. Technical and economic implications of the use of waterbeds as a freestall base in dairy herds. 2011-2013. $85,532. Advanced Comfort Technologies Research Support.

- Bewley, J.M., T.S. Stombaugh, E.S. Vanzant, and J.L. Taraba. 2011-2012. Impact of animal position within dairy compost bedded pack barns on animal performance and implications for barn design. $50,000. Precision Resource Management Special Grant.

- Bewley, J.M. and T.A. Reiter. 2010-2012. Effect of a liquid acid quaternary footbath solution containing a cationic surfactant on digital dermatitis in dairy cattle. $10,808. GEA Westfalia Surge Research Support.

- Bewley, J.M. 2011-2012. Effect of a footbath solution on digital dermatitis in dairy cattle. $5,095. Provita Research Support.

- Bewley, J.M. 2011. Characterization of management practices utilized by low somatic cell count Kentucky dairy herds. $750. Dairy Farmers of America Research Support.

- Maximize the use of canola meal in dairy feeds. $100,000. Kalscheur.

- Use of field peas in dairy cattle diets. $34,000. Kalscheur.

- Gifts funds from various groups to support on-going research at University of California-Davis. DePeters.

- Avoiding milk fat depression by feeding reduced fat DDGS (RFDDGS) to lactating dairy cows and understanding the associated rumen metagenome: $83, 855.00. Kononoff.

- Selection of corn silage hybrids to maximize productive performance of dairy cows. Mycogen Seeds; Total request: $121,465; Duration: 2012 – 2014. Young.

- Improving nutrient utilization, feed efficiency, and lactational performance of dairy cows by supplementing DEMP or/and Optigen in typical Intermountain West dairy diets. Alltech, Inc.; Total request: $62,442; Duration: 2012-2014. Young.

- Improved organic milk production through the use of the condensed tannin-containing forage legume birdsfoot trefoil. USDA-NIFA Organic Agriculture Research and Extension Initiative (competitive grant program), Total request: $1,019,411.00 ($16,446 as a co-PI), Duration: 2011 – 2016. Young.

- Work conducted leveraged approximately $248,000 of funding from private industry to support work to be reported during the FY12-13 reporting year. Overton.

Objective (Whole Farm):

- Two USDA-AFRI grants were funded. DeVries.

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