or above requirements. Using actual intakes the Mcal of NEg required for the observed gains were calculated to be within the NRC normal limits for lean tissue accretion. The 6BM treatment had similar gains and increases in carcass composition and a lower feed to gain than the other treatments indicating it balanced the AA and energy for lean tissue growth. Supplying an AA profile that is balanced for growth relative to available energy, maximizes lean tissue growth and minimizes excess CP.

## Ruminant Nutrition: Dairy - Minerals

### 162 Impact of minerals in water on ruminant production.

J. G. Linn* and M. L. Raeth-Knight, *University of Minnesota, St. Paul.*

Water is an essential nutrient for all animals. In the consumption of water to meet this requirement, animals often consume significant amounts of various minerals. The effects of the minerals contained in water on animal performance or health are not well researched or documented with the exception of sulfates, salinity and nitrates. Most studies or reports relating water quality to animal performance and even EPA water guidelines have only considered the total mineral content of the water and not the chemical form and the availability of minerals from the water. It is well documented in the animal sciences literature that the chemical form of a mineral used in feed supplementation affects the availability of the mineral supplemented. In water, pH along with the chemical form of the mineral, affect the potential availability of the mineral from water. Magnesium for example is found as $Mg^{+2}$ in most natural waters. When water pH is greater than 10, magnesium is usually combined with hydroxide to form MgOH. In water containing 1000 mg/L or more sulfate, significant amounts of Mg are combined with sulfate to form $MgSO_4$, whereas in waters low in sulfate, Mg complexes with bicarbonate or other anions. Routine water analysis only list total concentrations of minerals such as calcium, magnesium, chloride, sodium, sulfate, copper, iron, manganese and zinc along with pH. The chemical form or the availability of the mineral from water is not described. The objective of this presentation is to review what is known about the chemical forms of common minerals in water, the relationship between water pH and chemical form, the availability of minerals from water and ultimately relate this to requirements and potential affects on animal performance.

**Key Words:** Water Quality, Ruminant, Minerals

### 163 Quality water for dairy operations.

K. Mancl*, *Ohio State University, Columbus.*

Water quality is determined from the beneficial use of the water. In dairy operations water is used both for cleaning equipment and drinking water for the animals. Each use has its own requirements. To ensure that water meets quality requirements, regular water testing in necessary. A good water test is not a waste of money. Annual water tests present a record of the water system that is critical to every dairy operation. If the water supply is damaged through human activity, evidence of a safe, adequate water supply is required to present an effective legal case.
If regular testing reveals a water quality problem, dairy operators have 4 options to solve it. 1. Improve water supply protection. 2. Find and eliminate sources of contamination. 3. Develop a new source of water. 4. Treat water to remove contaminants.

**Key Words:** Water Treatment, Water Testing

### 164 Effects of inorganic and organic (4-Plex$^R$) trace mineral supplementation on milk production and reproduction.

J. D. Ferguson*[1], D. Tomlinson[2], and M. Socha[2], [1]*University of Pennsylvania, Kennett Square,* [2]*Zinpro Corporation, Eden Prairie, MN.*

A total of 138 pregnant Holstein cows were blocked by parity, production and season of calving and randomly assigned within block to one of two dietary treatments: daily supplementation with 443 mg of Zn, 444 mg of Mn, 261 mg Cu, and 25 mg of Co as inorganic sulfates (control) or a combination of inorganic salts and complexed trace minerals (treatment, 14 g of 4-Plex/day; containing 360 mg Zn from zinc methionine, 200 mg Mn from manganese methionine, 125 mg Cu from copper lysine, and 25 mg Co from cobalt glucoheptonate). Diets were fed from -60 d from projected calving date through 250 d postcalving. Liver biopsy and claw examination were performed at -60 d, 30 d, and 250 d relative to calving. Serum was collected at 30 d postcalving for analysis of NEFA, cholesterol, betahydroxy butyrate, and total protein. Milk production was measured twice daily. Insemination and health events were recorded as they occurred. Milk composition for fat, protein, SNF, MUN and SMSCC was analyzed weekly from composite of consecutive a.m. and p.m. samples. Milk production and composition were analyzed with a repeated measures model, covariately adjusted for EPA and previous milk production, where appropriate, using the PROC MIXED procedure in SAS statistical software. Reproduction was analyzed using PROC LIFEREG. Milk production, milk fat and MUN were not significantly different between supplement groups. Milk protein was significantly different between supplement groups (control, 2.91 sem .01; treatment 2.95 sem .02, $p<.04$). First service conception rate was not different between the supplement groups (33% overall), however pregnancy occurred more rapidly in the treatment cows after first insemination (hazard .194 sem .119 $p<.10$). There was no effect of treatment on any health variables or cows culled for health problems. To more closely exam reproductive effects of the organic trace mineral supplementation, a large trial across several farms would be valuable.

**Key Words:** Trace Minerals, Production, Reproduction

### 165 Effects of inorganic and organic (4-Plex$^R$) trace mineral supplementation on claw lesions.

J. D. Ferguson*[1], D. Tomlinson[2], and M. Socha[2], [1]*University of Pennsylvania, Kennett Square,* [2]*Zinpro Corporation, Eden Prairie, MN.*

A total of 138 pregnant Holstein cows were blocked by parity, production and season of calving and randomly assigned to one of two dietary treatments: daily supplementation with 443 mg of Zn, 444 mg of Mn, 261 mg Cu, and 25 mg of Co as inorganic sulfates (control) or a combination of inorganic salts and complexed trace minerals (treatment, 14 g of 4-Plex/day; containing 360 mg Zn from zinc methionine, 200 mg Mn from manganese methionine, 125 mg Cu from copper lysine, and 25 mg Co from cobalt glucoheptonate). Diets were fed from -60 d from projected calving date through 250 d postcalving. Cows were housed in a free stall barn with concrete alleys. Examination of claws and surrounding soft tissues was made by a trained clinician at -60 d, 30 d, and 250 d relative to calving. Cows were confined into a restraining stall for examination. Feet were washed and hoof detritus removed with a knife blade. Lesions were classified according to Toussaint (R.E. Toussaint, 1989) based on macroscopic examination of hoof and tissues. All feet were examined by one trained veterinarian throughout the study. Keratinous lesions were classified as follows: dorsal wall ridges, erosion of the heel bulb, abaxial wall lesions, double soling, white line separation, sole abscess, sole hemorrhage, sole ulceration or sole erosion. Lesions of the surrounding soft tissue were classified as follows: digital dermatitis, pododermatitis of the digit or interdigital area, interdigital fibroma, or hairy heel wart. Lesions were mapped for location on the claw and surrounding soft tissues and graded as to severity (.5, 1, 1.5, 2, 2.5, 3, .5 being mild and 3 being the most severe). A repeated measures, multinomial model was used to examine hoof lesions using PROC GENMOD in SAS statistical software. A total of 3160 claw examinations were made. Heel erosions were the most frequent claw lesion across all treatments and time periods. Supplementation with organic trace minerals was associated with a reduction in solar lesions at 30 d postcalving. By 250 d postcalving lesions were not different.

**Key Words:** Trace Minerals, Hoof Quality, Dairy Cows

## 166 Effect of exogenous phytase on phosphorus digestibility in dairy cows and calves.

D. Garikipati and R. Kincaid*, *Washington State University, Pullman.*

Two digestibility studies were conducted to determine if exogenous phytase improved phosphorus (P) digestibility in cattle fed diets containing barley. The first study evaluated exogenous dietary phytase on P digestibility in growing calves. Dietary treatments were: 0.37% P + no phytase; 0.37% P + 225 FTU/kg; 0.37% P + 450 FTU/kg; and 0.48% P + no phytase. Calves were fed the treatment diets from 6 to 12 wk of age. The diets contained an average of 0.86 mg phytate P/g of DM, i.e., about 23% of the dietary P was as phytate P. Growth rate (1.0 kg/d) and feed intake (1.2 kg/d) were not affected by dietary treatment. Plasma inorganic P (Pi) and the % P in the feces were increased ($P < 0.05$) by the high P diet but not by the exogenous phytase. Phosphorus digestibility, based upon lignin as an internal marker, was 81% in the calves and tended ($P = 0.1$) to be improved by exogenous phytase. The feces contained an average of 0.14 mg phytate P/g of DM and was not affected by exogenous phytase. In a second study, 16 lactating Holstein cows were arranged in 4 replicates of a Latin square with two grains (barley and corn), no or added exogenous phytase (427 FTU/kg TMR), and 4 periods of 21-d. Phytate P comprised about 50% of the total P (0.46%) in the TMR. Plasma Pi was higher ($P < 0.05$) in cows fed diets with exogenous phytase (5.7 vs 6.3 mg/dL). Using lignin as an internal marker, digestibility of phytate P (79.4% vs 85.3%) was increased ($P < 0.05$) by exogenous phytase. Although considerable phytase activity occurs in the rumen, physical properties of the diet and ruminal passage rates may prevent total hydrolysis of phytate. Whereas in young calves, exogenous phytase had little effect on P digestibility, exogenous phytase appears to increase absorption of P from dietary phytates in lactating cows.

**Key Words:** Phosphorus, Phytase, Cattle

## 167 Tissue selenium content and whole-blood glutathione peroxidase activity of lactating cows are increased by two organic forms of dietary selenium.

M. R. Waldron*[1], T. L. Ward[2], M. T. Socha[2], and T. R. Overton[1], [1]*Cornell University, Ithaca, NY*, [2]*Zinpro Corporation, Eden Prairie, MN.*

Forty lactating Holstein cows (90-170 DIM) were fed one of two organic forms of added dietary selenium (Se), an inorganic form, or placebo as a daily topdress to determine the effects of Se source on tissue selenium content and whole blood glutathione peroxidase (GPX) activity. All cows were fed a total mixed diet devoid of added Se. Following an initial 8-week depletion period, daily rations were topdressed with 7.5 mg of N-succinyl-L-selenomethionine (SSM; n=9), 7.5 mg of zinc-L-selenomethionine (ZSM; n=10), 7.5 mg of sodium selenite (NaSe; n=10), or 0 mg of added Se (CTL; n=10) in 25 g of sugar carrier. Treatments were continued for 8 wk and were then followed by a second four-week depletion period. Of the timepoints sampled, maximal tissue Se content occurred after 8 wk of supplementation; however, maximal whole blood GPX activity occurred 12 wk after the initiation of treatments, perhaps reflecting the time necessary for red blood cell turnover. Tissue Se content was increased by NaSe relative to CTL; however, both SSM and ZSM increased tissue Se content to a greater extent than NaSe. Whole blood GPX activity was increased by Se supplementation but was not different between NaSe, SSM, or ZSM. These results indicate that the SSM and ZSM forms of organic selenium have greater bioavailability and are thereby retained in tissues at higher concentrations than NaSe.

| Tissue | CTL | NaSe | SSM | ZSM | SEM |
|---|---|---|---|---|---|
| Liver (ng/g dry wt) | 660[a] | 1185[b] | 1709[c] | 1647[d] | 96 |
| Plasma Se (ng/ml) | 28.9[a] | 56.8[b] | 65.9[c] | 64.3[c] | 3.5 |
| Whole blood Se (ng/ml) | 92.6[a] | 119.1[b] | 137.1[c] | 139.6[c] | 5.6 |
| Milk Se (ng/ml) | 5.9[a] | 7.6[b] | 25.5[c] | 20.7[d] | 0.7 |
| Whole blood GPX (EU/ml) | 15.0[a] | 17.9[b] | 19.3[b] | 20.0[b] | 1.0 |

[1]Largest standard error of the means;
[abcd]Within row, means with uncommon superscripts differ ($P < 0.05$)

**Key Words:** Dairy Cow, Selenium, Bioavailability

## 168 Effects of molasses- versus corn-based supplements on the accumulation of selenium.

J. D. Arthington* and F. M. Pate, *Range Cattle Research and Education Center, University of Florida, Ona.*

Results from previous studies indicate that the S component of molasses interferes with Cu accumulation into the liver of cattle. Selenium can also combine with S to form insoluble complexes. Therefore, the objective of this study was to investigate the accumulation of Se into the liver of growing steers provided molasses- or corn-based supplements. Twenty-four crossbred (Brahman x British) steers were stratified by BW and randomly assigned to individual pens (two steers/pen). Two supplement treatments (6 pens/treatment) were formulated using corn and cottonseed meal or molasses and cottonseed meal. Each supplement was formulated to provide 1.5 kg of TDN and 0.3 kg of CP/hd. Supplemental Se (sodium selenite) was provided at a rate of 3.0 mg/hd daily. Supplements were fed 3 times weekly. To assess the effect of supplement composition on steer performance and Se status, individual steer weights, jugular blood, and liver biopsy samples were collected on d 0, 30, 60, and 90. Although intake of TDN did not differ among treatments, steers fed corn-based supplements tended ($P = 0.07$) to have a higher ADG compared to steers fed molasses-based supplements (0.10 and 0.24 kg/d for molasses- and corn-based supplements, respectively; SEM = 0.05). There was a significant ($P < 0.01$) sampling day x supplement source interaction for liver Se concentration. Steers fed molasses-based supplements had greater initial liver Se concentrations than steers fed corn-based supplements ($P = 0.02$). However, steers fed corn-based supplements had a greater overall increase in liver Se accumulation resulting in greater ($P < 0.01$) final liver Se concentrations vs molasses supplemented steers on d 90 (1.47 and 0.50 ppm; SEM = 0.18). There was no sampling day x supplement source interaction for plasma Se concentration or plasma glutathione peroxidase enzyme activity. These data suggest that components within molasses, namely S, inhibit the accumulation of Se into the liver of growing beef cattle.

**Key Words:** Selenium, Molasses, Corn

## 169 Manganese for lactating and dry dairy cows.

W. P. Weiss*[1] and M. T. Socha[2], [1]*Ohio State University, Wooster*, [2]*Zinpro Corporation, Eden Prairie, MN.*

The Mn requirement for lactating and dry dairy cows are 50 to 70% lower in NRC (2001) compared with the 1989 version. A Mn balance study (Exp. 1) was conducted using 18 dry Holstein cows to determine the intake of Mn needed to prevent body loss of Mn. These data were combined with a large data set (143 observations) in which Mn balance was measured using lactating (average milk yield = 30 kg/d) dairy cows (Exp. 2). In Exp. 1, dry Holstein cows were fed a standard diet (47 ppm Mn) starting at dry-off (approximately 60 d before parturition) and either given no supplemental Mn, or a daily bolus that provided 200 mg of Mn in the form of Mn sulfate or Mn methionine (Zinpro Corp., Eden Prairie MN). After approximately 30 d of receiving the treatments cows were moved to metabolism stalls for total collection of feces and urine for 4 d. Dry matter intake was not affected by treatment (11.8 kg/d). Intake of Mn for cows on the control, Mn sulfate, and Mn-met treatments were 471, 707, and 646 mg/d (control < supplemented; $P < 0.01$). Apparent digestibility of Mn (-2.6, 4.7, and 5.2% for control, Mn sulfate and Mn-met) was not different between supplemented groups but was higher ($P < 0.02$) for the supplemented groups than for the control group. Urinary excretion of Mn was not affected by treatment and was extremely low (< 0.5 mg/d). Apparent retention of Mn (-9.5, 20.2, and 24.5 mg/d for control, Mn sulfate, and Mn-met) was not affected by the form of supplemental Mn but was increased ($P < 0.06$) by Mn supplementation. When intake of Mn was regressed on Mn retention, tissue retention was 0 when the diet contained approximately 50 ppm Mn(approximately twice as high as the NRC requirement for dry cows). In Exp 2. Mn balance data measured in lactating dairy cows were regressed using Mixed Models procedures with trial included as a random variable to determine the average intake of Mn required to obtain 0 tissue retention. The resulting equation was: Mn balance (mg/d) = -190 + 0.29*Mn Intake (mg/d). Based on that equation an intake of 655 mg of Mn/d was required for 0 retention. That value corresponds to an average dietary concentration of 31 ppm of Mn which is approximately twice as high as the NRC recommendation for lactating cows.

**Key Words:** Manganese, Mineral, Requirement

**170 Effect of glutamine supplementation on immune responsiveness and milk production in dairy cattle.** L. Doepel*[1], N. Gagnon[1], M. Lessard[1], G. E. Lobley[2], J. F. Bernier[3], and H. Lapierre[1], [1]*AAC Dairy and Swine R & D Center, Lennoxville, QC, Canada*, [2]*Rowett Research Institute, Aberdeen, UK*, [3]*Université Laval, QC, Canada*.

Sixteen multiparous Holstein cows were used to determine the effect of glutamine (Gln) on immune responsiveness and milk production during the immediate postpartum period, when there are competing demands from the gut, mammary gland, and immune system. Cows received abomasal infusions of either 300 g/d Gln delivered in 10 L of water (8 cows) or water alone (8 cows) for 21 d following calving. During d14-21, treatments did not affect milk yield (39.3 vs. 40.5 kg, $P = 0.66$), protein content (2.99 vs. 2.98%, $P = 0.87$) or fat content (3.92 vs. 3.73%, $P = 0.46$), for water and Gln, respectively. Peripheral blood mononuclear cells (PBMC) were isolated from blood collected by jugular venipuncture on d -25, 4, 11, and 18 relative to calving. Interferon-$\gamma$ concentrations, the lymphocyte proliferative response to concanavalin A (0.5 $\mu$g/ml), and cell subpopulations were determined on the PBMC. Leukocyte counts and differential analysis were also performed on these days plus on d -12, -3 and 1 relative to calving. Interferon-$\gamma$ concentration did not change over time ($P=0.35$). Lymphocyte proliferation was not affected by treatment (0.84 vs. 0.71 for water and Gln, respectively; $P = 0.38$), or by time ($P = 0.44$). There was a tendency ($P=0.09$) for a treat*time interaction for the CD4 population, due to a reduction at d4 for the water treatment compared to d 11 and 18, while there was no change for Gln treatment. Leukocyte and neutrophil counts changed over time ($P < 0.001$), with the counts being higher on d1 than during the treatment period. The data from this study suggest that Gln supplementation does not improve the immune status of postpartum dairy cows.

| | Pretreat[1] | | | | Treat[2] | | | |
|---|---|---|---|---|---|---|---|---|
| | Precalf | SEM | Day 1 | SEM | Water | Gln | SEM | P[3] |
| IFN-$\gamma$, pg/ml | 1353.0 | 303.7 | —- | —- | 1042.4 | 1164.94 | 179.9 | 0.65 |
| Cell count/$\mu$l | | | | | | | | |
| Leukocytes | 6642.3 | 368.9 | 9749.6 | 549.7 | 7203.2 | 7229.8 | 498.4 | 0.90 |
| Eosinophils | 458.8 | —- | 227.0 | —- | 251.0 | 195.8 | —- | 0.59 |
| Lymphocytes | 2434.0 | 174.4 | 2536.0 | 243.5 | 2958.7 | 2717.6 | 220.7 | 0.58 |
| Monocytes | 686.7 | 58.9 | 1018.9 | 116.8 | 888.7 | 809.6 | 105.0 | 0.07 |
| Neutrophils | 2932.1 | 176.4 | 5830.7 | 520.5 | 3059.5 | 3276.8 | 528.1 | 0.75 |
| Cytometry, % | | | | | | | | |
| B cells | 14.2 | 5.0 | —- | —- | 16.2 | 13.8 | 2.1 | 0.43 |
| CD2 | 57.1 | 3.9 | —- | —- | 63.5 | 66.7 | 2.6 | 0.43 |
| CD4 | 28.0 | 3.1 | —- | —- | 33.7 | 38.1 | 1.5 | 0.06 |
| CD8 | 15.2 | 2.1 | —- | —- | 16.0 | 17.5 | 1.1 | 0.38 |
| Gamma-delta | 9.7 | 1.3 | —- | —- | 12.2 | 7.9 | 1.4 | 0.06 |

[1]Pretreat=mean of d -25, -12, and -3, and both treatments;
[2]Treat=mean of d 4, 11, and 18; [3]P=P-value for treatment effect

**Key Words:** Glutamine, Immune Response, Dairy

## Breeding and Genetics: Genetics of Efficient Feed Utilization

**171 Mechanisms regulating feed intake: role of appetite-regulating peptides.** M. G. Thomas* and K. L. Shirley, *New Mexico State University, Las Cruces*.

Feed intake, or appetite, is a multifaceted physiological event. Regulation of feed intake can be attributed to, or modulated by, energy expenditure, the interaction of diet with the digestive system, and (or) central mechanisms influenced by flux of neurotransmitters and neuropeptides. The latter directs discussion towards the basal hypothalamus as a focal point by which the brain receives input of the body's metabolic state and interprets this information for appetite and modulation of other systems such as growth, reproduction, or lactation. Discovery and research of gut and appetite-regulating peptides has been increasing for almost a century. In the last decade, considerable emphasis has been placed on hormones derived from adipose tissue, such as leptin and adiponectin. Leptin is a physiologic antagonist to a potent orexigenic brain peptide, neuropeptide Y (NPY). The leptin receptor is co-localized with NPY on neurons within the ventro-medial hypothalamus of the ruminant. Intracerebroventricular (ICV) infusion of NPY stimulates appetite and infusion of leptin suppresses appetite. Suppression of appetite has also been observed with central infusion of insulin. These types of studies were effective for evaluating neuro-regulation of appetite; however, they may only explain gross effects of these neuropeptides on appetite, as concomitant to ICV infusion studies, increases in serum concentrations of leptin parallel increases in daily feed intake level and body weight in growing animals. Thus, fine control of appetite may be more related to gene regulation or receptor binding affinity for factors such as NPY and leptin. For example, as ruminants age and fatten, leptin receptor expression levels appear dynamic within the hypothalamus and pituitary. Development of marker assisted selection programs are challenging, especially for polygenic traits such as level of feed intake or residual feed intake. Further understanding of the influences of environmental and intrinsic factors are needed to narrow this search for candidate genes. Physiologic knowledge of signals of adiposity, neuropeptides, and their receptors could aid this process.

**Key Words:** Appetite, Neuropeptide Y, Leptin

**172 Genetic variation in feed utilization: selection responses in mice.** M. K. Nielsen*, *University of Nebraska, Lincoln*.

Selection for high (MH) or low (ML) heat loss per unit size (kcal/kg$^{.75}$/d), measured in direct calorimeters, and no selection (MC), have been practiced in mouse lines as a proxy measure for feed energy requirement for maintenance. Selection was only in males. All selection lines were present in 3 independent replications making a total of 9 lines. Selection ceased after 16 generations. All 9 lines were maintained without intentional selection for 26 generations. Selection recently resumed and is practiced again for the same criterion (high or low or no selection) in each of the lines. During the original selection, realized heritability of heat loss was 0.28. After initial selection, feed intake was 9% greater in MH and 11% less in ML, both as compared to MC. After re-initiating selection, feed intake is 7% greater in MH and 15% less in ML, both as compared to MC. Differences in heat loss and feed intake persist through very mature ages. No difference in longevity has been detected. Genetic correlations with heat loss, and probably maintenance energy requirement, are: positive with ovulation rate and locomotor activity, negative with body fatness. Locomotor activity of MH mice was twice that of ML, and MC mice were intermediate. Locomotor activity differences explained 36% of the differences in maintenance feed intake between lines. When reared in hot or cold environments, there was no line x environment interaction for feed intake, body weight or fatness. MH mice had reduced litter size in the cold, but performance of ML mice relative to MC did not interact with environment. ML mice are adaptable to chronic stressors, but MH mice are not, as measured by serum corticosterone level. Estimates of energy costs per unit of gain (total, or fat and non-fat) do not appear to be different between the lines. Thus, genetic variation in feed intake, after accounting for possible differences in rate and composition of gain, appear to be mostly if not totally explained by differences in maintenance energy costs per unit size. Selection to reduce energy for maintenance was successful; non-desirable responses were a reduction in ovulation rate and an increase in body fatness.

**Key Words:** Selection, Feed Intake, Mice

**173 Genetic evaluation of efficient feed utilization in beef cattle.** D. H. Crews, Jr.*, *Agriculture and Agri-Food Canada Research Centre, Lethbridge, Alberta, Canada*.

The wide range of traits for which most beef breed associations predict EPD focus on increasing the outputs of the production system, thereby increasing the genetic potential of cattle for reproductive rates, weights, growth rates, and end product yield. Feed costs represent a large proportion of the variable cost of beef production and genetic improvement programs for reducing input costs will likely include traits related to feed utilization. Feed conversion ratio, defined as feed inputs per unit output, is a traditional measure of efficiency that has significant phenotypic and genetic correlation with feed intake, growth rate, and mature size. One limitation is that favorable decreases in feed to gain as correlated response to increased growth rate does not necessarily relate to specific improvement in efficiency. Residual feed intake is defined as the difference between actual feed intake and that predicted on the basis of requirements for maintenance of body weight and production. Phenotypic