The depression of energy intake in the peripartum period exacerbates the transition to lactation, increasing risk of ketosis and fatty liver and extending negative energy balance. Research with non-ruminants suggests that meals can be terminated by signals carried from the liver to the brain via afferents in the vagus nerve; these signals are affected by hepatic oxidation of fuels and generation of ATP. We call this the **Hepatic Oxidation Theory** of food intake control and find it consistent with effects of diet on feed intake of ruminants. Cows enter a lipolytic state pre-partum caused by decreased insulin concentration and increased insulin resistance of tissues, increasing plasma NEFA concentration. This provides abundant substrate for hepatic oxidation, likely depressing feed intake, even as negative energy balance increases.

While NEFA is a primary substrate for hepatic oxidation, its constant supply to the liver through the peripartum period cannot explain control of individual meals. Recent work suggests that temporal patterns of fuel absorption, mobilization, and metabolism affect feed intake in ruminants by altering meal size and frequency. Of fuels metabolized by the ruminant liver, propionate is likely a primary satiety signal because its flux to the liver increases greatly during meals. Propionate is extensively metabolized by the ruminant liver, but is little net metabolism of acetate or glucose, which may explain why these fuels do not consistently induce hypophagia in ruminants. Lactate is metabolized in the liver but has less effect on satiety probably because hepatic uptake during meals is low. Propionate is utilized for gluconeogenesis or oxidized in the liver and stimulates oxidation of acetyl CoA. A shortage of glucose precursors and increased fatty acid oxidation in the liver for fresh cows leads to an abundance of NADH and a lack of TCA cycle intermediates, resulting in a buildup of the intracellular acetyl-CoA pool and export of ketone bodies. In this situation, hypophagic effects of propionate are likely enhanced, because propionate entry into the liver provides TCA cycle intermediates that allow oxidation of acetyl-CoA. Oxidizing the pool of acetyl-CoA rather than exporting it dramatically increases ATP production causing satiety.

Strategies to increase energy intake through the transition period include reducing NEFA supply to the liver and reducing acetyl CoA oxidation during meals. A better understanding of metabolic regulation of feed intake will allow diets to be formulated to increase the health and productivity of dairy cows.
Abstract

The transition period is particularly important for health and subsequent performance of dairy cows, which are exposed to drastic physiological changes and metabolic stress. During that period cows are susceptible to increased incidence of metabolic and infectious diseases. Oxidative stress in a living organism is a result of an imbalance between reactive oxygen species production and neutralizing capacity of antioxidant mechanisms. Oxidative stress is responsible for a peroxidative damage of lipids, proteins and other macromolecules, with consequent alteration of cell membranes and other cellular components. This leads to the modification of important physiological and metabolic functions which can be responsible for alteration of the physiology and could cause pathologies. Inflammation is a basic way in which the body reacts as protective or destructive response to infection, irritation or other injury. Inflammation have a local defense meaning and is now recognized as a type of innate immune response (nonspecific).

The periparturient period of dairy cows is often characterized by an imbalance between oxidants and antioxidants leading cows to be more susceptible to oxidative stress. Moreover, periparturient period is also characterized by systemic inflammatory conditions. Metabolic stress, lipid metabolism, diseases and physiological changes are associated with oxidative stress and systemic inflammation during transition in dairy cows. Oxidative stress is probably a contributing factor to systemic inflammation, inflammation-based diseases, and immunosuppression in transition dairy cows. Reduced antioxidant capacity and enhanced proinflammatory status may be related and this relationship may play a role in dairy cattle disease susceptibility during the periparturient period. The possible role of oxidative stress and systemic inflammation in determining alteration of liver function and fatty liver in transition dairy cows is discussed.

Heat stress, metabolic stress, high body condition, high body weight loss and increased circulating concentrations of non-esterified fatty acids, are responsible in worsening oxidative stress and inducing systemic inflammation in transition dairy cows. The enhancement of oxidative status supplementing dairy cows diet with antioxidants during transition period, may be beneficial in improving metabolic status and liver function. Most of studies related to Se and vitamin E. More researches are needed to establish the requirements and the real beneficial effects from supplementation of antioxidants in preventing immune dysfunction and oxidative stress in transition dairy cows.

Understanding more about the primary causes of oxidative stress and systemic inflammation and the complex interactions of metabolism, immune activation, stress physiology, and endocrinology during peripartum, may facilitate to meet the nutrient requirements of cows during early lactation and reduce the susceptibility to disease as a function of compromised oxidative status and inflammatory responses.

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SUBCLINICAL KETOSIS: TO TREAT OR NOT TO TREAT?
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Postparturient (type II) ketosis, mostly subclinical in degree, is a common disease associated with decreased milk production, decreased reproductive performance and increased risk of displaced abomasum in dairy cattle. Based on the assumption that treating it will prevent the anticipated losses, it is often recommended to perform ketosis screen-and-treat programs in fresh cows. However, secondary prevention trials have yet to be published, and therefore it is still unknown how much of the losses may really be prevented by this intervention.

A clinical trial, which will be the focus of this presentation, was conducted to assess the effect of a post-parturient ketosis treatment on the occurrence of DA, milk production, reproductive performance and risk of removal from the herd. Fresh cows mostly between 1 and 15 DIM from 4 large Holstein herds were screened daily for the presence of urine ketones. Eligible positive cows were enrolled into the trial and randomly allocated to one of two groups: treated versus controls, allowing for the relief treatment of protracted or complicated cases in the control group for humane reasons.

The negative associations between ketosis and displaced abomasum, milk yield and reproductive performance were confirmed in this study. However, the ketosis treatment itself showed no positive effect on those clinical endpoints, and a negative association between treatment and culling hazard was even observed, but not explained.

The lack of response to this screen-and-treat program may raise questions about the actual role of ketosis on the causal pathway between some actual precursory metabolic disturbance and the observed changes in clinical outcomes. A better understanding of the how, and why, of ketosis development is necessary in order to help mitigate the negative effects that are so strongly, if not causally, associated with ketosis.

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PREPARTUM CONTROLLED ENERGY DIETS: WHAT SHOULD OUR DIETARY “ENERGY STRATEGY” BE?

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Scope and Nature of the Problem

Dairy cows during the transition period continue to be plagued by numerous health disorders around calving. As many as one of every two cows that calves succumbs to one or more metabolic disorders or infectious diseases around or after calving in some herds. While nutrition is known to influence the adaptations to lactation, the optimal nutrition program during the dry period has remained controversial.

Background

Requirements for energy during the dry period are quite modest, averaging around 14.5 Mcal of NEL (100 MJ ME) per day. Adequate energy intake can be easily achieved from a variety of diets; indeed it is easy for cows at ad libitum intake to consume too much energy if the dietary energy density is not controlled. Increased energy intake over requirements can cause larger drops in dry matter intake (DMI) before calving, increase body fat mobilization after calving, increase fat accumulation in the liver, and impair subsequent reproduction. Overfeeding during the dry period can lead to increased fat deposition in visceral adipose tissues, from which blood drains directly to the liver.

Evidence does not demonstrate conclusively that a short period of higher energy intake before calving, commonly called a “steam-up”, “close-up”, or “pre-fresh” diet, actually leads to greater milk production. It is clear, however, that it does increase body fat mobilization after calving, which increases milk fat content and production; thus, energy-corrected milk yield may increase. This increased fat mobilization also increases risks of fatty liver and subclinical ketosis, which in turn increase risks for other disorders and delayed reproduction.

Remedies, Solutions, Understanding – and benefits to society and the environment

Controlling energy intake by cows so that they meet but do not greatly exceed their requirements seems to be the most biologically justified approach. Energy intake can be controlled by limit-feeding or by increasing bulk and so limiting total energy intake by restricting total DMI. So-called “controlled-energy, high-fiber” diets use large amounts of cereal straw to dilute the energy content of corn silage and other high energy feeds and have been widely successful in the field if implemented appropriately. The approach is amenable to single-group dry cow management. Making sure that cows do not sort the bulky ingredient is the most important management concern. Successful implementation has shown large benefits in decreasing health problems which improves animal welfare and farm profitability.

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CALVING IS NOT A DISEASE: CAN GROUPING STRATEGIES ENHANCE DAIRY COW WELLBEING?
Mark E. Fox DVM, Deckerville Veterinary Clinic

The anticipation of dairy cows calving (“freshening”) has always been at the heart of most dairy farmers. For those of us in the dairy veterinary field, watching the dry cow as she re-enters the milking herd is an important and enjoyable part of our practice. However, this period of the dairy life-cycle (transition period) is often wrought with negative outcomes i.e. metabolic, immunologic, and infectious disease. These outcomes affect the dairy industry negatively in most areas, profitability, attitudes on the farms, and certainly animal wellbeing.

As we are aware, the reasons for transition difficulties are many, nutritional, environmental, behavioral, and exercise are factions to name a few. Volumes of new information and research in the biology of the transition cow have assisted in our management…yet we have room to improve!

Recently, there have been opportunities to re-address feeding and grouping strategies utilized on dairy farms. The reasons for this include tighter profit margins, relatively higher feed costs, and the restricted use of effective management tools, such as BST, due to market/consumer trends. One area of particular interest is developing feeding/grouping strategies to minimize excessive weight gain during mid-late lactation. In practice this involves body condition scoring all animals in the milking herd at timely interval thru lactation. Taking this “hands on” approach allows us to group animals and formulate diets to prevent excessive over conditioned cows. This practice, along with feeding low energy dry cow diets may alleviate some of the transition disease described some three plus decades ago by Morrow.

The adoption of management practices to reduce transition cow disease is truly an animal welfare issue as we are all aware. Hopefully, through management, the positive event of “freshening” the dairy cow will remain our goal.

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OPTIMAL BODY CONDITION SCORE FOR DAIRY COWS
Phil Garnsworthy, University of Nottingham.

Body condition score (BCS) provides a rapid evaluation of body fat reserves at almost zero cost. Body fat reserves play an important biological role in early lactation by buffering the cow against feed shortages at a time when she partitions energy mainly towards milk. However, rapid mobilisation of body fat reserves causes fertility and health problems. It is important that BCS at calving is optimised, bearing in mind the underlying biology of the cow.

Cows in negative energy balance mobilise body fat to support milk production. Increasing body fat reserves at calving allows greater fat mobilisation and higher milk yields; maximal milk yield response occurs between BCS 3.5 and 4.0. Studies in the 1980s showed that body fat has a negative feedback effect on feed intake. Each individual dairy cow has a genetically-programmed target BCS that she aims to reach about 10 to 12 weeks after calving. If BCS is above this target, DMI is reduced and she loses condition; if BCS is below this target, DMI is increased and she gains condition. Numerous studies confirm the strong negative relationship between BCS at calving and change in BCS during early lactation. The biological drive to attain a target BCS appears to be as strong as the drive to attain a genetically-programmed peak milk yield. The philosophy of getting cows in ‘good condition’ at calving is, therefore, counter productive. Instead of a high BCS at calving compensating for low feed intake in early lactation, it actually reduces feed intake still further and exacerbates negative energy balance.

Cows that are excessively fat at calving are more likely to develop fatty liver and ketosis because DMI is reduced and body fat is mobilised too rapidly. Such cows exhibit severe negative energy balance and poor reproductive performance. However, even moderate levels of fat mobilisation are associated with negative energy balance and reduced fertility. Several studies have shown that genetic selection for high milk yield, negative energy balance, body fat mobilisation, high plasma NEFA, and low plasma insulin are associated with delayed ovulation postpartum and reduced pregnancy rates.

BCS at calving predicted to give no change in early lactation has decreased from 2.49 in 1980s’ studies to 2.21 in recent studies. A BCS loss of 0.5 units is considered acceptable and provides a safety margin to allow for variation among cows. As with any biological parameter, there will be a spread of BCS values and responses among cows. Attention should be focussed on cows in late lactation and the dry period to ensure that they calve with BCS between 2.5 and 3.0 to optimise health, fertility and lifetime performance.

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2010 Discover Conference

Interpretive Summary

Transition Cow Overview

J.P. Goff1, T. Overton2, T. Duffield3, M. Overton4

1. Iowa State University, 2. Cornell University, 3. University of Guelph, 4. University of Georgia

In 1999, the 2nd ADSA Discover Conference focused on the problems of the transition dairy cow. Eleven years later we meet again to discuss these problems. Despite a great deal of work on this area and some dramatic improvements, the health of the dairy cow has not improved tremendously. This talk will summarize the thoughts from 1999 and give brief overviews of current thoughts on the etiology and preventative measures for the common disorders of the transition dairy cow. An introduction to the topic of some of the 2010 conference speakers will point to gaps in our current knowledge of the transition cow, which we hope these speakers can begin to fill in.

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Individual cow monitoring
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As a consequence of changes in price relations and a structural development in the dairy industry, the average herd size has increased rapidly in many countries, and e.g. in Denmark it has doubled over the last decade while the number of herds has been halved. This structural development is expected to continue. In these larger units the farmer or farm staff has to look after an increasing number of animals concerning disease, reproduction, production and welfare. This, together with the high labour costs or lack of qualified staff, consumer and society demands on product quality, animal welfare, and concerns about the environmental and climate effects of livestock production, calls for automated precision management, including individual cow monitoring.

The incidence risk of the production diseases and reproductive problems is still substantial despite decades of effort to prevent the diseases (Ingvartsen et al., 2003; Friggens et al., 2010; Ingvartsen, 2006). This is not to say that the preventive measures up till now have been useless. The preventive measures have most likely improved the health in many problem herds. But why is the incidence of production diseases still high? This is probably because the improvements in prevention have been outweighed by an increasing incidence of production diseases due to e.g. selection for higher production and altered production systems and conditions. Further, the preventive measures have generally focused on implementing changes at the herd level, for instance in feeding, rather than at individual cow level.

Monitoring of individual cows and use of automated precision management that combine advanced technologies and biological knowledge to organize dairy production are needed. Such systems should result in low disease incidence and severity, minimize impact on the environment and climate, result in the requested product quality, and secure optimal production and reproduction efficiency in order to be interesting and profitable for the dairy farmer. New opportunities in monitoring and early diagnostics on individual cow level are now available, e.g. Herd Navigator. Challenges for future disease prevention and management of individual dairy cows are believed to include monitoring “physiological imbalance” and understanding how e.g. nutrition and management of the individual cow should be changed to bring the cow in balance and thereby reduce risk of disease and suboptimal performance and improve welfare.


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MINIMIZING TIME IN NEGATIVE ENERGY BALANCE POSTPARTUM:
INCLUSION OF VARIOUS DIETARY FATS
Tom Jenkins, Clemson University

The timing of adding fat to lactation rations has been the subject of considerable debate. The addition of fat to the ration at the onset of lactation is often recommended to coincide with the rapid increase in energy demands of the cow. Alternative recommendations promote delaying the inclusion of fat supplements until one to two months postpartum when the milk response to the added fat is improved. The biological and production implications of feeding various fat sources prior to parturition will be examined, including a review of key studies. Four benefits of prepartum fat addition have been proposed and will be discussed. These include 

1) **Prepartum fat addition as a way to adapt cows to increased fat intake, perhaps enhancing feed intake and improved milk response in later lactation.** Well designed and controlled studies examining the merits of feeding fat prepartum to improve postpartum milk response are limited but generally do not support any production advantage. 

2) **Maintain energy intake and body energy reserves to prevent metabolic disease.** Increased energy demands immediately postpartum exceed energy intake by lactating cows causing a negative energy balance lasting several weeks. The energy deficit causes lipid mobilization from body fat reserves, which increases circulating nonesterified fatty acid (NEFA) concentrations in blood, which can lead to metabolic diseases such as ketosis and fatty liver. When examined across a multitude of studies, the general trend is for a net increase in plasma NEFA concentrations with increasing dietary fat fed prepartum. There were exceptions, however, where fat supplements reduced NEFA, but the fat effect was often confounded with fat-induced depressions in feed intake. 

3) **Feed CLA prepartum to reduce milk fat percentage and improve energy balance postpartum.** A few studies examined feeding of CLA that cause milk fat depression resulting in less milk fat and subsequently less milk energy output, which may reduce body fat mobilization and the rise in blood NEFA. As a result, reduced incidence of problems associated with high blood NEFA, namely ketosis and fatty liver, might be seen. 

4) **Feed fat prepartum to improve reproductive performance of cows.** The merits of feeding fat prepartum to improve reproductive performance of dairy cows continue to show promise. Much of the attention is directed at feeding additional omega fatty acids to enhance production of key prostaglandins involved in reproduction.

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Hepatic Oxidation in Transition Cows

Results from the Field

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I was introduced the Hepatic Oxidation Theory (HOT) in December of 2007 by Dr. Mike Allen at the Michigan State Dairy Nutrition Roundtable.

In the HOT theory simply the cow’s glucose demand drives intake. If the glucose demand is met by hepatic conversion of propionate and lactate, any additional propionate and lactate are oxidized in the liver causing firing of along the vagus nerve which causes satiety. If the cow’s glucose demand is not being met by the levels of propionate and lactate being converted in the liver she will eat until bulk fill limits intake. Therefore by optimizing the fermentability of the ration and limiting the amount of bulk fill milk production can be maximized.

I was intrigued by the theory and began looking for situations to implement this type of lactating cow rations.

The first opportunity I had to implement HOT was in January of 2008. The herd was 160 cow dairy in northern Indiana. The herd was housed in a 4 row barn and grouped in three pens - 1st calf heifers, high cows and low cows. The high cows were the 60 freshest mature cows on the farm and there were 60 freestalls and 60 headlocks in the pen. The dairy was averaging approximately 30 kg of milk with 3.6% milk fat. When we started the high group was averaging approximately 37 kg.

The high group ration contained 4 lbs of straw and the nutritionist was adding the straw to the diet to slow rate of passage as the cows were eating 27 kg DM and only milking 37 kg. The herd was also feeding below average alfalfa balage. The heifers were on the same diet as the high cows and low group was on a similar diet without as much straw and more forage.

I thought that this herd presented a great situation to try to feed these cows based on HOT. The producer allowed me to put an ideal diet together without regard to cost. So the confounding factor in saying the response we saw was based on HOT alone was that I also amino acid balanced the diet. Although the previous nutritionist had been formulating with CPM Dairy – the diet was lacking in MP methionine. The one challenge that I could see was there was no “just fresh” pen. I had suggested we move the just fresh cows into the low pen first, but the producer did not want to do that.

In the high group and 1st calf heifer ration I eliminated the straw, lowered the alfalfa balage and dry alfalfa hay to 18% of the diet dry matter, and raised the corn silage to 34% of diet DM. Additionally this diet contained 20% dry corn, 5% QLF Dairy Sugar 41, 2% cookie meal and 425 mg Rumensin. Starch was approximately 25% and sugar was 5%. For the low group diet we fed virtually the same ration as but replaced ~50% of the dry corn with dry corn gluten feed.
A home run:

Within 3 weeks the high group had increased to an average of 53 kg of milk an increase of 16 kg and DMI had dropped from 27 kg to 25 kg. The entire herd milk production average increased to 37 kg – what the high group had been averaging 3 weeks before. Milk fat % did not change.

Since that time we have been implementing more and more lactating cow rations based on HOT. We are confident that we have been successful in driving milk production in the right situations by increasing the fermentable carbohydrate in the rations.

In lower producing cows HOT would say the cow’s glucose demand is much lower and can be met easily by the propionate production during ruminal fermentation of the diet. When there is extra glucose, insulin is released causing the glucose to be converted to body fat. We do not want excessive body fat on these cows because of problems that it can cause during transition to the next lactation. In the past we have fed low cow diets that negatively affected milk production by feeding too much indigestible forage fiber. If we limit the amount of indigestible forage fiber and instead focus on replacing starch sources with non forage byproduct feeds we should be able to limit body fat deposition while maintaining milk production.

Although we don’t have as much experience, we tentatively think that we have been successful in situations where we have been allowed to feed the lower production cows based on the theory. We need to get better in formulating low group rations with non forage fiber byproducts and challenging producers to move lower producing cows based on body condition rather than production or reproductive status.

HOT for Transition Cows

As nutritionists we have to recognize that stresses other than nutrition are likely causing more transition challenges on dairies than we would care to admit. We need to continue to work with our producers to reduce the stresses that the cow experiences during transition.

I have come to believe that energy metabolism is the most important thing in transitioning dairy cows. We have to avoid excessive fat mobilization during transition. We have to keep these cows eating so that we minimize fat mobilization and displaced abomasums. The challenge that we see is: How do we maintain DMI and rumen fill while increasing the glucose supply so we do not have excessive body fat mobilization?

In the prefresh period the HOT theory would suggest we need a more fermentable diet. The cow needs enough glucose to keep insulin levels up so that the cow does not mobilize fat. However we do want to provide plenty of rumen fill.

We are still trying to determine what our prefresh diets should look like. In the last few years we have moved more and more herds to controlled energy diets with success. We are now trying to determine if we should modify those diets and shift more herds to low potassium grass hay. This could become an economics issue as often low potassium grass hay is sold at a premium over the cost of wheat straw.
In the herds we have had the opportunity to feed a fresh cow diet we have fed our low cow diet with an add pack on top of it to get more “goodies” into the ration. During the just fresh period utilizing HOT would say we need a diet that provides less propionate for glucose production because we do not want to meet the cow’s glucose demand and limit intake. Limiting intake in this group of cows could cause fat mobilization that could lead to ketosis and possibly fatty liver.

We also have to be cautious of feeding fat during this time as hepatic oxidation of fatty acids will also cause satiety.

In efforts to help cows deal with the energy balance challenges around the time of calving we have included 300 – 450 mg of Rumensin and ReaShure Choline and more recently Kemin’s ChemTrace Chromium Propionate into many diets with positive results. However we have implemented these products into diets without necessarily measuring the results.

I am concerned with leaving cows on these low fermentability diets too long as they may have too much condition loss as their milk production increases. I think we need to move them as soon as they are eating well and their milk production comes up.

**Challenges in implementing HOT theory:**

The challenges I see in implementing it is we have not designed dairies or grouping strategies based on milk production.

1. No method to analyze fermentability – Can we model it?
2. Can not allow for slug feeding.
   a. Thus 3 and 6 row barns present a challenge in that animals will be more likely to slug feed.
   b. Cows can not be held away from feed by spending excessive time in holding pens
   c. Overcrowding has to be controlled
   d. Sorting has to be controlled
3. Have to group based on milk production level and body condition
   a. Could make reproductive programs more challenging
   b. Will make body condition scoring more important when moving cows
4. Fresh Pens have to managed based on intake rather than a certain number of days
   a. Rumen Scoring
   b. Holding cows in fresh pen too long has potential to causing excessive condition loss
5. Multiple rations
   a. Many Producers are resistant to feeding multiple rations.
   b. Increased feed storage needs
   c. Potential to greatly increase how long it takes to feed

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Transition Cow Index® is a monitor of fresh cow health and performance based upon standard milk recording data, not disease records. The actual 1st test milk yield collected from 5-40 DIM is compared to a prediction of 1st test milk yield. The prediction equations were developed using mixed models and AgSource DHIA cow data from 4,025 herds over a two-year period merged with herd-level Posilac-purchase records supplied by Monsanto. Transition Cow Index®, the difference between actual and predicted first test milk, can be expressed as lbs on 1st test day (TCI-D®) or as lbs of 305-day 1st test projected 305-day milk (TCI®).

In a study to validate Transition Cow Index® as a marker of fresh cow health, AgSource technicians collected DairyComp 305 record from 110 herds believed to be recording disease events in early 2010. Of these herd records, 27 herds met the recording criteria of a minimal recorded incidence of ≥1% in the first 40 DIM of retained placenta or metritis, ketosis, displaced abomasum, and mastitis. Using the disease records from these herds, least squares means of TCI-D® (and TCI®) for cows with no recorded disease events during the first 40 days in milk were +5.0 (+690); ketosis only, +0.01 (-2); twins only, -1.7 (-177); metritis only, -5.8 (-762); retained placenta only, -6.8 (-899); mastitis only, -7.9 (-1,038); displaced abomasum only, -19.8 (-2,677); combination of any 2 diseases, -14.1 (-1,867); combination of any 3 diseases, -18.8 (-2,529); combination of any 4-6 diseases, -24.8 (-3,348).

Because TCI® values are generated from conventional DHIA data, herd average scores can be produced for all herds participating in DHIA testing programs. Using a stratified random selection of Wisconsin freestall herds, transition management practices and facilities were evaluated in 50 herds that averaged 699 cows in size. Herd average TCI® scores ranged from -4,404 to +2,413 lbs. Risk factors associated with herd average TCI scores were prefresh bunk space per cow, freestall base, size of freestalls, decreased days in dynamic calving pens, fresh pen bunk space per cow, and disease screening methods.

In a convenience sample of 25 open lot dairies in the Western US averaging 4,042 cows, herd average TCI-D® values ranged from -13 to +16 lbs. Risk factors associated with TCI-D® values were lower prevalence of prefresh cows with BCS ≥4.0 or ≤3.5, increasing prefresh bunk space, lower prevalence of lame cows, increasing fresh pen bunk space, and avoidance of movement into calving pens 3+ days before due date.

Using information from these associative studies, new transition cow barns have been constructed emphasizing 30 inches of bunk space per cow, deep sand-based freestalls measuring 50+ inches wide and 108+ inches long, and stable social groupings through the prepartum period. Experience with limited numbers of these barns suggests that these factors are more than associative with transition cow success.
Feeding and social behavior of the transition cow: Effects of feed bunk access, competition and illness

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In the last decade there has been a tremendous amount of empirical research focused on feeding and social behavior of dairy cattle largely due to the obvious links between feed intake and production, as well as its use in the identification of sick animals. It is critical to provide feeding environments that allow equal feed bunk access for dairy cattle during transition, particularly during periods of peak feeding activity after fresh feed is delivered and when competition is highest. Work has also focused on the negative effects of competition; namely, aggressive displacements and decreased dry matter intake. Subordinate animals (those displaced more often from the feed bunk) are most likely to return to the feed bunk during non peak feeding times when the risks is highest that there is little feed available and/or when the quality of the feed remaining is reduced. It follows that the greatest reductions in time spent feeding and intake are seen in these subordinate cows, despite their attempts to compensate by eating at a faster rate than more dominant cows. Moreover, other work has shown that those cows showing the greatest reductions in feeding time and DMI are also at greatest risk for succumbing to illness. This research has helped to identify management regimes that negatively affect feeding behavior in dairy cattle, as well as aid in identification of cows at risk for illness.
Overstocking During the Dry Period Alters Energy Metabolism in Dairy Cows

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Overstocking affects feeding behavior and can alter concentrations of circulating glucocorticoids; therefore, it may also alter the regulation of energy metabolism. The objectives of this study were to evaluate the effects of overstocking on energy metabolism and determine if behavior further influences these effects. Four groups of 10 Holstein cows (~60 d from expected calving) were exposed to two treatments (control = 1 lying stall/cow and 0.67m linear feed bunk (FB) space/cow; and overstocked = 0.5 lying stalls/cow and 0.34m FB space/cow) in a replicated 2x2 crossover design with 14-d treatment periods. During each period, blood and fecal samples were collected every 2 d and analyzed for NEFA, glucose, and fecal cortisol metabolites (FCORT), feeding behavior was recorded using video from d 7-10, and all cows were subjected to a glucose tolerance test (GTT: 0.25g dextrose/kg BW) on d 13. In crowded groups, NEFA and glucose concentrations were higher (106 vs. 91 µEq/L and 65 vs. 64 mg/dL respectively, \( P<0.05 \)) and FCORT tended to be higher (19 vs. 16 ng/g fecal DM, \( P=0.1 \)) than the control groups. There was a negative correlation (\( P\leq0.003 \)) between daily feeding time and NEFA (\( r=-0.54 \)), glucose (\( r=-0.32 \)) and FCORT (\( r=-0.60 \)) and a positive correlation between the time it took cows to approach the FB following fresh feed delivery and NEFA or glucose (\( r = 0.30 \) or 0.24 respectively, \( P\leq0.02 \)). This suggests metabolism may be affected by individual feeding strategies in groups. Area under the curve (AUC) responses of NEFA to GTT were not affected by treatment; however, rates of NEFA clearance during the first 30 min of GTT tended to be lower for crowded cows (1.4 vs. 1.9 µEq/L per min, \( P=0.1 \)). Basal glucose was not different (\( P=0.5 \)) prior to GTT. Following glucose infusion the overstocked group took longer to return to basal glucose concentration (55.1 vs. 51.5 min, \( P=0.05 \)) and tended to have a greater positive AUC (glucose values above basal: 2837 vs. 2630 mg/dL x 120 min, \( P=0.06 \)). Results suggest that overstocking dry cows may increase insulin resistance and thus alter the regulation of energy metabolism during the transition period.

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Is lameness a transition cow disease?
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Lameness is recognized as a major welfare concern for dairy cows arising from multiple causes. Recent research has acknowledged the transition period as a “trigger factor” for lameness. For example, work has discovered 1) physiological changes during parturition that reduce the resilience of the hoof and, 2) temporal consistency in the progression of some hoof conditions that cause lameness, such as claw horn lesions that take 8 to 12 wk to develop, and the time period relative to calving when these diseases are most likely to occur (i.e., in the few months after calving). A retrospective study by our lab has shown that cows diagnosed with claw horn lesions 7 to 15 wk after calving spent more time standing during transition compared to cows that did not develop lesions; cows that later developed lesions spent 121 min/d longer standing (832±29 vs. 711±29 min/d) and spent 94 min/d longer perching with their 2 front feet in the stall (241±22 vs. 147±22 min/d) during the 2 wk before calving compared to cows that did not develop lesions. These results provide further evidence that many lameness cases arising months into lactation may be triggered during transition – and that standing behavior can compound physiological changes in the hoof occurring during parturition. Standing behavior can be affected by a number of management practices, including overstocking (i.e., increased competition) at the feed bunk. The most recent research by our group aimed to discover whether competition at the feed bunk during transition increased the incidence of lameness. Table 1 shows the incidence of new cases of claw horn lesions (dark red sole hemorrhages and sole ulcers) during 7 to 15 wk after calving and digital dermatitis 3 wk after calving for cows housed in competitive and non-competitive feeding environments within the same pen. Feeding in a competitive environment tended to increase the risk of sole hemmorhages in primiparous cows and digital dermatitis and sole ulcers in multiparous cows, but sample sizes of each parity and hoof injury category were too small for meaningful statistical tests. These preliminary results add to a growing literature that supports the idea that many lameness cases arise as a consequence of behavior and management during transition; more studies using large sample sizes are thus highly encouraged in this line of research.

Table 1. The effect of a competitive feeding environment during transition on the incidence of hoof injuries after calving for primi- and multiparous dairy cows. % of cows within each parity with a hoof injury (total number of new cases).

<table>
<thead>
<tr>
<th></th>
<th>Competitive (n = 53)</th>
<th>Non-competitive (n = 27)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primiparous (n = 34)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sole ulcer</td>
<td>0</td>
<td>8% (1)</td>
</tr>
<tr>
<td>Sole hemorrhage</td>
<td>24% (5)</td>
<td>8% (1)</td>
</tr>
<tr>
<td>Dermatitis</td>
<td>5% (1)</td>
<td>8% (1)</td>
</tr>
<tr>
<td>Multiparous (n = 46)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sole ulcer</td>
<td>9% (3)</td>
<td>0</td>
</tr>
<tr>
<td>Sole hemorrhage</td>
<td>6% (2)</td>
<td>14% (2)</td>
</tr>
<tr>
<td>Dermatitis</td>
<td>22% (7)</td>
<td>7% (1)</td>
</tr>
</tbody>
</table>

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Optimal dry period length and management to maximize production and health

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The objective of this study was to determine optimal dry period (DP) length to maximize production and facilitate transition according to management used. Data were obtained from a previous study comparing effects of short (SDP; 35d dry; pre-calving ration only) and conventional DP (CDP; 60 d dry; dry-off ration until d-21 and 21d of pre-calving ration) management. The current dataset included information on 964 cows managed with either 21d (CDP; n=552) or 35d (SDP; n=412) of pre-calving ration. Optimal DP length was determined within each management group. Fixed effects of the model were DP length, parity, block, herd and DP*Parity in Proc GLIMMIX (disorders) or Proc MIXED (other variables). Within the CDP strategy, DP ≤42d tended to lower ketosis incidence but to increase incidence of retained placenta (RP) compared to the other DP lengths (P≤0.09). Average ECM yield in the following lactation was not affected by DP length (P=0.62). Pregnancy rate was negatively affected by DP ≥57d (P=0.05). Within the SDP strategy, DP ≤28d increased incidence of RP (P<0.01) and decreased incidence of ketosis and average ECM yield compared to DP ≥29d (P<0.01). Increased incidence of early calvings was also observed in this group (P<0.01). No effect was observed on other metabolic disorders. Calculation of the Transition Cow Index™ (TCI) revealed significant effects of DP length in both management groups. Results suggest no beneficial effect for longer than 56d DP when a strategy of 21d of pre-calving ration is used. With a management of 35d of pre-calving ration, a minimal DP of 29d is required to maximize milk yield and facilitate transition.

<table>
<thead>
<tr>
<th>DP length in a 21d of pre-calving ration management</th>
<th>≤42d</th>
<th>43-49d</th>
<th>50-56d</th>
<th>57-63d</th>
<th>64-70d</th>
<th>≥71d</th>
<th>se</th>
<th>P(DP)</th>
<th>P(Parity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>59</td>
<td>63</td>
<td>112</td>
<td>107</td>
<td>48</td>
<td>163</td>
<td>3.3</td>
<td>&lt;0.01</td>
<td>0.06</td>
</tr>
<tr>
<td>d dry</td>
<td>36.2a</td>
<td>47.7b</td>
<td>54.8c</td>
<td>61.9c</td>
<td>66.3d</td>
<td>102.2e</td>
<td>0.07</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>Avg ECM (kg/d)</td>
<td>29.5</td>
<td>32.5</td>
<td>31.9</td>
<td>30.9</td>
<td>31.5</td>
<td>31.2</td>
<td>1.0</td>
<td>0.62</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Ketosis (%)</td>
<td>11.7a</td>
<td>31.3b</td>
<td>31.9b</td>
<td>37.1b</td>
<td>35.4b</td>
<td>38.9b</td>
<td>7.8</td>
<td>0.09</td>
<td>0.33</td>
</tr>
<tr>
<td>RP (%)</td>
<td>34.8b</td>
<td>15.3a</td>
<td>12.1a</td>
<td>13.4a</td>
<td>8.2a</td>
<td>8.5a</td>
<td>9.1</td>
<td>0.23</td>
<td>0.01</td>
</tr>
<tr>
<td>TCI</td>
<td>-756c</td>
<td>10b</td>
<td>178bc</td>
<td>164bc</td>
<td>49c</td>
<td>23b</td>
<td>202</td>
<td>&lt;0.01</td>
<td>0.82</td>
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<table>
<thead>
<tr>
<th>DP length in a 35d of pre-calving ration management</th>
<th>≤28d</th>
<th>29-35d</th>
<th>36-42d</th>
<th>≥43d</th>
<th>se</th>
<th>P(DP)</th>
<th>P(Parity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>100</td>
<td>132</td>
<td>106</td>
<td>74</td>
<td>1.2</td>
<td>&lt;0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>d dry</td>
<td>22.3a</td>
<td>32.0b</td>
<td>38.6c</td>
<td>56.2a</td>
<td>6.2</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Avg ECM (kg/d)</td>
<td>29.8a</td>
<td>31.8b</td>
<td>32.5b</td>
<td>31.5b</td>
<td>0.7</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Ketosis (%)</td>
<td>7.3a</td>
<td>26.2b</td>
<td>15.7b</td>
<td>26.9b</td>
<td>7.6</td>
<td>&lt;0.01</td>
<td>0.02</td>
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<tr>
<td>RP (%)</td>
<td>31.0c</td>
<td>18.7bc</td>
<td>13.4ab</td>
<td>8.1a</td>
<td>6.6</td>
<td>&lt;0.01</td>
<td>0.05</td>
</tr>
<tr>
<td>TCI</td>
<td>-256a</td>
<td>64b</td>
<td>247bc</td>
<td>446c</td>
<td>132</td>
<td>&lt;0.01</td>
<td>0.03</td>
</tr>
</tbody>
</table>

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Effect of energy level and 2,4-thiazolidinedione on insulin and glucose metabolism in dry cows

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Specific mechanisms by which dry period dietary energy level and thiazolidinedione (TZD) administration affect transition cow metabolism are not known, but we hypothesize effects are mediated via changes in insulin, glucose, or fatty acid metabolism. The objective was to determine the effects of the insulin-sensitizing agent TZD and dietary energy level on glucose and fatty acid metabolism during the dry period. Multiparous Holstein cows (n = 32) approximately 50 d prior to expected calving date were dried-off and assigned to one of two dietary energy levels for 3-wk (High (H) 1.58, or Low (L) 1.46, Mcal/kg NE\textsubscript{L}) and treated daily during the final 2 wk with 4.0 mg TZD/kg BW (T) or saline (S) in a completely randomized design. Cows fed the L diet had lower DMI (12.8 vs. 16.1 kg/d; P < 0.001) and higher plasma NEFA (103.3 vs. 82.4 μEq/L; P<0.001) than cows fed H. TZD treatment increased plasma glucose (62.5 vs. 59.6 mg/dL; P = 0.03). After 2 wk of TZD, all cows were subjected to an intravenous glucose tolerance test (GTT; 0.25 g dextrose/kg BW) followed 110 min later by an insulin challenge (IC; 1.0 μg/kg BW). There was a trend for cows fed H to have lower area under the curve (AUC) for plasma glucose during GTT (1896 vs. 2410 mg/dLx90 min; P = 0.13). However, cows fed L had more negative NEFA AUC (-4838 vs -2137 μEq/Lx90 min; P = 0.04) and greater NEFA clearance (1.35 vs. 0.63 %/min; P = 0.01) during GTT, suggesting differential responses to dietary energy level in tissue glucose and fatty acid metabolism. During IC, TZD-treated cows tended to have more negative glucose AUC (-45.0 vs. -12.1 mg/dL x 15 min; P = 0.08), suggesting that TZD-treated cows had greater responses to insulin. Interaction of diet and TZD was only significant for NEFA responses to IC. Body condition score had significant influence on glucose AUC and clearance rate during GTT and NEFA AUC during IC. These results indicate that energy level and insulin-sensitizing agents affect glucose and lipid metabolism during the dry period, which may have implications for the transition period.

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