Ruminant Nutrition Symposium: Modulation of Metabolism Through Nutrition and Management

671 Optimizing production of the offspring: Nourishing and managing the dam and the calf early in life. A. Bach*[1,2], [1]*Department of Ruminant Production, IRTA, Barcelona, Spain,* [2]*ICREA, Barcelona, Spain.*

On several mammalian species, it has been shown that fetal and early life nutrition has a role in long-term lipid and glucose metabolism of the offspring, and thus it may also have consequences on milk yield in the dairy cow. For instance, high-energy diets during the last weeks of pregnancy may result in elevated glycemia, which in turn, may alter fetal adipose tissue development. However, most research efforts on management and nutrition of dry cows have focused on minimizing metabolic disorders of the postpartum cow without devoting any attention to potential consequences for the offspring. Similarly, nutritional needs for proper placental development and early fetal growth have received little attention, despite the fact that alterations in placental and fetal development may alter expression of genes participating in homeorhesis of the offspring. Similarly, newborn calves and young heifers are fed to ensure a particular growth target without compromising mammary development, however, data linking growth targets with future milk yield are scarce, and the impact of plane of nutrition on mammary development during prepubertal periods has been shown to be less important than initially thought. However, milk yield not only depends on mammary development, but also on nutrient partitioning, which is regulated by the endocrine milieu. There are some periods of time during development where nutrition may have long-lasting effects on milk production. For instance, the first months of life seem to be critical as recent data from both retrospective and controlled studies indicate that elevated growth rate (or plane of nutrition) during this phase is positively associated with future milk production. Growth rate during early life depends on nutrition (a necessary but not sufficient condition) and management (i.e., grouping strategies and housing systems), and thus optimal rearing programs should be designed considering long-term consequences on milk yield. Likewise, nutrition of the pregnant cow, both while lactating and dry, should also consider aspects of placental and fetal development that may affect milk performance of the progeny.

Key words: epigenetics, metabolism, imprinting

672 Optimizing production of the dairy cow: Nutrition and management during late pregnancy. J. K. Drackley*, *University of Illinois, Urbana.*

Nutrition and management during late gestation impact occurrence of peripartal health problems and influence subsequent milk production. Obesity at calving is a serious risk factor for health problems and suboptimal production. Likewise, extreme under-nutrition may adversely affect postpartum outcomes. The accumulated evidence is that higher energy-density close-up diets do not increase subsequent milk production or energy balance. Evidence from our laboratory indicates that even modest overfeeding results in changes analogous to obesity, with elevated insulin and NEFA before calving, poor DMI before calving, substantial body fat mobilization, increased fat deposition in the liver, prolonged increases in ketone bodies in blood after calving, and, if severe, impairment of liver function. The liver of modestly overfed cows displays a greater specific metabolic capacity for NEFA esterification and a decreased capacity to oxidize NEFA during the periparturient period. A modest energy excess during the dry period can lead to substantial internal fat deposition even in the absence of detectable changes in body condition. Adipose tissue of overfed cows undergoes marked changes in expression of enzymes and other gene products, including inflammatory responses. On the basis of available data, we conclude that requirements for energy (and other nutrients) should be met but not greatly exceeded during the dry period. This concept may be applied via several approaches, ranging from limit-feeding of moderate-energy diets to ad libitum feeding of high-roughage low-energy diets. Requirements for energy for dry cows and first-gestation heifers are modest (ca. 100 MJ ME or 14 Mcal NE per cow daily) and can be met with relatively low-energy diets. Conversely, diets high in starch from corn silage or whole-crop cereals and supplemented with additional concentrates result in excess energy intake relative to requirements, as cows do not regulate intake to meet energy needs over the short-term. Careful feeding management is critical to ensure that formulated nutrient intakes are actually achieved in practice.

Key words: periparturient period, transition period, management

673 Optimizing production of the dairy cow: Nutrition and management during early lactation. J. P. McNamara*, *Washington State University, Pullman.*

Optimal production of the dairy cow entails selecting top overall genetic attributes, not only of milk and component production but for fertility and longevity. Management of these animals from birth and through multiple cycles of pregnancy and lactation will help bring genetic efficiency to full fruition. We must take into account not only feed intake and milk production, but also metabolic flux in body tissues, primarily in visceral, muscle, and adipose tissues. Metabolic processes are affected by genotype, phenotype, and intake, processes that are usually under control of hormonal and neural systems. Reproductive processes leading to additional timely pregnancies must also be understood; as well as the interactions of the genome and transcriptome with the environment in terms of immune function and resistance to disease. A systems approach must be taken to lead to better genetic selection and management. We have continued our work with the objective of identifying the patterns of metabolic flux in the most efficient dairy cattle, using an existing mechanistic metabolic model (Molly, UC Davis) and have expanded that to integrate transcriptional control aspects and reproductive functions to identify the patterns of the most efficient animals. The combination of the transcriptomic and modeling analyses identified key differences in control of nutrient metabolism in the most efficient dairy cattle, rates of adipose tissue metabolism were directly related to overall efficiency. Feed intake was a major component of overall feed efficiency, while the ability of body tissue to support milk production and recover after peak production was another major contributor. We have created the first mechanistic model of control of estrogen and progesterone dynamics, early embryonic development and control of these processes by metabolic rate and genetic selection in the dairy cow. This systems approach can focus our research to make faster and large advances in efficiency, and show directly how this can be applied on the farms.

Key words: dairy cattle, systems biology, metabolic control

674 Optimizing production during heat stress: Nutrition and Management. L. H. Baumgard*[1] and R. P. Rhoads[2], [1]*Iowa State University, Ames,* [2]*University of Arizona, Tucson.*

Heat stress (HS) compromises efficient animal production by marginalizing efforts to reduce food production inputs while negating genetic selection for performance endpoints. Modifying farm infrastructure has yielded modest success in mitigating HS-related losses yet HS remains arguably the costliest issue facing livestock producers. Reduced output (milk yield, muscle growth, egg production, etc.) during HS was traditionally thought to result from decreased nutrient intake (a classic biological response shared by all animals during environmental-induced hyperthermia). Our recent observations have begun to challenge this belief and indicate heat-stressed animals employ novel homeorhetic strategies to direct metabolic and fuel selection priorities independently of nutrient intake or energy balance. Alterations in systemic physiology support a shift in carbohydrate metabolism, evident by increased basal and stimulated circulating insulin levels. Cellular metabolism of the hepatocyte and myocyte also show clear differences in glucose production and use, respectively due to HS. The apparent dichotomy in intermediary metabolism between the 2 tissue types may stem from factors such as mitochondrial function and antioxidant capacity. Perhaps most intriguing given the energetic shortfall of the heat-stressed animal is the apparent lack of basal adipose tissue mobilization coupled with a reduced responsiveness to lipolytic stimuli. Thus, the HS response markedly alters post-absorptive carbohydrate, lipid and protein metabolism independently of reduced feed intake through coordinated changes in fuel supply and utilization by multiple tissues. Interestingly, the systemic, cellular and molecular changes appear conserved among different species and physiological states as we have characterized similar events in growing and lactating ruminants, pigs, poultry and adult rodents. Ultimately, these changes result in the reprioritization of fuel selection during HS which appears to be primarily responsible for reduced animal productivity during the warm summer months.

Key words: heat stress, homeorhesis, metabolism