Lactation Biology Symposium: The Long-Term Impact of Epigenetics and Maternal Influence on the Neonate Through Milk-Borne Factors and Nutrient Status

742 Role of colostrum and colostrum components on glucose metabolism in neonatal calves. H. M. Hammon,* *Leibniz Institute for Farm Animal Biology (FBN), Dummerstorf, Germany.*

Mammalians undergo dramatic organ-specific as well as metabolic and endocrine changes after birth. Nutrient intake shifts from continuous glucose supply via the placenta to discontinuous colostrum and milk intake with lactose and fat as main energy sources. The development of the neonatal calf is influenced by colostrum intake when compared with colostrum replacement diets. Besides establishing a passive immunity, colostrum promotes maturation and function of the neonatal gastrointestinal tract (GIT) in calves. Nutrients and non-nutritive factors, such as hormones and growth factors, which are present in high amounts in colostrum of first milking, affect intestinal growth and function and enhance the absorptive capacity of the GIT. In addition, colostrum feeding improves the glucose status in neonatal calves. Glucose absorption increases and glycogen concentrations in liver rise much higher when colostrum instead of a milk-based colostrum replacer is fed. In contrast, first-pass glucose uptake in the splanchnic tissue is greater in calves fed colostrum replacer without growth promoting substances. The improved energy status in neonatal calves after enhanced colostrum intake leads to accelerated stimulation of anabolic processes indicated by an enhanced maturation of the postnatal somatotropic axis and increased production of endogenous IGF-I in neonatal calves. Besides the somatotropic axis, other endocrine changes such as higher postprandial insulin release, a reduced glucagon to insulin ratio and cortisol level in blood plasma, and an increased plasma leptin concentration after colostrum instead of replacer feeding support the concept of stimulation of anabolic processes. These endocrine changes may favor postnatal organ development and may improve growth and lactation performance in cattle in later life. Therefore, intensive colostrum and subsequent milk feeding by increasing amounts and frequency of colostrum and milk intake may have long-lasting effects on postnatal performances and might be a key factor of successful cattle breeding.

Key Words: neonatal calf, colostrum feeding, glucose metabolism

743 Nutrition of the dam affects mammary gland development and milk production in the offspring. P. Kenyon,* A. Paten, E. Garnett, H. Blair, S. Pain, C. Jenkinson, S. Peterson, and N. Martin, *Massey University, Palmerston North, New Zealand.*

In animal systems, the dam's milk production affects the growth and survival of its offspring. Further in agricultural systems any mechanism that can enhance milk production has the potential to increase financial returns. Our group has previously shown that maternal nutrition during pregnancy in sheep alters fetal mammary gland development and the volume and composition of milk produced by the offspring at their first lactation (fetal programming). Second generation offspring showed no difference in milk yield or composition. In 2009, 382 twin-bearing ewes (G0) were offered 1 of 3 nutritional treatments between d 21 and 50 of pregnancy: sub-maintenance (Sb), maintenance (M) or adlib (A) access to pasture. They were subsequently offered either M or A until d 139 of pregnancy. A sub-set of ewes were euthanized in late pregnancy. During 2010, puberty in ewe offspring (G1) was monitored and in 2011 G1 ewes were mated and a sub-set milked. At d 51 of pregnancy H G0 ewes were heavier than M which in turn were heavier than Sb ewes ($P < 0.05$, 69.5 ± 0.53 vs 65.1 ± 0.53 vs 62.2 ± 0.56kg). At P137, ewes offered H during d 51 to 139 of pregnancy were heavier than those offered M (88.2 ± 0.53 vs 82.6 ± 0.53). Fetal mammary gland weight was affected ($P < 0.05$) by ewe nutrition during d 21 to 50 of pregnancy, but not by nutrition in late pregnancy. Ewe nutrition during d 21 to 50 of pregnancy had no effect ($P > 0.05$) on G1 lamb birth weight, but during late pregnancy it did ($P < 0.05$). Ewe nutrition in either early or late pregnancy had no effect ($P > 0.05$) on puberty attainment in G1 ewes. Initial data analysis indicates G1 ewes born to G0 ewes fed M during d 21 to 50 of pregnancy produced a greater ($P < 0.05$) amount of milk over a 7-week, once-a-week milking period, compared with G1 ewes born to either G0 Sb or G0 H ewes. G0 nutrition in late pregnancy had no effect on G1 milk production. These preliminary results suggest that it is in the early pregnancy period that the fetal mammary gland is susceptible to the affects of dam nutrition. Molecular and physiological mechanisms for these effects are being examined.

Key Words: fetal programming, maternal nutrition, milk supply

744 Lactational programming of infant behavioral and somatic development. K. Hinde*[1,2], A. Foster[2], and J. P. Capitanio[2,3], [1]*Human Evolutionary Biology, Harvard University, Cambridge, MA,* [2]*Brain, Mind, and Behavior Unit, California National Primate Research Center, University of California-Davis,* [3]*Department of Psychology, University of California-Davis, Davis.*

Glucocorticoids in mother's milk have been associated with infant behavioral phenotype in rodents, macaques, and humans presumably by shaping the HPA axis. However, infant behavioral activity budgets are necessarily constrained by available energy. Cortisol, usually thought of only in the context of stress physiology, is actually a metabolic hormone that ties together both of these perspectives. Energy utilization, and the metabolic function of cortisol, becomes particularly critical during challenging conditions e.g., nutritional stress, predator encounters, and social conflicts- the same environmental conditions that have been implicated in the development of behavioral phenotype. We hypothesize that behavioral phenotype is organized in concert with the metabolism by energetic conditions during early development. Here we present data from rhesus macaque mother-infant dyads at the California National Primate Research Center, expanding upon previous findings that milk energy is correlated with milk cortisol and predicts infant behavioral phenotype. Changes in milk cortisol across lactation precipitate changes in infant growth velocity after controlling for maternal and infant covariates and predict infant temperament. In adulthood the HPA axis, metabolism, and behavior do not exist apart from one another. We present a synthesis of emerging evidence that suggests that the organization of these interconnected systems is likely shaped, in part, by mother's milk during ontogeny. Research supported by NSF BCS-0921978 and BCS-0525025 to KH and NIH RR019970 to JPC and NIH RR000169 to the CNPRC.

745 Lactocrine signaling and postnatal developmental programming. F. F. Bartol*[1], D. J. Miller[1], A. A. Wiley[1], J. C. Chen[2], A-L. Frankshun[2], M. E. Camp[2], K. M. Ferio[2], and C. A. Bagnell[2], *[1]Auburn University, Auburn, AL, [2]Rutgers, The State University of New Jersey, New Brunswick, NJ.*

Lactocrine signaling is defined as transmission of bioactive factors from mother to offspring as a consequence of nursing. Transmission of lactocrine-active signaling molecules is likely to be an evolutionarily conserved process through which bioactive factors of maternal origin necessary for support of neonatal development are delivered postnatally. Dependence on maternal resources for development in eutherian mammals extends into neonatal life for at least that period of time when nutrition is obtained solely from first milk (colostrum). Data for the pig (*Sus scrofa domesticus*) provide compelling evidence of lactocrine-mediated effects on development of female reproductive tract and other somatic tissues. Porcine uterine gland development is an estrogen receptor (ESR1)-dependent process that begins within 2 d of birth (postnatal d 0 = PND 0). A lactocrine-driven, ESR1-mediated process was proposed as a component of the regulatory mechanism governing onset of nascent uterine gland development and endometrial maturation in the neonatal pig. Compared with nursed controls, gilts maintained in a lactocrine-null state for 2 d from birth by being fed milk-replacer displayed altered patterns of endometrial gene expression and severely retarded uterine gland development by PND 14. For example, in the absence of lactocrine signaling, inhibition of endometrial ESR1 and vascular endothelial growth factor (VEGF) expression observed on PND 2 persisted to PND 14, even after gilts were returned to nursing on PND 2. Similar effects were observed in cervical and cardiac tissues and in male reproductive tissues at PND 2. Lactocrine induction of neonatal uterine and cervical ESR1 and VEGF expression is related directly to duration of nursing from birth and inversely to age at first colostrum consumption. Single feedings of porcine, equine or bovine colostrum (30mL/kg BW) to newborn gilts induced uterine and cervical ESR1 and VEGF expression. These effects were most pronounced with porcine colostrum. Collectively, data support a role for lactocrine signaling in regulation of critical neonatal developmental events. Maternal lactocrine programming of postnatal development may be essential to ensure healthy developmental outcomes.

Key Words: development, neonate, lactocrine programming

746 The effect of nutrient intake from milk or milk replacer of pre-weaned dairy calves on lactation milk yield as adults. F. Soberon* and M. E. Van Amburgh, *Cornell University, Ithaca, NY.*

Pre-weaning nutrition and management of dairy calves has generally focused on rumen development, starter intake and disease management. Recent data have shown that pre-weaning nutrition can have profound effects on development that enhance lifetime productivity. Using a combination of milk yield data from a test day model and a mixed model analyses incorporating pre-weaning nutrient intakes and growth rates of more than 1,800 calves on 2 dairy farms in NY, the relationship among growth and milk yield were evaluated. The relationship between pre-weaning average daily gain (ADG) and milk yield was positive and resulted in 850 and 1,113 kg more milk ($P < 0.01$) during first lactation for every kg of ADG before weaning for each farm, respectively. Further, pre-weaning ADG explained 22% of the variation in first lactation milk yield. In addition, for every megacalorie of intake above maintenance, calves yielded 235 kg more milk during first lactation. In addition, at least 11 studies have been reported describing milk yield of calves that had been fed various levels of pre-weaning nutrients, from both milk and milk replacer, which evaluated the effect of pre-weaning ADG and long-term productivity. A mixed model analysis of these studies was conducted, where study was considered a random effect and the analysis considered the number of animals per treatment in each study. Two models were utilized; the first model considered only treatment, high or low intake levels, and that analysis resulted in a prediction of 506.5 ± 99.1 kg ($P < 0.01$) first lactation milk yield in calves consuming higher levels of milk or milk replacer during the pre-weaning period. In a model that included pre-weaning ADG as a continuous variable with study as a random effect and weighted each study-treatment combination by the number of animals, the resulting equation was: Y = 8,974 kg + 1,404 ADG kg ($P < 0.001$) indicating that for every kg of ADG, heifers produced 1,404 kg more milk in the first lactation. This data reinforces the observation that early life nutrition of dairy calves positively impacts long-term productivity.

Key Words: pre-weaning nutrition, milk yield, dairy calves