Integrating Nutritional and Reproductive Models to Improve Reproductive Efficiency in Dairy Cattle

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The effects of nutrition and genetics on reproductive fertility have been recognized for many years, and we have in place practical practices and genetic breeding values that are used on farm to help ensure fertility. The biological processes regulating fertility are affected, for example, by genetic variation in hormone secretion, receptor amount and function, and metabolic rate. Rates of milk production and intake increase blood flow through the liver and can remove estrogen and progesterone faster, reducing the time of visible signs of estrus and decreasing the protective effect of progesterone on embryo survival. Although we do know a large amount about control of reproduction, we still lack a defined, systems approach to managing the genetics and nutrition of cows to improve reproduction. Therefore, our objective was to integrate two existing mechanistic, dynamic models of nutritional and reproductive processes in the dairy cow. The objective of this research model is to be suitable for evaluation of data, concepts, and hypotheses regarding underlying genetic, nutritional, and physiological control of reproduction. A model of metabolism (Molly, UC Davis); which describes metabolism of glucose, VFA, and amino acids for fat and protein synthesis and degradation and milk component production, as well as tracking energy transactions (ADP/ATP) (Baldwin, 1995), was integrated with a model of reproductive processes which describes growth and decay of the follicles and corpus luteum, gonadotropin releasing hormone, follicle stimulating hormone, luteinizing hormone , progesterone, estrogen, oxytocin, and prostaglandin F2α over time. The two models were integrated at 3 specific points based on available literature data: glucose and IGF-I affect rates of follicle stimulating hormone, luteinizing hormone, and follicular growth; and degradation of estrogen and progesterone is a function of metabolic clearance rate higher glucose supply (energy balance) increases IGF-1 and increases follicular growth, leading to an earlier ovulation. Increased metabolic rate from either increased milk production or feed intake decreases estrogen and progesterone concentration, reducing estrogen support of follicular growth, decreasing estrus detection and decreasing progesterone's protective effect on the pregnancy. The model describes the pattern and direction of response in reproductive processes consistent with literature values. This research model should be useful to frame specific hypotheses on control of reproductive processes by genetic and nutritional driven mechanisms and eventually provide the basis for better on-farm practices.

Keywords: Systems biology, reproduction, nutrition, research model