Global Veterinaria 8 (1): 15-17, 2012
ISSN 1992-6197

Time of Eating: An Emerging Evolutionary Pragmatism in Livestock Ecology

Akbar Nikkhah

Department of Animal Sciences, University of Zanjan, Zanjan 313-45195, Iran

Abstract: Time of feeding requires most deserving considerations in practical livestock and environmental sciences. Based on the most recent animal and human models discoveries, time of eating is a major regulator of periprandial patterns of feed intake, rumen fermentation and peripheral metabolism. As a result, time of feeding regulates nutrient assimilation along the gastrointestinal tract and splanchnic and peripheral nutrient metabolism. Consistent evidence established that evening instead of morning feed presentation improved nutrient efficiency, milk energy yield and reduced fecal and urinary nitrogen excretions in high-producing lactating cows. Time of feeding, thus, is a global feasible evolutionary strategy to manipulate and optimize natural resources use efficiency and environmental quality in the new era.

Key words: Evolution · Livestock · Ruminant · Science · Time of Eating

INTRODUCTION

For maximum efficiency, the time of nutrient delivery to the rumen, splanchnic tissues and the periphery needs to be synchronized with the endogenous rhythms in body metabolism. Circadian rhythms in body metabolism are reflected in endogenous and exogenous patterns of blood levels of metabolites and hormones [1-4].

It is hypothesized that time of feeding/eating regulates the synchrony of 1) animal internal and 2) environmental external factors in orchestrating animal endocrinology and metabolism. The objective of this perspective forum article is to delineate how time of feeding entrains circadian animal metabolism and production. The most recent animal and human models discoveries are discussed within a chronophysilogical framework to underline the significance of time of eating in optimal management of the post-modern livestock science and ecology.

Chronophysiological Intuitions and Discussion: Endogenous rhythms are regulated by the suprachiasmatic nuclei in the hypothalamous and not only by the environmental factors such as photoperiod and feeding time [5]. Blood glucose in humans has endogenous rhythmicity [6]. In contrast, exogenous rhythms are controlled by external cues. Blood urea is largely responsive to feeding and digestive function and, thus, is exogenously regulated [7]. It is important to determine if how feeding time can alter circadian patterns of the rumen and host animal metabolism. Such knowledge will indicate the time of day when nutrients can be assimilated more efficiently for both productivity and body energy expenditure. From a thermodynamics perspective, evening rather than morning feeding can improve beef cattle performance exposed to extremely cold conditions [8,9] and dairy cattle production persistency in summer [10]. In light of the most recent discoveries [1-4,11,12], the chronophysiological basis of feeding time in food-producing ruminants, especially in lactating dairy cows, requires profound exploration. The lactating cow is an exceptional mammal with uniquely high levels of feed intake and milk production (as high as 6× maintenance). Any chronobiological mediation of the rumen and intermediary metabolism will have an enormous impact on milk secretion and tissue deposition. Ruminants have evolved to ruminate mostly overnight, when the rumen possesses a greater fermentation capacity and volume, compared to day-time. Feeding in evening, when ruminants have evolved to ruminate,

Corresponding Author: Prof. Dr. Akbar Nikkhah, Ph.D., Highly Distinguished Professor of Science and Ruminant Nutrition; Highly Distinguished Mentor of Science Education and Dissemination; Highly Distinguished Science Composer; Highly Distinguished Elite-Generating Scientist, National Elite Foundation, Iran; Highly Distinguished Global Peace Promoter; Department of Animal Sciences; Faculty of Agricultural Sciences, The University of Zanjan, Zanjan 313-45195 Iran, Tel: +98-241-5152801, Fax: +98-241-5283202.

may significantly alter post-feeding rumen fermentation patterns. This can subsequently impact on circadian patterns of feed intake. In human and rat models, regulation of glucose metabolism and insulin sensitivity has been shown to heavily depend on time of day [6,13]. Humans are unable to metabolize or tolerate glucose as effectively in evening as do they in morning. This is because glucose tolerance and insulin sensitivity decreases as day progresses and evening begins [6]. Such crucial knowledge leads to a recommendation to avoid large evening meals for reducing risks of type-2 diabetes, metabolic syndrome and related cardiovascular complexities. Such alterations in ruminant ecology will dramatically affect animal production and health as well as the environmental quality [1-3].

Feeding at 2100 h instead of 0900 h consistently increased feed intake within 3-h of feeding [1-4,14,15]. Feed intake within 3-h of feeding was on average about 40% of the total ration offered in one study and 55% in another study. Consequently, rumen experience a larger nocturnal than diurnal volume (107 vs. 90 L)[12]. Based on the post-feeding rises in rumen VFA and blood metabolites, the impacts of the evening feed delivery on rumen fermentation, total tract nutrient digestion, blood parameters and milk secretion were all mediated most likely by the altered circadian patterns of feed intake. In prmiparous cows, feeding at 2100 h increased digestible dry matter intake by 1.67 kg which equals to 1.67 × 1.6 Mcal NE_L or 2.67 Mcal NE_L daily. Based on actual milk yield and milk percents of fat and protein, primiparous cows fed at 2100 h secreted 20.53 Mcal milk NE_L and primiparous cows fed at 0900 h secreted 18.94 Mcal milk NE_L[11]. Thus, feeding at 2100 h instead of 0900 h increased dietary NE_L availability by 2.67 Mcal/d, while 1.59 Mcal (20.53-18.94) was secreted in milk. This suggested that 1.08 Mcal NE_L was not used for milk production and was spent for internal energy expenditure by splanchnic and non-splanchnic peripheral tissues. In multiparous cows, however, feeding at 2100 h vs. 0900 h increased digestible dry matter intake only by 0.54 kg or 0.86 Mcal NE_L (equal to 1.2 kg of 4% fat-corrected milk), while it reduced NE_L secretion in milk by 0.25 Mcal/d [11]. This suggested that feeding at 2100 h, although increasing energy availability, did not partition it towards the mammary gland in multiparous cows. These findings indicated that parity can considerably affect the fate of the increased nutrients availability by evening vs. morning feeding. Altogether, the periprandial patterns of feed intake, rumen fermentation and peripheral metabolites, along with improved nutrient assimilation and efficiency base a global inference for time of feeding/eating as a feasible and cost-effective strategy to manipulate and optimize mammary and non-mammary nutrient use and partitioning.

CONCLUSIONS AND IMPLICATIONS

Feed delivery at 2100 h instead of at 0900 in tie-stall-housed lactating cows under no heat stress consistently increased feed intake shortly post-feeding by about 2-3 kg of dry matter. This led to greater daily feed intake in primiparous cows in one study. Feeding at 2100 h, also, consistently increased rumen VFA levels 4-6 h post-feeding and ammonia at 2-h post-feeding, without affecting microbial protein synthesis estimates. Evening feeding improved nutrient and fiber total tract digestibility, but did not affect total proportions of short, medium and long chain fatty acids in milk. Since milk fat yield was increased by evening feeding, daily yield of the fatty acids with implications for human health (e.g., monounsaturated fatty acids and *cis-9, trans-11*CLA) was also increased. Reduced fecal and urinary nitrogen excretion via evening feeding has significant environmental implications.

ACKNOWLEDGMENTS

Nature for its inspirational nature deserves the greatest admirations.

REFERENCES

1. Nikkhah, A., 2011a. Bioscience of ruminant intake evolution: feeding time models. Adv. Biosci. Biotechnol., 2: 271-274.
2. Nikkhah, A., 2011b. Ruminant chronophysiological management: an emerging bioscience. Open Access Anim. Physiol., 3: 9-12.
3. Nikkhah, A., 2011c. Postprandial rhythms of circulating urea in lactating dairy cows: feeding timing and diet effects. Biol. Rhythm Res. In press.
4. Nikkhah, A., 2011d. Eating timing an evolutionary manager of postmodern rumen physiology and health: a review. Open Access Anim. Physiol., 3: 13-19.
5. Sehgal, A., 2004. Molecular biology of circadian rhythms. John Wiley & Sons, Inc., Hoboken, New Jersey.

6. la Fleur, S.E., A. Kalsbeek, J. Wortel, M.I. Fekkes and R.M. Buijs, 2001. A daily rhythm in glucose tolerance: a role for the suprachiasmatic nucleus. Diabetes, 50: 1237-1243.
7. Piccione, G., G. Caola and R. Refinetti, 2003. Circadian rhythms of body temperature and liver function in fed and food-deprived goats. Comp. Biochem. Physiol., 134: 563-572.
8. Kennedy, A.D., R.D. Bergen, T.J. Lawson, J.A. Small and D.M. Veira, 2004. Effects of evening feeding and extended photoperiod on growth, feed efficiency, live animal carcass traits and plasma prolactin of beef heifers housed outdoors during two Manitoba winters. Can. J. Anim. Sci., 84: 491-500.
9. Small, J.A., A.D. Kennedy, D.M. Veira, W.P. McCaughey and D.R. Ward, 2004. Time of feeding and growth promotant effects on the winter growth performance and carcass traits of steers. Can. J. Anim. Sci., 84: 133-144.
10. Aharoni, Y., A. Brosh and Y. Harari, 2005. Night feeding for high-yielding dairy cows in hot weather: effects on intake, milk yield and energy expenditure. Livest. Prod. Sci., 92: 207-219.
11. Nikkhah, A., C.J. Furedi, A.D. Kennedy, S. Scott, G.H. Crow, J.C. Plaizier, 2011a. Feed delivery at 2100 h vs. 0900 h for lactating dairy cows, Can. J. Anim. Sci., 91: 113-122.
12. Nikkhah, A., J.C. Plaizier and A.D. Kennedy, 2011b. Rumen volume and passage kinetics depend on feeding time (0090 h vs. 2100 h). J. Dairy Sci., 94(E Suppl):374–375.
13. Van Cauter, E., J. Biackman, D. Roland, J.P. Spire, S. Refetoff and K.S. Polonsky, 1991. Modulation of glucose regulation and insulin secretion by circadian rhythmicity and sleep. J. Clin. Invest., 88: 934-942.
14. Nikkhah, A., 2011e. Time of Feed Provision (2100 vs. 0900 h) Orchestrates Postprandial Rhythms of Food Intake and Peripheral Glucose in Lactating Cows. Biol. Rhythm Res. In press.
15. Nikkhah, A., C.J. Furedi, A.D. Kennedy, G.H. Crow, J.C. Plaizier, 2008. Effects of feed delivery time on feed intake, rumen fermentation, blood metabolites and productivity of lactating cows, J. Dairy Sci., 91: 1-12.