LACTATION BIOLOGY SYMPOSIUM: Circadian clocks and photoperiod in mammary gland development and lactation

D. L. Hadsell

Department of Pediatrics, The USDA/ARS Children’s Nutrition Research Center, Baylor College of Medicine, Houston, TX 77030

©2012 American Society of Animal Science. All rights reserved.

http://dx.doi.org/10.2527/jas.2011-4983

Life on earth evolved with light-dark cycles. As a result there arose in all organisms, though probably first in photosynthetic archaebacteria, oscillatory mechanisms to time processes that were necessary for survival and reproduction (Woelfle et al., 2004). The first known account of these oscillations was given for plants in the 4th century BC by Androsthenes, a ship captain under Alexander the Great (reviewed by McClung, 2006). It was not until the early 20th century, however, that the presence of ~24-h patterns of activity in the absence of external queues was observed in mammals. In 1959, Franz Halberg coined the term circadian from the Latin words “circa” (about), and “dies” (day) to describe these ~24-h oscillations that are now known to occur in all living organisms.

The Lactation Biology Symposium on “Circadian Clocks and Photoperiod in Mammary Gland Development and Lactation” was held at the Joint Annual Meeting of the American Society of Animal Science and the American Dairy Science Association in New Orleans, Louisiana, July 11 to 15, 2011. The objective of the symposium was to provide the lactation biology community with new insights and perspectives from recent research findings on circadian biology as it related to mammary gland development and lactation.

The molecular mechanism governing circadian oscillations first became apparent in the early 1980s and 1990s with the cloning of the clock genes, first in Drosophila and then in mammals. In lactating mammals, diurnal rhythms have been described for several behavioral and physiological traits. Hardin (2011), as the first speaker of the symposium, gave a historical perspective on circadian biology and provided an introduction to the concepts of endogenous circadian clocks and entrainment. He then went on to present events leading to the discovery and description of molecular clock mechanisms in the fruit fly, Drosophila melanogaster, and compared these with the molecular clock mechanisms described in higher organisms and mammals.

As the second speaker of the symposium, Porter (2011) described the developmental changes that occur in the expression of Period (per)1, per2, and brain and muscle aryl hydrocarbon receptor nuclear translocator-like 1 genes within the murine mammary gland. He presented data to indicate that per genes interact with cell cycle DNA damage checkpoint proteins and are down-regulated in mammary cancer. Using the technique of mammary tissue grafting, he demonstrated that per1 and per2 are necessary for normal mammary ductal development and the maintenance of mammary epithelial cell polarity.

Casey and Plaut (2012), the third presentation for the symposium, reviewed the concept of homeorhetic adaptation, gave an overview of circadian and photoperiod biology in mammals, and reviewed recent data demonstrating the mRNA transcripts for core clock components in the mammary tissue of lactating rats as well as in RNA derived from human breast milk. Data were also presented to support the hypothesis that peripheral circadian clocks play an important role in the regulation of homeorhetic responses to the onset of lactation in dairy cows. In a microarray study comparing changes in gene expression with secretory activation among mammary tissue, liver, and adipose tissue, an induction of the positive limb of the core clock was observed in all 3 tissues, and the negative limb of the core clock was also suppressed. In addition, analysis of bovine milk-fat globule RNA demonstrated circadian oscillations in the transcripts of core clock components that were correlated with changes in milk composition.

The symposium concluded with a review on impacts of photoperiod on mammary gland development and lactation in the cow (Dahl et al., 2012). Long-day photoperiod is known to increase milk production in dairy cows when applied during lactation. In addition, long-day photoperiod also enhances overall growth and mammary gland development in calves and heifers, ul-
Ultimately leading to animals capable of producing more milk. On the other hand, short-day photoperiod during the dry period is beneficial to the subsequent lactation. Although the mechanism through which this occurs is complex, there are indications that a phylogenetically conserved interaction between melatonin and prolactin is involved, that IGF-I has a role, and that the effects are mediated through changes in mammary gland development.

In summary, the development of the mammary gland and lactation are subject to regulation by a set central and peripheral clock molecules that appear to be conserved across species. The work presented provides a useful basis for further studies aimed at understanding how peripheral clocks regulate the various aspects of mammary gland development and what their potential role is in determining milk production. It is only a matter of time.

**LITERATURE CITED**


