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# Changes in reproductive physiology of lactating dairy cows due to elevated steroid metabolism

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## Abstract

This manuscript focuses on potential changes in reproductive physiology that occur due to high milk production in lactating dairy cows. Four reproductive measures are discussed: interval to first ovulation, conception rate, duration of estrus, and multiple ovulation rate. The last two responses have now been closely linked to level of milk production. In contrast, time to first ovulation does not appear to be associated with level of milk production, and the association of conception rate with level of milk production is still controversial. In an attempt to explain some of the changes in reproductive physiology caused by high milk production a model of elevated steroid metabolism in lactating dairy cows is presented. Although many aspects of this model remain to be tested, a central role for elevated steroid metabolism in lactation-induced reproductive changes seems likely.

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*Keywords:* Dairy cow; Estrus; Steroid metabolism; Milk production; Double ovulation rate

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## 1. Introduction

Reproductive efficiency has major impacts on profitability of livestock operations, including commercial dairy herds. For several decades, researchers have described reproductive inefficiencies in lactating dairy cattle; however, in recent years the decline in reproductive efficiency has become particularly alarming [1–3]. Some of the problems in reproductive efficiency may be due to the increase in size of dairy operations and decreased

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management of individual dairy cows. However, substantial evidence is consistent with the role of high milk production in causing, or at least being associated with changes in reproductive physiology that may underlie the decline in reproductive efficiency. For example, average duration of estrus is reduced in lactating cows to less than 8 h [4]. Conception rate is lower in lactating cows (generally 25–40%) than heifers (60–75%) [1–3,5]. Twinning rate in dairy cows is higher than in heifers [6], and can be as high as 20% in some herds. Pregnancy loss is much higher in lactating cows than heifers [7]. Other reproductive abnormalities have been reported in lactating dairy cows, such as changes in interval to first ovulation, premature luteolysis and short estrous cycles, delayed luteolysis or persistent CL, prolonged inter-luteal intervals, development of follicular cysts and anovulation, as well as changes in follicular wave patterns, ovarian morphology, estrous cycle length, and circulating hormone concentrations [1–17]. Changes in some of these reproductive parameters have been clearly associated with level of milk production, while others have not yet been validly evaluated or show little or no relationship to level of milk production.

This short review cannot adequately describe the normal physiology of these numerous conditions or all the changes that occur during lactation that alter normal reproductive physiology. This manuscript will begin by briefly describing the association between the four reproductive measures alluded to above and level of milk production. Then, data on alterations in circulating steroid hormone concentrations and follicular and luteal sizes in lactating dairy cows and possible explanations for these alterations will be discussed. The primary focus will be a physiological model that may explain some of the changes in reproductive physiology that are closely associated with level of milk production. One of the key aspects of this model is that increasing milk production is associated with increased metabolism of the steroid hormones. In this model, an increase in steroid hormone metabolism might be expected to alter many aspects of normal reproductive physiology due to the central roles of steroid hormones in essentially all aspects of normal reproduction.

## **2. Changes in some reproductive measures in lactating dairy cows**

### *2.1. Time to first ovulation*

Use of ultrasonography, combined with hormonal assays has allowed a greater understanding of ovarian function during the period from parturition to first ovulation. Following parturition, there is a surge in circulating FSH during the first week [18], probably due to the decrease in circulating estradiol after calving. There is subsequent emergence of the first follicular wave on average at 4 [18] to 12 [10,19] days post-partum. Some cows ovulate the dominant follicle of the first follicular wave, however, first ovulation is delayed in many lactating dairy cows, with time to first ovulation averaging  $33.3 \pm 2.1$  days in Holsteins in the USA (compilation of 10 studies reported in [20]). Pasture-fed dairy cattle had, on average, 4.2 waves of follicle growth before first ovulation with maximal size of the largest follicle increasing as first ovulation approached [21]. This delay in first ovulation is generally attributed to the period of negative energy balance during the early post-partum period in dairy cattle, and a reduction in pulsatile LH

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