The Impact of Lactation on Reproductive Performance

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Take Home Messages

- Endocrine and metabolic regulation associated with lactation antagonizes reproductive processes.
- High levels of milk production are associated with reduced duration of estrus and increased frequency of multiple ovulations.
- Reproductive management systems that allow for programmed timed inseminations can manage first and second inseminations in which the second insemination is made within 3 days after a diagnosis of non-pregnancy within a 35 day period from first service.
- A 5 day-CIDR/Synch TAI protocol approaches a 60% pregnancy rate in non-lactating, virgin dairy heifers.
- Conception rates and pregnancy losses are associated with body condition change between calving and AI and body condition score at AI. Nutritional management from the time of “dry-off” to the time of insemination is critical to herd reproductive performance.
- Cows with a puerperal metritis do not necessarily have a fever (i.e., 39.5 C); there are marked differences in occurrence of metritis between primiparous and multiparous cows with a greater occurrence in the cool season for primiparous heifers.
- A metabolic and reproductive transition occurs during the postpartum period involving the integration of GH, IGF-1 and insulin secretion that drives reproductive cyclicity and pregnancy rates. IGF-1 secretion appears to be associated with fertility.
- Due to detrimental effects of excess protein feeding on re-establishment of ovarian cycles postpartum, as well as adverse alterations in the oviductal and uterine environment of the developing embryo, it is recommended that lactating dairy cows should not be fed in excess of

their needs for maintenance, growth and lactation.

Introduction

Conception rates measured for cows managed under controlled experimental conditions as reported in scientific journals have decreased. Rates dropped from ~55% to ~45% (breeding at spontaneous estrus) to ~35% (timed AI) over a 50-year period (Lucy, 2001). Clearly reproductive performance of today's high producing dairy cow is sub-optimal with pregnancy rates estimated to be 20% for the national USA herd (VanRaden et al., 2004) and 14.7% (De Vries and Risco, 2005) for the southeast region of the United States. The reasons for this infertility syndrome are multi-factorial, and seasonal periods of heat stress exacerbate the condition.

Many reasons for reduced reproductive efficiency have been offered, including an increase in postpartum disease (ketosis, mastitis, retained fetal membranes, cystic ovaries, fatty liver, etc.), an increase in herd size resulting in increased management challenges, an increase in the proportion of milking heifers in the herd which cycle later, an increase in genetic inbreeding, and an increase in milk production (Lucy, 2001). Average milk production per lactation has increased by 57% from ~12,000 to ~19,000 pounds per cow in the last 25 years (Eastridge, 2006). However, amount of milk production has not been an accurate predictor of the chance for pregnancy. For example, higher-producing cows that ate very well cycled sooner after calving than lower-producing cows that ate poorly (Staples et al., 1990). Those poor eaters lost more body weight in the first 2 weeks postpartum and had not cycled by 9 weeks postpartum and fewer became pregnant. Extent of negative energy balance (energy output in milk plus body maintenance minus energy intake from the diet) might be a more important factor influencing pregnancy. The lactating cow is more difficult to get pregnant than the nonlactating cow. Indeed the endocrine and metabolic regulation associated with lactation antagonizes reproductive processes. What are the associated factors associated with lactation that impact reproductive performance of dairy cows?

Reduced Estrus Activity and Multiple Ovulations

University of Wisconsin workers have documented clearly the impact of high milk production on duration of estrus and incidence of double ovulations (Wiltbank et al., 2007). When duration of estrus was monitored stringently in lactating dairy cows using the Heat Watch system (Lopez et al., 2004), it was shown that cows with milk production above the herd average had shorter duration of estrus compared to those with lower milk production (i.e., 6.2 h < 10.9 h), and this relationship was evident in both primiparous and multiparous cows. Production levels greater than 40 kg per day had intervals of estrus approximately 5 h versus 14.7 h in cows producing 25 to 30 kg per day, respectively. Occurrence of multiple ovulations was also directly related to milk production with incidence of 0% for cows producing 25 to 30 kg per day with an increase in multiple ovulations to 51.6 percent in cows producing 50 to 55 kg per day; indeed the inflection point for increased frequency of multiple ovulations appeared to occur at approximately 40 kg of milk per day (Lopez et al., 2005; Wiltbank et al., 2007). These physiological responses were carefully assessed and related to the current milk production determined 3 days before ovulation. Wiltbank and coworkers (2007) have hypothesized that high feed consumption to meet the energy requirements for high production increases blood flow to the digestive tract and the liver leading to a greater metabolism of steroids like estradiol and progesterone that contributes to a reduction in estrus duration and altered ovarian follicular dynamics that result in multiple ovulations.

▪ Programmed Inseminations

With low herd pregnancy rates in lactating dairy cows, controlled breeding programs were developed, such as Presynch-Ovsynch, to reduce the negative impacts of poor and inaccurate detection of estrus and decreased fertility (pregnancies per AI). The challenges are to optimize these systems to maximize fertility as we further understand the dynamics of regulating follicle growth, importance of progesterone priming and timing of insemination. Furthermore, we need to develop physiological systems to efficiently re-synchronize cows that did not conceive to the first service in a timely manner with good fertility.

Indeed we have used a Presynchronization/Ovsynch program for first service followed by a resynchronization program as a platform to evaluate pregnancy rates to first and second service in response to feeding various by-pass fats (Silvestre F.T. and W.W. Thatcher, unpublished observations). Cows were pre-synchronized with two injections of $PGF_{2\alpha}$ (25 mg; Lutalyse, Pfizer Animal Health; New York, NY) given at 42±3 and 56±3 days post partum. At 14 days after the second $PGF_{2\alpha}$ injection, cows received an injection of GnRH (100 µg; Cystorelin, Merial LTD; Iselin, NJ), followed 7 days later by an injection of $PGF_{2\alpha}$, and a second injection of GnRH at 56 hours after $PGF_{2\alpha}$ with timed AI (TAI) performed 16 hours after the second injection of GnRH. The resynchronization protocol for second service of open cows is based upon a CIDR insertion on day 18 after the first timed insemination. The CIDR insert is removed 7 days later on day 25 and GnRH is injected at time of CIDR removal. Ultrasonographic diagnosis of pregnancy to first service is made one week later on day 32, and open cows receive an injection of $PGF_{2\alpha}$. At 56 h after $PGF_{2\alpha}$ injection, GnRH is injected and cows are re-inseminated 16 h later on day 35 after first service. All cows diagnosed pregnant were re-examined for pregnancy at days 46 and 60.

Strategic administration of a CIDR insert after insemination will suppress estrus and sustain development of a dominant follicle in non-pregnant cows that will respond to a GnRH injection when administered at day 25 or 7 days before pregnancy diagnosis at day 32. The injection of GnRH will induce formation of a corpus luteum (CL) and recruit a healthy dominant follicle that is fertile. Thus, at the time of pregnancy diagnosis, a healthy dominant follicle and a functionally responsive CL will be available for a timed insemination in cows diagnosed open by ultrasound. Pregnancy rates at 32 days after insemination for first and second service were 37.9% (942 cows) and 32.2% (536 cows), respectively. Overall 54.5% of cows were pregnant to two inseminations given 35 days apart (i.e., open cows are re-inseminated within 3 days after being detected non-pregnant to first service). Pregnancy loss between day 32 and day 60 for cows that conceived to first service was 9.3%. This study was completed in a large commercial dairy herd and the reproductive management system has been adopted as a routine since it dramatically improved herd reproductive performance compared to the previous year during the same monthly periods.

Our experience is that we can further optimize reproductive performance via strategic timing of reproductive treatments to control ovulation and insemination. However, these alterations are not always practical to implement for farm personnel that specialize on managing reproductive performance. Such systems in lactating dairy cows are not optimal for virgin dairy heifers that are non-lactating.

We have recently utilized a timed insemination program in dairy heifers (n=436) that resulted in a 57.6% pregnancy rate at 46 days after a timed insemination and pregnancy loss between 32 to 46 days was only 2.3% (6/257; Thatcher et al., 2008). The protocol is referred to as a 5 day-CIDR/Synch TAI (intravaginal insertion of a CIDR® device [Pfizer Animal Health Inc.] and injection of GnRH in the AM; 5 days later in the AM the CIDR insert was removed and Lutalyse® was injected followed by a 2nd injection of Lutalyse® 12 h later; heifers were TAI and injected with GnRH at 72 h after CIDR removal). These results point to the marked difference between lactating and non-lactating cows. Apparently, the dairy heifers benefit due to a more prolonged proestrus period.

■ Postpartum Reproductive Status

Body Condition

It is evident that many of the lactating dairy cows presented for service are anovulatory and are not in a state to achieve optimal fertility. In a summary of nine studies from five dairy farms in California (Rutigliano and Santos, 2005), interrelationships among parity, body condition score (BCS; 1 to 5 scale), milk yield, AI protocol (inseminated at estrus or Timed AI (TAI)), and cyclicity (cyclic or anovular) were evaluated as to their impacts on pregnancy rate (PR) and embryonic survival to the first postpartum AI (n = 5,767). Cows were inseminated following a pre-synchronized (two PGF2α injections given 14 d apart) TAI protocol or estrous synchronization protocol initiated 12 to 14 days after pre-synchronization. Occurrence of cyclicity was greater for multiparous than primiparous cows (81.8 vs 69.5%) at 65 d postpartum. Cyclicity also was influenced by milking frequency (twice = 82.7% vs. thrice = 68.7%), BCS at both calving and AI, BCS change, and milk yield. However, milk yield, BCS at calving, and AI protocol had no effect on PR at 30 and 58 days after AI or on pregnancy loss. As expected, more cyclic than anovular cows were pregnant at 30 (40.0 vs 28.3%) and 58 (34.2 vs. 23.0%) days after AI, and cows that were anovulatory prior to estrus synchronization tended to experience greater pregnancy loss (14.5 vs. 18.6%) between 30 and 58 days of gestation. Pregnancy loss was highest (22.5 vs. 16.8 vs. 12.2%) and conception rate at day 58 lowest (21.7 vs. 30.4 vs. 35.6%) in cows that lost > 1 unit of BCS than those that lost < 1 or experienced no change in BCS from calving to AI, respectively. Likewise, cows having a greater BCS at the actual time of AI (> 3.75 vs. 3.0 to 3.5 vs. < 2.75) had better conception rates at 30 (46.4 vs. 40.1 vs. 33.9%, respectively) and 58 (41.8 vs. 34.6 vs. 27.9%) days after AI. Consequently, minimizing losses of BCS after calving and improving cyclicity early postpartum are expected to increase PR and enhance embryonic survival. The challenge is to manage body condition in healthy cows, with an inherent high dry matter intake, so that they have sufficient energy stores at parturition to meet the demands of ensuing negative energy status without a predisposition to fatty livers and metabolic disturbances and have sufficient body condition at the beginning of the breeding period such that they are cycling and able to sustain a pregnancy. These associations target the importance of nutritional management from the time of “dry-off” to the time of insemination as being critical to herd reproductive performance.

Metritis

Puerperal metritis (PM) is a serious condition in dairy cows since it affects production and fertility, and can be life-threatening. A better understanding of calving-related factors that predispose cows to PM would aid in the prevention, diagnosis, and treatment of this condition. A prospective longitudinal study was conducted with a 1000-cow dairy farm in north Florida between August 1, 2002 and April 15, 2003 to evaluate the effect of calving status, parity, and season on the incidence of postpartum PM in lactating dairy cows, and the role of rectal temperature as a predictor of this condition (Benzaquen et al., 2007). The farm employed a postpartum health monitoring program. Cows with a normal calving status (Nc) were those without any calving-related problems. Cows with an abnormal calving status (Ac) were those with dystocia, retained fetal membranes with or without dystocia, or twins at calving. Daily rectal temperature (RT) of all cows was taken between 0700 and 0900 h from days 3 to 13 post partum, and a health examination was performed by the on-farm veterinarian. Cows that appeared sick (depressed, eyes tented, etc.) or had a rectal temperature > 39.5ºC were examined for septic metritis. The criterion for diagnosis of septic metritis was the presence of a watery, brown-colored, fetid discharge from the vulva (noted after palpating the uterus rectally), with or without a rectal temperature > 39.5C. Cows diagnosed with septic metritis were treated with systemic antibiotics, anti-inflammatory agents, calcium, and energy supplements. The environmental thermal heat index (THI) was calculated using the daily ambient temperature and percent relative humidity recorded at the closest weather station. Two seasons were defined based on mean THI as the following: a cool season from October to April (i.e., THI < 76.2^{o}F) and a warm season from May to September (i.e., THI ≥ 76.2 ^{o}F).

A total of 450 parturitions was evaluated. Cows with Nc had a lower incidence of PM compared to cows with an Ac status (13 vs. 41%). A season by parity interaction was detected. During the cool season, primiparous cows had the highest incidence of PM (39.4%) compared to primiparous cows in the warm season (12.7%). In contrast, the incidence of PM in multiparous cows did not differ between the cool (11%) and warm (18%) seasons. The reasons for the parity difference are speculative; perhaps fetal stunting during the hot season in Florida reduced the incidence of dystocia, whereas larger calves born in the winter season increased occurrence of dystocia and subsequent PM in primiparous heifers. The RT of cows that were diagnosed with PM increased 24 h before diagnosis of PM and reached a maximum RT of 39.2°C ± 0.05 on day 0 (i.e., day of diagnosis). In cows with PM and fever at diagnosis, the RT started to increase between 72 to 48 h before the diagnosis of PM and continued to increase to a maximum RT of 39.7°C ± 0.09 on day 0. However, for cows with PM and no fever at diagnosis, no daily incremental increases of RT before the diagnosis of PM were detected; however, the RT on day 0 (38.9°C ± 0.08) was different from cows without PM (38.5°C ± 0.04). Cows without PM had a stable RT during the first 13 days postpartum (mean of 38.6°C ± 0.01). It is clear that many cows have puerperal metritis that do not necessarily have a fever (i.e., 39.5 C), that there are marked differences in occurrence of PM between primiparous and multiparous cows and that primiparous heifers had a greater occurrence in the cool season.

Metabolic and Reproduction Transition during the Postpartum Period

The dairy cow undergoes a major metabolic change associated with partitioning of nutrients to support lactation during the postpartum period. Multiple tissues, including the brain, liver, fat, and muscle link metabolism and reproduction through the production of various hormones and metabolites. The importance of growth hormone (GH), as a principal coordinator of these activities, in the high-producing dairy cow is clear (Lucy, 2003). In addition to directly stimulating liver, muscle, and fat to release metabolites such as glucose and non-esterified fatty acids (NEFA), GH acts on the liver and other organs, such as the pancreas and gut, to promote the release of several hormones such as IGF-I and insulin that act on the brain and also the reproductive tract. During the postpartum period of negative energy balance, the somatotropic axis (comprised of GH, the GH receptor and IGF-I) becomes uncoupled in the liver, and there is elevated GH and decreased IGF-I in the circulation. Blood insulin concentrations are low as well. The increase in GH and NEFA antagonizes insulin action and creates a state of insulin resistance in postpartum cows (Lucy, 2007). Insulin resistance reduces the uptake of glucose by non-mammary tissues, which makes glucose available for milk synthesis. As the GH receptor becomes coupled, liver secretion of IGF-1 increases which decreases pituitary secretion of GH and leads to a greater insulin secretion and responsiveness to insulin. Insulin and IGFI act directly on the ovary to increase the sensitivity of the ovary to luteinizng hormone (LH) and follicle stimulating hormone (FSH) as well as eliciting effects on the uterus and embryo. Therefore, insulin and IGF-I may be responsible for mediating the beneficial effect of a higher body condition on ovarian follicle development and ovulation as well as uterine function and embryo development leading to a higher pregnancy rate.

A vivid example of the transition in endocrine/metabolic regulation on reproduction of lactating cows is the resumption of ovarian follicular activity early in the pospartum period. With the drop in plasma concentrations of estradiol following delivery of the calf and fetal membranes, inhibition of FSH secretion is removed and early increases in plasma FSH begin to stimulate follicle development as early as 7 days after parturition. A dominant follicle develops in response to FSH; however, the follicle does not produce estradiol and this appears to be associated with an inadequate amount of plasma LH. A low pulse frequency of LH leads to inadequate LH availability to support continued growth of the follicle, and the follicle turns over. Also during this period, an inadequate amount of IGF-I is secreted due to the uncoupling of the somatotropic axis described above. Both LH and IGF-I are necessary for full functional development of an estrogenic follicle. The cow appears to sense its energy balance such that when the cow reaches her nadir in negative energy status and begins to have an increase in energy status, although still negative, LH secretion begins to increase as characterized by a higher LH pulse frequency. As a consequence, the next follicular wave induced by FSH produces a growing estrogenic dominant follicle in response to greater availability of LH as well as IGF-1 in association with a transitional re-coupling of the somatotropc axis. The cow now develops a positive feedback response to estradiol and induces a pre-ovulatory surge of LH that causes ovulation. It is not unusual for cows to have their first ovulation as early as 14 days postpartum. However, there is considerable variability among cows in the dynamics of this recovery period leading to cows that cycle early versus later, those that form ovarian cysts, and those that are anovulatory at the time of the voluntary waiting period. Nutritional management to regulate this period of metabolic and reproductive recrudescence is currently an active area of investigation.

At the time of insemination, there are inherent differences between non-lactating and lactating dairy cows in their IGF-1 status that provide insight into fertility differences. We examined day 17 pregnancy rate in nonlactating dairy cows treated with bST (27.2%; 9/33) or no bST (63.6%; 14/22) (Thatcher et al., 2006). In a subsequent study, pregnancy rate was higher for bST-treated cows (83%; 5/6) than for control cows (40%; 4/10). Although these were two separate experiments conducted in comparable months, but different years, the radioimmunoassay of plasma samples for IGF-1 and GH were done at the same time. The bST-induced increase in plasma GH was substantially lower in nonlactating pregnant cows (10 ng/mL) compared to lactating pregnant cows (25 ng/mL). This may reflect a greater utilization by the liver that accounted for a hyperstimulation in IGF-1 concentrations in bST-treated non-lactating pregnant cows (Figure 1.). It is clear that basal concentrations of IGF-1 are higher in more fertile, nonlactating, pregnant cows, than in lactating pregnant cows. However, when nonlactating dairy cows were treated with bST, there was a hypersecretion of IGF-1 which may have accounted for the bST-induced decrease in pregnancy rate. In contrast, lactating pregnant cows that received bST had an increase in plasma IGF-1 concentrations that approximated the range in basal concentrations of pregnant, non-lactating cows that did not receive bST and were more fertile (Figure 1.). Perhaps there is an optimal level of plasma IGF-1 concentrations for pregnancy that can be achieved in lactating dairy cows with bST injections (Figure 1). An increase in concentrations beyond this range may lead to a decrease in pregnancy rate.

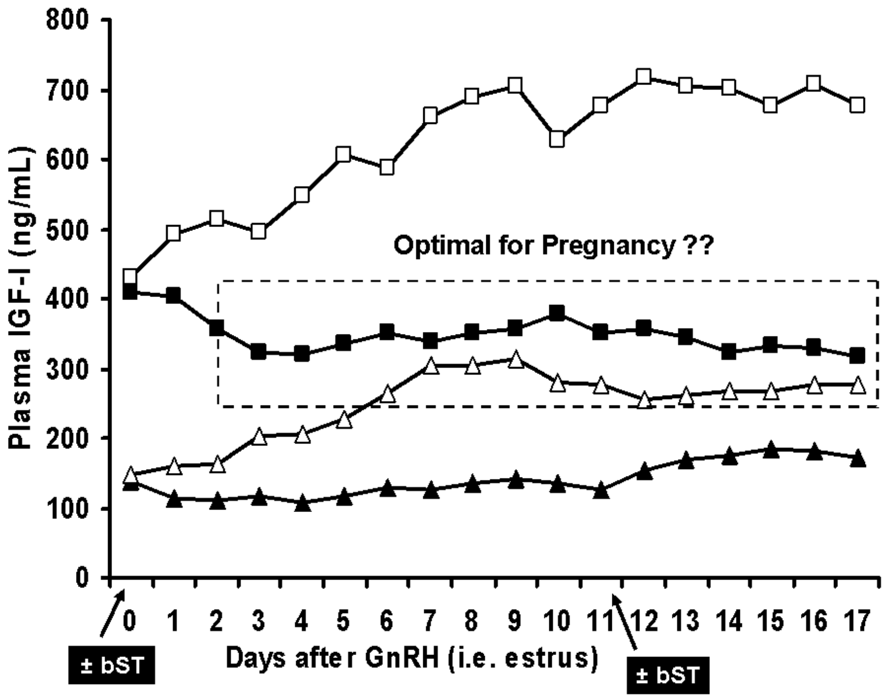


Figure 1. Plasma IGF-1 (ng/mL) of pregnant cows that were nonlactating or lactating. Cows received injections of bST (+/-; 500 mg) on days 0 (i.e., day of GnRH) and 11 after a synchronized insemination (Days 0 to 17). Nonlactating pregnant no bST (■; n = 14); Nonlactating pregnant bST (□; n = 9); Lactating pregnant no bST (▲; n = 4); Lactating pregnant bST (△; n = 5).

▪ Nutritional Regulation of Fertility in Lactating Dairy Cows

Organic Selenium

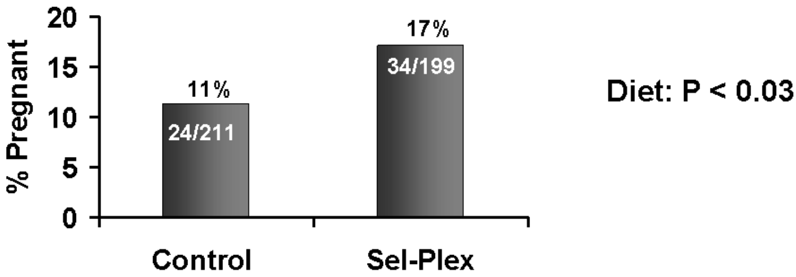
An alternative nutraceutical management strategy involves feeding organic selenium (Se; Se-yeast [SY; Sel-Plex®, Alltech]) during the prepartum to postpartum periods. An experiment involving n = 574 cows was conducted during the hot summer season in Florida, which is a Se-deficient area (Silvestre et al., 2007). Compared to feeding inorganic sodium Se (SS; 0.3 mg/kg [DM basis]) , the organic Se (0.3 mg/kg [DM basis]) increased plasma SE concentrations, reduced the incidence of cows experiencing a fever after parturition, enhanced innate and adaptive immune functions and improved uterine health (Table 1). Feeding the organic selenium reduced the occurrence of a purulent discharge and increased the occurrence of clean discharge at 5 and 10 days postpartum. This is indicative of improved uterine health.

Table 1. Overall Frequencies of Cervical Discharge Scores Measured at 5 and 10 days postpartum

	Discharge Score			
	Clean Mucus	Mucopurulent	Purulent	*P-Value*
Diet				
Control (SS) (n=437)	35% (153)	47% (209)	17% (75)	
Sel-Plex (SY) (n=460)	47% (217)	43% (200)	9.3% (43)	Diet*Score <0.01

Parity (P<0.01); Day (P<0.02); Calving Difficulty (P<0.01); RFM (P<0.01)

Of interest was the impact of diets on subsequent pregnancy rates at a programmed first and second service. Diet failed to alter first service PR at ~ 30 days post AI (SY, 24.9% [62/249] vs. SS, 23.6% [62/262]) or pregnancy losses between ~ 30 and ~ 55 days post AI (SY, 39.3% vs SS, 37.1%.) These low pregnancy rates and high embryonic losses are typical of cows managed during the summer heat stress period of Florida. Diet did alter second service PR [SY, 17% (34/199) vs. SS, 11.3% (24/211)]. The benefit of SY on second service pregnancy rate is very interesting (Figure 2). There was an increased second-service PR (17 vs. 11 %). Those cows fed organic Se which had lost their first pregnancy, tended to have a higher second-service PR (22.7 vs. 4.2 %) compared to their counterparts fed inorganic Se. Late embryonic losses normally are quite high during periods of heat stress. Perhaps feeding organic Se improved the uterine environment following a loss of a previous diagnosed pregnancy, such that PR to the second service was increased.



	2nd Service		
Status after 1st Service (US)	Control	Sel-Plex	*P-Value*
Open	12.3% (23/187)	16.3% (29/177)	NS
Preg (Lost)	4.2% (1/24)	22.7% (5/22)	=0.09

Figure 2. Second service pregnancy rates determined by rectal palpation (~42d) for cows fed Selenium Yeast (Sel-Plex) or control (sodium selenite) and for cows that were open or lost a pregnancy to first service.

Influence of Dietary Protein on Reproductive Performance

Feeding high concentrations (i.e., >10% of the dry matter) of ruminal degradable protein (RDP) increases the amount of amino acids not captured by the microbes to produce microbial crude protein (Tamminga, 2006). Consequently, the excess RDP is degraded with amino acids being converted into ammonia that readily diffuses into the blood and is detoxified via conversion to urea by the liver. Urea enters the circulation and is readily distributed in bodily fluids such as blood, milk, follicular and uterine fluids, and ruminal fluid. Diets high in RDP are associated with reduced fertility (Tamminga, 2006).

Feeding calcium salts of long chain fatty acids (CaLCFA; Megalac^R) at 2.2% of dietary DM) interacted with high dietary concentrations of RDP to improve cyclicity and increased PR in postpartum dairy cows (Garcia-Bojalil et al., 1998). The absence of CaLCFA from the diet resulted in a 10 kg greater loss in body weight and loss of body condition in cows fed a 15.7% RDP diet. The additional energy costs of detoxifying ammonia from highly degradable dietary protein possibly led to a greater reliance on body energy stores for milk production. This resulted in a more severe negative energy state that delayed ovarian activity. By including CaLCFA in the diet, the energy shortage was somewhat alleviated, allowing cows to rely more on feed energy and less on body reserves for milk production. Pregnancy rate by 120 days postpartum was increased from 52.3% (diets of 11.1 and 15.7% RDP without CaLCFA) to 86.4% (diets of 11.1% and 15.7% RDP with CALCFA) and evaluated as a main effect of CALCFA across diets.

More direct and detrimental effects of high protein feeding on embryo-maternal reproductive processes were reviewed recently by Santos et al. (2008). Increasing circulating concentrations of urea N by manipulating the dietary energy and protein reduced conception rates of heifers (Butler, 1998), and embryos collected from lactating dairy cows fed a diet containing excess protein had reduced pregnancy rates in nonlactating embryo transfer recipients (Rhoads et al., 2006). Increased concentrations of ammonia and urea in the reproductive tract may influence embryo viability by altering follicular and oviductal environments. One of the consistent effects of excessive dietary protein is a reduction in uterine lumen pH during the early luteal phase (Butler, 1998), which was associated with reduced conception rate. Infusion of urea increased plasma urea and reduced uterine luminal pH in dairy cows (Rhoads et al., 2004). Maturation of oocytes in the presence of increasing concentrations of urea in vitro did not affect subsequent cleavage of zygotes, but seemed to have a negative effect on the proportion of blastocysts. However, incubation of zygotes with the same concentrations of urea had no effect on embryo development (Ocon and Hansen, 2003). Results from in vivo embryo production studies in dairy cows were not consistent necessarily with the in vitro studies. When dry cows were superovulated and received diets with concentrations of protein and RDP much higher than recommended for high producing lactating dairy cows, no negative effects on embryo quality and viability were observed (Garcia-Bojalil et al., 1994). Similarly, excess protein (fed as urea) did not affect embryo quality in superovulated lactating cows (Rhoads et al., 2006). When lactating diets differing in protein degradability were fed, the ration with higher rumen degradable protein tended to reduce the proportion of transferable embryos, even though the number of transferable embryos was not affected (Blanchard et al., 1990). In vivo-produced embryos from dairy cattle fed excess protein often appear unaffected. Nevertheless, embryos of similar grade quality resulted in reduced pregnancy rate after transfer when they originated from cows consuming excess dietary protein (Rhoads et al., 2006). Due to possible detrimental effects of excess feeding of protein on re-establishment of ovarian cycles postpartum, as well as adverse alterations in the oviductal and uterine environment of the developing embryo, it is recommended that lactating dairy cows should not be fed in excess of their needs for maintenance, growth and lactation.

■ Conclusion

Reproductive performance of today's lactating dairy cow is sub-optimal and is attributed to a multitude of factors associated with the lactational state that encompasses metabolic status of the cow, and coordinated management strategies involving health, nutrition and reproductive management programs. Endocrine and metabolic regulation associated with lactation antagonizes reproductive processes. A transition occurs during the postpartum period involving the integration of GH, IGF-1 and insulin secretion that ultimately drives reproductive cyclicity and pregnancy rates. IGF-1 secretion appears to be associated with fertility. Early reproductive processes associated with cyclicity and establishing a pregnancy are not that energy demanding, but the associated balance of metabolic and reproductive hormones during early lactation including the breeding period impacts on reproductive success.

Cyclicity, conception rate and pregnancy losses are associated with body condition change between calving and insemination and body condition score at insemination. Consequently, nutritional management from the time of "dry-off" to the time of insemination is critical to herd reproductive performance. High levels of milk production are associated with reduced duration of estrus and increased frequency of multiple ovulations. Reproductive management systems that allow for programmed timed inseminations can manage first and second inseminations in which the second insemination is made within 3 days after a diagnosis of non-pregnancy within a 35 day period from first service. In a large commercial herd, 50% of lactating cows were pregnant following two timed inseminations. Traditional TAI protocols applied to non-lactating cows do not result in optimal fertility. Development of a 5 day-CIDR/Synch TAI protocol resulted in a pregnancy rate approaching 60% in virgin dairy heifers. This program induces a longer proestrus period that appears to enhance conception rate to a timed insemination. Such a program warrants further investigation in lactating dairy cows.

Occurrence of puerperal metritis differs between between primiparous and multiparous cows, with a greater occurrence in the cool season for primiparous heifers. Cows with metritis do not necessarily have a fever. The occurrence of metritis enhances the incidence of subsequent endometritis later postpartum and a lower pregnancy rate at first service. Nutritional management of the lactating dairy cow, beginning in the transition period and throughout the postpartum period, enhances immune function, uterine health, ovarian activity and subsequent pregnancy rates. Nutritional management strategies include the use of organic selenium, selected fat feeding, and attention to level of protein feeding. Managing the reproductive performance of the lactating dairy cow is a challenge that will involve the coordinated efforts of the veterinarian, nutritionist, and management personnel.

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