The Effect of Milk Production on Reproductive Performance in the High Producing and BST Supplemented Dairy Cow.

David McClary, *DVM*
Lilly Research Laboratories
Greenfield, IN

Introduction

Over the past 35 years numerous studies have measured the relationship between milk production and reproductive performance in dairy cows.[1-7]. Most reported studies indicate a negative relationship between milk yield and key reproductive indices. Hamudikuwanda *et al*[6] summarized this relationship to be an additional 0.3 days open and .005 services per conception for each 100 lb increase in milk yield for the first 120 days-in-milk. The factors contributing to this inverse relationship between milk production and reproductive performance are discussed.

Production vs Reproduction

Reduced reproductive efficiency in the dairy cow can be related to biological and managerial factors. In most dairy herds management related factors such as failure to detect estrus and faulty insemination technique have a much greater impact on reproductive performance than biological factors. Comparison of reproductive performance of over 40,000 cows from approximately 4,000 herds with annual milk rolling herd averages from 12,000 to 21,000 lbs indicates days open is longer in cows with lower milk production levels[8]. (Table 1) This analysis suggests that reproductive management factors such as heat detection contribute to reduced reproductive performance. Lower producing herds are likely suffering from a number of management deficiencies including deficiencies in reproductive management which contribute to lower production. To evaluate the biological influence of level of milk production or reproduction, management factors must be eliminated and cows must be compared under the same management system.

The negative relationship reported between milk production and reproductive performance is apparently not directly related to genetic improvement. As average milk yield has increased 6500 lb/cow/year since 1950, first service conception rates have declined (66% vs 45%)[9]. Yet over the same time period, conception rates in virgin heifers have remained approximately 70%.

The reduction in reproductive efficiency noted in the high producing dairy cow is most likely directly related to the energy balance of early lactation. In early lactation milk production increases rapidly, reaching a peak at four to eight weeks in lactation. Dry matter intake slowly increases during early lactation but does not peak until 10 to 14 weeks into lactation[10]. Since a lag exists between peak milk production and maximum dry matter intake, often the cow does not consume enough nutrients to support the high levels of milk production. To support the demands of peak milk production the cow mobilizes body tissue energy stores producing a negative energy balance. Maximum negative energy balance usually occurs at approximately 14 days-in-milk. As dry matter intake continues to increase during early lactation, the cow begins to reduce the magnitude of negative energy balance until an equilibrium between energy intake and energy output is achieved at 56 to 120 days-in-milk[11].

TABLE 1 Reproductive Efficiency at Various Milk Production Levels[1]

	Milk Rolling Herd Ave (1,000s)				
Indice	12-13	14-15	16-17	18-19	20-21
Ave. Herd Size	92	128	122	118	126
Days Open	142	135	128	126	127
Days to 1st Service	89	88	86	87	88
Breedings/Concept	1.9	2.2	2.3	2.2	2.3
Heat Detection %	31	40	47	50	54

[1]DHIA Records Raleigh, NC DRPC Nebel RA, Stallings CC: Hoard's Dairyman, 1990. [(8)]

During maximum negative energy balance there is little evidence of cyclic ovarian activity. Elevated progesterone concentrations seen throughout most of pregnancy are extremely low following lysis of the corpus luteum of pregnancy. Estrogen concentrations peak near the time of parturition and return to base line immediately postpartum. During the early postpartum period, the frequency of pulsatile GnRH release from the hypothalmus is markedly reduced compared to frequency patterns seen in cyclic cows. Subsequently the pulsatile release of pituitary gonadotropins (LH and FSH) is also reduced. A significant increase in the pulsatile release of GnRH usually starts approximately 14 days post calving. First ovulation in the postpartum dairy cow normally occurs approximately 10 days later or after maximum negative energy balance. Although first ovulation occurs 20 to 24 days-in-milk the range may be quite large (9 to 93 days). Days to first ovulation are likely directly related to the accumulated negative energy balance.

Cumulative negative energy balance is related to level of milk production and nutrient intake. While higher producing cows do tend to experience a greater magnitude of negative energy balance[11] (Figure 1), reduced nutrient intake can also produce a relative decrease in energy balance. Reduced intake or energy deficient rations may not support high levels of milk production placing increased demands on body tissue nutrient stores.

Numerous disease conditions seen in the postpartum dairy cow can contribute to reduced nutrient intake. Cows with excessive body condition at calving may also suffer reduced intake. Reduced intake often results in excessive mobilization of body fat reserves and a corresponding reduction in reproductive efficiency. Heinonen *et al*[12] demonstrated a significant correlation between percent body weight loss in early lactation and reproductive efficiency. Cows were categorized as having loss of body weights as >10%, 5-10%, and <5%. Those cows with greater losses of weight had a significant increase in days to first observed estrus (48.3+/-2.5 vs 42.8+/-1.3 and 45.7+/-2.1), days open (89.6+/-3.2 vs 79.4+/-1.7 and 78.6+/-2.5), and first service conception rate (53.1 vs 74.4 and 78.6) as compared to cows losing 5-10% and < 5% body weight, respectively. Butler *et al*[13] demonstrated similar results related to loss of body condition score (BCS) during the first 5 weeks of lactation. Cows losing >1.0 BCS regardless of the score at calving had significant reductions in all measured reproductive indices. (Table 2) Over-conditioned at calving (BCS > 4) should be avoided to prevent excessive loss in body condition score.

FIGURE 1 Milk Production and Energy Balance During Lactation

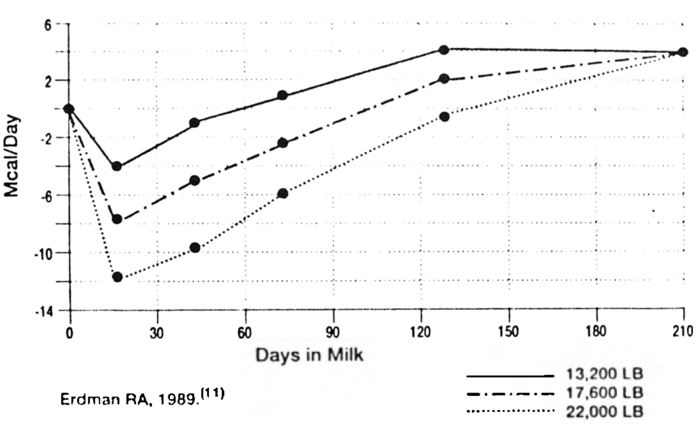

TABLE 2 Body Condition Score[1] Loss During First 5 Weeks of Lactation vs Reproductive Efficiency

	Body Condition Score Loss		
	<0.5	0.5-1.0	>1.0
Number	17	64	12
Days to 1st Ovulation	27+/-2[a]	31+/-2[a]	42+/-5[b]
Days to 1st Observed Estrus	48+/-6[ab]	41+/-3[a]	62+/-7[b]
Days to 1st Service	68+/-4[a]	67+/-2[a]	79+/-5[b]
1st Service Conc. Rate (%)	65[a]	53[a]	17[b]
Services/Conc.	18+/-0.4	2.3+/-9.2	2.3+/-0.4

[1]Body Condition Score 1-5 Scale
[ab]Means With Different Superscripts ($P < 0.05$)
Butler WR et al J Anim Sci, 1981. [(13)]

Nutritional Factors Affecting Ovarian Activity in the Postpartum Cow

Although reduced ovarian activity in the postpartum cow is apparently related to the cumulative negative energy balance of the postpartum period, the exact mechanism is complex and not completely understood. The nutritional factors related to ovarian activity are both physical and physiological. Maternalization or suckling apparently decreases the pulsatile release of LH and FSH from the anterior pituitary. While maternalization may be related to postpartum anestrus in the suckled beef cow, it is not an important factor in the dairy cow.

In the postpartum dairy cow, increased utilization of glucose leads to hypoglycemia and hypoinsulinemia which increase fat mibilization. Initially these conditions tend to stimulate appetite. Increased appetite increases the release of opoid compounds (beta-endorphins) within the hypothalamo-hypophyseal unit. Beta-endorphins directly inhibit the pulsatile release of GnRH which subsequently also reduces the pulsatile release of LH. GnRH pulsatility is also apparently reduced by the increased production and utilization of ketones secondary to increased lipolysis. Since insulin has been shown to have a gonadotrophic effect on the ovary[14], hypoinsulinemia in early lactation may adversely affect responsiveness of ovarian follicles to gonadotropin stimulation.

Evidence of suppressed ovarian activity in the early postpartum dairy cow can be further measured by reduced serum progesterone levels subsequent to early ovulations. Villa-Godoy *et al*[15] noted a direct relationship between serum progesterone concentrations and the relative energy balance in postpartum dairy cows. Apparently excessive caloric deficiency contributes to poor luteal function in the second and third estrus cycles. This relationship likely explains the reduced early postpartum conception rates seen in many high-producing, negative-energy-balance cows.

Effect of BST on Reproductive Efficiency

While numerous studies conducted in the US and other countries have consistently demonstrated increases of 10 to 20% in milk yield in BST-supplemented cows, the effect of BST on reproductive performance is less clear. Some studies have shown no effect on reproductive indices[16-26] while others indicate slight increases in days open, calving interval, and/or services-per-conception when BST supplementation was initiated prior to breeding[27-32]. Days-in-milk relative to the initiation of BST supplementation is an important consideration in measuring any negative impact of BST on reproductive efficiency. Treatment during early lactation may contribute to a greater cumulative negative energy balance resulting in a delayed return of cyclic ovarian activity and an increase in days-open.

Data from a series of five trials including 113 non-pregnant cows in early lactation (29-42 days-in-milk) at the initiation of BST treatment were evaluated to determine BST's effect, if any, on reproductive indices[33]. Groups consisting of 27, 29, 28, and 29 animals were treated with 0, 320, 640, or 960 mg/28-days BST, respectively. Pregnancy rates were 25 to 27 (93%), 23 of 29 (79%), 24 of 28 (86%), and 24 of 29 (83%) for the respective groups. There was no significant difference nor was there a dose-related pattern in the number of days to first service among the groups. Although increases were noted in the BST-supplemented groups, the differences were not statistically significant. The differences do indicate, however, a trend toward reduced reproductive efficiency in the BST-supplemented cow when BST supplementation is initiated in early lactation. (Table 3)

TABLE 3 FIVE TRIAL SUMMARY
Reproductive Performance of Early Lactation Cows Receiving Somidobove

	Somidobove (mg/28 days)			
Stage	0	320	640	960
No. Cows	27	29	28	29
No. Pregnant (%)	25(93)	23(79)	24(86)	24 (83)
Days to 1st Service	83	68	92	78
Days Open	113	120	138	129
No. Calving	23	23	23	23
Calving Interval	393	401	411	399
1st Service Conc. Rate (%)	56	31	36	28
Services/Conception	1.8	2.7	2.5	2.6

(33)

Ferguson[34] evaluated the reproductive data from a number of BST dose-titration trials in an attempt to measure the effect of treatment prior to pregnancy on reproductive efficiency. Pregnancy rates of 2187 BST-supplemented cows were slightly reduced compared to 1170 nontreated controls (81.2 vs 89.2%). When analyzed on average daily dose equivalent of 0, <10.5, 10.6-25, 26-46, or >46 mg/day BST regardless of the dosage form, daily or sustained release, pregnancy rates tended to be negatively related to dose, (89.5, 87.1, 79.8, 81.4, and 73.8%, respectively). He also noted that pregnancy rates tended to be lower in cows that had below average milk production responses to BST at the various dosage levels.

In the same analysis, Ferguson determined conception rates to be similar in treated and control cows (47.8 vs 48.4%, respectively). Days open were increased 17.2 days in cows receiving >25 mg BST/day compared to controls.

A summary of 21 European BST trials comparing 402 nontreated controls and 483 cows treated with 640 or 960 mg/28 day BST indicated no difference in a number of reproductive indices when BST supplementation was initiated 23 to 130 days-in-milk. A significant increase ($p < 0.01$) was noted in the multiple birth rate in BST- supplemented cows compared to controls (10.7 vs 4.7%, respectively)[35]. (Table 4)

TABLE 4 SUMMARY OF 21 EUROPEAN BST TRIALS
Reproductive Performance of Lactating Cows Receiving Somidobove

	Somidobove (MG/28 Days)	
	0	640/960
No. Cows	402	483
No. Pregnant (%)	327(81.3)	387(80.1)
Pregnant Before Treatment	88	115
Days to 1st Service	71.5	72.4
Days Open	96.9	100.4
Calving Interval	384.7	386.2
1st Service Conc. Rate (%)	45	41.5
Conc. Rate All Services (%)	45.7	44.2
Services/Conception	2.32	2.42
No. Calving (%)	296(90.5)	347(89.6)
No. Abortions	10	8
% Male Calves	51.0	48.2
Male Birth Wt. (KG)	46.3	46.5
Female Birth Wt. (KG)	44.3	43.6
Assisted Birth (%)	72(25.2)	84(23.5)
Milk Fever	31	27
No. Calving (%)	298(90.5)	347(89.6)
Total Calves	310	385
Single Births	282	310
Twin Births (CBTI)	14(4)	36(6)
Multiple Birth Rate %	4.7	10.7*

*$p < 0.01$

(35)

Herrler *et al*[36] reported a two fold increase (3.8+/-1.1 vs 1.9+/-0.7) in the number of transferable embryos in cows treated with 640 mg/28 day BST five days prior to superovulation treatment with 2500 IU PMSG.

These data suggest BST has an effect on folliculogenesis and ovulation rates in supplemented cows. BST's influence on ovarian function is likely related to the interactions of BST, insulin growth factor-1 (IGF-1), gonadotropins (FSH and LH), and ovarian follicles. Receptors for BST and insulin have been isolated from the bovine ovary. Granulosal cells in the ovary produce IGF-1. IGF-1 production and/or release is increased by BST supplementation. IGF-1 acts synergistically with FSH to; 1) increase granulosal cell division, 2) increase follicular estrogen and progesterone production, and 3) increase granulosal cell LH receptor numbers. Spicer et al[37] concluded that treatment with bovine growth hormone-releasing factor (GRF) did not increase IGF-1 concentrations in the ovarian follicle but instead affected the development of large follicles. These factors should be considered when initiating BST supplementation in the postpartum period.

BST will likely have minimal impact on reproductive efficiency in the dairy cow when supplementation is initiated after 100 days-in-milk or after peak lactation and maximum negative energy balance. When BST treatment is initiated earlier in lactation, ie. 30-40 days-in-milk, total lactation milk yield will likely be increased but reproductive efficiency will likely be slightly reduced due to an exacerbated negative energy balance. The reduction in reproductive efficiency will likely be of the same magnitude seen in the genetically-superior, higher-producing cow. If nutrient intake is increased in the early lactation cow the effects of negative energy balance on reproductive efficiency can be minimized. BST supplementation at the time of breeding may increase the incidence of multiple births in the dairy cow.

Summary

Higher-producing dairy cows have reduced reproductive efficiency compared to lower producing herdmates. This relationship is likely to be seen whether increased production is achieved through superior genetics or BST supplementation. Increased days open in the high-producing cow are most likely related to a slight delay in return of cyclic ovarian activity and reduced first service conception rates. Reduced fertility in the high-producing cow is not directly related to increased milk yield but rather to loss of body weight and body condition. The magnitude of the negative impact of milk production on reproduction depends on the cumulative negative energy balance in early lactation. High-producing cows can achieve optimal reproductive efficiency if they are fed adequate energy and protein to support high levels of milk production in early lactation and replenish adequate body condition in late lactation and the dry period.

While BST-supplemented cows are similar to higher-producing, genetically superior cows in that total milk is increased for the lactation, they may differ in the patterns of milk production over the lactation. Depending on the time of initiation of BST supplementation and the duration of administration, the BST-supplemented cow may have a greater persistency of the lactation curve. Subsequently, the BST-supplemented cow will produce a higher percentage of total milk in the latter part of lactation, changing the rate of profit accumulation. With more milk being produced in late lactation, the importance of maintaining a minimal calving interval may be reduced. The voluntary waiting period prior to breeding may be intentionally extended, thereby reducing the pressures of early postpartum rebreeding when first service conception rates are often low in high-producing cows. Maintaining profitable levels of milk production for longer lactation cycles will allow for later postpartum breeding and reduce culling for reproductive failure. Reduced calvings per year may actually extend herd life by reducing the number of disorders associated with the early postpartum period.

BST will not be indicated for all cows. Even within herds using BST, programs for recommended use will vary depending on a number of factors including milk production, body condition, and reproductive status. The dairy farmer and the health consultant will need to scrutinize individual cows to determine which are most likely to benefit from BST supplementation. To maximize efficiency and profitability, the appropriate stage of lactation in which to use BST must be determined. The bovine practitioner can play a meaningful role in making those management decisions.

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