Managing The Postpartum Cow To Maximize Pregnancy Rates

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Introduction

The main objective of a reproductive program in a dairy herd should be to maximize pregnancy rate (PR) to first service. Pregnancy rate is the product of the heat detection and conception rates of the herd (PR = HDR x CR). Pregnancy rate represents the proportion of cows that become pregnant each estrous cycle, and determines the number of days cows are open after the voluntary waiting period. As the PR increases from a higher HDR, greater CR or both, days open decreases (Figure 1). Ferguson and Galligan [13], have shown that PR to first insemination explained 79% of the variation in the calving interval. These authors concluded that maximizing the HDR and CR for first insemination is the most important factor influencing the calving interval. Therefore, dairy herds should allocate significant resources to maximize PR to first service.

To improve pregnancy rate to first service, estrous synchronization protocols such as the targeted breeding, modified targeted breeding or the OvSynch/timed AI programs are commonly used. By synchronizing a group of cows, estrus periods are concentrated within a 7-day period which helps to improve estrus detection rate or in the case of OvSynch/timed AI, cows can be inseminated without being detected in heat. These estrous synchronization or timed artificial insemination protocols increase PR because more cows are inseminated at the end of the voluntary waiting period. However, to maximize first service PR from these protocols, dairy cows must have experienced multiple estrous cycles early post partum. Cows expressing one or more estruses during the first 30 days post partum had improved pregnancy rates to first service compared to cows with no estruses [41]. This observation indicates that the physiological and hormonal events associated with estrus help restore uterine and ovarian function to a state conducive to the establishment of pregnancy. The severity and duration of negative energy balance postpartum, is the most important factor that influences ovarian activity and resumption of cyclicity postpartum in dairy cows [6,11].

Objectives of this presentation are 1) to describe the association between calcium status to periparturient disorders and its effect on postpartum energy status; 2) to relate the effect of postpartum energy status on reproductive performance; 3) to describe a protocol for management of the postpartum dairy cow with the ultimate aim of maximizing the pregnancy rate to first insemination.

Associations of Hypocalcemia to Calving Related Problems

During calving or shortly thereafter, hypocalcemia is inevitable in the dairy cow and is characterized by a blood calcium concentration < 8.0 mg/dl [16,17,18,30,31]. Hypocalcemia develops as a result of the sudden drain of calcium to colostrum at the onset of lactation, resulting in a tremendous challenge to the cow's ability to maintain normal calcium levels in blood. Milk fever is the clinical manifestation of hypocalcemia and the decreased plasma calcium content is accentuated in affected cows. Affected cows are recumbent and are unable to rise and have a calcium deficit of 8 grams. A standard intravenous dose of 500 ml of a 23 per cent calcium gluconate solution provides 10.8 gms of calcium.

Hypocalcemia after calving may affect organs that have smooth muscle function such as the uterus, rumen and the abomasum (stomach). A significant association between parturient hypocalcemia, dystocia and retained fetal membranes in dairy cows, has been reported [7,8,19]. Cows with parturient hypocalcemia were 6.5 times more likely to have dystocia, 3.2 times more likely to have RFM and 3.4 times more likely to have a left displaced abomasum [13]. Grohn et al [19], after evaluating the lactational and health records of over 61,000 dairy cows in Finland, found that parturient hypocalcemia was a significant risk factor for dystocia, RFM and clinical ketosis. The latter was associated with silent heats, cystic ovaries and infertility.

Reductions in blood calcium content may affect normal function of the uterus, rumen and abomasum, without causing the animal to become recumbent and unable to rise. This condition has been referred to as subclinical hypocalcemia and has been associated with various periparturient disorders[19,37]. In a California study, hypocalcemia without paresis was more common in cows affected with uterine prolapse than controls [37]. The prolapse uterus was related to uterine atony, a delay in cervical involution and continued abdominal presses soon after parturition. Parturient hypocalcemia has been shown to delay cervical involution and cause uterine inertia [29]. In the study mentioned above [37], there was no difference in serum calcium concentrations between 9 pairs of first parity cows which had prolapsed and their control contemporaries. This supports the clinical finding that primiparous cows seldom experience milk fever.

Hypocalcemia has been associated with displaced abomasum and reduced rumen contraction. Cows that had abomasal displacement in an Iowa study had abnormally low blood calcium content preceding displacement [22]. Cows affected with hypocalcemia without paresis (total Ca < 8 ng/ml) where 4.8 times more likely to develop left displacement of the abomasum [26]. In a study involving sheep, Huber et al [21], demonstrated a true cause and effect relationship between hypocalcemia and normal smooth muscle contractility in the ruminant stomach. The major conclusions of this study were that: 1) ruminal contractions ceased long before signs of hypocalcemia were observed, 2) ruminal dysfunction may occur substantially before the clinical signs of hypocalcemia. In a study [10], that compared total serum calcium concentrations of cows diagnosed with abomasal displacement or volvulus with that of unaffected cows from the same herds, hypocalcemia occurred in over two-thirds of cows affected with displaced abomasum or volvulus, suggesting that calcium administration at the time of correction of these conditions may be beneficial.

Energy Status

Postpartum dairy cows undergo a marked change in energy status proceeding the time they are returning to normal restoration of ovarian cycles. Energy status has been defined as the net energy intake of the animal minus the net energy required for maintenance and minus the net energy necessary for milk production. Dairy cattle undergo a period of negative energy status in early lactation because energy output via milk production exceeds energy intake via feed consumption.

Any calving related disorder that causes the cow to go off feed will further contribute to the negative energy status already present during post partum. Prolonged hypocalcemia after calving may suppress feed intake, and may exacerbate the negative energy status of the cows during early lactation. Cows with milk fever have been reported to have a lower dry matter intake post partum than non paretic cows [25]. Further, hypocalcemia prevents secretion of insulin, preventing tissue uptake of glucose which would enhance lipid mobilization, increasing the risk for ketosis [24]. In a study that evaluated uterine involution in cows with milk fever, mean uterine horn diameter was larger between days 15 to 32 post partum when compared to non milk fever postpartum cows [37]. The slower rate of uterine involution was attributed to a more severe negative energy balance reflected by a greater loss of BCS during 30 days post partum in milk fever cows and not to hypocalcemia [37]. Beede et al [1], have suggested that postpartum disorders associated with hypocalcemia, may have major consequences on the health and productivity of the postpartum cow. Hypocalcemia may result in the “droopy cow” syndrome sometimes observed early postpartum, even in cows that did not show clinical milk fever at calving. Goff et al [16], have reported that 10 to 50% of cows remained subclinically hypocalcemic (plasma calcium < 7.5 mg/dl) up to 10 days post partum. Similarly, in cows with RFM and uterine prolapse without signs of milk fever, hypocalcemia was observed during the first 7 days post partum [37]. Calcium treatment early post partum, particularly cows affected with dystocia or RFM, would help restore blood calcium concentration and promote normal function of calcium-dependent organs. This treatment would aid the cow in making a smoother transition during the early postpartum period. Intravenous calcium gluconate products can be given as in milk fever cases. Alternatively, per oral calcium products are available for treatment of hypocalcemia [16,18,30,35].

Postpartum reproductive function can be divided into recrudescence of ovarian follicular activity, ovulation, and formation of fully functional corpora lutea (yellow body) that will maintain a pregnancy. The effect of energy status upon integrated ovarian activity during early lactation was assessed in 54 Holstein cows during the first 9-week postpartum [40]. Twenty-eight percent of the cows (n=15) were anestrous (did not cycle) for the 9-week postpartum period. These cows were compared with two cycling groups:

a group of 25 cows that resumed cyclicity within 40 days after parturition and a second group of 14 cows that resumed cyclicity between 40 and 63 days postpartum. The energy status during the first 2 weeks postpartum was very important. Both the later cycling and non-cycling cows were in progressively negative energy states, that is, they continued to be in a more negative energy state in the second week than in the first week. This was especially true for the anestrous cows. Intake of feed by anestrous cows continually lagged behind that of cycling cows. Not only did anestrous cows eat less at week 1 postpartum, but the difference between them and cycling cows became greater as time went on. On the average, anestrous cows ate between 2.5 and 3.6 kg less feed per day than cycling cows. The cows returning to CL activity the earliest started their recovery to a positive energy state immediately after the first week. The marked deficit in early energy status for the anestrous cows in this study exerted a marked carryover effect on conception. Only 33% (5/15) of anestrous cows eventually conceived compared to 84% (21/25) and 93% (13/14) for early and late cycling cows, respectively.

Body Condition

Body condition scores (BCS) post partum are related with the magnitude and severity of negative energy balance. Cows that lose more than 0.5 BCS, during post partum have been reported to have compromised reproductive performance [11]. Furthermore, pregnancy rates to first service are lower in cows with a BCS < 2.5 during the first 100 days post partum [3,4,27,28]. Because nearly all cows lose body condition postpartum, cows should be in good body condition at calving. A score of 3.25 to 3.75 at calving is recommended. Cows that are over-conditioned at calving are also candidates for excess body condition loss postpartum. Over-conditioned cows are unable to increase their dry matter intake quickly postpartum. As a result, body reserves are relied upon heavily to help support milk production. Heifers carrying approximately 21.8 kg more fat at calving (BCS of 3.72) ate 0.95 less kg/day of DM and lost approximately 34 more kg of BW than controls [20]. Over-conditioned cows were 2 weeks later in achieving a positive energy status than cows in good body condition and fed high energy diets. One BCS unit (converted to U.S. system) was lost in order to support milk production by overconditioned cows compared to a slight gain in body condition for control cows over the 10 week period [23]. The reproductive problems of fat cows may not be due solely to lowered feed intakes. Studies from Florida indicates that fatter non-lactating cows were less able to maintain a persistent follicle in the absence of a CL but exposed to progesterone from an intravaginal controlled internal drug releasing device (CIDR), whereas thinner cows maintained a persistent follicle [3]. This difference in ovarian follicular response could be due to greater clearance of supplemental progesterone from the blood stream by fat cows.

Changing body condition through dietary manipulations requires some strategic planning and careful consideration. Under-conditioned cows should put on condition during the late lactation period because they are more efficient at utilizing metabolizable energy during this time than during the dry period (75 vs. 60%). In addition, the dry period may be too short to fully recover condition needed prior to calving. Cows should not lose weight during the dry period as the cow must gain 1 to 1.5 lb/day simply to meet the needs of the rapidly developing fetus.

The probability of conception to occur at first insemination can be determined by the loss of BCS during the postpartum period. Domecq et al [11], investigated the relationship between changes in BCS during the dry period, early lactation and conception to first service in 720 Holstein cows. This study [11] concluded that : 1) cows that lost one point of BCS in the 1st month of lactation were 1.5 times less likely to conceive than were cows that did not lose one point of BCS and 2) energy balance during the dry period and early lactation, as monitored by BCS, was more important to conception to first service than were health disorders or other risk factors evaluated. In several Florida field trials with lactating dairy cows, body condition during the first 100 days postpartum was related to conception rate [3,5]. An experiment was designed that compared pregnancy rates to timed insemination using the Ovsynch protocol for the first service of lactating dairy cows with body condition scores $<$ 2.5 (Low BCS group) versus $\geq$ 2.5 (Control group) using a 1 to 5 scale [27,28]. The Ovsynch timed insemination protocol has been tested against control treatments that employ insemination at detected estrus in dairy heifers and in lactating dairy cows. In general, the program has been producing pregnancy rates that are either similar or greater when compared to pregnancy rates for the control group [2,3,4,5,32,33,34,39]. This is an excellent reproductive management system to evaluate specific nutritional and hormonal effects on pregnancy rates and was used to examine the effect of BCS on pregnancy rates. At 63±3 days postpartum, cows were assigned to experimental groups (n=81 for the Low BCS group and n=126 for the Control group) and began the 9-day Ovsynch timed insemination protocol. Cows returning to estrus were re-inseminated at detected estrus. Cows were examined by ultrasonography for pregnancy at 27 days after insemination and again at 45 days by rectal palpation. Pregnancy rates were less for the Low BCS group compared to the Control group at day 27 (18.11% (±6.10) < 33.83% (±4.55); $P<0.02$) and at day 45 (11.14% (±5.49) < 25.64% (±4.10); $P<0.02$). Rates of cumulative pregnancies through either 120 or 365 d PP were lower for Low BCS cows ($P<0.01$). Thatcher et al [42], used a dynamic programing model to determine the additional revenue per cow per year in dollars of various scenarios in which the percentage of the herd with low body condition score (<2.5) varies (Figure 2). For example there is an increase in net revenue per cow per year of $10.33 between a herd of cows with a low body condition rate of 10% versus 30%. The data presented in Figure 2 is unique to this commercial herd of cows in which the study was completed. However, it gives one the relative costs under various herd management scenarios.

Relationship Between Elevated Crude Protein Intake and Energy Status

Postpartum changes in uterine involution, restoration of ovarian activity and increased milk production are accompanied by dramatically changing energy and protein states of the animal. Changes in these nutritional conditions have been shown to influence physiological changes associated with reproduction. If more crude protein

(CP) is fed than can be utilized by the cow, urea concentrations in body tissues can be elevated. Feeding of diets containing 19 to 21% CP result in elevated BUN concentrations and frequently in lowered conception rates compared with cows fed 15 to 16% CP diets. Older cows are more likely to be affected negatively by elevated dietary CP than younger cows. Not only has the total CP content of a diet proven important for reproductive performance but also the dietary concentration of degradable intake protein (DIP). Replacing soybean meal with a less ruminally degradable protein feedstuff such as fish meal, corn gluten meal,etc. often alleviated some reproductive inefficiency, including delayed first ovulation, lowered conception rates, and elevated embryonic deaths. In general, feeding of excess protein leading to elevated BUN concentrations resulted in some reduction in reproductive performance of lactating dairy cows.

High protein feeding may adversely affect reproductive performance by increasing energy costs to the animal for detoxification of ammonia resulting in a "weakening" of the cow's energy state. The need to detoxify ammonia by animal tissues can be energetically costly. Feeding 100 g of unutilized CP results in a loss of 0.2 Mcal of energy [43]. If 500 to 1000 g of excess protein is consumed, energy costs could be a quite substantial 2 Mcal/d (up to 7% of NEL requirement for maintenance and production of 30 kg of milk). With energy status averaging about -11 Mcal/d during the first three weeks postpartum [40], an additional 1 to 2 Mcal/d cost is not small. This energy cost is likely to push early postpartum cows even further into negative or less positive energy states, thus delaying return to normal ovarian activity.

Results from a Florida study indicate that dynamics of postpartum ovarian activity can be suppressed indirectly by feeding of high DIP (15.7%), but this adverse effect can be alleviated partially by feeding of 2.2% CaLCFA (Megalac) [14,15]. Also of interest was the observation that pregnancy rate by 120 days postpartum was increased from 52.3% to 86.4% when CaLCFA was supplemented and evaluated as a main effect across diets. The fact that elevated intakes of protein may exert its effect through increased energy costs to the animal is supported by the work of Elrod and Butler [12]. They demonstrated that feeding excess CP (21 vs. 15% of diet) lowered conception rates of heifers from 82 to 61% when heifers were fed an energy deficient diet (70% of ME requirements).

Conclusion

Successful management of lactating dairy cows needs to integrate the disciplines of reproduction and nutrition with standard postpartum herd health programs to optimize both milk and reproductive performance. In addition to milk fever, hypocalcemia appears to be a risk factor for dystocia, uterine prolapse, RFM and displaced abomasum, disorders which can negatively affect postpartum health and reproductive performance. Consequently, nutritional management strategies should be implemented during the last 3 to 4 weeks prepartum in order to promote a rapid return to normocalcemia early postpartum. The achievement of high energy intake, to bring cows out of a decreasing negative energy status as early as possible postpartum, is critical for both productivity responses. In the majority of lactating dairy cows, development of dominant follicles on the ovary occurs very early in the postpartum period. Low body condition scores at the time of insemination is associated with lower pregnancy rates to a detected or timed insemination. Feeding of high degradable protein results in greater loss of body weight and body condition which is associated with a decrease in ovarian activity. In contrast feeding of supplemental fat in the highly degradable protein diet restores ovarian activity.

Figure 3 represents a time line protocol for the strategic management of postpartum dairy cows to ultimately maximize pregnancy rate to first insemination using the OvSynch/timed AI protocol. Consult your veterinarian on how to implement this protocol:

1. Transition cow nutrition: Appropriate nutritional management of the prepartum transition dairy cow with the objective of reducing the incidence of hypocalcemia and energy related disorders (milk fever, dystocia, retained placenta, ketosis and metritis). The following checklist is recommended to determine wether or not the nutritional management of the transition cows is appropriate to prevent theses problems.

   1. Work with a consultant in the area of nutrition to make sure that the transition ration is properly balanced for dietary-cation-anionic difference (DCAD), energy, fiber, vitamins and minerals content
   2. Are the cows eating 24 to 26 lbs of dry matter per day?
   3. Is there enough feedbunk space (at least 2 feet per cow)?
   4. Is there adequate shade (50 square feet per cow)?
   5. Do you provide clean, well - designed calving facilities?
   6. Do you evaluate body condition score during the dry period?
   7. Do you determine urine pH and ketone bodies periodically to ascertain the DCAD and energy content of the ration?

2. Calving management: Sound treatment and management of disorders that are associated with calving such as dystocia, milk fever, retained fetal membranes and udder edema. Who treats, what training have they received, when and how do they treat these problems?

3. Health monitoring of all postpartum cows during the first 10 days postpartum. There are two general purposes for this program. First, to reduce the unnecessary use of antibiotics and hormones in cows that will not benefit from this type of treatments. Second, it also assures, that all postpartum cows are examined daily during the time when they are most susceptible to disease and the implementation of judicious treatment early in the course of disease. Health disorders such as, infection of the uterus, displacement of the abomasum and ketosis can be evaluated by monitoring rectal temperature, appetite, rumen function and urine ketone. At the time of disease

diagnosis cows should be treated promptly according to a farm protocol specified by your veterinarian.

4. Postpartum cow nutrition: Is the postpartum transition cow ration properly balanced for energy, fiber, vitamins and minerals to maintain health and promote an early return to a positive energy balance? After calving, cows should be monitored for body condition, they should not loose more than one point of body condition score during the first 60 days after calving.

5. Breeding program at the end of the voluntary waiting period: Application of the OvSynch timed artificial insemination protocol 60 to 80 days after calving to all cows. This will assure that all cows receive an insemination at the end of the voluntary waiting period which results in an increase in the pregnancy rate to first service. Studies at the University of Florida have shown that timed insemination using OvSynch for all first service in both cool and hot seasons increased net revenue per cow by $16.57 [36]. After timed insemination, cows should be detected daily for estrus during the next 6 weeks and inseminated at detected estrus. Cows that have not been seen in estrus by the end of the 6 week period are palpated for pregnancy status. Cows that are found open can be re-assigned to the OvSynch/timed AI program.

Literature Cited

1. Beede D.K., Risco C.A., Donovan G.A., Wang C., Archbald L.F., Sanchez W.K. 1991. Nutritional management of the late pregnant dry cow with particular reference to dietary cation-anion difference and calcium supplementation, in 24th Annual Convention Proceedings AABP, Orlando, FL, 1991, pages 51 - 55.
2. Britt, J.S., and J. Gaska. 1998. Comparison of two estrus synchronization programs in a large, confinement-housed dairy herd. JAVMA 212(2):210.
3. Burke, J.M. J.H. Hampton, C.R. Staples, W.W. Thatcher. 1998. Body condition influences maintenance of a persistent first wave dominant follicle in dairy cattle. Theriogenology 49: 751.
4. Burke, J.M., C.R. Staples, C.A. Risco, R.L. de la Sota, and W.W. Thatcher. 1997. Effect of ruminant grade menhaden fish meal on reproductive and productive performance of lactating dairy cows. J. Dairy Sci. 80: 3386.
5. Burke, J.M., R.L. De la Sota, C.A. Risco, C.R. Staples, E. J-P Schmitt and W.W. Thatcher. 1996. Evaluation of timed insemination using a Gonadotropin-Releasing Hormone agonist in lactating dairy cows. J. Dairy Sci. 79:1385.
6. Butler, W.R. and R.D. Smith. 1989. Interrelationships between energy balance and postpartum reproductive function in dairy cattle. J. Dairy Sci.72:767.
7. Curtis C.R., Erb H.N., Sniffen C.J., et al. Path analysis of dry period nutrition, postpartum metabolic and reproductive disorders, and mastitis in Holstein cows. J Dairy Sci. 68:2347,1985.
8. Curtis C.R., Erb H.N., Sniffen L.J., et al. Association of parturient hypocalcemia with eight periparturient disorders in Holstein cows. J Am Vet Med Assoc 1983;183:559-561.

9. De La Sota, R.L., J.M. Burke, C.A. Risco, F. Moreira, M.A. DeLorenzo, and W.W. Thatcher. 1998. Evaluation of timed insemination during summer heat stress in lactating dairy cattle. Theriogenology 49:761.
10. Delgado-Lecaroz R., Warnick L.D., Guard C.L., Smith M.C., Barry D.A.: A cross-sectional study of the relationship between abomasal displacement or volvulus and hypocalcemia in dairy cattle, in 31st Annual Convention Proceedings AABP, Spokane, WA, 1998, page 205.
11. Domeck J.J., Skidmore A.L., Lloyd J.W., Kaneene J.B.: Relationship between body condition scores and conception at first artificail insemination in a large dairy herd of high yielding Holstein cows. J. Dairy Sci. 80: 101, 1997.
12. Elrod, C.C. and W.R. Butler.1993. Reduction of fertility and alteration of uterine pH in heifers fed excess ruminally degradable protein. J. Animal Sci.71:694.
13. Ferguson S.D. and D.T. Galligan. Reproductive programs in dairy herds. 1993. Proc. Central Veterinary Conference: 1: pp 161-178, Kansas City, MO.
14. Garcia-Bojalil, C.M., C.R. Staples, C.A. Risco, J.D. Savio and W.W. Thatcher. 1998a. Protein degradability and calcium salts of long-chain fatty acids in the diets of lactating dairy cows: productive responses. J. Dairy Sci. 81: 1372.
15. Garcia-Bojalil, C.M., C.R. Staples, C.A. Risco, J.D. Savio and W.W. Thatcher. 1998b. Protein degradability and calcium salts of long-chain fatty acids in the diets of lactating dairy cows: reproductive responses. J. Dairy Sci. 81: 1385.
16. Goff J.P., Horst R.L. Factors to concentrate on to prevent periparturient disease in the dairy cow with special emphasis on milk fever, in 31st Annual Convention Proceedings AABP, Spokane, WA, 1998, pages 154 - 163.
17. Goff J.P., Horst R.L. Calcium salts for treating hypocalcemia: carrier effects, acid-base balance, and oral versus rectal administration. J Dairy Sci. 77:1451, 1994.
18. Goff J.P., Horst R.L. Oral administration of calcium salts for treatment of hypocalcemia in cattle. J. Dairy Sci. 76:101, 1993.
19. Grohn Y.T., Erb H.N., McCulloch C.E. and H.S. Saloniemi. Epidemiology of reproductive disorders in dairy cattle: Associations among host characteristics, disease and production. Prev. Vet. Med. 8:25, 1990.
20. Grummer, R.R., P.C.Hoffman, M.L. Luck and S.J. Bertics. 1995. Effect of prepartum and postpartum dietary energy on growth and lactation of primiparous cows. J. Dairy Sci. 78:172.
21. Huber T.L., Wilson R.C., Stattelman A.J., Goetsch D.D. Effect of hypocalcemia on motility of the ruminant stomach. Am. J. Vet. Res. 42:1488, 1981.
22. Hull T.L. and W.M. Wass. Abomasal displacement 2: Hypocalcemia as a contributing factor. Vet. Med. 4:12, 1973.
23. Jones, G.P. and P.C. Garnsworthy. 1989. The effects of dietary energy content on the response of dairy cows to body condition at calving. Anim. Prod. 49:183.
24. Littledike E.T.S, Whipp S.C., Witzel D.A., Baaetz A.L. Insulin, corticoids and parturient paresis. Academic Press, New York, in Goff J.P., Horst R.L. Factors to concentrate on to prevent periparturient disease in the dairy cow with special emphasis on milk fever, in 31st Annual Convention Proceedings AABP, Spokane, WA, 1998, pages 154 - 163.
25. Marquardt J.P., Horst R.L, Joregensen: Effect of partiy on dry matter intake at parturition in dairy cattle. J. Dairy Sci., 60:929, 1977 in, Goff J.P., Horst R.L.: Factors to

concentrate on to prevent periparturient disease in the dairy cow with special emphasis on milk fever, in 31st Annual Convention Proceedings AABP, Spokane, WA, 1998, pages 154 - 163.
26. Massey C.D., Wang C., Donovan G.A., et al. Hypocalcemia at parturition as a risk factor for left displacement of the abomasum in dairy cows. J Am Vet Med Assoc 1993;203:852, 1993.
27. Moreira, F., C. Risco, M.F. A. Pires, J.D. Ambrose, M. Drost, M. DeLorenzo and W.W. Thatcher. 1998. Effect of body condition on reproductive efficiency of lactating dairy cows receiving a time insemination. J. Animal Sci. 76 (Suppl. 1)/ J. Dairy Sci. 81 (Suppl. 1): 215. (Abstract).
28. Moreira, F., C. Risco, M.F.A. Pires, J.D. Ambrose, M. Drost, and W.W. Thatcher. 1997. Use of timed insemination in lactating dairy cows receiving bovine somatotropin. J. Dairy Sci. 80(Suppl.1).
29. Odegaard S.A. Uterine prolapse in dairy cows. Acta Vet Scand (Suppl) 63:1-124, 1977.
30. Oetzel G.R. Effect of calcium chloride gel treatment in dairy cows on incidence of periparturient diseases. J Am Vet Med Assoc. 209:958, 1996.
31. Oetzel G.R., Olson J.D., Curtis C.R., et al. Ammonium chloride and ammonium sulfate for prevention of parturient paresis in dairy cows. J Dairy Sci 1988;71:3302-3309.
32. Pursley, J.R., M.C. Wiltbank, J.S. Stevenson, J.S. Ottobre, H.A. Garverick, and L.L. Anderson. 1997a. Pregnancy rates per artificial insemination for cows and heifers inseminated at a synchronized ovulation or synchronized estrus. J. Dairy Sci. 80:295.
33. Pursley, J.R., M.R. Kosorok, and M.C. Wiltbank. 1997b. Reproductive management of lactating dairy cows using synchronization of ovulation. J. Dairy Sci. 80:301.
34. Pursley, J.R., R.W. Silcox and M.C. Wiltbank. 1995. Conception rates at differing intervals between AI and ovulation. J. Dairy Sci. 78; 279 (Abstract).
35. Queen W.G., Miller G.Y., Masterson M.A.. Effects of oral administration of a calcium-containing gel on serum calcium concentration in postparturient dairy cows. J Am Vet Med Assoc 1993;202:607-609.
36. Risco C.A., Moreira F., DeLorenzo M., Thatcher W.W.: Timed artificial insemination in dairy cattle - Part II. Compendium on Continuing Education 20(11): 1284-1289, 1998.
37. Risco C.A., Drost M., Thatcher W.W., et al. Effects of retained fetal membranes, milk fever, uterine prolapse or pyometra on postpartum uterine and ovarian activity in dairy cows. Theriogenology 42:183, 1994.
38. Risco C.A., Reynolds J.P., Hird D. Uterine prolapse and hypocalcemia in dairy cows. JAVMA, 185: 1517, 1984.
39. Schmitt, E. J.-P., T. Diaz, M. Drost, and W.W. Thatcher. 1996. Use of a gonadotropin releasing hormone agonist or human chorionic gonadotropin for timed insemination in cattle. J. Anim. Sci. 74:1084.
40. Staples, C.R., W.W. Thatcher and J.H. Clark. 1990. Relationship between ovarian activity and energy status during the early postpartum period of high producing dairy cows. J Dairy Sci.73:938.
41. Thatcher W.W., Wilcox C.J.: Postpartum estrus as an indicator of reproductive status in the dairy cow. J. Dairy Sci. 56:608-612, 1973.

42. Thatcher W.W., Staples C.R., Van Horn H.H. and C.A. Risco. Reproductive and Energy Status Interrelationships That Influence Reproductive-Nutritional Management of the Postpartum Lactating Dairy Cow. Proceedings of the 1999 S.W. Nutritional Conference, Phoenix AZ. February 27,28, 1999.
43. Twigge, J.R., and L.G.M. Van Gils.1998. Practical aspects of feeding protein to dairy cows. In: Haresign W., Cole D.J.A. (eds), Recent Developments in Ruminant Nutrition 2, Butterworths, London: 196.

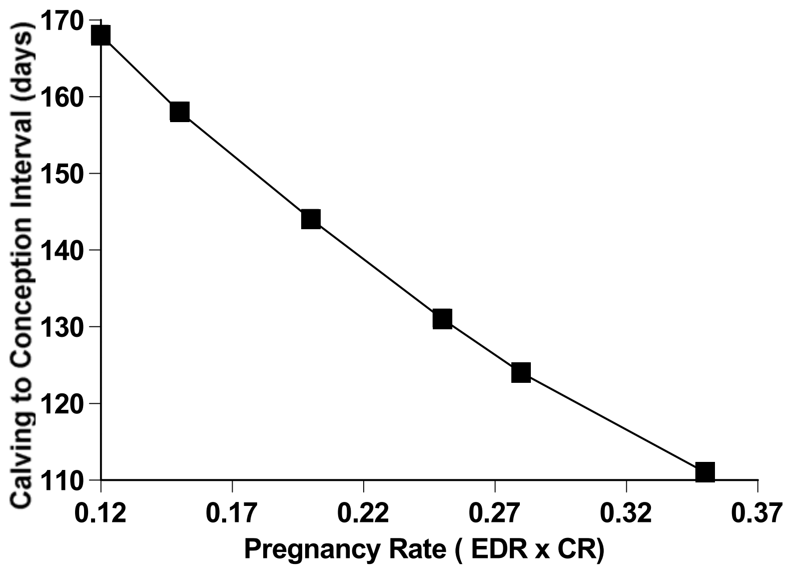

Figure 1. Effect of pregnancy rate (HDR X CR) on the calving to conception interval or days open. From Risco et al. [36]

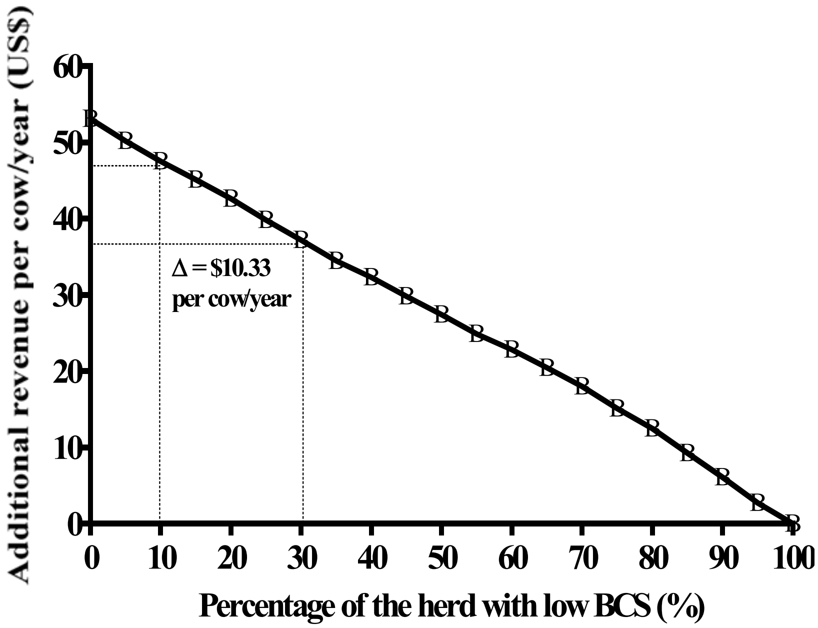

Figure 2. Economical estimates of additional revenue using different scenarios based on the percentage of cows with low body condition in the herd (From: Thatcher et al., Proceedings SW Nutritional Conference, Phoenix, AZ, 1999).

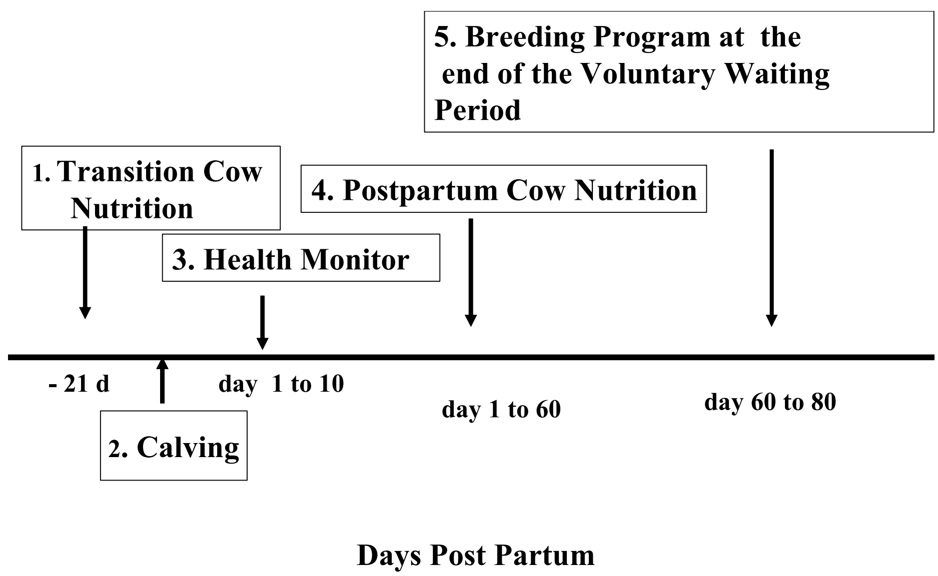

Figure 3. Strategic management considerations of postpartum dairy cows to maximize pregnancy rate to first service.