Extension
UNIVERSITY OF WISCONSIN–MADISON

The High Fertility Cycle

Paul M. Fricke[1], Milo C. Wiltbank[1], and J. Richard Pursley[2]
[1]Department of Dairy Science, University of Wisconsin – Madison
[2]Department of Animal Science, Michigan State University

SUMMARY

- Over the past two decades, a reproduction revolution has occurred in the dairy industry in which average 21-day pregnancy rates have more than doubled from around 14% to more than 30% in many herds.
- Much of this increase in reproductive performance has been driven by development and adoption of fertility programs.
- In spite of the dramatic increase in 21-day pregnancy rates, substantial variation exists among herds using the exact same reproductive management suggesting that factors other than fertility programs can affect fertility.
- Change in body weight or body condition score postpartum or during the periparturient period dramatically affects embryo quality, reproductive outcomes, and transition cow health.
- Although some cows lose body weight or body condition score after calving, some cows maintain, whereas some cows even gain body weight or body condition score during this time period.
- Surprisingly, milk production during early lactation is not affected based on body condition score change during the first 3 weeks postpartum; however, peak milk measured near 60 DIM was less in both primiparous and multiparous cows that either gained or maintained compared to cows that lost body condition during the 1st 30 DIM.
- The high fertility cycle coupled with the dramatic increases in reproductive performance due to the development and adoption of fertility programs is a new paradigm that we can now use to explain much of the variation in reproductive performance among herds.
- The high-fertility cycle: How timely pregnancies in one lactation may lead to less BCS loss, fewer health issues, greater fertility, and reduced early pregnancy losses in the next lactation.

INTRODUCTION

Over the past two decades, a reproduction revolution has occurred in the dairy industry. Twenty years ago, the 21-day pregnancy rate in U.S. dairy herds averaged about 14% with conception rates rarely exceeding 40%. In 1998, the annualized 21-day pregnancy rate goal was 20% which few herds could achieve. Today, the average 21-day pregnancy rate in the U.S. exceeds 21% with more than 60% of DRMS Holstein herds achieving 21-day pregnancy rates greater than 20% with average conception rates that exceed 50% in high-producing Holsteins. The development of fertility programs and their adoption by the dairy industry over the past decade has largely driven this reproduction revolution (Carvalho et al., 2018). Fertility programs, such as Double-Ovsynch or G6G protocols for first timed AI not only increase the AI service rate, but also increase pregnancies per AI (P/AI) beyond that achieved based on AI to a detected estrus (Santos et al., 2017). Despite this increase in reproductive performance, many veterinarians, nutritionists, and consultants observe dramatic variation in reproductive performance among herds that manage reproduction using the exact same reproductive management programs. Although on-farm protocol compliance with complex fertility programs that require multiple treatments across many days remains an issue, it cannot explain all of this variation among herds.

The "Britt Hypothesis"

In 1992, Dr. Jack Britt sorted 76 lactating Holstein cows based on whether they Lost (Lost, n = 30) or Maintained (n = 46) BCS during the first 5 weeks after calving (Britt, 1992). Body condition scores were recorded for the first 10 weeks after calving for these two groups of cows (Figure 1).

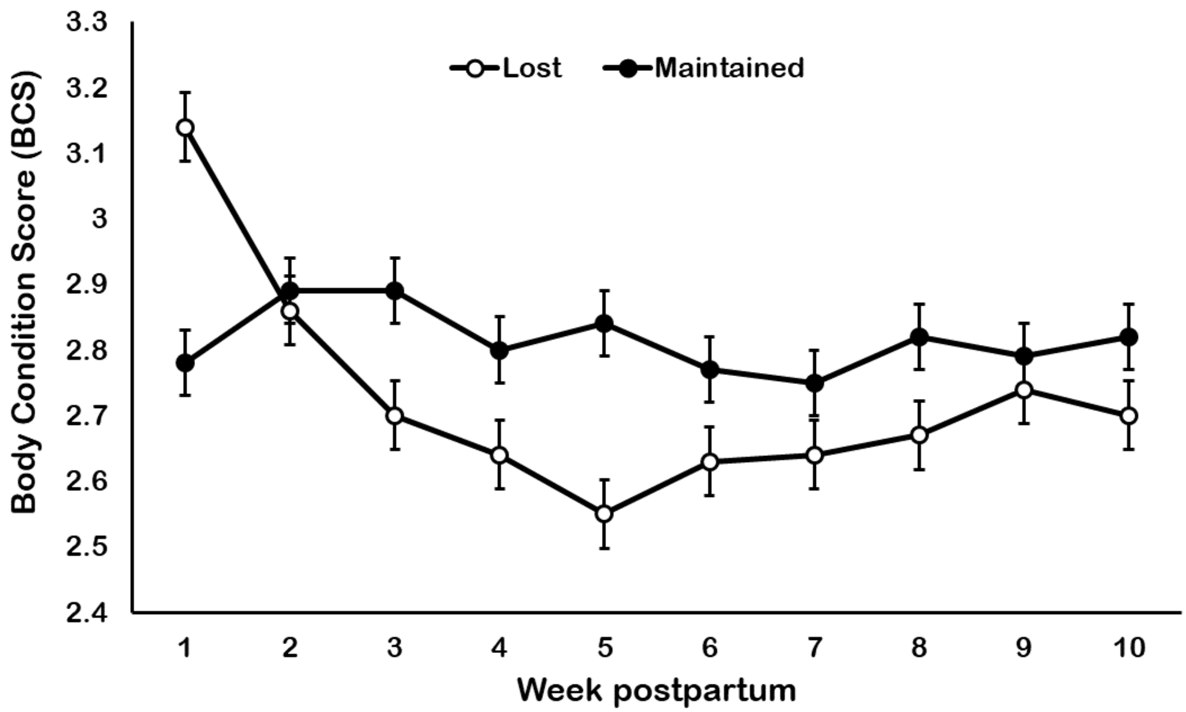

Figure 1. Change in body condition score (BCS) in Holstein cows (n = 76) during the first 10 weeks postpartum. Cows were sorted into two groups based on whether they Lost (Lost, n = 30) or Maintained (n = 46) BCS during the first 5 weeks postpartum. Adapted from Britt (1992).

Cows that maintained BCS post calving had a greater conception rate at first service than cows that lost BCS post-calving (Table 1). Based on these data, Dr. Britt speculated that high producing cows which experience severe weight losses during the first 3 to 5 weeks after calving presumably subject their developing follicles to adverse metabolic conditions associated with the rapid weight loss that compromises fertility later during lactation at first insemination (Britt, 1992). The results from three recent studies; two from the University of Wisconsin - Madison, and one from Michigan State University, support Dr. Britt's observation from 1992 and challenge the long-held assumption that all cows normally lose BCS after calving.

Table 1. Results of retrospective analysis of data from Holstein cows sorted based on BCS change during the first 5 weeks postpartum. Adapted from Britt, 1992.

Item	Lost	Maintained
n	30	46
BCS[1] change		
Week 1 to 5	-0.58[a]	+0.06[b]
Week 5 to 10	+0.17[a]	-0.02[b]
Interval to first ovulation (d)	23.3[a]	17.2[b]
Milk yield		
Mean during first 70 d (lbs)	60	58
Mean 305 d lactation (lbs)	18,198	17,941
Interval to first AI (d)	82.9	84.9
Conception rate		
First service (%)	25[a]	62[b]
All services (%)	42[a]	61[b]

[a,b]Items with different superscripts differ ($P < 0.05$)

[1]Body condition scores based on a 1 (thin) to 5 (fat) scale.

Effect of body weight change on embryo quality

The first study from the first paper (Carvalho et al., 2014) included an experiment in which lactating Holstein cows (n = 71; 27 primiparous and 44 multiparous) were weighed weekly from calving until 10 weeks postpartum. Cows were divided into quartiles based on percent body weight change from the first week after calving (Figure 2). The quartile analysis divided cows based on those that gained weight (First Quartile), maintained weight (Second Quartile), slightly lost weight (Third Quartile), and dramatically lost weight (Fourth Quartile), and the majority of the body weight change occurred during the first 3 weeks postpartum (Figure 2). Cows in the Fourth Quartile that dramatically lost weight had increased NEFA concentrations during the first 3 weeks after calving, whereas NEFA concentrations did not differ at 10 weeks postpartum when superovulation and embryo flushing was performed (Carvalho et al., 2014).

To assess embryo quality, cows were superovulated using a modified Double-Ovsynch protocol. All cows were inseminated and flushed by two technicians, and cows were inseminated twice at 12 and 24 h after GnRH treatment. Seven days after GnRH treatment, ova/embryos were recovered using a nonsurgical shallow uterine horn flushing technique. Embryo characteristics were affected based on body weight quartile in which cows in the Fourth Quartile that dramatically lost weight during the first 3 weeks postpartum had overall poorer embryo characteristics than cows in the other three quartiles (Table 2).

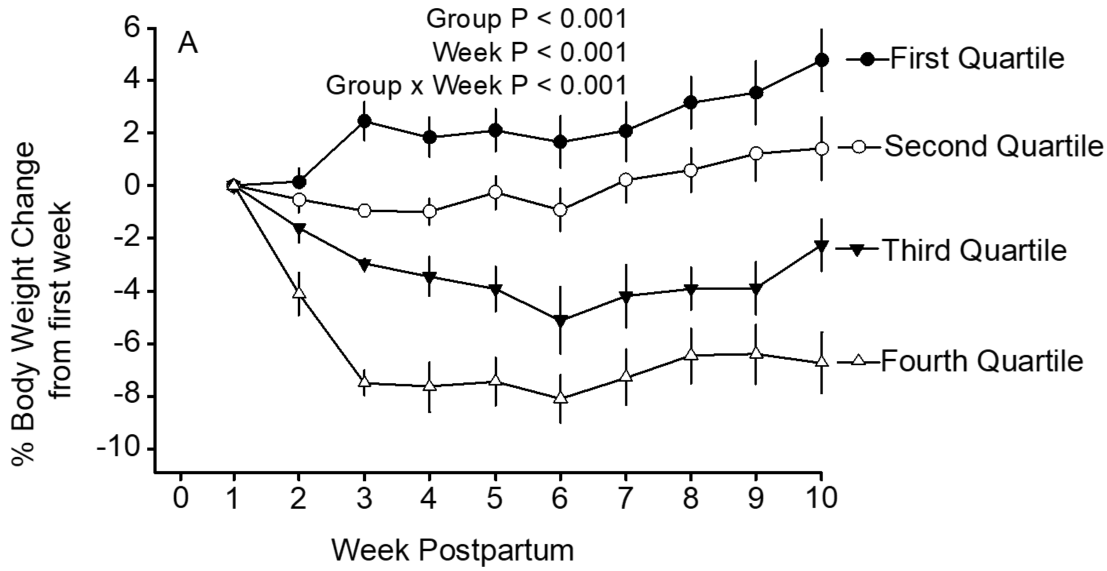

Figure 2. Quartile analysis of percent body weight change from the first week postpartum in Holstein dairy cows. Adapted from Carvalho et al. (2014).

Table 2. Embryo characteristics of lactating Holstein cows based on body weight change[1] from first to third week postpartum. Adapted from Carvalho et al. (2014).

Item	Fourth Quartile	Third Quartile	Second Quartile	First Quartile	*P*
CL (number)	18.4 ± 2.6	18.4 ± 1.7	19.0 ± 1.7	16.0 ± 2.0	0.67
Fert structures (#)	7.6 ± 2.1	7.3 ± 1.1	4.8 ± 1.1	5.8 ± 1.4	0.43
Deg embryos (#)	2.7 ± 0.7^{a}	1.7 ± 0.7^{ab}	0.7 ± 0.2^{b}	0.6 ± 0.2^{b}	0.02
Quality 1 & 2 (#)	4.2 ± 1.4	5.3 ± 0.9	3.9 ± 1.1	4.9 ± 1.4	0.47
Quality 1, 2 & 3 (#)	4.9 ± 1.6	5.6 ± 0.8	4.1 ± 1.1	5.3 ± 1.4	0.49
Fertilized (%)	76.9 ± 7.1	77.0 ± 6.6	77.6 ± 7.6	78.4 ± 7.1	0.99
Degenerate (%)	35.2 ± 8.5^{a}	12.6 ± 4.6^{b}	14.5 ± 6.3^{b}	9.6 ± 3.7^{b}	0.02
Quality 1 & 2 (%)	38.0 ± 8.7^{b,B}	61.3 ± 8.2^{ab,A}	60.6 ± 9.4^{ab,A}	63.4 ± 8.6^{a,A}	0.14
Quality 1, 2 & 3 (%)	41.7 ± 8.8^{b,B}	64.4 ± 8.2^{ab,A}	63.1 ± 9.3^{ab,A}	68.9 ± 8.7^{a,A}	0.13
Degen of Fert (%)	46.9 ± 9.6^{a,A}	17.4 ± 6.4^{b,B}	24.8 ± 9.3^{ab,A}	16.2 ± 7.0^{b,B}	0.04
1 & 2 of Fert (%)	48.4± 9.5^{b}	78.3 ± 6.6^{a}	72.6 ± 9.5^{a}	77.7 ± 7.4^{a}	0.05
1, 2 &3 of Fert (%)	53.2 ± 9.6^{b,B}	82.6 ± 6.4^{a,A}	75.2 ± 9.3^{a,AB}	83.8 ± 7.0^{a,A}	0.04
Recovery Rate (%)	45.6 ± 7.4	55.1 ± 6.9	35.4 ± 6.7	45.3 ± 5.8	0.25

^{a,b}Items with different superscripts within the same row differ ($P < 0.05$).
^{A,B}Items with different superscripts within the same row differ ($P < 0.15$).
[1]First quartile = gaining body weight; Fourth quartile = most body weight loss.

Effect of BCS change after calving on fertility

The second study from the first paper (Carvalho et al., 2014) included a retrospective analysis in which 1,887 Holstein cows from two commercial dairy farms in Wisconsin were submitted to a Double-Ovsynch protocol for first timed AI, and BCS was evaluated at calving and 21 days after calving. Overall, 42% of cows lost BCS, 36% of cows maintained BCS, and 22% of cows gained BCS during the first 3 weeks of lactation (Table 3).

Table 3. Effect of BCS change on pregnancies /AI (P/AI) for cows on Farm 1 and 2 classified as losing, maintaining or gaining BCS from parturition to three weeks postpartum. Adapted from Carvalho et al. (2014).

	BCS[2] change		
Item	Lost	Maintained	Gained
All cows			
% of cows, (n)	41.8 (789/1887)	35.8 (675/1887)	22.4 (423/1887)
P/AI at 40 d, % (n/n)	25.1 (198/789)[c]	38.2 (258/675)[b]	83.5 (353/423)[a]
P/AI at 70 d, % (n/n)	22.8 (180/789)[c]	36.0 (243/675)[b]	78.3 (331/423)[a]
Pregnancy Loss, % (n/n)	9.1 (18/198)	5.8 (15/258)	6.2 (22/353)
BCS at parturition	2.93 ± 0.01[a]	2.89 ± 0.02[b]	2.85 ± 0.02[b]
BCS at 21 DIM	2.64 ± 0.01[c]	2.89 ± 0.02[b]	3.10 ± 0.02[a]
ECM (kg/d)[1]	30.9 ± 0.4	31.5 ± 0.4	28.7 ± 0.4

[a,b,c]Items with different superscripts within the same row differ (P < 0.05).

[1]Mean Energy Corrected Milk from calving to 21 DIM.

[2]Body Condition Score was evaluated at calving and at 21 DIM based on a point 5 scale.

Similar to the experiment by Britt (1992), energy corrected milk (ECM) did not differ among cows based on BCS change (Table 3). Most impressively, P/AI 40 d after timed AI was only 25% for cows that lost BCS, 38% for cows that maintained BCS, and was 84% for cows that gained BCS. It is important to note that there were dramatic farms effects in this study in which one farm had most of the cows that gained BCS (Carvalho et al., 2014). Based on data presented thus far, the key question is: can we increase the proportion of cows that gain BCS after calving? The next study by Barletta et al. (2017) helps us to answer this question.

Effect of BCS change during the periparturient period on reproduction and health

In the second study (Barletta et al., 2017), BCS change was evaluated in 233 Holstein cows from 3 weeks before the expected date of calving until 3 weeks after calving (Table 4). Similar to the experiment by Carvalho et al. (2014), P/AI 30 d after AI for cows submitted to first timed AI was 18% for cows that lost BCS (28% of cows), 27% for cows that maintained BCS (23% of cows), and 53% for cows that gained BCS (49% of cows). Average milk production during the first 3 weeks of lactation did not differ among cows based on BCS change during the periparturient period.

Table 4. Effect of changes in body condition score (BCS) during the transition period on pregnancies per artificial insemination (P/AI) and pregnancy loss. Adapted from Barletta et al. (2017).

	Change in BCS[1]			
Item	Gained	Maintained	Lost	*P*-value
Cows, % (no./no.)	28 (69/245)	22 (54/245)	50 (122/245)	
P/AI 30 d, % (no./no.)	53.0 (35/66)[a]	26.9 (14/52)[b]	18.3 (21/115)[b]	< 0.01
P/AI 60 d, % (no./no.)	45.5 (30/66)[a]	25.0 (13/52)[b]	15.7 (18/155)[b]	< 0.01
Pregnancy loss, % (no./no.)	14.3 (5/35)	7.1 (1/14)	14.3 (3/21)	0.79

[a/c]Within a row, items with different superscripts differ (P < 0.05).

[1]BCS was evaluated during the transition period (-21 to 21 d) using a 5-point scale.

In addition to increased fertility, cows that gained BCS during the periparturient period were also healthier, with less than 40% of these cows experiencing more than one health event, whereas greater than 60% of cows that lost BCS after calving experienced more than one health event (Table 5).

Table 5. Effect of changes in body condition score (BCS) during the transition period (-21 to 21) on incidence (%) of retained placenta, mastitis, ketosis and pneumonia for cows that lost, maintained, or gained BCS. Adapted from Barletta et al. (2017).

	Change in BCS[1]			
Item	Gained	Maintained	Lost	*P*-value
n	66	52	116	
Metritis	19.70 (13/66)	21.20 (11/52)	23.30 (27/116)	0.85
Mastitis	16.70 (11/66)[b]	17.30 (9/52)[a,b]	29.30 (34/116)[a]	0.09
Ketosis	15.20 (10/66)	19.20 (10/52)	26.70 (31/116)	0.18
Pneumonia	9.10 (6/66)	11.50 (6/52)	14.70 (17/116)	0.55
> 1 Health problem	39.4 (26/66)[b]	46.2 (24/52)[b]	62.9 (73/116)[a]	0.007

In this study by Barletta et al. (2017), the major factor associated with BCS change during the transition period was BCS 3 weeks before expected calving. Only 34% of cows with BCS less than 3.0 lost BCS during the transition period, whereas 51% of cows with BCS = 3.0 lost BCS and 92% of cows with BCS > 3.0 lost BCS. So, how can we ensure that more cows gain BCS after calving? Nearly all of the cows in the study by Barletta et al. (2017) that gained BCS during the transition period had a BCS less than 3.0 3 weeks before calving. Thus, calving cows at a lower BCS was associated with less BCS loss, greater fertility, and fewer health issues. Based on data presented thus far, the next question is: how do I prevent calving cows with a high BCS? The final study provides the answer to this question.

The High Fertility Cycle

The final study evaluated BCS change within 1 week of calving until 30 days after calving in 851 Holstein cows on a commercial dairy farm in Michigan (Middleton et al., 2019). This study linked previous calving intervals of individual cows to BCS changes after calving. Calving interval is determined by the fixed interval of gestation length and the highly variable interval of calving to conception. Thus, cows with longer calving intervals during the previous lactation took longer to get pregnant than cows with shorter calving intervals. In this study, cows with longer calving intervals in the prior lactation had greater BCS at calving and lost BCS during the first 30 days after calving. In agreement with the first two studies (Carvalho et al., 2014; Barletta et al., 2017), cows that maintained or gained BCS after calving had greater conception rates, less pregnancy loss, and were healthier than cows that lost BCS after calving (Middleton et al., 2019). Amazingly, even when cows with health problems were removed from the data set, differences in conception rates and pregnancy losses in favor of cows that maintained or gained body condition during the 1st 30 DIM were maintained. An excellent overview of the results from this study is captured by the title of the paper: The high-fertility cycle: How timely pregnancies in one lactation may lead to less BCS loss, fewer health issues, greater fertility, and reduced early pregnancy losses in the next lactation (Figure 3).

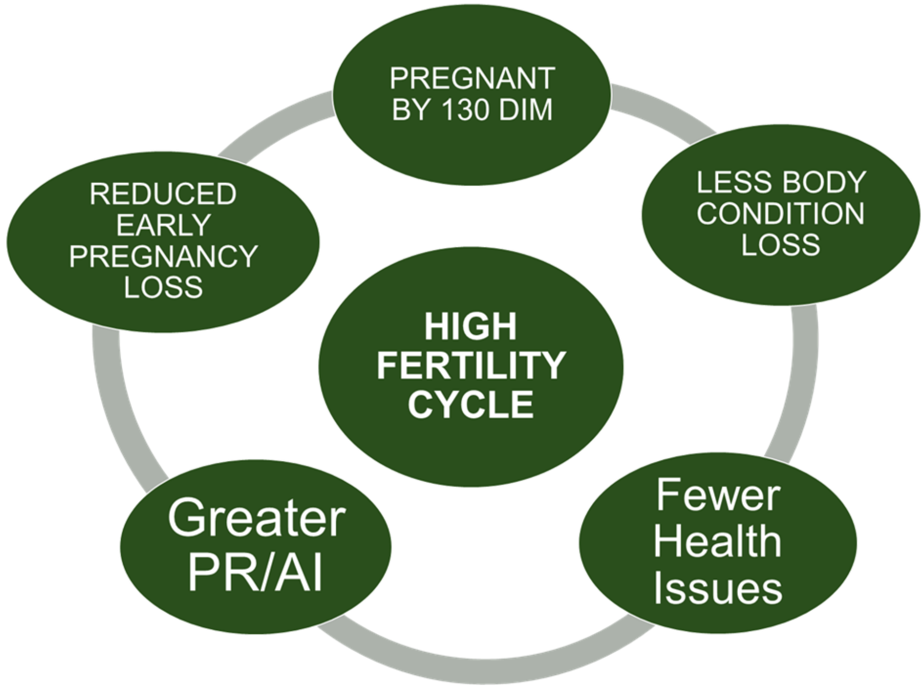

Figure 3. The high-fertility cycle: How timely pregnancies in one lactation may lead to less BCS loss, fewer health issues, greater fertility, and reduced early pregnancy losses in the next lactation. Adapted from Middleton et al. (2019).

CONCLUSION

Based on the collective results from these studies we can now clearly define a relationship in which herds that manage to get their cows pregnant rapidly after the end of the voluntary waiting period calve cows at a lower BCS which in turn leads to more cows maintaining or gaining BCS after calving. Cows that maintain or gain BCS after calving have greater fertility than cows that lose BCS. The High Fertility Cycle coupled with the dramatic increases in reproductive performance due to the development and adoption of fertility programs is a new paradigm that we can now use to explain much of the variation in reproductive performance among herds. The goal of every farm should be to strive to get their cows into the high-fertility cycle and keep them there. The following are key considerations to achieve this: 1) implement BCS monitoring for transition cows 3 weeks before calving, at calving, 3 weeks after calving, and at AI; 2) use fertility programs to help get cows pregnant quickly after the end of the voluntary waiting period; 3) set a hard cutoff for the number times individual cows will be inseminated; and 4) consider nutritional strategies to prevent late lactation cows from gaining too much body condition.

REFERENCES

Barletta, R. V., M. Maturana Filho, P. D. Carvalho, T. A. Del Valle, A. S. Netto, F. P. Rennó, R. D. Mingoti, J. R. Gandra, G. B. Mourão, P. M. Fricke, R. Sartori, E. H. Madureira, and M. C. Wiltbank. 2017. Association of changes among body condition score during the transition period with NEFA and BHBA concentrations, milk production, fertility, and health of Holstein cows. Theriogenology 104:30-36.

Britt, J. 1992. Impacts of early postpartum metabolism on follicular development and fertility. Pages 29–43 in Proc. Annu. Conv. Am. Assoc. Bovine Pract. Am. Assoc. Bovine Pract., Auburn, AL.

Carvalho, P. D., V. G. Santos, J. O. Giordano, M. C. Wiltbank, and P. M. Fricke. 2018. Development of fertility programs to achieve high 21-day pregnancy rates in high-producing dairy cows. Theriogenology 114:165-172.

Carvalho, P. D., A. H. Souza, M. C. Amundson, K. S. Hackbart, M. J. Fuenzalida, M. M. Herlihy, H. Ayres, A. R. Dresch, L. M. Vieira, J. N. Guenther, P. M. Fricke, R. D. Shaver, and M. C. Wiltbank. 2014. Relationships between fertility and postpartum changes in body condition and body weight in lactating dairy cows. J. Dairy Sci. 97:3666-3683.

Middleton, E. L., T. Minela, and J. R. Pursley. 2019. The high-fertility cycle: How timely pregnancies in one lactation may lead to less body condition loss, fewer health issues, greater fertility, and reduced early pregnancy losses in the next lactation. J. Dairy Sci. 102:5577-5587.

Santos, V. G., P. D. Carvalho, C. Maia, B. Carneiro, A. Valenza, and P. M. Fricke. 2017. Fertility of lactating Holstein cows submitted to a Double-Ovsynch protocol and timed artificial insemination versus artificial insemination after synchronization of estrus at a similar day in milk range. J. Dairy Sci. 100:8507-8517.