Journal of Reproduction and Development, Vol. 58, No 3, 2012

—Original Article—

Relationships between Body Weight and Milk Yield During the Early Postpartum Period and Bull and Technician and the Reproductive Performance of High Producing Dairy Cows

Pilar SANTOLARIA[1), Fernando LÓPEZ-GATIUS[2), José Antonio SÁNCHEZ-NADAL[1) and Jesús YÁNIZ[1)

[1) *Instituto de Investigación de Ciencias Ambientales de Aragón (IUCA), Escuela Politécnica Superior, Universidad de Zaragoza, 22071 Huesca, Spain*
[2) *Departamento de Producción Animal, Universidad de Lleida, 25191 Lleida, Spain*

Abstract. The aim of this study was to evaluate the effect of body weight (BW) change during the early postpartum period and BW on day 50 post partum on the subsequent expression of estrus and fertility at first insemination before day 90 post partum. The data were derived from 1036 postpartum cows reaching 90 days in milk. The following data were recorded for each animal: lactation number, daily milk production at day 50 post partum, calving date, days in milk at estrus and at AI, insemination date, insemination number, inseminating bull, AI technician and body weight at calving, at day 50 post partum and at AI. Of the 1036 cows registered, 817 (78.9%) showed first estrus before day 90 post partum and were inseminated. Using logistic regression procedures and based on the odds ratio a one unit (kg) increase in the daily milk production at day 50 post partum and a one unit (kg) decrease in the BW between calving and day 50 post partum were related to a 1.03-fold increase and a 0.97-fold decrease in the estrus expression rate before day 90 post partum, respectively. Of the 817 cows inseminated before day 90 post partum, 437 became pregnant (53.5%). A one unit increase in the BW at day 50 post partum produced a 1.003-fold increase in the early fertility rate. Pregnancy rate before day 90 was also influenced by the season at calving, bull providing semen and technician. In conclusion, the register of BW during the postpartum period may be a useful tool for evaluating the nutritional status and its relationship with the subsequent reproductive efficiency in dairy cows.

Key words: Body weight, Dairy cows, Estrus expression, Fertility

(**J. Reprod. Dev. 58:** 366–370, 2012)

The past few decades have seen a decline in fertility as well as rising milk yields [1–3]. Milk production per cow has increased steadily due to a combination of improved management, better nutrition and intense genetic selection. This shift toward more productive cows seems to be culminating in a decrease in reproductive efficiency. However, the association between milk production level and fertility is not so clear. In a recent study [4], a positive correlation was found between milk production and fertility, suggesting that milk production level is only detrimental to fertility when combined with other physiological and management factors [2].

Dairy cattle having a high milk production cannot maintain a positive dietary energy balance during early lactation and must mobilize body reserves [5]. The magnitude of this negative balance is associated with a failure in reproduction [6]. However, energy balance is difficult to measure in large populations, leading to increased interest in other traits, such as body condition score (BSC) or body weight (BW), which may be indicators of the energy balance of the cow [7] and may subsequently be related to the health and fertility status of an animal.

BCS has proved useful as a management tool for subjectively assessing the nutritional status of dairy cows [8]. In a meta-analytical study [9], a clear association was found between BCS or change in score postpartum and the reproductive performance of dairy cows, particularly in the number of days open. However, the subjective nature of condition scoring and the fact that the automation of its measurement has to date been unsuccessful make it difficult for inexperienced herd managers to use BCS in practice [10]. Nonetheless, automatic daily weighing of cows is commercially available and facilitates the monitoring of daily BW change as well as BW change during key periods of lactation. In previous studies, different associations between BW and BW changes with reproductive performance of Holstein dairy cows have been described, although some of them were contradictory [10–12]. The aim of this study was to evaluate the effect of BW at partum, at day (d) 50 post partum and at first AI and BW change during the early postpartum period on the expression of estrus and fertility at first AI before d90 post partum.

Materials and Methods

Cattle and herd management

Data derived from 1036 postpartum cows reaching 90 days in milk in a commercial Holstein-Friesian dairy herd in northeastern

Received: November 25, 2011
Accepted: February 26, 2012
Published online in J-STAGE: March 28, 2012

Correspondence: P Santolaria (e-mail: psantola@unizar.es.)

Spain, over a 16-month period (1 December 2009 to 1 April 2011), were analyzed. Mean annual milk production of the herd for this period was 11,720 kg per cow. All the animals were tested free of tuberculosis and brucellosis. The cows, calved all year round and grouped according to their milk production, were milked three times daily and fed complete rations. Feeds consisted of cotton seed hulls, barley, corn, soybean and bran along with roughage, primarily corn, barley or alfalfa silage and alfalfa hay. Rations were in line with NRC recommendations [13]. Dry cows were kept in a separate group and transferred to a "parturition group," depending on their body condition score and age, 7–25 days prior to parturition. An early postpartum group designated the "fresh cows group" was set up for postpartum nutrition and controls, and 7–20 days postpartum primiparous and multiparous lactating cows were transferred to separate groups. The voluntary waiting period from calving to first AI set in this dairy herd was 50 days. All cows were artificially inseminated. The mean annual culling rate for the study period was 30%. Cows producing less than 25 kg per day were not inseminated.

Management practices included the use of pedometers, housing in free stalls with cubicles and a concrete slatted floor, daily strict veterinary supervision for all cows, a rigorous postpartum revision protocol, application of the same reproductive management program, confirmation of estrus at AI and performance of AI by veterinarians.

In the present study, only healthy cows with no detectable reproductive disorders and that were free of clinical disease were included. The exclusion criteria were: mastitis, lameness, digestive disorders, abnormal genital discharges and pathological abnormalities of the reproductive tract detectable on palpation per rectum. Efforts were made to reduce variation in the general status of the animals so that failure to exhibit estrus or conceive could be attributed to factors other than the clinical condition of the cows during the study.

Insemination and pregnancy diagnosis

The herds were maintained on a weekly reproductive health program. This involved examining the reproductive tract of each animal by palpation per rectum within 30 to 36 days postpartum to check for normal uterine involution and ovarian structures. Reproductive disorders such as incomplete uterine involution, endometritis, pyometra and ovarian cysts, diagnosed either at gynecological postpartum examination or at any subsequent time, were treated until resolved.

Estrus detection was performed using a pedometer system (AfiFarm System, S.A.E. Afikim, Israel). Pedometer values were recorded at the milking parlor (three times daily) and analyzed automatically using a herd management program. An increased walking activity of more than 80% above the mean activity recorded for the previous two days was taken as the lower limit for a cow to be considered in estrus [14]. The cows were finally inseminated after estrus had been confirmed by examination of the genital tract and vaginal fluid [15].

Pregnancy diagnosis was performed 38–45 days post insemination by palpation per rectum. Cows diagnosed as negative were either included again within the reproductive program or registered for culling. All gynecological exams and pregnancy diagnoses were performed by the senior author.

Body weight assessment

Body weight (BW) was retrieved from AfiFarm herd management software (S.A.E. Afikim, Kibbutz Afikim, Israel). Daily BW obtained from an AfiWeigh was cow body weighing system, which recorded the weight of every cow entering the milking parlor. Body weights from the three daily milkings were averaged and stored as a single value.

Data collection and analysis

The following data were recorded for each animal: lactation number, daily milk production at d50 post partum (the average of the previous 3 days), calving date, days in milk at estrus and at AI, insemination date, insemination number, inseminating bull, AI technician and body weight at calving, at d50 post partum and at AI.

In the geographical area of the study there are only two clearly differentiated weather periods: the warm (May to September) and cool (October to April) periods [16]. Over an 18-year period, the mean number of days in a month that the maximum temperature was higher than 25 C ranged from 20 to 31 days and from 0 to 4 days for the warm and cool periods, respectively. Reproductive variables are generally significantly impaired during a warm period [3, 17]. For this reason, calving dates were used to analyze the effect of the season (warm versus cool period) of calving on the probability of reproductive performance.

Study 1. Factors affecting the expression of estrus before d90 post partum

The variables possibly affecting expression of estrus before d90 are listed in Table 1. The relative contribution of each factor to the probability of expressing estrus before d90 post partum was determined by logistic regression methods. Expressing estrus before d90 post partum or not was considered to be the dependent variable, and calving season, lactation number, daily milk production at d50 post partum, body weight at calving and at d50 postpartum and relative body weight change between calving and d50 post partum were considered to be independent factors. Calving season was considered to be a class variable and coded as a dichotomous variable (where 1 denotes presence and 0 absence).

Study 2. Factors affecting high fertility

The variables possibly affecting high fertility are listed in Table 1. Cows that were not inseminated before d90 postpartum were excluded from the model. Cows with estrus before d90 post partum (n=817) were classified as having high or low fertility based on conception during the interval from 50 to 90 days in milk or after this interval, respectively [4]. The relative contribution of each factor to the probability of high fertility was determined by logistic regression methods. High fertility was considered to be the dependent variable, and calving season, lactation number, daily milk production at d50 post partum, body weight at calving, d50 post partum and AI, relative body weight change between calving and d50 post partum, relative body weight change between calving and AI date and relative body weight change between d50 post partum and the AI date were considered independent factors. Calving seasons were coded as dichotomous variables (where 1 denotes warm period and 0 cold period). Technician and bull inseminated were included as

Table 1. Risk factors investigated regarding their effects on reproductive performance

Risk factor	N classes	Class description (*N* per class or AI ranges within classes)	Mean ± SD (range)
Study 1 (n=1036)			
Cows with estrus by d90 post partum	2	Yes (817)	
		Non (219)	
Season at calving	2	Warm (459)	
		Cool (577)	
Lactating number	Continuous		2.2 ± 1.4 (1–9)
Milk production at d50 post partum	Continuous		45.1 ± 10.9 (14–79)
Body weight at calving	Continuous		613 ± 73.3 (427–900)
Body weight at 50 days post partum	Continuous		575 ± 59.9 (420–782)
Relative body weight change between calving and d50 post partum (rW50c)	Continuous		5.4 ± 5.7 (–22.7–14.3)
Study 2 (n=817)			
Number of cows receiving AI by d90 post partum	2	Yes (437)	
		Non (380)	
Season at calving	2	Warm (372)	
		Cool (445)	
Bulls	9	Range 19–325 AI	
Technicians	5	Range 8–370 AI	
Lactating number	Continuous		2.2 ± 1.4 (1–9)
Milk production	Continuous		45.6 ± 10.7 (14–79)
Body weight at calving	Continuous		613 ± 73.9 (427–900)
Body weight at d50 post partum	Continuous		575 ± 60 (420–782)
Body weight at AI	Continuous		574 ± 60 (435–828)
Relative body weight change between calving and d50 post partum (rW50c)	Continuous		–5.4 ± 5.7 (–22.7–14.3)
Relative body weight change between calving and AI	Continuous		–5.9 ± 6.2 (–24–18)
Relative body weight change between d50 post partum and AI	Continuous		0.07 ± 2.8 (–17–10.6)

class variables.

In studies 1 and 2, logistic regression analyses were performed using the SPSS package, version 13.0 (SPSS Inc., Chicago, IL, USA) according to the Hosmer and Lemeshow method [18]. Basically, this method involves five steps as follows preliminary screening of all variables for univariate associations, construction of a full model using all the variables found to be significant in the univariate analysis, stepwise removal of non-significant variables from the full model and comparison of the reduced model with the previous model for model fit and confounding and evaluation of plausible interactions among variables and assessment of model fit using Hosmer–Lemeshow statistics. Variables with univariate associations showing P values <0.25 were included in the initial model. Modelling was continued until all the main effects or interaction terms were significant according to the Wald statistic at $P <0.05$.

Results

Factors affecting the expression of estrus before day 90 postpartum

Of the 1036 cows registered, 817 (78.9%) showed first estrus before d90 post partum and were inseminated. Table 2 shows the odds ratios of variables included in the final logistic regression model. Based on the odds ratio, a one unit increase in the daily milk production at d50 post partum produced a 1.03-fold increase in the estrus expression rate before d90 post partum, and a one unit decrease in the body weight between calving and d50 post partum produced a 0.97-fold decrease in the estrus expression rate before d90 post partum. No significant interactions were found.

Factors affecting fertility

High fertility was recorded in 437 of the 817 cows inseminated before day 90 post partum (53.5%). Logistic regression analysis indicated no significant effects of calving season, lactation number, milk production and relative body weight change between calving and d50 post partum, between calving and AI date and between d50 post partum and AI date. Table 3 shows the variables finally included in the logistic model. Based on the odds ratio, a one unit increase in the body weight at d50 post partum produced a 1.003-fold increase in the high fertility rate. The likelihood of high fertility decreased in cows calving during the warm season by a factor of 0.49. High fertility was more likely found in cows inseminated with semen from bulls 5, 7, 8 and 10 (by factors of 4.97, 4.04, 3.9 and 3.21, respectively) and for those inseminated by technician 4 (by a factor of 1.75). No significant interactions were found.

Table 2. Odds ratios of variables included in the final logistic regression model for cows showing estrus before day 90 postpartum

Factor	Class	n	Odds ratio	95% Confidence Interval	P value
Milk production (d50)	Continuous	1036	1.03	1.01–1.04	0.001
rW50c[a]	Continuous	1036	0.97	0.94–0.99	0.017

Likelihood ratio test = 1053.7; 2df, P=0.0001. Hosmer and Lemeshow Goodness-of-fit test = 5.3; 8 df, P = 0.72 (the model fits). [a] rW50c: Relative body weight change between calving and AI.

Table 3. Odds ratios of variables included in the final logistic regression model for high fertile cows [a]

Factor	Class	n	%	Odds ratio	95% Confidence Interval	P
Postpartum Weight at d50	Continuous	817		1.003	1–1.005	0.02
Season	Cool	445	58.9	Reference		
	Warm	372	47	0.49	0.41–0.81	0.001
Bull	9 classes	Bull 5	28/41=68.3	4.97	1.5–16.4	0.009
		Bull 7	192/325=59	4.04	1.46–11.15	0.03
		Bull 8	18/36=50	3.9	1.13–13.46	0.007
		Bull 10	52/96=54.2	3.21	1.09–9.42	0.03
Technician	5 classes	Technician 4	164/265=61.9	1.75	1.25–2.45	0.001

Likelihood ratio test = 1075; 14 df. P=0.0001. Hosmer and Lemeshow Goodness-of-fit test = 6.9; 8 df, P = 0.46 (the model fits).
[a] Represented by cows becoming pregnant before 90 days in milk.

Discussion

This study assessed whether automated measurements of body weight during the postpartum period could be related with the subsequent reproductive efficiency of lactating dairy cows. It was observed that body weight loss between calving and d50 and body weight at d50 post partum were associated with expression of estrus and fertility before d90, respectively.

The association between BW and BW changes and reproductive efficiency is not clearly known and the results of previous studies are controversial [11, 12, 26]. In a more recent large-scale study, Van Straten *et al.* [19] observed an association between BW changes post partum and conception rate at first AI. The present work has been performed under different management practices (VWP 50d *vs.* 94-133d in the study of Van Straten *et al.* [19]) and evaluated different reproductive variables (estrus expression determined by pedometers and high fertility). We concluded that estrus expression may be more sensitive to body weight changes than fertility. Sakaguchi [20] reported in an experimental study with 50 animals that cows with early ovulation and early estrus showed earlier recovery of BW compared with cows with late ovulation and estrus, suggesting that BW loss (%) is available as a monitoring tool for certain reproductive events such as postpartum first ovulation, estrus and insemination. Our work, with 1036 postpartum cows, confirms these results under field conditions. Different factors may influence body weight in the cow, but one of the most relevant is the magnitude of body fat stores [21-22]. Repeated measurements of body weight the postpartum period could be good indicators of the nutritional status of the cow. In this study, each unit of body weight loss between parturition and d50 was related to a significant 0.97-fold decrease in the estrus expression rate before d90 post partum. Although ovarian follicular dynamics in the postpartum dairy cow appear to be unaffected by a negative energy balance [23], estrus expression may be more sensitive to a decrease in body fat stores. In fact, inability to display estrus in normal cycling cows is one of the most common reproductive disorders associated with high milk production, as, for example, about 40% of cyclic cows do not show clear expression of estrus measured by pedometers [17, 24].

The increase in BW at d50 post partum significantly increased the probability of fertility for cows showing estrus before d90. In a previous study [9], it was determined using meta-analytical methods that animals with a high body condition (score above 3.5) at first AI had a lower number of days open when compared with animals in the intermediate (score 2.5–3.5) or low (score under 2.5) body condition category. In the present study, body weight at d50 was more important to high fertility than body weight at AI. The mean interval between partum and AI was 71.0 days. Body weight at d50 post partum may be more determinant of fertility than BW at AI, as this time could be more important for discriminating which cows are recovering from metabolic stress post partum. Other authors have found associations between BW and reproductive performance, although results were contradictory. Moore *et al.* [11] reported a negative genetic correlation between BW at calving and number of services per conception in Holsteins, suggesting that genetically heavier cows require fewer services to conceive. This was contradictory to the reports by Badinga *et al.* [25] and Berry *et al.* [26], who obtained the opposite results and concluded that selection for increased weight could lead to decreased reproductive efficiency.

A higher milk production was related with a higher estrus expression at d90 post partum (odds ratio 1.03, P<0.001). Seventy-eight percent of cows showed estrus before 90 days in milk and produced a mean of 45.6 kg milk within the peak yield period, in contrast to the 43.2 kg milk of cows that showed estrus later. Lopez-Gatius *et al.* [4] found a positive correlation between milk production at d50 post partum and high fertility (expressed as the percentage of cows that became pregnant before d90 post partum). This high fertility could be explained both by a higher cyclicity (accompanied by manifestation of estrus) and a higher conception rate. In the present study, milk production had a clear impact on estrus expression before d90 post partum. However, when anestrous cows were excluded from the model, we failed to find any association between milk production and high fertility.

In conclusion, automatic assessment of BW may be a useful tool for evaluating nutritional status and its relationship with reproductive efficiency in dairy cows.

References

1. **Royal MD, Darwash AO, Flint APF, Webb R, Woollians JA, Lamming GE.** Declining fertility in dairy cattle: changes in traditional and endocrine parameters of fertility. *Anim Sci* 2000; **70**: 487–501.
2. **Lucy MC.** Reproductive loss in high-producing dairy cattle: where will it end? *J Dairy Sci* 2001; **84**: 1277–1293. [Medline] [CrossRef]
3. **López-Gatius F.** Is fertility declining in dairy cattle? A retrospective study in north-eastern Spain. *Theriogenology* 2003; **60**: 89–99. [Medline]
4. **López-Gatius F, García-Ispierto I, Santolaria P, Yániz J, Nogareda C, López-Béjar M.** Screening for high fertility in high-producing dairy cows. *Theriogenology* 2006; **65**: 1678–1689. [Medline] [CrossRef]
5. **Butler WR, Smith RD.** Interrelationships between energy balance and postpartum reproductive function in dairy cattle. *J Dairy Sci* 1989; **72**: 767–783. [Medline] [CrossRef]
6. **Roche JF.** The effect of nutritional management of the dairy cow on reproductive efficiency. *Anim Reprod. Sci* 2006; **96**: 282–296. [Medline] [CrossRef]
7. **Coffey MP, Simm G, Brotherstone S.** Energy balance profiles for the first three lactations of dairy cows estimated using random regression. *J Dairy Sci* 2002; **85**: 2669–2678. [Medline] [CrossRef]
8. **Hady PJ, Domecq JJ, Kaneene JB.** Frequency and precision of body condition scoring in dairy cattle. *J Dairy Sci* 1994; **77**: 1543–1547. [Medline] [CrossRef]
9. **López-Gatius F, Yániz J, Madriles-Helm D.** Effects of body condition score and score change on the reproductive performance of dairy cows: a meta-analysis. *Theriogenology* 2003; **59**: 801–812. [Medline] [CrossRef]
10. **Berry DP, Macdonald KA, Penno JW, Roche JR.** Association between body condition score and live weight in pasture-based Holstein-Friesian dairy cows. *J Dairy Res* 2006; **73**: 487–491. [Medline] [CrossRef]
11. **Moore RK, Kennedy BW, Schaeffer LR, Moxley JE.** Relationships between reproduction traits, age and body weight at calving, and days dry in first lactation Ayrshires and Holsteins. *J Dairy Sci* 1990; **73**: 835–842. [Medline] [CrossRef]
12. **Buckley F, O'sullivan K, Mee JF, Evans RD, Dillon P.** Relationships among milk yield, body condition, cow weight, and reproduction in spring-calved Holstein-Friesians. *J Dairy Sci* 2003; **86**: 2308–2319. [Medline] [CrossRef]
13. **National Research Council** Nutrient Requirements of Dairy Cattle. 7th rev. ed. Washington, DC: National Academic Science. 2001.
14. **López-Gatius F, Santolaria P, Mundet I, Yániz JL.** Walking activity at estrus and subsequent fertility in dairy cows. *Theriogenology* 2005; **63**: 1419–1429. [Medline] [CrossRef]
15. **López-Gatius F, Camón-Urgel J.** Confirmation of estrus rates by palpation per rectum of genital organs in normal repeat dairy cows. *Zentralbl Veterinarmed A* 1991; **38**: 553–556. [Medline] [CrossRef]
16. **Labèrnia J, López-Gatius F, Santolaria P, Hanzen C, Lurent Y, Houtain JY.** Influence of calving season on the interactions among reproductive disorders of dairy cows. *Anim Sci* 1998; **67**: 387–393. [CrossRef]
17. **Yániz J, López-Gatius F, Bech-Sàbat G, García-Ispierto I, Serrano B, Santolaria P.** Relationships between milk production, ovarian function and fertility in high-producing dairy herds in north-eastern Spain. *Reprod Domest Anim* 2008; **43**: 38–43. [Medline] [CrossRef]
18. **Hosmer DW, Lemeshow S.** Applied Logistic Regression. 1989. New York: Wiley.
19. **van Straten M, Shpigel NY, Friger M.** Associations among patterns in daily body weight, body condition scoring, and reproductive performance in high-producing dairy cows. *J Dairy Sci* 2009; **92**: 4375–4385. [Medline] [CrossRef]
20. **Sakaguchi M.** Differences between body condition scores and body weight changes in postpartum dairy cows in relation to parity and reprodcutive indices. *Can Vet J* 2009; **50**: 649–656. [Medline]
21. **Veerkamp RF, Brotherstone S.** Genetic correlations between linear type traits, food intake, live weight and condition score in Holstein-Friesian dairy cattle. *Anim Sci* 1997; **64**: 385–392. [CrossRef]
22. **Berry DP, Buckley F, Dillon P, Evans RD, Rath M, Veerkamp RF.** Genetic parameters for level and change of body condition score and body weight in dairy cows. *J Dairy Sci* 2002; **85**: 2030–2039. [Medline] [CrossRef]
23. **Beam SW, Bulter WR.** Effects of energy balance on follicular development and first ovulation in postpartum dairy cows. *J Reprod Fert* 1999; **54**: 411–424.
24. **López-Gatius F, Mirzaei A, Santolaria P, Bech-Sàbat G, Nogareda C, García-Ispierto I, Hanzen C, Yániz JL.** Factors affecting the response to the specific treatment of several forms of clinical anestrus in high producing dairy cows. *Theriogenology* 2008; **69**: 1095–1103. [Medline] [CrossRef]
25. **Badinga L, Collier RJ, Wilcox CJ, Thatcher WW.** Interrelationships of milk yield, body weight, and reproductive performance. *J Dairy Sci* 1985; **68**: 1828–1831. [Medline] [CrossRef]
26. **Berry DP, Buckley F, Dillon P, Evans RD, Rath M, Veerkamp RF.** Genetic relationships among body condition score, body weight, milk yield, and fertility in dairy cows. *J Dairy Sci* 2003; **86**: 2193–2204. [Medline] [CrossRef]