STM JOURNALS
Research & Reviews: Journal of Dairy Science and Technology
ISSN: 2319-3409 (online), ISSN: 2349-3704(print)
Volume 3, Issue 2
www.stmjournals.com

Effect of Prepartum Body Condition Score on Dairy Cattle Performance

Dawod A.*, Helal M.A., Mahboub H.D.
Department of Husbandry and Animal Wealth Development, Faculty of Veterinary Medicine, Sadat City University, Egypt

Abstract
The present study was conducted to detect the effect of prepartum body condition score (BCS) on dairy cattle performance. Throughout the study, a total of 7956 dairy records were collected from six Holstein Friesian farms. According to the prepartum BCS, dairy cows were grouped into three main categories— low, medium, and over condition score cows for BCS values of 2–3, 3–4 and 4–5, respectively. Dairy cattles with BCS values under the level of 2 were culled as a part of culling policy in these farms. Productive parameters of milk yield (daily yield, 305-day yield and total yield), milk curve (days to peak, initial milk yield, peak milk yield and lactation persistency [LP]), milk somatic cell count (SCC) and somatic cell score (SCS), as well as some reproductive parameters (days to first estrus and days open) were determined to indicate the best dairy cattle prepartum BCS sustained high dairy performance. Prevalence of lameness and metabolic diseases (milk fever, abomasum displacement [DA] and ketosis) were also investigated in dairy cattle among different prepartum BCS. The best prepartum BCS was elucidated to reduce the prevalence of such diseases. Results of the present study revealed that the medium condition score cows produce more milk as compared to the over condition score cows. Medium condition score cows showed improved udder health and reproductive parameters. On the other hand, they showed decreased prevalence of lameness, milk fever, DA and ketosis. In contrast, it was obvious that over condition score cows suffered more from these metabolic disorders than low and medium BCS cows. The prevalence of lameness was more evident in low than in medium and over condition score cows.

Keywords *Prepartum body condition score, dairy cows, lameness, lactation persistency, holstein friesian*

****Author for Correspondence*** E-mail: adawod1980@yahoo.com

INTRODUCTION

Dairy cattle performance is one of most important subjects in dairy industry [1]. Dairy producers extreme their efforts to increase dairy performance with little chance of adverse events or diseases risks [2]. Body condition score (BCS) of dairy cows during prepartum period is considered as the main management tool governing dairy production success during the succeeding lactation cycle [3]. Therefore, an ideal prepartum BCS is the one factor which accelerates dairy cows performance with little lameness and metabolic diseases affections. Fatty cows with high BCS value had high productive and reproductive parameters. However, these cows suffered more from negative energy balance [4, 5]. Reproductive parameters of dairy cattle were affected greatly via BCS [6]. Improvement of BCS in dairy cattle improves the reproductive performance of the animal [7].

The majority of metabolic diseases (milk fever, DA and ketosis) occurred at late dry off period (prefresh period) as well as early lactation period, as these diseases are mainly concerned with transition phase. Proper management practices and adjustment of body condition at prepartum period greatly govern the incidence of such diseases [8]. This study was conducted to investigate the best dairy cattle prepartum BCS sustained high dairy performance as well as eliminate lameness and incidence of metabolic diseases.

MATERIALS & METHODS

Dairy records of 7956 cows were collected from six Holstein Friesian farms. The dairy farms were located at Giza, Menofia, and Behera governorates in Egypt. The study was conducted from October 2010 to June 2011. Dairy cows were grouped into three main categories according to their prepartum BCS, as low, medium, and over condition score cows for BCS values of 2–3, 3–4, and 4–5, respectively. Dairy cattles with BCS values under the level of 2 were culled as a part of dairy farms culling policy. Productive parameters of milk yield (daily yield, 305 days yield, and total yield), milk curve (days to peak, initial milk yield, peak milk yield, and lactation persistency [LP]), milk somatic cell count (SCC) and somatic cell score (SCS), as well as some reproductive parameters (days to first estrus, and days open) were determined.

Dairy farmers estimated the BCS values for dairy cows during late dry off phase (260 days of pregnancy), in order to ensure that dairy cows calved in proper BCS. LP value is the ability of dairy cow to withstand high milk production as long as it can. Dairy cows with high LP value, had high production performance. LP value determined as in Ref. [9] is given in equation:

LP= total milk yield/ weekly peak milk yield.

SCC was recorded in milk samples of dairy cows within different farms at 30 days postpartum. Logarithmic transformation of SCC data was done before the statistical analysis and means were presented after retransformation of logarithmic values of SCC [10]. SCS was calculated from SCC according to Table 1 [11].

Table 1: *Relationship between Somatic Cell Scores and Somatic Cell Counts.*

SCC score	SCC range
0	0 –18,000
1	19,000 –35,000
2	36,000 –71,000
3	72,000 – 141,000
4	142,000 –283,000
5	284,000–565,000
6	566,000 –1,130,000
7	1,131,000 –2,262,000
8	2,263,000 – 4,523,000
9	4,524,000 – 9,999,000

Prevalence of lameness and metabolic diseases (milk fever, DA, and ketosis) were detected in each prepartum BCS group Statistical analysis was done after complete data collection, via SAS computer program [12].

RESULTS AND DISCUSSION

Effect of Prepartum BCS on Dairy Cows Performance

BCS refers to the relative amount of subcutaneous body fat or energy reserve in the cow. It is an important management tool for maximizing milk production and reproductive efficiency while reducing the incidence of metabolic and other peripartum diseases. The most interesting results from the present study were the effect of prepartum dairy cattle BCS upon dairy Holstein performance and prevalence of lameness and some metabolic diseases.

Different dairy cattle prepartum BCS possessed significant difference in daily milk yield as shown in Table 2, as either medium or over condition cows increased daily milk yield values (28.09± 0.20 and 29.86± 0.25 kg, respectively) compared to low condition cows (16.26± 0.15 kg) at ($p<0.05$). Same trend appeared in 305 days milk yield values where both medium and over condition score cows significantly increased 305 days milk yield (8558.21± 36.53 and 8719.04± 98.11 kg, respectively) as compared to low condition cows (4550.31± 14.44 kg) at ($p<0.05$). While, total milk yield value (11107.80± 49.34 kg) increased significantly in medium condition score cows followed by over condition score cows (10798.30± 85.47 kg) then by low condition score cows (5408.05± 62.84 kg) at ($p<0.05$). These results could be attributed to both medium and over condition score cows which had medium and/or high body reserve, which helped dairy cow to produce more milk yield and withstand the high yield for longer period of time as much as possible, thus explaining the low values of total milk yield in low condition cows. These results go in barrel with the findings of Pryce and Lovendahl (1999), Overton and Waldron (2004), and Grummer et al. (2004), as they concluded that medium and high BCS of dairy cattle attained high milk yield [1, 3, 4]. In contrast, Boisclair (1986) and Flamenbaum et al. (1995) proved that there was no significant difference among different dairy cattle condition scores on dairy performance parameters [12–14].

***Table 2:** Effect of Prepartum BCS on Dairy Cows Performance.*

Classification	Parameters	Low condition Mean± SE	Medium condition Mean± SE	Over condition Mean± SE
Milk yield	Daily milk yield (kg)	16.26± 0.15 B	28.09± 0.20 A	29.86± 0.25 A
	305 days milk yield (kg)	4550.31±14.44 B	8558.21±36.53 A	8719.04±98.11 A
	Total milk yield (kg)	5408.05±62.84 C	11107.80±49.34 A	10798.30±85.47 B
Milk curve	Days to peak (days)	48.70± 0.93 A	55.70± 1.02 A	52.84± 0.88 A
	Initial milk (kg)	20.40± 0.18 B	27.96± 0.12 A	27.69± 0.11 A
	Peak milk yield (kg)	25.90± 0.13 B	35.32± 0.16 A	37.20± 0.18 A
	Persistency (%)	26.83± 0.20 B	32.88± 0.08 A	32.23± 0.13 A
Somatic cell count and score	Somatic cell count	100000.93± 0.04 A	66069.35± 0.02 B	93325.43± 0.03 A
	Somatic cell score	2.57± 0.12 A	2.43± 0.02 B	2.53± 0.09 A
Reproductive	Days to first estrus (days)	71.58± 2.21 A	55.81± 1.93 B	51.51± 1.35 B
	Days open (days)	130.14± 2.93 A	116.65± 2.83 B	91.51± 2.31 C

A–B: within the same row among different dairy cows BCS groups having different litter are significantly different at (p< 0.05).

Dairy cattle BCS possessed no significant difference in days to peak values, while it significantly differed in initial milk, peak milk yield as well as LP values. As, medium condition score cows produced significantly more initial and peak milk values (27.96± 0.12 and 35.32± 0.16 kg, respectively) as much as over condition score cows (27.69± 0.11 and 37.20± 0.18 kg, respectively) and it produced more initial and peak milk than low condition score cows (20.40± 0.18 and 25.90± 0.13 kg, respectively) at (p<0.05). The same trend appeared clearly in LP values, where it increased significantly in both medium and over condition score cows (32.88± 0.08 and 32.23± 0.13%, respectively) compared to low condition score cows (26.83± 0.20%) at (p<0.05). These results could be attributed to medium condition score cows as same as over conditions score cows had good body reserves and produced more milk yield than other dairy cows. Medium condition score cows suffered less from post parturient negative energy balance which governs milk yield during early lactation phase [15]. While, over condition score cows also produce more initial milk yield as medium condition score cows. However, these cows suffered from high value of negative energy balance thus may be due to their high body store [5]. Suriyasathaporn et al. (1998) reported that low condition score cows usually suffer from low body reserve during prepartum period which govern their production especially during early lactation stage [16]. Thus, low condition score cows depressed initial and peak milk yield values than other cattle. The results were in agreement with those of ref 16 and 17, as they concluded that good initial and total milk yield value was attained from medium and over condition score cows. On the other hand Corro et al. (1999) reported that, there was no significant difference between different dairy cattle BCS in milk production and dairy cattle LP values [17, 18].

SCC is a measure of the concentration of white blood cells and shed epithelial cells present in milk. Therefore, SCC increases during udder infection such as mastitis and decrease in healthy udder tissue [19]. Many dairy producers do their best to decrease SCC within the milk of their farm as this indicates hygienic milk production. Prepartum BCS of the dairy Holstein could be considered as a good management tool for controlling milk SCC. Our study indicated that dairy cattle prepartum BCS significantly influenced the milk SCC and SCS values at 30 days postpartum. As, medium condition score cows significantly decreased the SCC and SCS values (66069.35± 0.02 and 2.43± 0.02, respectively) than either low (100000.93± 0.04; 2.57± 0.12, respectively) or over condition score cows (93325.43± 0.03; 2.53± 0.09, respectively) at (p<0.05), which were nonsignificant. From the above results it was concluded that, low condition score cows increased milk SCC and SCS values, while the opposite of this trend appeared in medium condition score cows, which could be due to high immunosuppression during prepartum in low condition score cows. Kehrli et al. (1989) concluded that greater SCC and SCS values were recorded for low condition score cows in early lactation phase [20].

Medium condition score cows had high milk to cell ratio, low immunosuppression, low negative energy balance (NEB), and high dry matter intake (DMI) during their transition. All these factors might depress SCC value, while the opposite of this trend appeared clearly in over condition score cows, which may attribute to very large udder tissue, low DMI, severe NEB, and high prepartum immunosuppression. These results were in agreement with those of Suriyasathaporn et al. (2000), who concluded that, there was a positive relationship between BCS, SCC and SCS [21]. Also, the results disagreed with Busato et al. (2000) and Berry et al. (2007), who reported that there was no significant association between BCS, SCC, SCS and subclinical mastitis in early and late lactation period across 10000 quarter milk samples [22, 23].

Concerning to the effect of dairy cattle prepartum BCS on their reproduction, it was evident that different BCS groups differed significantly in days to first estrus. Either medium and over condition score cows improved dairy cattle reproductive performance, as these cows decreased days to first estrus significantly (55.81± 1.93 and 51.51± 1.35 days, respectively) than low condition score cows (71.58± 2.21 days) at ($p<0.05$). These results could be due to low body reserve among low condition score cows which suffered more from NEB balance especially during early lactation phase in contrast to medium condition score cows which suffered less from NEB and had high DMI. Severe NEB in low condition score cows together with progressive increase of milk yield during early lactation resulted in high days to first estrus as well as days opens [7]. These results agreed with those of Galina and Arthur (1989), and DeVries et al. (1998), as they reported that low condition score cows had low body reserve which was reflected by high days to first estrus and days open [24, 25]. Whitaker et al. (1999) reported that better fertility was recorded in cows, which had high BCS at calving [6].

Over condition score cows decreased days open value (91.51± 2.31days) followed by medium (116.65± 2.83days) then by low condition score ones (130.14± 2.93days) at ($p<0.05$). This trend could be attributed to large body reserve in over condition score cows and they suffered less from deficiencies during early postpartum period. Fatty cows had better reproductive performance. They had huge body reserves which overcome severe deficiencies during early postpartum period, thus accelerating the estrus rhythm just in time among dairy herds [7, 26]. These results were in agreement with those of Whitaker et al. (1999), Butler (2000), Ferguson (2001), and Gillund et al. (2001), as they reported that over condition score cows (fatty cows) had high reproductive efficiency and short days open[6, 7, 26, 27].

Effect of Prepartum BCS on Dairy Cows Lameness Prevalence

Lameness is one of the major economic and animal welfare problem faced by most dairy Holstein herds. Clinical lameness is of concern because of its high prevalence and high economic losses [28]. This study elucidated the relationship between Holstein prepartum BCS and clinical lameness prevalence. Results indicated that prepartum condition score possessed significant differences in lameness prevalence among dairy cows Table 3. This trend was indicated via chi square test (chi square value χ^2= 50.17***) at ($p<0.0001$). It was evident that low condition score cows significantly increased the prevalence of lameness compared to medium and over condition score cows. Out of 462, 6698 and 796 cows of low, medium and over condition score respectively; 104 (22.51%); 763 (11.39%) and 98 cows (12.31%), respectively suffered from leg disorders and lameness, respectively. The results could be due to the reason that commonly lame cows cannot reach the feeding manager easily and also it theoretically be subordinated by other dairy cattle, thus resulted in decrease in body weight as well as score unless these cattle had a history of high milk yield. Also, Rodrigo and Bicalho (2011) reported that, cows with low BCS values have significantly thinner digital cushions and therefore a lower capacity to protect corium tissue from compression by the third phalanx [29]**.** These results agreed with the findings of Hoedemaker et al. (2009), as they reported that low condition score cows with BCS value <3.0 at calving and during early lactation were more likely to be lame [2]. The results were not in agreement with those of Ruegg and Milton (1995), and Heuer et al. (1999), as their studies failed to identify a relationship between BCS and lameness [30, 31].

Table 3: *Effect of Prepartum BCS on Dairy Cows Lameness Incidence.*

BCS groups	N=7956	Lame cows	
		No.	%
Low condition	462	104	22.51
Medium condition	6698	763	11.39
Over condition	796	98	12.31
*Chi square value χ^2 = 50.17****			*p<0.0001*

Also,the prevalence of lameness increased in over condition score cows versus medium one, as over condition score cows suffered highly from severe NEB, low DMI during early lactation, and high body weight. All these factors together with increase of subacute rumenal acidosis (SARA) during early postpartum period resulted in high lameness incidence, as the later factor govern the conversion of dietary histidene amino acid to histamine, which is responsible for initiation of transition lameness [32].

Effect of Prepartum BCS on Dairy Cows Metabolic Diseases Prevalence

Milk Fever (Hypocalcaemia)

Milk fever (hypcalcaemia) is one of the dangerous diseases faced by heavy producers especially Holsteins. The prevalence of such disease among dairy Holstein herds were investigated in relation to prepartum BCS. The outcome of this work prooved that the prevalence of milk fever differed significantly among different dairy cattle prepartum BCS Table 4. Over condition score cows suffered more from milk fever prevalence 18 (2.26%) followed by medium condition score cows 78 (1.16%). While, the prevalence among low condition score cows was 1 (0.22%) (chi square value χ^2 = 11.20**) at (p<0.001). These results could be due to the reasons that over condition score cows eat less during their transition in addition to the fact that they suffer more from NEB. Thus, this condition may decrease the calcium intake and/or interfer with efficient calcium metabolism. Also, over condition score cows produced high milk yield which accelerate calcium demand during early pre and postpartum period as this cannot be tolerated by the body calcium balance thereby developing hypocalcaemia soon. The results go in barrel with the finding of Heuer et al. (1999), Lacetera et al. (2005), Roche and Berry (2006) and Roche et al. (2007), who reported that, cows with high BCS values at calving had high risk of milk fever incidence, in contrast to the findings of Dyk (1995) who prooved that, milk fever incidence possessed no significant difference among different BCS values during the last 2 weeks prepartum [31, 33–36].

Table 4: *Effect of Prepartum BCS on Dairy Cows Metabolic Disease Incidence (Milk Fever).*

BCS groups	N=7956	Milk fever cows	
		No.	%
Low condition	462	1	0.22
Medium condition	6698	78	1.16
Over condition	796	18	2.26
*Chi square value χ^2 = 11.20***			*p<0.001*

Abomasum Displacement

The displacement of the abomasum (DA) is an affection in high producing dairy herds. The prevalence of such disease varies in different dairy herds depending upon various factors. Abomasums displacement is considered as a multifactorial problem [37]. One of these factors was investigated in the present study that the prepartum BCS values of dairy animals significantly affected the prevalence of abomasum displacement among dairy herds Table 5 This trend was expressed via chi square test (chi square value χ^2 = 67.37***) at (p<0.0001). Fatty cows with high BCS value suffered from high incidence of abomasum displacement 13 (1.63%) followed by medium condition score cows 7 (0.10%). Thin cows with low BCS in had no susceptibility to abomasum displacement 0 (0%). These results may be due to over condition cows being fed with high energy ration in pre and postpartum stage to stimulate their milk yield potential. Very high energy ration during transition phase increase free volatile fatty acids in the rumen and rumenal acidosis which acts as the main cause of abomasum displacement. Similar results were reported by Dyk (1995) and Cameron et al. (1998), as they evident that the incidence of abomasum displacement increased with an increase of prepartum BCS [36, 38]. While, Hoedemaker et al. (2009) prooved that cows with high BCS values losses during early lactation were more likely to have a displaced abomasum [2].

Table 5: *Effect of Prepartum BCS on Dairy Cows Metabolic Disease Incidence (Abomasum Displacement).*

BCS groups	**N**=7956	**Abomasum displacement cows**	
		No.	%
Low condition	462	0	0
Medium condition	6698	7	0.10
Over condition	796	13	1.63
*Chi square value χ^2 = 67.37****			*p<0.0001*

Ketosis

Ketosis is a production disease that is common among high yielding cows in the post-calving period. The present study indicated that dairy cattle prepartum BCS possessed a significant effect on ketosis prevalence among dairy herds **Table 6** Low condition score cows were not affected with ketosis, whereas over condition score cows had the higher incidence of ketosis among different dairy cattle score groups 38 (4.77%). However, medium condition score cows had a decreased ketosis incidence value of 33 (0.49%) than those of over condition score cows (chi square value χ^2 = 151.85***) at (p<0.0001). Results may be attributed to the fact that over condition cows suffer from severe NEB as well as low DMI during their transition stage especially at early postpartum phase, thus obligate over condition cows to mobilize more energy (fat) from the tissues by catabolism, which resulted in the presence of high ketone bodies in their blood thereby developing ketosis. While, low condition score cows had very low fat stored in their bodies so that the breakdown of fat store was very low; therefore, these cattles could not suffer from such diseases. These results were similar to those of Oetzel (2004), Lacetera et al. (2005) and Nir (2007), who reported that over condition score dairy cows had high risks of ketosis incidence [33, 39, 40].

Table 6: *Effect of Prepartum BCS on Dairy Cows Metabolic Disease Incidence (Ketosis).*

BCS groups	**N**=7956	**Ketosis cows**	
		No.	%
Low condition	462	0	0
Medium condition	6698	33	0.49
Over condition	796	38	4.77
*Chi square value χ^2 =151.85****			*p<0.0001*

CONCLUSION

Dairy producers should direct their management plans to keep the BCS values of their dairy cows at medium levels (3–4 BCS) as medium condition score cows had high milk yield performance similar to over condition score cows (BCS >4), but they may have a little risks of lameness and metabolic diseases incidences. Also, low condition score cows should be treated with care and examined periodically for lameness affection, as this tolerate lameness in such cattle, as well as eliminate culling levels among dairy farms.

REFERENCES

1. Grummer RR, Mashek DG, Hayirli A**.** Dry matter intake and energy balance in the transition period. *The Veterinary Clinics of North America: Food Animal Practice*, 2004; 20: 447–70p.
2. Hoedemaker M, Prange D, Gundelach Y. Body condition change ante and postpartum, health and reproductive performance in German Holstein cows. *Reprod Domest Anim.* 2009**;**, 10: 1111p.
3. Pryce JE, Lovendahl P. Options to reduce vulnerability to metabolic stress by genetic selection. In: *Metabolic stress in dairy cows, British Society of Animal Science occasional publication***;** 1999. 24: 119–27p.
4. Overton TR, Waldron MR Nutritional management of transition dairy cows: strategies to optimize metabolic health. *J Dairy Sci.* 2004; 87 (1): 105–19p.
5. Broster WH, Broster VJ**.** Body score of dairy cows. *J Dairy Res***.** 1998**;** 65: 155–73p.
6. Whitaker DA, Goodger WJ, Garcia M, et al. Use of metabolic profiles in dairy cattle in tropical and subtropical countries on smallholder dairy farms. *Prev Vet Med.*1999; 38: 119–31p.

7. Butler WR. Nutritional interactions with reproductive performance in dairy cattle. *Animal Rep Sci*. 2000; 60-61: 449-57p.
8. Samarütel J, Ling K, Jaakson H, et al. Effect of body condition score at parturition on the production, fertility and culling in primiparous Estonian Holstein cows. *Veterinarija IR Zootechnika, T*. 2006; 36(58): 69–74p.
9. Elmaghraby MA. Lactation persistency and prediction of total milk yield from monthly yields in Egyptian buffaloes. Universitatea de Şãtiinţe Agricole şi Medicină veterinară Laşi. *Lucrări Ştiinţifice Seria zootehnie*. 2009; 53: 242–9p.
10. Overton TR, Waldron MR Nutritional management of transition dairy cows: strategies to optimize metabolic health. *J Dairy Sci.* 2004; 87 (1): 105–19p.
11. DHIA-202 Herd Summary Fact Sheet: A-1. Dairy records management systems, Raleigh, NC**.; 1997.**
12. SAS User’s Guide Version 9.1: Statistics. SAS Institute, Cary, NC**.** 2006.
13. Boisclair Y. Effect of prepartum energy, body condition, and sodium bicarbonate on production of cows in early lactation. *J Dairy Sci*.1986; 69: 2636–47p.
14. Flamenbaum I, Wolfenson D, Kunz PL, et al. Interactions between body condition at calving and cooling of dairy cows during lactation in summer. *J Dairy Sci.* 1995; 78:2221–9p.
15. Pedron O, Cheli F, Senatore E, et al. Effect of body condition score at calving on performance, some blood parameters, and milk fatty acid composition in dairy cows. *J Dairy Sci.* 1993; 76: 2528–35p.
16. Suriyasathaporn W, Nielen M, Dieleman SJ, et al. A Cox proportional-hazards model with time-dependent covariates to evaluate the relationship between body-condition score and the risks of first insemination and pregnancy in a high producing dairy herd. *Prev Vet Med*. 1998; 37: 159–72p.
17. De Vries MJ, Veerkamp RF. Energy balance of dairy cattle relation in to milk production variables and fertility. *J Dairy Sci.* 2000; 83: 62–9p.
18. Corro M., Rubio I., Castillo E., et al. Effect of blood metabolites, body condition and pasture management on milk yield and postpartum intervals in dual purpose cattle farms in the tropics of the state of Veracruz, Mexico. *Prev Vet Med*. 1999; 38: 101–17p.
19. Caraviello DZ., Weigel KA, Shook GE., et al. Assessment of the impact of somatic cell count on functional longevity in Holstein and Jersey cattle using survival analysis methodology. *J Dairy Sci*. 2005**;** 88: 804–11p.
20. Kehrli ME, Nonnecke Jr BJ, Roth JA Alterations in bovine neutrophil function during the periparturient period. *Am J Vet Res*. 1989; 50: 207–15p.
21. Suriyasathaporn Y, Schukken H, Nielsen M, et al. Low somatic cell count: A risk factor for subsequent clinical mastitis in a dairy herd. *J Dairy Sci.* 2000; 83: 1248–55p.
22. Busato A, Trachsel P., Schällibaum M., et al. Udder health and risk factors for sub-clinical mastitis in organic dairy farms in Switzerland. *Prev Vet Med.* 2000**;** 44: 205–20p.
23. Berry DP, Lee JM, Macdonald KA, et al. Associations Among Body Condition Score, Body Weight, Somatic Cell Count, and Clinical Mastitis in Seasonally Calving Dairy Cattle. *J Dairy Sci*. 2007; 90: 637–48p.
24. Galina CS, Arthur GH**.** Review of cattle reproduction in the tropics. 2. Parturition and calving intervals. *Anim Breed Abstr.* 1989; 57: 679–86p.
25. De Vries MJ, Van Der Beek S, Kaal-Lansbergen LM, et al. Modeling of energy balance in early lactation and effect of energy deficits in early lactation on first detected estrus post partum in dairy cows. *J Dairy Sci*. 1998; 82: 1927–33p.
26. Ferguson JD**.** Nutrition and reproduction in dairy herds. In: *Proceedings of the Intermountain Nutrition Conference;* 2001; Salt Lake City, UT. Utah State Univ. Logan; 65–82p.
27. Gillund P, Reksen O, Gröhn YT, et al. Body condition related to ketosis and reproductive performance in Norwegian dairy cows. *J Dairy Sci.* 2001; 84: 1390–6p.

28. Okaiyeto SO, Ernest A., Danbirini S., et al.Effects of lameness on milk yield of Holstein Friesian cattle on a dairy farm in Niger State of Nigeria. *J Anim Sci Adv*. 2012; 2 (3): 282–86p.
29. Rodrigo C, Bicalho D. Lameness in dairy cattle: A debilitating disease or a disease of debilitated cattle. Cornell University, Western Dairy Management Conference J. 2011; 73–83p.
30. Ruegg PL, Milton RL Body condition scores of Holstein cows on Prince Edward Island; relationships with yield, reproductive performance, and disease. *J Dairy Sci.* 1995; 78: 552–64p.
31. Heuer C, Schukken YH, Dobbelaar P. Postpartum body condition score and results from the first test day milk as predictors of disease, fertility, yield, and culling in commercial dairy herds. *J Dairy Sci*. 1999; 82: 295–304p.
32. Donovan GA, Risco CA, Temple GMD, et al. Influence of transition diets on occurrence of subclinical laminitis in Holstein dairy cows. *J Dairy Sci*. 2004; 87(1):73–84p.
33. Lacetera N, Scalia D., Bernabucci U., et al. Lymphocyte functions in over conditioned cows around parturition. *J Dairy Sci.* 2005; 88: 2010–16p.
34. Roche JR, Berry DP. Periparturient climatic, animal and management factors influencing the incidence of milk fever in grazing systems. *J Dairy Sci.* 2006: 89: 2775–83p.
35. Roche JR, Macdonald KM, Burke CR, et al. Associations among body condition score, body weight and reproductive performance in seasonal-calving pasture-based dairy cattle. *J Dairy Sci.* 2007; 90: 376–91p.
36. Dyk PB. The association of prepartum non-esterified fatty acids and body condition with peripartum health problems of 95 Michigan dairy farms. *MS Thesis. Michigan State Univ., East Lansing.* 1995.
37. Trent AM. Surgery of the bovine abomasum. *Veterinary Clinics of North America: Food Animal Practice* **1990;** 6: 399–448p.
38. Cameron RE, Dyk PB, Herdt TH, et al. Dry cow diet, management, and energy balance as risk factors for displaced abomasum in high producing dairy herds. *J Dairy Sci.* 1998**;** 81: 132p.
39. Oetzel GR. Monitoring and testing dairy herds for metabolic disease. *Vet Clin North Am Food Anim Pract.* 2004; 20: 651p.
40. Nir OM. Achieving optimal cow performance. *Int Dairy Top.* 2007; 6: 13p.

