

Impact of body condition change post-breeding on reproductive performance of beef cows

Ramanathan Kasimanickam,^a Phillip Firth,^a Matthew Asay,^a Ahmed Tibary,^a Dale Moore,^a John Hall,^b William Whittier^c

^aDepartment of Veterinary Clinical Sciences, Washington State University, Pullman, WA; ^bNancy M Cummins Research Extension and Education Center, University of Idaho, Carmen, ID; ^cDepartment of Large Animal Clinical Sciences, Virginia Tech, Blacksburg, VA

Abstract

Body condition score (BCS) is a commonly used tool for evaluating the nutritional status of beef cows. Good nutritional status of beef cows is one of the essential components for improved reproductive performance. The objective was to evaluate the impact of change in body condition during two months after breeding on the artificial insemination (AI) pregnancy rate in beef cows. Angus cross beef cows (N = 2571) from 11 locations were included in this study. All cows were given a BCS (1-emaciated; 9-obese), by the same clinician in each location at the initiation of synchronization (CO-Synch+CIDR) protocol and again at pregnancy diagnosis, 55 to 70 days later. Cows were fitted with Kamar heat detection patches at CIDR removal and observed three times daily for estrus expression until inseminated. Pregnancy status was determined by per-rectal palpation or using ultrasonography. Variables included in the model (PROC MIXED) were change in BCS (no change or gain vs. loss), cows expressed estrus at or prior to AI (activated, partially activated, or lost Kamar) or not (intact Kamar), age of the dam (2, 3 to 6 and >6 years), days post-calving at initiation of synchronization (30 to 60, 61 to 80 and > 81 days) and appropriate 2-way interactions. Season (location) and AI sires were considered as random effects. The results showed AI pregnancy rate was influenced by change in the BCS [No change or gain: 55.3%; (1034/1870) vs loss: 50.1% (352/703); P<0.05] and cows that showed estrus at or prior to AI [estrus: 57.8% (825/1423) vs no estrus: 48.9% (560/1148); P<0.0001]. In conclusion, cows that lost body condition after breeding had lower AI pregnancy rates compared to cows that maintained or gained body condition. It is essential to feed cows following breeding to maintain their BCS and optimize their conception rates.

Keywords: Body condition, pregnancy rate, timed artificial insemination, beef cows, fertility

Introduction

Variability in quantity and quality of pastures limits the energy intake in extensive rangeland based cow-calf systems. Poor quality pasture negatively impacts reproductive performance of beef cows. Nutritional program prior to calving reflects in body condition score (BCS) at calving and after calving. It is the most important factor determining the duration of the postpartum anestrus period beef cows.^{1,2} However, post-calving nutrition may partially overcome the negative effects of a restriction in pre-partum nutrition in thin to moderate BCS beef cows.^{1,2} The nutritional status of a pregnant beef cows throughout gestation is important for the development and health of fetus and nutritional status after calving is important for growth and health of calf. Studies have focused BCS at calving, BCS change from calving to breeding and BCS at breeding on reproductive performance and not many studies focused on the effect of BCS change immediately after breeding on reproductive performance. Increased energy intake for three to four weeks, before or during the mating period, in combination with temporary weaning (with or without separation of the calf) has been shown to increase pregnancy rates during the first half of the mating period in cows with low-to-moderate BCS.²

Nutritional status is reflected in changes in body weight (BW) and BCS as well as in the levels of metabolites and hormones in blood. Blood concentrations of glucose, insulin and insulin-like growth factor-I (IGF-I) are indicative of the availability of energy, provide short- or long-term signals that mediate the effects of nutrition on reproduction.³ Insulin-like growth factor-I plays a pivotal role in cattle fertility, acting as a monitoring signal that allows reproductive events to occur when nutritional conditions

for successful reproduction are reached.⁴ The objective of this study was to evaluate the impact of body condition change during two months after breeding on AI pregnancy rate in beef cows.

Materials and methods

Multiparous Angus cross beef cows (n=1054) from 11 locations were included in this study. All cows were given a BCS (1-emaciated; 9-obese), by the same clinician in each location at the initiation of synchronization (CO-Synch+CIDR; Figure 1) protocol and again at pregnancy diagnosis, 55 to 70 days later. Briefly, cows received 100 µg gonadotropin releasing hormone (GnRH) im (Cystorelin®, Merial Ltd. Duluth, GA) and a controlled internal drug release insert (CIDR; Eazi-Breed™ CIDR® cattle insert, Pfizer Animal Health, New York, NY) on Day 0. The CIDR insert was removed and 25 mg prostaglandin F2α (PGF) im (Lutalyse® sterile solution; Pfizer Animal Health) was given on Day 7. On Day 10, starting at 8:00 AM, at 66 h (N=544) after CIDR removal cows were inseminated and were given 100 µg of GnRH im concurrently.

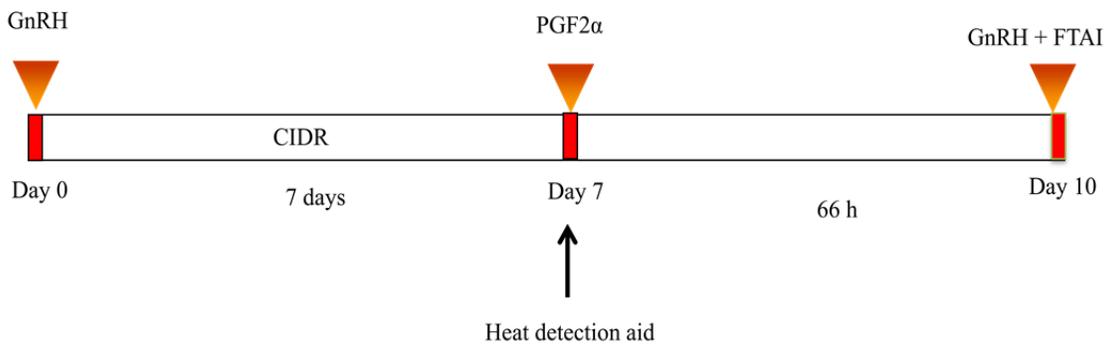


Figure 1. Diagrammatic representation of the CO-Synch+CIDR synchronization protocol

All cows received a Kamar® Heatmount detector (Kamar, Inc., Steamboat Springs, CO) at the time of CIDR insert removal on Day 7. During the period from CIDR insert removal to insemination, cows were observed three times daily for estrus and heat detector aid status (activated, partially activated and lost vs. intact). A cow was determined to be in estrus if the cow was observed to stand for mounting or if the cow had an activated, lost (with mount marks) or partially-activated heat detector aid.

Two weeks later, intact Angus bulls were placed with cows (approximately 1:40 bull: cow ratio), for the remainder of the 60 to 70 d breeding season. Cows were examined for pregnancy status at 55 to 70 days after fixed-time AI (FTAI) by ultrasonography (Aloka-500, Sysmed Lab Inc., Chicago, IL) to identify time of conception. In all locations, cows were inseminated by AI technicians from stud companies and/or clinicians. The AI sires were selected and assigned to cows based on sire traits and to avoid inbreeding. The AI pregnancy rate was calculated as number of cows pregnant to AI divided by total number of cows inseminated.

Statistical analyses

The data were analyzed using SAS statistical software (SAS version 9.12, SAS Institute Inc., Cary, NC). Variables included in the model (PROC MIXED) were change in BCS (no change or gain vs. loss), cows expressed estrus at or prior to AI (activated, partially activated, or lost Kamar) or not (intact Kamar), age of the dam (2, 3 to 6 and >6 years), days post-calving at initiation of synchronization (30 to 60, 61 to 80 and > 81 days) and appropriate 2-way interactions. Season (location) and AI sires were considered as random effects.

General linear model procedure was used to determine the differences in the AI pregnancy among season (spring and fall), locations (N=11), and AI sires (N=13).

Results

There were 1227 spring cows and 1346 fall cows. The mean body condition difference was different between seasons (spring: 0.45 ± 0.03 vs. fall -0.22 ± 0.03 ; $P < 0.05$). The mean body condition scores difference among locations were significantly different (Fig 2). The range for BCS difference was -3 to +3.

The results showed AI pregnancy rate was influenced by change in the BCS [Table 1; No change or gain: 55.3% (1034/1870) vs. loss: 50.1% (352/703); $P < 0.05$] and cows that showed estrus at or prior to AI [Table; estrus: 57.8% (825/1423) vs. no estrus: 48.9% (560/1148); $P < 0.0001$]. No interactions were observed ($P > 0.1$). No differences in AI pregnancy (%) were observed for dam's age ($P > 0.1$) and days post-calving ($P > 0.1$).

Mean AI pregnancy (%) for mean body condition score differences during first two months after breeding in beef cows were different (Fig 3; $P < 0.05$). There was no difference in AI pregnancy between seasons (Fig 4; $P > 0.1$). The AI pregnancy ranged from 50.4 to 66.7% for locations. Among locations, the AI pregnancy differed significantly (Fig 5; $P < 0.05$). Pregnancy for AI sires ranged from 49.0 to 71.3%. The AI pregnancy differed among AI sires (Fig 6; $P < 0.05$). Pregnancy rates for BCS at initiation of synchronization were different (Fig 7; $P < 0.05$).

Discussion

In this study, we observed that cows that lost body condition during the first two months after breeding had decreased odds of becoming pregnant to AI compared to cows that maintained or gained body condition. In spite of the facts that fertilization occurs in 90% of inseminated cows, but only 60% of those diagnosed to be pregnant at 60 days after breeding indicates that there is an estimated 30 % pregnancy wastage from fertilization to 60 days after breeding due to various reasons.⁵ Several factors contribute to low AI pregnancy rates. The greatest of these risk factors is acute body condition loss.

Studies on body condition loss and reproductive performance determined the body condition loss from calving from breeding.⁶⁻⁸ These studies focused on the effect nutrition on resumption ovarian cyclicity, duration of the anestrus period after calving and/or proportion of anestrus cows at the beginning of the breeding season. Duration of the anestrus period after calving is a key factor and is variable in beef cows. Evidence suggests that cows that lose body condition have a longer postpartum interval to first ovulation. Follicular growth generally resumes within a week or two in the majority of cows associated with a transient rise in follicle-stimulating hormone (FSH) that occurs within three to five days of parturition.⁵ Beef cows with calf alongside in good body condition normally have 30 days to first ovulation whereas beef cows in poor body condition have 70 to 100 days to first ovulation.⁵ The lack of ovulation of dominant follicles during the postpartum period is associated with infrequent luteinizing hormone (LH) pulses, with both suckling and low level of nutrition being implicated in the prolonged suppression of LH pulses in the absence of progesterone. The key to optimizing resumption of ovulation in beef cows is appropriate pre-calving nutrition and management so that cows calve in an optimal body condition (BCS 5 to 6) with post-partum body condition loss restricted to < 0.5 BCS units.

In this study, we evaluated the effect of body condition loss during two months after breeding. There are several key factors regulating embryonic development during first 60 days of gestation. Leptin, originally described as a regulator of food intake and energy balance, was found to play a critical role in reproductive function.⁹ Leptin promotes preimplantation embryo development.¹⁰ This is supported by evidence that blastocysts cocultured with endometrial epithelial cells modulate leptin secretion.⁹ Adiponectin is another cytokine that plays an important role in regulating energy homeostasis, specifically lipid and glucose metabolism.¹¹ Recent data suggest that adiponectin can also directly regulate reproductive and placental processes.¹² Adiponectin can play a complementary role in the regulation of several key female reproductive functions. It has been demonstrated that adiponectin is involved in the modulation of ovarian and endometrial functions, influencing periovulatory remodeling of the ovarian follicle, and steroid synthesis/secretion, as well as energy supply, and inflammatory response of endometrial cells.¹³⁻¹⁵ Adiponectin has also been involved embryonic development and implantation supported by its expression in rat embryos and uterus and adiponectin receptors expression during the

mid-secretory phase that corresponds to the embryo implantation window in humans, mice and pigs.¹⁶⁻¹⁹ These findings strongly suggests that maintenance of body condition and energy status is critical during early gestation.

Artificial insemination pregnancy was higher for cows gaining BC 1 or 2 scores compared to cows gaining 3 scores. It is possible that cows gaining 3 scores may suffer from poor embryonic development due to metabolic changes in the uterine environment compared to cows gaining 1 or 2 scores. It should be noted that cows gaining 3 scores from 3 to 6 or 4 to 7 may benefit more than cows gaining 3 scores from 5 to 8. However, the AI pregnancy for cows gaining 3 scores was higher compared to cows losing BC.

In this study, there was difference in AI pregnancy among locations. It should be noted that the number of cows that lost or gained body condition differed among locations. The increase in BCS might have been associated with the increase in forage availability and quality during winter and spring months is supported by the BCS difference was different between the fall and spring in this study. The BCS gains in cows could be explained by increased intake of energy and/or nutrients. In addition, increased forage availability and quality have been associated with reduced grazing energy cost by decreasing grazing time.²⁰ It should be noted that there was no difference in AI pregnancy between seasons. It is plausible that the gain or loss in body condition was associated with the individual cow needs.

Blood concentrations of glucose, insulin and IGF-I are indicative of the availability of energy, and provide short- or long-term signals that mediate the effects of nutrition on reproduction.³ In agreement with BCS maintenance, recovery or gain, the total protein and albumin concentrations increased and urea and non-esterified fatty acids (NEFA) decreased which would indicate a better nutritional status²¹ and decreased mobilization of reserves from muscle²² and adipose tissue,²³ respectively. Similarly, serum NEFA was reduced in beef cows as range forage quantity and quality improved.²⁴ It should be noted that adipose depot depletion and associated increase in adiponectin alter cytokine production. This alteration in cytokines may initiate neuroendocrine signals to interfere with feed intake.²¹⁻²⁴ So cows that loose body condition may not be interested in feed intake which may further prolong the decrease in essential metabolites involved and hence affect the reproductive performance. The economic benefit of a beef operation is directly related to pounds of beef produced per cow per year. In order to maximize the production not only the cow need to become pregnant but also it should become pregnant early in the breeding season. Cows that loose body condition take more time to become pregnant and thus incurring economic loss to beef producers. It is also conceivable that cows with poor body condition may lose their pregnancy and need to become pregnant again after early embryonic death during the breeding season. Several studies focus on alternative approach to address this by supplementing essential fatty acid and amino acids; however, further studies needed to focus on increasing key makers that are important for early pre- and peri-embryonic development, and placental development.

In conclusion, cows that lost body condition after breeding had lower AI pregnancy rates compared to cows that maintained or gained body condition. It is essential to feed cows following breeding to maintain their BCS and optimize their reproductive performance.

References

1. Lalman DL, Keisle DH, William JE, et al: Influence of postpartum weight and body condition change on duration of anestrus by undernourished suckled beef heifers. *J Anim Sci* 1997;75:2003-2008.
2. Perry RC, Corah LR, Cochran RC, et al: Influence of dietary energy on follicular development, serum gonadotropins, and first postpartum ovulation in suckled beef cows. *J Anim Sci* 1991;69:3762-3773.
3. Bossis I, Wettemann RP, Welty SD, et al: Nutritionally induced anovulation in beef heifers: ovarian and endocrine function during realimentation and resumption of ovulation. *Biol Reprod* 2000;62:1436-1444.
4. Velazquez MA, Spicer LJ, Wathes DC: The role of endocrine insulin-like growth factor-I (IGF-I) in female bovine reproduction. *Domest Anim Endocrinol* 2008;35:325-342.
5. Crowe MA: Resumption of ovarian cyclicity in post-partum beef and dairy cows. *Reprod Domest Anim* 2008;43 Suppl 5:20-28.
6. Crowe MA, Goulding D, Baguisi, et al: Induced ovulation of the first postpartum dominant follicle in beef suckler cows using a GnRH analogue. *J Reprod Fertil* 1993;99:551-555.

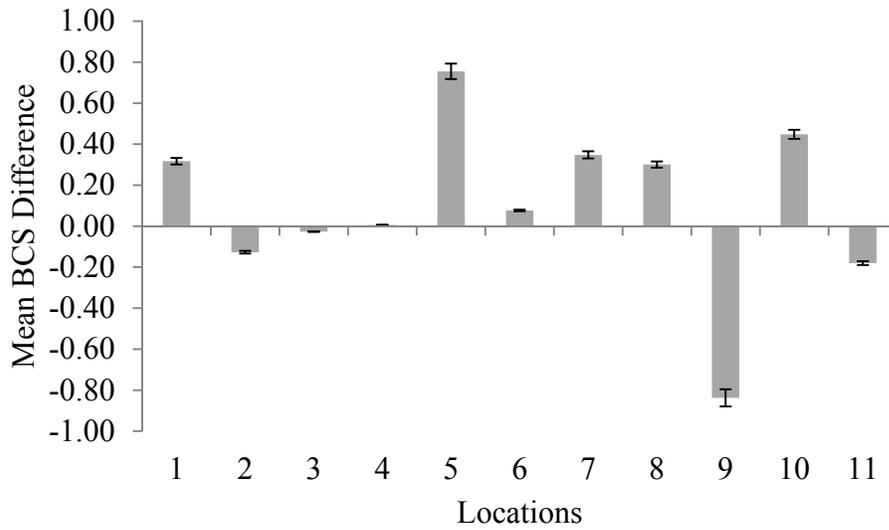
7. Crowe MA, Padmanabhan V, Mihm M, et al: Resumption of follicular waves in beef cows is not associated with periparturient changes in follicle-stimulating hormone heterogeneity despite major changes in steroid and luteinizing hormone concentrations. *Biol Reprod* 1998;5:1445-1450.
8. Duffy P, Crowe MA, Boland MP, et al: Effect of exogenous LH pulses on the fate of the first dominant follicle in postpartum beef cows nursing calves. *J Reprod Fertil* 2000;118:9-17.
9. Gonzalez RR, Simon C, Caballero-Campo P, et al: Leptin and reproduction. *Hum Reprod Update* 2000;6:290-300.
10. Kawamura K, Sato N, Fukuda J, et al: Leptin promotes the development of mouse preimplantation embryos in vitro. *Endocrinology* 2002;143:1922-1931.
11. Yamauchi T, Kamon J, Waki H, et al: The fat derived hormone adiponectin reverses insulin resistance associated with both lipodystrophy and obesity. *Nat Med* 2001;7:941-946.
12. Tilg H, Moschen AR: Adipocytokines: mediators linking adipose tissue, inflammation and immunity. *Nat Rev Immunol* 2006;6:772-783.
13. Takemura Y, Osuga Y, Yamauchi T, et al: Expression of adiponectin receptors and its possible implication in the human endometrium. *Endocrinology* 2006;147:3203-3210.
14. Smolinska N, Siawrys G, Kaminski T, et al: Leptin gene and protein expression in the trophoblast and uterine tissues during early pregnancy and the oestrous cycle of pigs. *J Physiol Pharmacol* 2007;58:563-581.
15. Gosman GG, Katcher HI, Legro RS: Obesity and the role of gut and adipose hormones in female reproduction. *Hum Reprod Update* 2006;12:585-601.
16. Dos Santos E, Serazin V, Morvan C, et al: Adiponectin and leptin systems in human endometrium during window of implantation. *Fertil Steril* 2012;97:771-778.
17. Schmidt T, Fischer S, Tsikolia N, et al: Expression of adipokines in preimplantation rabbit and mice embryos. *Histochem Cell Biol* 2008;129:817-825.
18. Chappaz E, Alborno MS, Campos D, et al: Adiponectin enhances in vitro development of swine embryos. *Domest Anim Endocrinol* 2008;35:198-207.
19. Maillard V, Uzbekova S, Guignot F, et al: Effect of adiponectin on bovine granulosa cell steroidogenesis, oocyte maturation and embryo development. *Reprod Biol Endocrinol*. 2010;8:23.
20. Brosh A: Heart rate measurements as an index of energy expenditure and energy balance in ruminants: a review. *J Anim Sci* 2007;85:1213-1227.
21. Ndlovu T, Chimonyo M, Okoh AI, et al: Assessing the nutritional status of beef cattle: current practices and future prospects. *Afr J Biotechnol* 2007;6:2727-2734.
22. Chimonyo M, Hamudikuwana H, Kusina NT, et al: Changes in stress-related plasma metabolite concentrations in working Mashona cows on dietary supplementation. *Livest Prod Sci* 2002;73:165-173.
23. Meikle A, Kulesar M, Chilliard Y, et al: Effects of parity and body condition at parturition on endocrine and reproductive parameters of the cow. *Reproduction* 2004;127:727-737.
24. Waterman RC, Grings EE, Geary T et al: Influence of seasonal forage quality on glucose kinetics of young beef cows. *J Anim Sci* 2007;5:2582-2595.

Table. Logistic regression for the effect of body condition change from breeding to pregnancy diagnosis at two months after AI and estrus status at or before the time of AI on the odds of pregnancy in beef cows

Predictor	Coefficient	SE Coefficient	Z	'P' value	Odds Ratio	95% CI	
						Lower	Upper
Constant	-0.05555	0.059197	-0.94	0.348			
Estrus status	0.370487	0.079877	4.64	0.0001	1.45	1.24	1.69
Body condition change	0.072708	0.037397	1.94	0.052	1.08	1	1.16

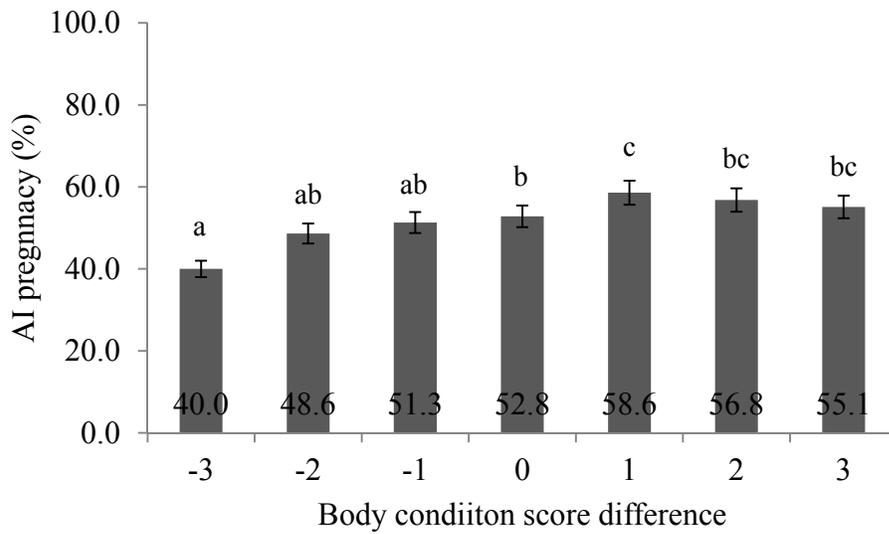
CI – Confidence Interval; SE – Standard error;
Accounted for season (location) and AI-sires;

Figure 2. Mean (\pm SEM) body condition difference for cows in different locations.



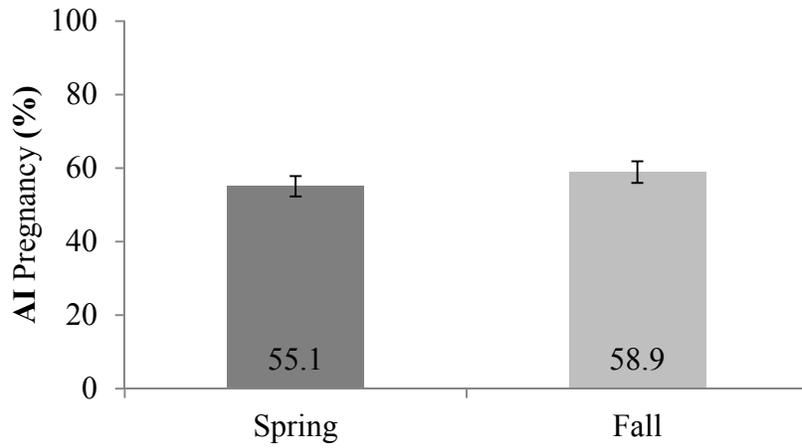
Mean BCS difference differed among locations ($P < 0.05$).

Figure 3. Mean AI pregnancy (%) for mean body condition score differences during first 2 months after breeding in beef cows.



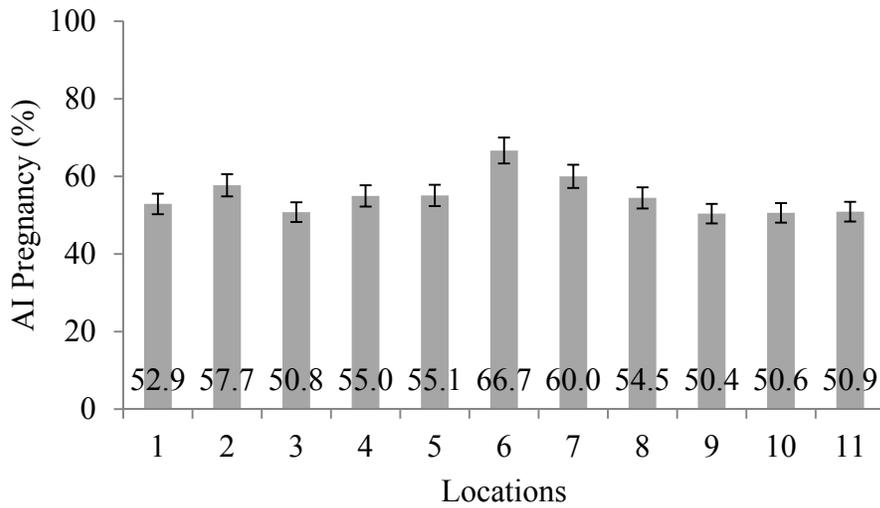
abc- Different superscripts are significantly different ($P < 0.05$)

Figure 4. Mean AI pregnancy (%) differences in Angus cross beef cows inseminated during fall and spring season.



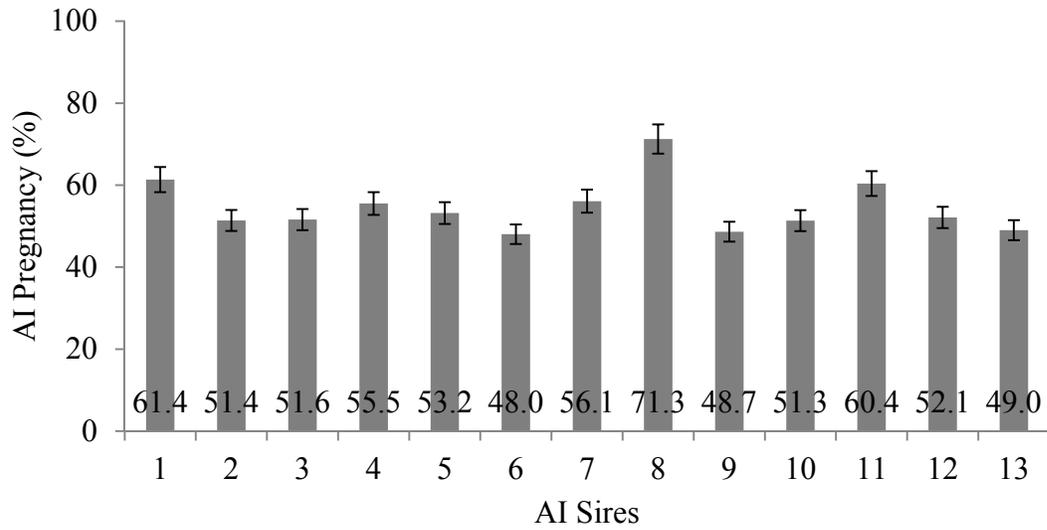
No differences in AI pregnancy (%) between seasons ($P>0.1$)

Figure 5: Mean AI pregnancy (%) differences in Angus cross beef cows inseminated at different locations



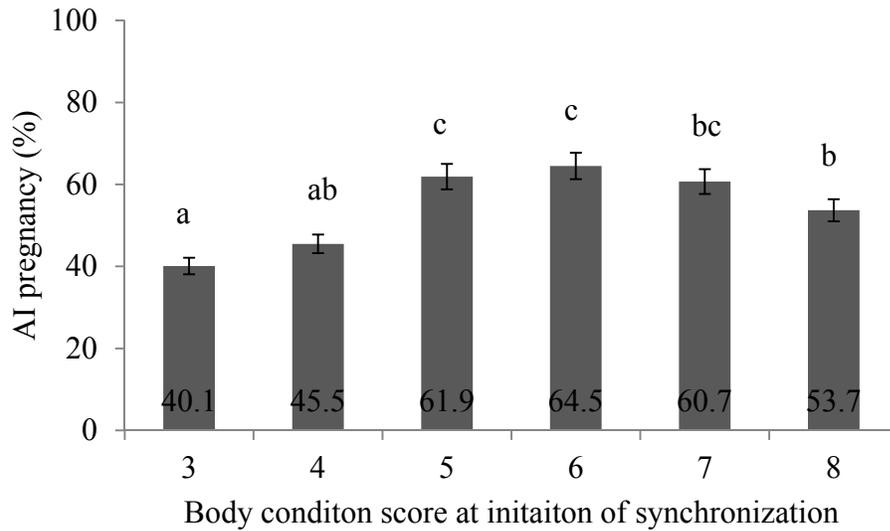
Differences in AI pregnancy (%) observed between different locations ($P<0.05$)

Figure 6: Mean AI pregnancy (%) differences in Angus cross beef cows inseminated using different AI sires



Differences in AI pregnancy (%) observed between different locations ($P < 0.05$); Locations 1, 2, 3, and 8 were both fall and spring locations.

Figure 7. Mean AI pregnancy for body condition score at initiation of synchronization in Angus cross beef cows.



abc- Different superscripts are significantly different ($P < 0.05$)