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PUBERTY AND ANESTRUS: DEALING WITH NON-CYCLING FEMALES

Les Anderson, Ph.D.
Department of Animal and Food Science
University of Kentucky, Lexington, KY 40546-0215

Introduction

Anestrus has long been recognized as the primary factor reducing reproductive efficiency in beef cow-calf operations (Short, 1990). Unfortunately, anestrus occurs annually in productive females; heifers are anestrus prior to puberty and cows undergo a period of anestrus after each calving. The length of the anestrous period is governed by many factors including presence of a calf, nutritional status, cow age, and degree of calving difficulty. Regulation of anestrus is essential to maintaining productivity and profitability in beef cattle production.

Incidence of Anestrus

Early conception is limited by the proportion of suckled cows not exhibiting regular estrous cycles (anestrus) at the beginning of the breeding season (Short et al., 1990). The incidence of anestrus at the initiation of the breeding season is significant in the beef cow-calf operations. In an experiment that included 851 postpartum cows from six states (Lucy et al., 2001), 53% of cows were anestrous 7 days before the beginning of the breeding season (range 17-67%). In other experiments the incidence of anestrus ranged from 44% (Gasser et al., 2003) to 46% (Stevenson et al., 2003). Reproductive rate in beef cattle can only be maximized when methods are used that successfully synchronize a fertile estrus in anestrous beef cows.

The factors regulating anestrus have been reviewed extensively (Short et al., 1990; Yavas and Walton, 2000; Rhodes et al., 2003; Stevenson et al., 1997). Anestrus is initiated by the presence of a suckling calf; weaning at birth results in the resumption of estrous cycles in about 14 days (Williams, 1990). Nutritional status greatly influences the length of the anestrous period. Reduced body energy reserves or inadequate energy or protein intake at calving can delay the return to estrus. In a recent summary, Stevenson and coworkers (2003) identified three key issues (body condition, parity, and days postpartum) that were associated with the incidence of anestrous and pregnancy failure.

Body Condition

The degree of fatness (body condition score or BCS) of a female's body has been shown to be an accurate indicator of her energy and/or nutritional status. Body condition at calving influences the length of the postpartum interval (time from calving to first estrus). Short and coworkers (1990) reviewed several studies examining the influence of different nutritional regimes. Cows that calve with a body condition score less than 5 (1 = emaciated and 9 = obese) have longer postpartum intervals than cows calving with a body condition score 5 or greater (Figure 1). Increasing energy supplementation reduced the length of the anestrous period in thin (BCS < 5) cows but not heavier conditioned cows (Short et al., 1990). Recently, Stevenson and coworkers (2003) demonstrated that the proportion of cows initiating estrous cycles (cycling cows) increased linearly by approximately 18% per unit as BCS increased from 3.5 to 6.0 at the onset of the breeding season (Figure 2). Thus, to minimize the length of the anestrous period, cows must calve in a BCS of 5 or greater.

Parity

Most beef producers understand the influence of parity on anestrus. Two-year old suckled beef cows simply require more time postpartum to initiate estrous cycles because of they need additional energy to support both lactation and growth (Short and Adams, 1988). Fewer 2-year-old cows were cycling, despite calving up to 3 weeks earlier, compared to the multiparous cows (Stevenson et al., 2003). Cycling activity increased linearly from 9% (30 days) to a peak of 70% at 81-90 days postpartum (Figure 3). The delay in estrus is the result of altered nutrient partitioning after calving. The priority system for energy use in cows is as follows; first, maintenance of essential body functions; second, growth; third, lactation; and finally, reproduction and initiation of estrous cycles. Most cows complete their physical growth at approximately 4 years of age. Mature cows, then, have no growth requirement and nutrients are more readily partitioned to lactation and reproduction. It is not surprising that cows are most productive from 4-10 years of age.

Days Since Calving

Time is an essential component of the postpartum period. Stevenson and coworkers (2003) demonstrated that the proportion of cows cycling on the first day of the breeding season was influenced by calving date. Regardless of parity, the proportion of cows cycling increased in a curvilinear fashion (Figure 4). Days postpartum averaged 86 ± 0.7 for primiparous and 68 ± 0.3 for multiparous cows. The percentage of cycling cows decreased after 90 days postpartum due mostly to the reduced cyclicity of the primiparous cows (85% of the cows at this time). The proportion of cows initiating estrous cycles increased by approximately 7% for every 10-day interval from calving. Thus, more cows had initiated estrous cycles when they had longer periods of time between calving and the breeding season.

Interestingly, the influence of time on cyclicity on the first day of the breeding season differed between primiparous and multiparous cows. For primiparous cows, the percentage of cows cycling at the onset of the breeding season did not differ among the first three 21-day calving intervals (Figure 4) but was lower for those very late-calving primiparous females. In contrast, cyclicity was higher for multiparous cows calving in the first 6 weeks of the calving season (> 50%) compared with those that calved after 6 weeks (< 40%). Early calving appears critical for both primiparous and multiparous cows.

Postpartum Reproductive Activity and Short Cycles

The endocrine changes that precede first estrus must be imitated to successfully induce estrus in anestrous cows. Ovarian function begins rapidly after calving. A wave-like pattern of follicle growth begins approximately two weeks postpartum and multiple waves of growth occur prior to the first ovulation (Murphy et al., 1990). Diameter of the dominant follicle increases with each successive follicular wave up to either ovulation (Murphy et al., 1990) or the fourth or fifth wave in cows with longer postpartum intervals (Stagg et al., 1995). The first ovulation postpartum is preceded by an increase in the pulsatile secretion of LH (Walters et al., 1982). The initial postpartum ovulation occurs if the dominant follicle can produce sufficient estradiol to induce the preovulatory gonadotropin surge.

The initial postpartum ovulatory event results in the formation of a corpus luteum (CL) that is short-lived (7-10 days). The short cycle is a normal occurrence at the first spontaneous postpartum ovulation in beef females (Day et al., 1990). The first CL postpartum is short-lived because of the premature release of prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) from the uterus (Cooper et al., 1991) due to the low concentrations of progesterone (Zollers et al., 1993) and estradiol (Mann and Lamming, 2000) before ovulation. Low concentrations of progesterone and estradiol before ovulation alter endometrial progesterone and oxytocin receptor concentrations leading to the premature release of $PGF_{2\alpha}$ and the early regression of the CL. Protocols that increase progesterone before ovulation and enhance pulsatile LH secretion and follicle growth are important components of any program to successfully induce fertile estrous cycles in anestrous cows.

Induction of Estrus and Ovulation

Progestins. Administration of a progestin to anestrous cows for a short time period (5-9 days) can successfully induce estrus in many anestrous cows (Day, 2004) and is the core treatment used to induce resumption of estrous cycles in most protocols to synchronize estrus. Treatment of postpartum anestrous cows with a progestin not only induces estrus (Fike et al., 1997) but also the duration of the subsequent estrous cycle is of normal length (Ramirez-Godinez et al., 1981; Hu et al., 1990). Progestin treatment likely induces estrus by increasing LH secretion in postpartum cows (Garcia-Winder et al., 1986), seasonal dairy cows (Rhodes et al., 2002) and prepubertal heifers (Anderson et al., 1996; Hall et al., 1997; Imwalle et al., 1998). The secretion of LH increased both during progestin exposure and after removal of the progestin.

Progestin treatment has direct ovarian effects in postpartum anestrous cows. Both systemic and intrafollicular estradiol concentrations were increased by progestin exposure (Garcia-Winder et al., 1986; Inskeep et al., 1988). Progestin treatment appears to enhance follicle growth in postpartum anestrous cows (Rhodes et al., 2003).

The effectiveness of progestin treatment appears to be dependent upon the progestin used. Treatment of cows with progesterone from the EAZI-BREED CIDR® (DEC International, NZ, Ltd) device appears to be more effective (Fike et al., 1997) than the orally active synthetic progestin melengestrol acetate (MGA; Perry et al., 2004). Feeding early (day 12-42) postpartum cows MGA for 7 days did not induce estrous cycles (Perry et al., 2004). In contrast, 7 or 9 days of MGA has been shown to increase the expression of estrus and the ovulation rate in anestrous cows (Stevenson et al., 2003; Anderson, unpublished data) and prepubertal heifers (Imwalle et al., 1998). The major difference in the experiments was the timing of administration of the progestin. The synthetic progestins may be less effective at inducing estrus in anestrous cows than progesterone when administered early in the postpartum period.

GnRH. Administration of gonadotropin releasing hormone (GnRH) 7 days before treatment with $PGF_{2\alpha}$ has been shown to increase estrus and ovulation rate in anestrous cows (Stevenson et al., 2003). Induction rate appears to be highest when cows receive a combination of progestin and GnRH (Table 1; Stevenson et al., 2003). More anestrous cows ovulated after GnRH treatment if they were exposed to a progestin either before or coincident with the GnRH injection (Stevenson et al., 2003). The induction of ovulation was increased linearly with BCS in multiparous cows and primiparous cows with a BCS greater than 5. The ability to induce ovulation in anestrous primiparous cows was limited (< 20%) when BCS was less than 5.

Protocols to Induce a Fertile Estrus in Anestrous Cows

Several different protocols have been shown to effectively synchronize a fertile estrus in anestrous cows (Figure 5). Treatment of anestrous cows with a CIDR insert for 7 days and an injection of $PGF_{2\alpha}$ at CIDR removal increased the proportion of cows in estrus and increased pregnancy rate compared to anestrous cows treated with $PGF_{2\alpha}$ alone (Table 2; Lucy et al., 2001). Injection of GnRH at CIDR insertion in this protocol has been shown to increase pregnancy rates of anestrous cows compared to administration of GnRH+PGF or PGF alone (Table 2; Stevenson et al., 2003). In these experiments, cows were exposed to timed insemination (TAI) and a second GnRH injection 60 hours after CIDR removal.

Feeding MGA for 14 days before treatment of cows with GnRH+PGF increased pregnancy rates of anestrous cows compared to those treated with GnRH+PGF or PGF alone (Stevenson et al., 2003). Although this treatment (called MGA Select Synch) is an effective method to synchronize a fertile estrus in anestrous females, it is difficult to incorporate into many beef cattle operations because of the 33-day treatment period.

Another protocol that effectively synchronizes estrus in anestrous cows is called 7-11 Synch (Figure 5). In this protocol, cows are administered a progestion (either fed MGA or a CIDR is inserted) for 7 days and PGF is injected on the 7th day. Four days after PGF, cows are administered GnRH and PGF is injected 7 days later. Cows are submitted to TAI and a second GnRH is administered 60 hours after the second PGF. Treatment of anestrous cows with 7-11 Synch has been shown to result in pregnancy rates in excess of 60% (Baden et al., umpublished data (University of Missouri)).

Puberty in Heifers

Current concepts on the control of puberty in heifers have been recently reviewed (Kinder et al., 1995; Day and Anderson, 1998). To calve at 24 months of age, heifers must reach puberty and conceive by approximately 15 months of age. Several factors influence the age at puberty including breed composition, nutrition, body weight, bull exposure and the environment (Patterson et al., 1992b). Lifetime productivity of a female is affected by age at puberty. Heifers that conceive early in the first breeding season are more likely to conceive early in subsequent season and become more productive cows (Lesmeister et al., 1973).

Similar to postpartum anestrous in cows, the proportion of heifers that are pubertal at the beginning of the breeding season influences reproductive rate. The incidence of pubertal anestrous at the onset of the breeding season has been estimated. In earlier work, Patterson and coworkers (1992b) indicated that approximately 35% of heifers were prepubertal at the onset of the breeding season. In more recent studies, 88% (1,245 heifers total; Larson et al., 2004b), 83% (203 heifers total; Lamb et al., 2004), and 57% (724 heifers total; Lucy et al., 2001) were prepubertal on the first day of the breeding season.

Induction of Estrus in Prepubertal Heifers

The most effective method to induce puberty in heifers involves administration of a progestin. Several progestins have been used to induce puberty in heifers including norgestomet, MGA, and progesterone (Patterson et al., 1992a). Feeding MGA (.5 mg/hd/day) for 7 – 14 days induces estrus in peripubertal heifers (Table 3; Patterson et al., 1990; Imwalle et al., 1998; Lamb et al., 2004a). Insertion of a CIDR device for 7 days increased the proportion of anestrous heifers in estrus early in the breeding season (Table 2; Lucy et al., 2001).

Protocols to Synchronize a Fertile Estrus in Heifers

Feeding MGA for 14 days followed by administration of PGF 17-19 days later has been reliable method for synchronization of estrus in heifers for several years (Brown et al., 1988; Lamb et al., 2000). Recent trials have shown a significant advantage in pregnancy rate in peripubertal heifers fed MGA for 14 days 19 days before an injection of PGF compared to PGF treatment alone (Lamb 2004). Administration of a CIDR device for 7 days with PGF given 24 hours before CIDR removal increased the pregnancy rates to AI (Table 4; Lucy et al., 2001). Injection of GnRH at CIDR insertion does not increase pregnancy rates (Lamb et al., 2004).

Conclusions

Anestrus, whether prepubertal or postpartum, greatly influences successful reproduction in beef cow-calf operations. Protocols have been developed that effectively induce a fertile estrus in anestrous females. Incorporation of these protocols will enable beef cow-calf operations to maximize reproductive potential.

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Table 1. Induction of Estrus and(or) Ovulation in Suckled Anestrous Beef Cows After Various Treatments

Reference	Trait	Protocol [1]			
Stevenson et al., 2003	% estrus by 5 d after $PGF_{2\alpha}$	**GnRH**+PGF-7 75/206 (33%)^{X}	PGF 25/172 (14%)^{y}		
Stevenson et al., 2003	% ovulated by 7 d after GnRH	**GnRH**+CIDR-7+PGF-7 148/187 (79%)^{X}	**MGA**-14 + GnRH + PGF-7 19/24 (79%)^{X}	GnRH +PGF-7 236/530 (45%)^{Y}	PGF 51/216 (24%)^{z}
Perry et al., 2004	% in estrus by 2 d after insert removal or MGA % in estrus by 14 d after insert removal or MGA	**CIDR**-6 10/22 (45%)^{X} 13/22 (59%)	**MGA**-7 6/17 (36%)^{xy} 9/17 (53%)	MGA[2]-7 0/20 (0%)^{Y} 4/20 (20%)	Nothing 2/22 (9%)^{y} 9/22 (41%)
Fike et al., 1997	% ovulated with a CL of normal duration	**CIDR**-7 51/92 (55%)^{X}	Nothing 15/91 (16%)^{z}		
Mackey et al., 2000	% ovulated with a CL of normal duration	**CIDR**-7 + 1 × daily suckling 9/13 (69%)^{X}	Nothing 0/13 (0%)^{z}		
Lucy et al., 2001	% in estrus by 3 d after PGF_2 % in estrus by 31 d after PGF_2	CIDR-7 + PGF-6 64/142 (45%)^{X} 94/142 (66%)	PGF 30/154 (20%)^{y} 105/154 (68%)	Nothing 16/151 (11%)^{z} 101/151 (67%)	
Lamb et al., 2001	% ovulated by 7 d after GnRH	GnRH + CIDR-7 + PGF-7 32/61 (52%)^{X}	GnRH +PGF-7 30/56 (54%)^{X}		

[1]Melengestrol acetate (MGA) was fed (0.5 mg per cow per day) for 7 d (MGA-7). The CIDR (progesterone-releasing controlled internal drug releasing insert) was placed intravaginally for 6 (CIDR-6) or 7 d (CIDR-7). Where $PGF_{2\alpha}$ was administered, it was injected 6 (PGF-6) or 7 d (PGF-7) later after CIDR insertion. Where GnRH was administered, it was injected at CIDR insertion or 7 d before $PGF_{2\alpha}$.

[2]MGA was fed at 4.0 mg per cow per day.

[x,y,z]Mean percentages having different superscript letters differ ($P<0.05$).

Table 2. Induction of Pregnancy in Suckled Anestrous Beef Cows after Various Treatments.

Reference	Trait	Protocol[1]			
Geary et al., 2001	% pregnant (TAI)	GnRH + PGF-7 + calf removal + GnRH at or 24 before TAI-48 h 77/132 (58%)^{X}		GnRH + PGF-7 + GnRH at or 24 h before TAI -48 h 70/145 (48%)^{X}	
Lucy et al., 2001	% pregnant by 3 d after PGF_2 % pregnant by 31 d after PGF_2	CIDR-7 + PGF-6 36/141 (26%)^{X} 64/140 (46%)	PGF 17/154 (11%)^{Y} 72/152 (47%)	Nothing 6/151 (4%) 63/149 (42%)	
Stevenson et al., 2003	% pregnant (estrus or TAI)	GnRH + CIDR-7 + PGF-7 + GnRH at TAI-48 h 377/749 (50%)^{X}	MGA-14 + GnRH + PGF-7 + GnRH at TAI-48 h 167/315 (53%)^{X}	GnRH + PGF-7 + GnRH at TAI-48 h 210/520 (40%)^{Y}	PGF + GnRH at TAI-48 h 13/71 (18%)^{z}
Larson et al., 2004b	% pregnant (estrus + cleanup TAI)	GnRH + CIDR-7 + PGF-7 + TAI-60 h or estrus AI + GnRH at cleanup TAI-84 h 349/600 (58%)^{X}	CIDR-7 + PGF-7 + estrus AI + estrus AI + GnRH at cleanup TAI-84 h 159/296 (50%)^{X}	GnRH + PGF-7 + GnRH at TAI-60 or estrus AI + GnRH at cleanup TAI-84 h 327/638 (51%)^{X}	
Bader et al., unpublished	% pregnant after TAI	MGA-14 + GnRH + PGF-7 + GnRH at TAI-72 h (MGA Select) 104/159 (65%)		MGA-7 + PGF-7 + GnRH-4 + PGF-7 + GnRH at TAI-60 h (7-11 Synch) 87/150 (58%)	

[1]Melengestrol acetate (MGA) was fed (0.5 mg per heifer per day) for 7 d (MGA-7). The CIDR (progesterone-releasing controlled internal drug releasing insert) was placed intravaginally for 7 d (CIDR-7). Where $PGF_{2\alpha}$ was administered, it was injected 6 (PGF-6) or 7 d (PGF-7) later after CIDR insertion. Where GnRH was administered, it was injected at CIDR insertion or 7 d before $PGF_{2\alpha}$.

^{x,y,z}Mean percentages having different superscript letters differ (P<0.05).

Table 3. Induction of Estrus or Ovulation in Peripubertal Heifers after Various Treatments.

Reference	Trait	Protocol [1]	
Patterson et al., 1990	% in estrus by 14 d after MGA	**MGA**-7 + **GnRH (**48 h after MGA) 19/30 (63%) [x]	**MGA**-7 + saline (48h after MGA) 26/30 (87%)
Imwalle et al., 1998	% ovulated by 17 d after MGA	**MGA-**8 8/8 (100 %) [x]	Carrier only 4/9 (45%)
Lamb et al., 2004	% ovulated by 12 d after MGA	**MGA-**14 14/31 (45%) [x]	Carrier 6/41 (15)%
Lucy et al., 2001	% in estrus by 3 d after PGF_2 % in estrus by 31 d after PGF_2	**CIDR**-7 + PGF-6 50/105 (48%) [x] 75/105 (71%) [x]	PGF 11/101 (11%) 45/101 (45%)
Larson et al., 2004a	% in estrus by 3 d after PGF_2	**GnRH** + **CIDR**-7 + PGF-7 41/54 (76%)	**CIDR**-7+PGF-7 25/36 (69%)

[1]Melengestrol acetate (MGA) was fed (0.5 mg per heifer per day) for 7 (MGA-7), 8 (MGA-8), or 14 days (MGA-14). The CIDR (progesterone-releasing controlled internal drug releasing insert) was placed intravaginally for 7 d (CIDR-7) with $PGF_{2\alpha}$ administered 6 days later (PGF-6). Where GnRH was administered, it was injected at CIDR insertion or 6 days before $PGF_{2\alpha}$ (GnRH+PGF-6).

[x]Different ($P<0.05$) from control.

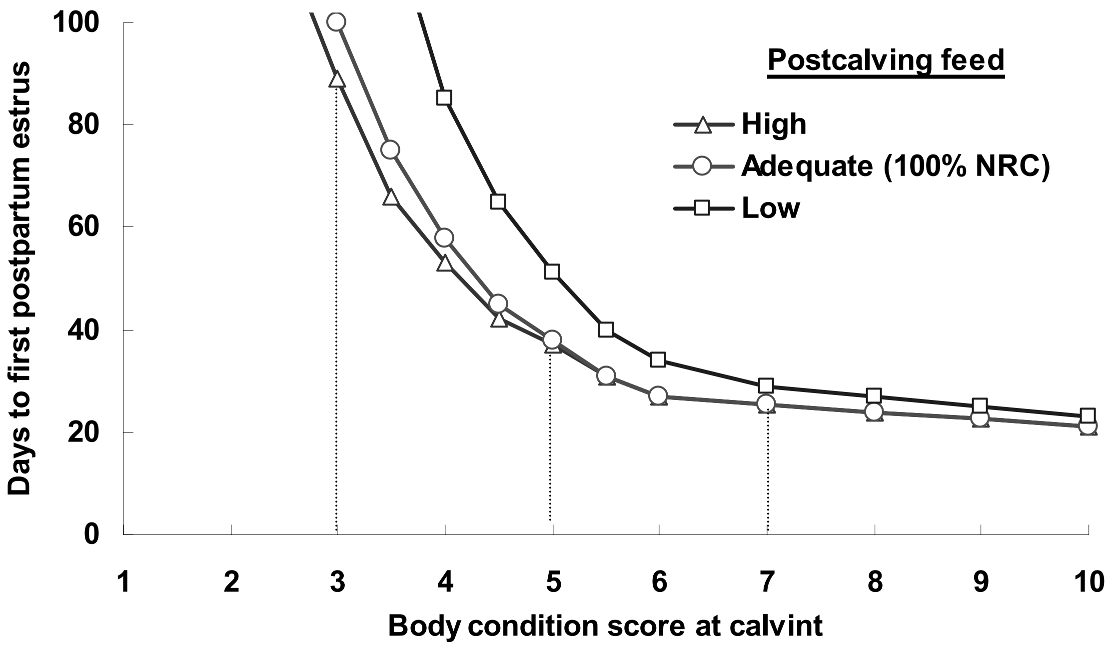
Table 4. Induction of Pregnancy in Peripubertal Heifers after Various Treatments.

Reference	Trait	Protocol [1]	
Lucy et al., 2001	% pregnant by 3 d after PGF_2	**CIDR**-7 + PGF-6 50/105 (48%) [X]	PGF 11/101 (11%)
	% pregnant by 31 d after PGF_2	75/105 (71%) [X]	45/101 (45%)
Lamb et al., 2004	% pregnant (estrus checked for 5 d)	**MGA-**14+PGF-19 14/27 (52 %)	PGF 4/17 (24%)
Larson et al., 2004a	%$ pregnant by 3 d after PGF_2 (estrus or TAI)	**GnRH** + **CIDR-7** + PGF-7 + TAI-60 h or estrus AI + GnRH at cleanup TAI-84 h 32/54 (59%)	CIDR-7 + TAI-60 h or estrus AI + GnRH at cleanup TAI-84 h 19/36 (53%)

[1]Melengestrol acetate (MGA) was fed (0.5 mg per heifer per day) for 14 days (MGA-14) followed in 10 days by $PGF_{2\alpha}$ (PGF-19). The CIDR (progesterone-releasing controlled internal drug releasing insert) was placed intravaginally for 7 days (CIDR-7) with $PGF_{2\alpha}$ administered 6 days later (PGF-6). Where GnRH was administered, it was injected at CIDR insertion or 6 days before $PGF_{2\alpha}$ (GnRH+PGF-6).

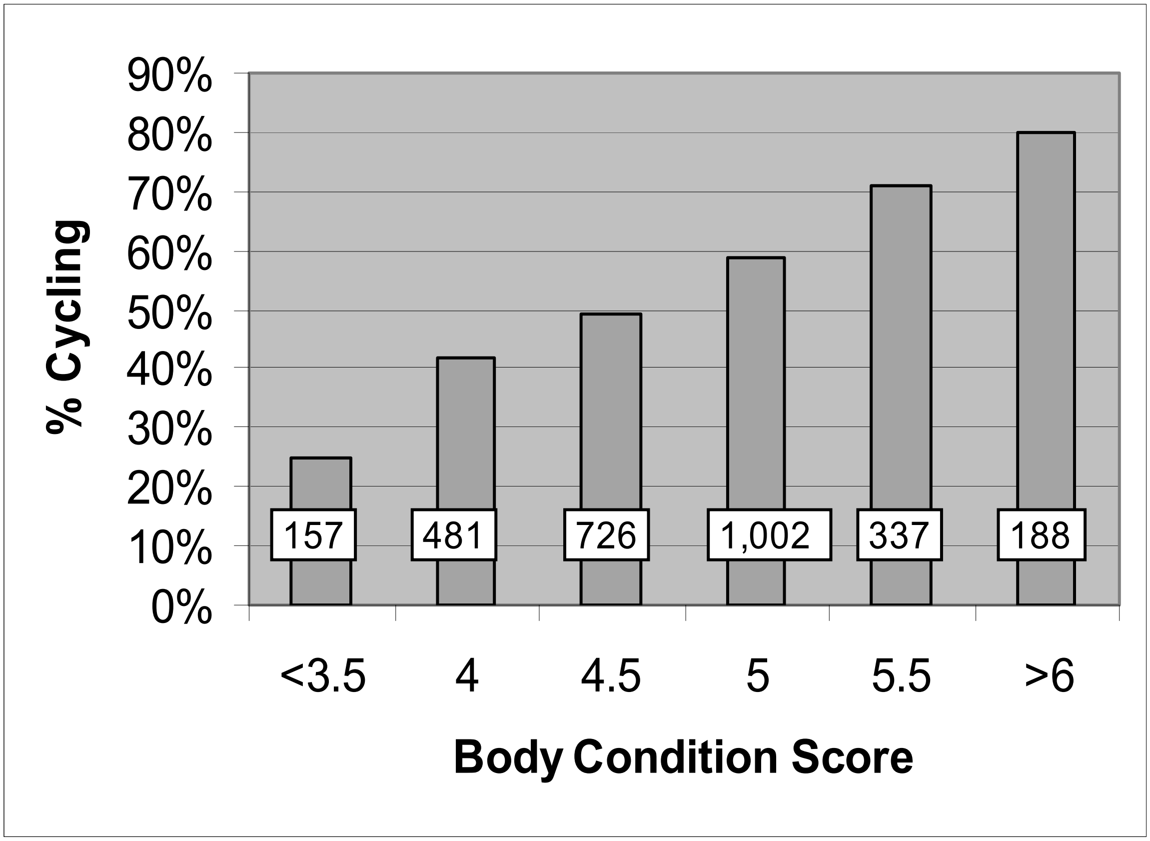
[X]Different ($P<0.05$) from control.

Figure 1. Days to first postpartum estrus on the basis of body condition scores assessed at parturition and postcalving feeding regimen. Those cows with a body condition score 5 or greater are less likely to respond to improved postcalving nutrition but thinner cows may benefit from increased nutritional regimens postcalving.



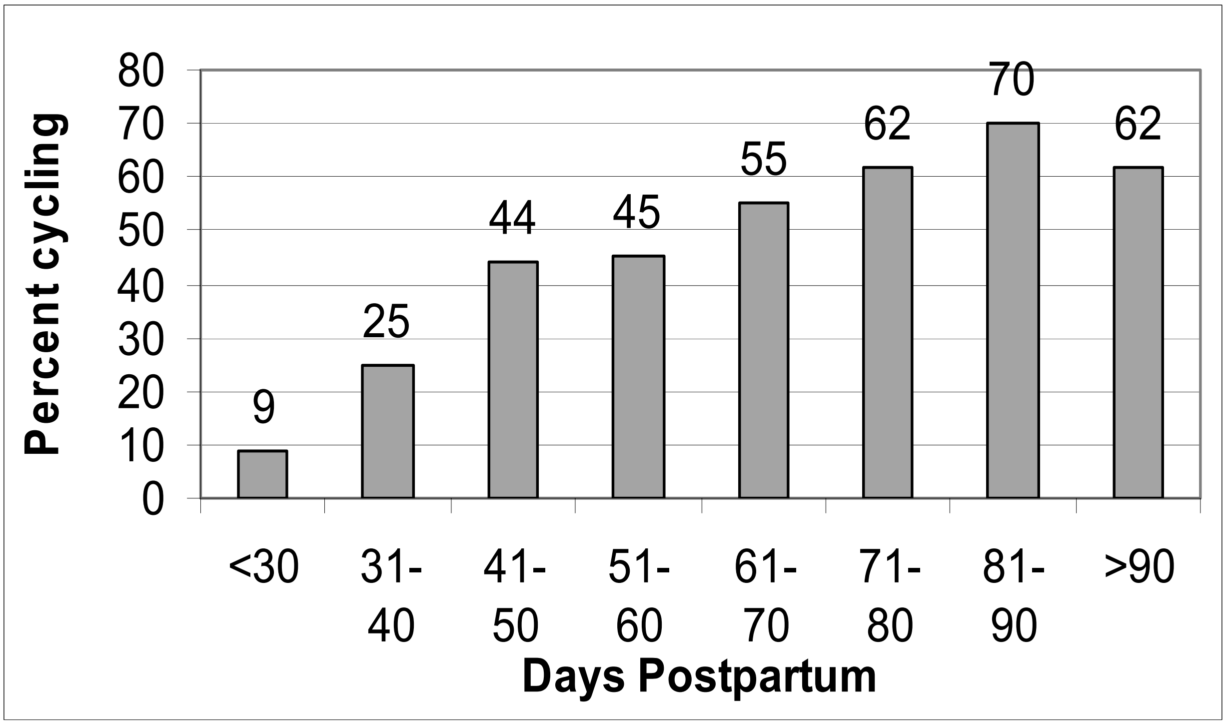
Source: Short et al. (1988)

Figure 2. Proportion of suckled cows that were cycling on the first day of the breeding season on the basis of body condition score assessed at that time. Cycling status was estimated by concentrations of progesterone in blood serum of cows sampled during 7-10 days before the breeding week.



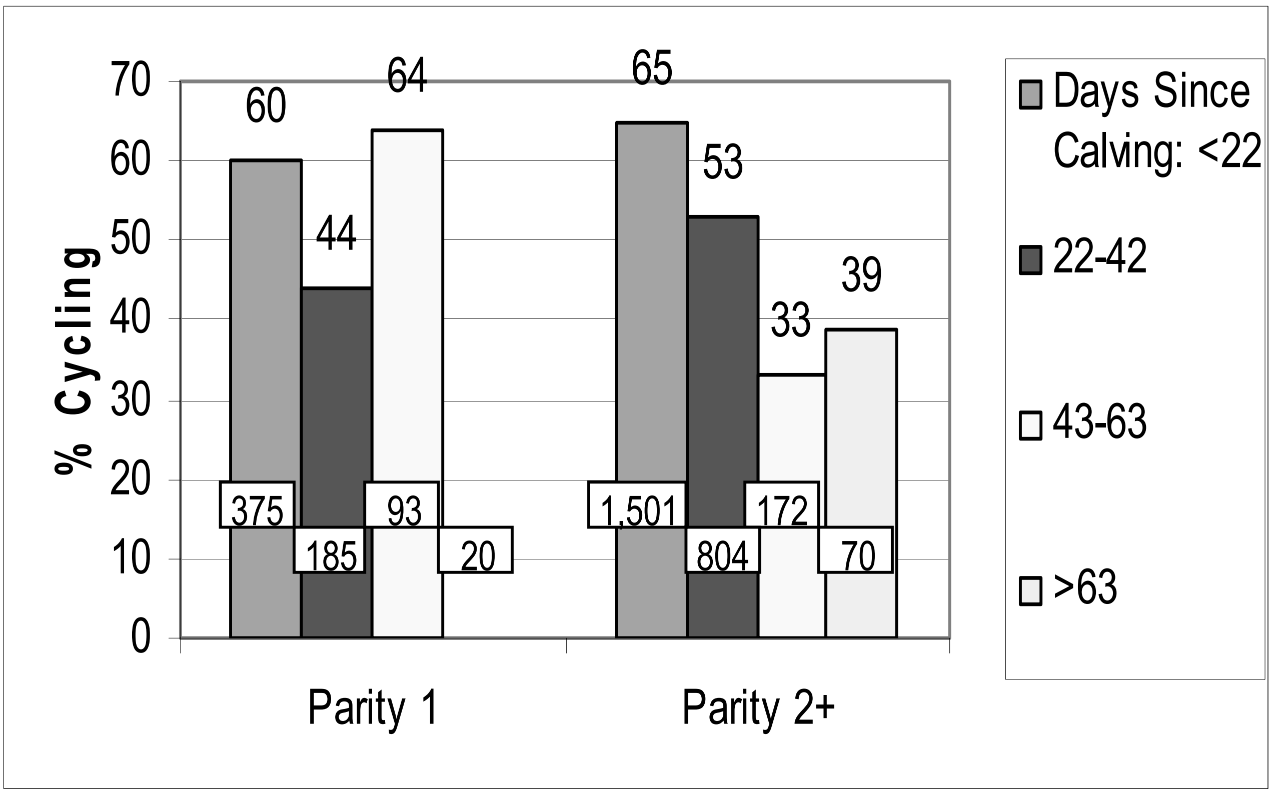
Source: Stevenson et al. (2003)

Figure 3. Proportion of suckled cows that were cycling on the first day of the breeding season on the basis of days since calving. Cycling status was estimated by concentrations of progesterone in blood serum of cows sampled during 7 to 10 days before the breeding week.



Source: Stevenson et al. (2003)

Figure 4. Proportion of primiparous (parity 1) and multiparous (parity 2+) suckled cows that were cycling on the first day of the breeding season on the basis of when they calved during the first (< 22 days), second (22-42 days), or third or more (> 63 days) 3-week period of the calving season. Cycling status was estimated by concentrations of progesterone in blood serum of cows sampled during 7 to 10 days before the breeding week.



Source: Stevenson et al. (2003)

Figure 6. Protocols likely to produce the best pregnancy rates in peripubertal heifers and suckled anestrous beef cows after timed AI.