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INCIDENCE OF POSTPARTUM ANESTRUS IN SUCKLED BEEF CATTLE: TREATMENTS TO INDUCE ESTRUS, OVULATION AND CONCEPTION

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Abstract

Early herd conception is limited by the proportion of cows that have resumed normal estrous cycles (cycling) before the beginning of the breeding season. Only 54% of 3,269 beef cows studied were cycling before onset of the breeding season. Parity, days postpartum, and body condition score (BCS) influenced the proportion of cows cycling as assessed by concentrations of blood progesterone. Compared to multiparous cows, fewer (*P*<0.01) primiparous cows were cycling, despite calving up to 3 wk earlier. Cycling activity increased linearly (*P*<0.001) from 9% (<30 d) to a peak of 70% 81 to 90 d postpartum. For every 10-d interval from <30 to >90 d, cycling activity increased (*P*<0.05) by 7.5 " 0.7%. As BCS increased from #3.5 to $6.0 (1 = thin and 9 = fat), the percentage of cows cycling increased linearly (*P*<0.001) by 18 " 2% for each unit increase in BCS. Ovulation was induced most successfully in noncycling cows after injection of GnRH or GnRH plus a progestin (7-d CIDR or 14-d feeding of melengestrol acetate [MGA] ending 12 d before GnRH). Ovulation induction was limited in primiparous cows until BCS were $5.0. In older cows, induction of ovulation increased linearly (*P*<0.05) with increasing BCS. As BCS increased from #3.5 to $6.0, expressed estrus increased (*P*<0.05), with more cycling than noncycling cows expressing estrus during the first week of the breeding season. Expression of estrus in cycling and noncycling cows was greatest after treatment with norgestomet for 7 d and GnRH and $PGF_{2\alpha}$ when the implant was inserted and removed, respectively. Conception rates after timed AI (TAI) were greater for cows treated with the CIDR or norgestomet for 7 d if they were inserted or implanted just prior to GnRH injection and received $PGF_{2\alpha}$ 7 d later at removal, with TAI occurring between 48 and 60 h later. Based on detected estrus, treatments with $PGF_{2\alpha}$ were superior in primiparous cows, with no superior treatment identified for multiparous cows. Of the systems studied, anestrous suckled cows responded best to treatments that included GnRH plus a short-term progestin to maximize ovulation induction before $PGF_{2\alpha}$, and expression of estrus and conception after $PGF_{2\alpha}$.

(Key Words: Suckled Cows, Body Condition, Progestin, Postpartum, Anestrus, Ovulation.)

Introduction

The factor that most limits early conception of suckled cows is the proportion of cows that are not cycling (anestrus) at the beginning of the breeding season (Short et al., 1990). Other factors influencing the incidence of anestrus were reviewed (Stevenson et al., 1997). Continual presence of a suckling calf prolongs anestrus and delays the reinitiation of estrous cycles (Williams, 1990). Insufficient energy and protein intake and insufficient body condition at calving are also limiting factors, but temporary or permanent weaning of the calf usually initiates estrus within a few days (Williams, 1990). Primiparous cows generally have a more prolonged anestrus because of their additional growth requirement (Short and Adams, 1988; Randel, 1990; Short et al., 1990).

Nutrients are used by cows according to an established priority (Short and Adams, 1988). The first priority is maintenance of essential body functions to preserve life. Once that maintenance requirement is met, remaining nutrients accommodate growth. Finally, lactation and the initiation of estrous cycles are supported. Older cows have no growth requirement, thus nutrients are more likely to be available for milk synthesis and initiation of estrous cycles. Because of this priority system, young, growing cows generally produce less milk and are anestrus longer after calving.

Since 1994, we have treated more than 3,269 beef cows with various hormonal treatments to synchronize estrus, ovulation, or both, in an attempt to achieve conception early in the breeding season and maximize the proportion of cows pregnant to genetically superior AI sires (Stevenson et al., 1997a,b; Thompson et al., 1999; Stevenson et al., 2000). As part of these studies, we measured the incidence of cyclicity at the beginning of the breeding season, both prior to hormonal injections and in response to these treatments. The major risk factors that limit a high rate of cyclicity at the beginning of the breeding season include age of cow, body condition, and days postpartum (Short et al., 1990).

The objectives of this report were to quantify the effects of body condition, parity, and days postpartum of suckled beef cows on the initiation of estrous cycles and to determine their influence on the proportion of cows cycling before and in response to hormonal treatments, as well as their effect on resulting fertility of such treatments.

Materials and Methods

Seven studies were conducted during spring 1994-2001 breeding seasons at five private ranches in Kansas and Minnesota, at the Kansas State University Purebred Beef Unit, and Agricultural Research Center–Hays.

Study 1 (1994-1995)

Purebred suckled cows (Simmental, Angus, and Hereford) at Kansas State University were used (n = 279). Controls received two injections of $PGF_{2\alpha}$ (2HPGF; 5 mL of Lutalyse; Pharmacia Animal Health, Kalamazoo, MI) on d ! 14 and 0, and were inseminated at estrus, or in the absence of estrus, at 80 h after the second injection of $PGF_{2\alpha}$. Treated cows received 25 mg of $PGF_{2\alpha}$ on d ! 14 and 0 plus 100 µg of GnRH (GnRH; 2 mL of Cystorelin, Merial Limited, Iselin, NJ) on d ! 7 and had a norgestomet ear implant (NORG, Syncro-Mate-B; Merial Limited, Iselin, NJ) in place for 8 d beginning on d ! 7. Treated cows were inseminated at 72 h after $PGF_{2\alpha}$ or 18 h after a second injection of GnRH given at 54 h after $PGF_{2\alpha}$.

Study 2 (1996)

Purebred suckled Angus, Gelbvieh, and Hereford cows and crossbred suckled cows (Simmental, Angus, and Hereford) on three private ranches were used (n = 890). Treatments are illustrated in Figure 1. Control cows received two injections of $PGF_{2\alpha}$ (5 mL of Lutalyse; Pharmacia Animal Health, Kalamazoo, MI) on d ! 14 and 0 (2HPGF). A second group of cows received GnRH on d ! 7 and $PGF_{2\alpha}$ on d 0 (GnRH; 2 mL of Cystorelin, Merial Limited, Iselin, NJ or 2 mL of Factrel, Fort Dodge Laboratories, Fort Dodge, IA). A third group was treated as the previous group plus an ear implant containing 6 mg of norgestomet (Syncro-Mate-B; Merial Limited, Iselin, NJ) for 7 d beginning on d ! 7 (NORG). Cows were inseminated after detected estrus. In addition, 164 purebred suckled cows received the NORG treatment at the Kansas State University Purebred Beef Unit. Cows were either inseminated after detected estrus (one-half) or at 48 h after $PGF_{2\alpha}$ and given 100 µg of GnRH at the time of AI.

Study 3 (1997)

Crossbred suckled cows (Simmental, Angus, and Hereford crosses) on two private ranches, plus purebred Simmental, Angus, and Hereford suckled cows at Kansas State University were used (n = 406). Treatments are illustrated in Figure 1. Cows were treated with 100 µg of GnRH (Cystorelin, Merial Limited, Iselin, NJ) on d ! 7 and $PGF_{2\alpha}$ (5 mL of Lutalyse; Pharmacia Animal Health, Kalamazoo, MI) on d 0 (GnRH) . They were inseminated after detected estrus, or in the absence of estrus, at 54 h after $PGF_{2\alpha}$ and given 100 µg of GnRH at the time of AI.

Study 4 (1998)

Purebred Angus, Simmental, and Hereford cows at Kansas State University were used (n = 187). Treatments are illustrated in Figure 1. All cows received 100 µg of GnRH (2 mL of Cystorelin, Merial Limited, Iselin, NJ) on d ! 7 and 25 mg of $PGF_{2\alpha}$ (5 mL of Lutalyse; Pharmacia Animal Health, Kalamazoo, MI) on d 0 (GnRH). Half of the cows also received an intravaginal progesterone-releasing insert (CIDR-B, InterAg, Hamilton, NZ) on d ! 7, which was removed on d 0 (CIDR). All cows were inseminated at 48 h after $PGF_{2\alpha}$ and given 100 µg of GnRH at the time of AI.

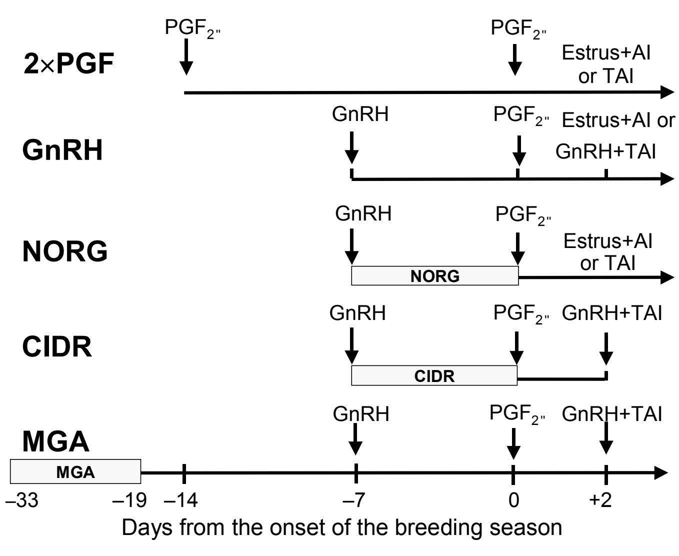

Figure 1. Experimental protocols used in the studies 2 through 7.

Study 5 (1999)

Purebred Angus, Simmental, and Hereford cows at Kansas State University were used (n = 187). Treatments are illustrated in Figure 1. All cows received 100 µg of GnRH (2 mL of Cystorelin, Merial Limited, Iselin, NJ) on d ! 7 and 25 mg of $PGF_{2\alpha}$ (5 mL of Lutalyse; Pharmacia Animal Health, Kalamazoo, MI) on d 0 (GnRH). Half also received an ear implant containing 6 mg of norgestomet (Syncro-Mate-B; Merial Limited, Iselin, NJ) on d ! 7 (NORG). It was removed on d 0. All cows were inseminated 48 h after $PGF_{2\alpha}$ and given 100 µg of GnRH at the time of AI.

Study 6 (2000)

Purebred suckled Angus, Charolais, and South Devon on one private ranch in Minnesota, purebred Angus cows at the North Central Research and Outreach Center, University of Minnesota, Grand Rapids, purebred Angus, Simmental, and Hereford cows at Kansas State University, and crossbred suckled cows (Simmental, Angus, and Hereford) on a private ranch in north central Kansas were used (n = 609). Treatments are illustrated in Figure 1. All cows received 100 µg of GnRH (2 mL of Cystorelin, Merial Limited, Iselin, NJ) of d ! 7 and 25 mg of $PGF_{2\alpha}$ (5 mL of Lutalyse; Pharmacia Animal Health, Kalamazoo, MI) on d 0 (GnRH). Half of the cows also received an intravaginal progesterone insert (CIDR-B, InterAg, Hamilton, NZ) on d ! 7, which was removed on d 0 (CIDR), whereas the other half were fed 0.5 mg of melengestrol acetate (MGA; Pharmacia Animal Health, Kalamazoo, MI) for 14 d, ending 12 d before the first GnRH injection. All were inseminated at 48 h after $PGF_{2\alpha}$ and given 100 µg of GnRH at the time of AI.

Study 7 (2001)

Purebred Angus, Simmental, and Hereford cows at Kansas State University, and crossbred cows (Angus crossed primarily with Hereford, Simmental, and South Devon) at the Agricultural Research Center–Hays of Kansas State University were used (n = 359). Treatments are illustrated in Figure 1. All cows received 100 µg of GnRH (2 mL of Cystorelin, Merial Limited, Iselin, NJ) of d ! 7 and 25 mg of $PGF_{2\alpha}$ (5 mL of Lutalyse; Pharmacia Animal Health, Kalamazoo, MI) on d 0. In addition, all cows received an intravaginal progesterone-releasing insert (CIDR-B, InterAg, Hamilton, NZ) on d ! 7, which was removed on d 0 (CIDR). All were inseminated either at 48 or 60 h after $PGF_{2\alpha}$ and one-half of the cows within each timed insemination group received 100 µg of GnRH at the time of AI.

Definitions

Blood samples were collected prior to hormonal injections to determine if cows had a functional corpus luteum. At least two blood samples were collected between 7 and 11 d before each hormone injection. Progesterone was measured by radioimmunoassay (Skaggs et al., 1986). If either or both samples of blood serum contained concentrations of progesterone $1 ng/mL, then the cows were assumed to have ovulated and resumed estrous cycles (cycling). If neither sample contained elevated concentrations of progesterone, then the cow was assumed to be anestrous (anestrus). Any cow classified as anestrus on d ! 7 that subsequently had elevated concentrations of progesterone on d 0 was assumed to have ovulated in response to GnRH administered on d ! 7 (induced ovulation). Body condition scores (BCS; 1 = thin, 9 = fat; Whitman, 1975) were assigned to cows on the first day of the breeding season and days postpartum were calculated for each cow on the first day of the breeding season.

The onset of the calving season was defined to be when the third mature cow (Standardized Performance Analysis definition) or heifer calved and deviations of calving dates from that date for all other cows were calculated to create four calving periods of #21, 22 to 42, 43 to 63, and >63 d.

Statistical Analyses

Data were subjected to analyses of variance in which herd-year was used as the testing variance for effects of cyclicity, induced ovulation, incidence of estrus, and conception rate. Parity (primiparous vs. multiparous), treatments (PGF, GnRH, NORG, CIDR, or MGA), insemination timing (TAI or after detected estrus) or BCS and days postpartum (DPP) were independent variables included in models. Procedures GLM and MIXED (SAS, 1998) were used to generate regressions, variances, and estimate contrasts were constructed to test hypotheses of interest about the treatments using the within herd-year variance. Herd-year was declared to be random in each model.

The model used to estimate cycling status included year, herd within year, parity, parity within herd-year, DPP, BCS, DPP H BCS, DPP H parity within herd-year, BCS H parity within herd-year, and DPP H BCS H parity within herd-year.

The model used to estimate the incidence of induced ovulation in cows that were classified as anestrus before the onset of treatments included treatment H parity within herd-year, DPP, BCS, DPPHBCS, DPP H treatment within herd-year, DPP H parity within herd-year, BCS H treatment within herd-year, BCS H parity within herd-year, DPP H treatment H parity within herd-year, BCS H treatment H parity within herd-year, and DPP H BCS H treatment H parity within herd-year.

The model used to estimate the incidence of expressed estrus during 48 to 120 h after $PGF_{2\alpha}$ in those studies in which estrus was detected (Studies 1, 2, and 3) and conception rates in all studies included year, herd within year, treatment within herd-year, parity within herd-year, treatment H parity within herd-year, cycling status on d 0 (C), DPP, BCS, C H DPP, C HBCS, DPP H BCS, C HBCS H DPP, C H treatment within herd-year, C H parity within herd-year, C H treatment H parity within herd-year, DPP H treatment within herd-year, BCS H treatment within herd-year, DPP H parity within herd-year, BCS H parity within herd-year, DPP H treatment H parity within herd-year, BCS H treatment H parity within herd-year, and DPP H BCS H treatment H parity within herd-year. In addition, to when testing conception rates, occurrence of TAI or insemination after detected estrus was included in that model plus all possible interactions with the independent variables cited above.

Results and Discussion

Cyclicity

Similar percentages of heifers and cows calved during each 21-d interval after the onset of the calving season (Figure 2). In both parity groups, over 55% of the females calved during the first 21 d of the calving season, whereas <4% calved after 63 d. In all but one herd early breeding and calving of replacement heifers was carried out before that of the cow herd (22.9 " 1.7 d; range: 12 to 36 d).

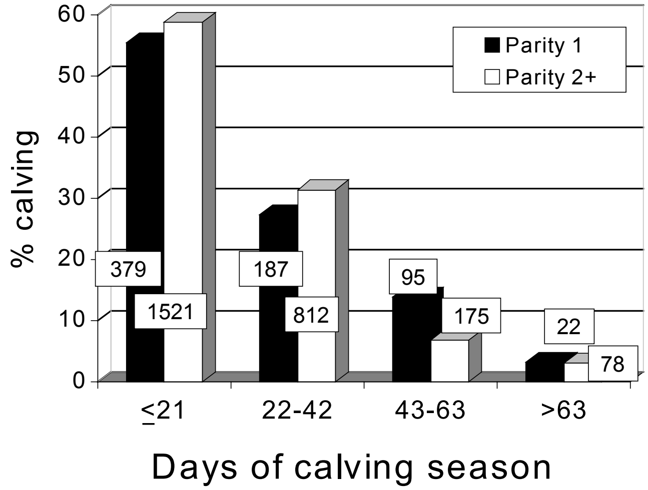

Figure 2. Within herd calving distribution for 3,269 suckled beef cows. Values in boxes are numbers of cows per category. Subsequent figure legends may display varying numbers of cows in boxes because of missing observa-tions in each category.

Despite the earlier calving of heifers in all but one herd, the percentage of primiparous cows (55%) that were cycling before the onset of the breeding season was less ($P<0.001$) than that of the older cows (64%; Figure 3). The extra nutrient demand for growth clearly limits the proportion of primiparous cows that are cycling at the beginning of the breeding season (Short and Adams, 1988).

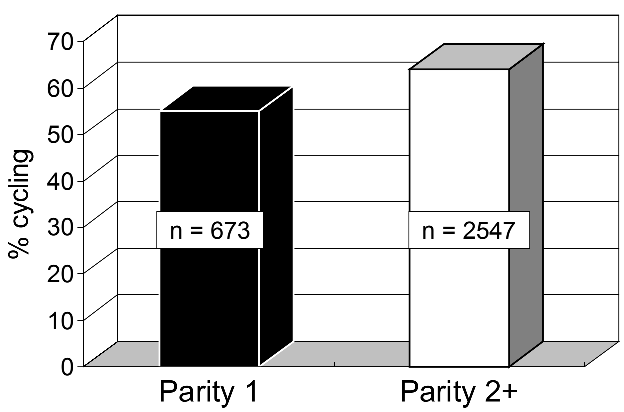

Figure 3. Percentage of cows that had resumed estrous cycles (based on at least two estimates of con-centrations of progesterone in blood collected 7 to 11 d before treatments) before initiation of treatments regressed on parity. Values in boxes are numbers of cows per category.

The percentage of cows cycling increased in a curvilinear fashion ($P<.001$) in all parities across days postpartum, reaching a peak at 81 to 90 d and tending to decrease thereafter (Figure 4). Average days postpartum were 86 " 0.7 for primiparous and 68 " 0.3 for multiparous cows. The decrease in percentage cycling for those >90 d postpartum may be partly a reflection of reduced cyclicity in primiparous cows, which comprised 85% of the cows this interval. For every 10-d interval since calving (from #30 to >90 d), the percentage of cows cycling increased ($P<0.01$) by 7.5 " 0.7%.

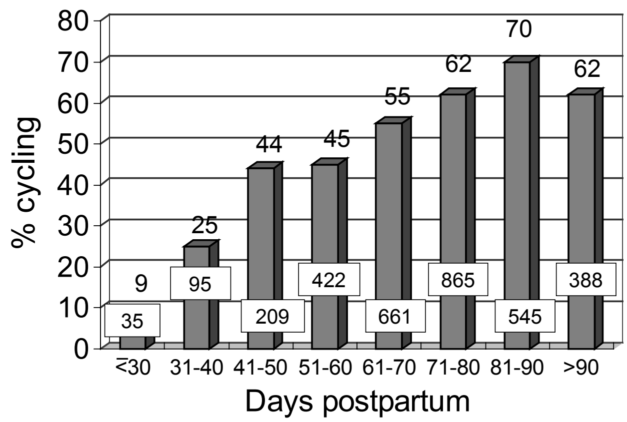

Figure 4. Percentage of cows that had resumed estrous cycles before initiation of treatments regressed on days post-partum at the beginning of the breeding season. Values in boxes are numbers of cows per category.

Similar to days postpartum, the percentage of cows cycling increased linearly (*P*<0.001) with increasing BCS (Figure 5) indicating that cows in lesser body condition were at risk for not cycling at the onset of the breeding season. An effect of parity was detected (P =0.06) as observed in Figure 3, but no interactions were detected between parity and BCS or parity and days postpartum. For every unit increase in BCS (range of 1 to 7), percentage of cows cycling increased (*P*<0.01) by 18 " 2%. Beef cows should calve with a body condition score of at least 5 to prevent prolonged anestrus after calving (Short et al., 1990). Cows may gain or lose body condition between calving and the beginning of the breeding season, depending on postpartum nutritional conditions, early grass growth, and supplementation. Clearly, body condition scores are predictive of cycling activity.

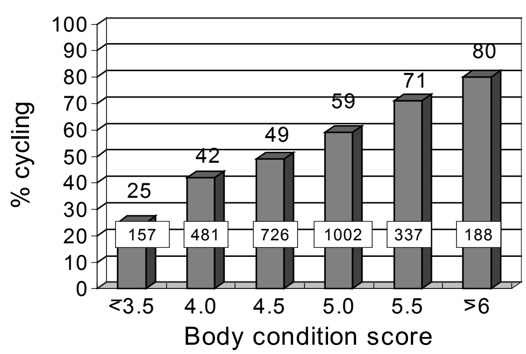

Figure 5. Percentage of cows that had resumed estrous cycles before initiation of treatments regressed on body condition scores (1 = thin and 9 = fat) assessed on the first day of the breeding season. Values in boxes are numbers of cows per category.

Percentage of primiparous and multiparous cows cycling based on their within herd-year calving distribution is illustrated in Figure 6. For primiparous cows, the cycling status at the onset of treatments (7 d before the breeding season began) was not different among the first three 21-d intervals but greater (*P*<0.05) than those very late-calving cows (>63 days into the calving season). This supports the general recommendation to use a shorter breeding season for heifers to avoid problems getting late-calving heifers rebred. In contrast, cycling rates were greater (*P*<0.05) for older cows that calved during the first 42 d of the calving season compared to those that calved after d 42. Thus, although early calving is critical because it allows more time for cows to resume estrous cycles before the breeding season, it seems to be more critical in older cows partially because they typically have 2 to 3 fewer weeks to resume estrous cycles before the breeding season than the primiparous cows.

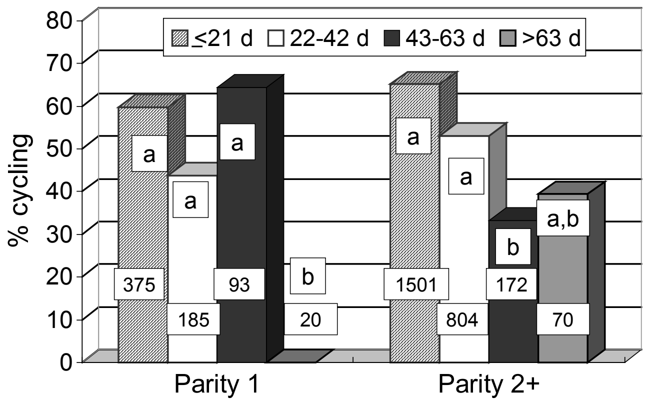

Figure 6. Percentage of cows that had resumed estrous cycles before initiation of treatments based on when parturition occurred during the calving season for primiparous and mulitparous cows. Values in boxes are numbers of cows per category. Percentages within parity without a common letter differ (P≤0.05).

Induction of Ovulation

Ability to induce ovulation in anestrous cows is key to the success of some of the most recently developed estrus- and ovulation-synchronization protocols in cattle (Stevenson et al., 2000). Based on the combined results of our seven studies, inducing ovulation was greatest in cows, regardless of parity, that received a combination of a progestin plus GnRH injection (Figure 7). A greater (*P*<0.05) percentage of cows treated with GnRH (plus $PGF_{2\alpha}$ 7 d later) and previously fed MGA for 14 d (Figure 1) or treated with a CIDR insert concurrent with the GnRH (plus $PGF_{2\alpha}$ 7 d later) were induced to ovulate in response to GnRH than the remaining treatments that included concurrent administration of another progestin (norgestomet), received either the treatments designated as GnRH or 2HPGF alone. The percentage response in the 2HPGF treatment reflects spontaneous ovulation because $PGF_{2\alpha}$ is incapable of inducing estrus in the absence of a corpus luteum.

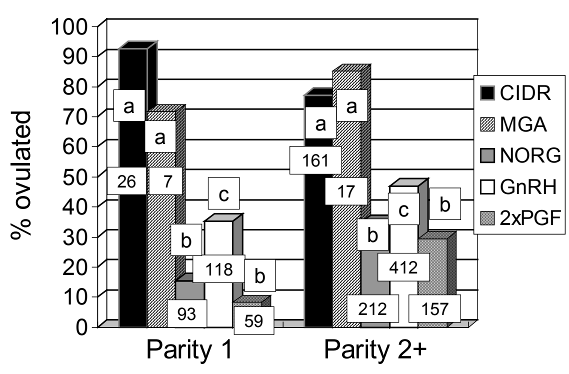

Figure 7. Percentage of anestrous cows that were induced to ovulate 7 d after GnRH for primiparous and multiparous cows. Abbreviations in legend refer to treatment protocols illustrated in Figure 1. Values in boxes are numbers of cows per category. Percentages within parity without a common letter differ (P≤0.05).

The response to GnRH-induced ovulation was limited to less than 20% in primiparous cows until BCS were $5 at the onset of the breeding season and then as BCS increased, induction of ovulation increased in a parallel fashion (Figure 8). In contrast, induction of ovulation increased linearly in older cows as BCS increased. Because of the growth requirement of primiparous cows, and despite being further postpartum than older cows, induction of ovulation is limited until a minimal body condition is achieved.

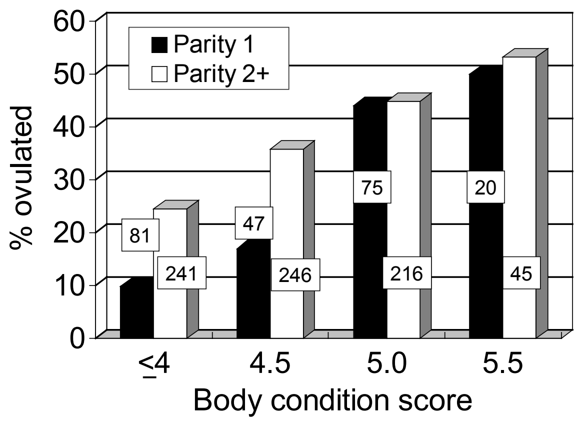

Figure 8. Percentage of anestrous cows that were induced to ovulate 7 d after GnRH according to body condition scores (1 = thin and 0 = fat) assessed on the first day of the breeding season. Values in boxes are numbers of cows per category.

Injections of GnRH induce release of both LH and FSH from the anterior pituitary gland resulting in ovulation if a mature ovarian follicle(s) is present. Injections of GnRH initiated turnover of large follicles (>10 mm) or induced ovulation of the dominant follicle (Crowe et al., 1993; Twagiramungu et al, 1995; Thompson et al., 1999). Recent studies, using transrectal ultrasonography or daily-collected blood samples to monitor concentrations of progesterone, showed that a single GnRH injection was quite effective (>80%) in inducing ovulation and formation of the first corpus luteum in late-calving (34 " 6 days postpartum), suckled anestrous cows (Thompson et al., 1999). Fewer anestrous cows ovulated in the presence of a progestin treatment, as observed with concurrent norgestomet implants at the time of GnRH injection in our study or short-term feeding of MGA concurrent with GnRH injection (D.J. Patterson, personal communication).

Estrus Expression

A greater (P<.001) proportion of cycling cows than anestrous cows (70 vs. 40%) showed behavioral estrus early in the breeding season. Included in these results are those cows that were induced to cycle after the initial GnRH injection and had elevated progesterone at the time of $PGF_{2\alpha}$ (d 0). Although the NORG treatment was less effective in inducing ovulation in anestrous cows than use of MGA or the CIDR insert, its inclusion increased (P<0.05) the proportion of cycling cows showing estrus compared to the GnRH + PGF or 2HPGF treatments alone (Figure 9).

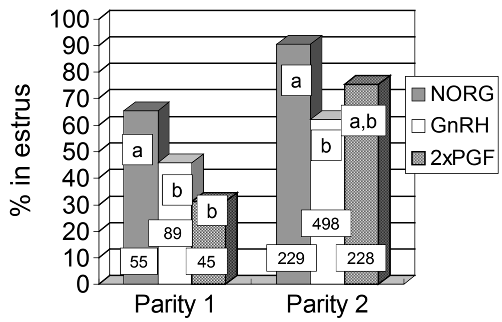

Figure 9. Percentage of cycling cows (cycling before treatments plus those induced to cycle after GnRH injection of treatments described in Figure 1) detected in estrus after PGF_2". Abbreviations in legend refer to treatment protocols illustrated in Figure 1. Values in boxes are numbers of cows per category. Percentages within parity without a common letter differ ($P \leq 0.05$).

The combination of norgestomet and GnRH increased ($P<0.05$) the proportion of cows in estrus in both parity groups (Figure 10). This is consistent with the findings in cycling cows, anestrous cows at the time of $PGF_{2\alpha}$ (d 0) that had also failed to respond to GnRH on d !7. Distribution of estrus and interval to estrus of cows in these treatments were reported earlier (Stevenson et al., 2000). Pretreatment of cows with norgestomet before GnRH increased the amount of GnRH-induced LH release (Thompson et al., 1999), increased the size of the dominant follicle (Garcia-Winder et al., 1987), and the proportion of GnRH-induced ovulations in noncycling, suckled cows (Troxel et al., 1993).

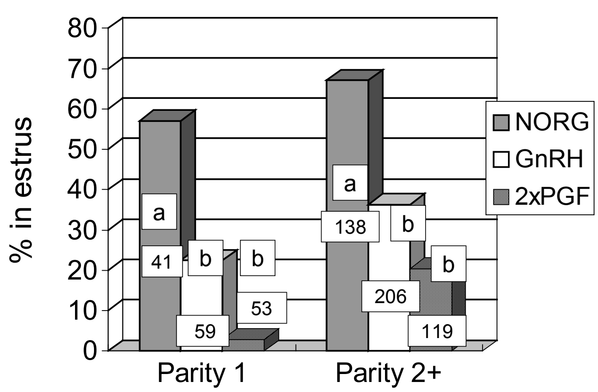

Figure 10. Percentage of anestrous cows (non-cycling before treatments plus those that did ovulate by responding to treatments described in Figure 1) detected in estrus after PGF_2" (during the first 5 d of the breeding season). Abbreviations in legend refer to treatment protocols illustrated in Figure 1. Values in boxes are numbers of cows per category. Percentages within parity without a common letter differ ($P \leq 0.05$).

Fertility

Among primiparous cows, pregnancy rates after TAI were greater ($P<0.05$) in those receiving the CIDR and NORG protocols than in those treated with the 2HPGF protocol (Figure 11). Pregnancy rates in primiparous cows treated with the MGA and GnRH protocols were intermediate, but all protocols produced more pregnancies than that of 2HPGF protocol. Among multiparous cows, the CIDR, MGA, and NORG protocols were superior ($P<0.05$) to that of GnRH, whereas all protocols increased ($P<0.05$) pregnancy outcomes above 2HPGF alone.

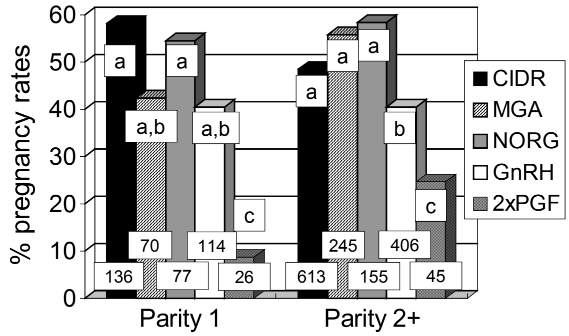

Figure 11. Percentage of cows pregnant after a timed AI associated with treatments described in Figure 1. Abbreviations in legend refer to treatment protocols illustrated in Figure 1. Values in boxes are numbers of cows per category. Percentages within parity without a common letter differ ($P \leq 0.05$).

In cows from three studies in which estrus was detected and inseminations were based on detected estrus, conception rates after the 2HPGF protocol were superior in primiparous cows to those after the GnRH protocol, with the NORG treatment being intermediate (Figure 12). No protocol tested in older cows was superior for cows detected in estrus. Although conception rates were greater in cows inseminated after detected estrus, pregnancy rates were not greater than those observed in protocols in which TAI was used because AI submission rates were 100% for TAI cows, whereas AI submission rates were <80% for cows detected in estrus (Stevenson et al., 2000).

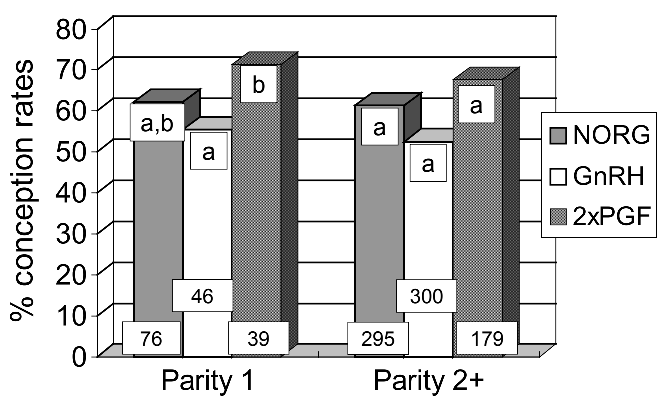

Figure 12. Percentage of cows conceiving after detected estrus and AI associated with treatments described in Figure 1. Abbreviations in legend refer to treatment protocols illustrated in Figure 1. Values in boxes are numbers of cows per category. Percentages within parity without a common letter differ ($P \leq 0.05$).

Conception rates of cows according to when they calved during the calving season are illustrated in Figure 13. Those calving early tended to have the best fertility regardless of parity, despite having slightly less BCS. Only late calvings after d 63 of the calving season were associated with the lowest fertility, particularly for late-calving heifers.

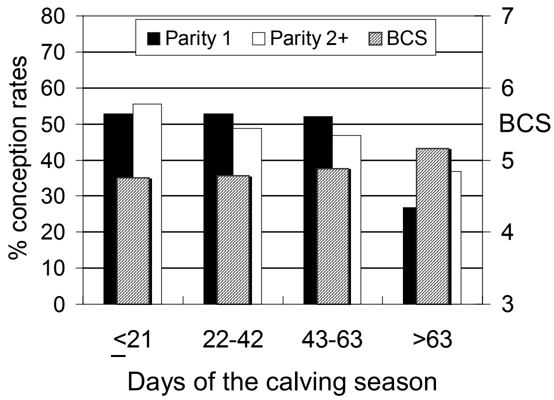

Figure 13. Percentage of cows conceiving after AI according to when they calved during the calving season and their body condition scores (1 = thin and 9 = fat) assessed on the first day of the breeding season.

In conclusion, incidence of anestrus in these herds over multiple years varied from 11 to 92% (0 = 62%). Resumption of estrous cycles was severely limited when BCS were <5 and cows were <63 d postpartum at the onset of the breeding season. Based on our observations, primiparous cows must calve during the first 60 d and older cows during the first 42 d of the calving season to reach a cycling status of 50% by the onset of the breeding season. Induction of ovulation prior to the breeding season was best achieved by either feeding MGA for 14 d before injecting GnRH 12 d later or inserting a CIDR at the time of a GnRH injection. These treatments were superior to the NORG or GnRH protocols (Figure 1). Further, success of ovulation induction in primiparous cows is limited unless BCS $5.0. Of those systems studied, expression of estrus by anestrous and cycling cows was better achieved with a progestin + GnRH treatment or 2HPGF protocols (Figure 1). Conception rates after TAI were superior for treatments that included MGA, NORG, or CIDR plus GnRH relative to GnRH + PGF or 2HPGF. Conception rates were greater in cows that calved during the first 63 d of the calving season, despite these having lower overall BCS than later calving cows.

Implications

Having more cycling cows at the beginning of the breeding season should maximize the proportion of cows that conceive to AI sires. More cows calving early during each successive calving season will enhance AI pregnancy rates, because of a year-to-year cumulative effect, thus increasing the number of cows that have initiated estrous cycles before the breeding season begins. In addition, winter supplementation programs must maintain cows in a body condition (minimum of BCS = 5) sufficient to resume estrous cycles before the breeding season in a cost-efficient manner. Overall pregnancy rates to a single timed insemination were superior for treatments that included MGA, NORG, or CIDR over GnRH + PGF or 2HPGF treatments (Figure 1), because in the presence of a progestin, no estrus occurs before $PGF_{2\alpha}$ and more estrus expression occurs after $PGF_{2\alpha}$.

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