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PUBERTY AND ANESTRUS: DEALING WITH NON-CYCLING FEMALES

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Introduction

Achieving a consistently successful A.I.-breeding program in a cow-calf operation requires attention to those heifers and cows not having normal estrous cycles (cycling) at the beginning of the breeding season. Because so many factors contribute to whether breeding females are cycling, including weather patterns, nutrition (availability of native forages or stored feeds), age or days since calving, body condition, suckling intensity, and breed composition, to name a few, each breeding season is a challenge. A second challenge is matching the many products and programs available to synchronize estrus, ovulation, or both, to the needs of the breeding females and the objectives of the operation. Some programs will succeed in most operations when a large proportion of the breeding females are cycling at the onset of the breeding season. Other programs, which are sometimes more costly or more difficult to administer, are more successful when applied to females that are not cycling. The management challenge is to determine which program will best meet the needs of the breeding herd in any given year. Fortunately, due to some excellent research in recent years, a few programs have been identified that provide acceptable pregnancy rates in those herds that have larger proportions of non-cycling females than desired.

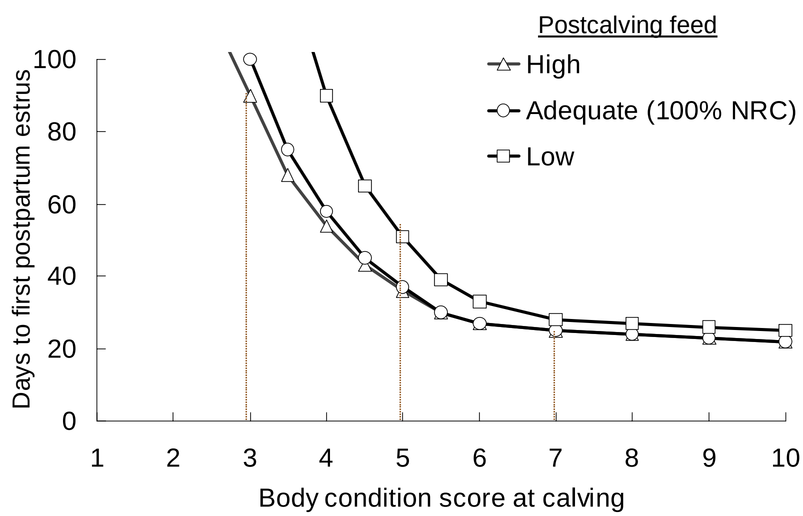
Incidence of Anestrus in Suckled Cows

The factor that most limits early conception of suckled cows is the proportion of cows 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 poor body condition at calving are also limiting factors, but temporary or permanent weaning of the calf usually initiated estrus within a few days (Williams, 1990), unless nutritional and body conditions are very poor. Primiparous cows generally have a more prolonged anestrus because of their additional growth requirement (Short and Adams, 1988; Randel, 1990; Short et al., 1990).

Recent reviews have addressed the incidence and causes of anestrus or anovulation in suckled beef cattle (Stevenson et al., 1997; Yavas and Walton, 2000; Rhodes et al., 2003). In a recent summary conducted in 3,269 cows from 14 commercial and University-owned operations in Kansas and Minnesota, a number of key issues were identified (Stevenson et al., 2003). First, the incidence of cows not undergoing normal estrous cycles before the first day of the breeding season was estimated by evaluating serum concentrations of progesterone in those cows prior to applying various protocols designed to induce or synchronize estrus and ovulation. Only 54% of the cows studied had been exposed to elevated progesterone (evidence of a functional corpus luteum and ongoing estrous cycles) before the onset of the breeding season. Three variables (body condition, parity, and days postpartum), known to be contributors to anestrus, were correlated to the proportions of cycling cows, and are known risk factors for preventing pregnancy during the breeding season.

Body Condition

Body condition is a reflection of the immediate past and current nutritional status of the female. Gestating cows that endure varied wintering conditions with inadequate supplementation are likely candidates to be thinner and less-well nourished as parturition approaches. The extent of this negative carry-over is a function of whether cows calve earlier or later in the winter or spring, and the condition of native pastures and supplementation before or after calving. Body condition at calving is a good predictor of when first estrus will occur. A review of multiple studies in which postpartum nutritional treatments were imposed and body condition was assessed at calving revealed cows calving with body condition scores of < 5 (1 = emaciated and 9 = obese) are at greater risk for prolonged intervals to first estrus than cows in better body condition (Figure 1; Short et al., 1990). In those studies, postpartum supplementation of energy in excess of NRC requirements was only beneficial to reducing intervals to first estrus in cows with body condition scores of < 5. We demonstrated as body condition score increased from 3.5 to 6.0 at the onset of the breeding season, the proportion of cows cycling increased linearly by 18 ± 2% for each unit increase in body condition score (Figure 2; Stevenson et al., 2003). Ovulatory responses to GnRH following progestin exposure before PGF_2 is dependent on parity and body condition score (Figure 3). Younger cows do not respond as well as older cows when body condition is < 5. Cows may gain or lose body condition between calving and the beginning of the breeding season, depending on postpartum nutritional conditions, onset of spring vegetative pasture growth, and supplementation. Clearly, body condition scores are predictive of cycling activity.



Source: Short et al. (1988)

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

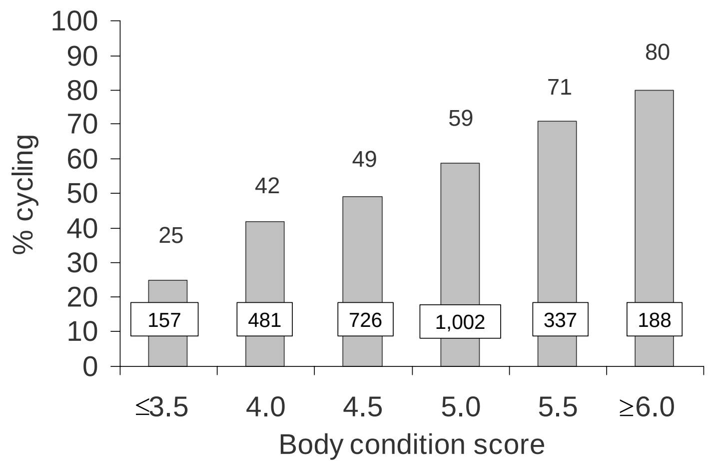


Figure 2. Proportion of suckled cows that were cycling on the first day of the breeding season on the basis of body condition score assessed at that time. Cycling status was estimated by concentrations of progesterone in blood serum of cows sampled during 7 to 10 days before the breeding week.

Source: Stevenson et al. (2003)

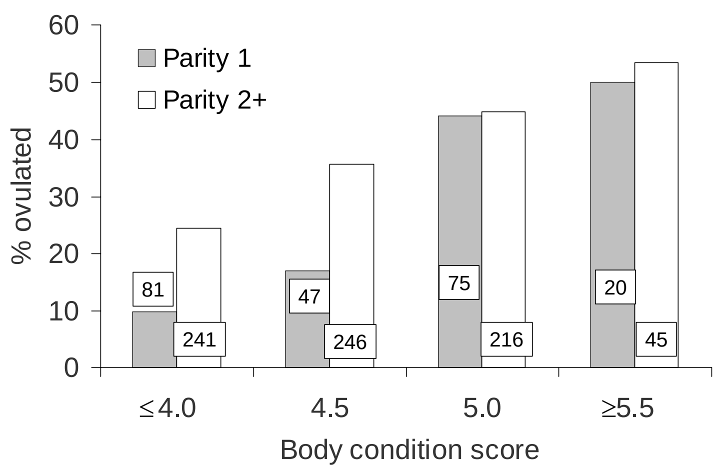


Figure 3. Proportion of primiparous (parity 1) and multiparous (parity 2+) suckled cows that ovulated during the first week of the breeding season was dependent on body condition score assessed at that time. Incidence of ovulation was estimated by concentrations of progesterone in blood serum of cows sampled during the first week of the breeding week.

Source: Stevenson et al. (2003)

Parity

Compared with multiparous cows, fewer 2-yr-old cows were cycling, despite calving up to 3 weeks earlier. Cycling activity increased linearly from 9% (< 30 days) to a peak of 70% at 81 to 90 days postpartum (Figure 4). Two-year-old cows required more time than older cows, even when they calved before the cow herd, in part, due to their greater energy needs and added burden to sustain lactation and their own growth, which have greater energy priority than the onset of reproductive cycles (Short and Adams, 1988). The cow's first priority is maintenance of essential body functions to preserve life. Once that maintenance requirement is met, remaining nutrients accommodate her own growth. Finally, lactation and then initiation of estrous cycles are supported. Older cows have no growth requirement, thus nutrients are more likely to be prioritized 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.

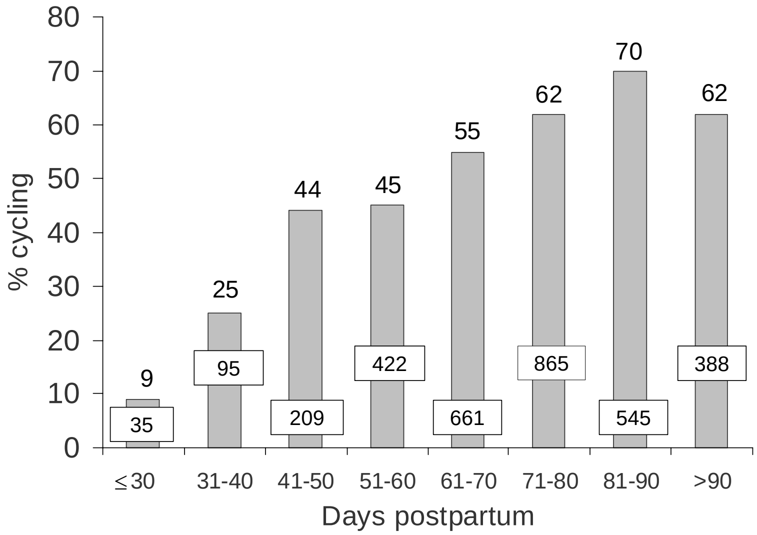


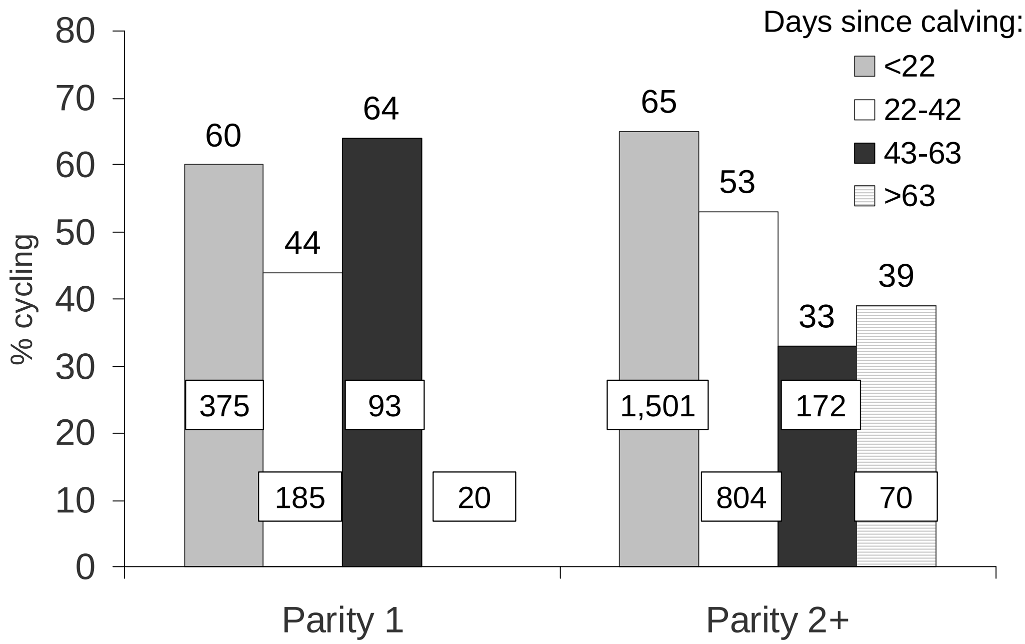
Figure 4. Proportion of suckled cows that were cycling on the first day of the breeding season on the basis of days since calving. Cycling status was estimated by concentrations of progesterone in blood serum of cows sampled during 7 to 10 days before the breeding week.

Source: Stevenson et al. (2003)

Days Since Calving

The proportion of cows cycling increased in a curvilinear fashion in all parities across days postpartum, reaching a peak at 81 to 90 days and tending to decrease thereafter (Figure 4; Stevenson et al., 2003). Average days postpartum were 86 ± 0.7 for primiparous and 68 ± 0.3 for multiparous cows. After 90 days postpartum, the percentage of cycling cows decreased, partly reflecting reduced cyclicity in primiparous cows, which comprised 85% of the cows this interval. For every 10-day interval since calving (from ≤ 30 to > 90 days), the proportion of cows cycling increased by 7.5 ± 0.7%. In other words, as expected, more cows began estrous cycles when they had longer periods between calving and onset of the breeding season.

Further, proportions of primiparous and multiparous cows cycling, based on their within herd-year calving distribution (Figure 5), showed that for primiparous cows, the cycling status at the onset of treatments was not different among the first three 21-day calving periods (> 40%), but greater for those very late-calving cows (> 63 days into the calving season; 0%; Stevenson et al., 2003). These results support the general recommendation to use a shorter breeding season for heifers to avoid problems associated with rebreeding late-calving heifers. In contrast, cycling rates were greater for older cows that calved during the first 6 weeks of the calving season (> 50%) compared with those that calved after 6 weeks (< 40%). 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.



Source: Stevenson et al. (2003)

Figure 5. Proportion of primiparous (parity 1) and multiparous (parity2+) 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 to 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.

Treatments to Initiate Cycling Activity in Suckled Cows

Induction of Estrus and Ovulation

GnRH. Ability to induce estrus, ovulation, or both, in anestrous cows is key to the success of some of the most recently developed estrus- and ovulation-synchronization protocols in beef cattle (Stevenson et al., 2000; 2003). Injection of GnRH 7 days before PGF_2 increased the proportion of anestrous cows showing estrus during the first 5 days of the breeding season by two fold compared with injection of PGF_2 alone (Table 1; Stevenson et al., 2003). Pretreatment of cows with a progestin (norgestomet; Thompson et al., 1999; or MGA; Imwalle et al., 1998) increased the: 1) amount of LH release, 2) size of the dominant follicle (Garcia-Winder et al., 1987), and 3) proportion of GnRH-induced ovulations in non-cycling, suckled cows (Thompson et al., 1999).

Progestins. Treating suckled anestrous cows with melengestrol acetate (MGA) for 7 to 14 days induces various characteristics necessary to initiate estrous cycles (Table 1; Stevenson et al., 2003). Estrus or ovulation was induced after applying a progesterone-releasing intravaginal insert (CIDR) for 7 days or feeding MGA (Table 1). The corpus luteum (CL) that formed after similar treatments generally had a normal duration as determined by normal luteal phases following ovulation and normal fertility (Table 1; Fike et al., 1997; Mackey et al., 2000). Progesterone (via the CIDR) seems to be more effective than feeding MGA when anestrous cows were treated between 12 and 42 days postpartum (Table 1; Perry et al., 2004).

Administering the CIDR insert is effective to induce estrus in suckled anestrous cows within 2 to 3 days compared with anestrous controls (Table 1; Lucy et al., 2001). Based on the combined results of seven studies, inducing ovulation was greatest in cows, regardless of parity, if they received a combination of a progestin plus GnRH injection as part of a synchronized breeding program before AI (Stevenson et al., 2003). More cows treated with GnRH (plus PGF_2 7 days later) and previously fed MGA for 14 days (Table 1) or treated with a CIDR insert concurrent with the GnRH (plus PGF_2 7 days later) were induced to ovulate in response to GnRH than those receiving only GnRH or PGF_2 alone. 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. 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.

Conception

Conception rates of anestrous cows treated with GnRH before PGF_2 in a Ovsynch (injection of GnRH 7 days before and 48 hr after PGF_2 with a timed AI 24 h after the second GnRH injection) or Cosynch (injection of GnRH 7 days before and 48 hr after PGF_2 with a timed AI concurrent with the second GnRH injection) protocol were improved by 48 hr of temporary calf removal during the 48 hr between PGF_2 and the second injection of GnRH (Table 2; Geary et al., 2001). Fertility of anestrous cows was two-fold greater when cows were treated with the CIDR insert for 6 days before PGF_2 (Table 2; Lucy et al., 2001). Administration of GnRH before CIDR insertion followed in 7 days by PGF_2 injection or feeding MGA for 14 days before initiating the GnRH + PGF_2 treatment improved pregnancy rates of anestrous cows compared with GnRH + PGF_2 or PGF_2 alone (Table 2; Stevenson et al., 2003). Another large-scale, recent study (Table 2; Larson et al., 2004b) reported similar pregnancy rates for cows treated with Cosynch-like protocols with and without the CIDR insert. A recent study in which MGA was fed for either 7 (7-11 Synch) or 14 (MGA Select) days in combination with timed AI at 60 or 72 hr, respectively, pregnancy rates of previous anestrous cows were nearly or >60% (Table 2; Bader et al., unpublished [University of Missouri]).

Suckled cows in which a large proportion of cows are not cycling most consistently responded to treatments that included some form of prebreeding progestin administration with the up front administration of GnRH. Alternatives are to feed MGA for 7 to 14 d or administer a CIDR insert during 7 d before a PGF_2. Although few comparisons have been made between feeding MGA and use of the CIDR insert, in those cases in which MGA was fed for 14 d and followed in 12 d with a GnRH + PGF_2 sequence, pregnancy rates were comparable with using a GnRH + PGF_2 sequence with an intervening 7-d CIDR insert (removed at PGF_2 injection). Although the up front GnRH injection improved pregnancy rates from 50 to 58% in a recent large-scale study (Larson et al., 2004b), its use may not be economical. The most consistent results in those anestrous cow populations that are at greater risk for not conceiving during the first week of the breeding season (2-yr-olds, thin females, and late-calving cows) are generally obtained when GnRH is used up front in addition to a form of progestin (MGA or CIDR). Protocols likely to be most effective in suckled anestrous cows for producing acceptable pregnancy rates after timed AI are illustrated in Figure 6.

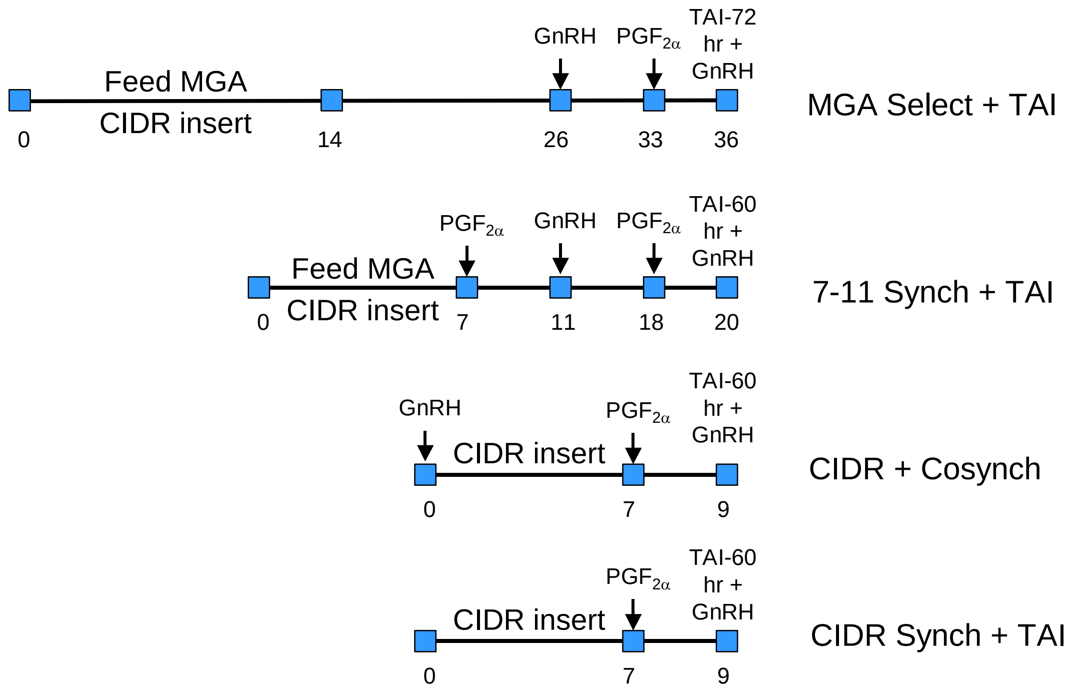


Figure 6. Protocols likely to produce the best pregnancy rates in peripubertal heifers and suckled anestrous beef cows after timed AI.

Incidence of Prepubertal Anestrus in Heifers

Current concepts on the control of puberty in cattle have been reviewed (Kinder et al., 1995; Day and Anderson, 1998). Heifers must achieve puberty by 15 months of age if they are to conceive and calve by 24 months. Reports estimating the extent of delayed puberty before 1980 (Patterson et al., 1992b) estimated as many as 35% of all beef heifers are not cycling by 15 months of age. More recent estimates of pubertal status of heifers at the onset of the breeding season were 88% (1,245 purebred and crossbred heifers from 12 herds in 7 states; Larson et al., 2004a), 83% (203 purebred and crossbreed heifers from 2 Kansas herds; Lamb et al., 2004), and 57% (724 purebred and crossbred heifers from 5 herds in 5 states; Lucy et al., 2001). In the latter study, heifers were selected for subsequent treatments when it was estimated 50% of the heifers were cycling.

Numerous factors are involved in the process of initiating puberty, including breed composition, nutrition, body weight, growth rate, bull exposure, and various environmental interactions with these factors (Patterson et al., 1992b). Further, interaction of these factors influence subsequent performance of heifers after calving. Evidence for a significant negative relationship between age at puberty and interval to first postpartum estrus indicates heifers weighing more at weaning reach puberty at younger ages, but often have longer postpartum intervals to first estrus than their contemporaries that weighed less at weaning (Patterson et al., 1992a). Because heritabilities of reproductive traits are small, the relationship between age at puberty and duration of the postpartum interval to first estrus is largely determined by management and environmental related factors.

Treatments to Initiate Cycling Activity in Peripubertal Heifers

Induction of Estrus or Ovulation

Various progestins have been used to induce puberty in peripubertal heifers including norgestomet, MGA, and progesterone (Patterson et al., 1992). Some have been combined with estrogen, or more recently with GnRH, to mimic hormonal changes that occur around the time of puberty. Because norgestomet is not available in the U.S., only information concerning the use of MGA and progesterone will be highlighted herein.

Feeding MGA (0.5 mg per heifer per day) for 7 to 14 days was effective to increase the proportion of peripubertal heifers that either showed estrus or ovulated by 12 to 17 days after the end of the MGA feeding period (Table 3; Paterson et al., 1990; Imwalle et al., 1998; Lamb et al., 2004). Administering the CIDR insert increased the proportion of heifers in estrus after 3 or 31 days in one large multi-state experiment (Table 2; Lucy et al., 2001). Providing progesterone by injection of microspheres (625 mg) or via the CIDR insert placed intravaginally for 7 days also was effective to induce estrus in peripubertal heifers (Table 3; Whisnant and Burns, 2002).

Addition of GnRH before inserting the CIDR for 7 days numerically increased the proportion of prepubertal heifers that subsequently were detected in estrus during 3 days after the PGF_2 injection upon CIDR insert removal (Table 3; Larson et al., 2004a).

Conception

Conception rates of prepubertal heifers treated with the CIDR insert for 7 days and given PGF_2 24 hr before insert removal improved pregnancy rates after 3 or 31 days of AI (Table 4; Luch et al., 2001). Conception rates of peripubertal heifers treated were normal compared with cycling controls treated with the CIDR insert (Lucy et al., 2001) or slightly exceeded that of cycling heifers (59% [n = 145] vs. 55% [n = 1100], respectively) in a large field trial (Larson et al., 2004a). Feeding MGA for 14 days to peripubertal heifers doubled the proportion pregnant during 5 days after PGF_2, when PGF_2 was injected 19 days after terminating MGA feeding compared with similar heifers not fed MGA (Table 4; Lamb et al., 2004). Addition of GnRH up front at insertion of the CIDR insert increased slightly, but not significantly, the proportion of heifers that conceived during 3 days after the PGF_2 injection administered at CIDR insert removal (Table 4; Larson et al., 2004a).

Implications

Combinations of progestins and GnRH are quite effective as means to induce estrus, ovulation, or both in both anestrous suckled cows and peripubertal heifers. Subsequent conception or pregnancy rates are often similar to cycling females. The challenge in managing these protocols is determining to which cows or heifers these more expensive treatments are justified and should be applied. More research is warranted in addressing ways to apply these treatments to females of unknown cycling status that may be most profitable.

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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	**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 was administered, it was injected 6 (PGF-6) or 7 d (PGF-7) after CIDR insertion. Where GnRH was administered, it was injected at CIDR insertion or 7 d before PGF_2.

[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 cow 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 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.

^{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 (48 h 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%)
Whisnant and Burns, 2002	% in estrus by 21 d after injections	P4 (625 mg) + estrogen (50 mg) injected microspheres 11/13 (85%)	P4 (625 mg) injected microspheres 11/13 (85%)
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 d (MGA-14). The CIDR (progesterone-releasing controlled internal drug releasing insert) was placed intravaginally for 7 d (CIDR-7) with PGF_2 administered 6 d later (PGF-6). Where GnRH was administered, it was injected at CIDR insertion or 6 d before PGF_2 (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 $PGF_{2\alpha}$ % pregnant by 31 d after $PGF_{2\alpha}$	**CIDR**-7 + PGF-6 50/105 (48%) [x] 75/105 (71%) [x]	PGF 11/101 (11%) 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 $PGF_{2\alpha}$ (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 + PGF-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 d (MGA-14) followed in 10 d by $PGF_{2\alpha}$ (PGF-19). The CIDR (progesterone-releasing controlled internal drug releasing insert) was placed intravaginally for 7 d (CIDR-7) with $PGF_{2\alpha}$ administered 6 d later (PGF-6). Where GnRH was administered, it was injected at CIDR insertion or 6 d before $PGF_{2\alpha}$ (GnRH + PGF-6).

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

NOTES