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Contrasting effects of progesterone on fertility of dairy and beef cows[1,2]

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ABSTRACT

The role of progesterone in maintaining pregnancy is well known in the bovine. Subtle differences exist between dairy and beef cows because of differing concentrations of progesterone during recrudescence of postpartum estrous cycles, rate of follicular growth and maturation, proportions of 2- and 3-follicular wave cycles, and other effects on pregnancy outcomes per artificial insemination (P/AI). Because proportions of anovulatory cows before the onset of the artificial insemination (AI) period are greater and more variable in beef (usually ranging from 30 to 70%) than dairy (25%) cows, AI programs were developed to accommodate anovulatory and cycling beef cows enrolled therein. Incorporating a progestin as part of an AI program in beef cows improved P/AI by reducing the proportion of cows having premature luteal regression and short post-AI luteal phases. In both genotypes, prolonged dominant follicle growth in a reduced progesterone milieu resulted in increased (1) LH pulses, (2) preovulatory follicle diameter, and (3) concentrations of estradiol and a subsequently larger corpora lutea (CL). In contrast, the progesterone milieu during growth of the ovulatory follicle in an ovulation control program does not seem to affect subsequent P/AI in beef cows, whereas in dairy cows follicle development in an elevated compared with a low progesterone environment increases P/AI. Progesterone status in beef cows at the onset of ovulation synchronization is not related to P/AI in multiparous cows, whereas P/AI was suppressed in primiparous cows that began a timed AI program in a low-progesterone environment. In timed AI programs, elevated concentrations of progesterone just before $PGF_{2\alpha}$ and reduced concentrations at AI are critical to maximizing subsequent P/AI in dairy cows, but seemingly much less important in beef cows. By inducing ancillary CL and increasing concentrations of progesterone, human chorionic gonadotropin may increase P/AI when administered to beef cows 7 d after AI or at embryo transfer, and its success seems to depend on induction of ancillary CL, whereas in dairy cows increased fertility was detected in cows with multiple CL, human chorionic gonadotropin-enhanced progesterone from original CL, or both. Pregnancy losses after AI are less frequent in beef cows and are not associated with pre-AI progesterone or cycling status, whereas losses in dairy cows are inversely related to progesterone and adversely affected in anovular dairy cows. Genotype and nutritional management likely influence several physiological differences including circulating concentrations of progesterone and responses to supplemental progesterone.
Key words: beef cows, dairy cows, progesterone, fertility

INTRODUCTION

Factors that influence establishment and retention of pregnancy were identified in an earlier review (Inskeep, 2004). These include (1) preovulatory effects on the follicle and oocyte, (2) early postovulatory uterine and luteal function, (3) hormonal concentrations associated with conceptus and endometrial function during maternal recognition of pregnancy, and (4) less well-understood factors during the peri-attachment period. The present report will focus on differences that may exist between *Bos taurus* beef and dairy cattle with respect to the effects of progesterone in its role as a facilitator to establishing and maintaining pregnancy.

One factor that limits conception is the proportion of cows remaining anestrous or anovulatory at the beginning of the breeding period in suckled and milked cows (Crowe et al., 2014). Factors influencing the incidence of anestrus have been reviewed (Stevenson et al., 1997; Yavas and Walton, 2000; Diskin et al., 2003; Crowe et al., 2014). Traditional differences in management of beef and dairy cows partly contribute to the vary-

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ing recrudescence of postpartum ovarian activity with suckled beef cattle having more prolonged periods of anovulation than dairy cattle (Crowe et al., 2014), despite the fact that regular continuous follicular waves occur every 7 to 10 d beginning 5 to 10 d after calving in beef (Stagg et al., 1998) and dairy cows (Lucy et al., 1992). The most common type of anovular lactating dairy cow (60% of anovular dairy cows) had follicles larger than ovulatory size but smaller than the classically defined cystic follicle (Wiltbank et al., 2011). In contrast, before first ovulation in suckled cows, recurrent periods of growth and regression of dominant follicles occur, but these dominant follicles fail to ovulate and consequently undergo atresia (Murphy et al., 1990) because of a lack of appropriate LH pulse frequency (Crowe et al., 2014). Thus, although suckling increased the interval to first ovulation relative to the intervals reported for dairy cows (Fonseca et al., 1983), it did not delay resumption of follicular growth or development of dominant follicles in suckled beef cows (Murphy et al., 1990).

The nature of the first postpartum ovulation is silent in more than 70% of beef and dairy cows and is more prolonged in beef cattle because of suckling-induced inhibition of LH pulse frequency (Williams, 1990), with the postpartum interval to first ovulation ranging from 25 to 45 d in dairy and 30 to 130 d in beef cattle (Crowe et al., 2014). Direct comparisons of Angus, Simmental, and Holstein cows milked twice daily and fed the same diet revealed that Angus cows (36 ± 4 d) had longer intervals to first postpartum ovulation than Holstein (20 ± 3 d) and Simmental cows (22 ± 4 d), and at 30 d after calving, 50, 88, and 92% of the cows had initiated ovarian cyclicity in the Angus, Simmental, and Holstein breeds, respectively (Masilo et al., 1992). As expected, Holsteins produced more milk (unadjusted or 3.5% FCM) than Angus or Simmental cows during the first 30 DIM.

Proportions of anovulatory cows at the onset of the AI period are greater and more variable in beef (30 to 70%; Lamb et al., 2010) than dairy (5 to 41%; Bisinotto et al., 2014) cows. Exposure to progesterone is a prerequisite to first postpartum behavioral estrus in a large portion of beef cows (Lamb et al., 2010) and dairy cows (Crowe et al., 2014). Although duration and intensity of estrus is compromised in superior milk-producing dairy cows (Lopez et al., 2004), interval from onset of estrus to ovulation seems to be similar in beef (31 h; White et al., 2002) and dairy (28 h; Walker et al., 1996) cows.

Although most US dairy operations are not seasonal as beef cow-calf operations, many worldwide grazing dairy operations are managed with seasonal breeding patterns as beef cattle. Dairy cows generally are fed ad libitum diets calculated to meet maintenance, growth, and milk production requirements or nutritionally supplemented during part of the year in seasonally managed operations. In contrast, beef cows are generally managed to graze native range with some nutrient supplementation depending on the time of their calving and breeding seasons. Therefore, nutritional management of cattle is likely to influence several physiological differences in cattle. Several of these differences may be directly or indirectly influenced by progesterone and luteal function, because circulating concentrations of progesterone are reflective of their biosynthesis by the corpus luteum (**CL**) and rate of metabolism primarily by the liver (Wiltbank et al., 2014).

Our objective was to contrast the differences in the role progesterone plays in fertility of *Bos taurus* beef and dairy cattle. Several excellent reviews examining some of the physiological and practical effects of progesterone on reproduction in dairy cattle are available (Bisinotto et al., 2015b; Wiltbank and Pursley, 2014; Wiltbank et al., 2014), which go beyond the scope of this report. A paucity of information exists, however, including reviews of the literature, elucidating the role of progesterone on pregnancy outcomes in beef cattle. Two recent reports (Lamb et al., 2010; Stevenson et al., 2015) provided some information regarding prebreeding progesterone milieu or supplementation and its effects on pregnancy outcomes in beef cattle.

PREOVULATORY INFLUENCES OF PROGESTERONE

Ovarian Follicular Waves

Greater DMI in dairy cows of superior milk yield alters splanchnic tissue metabolism and increases catabolism of ovarian steroids, including estradiol and progesterone (Wiltbank et al., 2006). Lactating dairy cows have lesser progesterone concentrations during the estrous cycle than cycling dairy heifers, and concentrations of progesterone are inversely related to CL size (Sartori et al., 2004; Wolfenson et al., 2004). These reduced concentrations of progesterone facilitate a subtle increase in LH pulse frequency and generally prolong the growth phase of dominant follicles compared with that of heifers. Number of follicular waves and rate of turnover of dominant follicles are directly related to the duration of follicle dominance, and cattle with shorter durations of dominance reportedly have greater pregnancy per AI (**P/AI**; Austin et al., 1999; Santos et al. 2010). Because grazing beef cattle have less DMI compared with dairy cows, nutritional influences, by altering metabolic clearance rate of progesterone and estradiol, likely affect follicle dominance, the number of