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Subcutaneous body lipids affect cyclicity and estrus behavior in primiparous Charolais cows

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ABSTRACT

Conception rate and the calving interval of beef cows are known to be influenced by body reserves at calving and subsequent postpartum changes. However, few studies have focused on the effect of body reserve dynamics on both postpartum cyclicity and estrus expression. Two successive similar experiments (Year 1: $n = 14$; Year 2: $n = 16$) were carried out on primiparous Charolais cows reared indoors during winter to quantify the effects of adipose cell diameter at calving (ACDca) and their postpartum changes (ACDch) on cyclicity and estrus behavior. Cows were managed to calve with a body condition score (BCS, scale 0–5) of 2.5 (Year 1) and 1.5 (Year 2). After calving cows were assigned to a Low *vs.* a High energy level diet until turn out to pasture in May. Within years ACDca was similar between Low and High groups whereas calving to turnout changes of body weight (BW), BCS and adipose cell diameter differed ($P < 0.0001$). The interval between calving and resumption of luteal activity was negatively correlated with ACDca ($P = 0.001$). Estrus duration (interval between first and last standing to be mounted (STBM)) was longer in Low than in High groups ($P = 0.02$). Number of STMB was higher in Low than in High cows. Adipose cell diameter at calving and postpartum changes had distinct effects on the components of reproductive performance; emphasizing the need to consider both amounts and changes of body lipids to predict relationships between nutrition and reproduction in cows.

1. Introduction

As economic and weather conditions become more variable it is expected that beef cattle production systems will experience more frequent periods of feed restriction. These could also become longer and more severe. This would have an effect on the reproductive performance of females and consequently on the economic viability of farms. Effects of nutrition on cow reproductive performance can be studied through the physiological mechanisms whereby nutrients influence reproduction (Scaramuzzi et al., 2010) or by considering the whole animal. This latter approach often tries to predict reproductive performance according to management rules by the use of mathematical modeling. These models often assume that reproductive success results from a dynamic process that includes successive stages, each corresponding to a specific reproductive status (open not cycling, open cycling, pregnant) that cows experience over time (Blanc and Agabriel, 2008). Based on such a representation of reproductive efficiency, a question arises about how to account for the influence of body reserves at each of these stages. In dairy cows, Friggens (2003) described the combined effects of body lipids and postpartum body lipid changes on the likelihood of onset of ovarian activity after calving. To extend this conceptual framework to beef cows and to other stages of the

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reproductive process (cyclicity, estrus behavior, fertilization, embryo survival) a quantification of the effects of body lipids and their postpartum changes on each of these stages is needed.

Previous studies in beef cows showed that low body lipid amount at calving lengthened the postpartum anoestrus period (Richards et al., 1986) and body lipid amount at the start of mating influenced the likelihood of conception (Petit et al., 1992). With regard to the effects of body lipid levels and their postpartum changes on estrus behavior, few data are available in beef cattle. Previous studies reported that estrus duration was affected neither by the postpartum body weight gain (Ciccioli et al., 2003) nor by the body condition at start of mating (Flores et al., 2007). In contrast, in dairy cows the effects of body lipid amount and changes on reproductive performance have been widely studied (Butler and Smith, 1989; Roche, 2006) and it is accepted that intake level and milk yield influence estrus behavior (Cutullic et al., 2009; Villa-Godoy et al., 1990). Further investigations on the effects of body lipid changes on the different reproductive stages are needed in beef cattle and particularly in cases where body lipid mobilization is induced by feeding restriction.

The objectives of this study were to quantify the effects of body lipid amount at calving and postpartum body lipid changes on ovarian cyclicity and estrus behavior in Charolais cows. We hypothesized that the interval from calving to resumption of luteal activity becomes longer with decreased body lipid amount at calving. We also tested whether postpartum body lipid mobilization influences estrus expression. These two aspects are important for predicting how females cope with underfeeding/refeeding dynamics. The present study focused on primiparous cows for which reproduction is more sensitive to nutrition than in multiparous cows due to their energetic needs for growth and their lower intake capacity (Garel et al., 1988; Meikle et al., 2004).

2. Materials and methods

Two successive experiments were carried out in the winters of 2009 and 2010 at the INRA experimental station in Laqueuille (Auvergne, mountain conditions). All the scientists working on this study were licensed to perform experiments on animals. Procedures involving the use of animals were approved by the regional ethics committee (approval number A 63.189.04.).

2.1. Experimental design and feeding treatment

Primiparous Charolais cows (Year 1: $n = 14$; Year 2: $n = 16$) were managed in a winter calving system. Both experiments followed the same experimental design divided into 2 successive periods: During the prepartum period (P1) cows were randomly allocated to two groups with similar body weight (BW) and expected calving date. From the beginning of October to November 18, 2009 (Year 1) or December 14, 2010 (Year 2), cows from both groups were maintained on the same high hill pasture and were managed similarly to reach a BCS at calving of 2.5 (Year 1) or 1.5 (Year 2). In order to reach a lower BCS at calving in Year 2, cows were maintained on pasture for a longer period and stocking density was higher than in Year 1. From November 18, 2009 (Year 1) and December 14, 2010 (Year 2) cows were turned into the barn to stabilize their BCS until calving and housed in groups in pens with a concrete feeding area and a straw area (Fig. 1). Within-year, feeding management of the two groups of cows was similar over this period. Mean calving dates of each group of cows were respectively January 6, 2009 (±15 d) *vs.* January 7, 2009 (±18 d) in Year 1 and January 10, 2010 (±11 d) *vs.* January 10, 2010 (±10 d) in Year 2 (mean ± s.d.). The second experimental period (P2) started after calving. Each group of cows was assigned an energy level diet (High *vs.* Low) from calving until mid-May (131 ± 16 d postpartum in Year 1 and 129 ± 10 d postpartum in Year 2 (mean ± s.d.)) (Fig. 1).

During the indoor periods (end of P1 and the whole of P2), cows were individually fed concentrate. Hay was offered collectively to each group once a day. Animals were tied up for 1 h for feeding in the morning (08:00 h) and then had free access to the trough to eat the remaining hay. The same pasture hay (with an average energy concentration of 4.6 MJ/kg dry matter (DM) and a crude protein content of 97 g/kg DM) and the same concentrate (with an energy content of 7.5 MJ/kg DM) were used throughout P1 and P2. Individual DM intake was estimated as the total DM intake of the group divided by the number of cows within the group. Hay and concentrate DM intakes as well as net energy supplied by diets during P1 and P2 are reported in Table 1. The diets were balanced for nitrogen supply (INRA, 2007).

During P2, calves were housed in a separate pen near to their dams enabling visual and olfactory contact. Suckling was allowed only twice a day (at 08:00 h and 16:00 h). Milk production was measured every 2 weeks by the weigh-suckle-weigh method (Le Neindre, 1973). Cows were allowed to mate by natural service during P2 but only from the third estrus when detected by visual observation.

2.2. Calving difficulty and body reserves

Calving difficulty was assessed on a 5-point scale from 1 (calving without any assistance) to 5 (cesarean done by a veterinarian).

During P1, cows were weighed once (Year 1) or twice (Year 2) a month. As the total weight of the fetus (fetus plus fetal membranes and placenta) is known to increase exponentially from conception to calving, live weights of pregnant cows were corrected to take into account the fetus weight at each stage of pregnancy (Petit and Agabriel, 1989). This correction was made using equations established by Bereskin and Touchberry (1967). During P2, cows were weighed once (Year 1) or twice (Year 2) a week at 13:00 h. Body condition was scored (scale 1–5) by two independent evaluators once (Year 1) or twice (Year 2) a month during P1 and P2.

Subcutaneous adipose tissue was collected by biopsy in the rump after local anesthesia (4-mL of Lidocaïne®) (Robelin and Agabriel, 1986). After collection, adipose cells were fixed by osmium tetroxide and isolated in urea solution. The fixed cells were trapped on a cellulose