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The concurrent and carry over effects of long term changes in energy intake before insemination on pregnancy per artificial insemination in heifers

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ABSTRACT

Follicle development in a period of negative energy balance (NEB), as experienced by the postpartum dairy cow, could be affected by undesirable metabolic changes, and may contain a developmentally incompetent oocyte with an impaired potential to establish a pregnancy. A differential feeding model in heifers was developed to evaluate the concurrent and carryover effects of reduced energy intake before insemination on pregnancy per artificial insemination (P/AI). Heifers were randomly assigned to either (i) control feed intake group (CF), $n = 68$, 1.3 times estimated maintenance energy (M) requirements for 50 days and 2.0 M for 83 days or (ii) restricted feed intake (RF), $n = 88$, 0.65 M for 50 days and 2.0 M for 83 days. Pregnancy per AI was determined by transrectal ultrasonography at day 30 following AI. Despite significant loss of live weight (LW; 5.8 ± 2.1 vs 70.5 ± 2.8 kg, respectively) and body condition score (BCS; 0.05 ± 0.03 vs 0.45 ± 0.03) and a significant elevation in systemic concentrations of non-esterified fatty acids in RF heifers, there was no concurrent effect on P/AI (69 vs 72%) following AI at day 50. However, there was a carryover effect on P/AI as there was an 18 percentage point difference (64 vs 82%) between CF and RF heifers following AI on day 93. The results of the study indicate that a reduction in energy intake for a 50-day period pre-insemination had no concurrent effect but had a positive carryover effect on P/AI.

1. Introduction

Nutritional management has an effect on the productive efficiency of both dairy and beef cattle. Lactating cows enter a state of negative energy balance (NEB) in the postpartum period when energy requirements for milk production and maintenance surpass dietary energy intake. Negative energy balance causes lipolysis of adipose tissue which leads to large quantities of non-esterified fatty acids (NEFA) being released into circulation to fuel tissues in key organs such as the brain and the heart. The biochemical environment of the follicle reflects the blood serum concentrations of metabolites, which is a key indicator of an animal's energy status (Leroy et al., 2004). It has been hypothesised that follicles grown in a period of NEB, as typically experienced by the postpartum dairy cow, could be affected by undesirable metabolic changes, and may contain a developmentally incompetent oocyte with an impaired potential to establish as a pregnancy (Britt, 1992). Oocyte development from the early pre-antral stage to the pre-ovulatory follicle takes up to 90 days (Lussier et al., 1987; Fair, 2003).

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There is no direct experimental evidence in the literature of the effects of a long period of dietary restriction on the ability of the oocyte to be fertilised and form a viable embryo, i.e., in support of the 'Britt hypothesis'. Therefore, the overall objective of this study was to determine the effects of a 50-day period of dietary restriction on the ability of the oocyte to be fertilised and establish a pregnancy in heifers. The specific aims of the study were to establish (1) the concurrent, and (2) the carryover effects of a 50 day period of dietary restriction on pregnancy per artificial insemination (P/AI) in heifers; (3) the concentration of NEFA in follicular fluid on days 50 and 93 after the start of differential feeding; (4) the relationship between concentrations of metabolites in plasma and follicular fluid on days 50 and 93 after the start of differential feeding; and determine the concentrations of progesterone (P4) on days 4–7 following insemination on days 50 and 93.

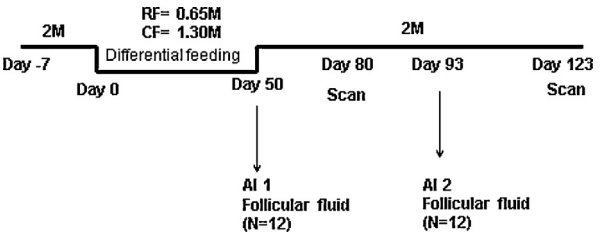

Fig. 1. Experimental design. All heifers received 2.0 maintenance (M) for 7 days before the commencement of differential feeding. Differential feeding commenced on day 0. Heifers on restricted feed intake (RF) received 0.65 M for a 50-day period. Heifers on control feed intake (CF) received 1.30 M for a 50-day period. All heifers received 2.0 M thereafter. Heifers were inseminated on day 50, aborted, re-synchronised and re-inseminated at day 93. Pregnancy diagnosis by ultrasound scanning took place on days 80 and 123. Follicular fluid was collected from a subset of heifers following slaughter on days 50 and 93.

2. Materials and methods

2.1. Animals and management

All experimental procedures involving animals were licensed by the Department of Health and Children, Ireland. Protocols were in accordance with the Cruelty to Animals Act (Ireland 1876, as amended by European Communities regulations 2002 and 2005) and the European Community Directive 86/609/EC and were sanctioned by the Institutional Animal Research Ethics Committee of University College Dublin. The study was conducted over three replicates involving 180 reproductively normal nulliparious mixed breed [120 Holstein Friesian (dairy) and 60 Charolais cross and Limousin cross (beef)] heifers (approximately 24 months of age) from the same herd. Replicate 1 consisted exclusively of Holstein Friesian heifers ($n = 106$), while replicate 2 consisted exclusively of beef cross heifers ($n = 50$). Replicate 3 ($n = 24$) consisted of 14 Holstein Friesian and 10 beef heifers. All heifers were weighed and body condition scored at the start of each replicate and had a (mean ± SE) live weight (LW): 581 ± 4.4 kg and a body condition score of (BCS) 3.45 ± 0.05. Body condition score was measured on a scale of 0–5 according to Lowman et al. (1976). All heifers were housed in concrete slatted pens throughout the study.

2.2. Experimental design, diets and feeding

The experimental design is illustrated in Fig. 1. Live weight and BCS were measured on two occasions before the commencement of the experiment. All heifers received 2.0 maintenance (M) for 7 days before the commencement of differential feeding. Heifers were randomly assigned to one of two treatments. Restricted feed intake (RF) consisted of a diet supplying 0.65 maintenance (M) for 50 days and control feed intake (CF) consisted of a diet supplying 1.30 M for 50 days. Energy for maintenance was calculated from the following equation: (0.091 × LW) + 8.3 (ADAS, 1984), validated by Mackey et al. (1999). Eighty-eight heifers were assigned to RF and 68 heifers were assigned to CF on day 0. After the 50-day differential dietary treatment period, all heifers were fed a 2.0 M diet until the end of the study (day 123). All heifers were individually fed using an electronic feeding system (Calan Inc., Northwood, New Hampshire 03261, USA) with a concentrate and grass silage diet (fed 60:40 on an energy basis) supplying the energy for maintenance. The chemical composition of the silage and concentrates was determined as described by Keady et al. (1998, 1999). The ME concentration of the silage and concentrate were predicted as described by Park et al. (1998) and Given et al. (1995). The energy density of the feed was 12.1 MJ ME/kg DM for concentrates and 9.9 MJ ME/kg DM for silage. The crude protein percentage was 15.4 and 13.2% for concentrate and silage, respectively. Consumption of feed was monitored daily throughout the experiment.

2.3. Estrous synchronisation, AI and determination of pregnancy per AI

Estrous cycles were synchronised by using two injections (2 ml equivalent to 500 mcg cloprostenol) of a synthetic prostaglandin $F_{2\alpha}$ analogue (PGF, Estrumate; Intervet/Schering-Plough Animal Health, Hertfordshire, UK) administered intra-muscularly 11 days apart. Prostaglandin was administered on day 37 and 48 for AI on day 50 and on day 80 and 91 for AI on day 93. All heifers were monitored for signs of estrus five times daily, beginning 2 days after administration of the second PGF injection and continuing for a further 96 h. Estrotect™ heat patches (Dairymac Limited, Hampshire, UK) were used as an aid to estrus detection. Only heifers displaying standing estrus were inseminated by one experienced operator using frozen–thawed semen from one high fertility bull. All AI took place within 12 h of the onset of standing estrus.

Pregnancy per AI was determined by ultrasound scanning of the uterus using an Aloka SSD-500 V ultrasound scanner fitted with a 7.5-MHz transducer (Aloka Co. Ltd., Tokyo, Japan) at day 30 after AI. A positive pregnancy diagnosis was based on the presence of an apparently viable embryo with a visible heartbeat and clear amniotic fluid. After diagnosis, pregnancy was terminated by administration of PGF to induce corpus luteum regression, embryo death and estrus.