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The relationship between periovulatory endocrine and follicular activity on corpus luteum size, function, and subsequent embryo survival

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Abstract

The objectives of this study were to examine the relationships between periovulatory endocrine events, ovarian activity, and embryo survival after artificial insemination (AI) in cattle (Bos taurus). Eighty-four reproductively normal beef heifers were estrus synchronized using a prostaglandin-based regimen. Artificial insemination was performed between 5 and 21 h after heat onset. Ultrasonic examination of ovarian structures began 12 h after the onset of heat and continued every 6 h until confirmed ovulation. Blood samples were collected for measurement of estradiol, progesterone, and insulin-like growth factor-1 (IGF-1). Pregnancy diagnosis was conducted on Days 30 and 100 after AI. Embryo survival was defined as the presence of an embryo with a detectable heartbeat in a clear amniotic sac at Day 30 postinsemination. There was no effect of the intervals from the onset of heat to AI or ovulation or from AI to ovulation on embryo survival ($P > 0.10$). There was a tendency ($P = 0.09$) of an inverse relationship between preovulatory follicle size and embryo survival that was unrelated to concentrations of estradiol or IGF-1 during the periovulatory period ($P > 0.05$). There was evidence ($P = 0.08$) of a positive association between embryo survival and concentrations of progesterone on Day 7; however, this relationship was independent ($P < 0.05$) of hormonal and follicular measurements during the periovulatory period. This study shows that heifers could be inseminated up to 31.5 h before ovulation without compromising the probability of embryo survival. This study suggests that there is an optimum range of follicle size within which high embryo survival rates can be achieved.

Keywords: Artificial insemination; Estradiol; Follicle; IGF-1; Ovulation

1. Introduction

Improving embryo survival rate is a key objective in increasing the profitability of dairy and beef cattle production systems. Early embryo mortality is a major contributor to reproductive failure [1] with the majority of this loss occurring in the first 16 d of gestation [2]. This period covers the cascade of events that occurs from ovulation up to maternal recognition of pregnancy. Recently, a number of studies have indicated that the probability of a conception occurring is related to the size of the ovulatory follicle [3–5]. It has been suggested that ovulatory follicle size influences subsequent luteal size and function during the early luteal phase [6]. Low peripheral concentrations of progesterone (P4) during the early luteal phase has been shown to be associated with low embryo survival rate [7]. Whether the effects of ovulatory follicle size on subsequent embryo survival are mediated directly or

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indirectly through its effect on subsequent corpus luteum size and P4 secretion is not yet fully elucidated. The periovulatory period also encompasses the various intervals from the onset of heat to artificial insemination (AI) and ovulation. Their effects on subsequent embryo survival are not clearly delineated [8,9]. The interrelationship between these variables with follicle size and circulating concentrations of estradiol (E2) is not well understood. Concentrations of insulin-like growth factor-1 (IGF-1) have been shown to affect steroidogenesis, proliferation, and differentiation of bovine follicles [10], however how this relates to follicular size and ultimately embryo survival during the periovulatory period is not clear.

The objectives of this study therefore, were to (1) examine the effects of ovulatory follicle size and periovulatory peripheral concentrations of E2 and IGF-1 on embryo survival; (2) establish the relationships between ovulatory follicle size and subsequent corpus luteum size and peripheral concentrations of P4 and their effect on embryo survival, and (3) examine the relationships between the intervals from the onset of heat to AI and from AI to ovulation and embryo survival.

2. Materials and methods

2.1. Animals and management

Reproductively normal nulliparous crossbred beef heifers (Bos taurus) (n = 84) had their estrous cycles synchronized using two intramuscular administrations of 500 μg of the prostaglandin $F_{2\alpha}$ analogue cloprostenol (Estrumate; Schering-Plough Limited, Shire Park, Welwyn Garden City, Hertfordshire, UK) given 11 d apart (PG1 and PG2, respectively). Estrous activity was monitored continuously using an electronic heat mount detection system (HeatWatch; CowChips, LLC, Denver, CO, USA) as described by Dalton et al. [11]. Each heifer was fitted with a transponder and enrolled in the HeatWatch system at PG2 administration. Animals were also visually observed for signs of estrous activity every 3 h beginning 24 h after PG2. For management purposes, only those animals that were recorded in standing heat in the period between 24 and 96 h after PG2 were used (n = 84). At PG1 administration, all animals were weighed and had their body condition score (BCS) assessed using a 6-point scale [12] in which a score of 0 indicates severe emaciation and a score of 5 indicates obese animals. These had a mean live weight of 459.6 ± 38.3 kg and a BCS of 3.4 ± 0.35. From 15 d pre-estrus to 35 d post-estrus, heifers were kept on slatted floor pens and had ad libitum access to grass silage (Metabolisable energy (ME) of 10.1 Mega joules (MJ)/kg and a Crude protein (CP) of 10.8%) with each heifer offered 2 kg of a concentrate supplement each day (10.7 MJ/kg ME, CP 15.4%). After this, animals were turned out to pasture and remained at pasture until final pregnancy diagnosis at 100 d after AI.

2.2. Artificial insemination

Inseminations were carried out by two experienced technicians. All heifers observed in standing estrus were given a single insemination of frozen-thawed semen that was collected from a single ejaculate of one high-fertility bull. The mean and range in hours after the onset of heat at which heifers were inseminated are shown in Table 1.

2.3. Ultrasound scanning

Ovarian structures were examined per rectum using an Aloka SSD-500 V ultrasound scanner fitted with a 7.5-MHz transducer (Aloka Co. Ltd, Tokyo, Japan). Scanning of structures on both ovaries began 12 h after the onset of heat and was repeated every 6 h thereafter until ovulation occurred, defined as the disappearance of a previously dominant follicle (DF). A subsequent scan was conducted on 11 heifers that had other large follicle structures present on either ovary to confirm twin ovulation. Time of ovulation was denoted as the time of the first scan at which the DF had disappeared, minus 3 h. Ovulatory follicle size was measured by taking a mean of the height and width of the dominant follicle. Both ovaries were reexamined again on Day 7 post-estrus to confirm ovulation and to measure the size of the corpus luteum (CL). The size of the CL and lacuna (where present) was

Table 1
Means of chronological and ovarian values, standard deviations, and the range of observed values.

Variable	Mean ± SD	Range
Interval from PG2 to the onset of heat (h)	60.7 ± 13.9	41.1–96.9
Interval from PG2 to ovulation (h)	88.1 ± 15.3	68.0–128.0
Interval from the onset of heat to ovulation (h)	27.4 ± 5.9	16.4–46.4
Interval from the onset of heat to AI (h)	12.4 ± 4.4	4.9–21.3
Interval from AI to ovulation (h)	15.1 ± 6.9	0.71–31.5
Ovulatory follicle size (mm)	14.1 ± 1.9	10.1–20.9
CL size Day 7 (mm)	21.61 ± 4.51	13.00–37.25