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Timing of follicular phase events and the postovulatory progesterone rise following synchronisation of oestrus in cows

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Abstract

In cows the timing of both ovulation and the subsequent postovulatory progesterone rise are critical to successful fertilisation and early embryo development. The aim of this study was to determine the degree of variability in the timing of ovulation relative to other follicular phase events and to determine how variations in the timing of follicular phase events contribute to the timing of the postovulatory progesterone rise. Plasma concentrations of progesterone, oestradiol and luteinising hormone (LH) and the timing of oestrus and ovulation were determined following induction of luteolysis were determined in 18 mature, non-lactating Holstein–Friesian cows. Four cows were excluded on the basis of abnormal reproductive function. In the remaining 14 cows oestrus occurred at 57.4 ± 4.3 h and the LH surge at 54.6 ± 4.0 h following luteolysis (progesterone <1ng mL^{-1}) followed by a fall in circulating oestradiol concentration at 64.6 ± 4.4 h.

Cows ovulated at 88.0 ± 4.7 h with the postovulatory progesterone rise (to >1 ng mL^{-1}) occurring 159 ± 7.2 h after luteolysis. There was considerable variation in the timing of ovulation following luteolysis (range 64–136 h) onset of oestrus (range 24–40 h) and onset of the LH surge (range 24–44 h). Cows were then split on the basis of interval from progesterone fall to progesterone rise giving groups ($n = 7$ per group) with intervals of 180.6 ± 6.7 and 138.3 ± 5.7 h ($P < 0.001$). Between groups, both the intervals from luteolysis to ovulation (98.3 ± 6.9 vs 77.7 ± 3.4 h; $P < 0.05$) and ovulation to progesterone rise (82.3 ± 4.2 vs. 60.6 ± 5.5 h; $P < 0.01$) were longer in late rise cows. There was no difference between groups in the interval from oestrus or LH surge to ovulation. In conclusion the results of this study further highlight the high variability that exists in the timing and interrelationships of follicular phase events in the modern dairy cow, reemphasising the challenges that exist in optimising mating strategies. However, the data do suggest that in cows with poor post ovulatory progesterone secretion, the key problem appears to be poor post ovulatory development rather than a delay in ovulation.

Keywords: Oestrus; Ovulation; Oestradiol; Progesterone; Luteinising hormone

1. Introduction

In cows, failure to detect oestrus and insemination at the wrong time are two of the many constraints to good fertility in dairy cows. Oestrus detection efficiency in dairy cows is only around 50% while insemination at the wrong time may occur in up to 30% of cows (De Rensis and Peters, 1999). Even when oestrous is successfully detected numerous studies have shown variations in the success of mating depending on when mating takes place relative to oestrus. It is generally accepted that optimum fertility is achieved if cows are inseminated 12–24 h following the onset of oestrus (Peters and Ball, 1995). However, the success of insemination

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depends on both the detection of oestrus and the timing of ovulation relative to insemination and, as fluctuations exist between individuals in the interval from oestrus to ovulation (Saumande and Humblot, 2005) optimum fertility is rarely achieved. Following synchronisation of cycles problems can be worse (Ryan et al., 1999) and many studies have attempted to improve the synchrony of oestrus and ovulation in controlled breeding programmes (for reviews see Nebel and Jobst, 1998; Thatcher et al., 2002). However, the success of these approaches is varied and involves considerable use of pharmaceuticals.

Both the timing of ovulation and the timing of the subsequent postovulatory progesterone rise are critical to successful fertilisation and early embryo development. Thus, even if mating has resulted in successful fertilisation, both the early development of the embryo (Kerbler et al., 1997; Mann and Lamming, 2001) and ultimately the successful establishment of pregnancy (Larson et al., 1997; Starbuck et al., 2001) rely on the timely initiation of post ovulatory progesterone secretion during the early luteal phase. While a link between a delayed post ovulatory progesterone rise following oestrus and insemination and poor embryo development and pregnancy rate has been established, whether this late rise results from a delay in ovulation or delay in the post ovulatory luteinisation has not been determined.

In this study we have characterised the variation in follicular phase events in cattle and related these to the time of ovulation and the timing of the post ovulatory progesterone rise in an attempt to quantify the problems associated with achieving successful mating and pregnancy rates.

2. Materials and methods

2.1. Experimental protocol

The study was performed 18 mature non-lactating Holstein–Friesian cows. Throughout the study, animals were maintained on a diet of hay and concentrate pellets and housed in group pens. Oestrous cycles were synchronised by two intramuscular injections of 50 μg of the prostaglandin $F_{2\alpha}$ analogue, cloprostenol (Estrumate; Schering-Plough Animal Health) administered 12 days apart. Prior to the second injection of prostaglandin, a jugular vein of each animal was cannulated under local anaesthesia with a 30-cm indwelling catheter (Secalon Universal Tubing, BOC Health Care). Cannulae were then maintained for the duration of the experiment and used for the collection of all blood samples. Blood samples were collected at 8 h intervals commencing at the time of the second prostaglandin injection until 240 h following prostaglandin. Additional samples were collected at 4 h intervals from 24–96 h following the second prostaglandin injection to determine the time of the luteinising hormone (LH) surge.

Cows were observed for signs of behavioural oestrus at 8 h intervals for 15 min prior to the collection of samples and throughout the movement of animals from the lose housing to the sampling stalls. To assist in the detection of oestrus, cows were fitted with Kamar Heatmount detectors (Kamar Inc.).

Commencing at the onset of oestrus, and continuing until the observation of ovulation, cows underwent trans rectal ultrasound scanning at 8 h intervals, using an Aloka scanner equipped with a 5-MHz linear array transducer (SSD-500, Zandersteen). The position of all large follicles (>10 mm) was noted at each scanning period. Ovulation was then determined as the time point at which a large follicle that had been present at the previous scan has disappeared.

2.2. Hormone assays

Progesterone was measured in plasma by previously described radioimmunoassay (Law et al., 1992). Intra and inter-assay coefficients of variation were 8.3% and 9.6% and sensitivity was 0.2 ng mL^{-1} plasma. Oestradiol was measured in plasma following extraction with diethyl ether using an assay kit produced by Serono Diagnostics (E2 MAIA, Serono Diagnostics Ltd) modified for use in the cow (Mann et al., 1995). Intra and inter-assay coefficients of variation were 7.1% and 11.6% and sensitivity was 0.5 pg mL^{-1}. LH was measured by radioimmunoassay (Mann and Lamming, 2000). All samples were included in a single assay with an intra-assay coefficient of variation of 10.1% and sensitivity of 0.1 ng mL^{-1}.

2.3. Analysis of data

Throughout the paper means are presented with SEM. The length of the follicular phase was calculated for each animal and cows divided into two groups with longer and shorter follicular phases for subsequent comparison. Patterns of plasma progesterone in the two groups were compared by repeated sample analysis of variance. Other characteristics were compared by Student's *t* test.

3. Results

One cow became lame while in oestrus and was removed from the study. A further cow showed bleeding of the rectal wall after only one ultrasound scan and was also removed from the study. Another cow did not come into oestrus until seven days after prostaglandin and was also excluded as was a cow that had already