Timing single fixed-time inseminations in ewes: Some new concepts

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ABSTRACT

The mean interval from the end of synchrony treatment to the onset of oestrus can be highly variable and as a consequence 'single-time' inseminations *may* occur at other than optimal times. This study was undertaken to identify some of the factors influencing the interval to oestrus following synchrony treatment, and to develop a spreadsheet model to assist with determining the timing of AI in ewes under a range of oestrous onset patterns. Synchrony device, PMSG, time of year, and live weight tended to have important effects on the interval to oestrus. Ewe genotype and year effects were generally small. Three new concepts have arisen from the modelling exercise. Firstly, the actual timing of AI to achieve near maximum fertility depends on the mean interval to oestrus in a given flock, but not the precision of synchrony or the incidence of ewes that are synchronised. Secondly, the 'tolerance' about this optimum time of insemination depends on how much is known about the mean interval to onset (more information means more tolerance). Thirdly, the 'tolerance' about this optimum time of insemination depends on the maximum reduction in flock pregnancy rate that is acceptable to the flock owner (higher reduction means more tolerance). If the onset pattern in a particular flock is unknown, the 'universal' timing for a single fixed-time AI during the breeding season is 42-46 h after CIDR® removal, provided a drop in flock pregnancy rate of up to 5% is acceptable.

Keywords: ewes; AI; oestrous synchronisation; fixed-time AI; interval to oestrus.

INTRODUCTION

Synchronisation of oestrus in livestock is used to facilitate conception on a pre-determined date, and commonly, at a pre-determined hour. Where synchronisation is used to facilitate out-of-season conception with natural mating in ewes, synchrony need not be precise (3-5 d spread acceptable). Where synchrony is used as an adjunct to artificial insemination (AI), the synchrony may need to be more precise, if high conception rates are required following a single insemination at a fixed time (abbreviated using the acronym SIFT). Thus, the major biological benefit of synchrony is that high fertility would be expected following an appropriately timed SIFT, as a consequence of more ewes inseminated at or near the optimum time for high fertility. The major logistical benefit accruing to the use of a synchrony treatment in conjunction with SIFT is the greatly reduced need for oestrous detection, and therefore a saving in time and labour. However, one of the practical issues associated with SIFT is determining when to time AI relative to the end of synchrony treatment. In particular, the extent to which oestrous activity must be monitored to ensure correct timing of insemination is unknown.

This study was undertaken to develop some new concepts to consider which may assist with determining when to time AI relative to the end of synchrony treatment by: 1. summarising some of the factors likely to influence the interval from the end of synchrony treatment to the onset of oestrus, and 2. developing a spreadsheet model to assess the consequences for flock fertility of varying the timing of AI.

FACTORS AFFECTING THE MEAN INTERVAL TO ONSET OF OESTRUS

This section deals exclusively with results from NZ studies. In the main, the studies reported have used progesterone-impregnated controlled internal drug release devices (CIDR®) to control the onset of oestrous activity. Unless otherwise stated, the intervals were recorded during the breeding season.

Synchrony device: CIDR®-treated ewes generally have 10-24 h shorter mean intervals when compared with MAP (medroxy acetate progesterone) and FGA (fluoro gestone acetate) sponge-treated ewes, depending on feeding level (eg, Welch *et al.*, 1990; Shackell, 1991). The difference is greater at higher (5 kg dry matter/head/day) compared with lower (1 kg DM/h/d) feed allowances during synchrony treatment (Welch *et al.*, 1990).

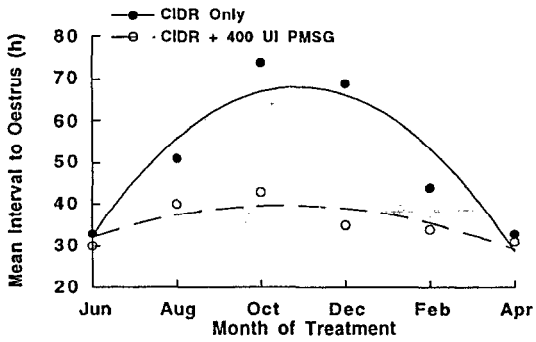
Dose of pregnant mares' serum gonadotrophin (PMSG): Ewes treated with PMSG at doses of either 0, 400 or 800 IU during the breeding season (April) have similar mean (± sem) intervals (33 ± 1.7 vs 31 ± 1.6 vs 30 ± 1.6 h respectively, Smith *et al.*, 1991). However, compared with untreated controls, treatment with 400 or 800 IU outside the breeding season (August) decreased the mean interval as well as the variation (50 ± 3.9 vs 39 ± 2.1 vs 37 ± 2.1 h, respectively). There appears to be no advantage in increasing the dose from 400 to 800 IU.

Breed/strain of ewe: Little NZ data exists on breed of ewe effects, although during the breeding season Coopworth ewes appear to differ little from Dorset x Coopworth (31 ± 1.4 vs 33 ± 2.1 h, Smith *et al.*, 1991) and similarly no difference exists between Romney and Perendale ewes (29 vs 30 h, McMillan, unpublished data). Strains of Romney ewe selected either for or against lamb faecal egg count have similar mean intervals to oestrus ((27 ± 1.1 vs 25 ± 1.1 h, McMillan *et al.*, 1992).

Week, month and year: During March (early breeding season), the mean interval to the onset of oestrus is shorter in ewes treated later in the month (McMillan, W.H. unpublished). For example, an 8 h difference (35 vs 27 h) was

apparent between groups of ewes with the earliest (9-th March) and latest dates (23-rd March) at end of synchrony treatment. Month can have a very large effect on both the mean interval to oestrus as well as the variation around the mean interval (Figure 1). During the breeding season, (March to June), the mean interval in ewes receiving no PMSG is shorter (30-35 h) and less variable between ewes within a mob. By contrast, during the non-breeding season (July to February) the mean interval is longer (45-75 h) with more variation between ewes within a mob. There appears to be no published data on the between-flock variation in the mean interval to onset of oestrus during the year. Interestingly, there is little variation in the mean interval between years at the same location (eg, 35 ± 1.0 to 37 ± 1.0 h over a 4 year period, Smith *et al.*, 1991).

FIGURE 1: Effect of month of treatment on the mean interval to oestrus in ewes treated with either a CIDR® or a CIDR® and 400 IU PMSG (from Smith *et al.*, 1988).



Live weight and feeding level: Within a mob of ewes, heavier ewes tend to show oestrus sooner after the end of synchrony treatment compared with lighter ewes. For example, when the heaviest 25% of ewes in a 1000 ewe Romney flock (mean live weight = 50 kg) were compared with the lightest 25% of ewes (mean live weight = 40 kg), the mean interval differed by about 8 h (27 vs 35 h) when ewes were fed to maintain weight and by 10 h (26 vs 36) when ewes were fed to rapidly gain weight (Welch *et al.*, 1990). The effect of feeding level on the mean interval to oestrus in all ewes was small.

EFFECTS OF VARYING THE INTERVAL TO OESTRUS ON FLOCK FERTILITY: A MODELLING APPROACH

Materials and Methods

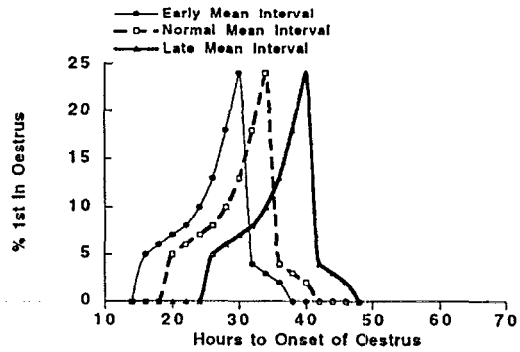
A spreadsheet model was developed which had 3 input factors; a frequency distribution of intervals from the end of synchrony treatment to oestrus (synchrony pattern); the pregnancy rate of ewes inseminated at various times relative to the onset of oestrus (fertility profile); and the timing of SIFT relative to the end of synchrony treatment. For a given synchrony pattern, fertility profile and timing of SIFT, the model calculates the flock pregnancy rate.

In the current study, only one fertility profile was used and the timing of SIFT varied between 30 and 55 h after the end of synchrony treatment for all analyses (see details later).

The model then calculated the flock pregnancy rate for a range of different synchrony patterns in order to test the sensitivity of flock pregnancy rate to variations in the timing of SIFT. For each synchrony pattern, the resulting flock pregnancy rate was then plotted against the timing of SIFT and the relationship between the two variables established using regression techniques. The regression relationship (curvilinear in each case) was then used to estimate the optimum timing of SIFT ($SIFT_{Opt}$) and the expected maximal flock pregnancy rate (PR_{Max}) (using differential calculus). In addition, the range in the timing of SIFT to achieve expected flock pregnancy rates at 5 ($SIFT_{\leq 5\%}$) and 10 ($SIFT_{\leq 10\%}$) percentage units lower than PR_{Max} were also determined through substitution in the regression equation. Twelve different synchrony patterns (3 mean intervals x 2 precision of synchrony x 2 incidence of ewes responding to synchrony treatment) were modelled. The twelve synchrony patterns were chosen to represent the likely range following CIDR®-synchrony in New Zealand during the breeding season.

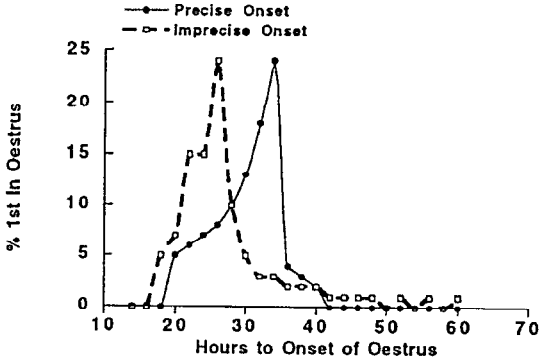
Synchrony patterns with different mean intervals to onset of oestrus: The three synchrony patterns used in the model differed with respect to the mean interval to onset of oestrus after the end of synchrony treatment (Early = 25 h, Normal = 30 h and Late = 35 h, Figure 2). These mean intervals were chosen because they represent the range in mean intervals reported during the breeding season in an earlier section of this paper. If the research flocks from which this data was recorded fairly represent the synchrony patterns expected in commercial flocks, then the outcomes from the modelling analysis would be expected to have widespread relevance.

FIGURE 2: Distribution of intervals from CIDR® removal to onset of oestrus in ewe flocks with an Early, Normal or Late onset pattern.



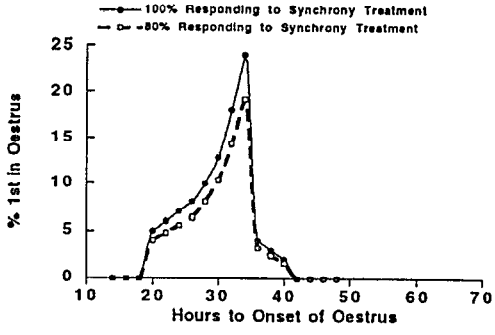
Synchrony patterns with different levels of precision of onset: It was considered important to model the likely impact of a precise compared with an imprecise synchrony pattern on flock fertility (Figure 3). Precise synchrony patterns were considered to be patterns in which all oestrous onset occurred over a 20 h interval. This is close to the highest level of precision of onset that current synchrony treatments are able to achieve (McMillan, W.H. unpub.). Imprecise oestrous onset occurred over a 40 h interval. In modelling the effects of Precise and Imprecise synchrony patterns, the mean interval to onset was kept constant for each pair so as to fairly identify the effect of precision of synchrony unconfounded by variation in the mean interval to onset.

FIGURE 3: Distribution of intervals from CIDR® removal to onset of oestrus in ewe flocks with a precise or an imprecise onset pattern.



Synchrony patterns with different proportions of ewes responding: The effect of a high (High = 100%) and a low (Low = 80%) proportion of ewes responding with an oestrus within 72 h of device removal was included in the analysis. They represent the extremes encountered in CIDR®-treated ewes during the breeding season in New Zealand (McMillan, W.H. unpub.).

FIGURE 4: Distribution of intervals from CIDR® removal to onset of oestrus in ewe flocks with 100% or 80% of ewes responding with an oestrus within 72 h of device removal.



Fertility profile of inseminated ewes: A single fertility profile was constructed for use in the model using the data from Paton *et al.*, 1993 with fresh cervical inseminations. Other than the data from Shackell *et al.*, 1990, apparently no other local information is published from which alternative fertility profiles can be constructed.

Timing of SIFT: The timings evaluated in the model were 30, 35, 40, 45, 50 and 55 h after the end of synchrony treatment. These cover the range in timings used in most studies (Harvey *et al.*, 1984; 1986; Paton *et al.*, 1993).

Results

In each instance, the flock pregnancy rate varied in a curvilinear manner as the timing of SIFT was varied from 30 to 55 h after the end of synchrony treatment (see for example Figure 6). Over 98% of the variation in flock pregnancy rate could be explained by variation in the timing of SIFT for each of the twelve synchrony patterns examined. The effect on $SIFT_{Opt}$, PR_{Max}, $SIFT_{\leq 5\%}$ and $SIFT_{\leq 10\%}$ of Early, Normal and Late mean intervals to onset were largely independent of the

FIGURE 5: Effect of timing of AI relative to onset of oestrus, on ewe pregnancy rate (based on Paton *et al.*, 1993).

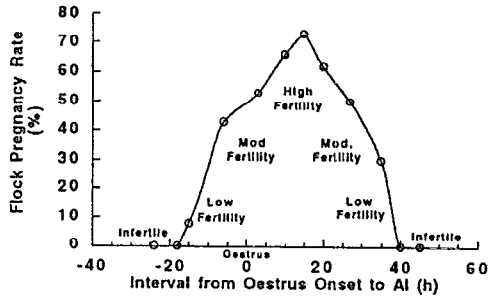
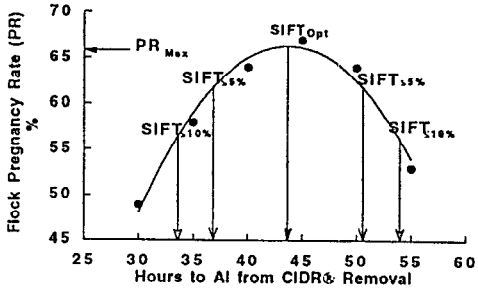


FIGURE 6: Relationship between timing of AI relative to CIDR® removal, and flock pregnancy rate (Normal mean interval to onset, precise synchrony, 100% ewes in oestrus).



precision of the synchrony, and the incidence of ewes responding (Table 1), with one exception. With only 80% of ewes responding to synchrony treatment, PR_{Max}, was reduced by a factor of 0.8, but $SIFT_{Opt}$, $SIFT_{\leq 5\%}$ and $SIFT_{\leq 10\%}$ did not alter compared with 100% of ewes responding.

Maximum flock pregnancy rate was similar in Early, Normal and Late ewes (59 vs 59 vs 58%), and was achieved with SIFT timed at 15, 14 and 17 h after the mean interval to onset in *each* of the three respective groups of ewes (Table 1). Only 6% of ewes in flocks with an imprecise onset pattern and no ewes in flocks with a precise onset pattern had failed to initiate oestrous activity by these optimum times for SIFT.

For Early, Normal and Late ewes a flock pregnancy rate within 5% of the maximum could be achieved if SIFT was timed over a 13 h (33-46 h), 14 h (36-50 h) and 21 h (42-63 h) period respectively (Table 1). The respective values for a flock pregnancy rate within 10% of the maximum are 20 h (30-50 h), 20 h (33-53 h) and 29 h (38-67 h).

If the onset pattern for a particular flock is not known, but is expected to be within the range of the twelve scenarios covered by this analysis, the data in Table 1 can be used to determine a timing for SIFT that maximises the chance of high pregnancy rates. The indication is that timing SIFT between 42 and 46 h after the end of synchrony treatment would result in a flock pregnancy rate within 5% of the maximum achievable. This 4 hour window overlaps all twelve patterns of onset examined.

DISCUSSION

The four key findings in this study are: 1. during the breeding season, the mean interval to onset of oestrus ranges between 25 and 35 h although for any given flock and

TABLE 1: Effect of mean interval to onset, precision of synchrony and incidence of ewes responding on PR_{Max}, $SIFT_{Opt}$, $SIFT_{\leq 5\%}$ and $SIFT_{\leq 10\%}$ (see text for definitions).

Mean Interval	Precision	Incidence Responding	PR_{Max} %	$SIFT_{Opt}$ h*	$SIFT_{\leq 5\%}$ h*	$SIFT_{\leq 10\%}$ h*
Early	Precise	100%	67	40	34-47	31-50
		80%	53	40	33-47	30-51
	Imprecise	100%	64	39	32-45	29-48
		80%	53	40	33-47	30-51
	Overall	Overall	59	40	33-46	30-50
Normal	Precise	100%	66	44	37-50	34-53
		80%	53	44	36-51	33-54
	Imprecise	100%	65	44	36-49	33-52
		80%	52	42	35-49	31-53
	Overall	Overall	59	44	36-50	33-53
Late	Precise	100%	66	52	45-68	40-72
		80%	53	56	43-69	38-74
	Imprecise	100%	63	49	41-57	37-61
		80%	50	49	40-58	36-62
	Overall	Overall	58	52	42-63	38-67

* hours post CIDR® removal

location this interval appears largely unpredictable; 2. the mean interval to onset of oestrus has a major impact on the timing of AI for maximum fertility, 3. the precision of synchrony has only minor effects on maximum flock pregnancy rates and the timing of SIFT, and 4. SIFT can be timed over a period as short as 4 h (if no information is available on synchrony pattern) or as long as 21 h (in a flock with a known late onset pattern) with maximum or near maximum flock pregnancy rate, depending on how much monitoring of oestrous activity is carried out to define the synchrony pattern

Although the mean interval to oestrus is largely unpredictable, the modelling analysis suggests some important strategies for coping with this when determining the timing of SIFT. An important outcome of the analysis was that acceptably wide 'windows' for timing AI do exist, and that the greater the extent to which the mean interval to onset for a particular flock is known, then the wider these 'windows' become. Thus, if a flock is known to have a given mean interval to onset (say early), then SIFT can be timed between 33 and 46 h after CIDR® removal to achieve near maximum flock pregnancy rate. The appropriate intervals for normal and late intervals to onset are 36-50 h and 42-63 h respectively. Under most practical conditions, these 'windows' are sufficiently wide to cope with the unexpected (eg mis-timed arrival of semen, etc), without jeopardising flock pregnancy rate. In flocks where bookings for inseminators are made some days or weeks prior to the day of AI, then the timing of the end of synchrony treatment should be about 42 h prior to the expected start of inseminations to ensure SIFT takes place at a time to maximise flock pregnancy rate. In practice, this would mean that synchrony treatment would end between 2 pm and 6 pm for inseminations booked to start between 8 am and noon two days later, and between 6 pm and 10 pm for inseminations booked to start between noon and 4 pm.

If detailed monitoring of flocks for oestrus is not possible, the modelling analysis predicts appropriate 'windows' that allow for the fact that little (or even no) information is available on the mean interval to onset. If, through a limited amount of monitoring of oestrous activity, we know that the flock is not early (ie it could be normal or even late), then SIFT can be timed between 42 and 50 h after the end of synchrony treatment for maximum or near maximum flock pregnancy rates. Although this 'window' is only 8 h wide, it still provides reasonable scope under most practical conditions to appropriately time SIFT. If no information is available on the mean interval to onset, then the 'window' between 42 and 46 h will result in near maximum flock pregnancy rates. This 'window' is the only common time when timing SIFT for early, normal and late mean intervals to onset. Although this versatile 'window' is only 4 h wide, it enables the maximum 'labour saving' benefit of a SIFT system since no oestrous monitoring is required.

The finding that precision of synchrony has little impact on the appropriate timing of SIFT and the resulting flock pregnancy rate was unexpected. This finding arose largely because an imprecise onset was defined essentially as one in which about 70% of the ewes were in oestrus before the mean interval and that intervals were delayed in the remaining 30% of ewes. This 'tail' effect did not occur in the precise onset pattern where about 50% of the ewes were in oestrus after the mean interval. Furthermore, only 6% of ewes in flocks with an imprecise onset pattern and no ewes in flocks with a precise onset pattern had failed to initiate oestrous activity by the optimum times for SIFT.

CONCLUSIONS

In conclusion, well-defined 'windows' exist for timing single-time fixed-time inseminations in sheep. The effective width of these 'windows' and their position relative to the end of synchrony treatment is dependent on the amount of oestrous monitoring that is undertaken and the reduction in fertility that is acceptable in return for an AI system involving only a single fixed-time insemination. Both of these conditions are fully under the control of flock managers. A 'window' exists which allows a maximum in labour saving (ie no oestrous monitoring) and which is compatible with near maximum flock pregnancy rates. Further data on 'fertility profiles' of

ewes inseminated by other means (eg laparoscopic, trans-cervical, frozen-thawed semen) and in other flocks at a range of locations would allow the model to be further enhanced.

REFERENCES

Harvey, T.G., Johnson, D.L., Baker, R.L., Trust, B.K., Thomson, B.C. 1986. Artificial insemination in sheep - comparison of storage time, dose rate and insemination technique. *Proceedings of the New Zealand Society of Animal Production* **46:** 229-232.

Harvey, T.G., Johnson, D.L., Tervit, H.R., Welch, R.A.S. 1984. Synchronisation and artificial insemination of ewes - techniques which have possible commercial application. *Proceedings of the New Zealand Society of Animal Production* **44:** 7-9.

McMillan, W.H., Hall, D.R.H., Watson, T.G. 1992. Reproduction in flocks selected for and against lamb faecal egg count. *Proceedings of the New Zealand Society of Animal Production* **52:** 65-68.

Paton, A.J., Harvey, T.G., McCutcheon, S.N. 1993. Effects of CIDR removal-insemination interval on conception rate in sheep AI. *Proceedings of the New Zealand Society of Animal Production* **53:** 291-293.

Shackell, G.H. 1991. The timing of oestrus, LH surge and ovulation in ewes following synchronisation with MAP sponges FGA sponges or CIDR's. *Proceedings of the New Zealand Society of Animal Production* **50:** 73-77.

Shackell, G.H.; Kyle, B. and Littlejohn, R.P. 190. Factors influencing the success of a large artificial insemination programme in sheep. *Proceedings of the New Zealand Society of Animal Production* **50:** 427-430.

Smith, J.F., Cruickshank, G.F., McGowan, L.T., Parr, J. Mortimer, J. 1988. Seasonal changes in oestrus, ovulation rate and conception of Coopworth ewes treated with CIDRs and PMSG. *Proceedings of the New Zealand Society of Animal Production* **48:** 99-102.

Smith, J.F., Konlechner, J.A., Parr, J. 1991. Factors influencing the time to onset of oestrus after synchronisation treatment in ewes. *Proceedings of the New Zealand Society of Animal Production* **51:** 117-121.

Welch, R.A.S., Kelly, R.W., Macmillan, K.L., Henderson, H.V. 1990. Some effects of ewe liveweight and feed allowance on the oestrous response of synchronised ewes. *Proceedings of the New Zealand Society of Endocrinology* **33:** 40 (Abstract).