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Modelling the effects of zero-inductions on profitability in dairy systems

P.C. BEUKES, B.S. THORROLD, M.E. WASTNEY, C.B. GLASSEY, C.R. BURKE and A.M. VAN BYSTERVELDT

Dexcel Limited, Private Bag 3221, Hamilton, New Zealand

ABSTRACT

Inductions are an animal welfare issue and regulations aim to achieve < 2% inductions on a national basis by 2010. There is a need to assess the longer-term impacts of alternative reproduction management strategies on farm economics and their success in solving the problem of poor reproductive performance. Dexcel's Whole Farm Model was calibrated against observed data from Lincoln University Dairy Farm where 11% of the herd was subjected to inductions in the 2002/03 season, but a zero-induction policy has since been adopted. Results from one-year simulations over five different climate years showed a significant decrease in farm profit ($105/ha, $P < 0.05$) from the benchmark farm with 11% inductions (following 'best practice' guidelines) to a farm where the late-calvers were culled and replaced by bought-in early-calving heifers and where stocking rate was raised moderately (< 10%) to compensate for the higher proportion of heifers in the herd. Multiple-year simulations reflecting carry-over effects showed that a strategy with a 10-week mating period, annual culling of 25% of the herd including all empties and replacement with synchronized heifers mated to start calving one week before planned start of calving can match the farm profitability of the 'Induction' strategy if implemented consistently for 5-8 years.

Key words: calving spread; modelling; synchrony; mating; replacement.

INTRODUCTION

Inducing cows to calve earlier achieves more days in milk (Verkerk *et al.*, 2000) and improves pregnancy rates in the following mating season (Xu & Burton, 2003). However, inductions are seen as non-animal-friendly and the national trend on dairy farms is to move away from inductions (Macmillan, 1995). At Lincoln University Dairy Farm (LUDF), calving in 11% of the herd was induced in the 2002/03 season. However, LUDF has since adopted a zero-induction policy.

The effects of this change in policy on the performance and profitability of the herd, and the risks attached to the change, are not known. The objective of this modelling exercise was to explore different calving strategies over different climate years, and to make recommendations on how to manage calving spread and stocking rate to achieve high profit and low risk, in a system from which inductions have been eliminated.

METHODS

Modelling was undertaken using the Whole Farm Model (WFM) version 8.8.1.0 [with the McCall pasture model (McCall & Bishop-Hurley, 2003) and the 'Molly' cow model (Baldwin, 1995) modified for New Zealand cows (Palliser *et al.*, 2001)]. Three steps were involved: 1) model set-up and comparison to observed data from LUDF; 2) modelling an induction strategy and two alternative calving strategies over five individual climate years; and, 3) modelling an induction strategy and two alternative calving strategies over eight consecutive climate years including carry-over effects.

Basic model set-up and comparison to observed data

An animal input file was compiled using observed data from 44 cows from the LUDF monitor herd at the start (1 June) of the 2002/03 season. Observed initial live weight, age, calving and dry-off dates were used to initialize individual cows in the model.

A land input file was compiled using the observed covers for the 21 paddocks at the start of the 2002/03 season. Paddock sizes were proportionally reduced from observed to model input to give a stocking rate of 3.65 cows/ha (44 cows on 12.05 ha).

The observed amounts of grass and maize silage fed over the 2002/03 season were used to set the size of the initial grass silage reserve (70 t wet mass @ 25% DM content) and maize silage reserve (14 t wet mass @ 33% DM content). Feed out loss factors were set to 10% for both reserves.

The management policy for feeding supplements was set to feed both dry and milking cows pasture first, as long as there was adequate pasture available (according to each day's fixed break size), then to feed grass silage to depletion, followed by maize silage. For conservation of silage, paddocks could be closed when there was excess pasture (according to rules derived from Macdonald & Penno, 1998) during the period 1 September to 1 April. Silage made was added to the grass silage reserve with a loss factor of 15%.

All paddocks received irrigation water to a maximum of 6 mm per day according to the observed schedule for the 2002/03 season, totaling 600 mm for the year. This irrigation strategy was identical in all years. Irrigation water was added to rain water in affecting the behaviour of the pasture model. N-fertilizer was added to individual paddocks according to the observed schedule for 2002/03 season of 20 kg/ha/month for the period August – May totaling 200 kg N/ha/year.

The observed grazing-off strategy was simulated by fully feeding all cows off farm between 1 June and 22 July.

Modelling calving strategies over individual climate years

An induction strategy and two alternative calving strategies were simulated over five climate years (1994/95 to 1998/99) using the observed climate data from Lincoln University Meteorological station to drive the pasture model. Each climate year was modelled individually, with no carry-over of effects from year to year. Each year was started with the same inputs of animals, land and silage. Changes in farm cover, silage reserves and cow condition between the start and end of the simulation for each year were accounted for in the Economic Farm Surplus (EFS).

For the 'Induction' strategy, the calving dates of some cows in the monitor herd (44 cow animal input file) were adjusted to reflect the observed calving spread for the full LUDF herd in the 2002/03 season with 11% inductions in the first two weeks after planned start of calving (PSC, 29 July) (Table 1). For the 'No-Management' strategy, inductions were eliminated with no other management practices to improve calving spread. For the 'Cull-and-Replace' strategy, inductions were eliminated and the late-calvers (those that were induced in the 'Induction' strategy) were culled and replaced with heifers, all of which calved a week before planned start of calving (Table 1). Cows were dried off according to the observed dates of mid-May for part of the herd and end-May for the rest.

For the economic analysis the payout was assumed to be \$3.90/kg milksolids, the cost of maize silage to be \$220/t DM, and the cost of winter grazing-off to be \$15/dry cow per week. The default animal health cost of \$68/cow includes the cost of inductions (Dexcel, 2004). Induced cows were initialized in the model to reflect a reduction in their milk production potential of 6% (Verkerk *et al.*, 2000). When inductions were eliminated a saving of \$40/induced cow was assumed (includes drugs, labour and more live calves). The culling and replacement of 11% late-calvers in the 'Cull-and-Replace' strategy was assumed to be over and above the 'normal' culling and replacement of 25% of the herd accounted for in the default stock income and replacement costs. For this extra culling the income from culled cows was assumed to be \$600/cow and the cost of a replacement heifer \$750/cow. Labour costs were assumed to be similar for all strategies.

Modelling calving strategies over multiple years with carry-over effects

The three strategies studied were (a) 'Induction', with all cows due to calve more than ten weeks after PSC induced to calve within the first two weeks post-PSC, and normal culling and replacement to keep the herd structure at 25% heifers per year. It was assumed that inductions were 100% effective with no deaths and no effects on subsequent in-calf rate (Xu & Burton, 2003). The calving spread in year 1 was similar to 'Induction' in Table 1; (b) a 'No-Induction plus No-Synchrony' strategy with a 10-week mating period, culling of all empty cows plus randomly selected cows up to 25% of the herd at the end of the year after dry-off. Replacement heifers had a calving spread starting at PSC and extending for 10 weeks after PSC. The calving spread in year 1 was similar to 'No-Management' in Table 1; (c) a 'No-Induction plus Synchrony' strategy with everything the same as with 'No-Induction plus No-Synchrony' except that the replacement heifers were subjected to a synchrony programme and mated to start calving one week before PSC with a calving spread extending for 10 weeks after PSC. The initial calving spread was similar to 'No-Management' in Table 1.

TABLE 1: Model settings for herd proportions (%) calving at different times after planned start of calving (PSC) for an induction and two alternative calving strategies.

Days after PSC	Date	Induction	No-Management (no inductions)	Cull-and-Replace (no inductions)
< 0	29 Jul	0	0	11
14	12 Aug	36	25	36
28	26 Aug	64	52	64
56	23 Sep	92	80	92
70	7 Oct	100	89	100
84	21 Oct		100	culled

These strategies were modelled for eight consecutive climate years (1994/95 – 2001/02) using observed climate data to drive the pasture model. Cow live weights, paddock covers and silage reserves were carried over from the end of one year's simulation to the start of the next year, together with their consequences.

Predicting conception

In the multiple-year simulations cows were mated (and assumed to conceive) on a specified date depending on their calving date in a particular year. The mating (and conception) of cows in the model was implemented by a mating management policy which calculated mating/conception dates based on a derived relationship between calving date in one year and calving date the following year. This policy was based on the known relationships between calving date, post-partum anoestrus, submission and non-return rates (Holmes *et al.*, 2002). Target and observed calving and mating performances from LUDF over a number of seasons were used to derive an equation used in the mating management policy to calculate mating date:

$$MD = CD + 83+[(0.0091*(CD-PSC)^2+0.9973*(CD-PSC)-0.5229)-(CD-PSC)]$$

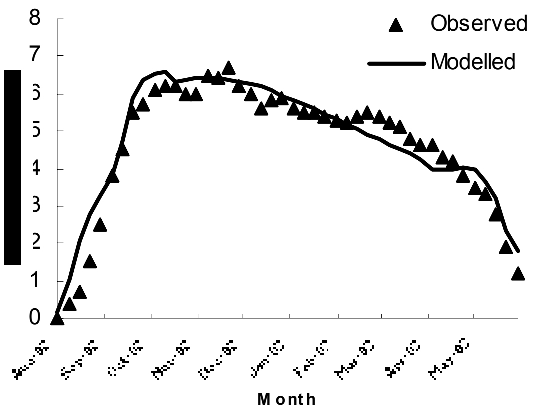
where MD = Mating date
CD = Calving date
PSC = Planned start of calving

This gives the lag from calving date to mating date with a minimum of 83 days. As calving date is later than PSC, lag to mating date is greater. The implementation of this policy in the model assumed a constant level of mating management and reproductive genetics not influenced by the culling measures in any of the strategies. The policy resulted in a constant rate of 'disintegration' of the calving spread from year to year. It also assumed no feedback of cow nutrition on reproductive performance, and no effect of cow age on lag time. With the no induction strategies, cows not mated within a ten week mating period (20 Oct – 29 Dec) were regarded as empty and were culled at the end of the year. With the 'No-Induction plus Synchrony' strategy it was assumed that the 25% replacement heifers were synchronized every year at a cost of $15/heifer.

RESULTS

The calibrated WFM (Basic model set-up described above) predicted a milk solids yield of 1463 kg/ha compared to the observed 1411 kg/ha for LUDF in the 2002/03 season (Figure 1).

FIGURE 1: Calibration of the Whole Farm Model: Modelled versus observed weekly milksolids yield for LUDF over 2002/03 season.



A one-way analysis of variance with the three calving strategies as treatments and year as a randomized block (Genstat 7.1) showed that calving strategy had a significant effect ($P < 0.001$) on farm profit and that this effect was consistent across different climate years (Table 2).

TABLE 2: Average Economic Farm Surplus (EFS) and standard deviation (SD) for an induction and two alternative calving strategies over five climate years. Means with similar superscripts do not differ significantly.

	Induction	No-Management (no induction)	Cull-and-Replace (no induction)
EFS ($/ha)	2,203[a]	2,116[b]	1,978[c]
SD	268	265	246

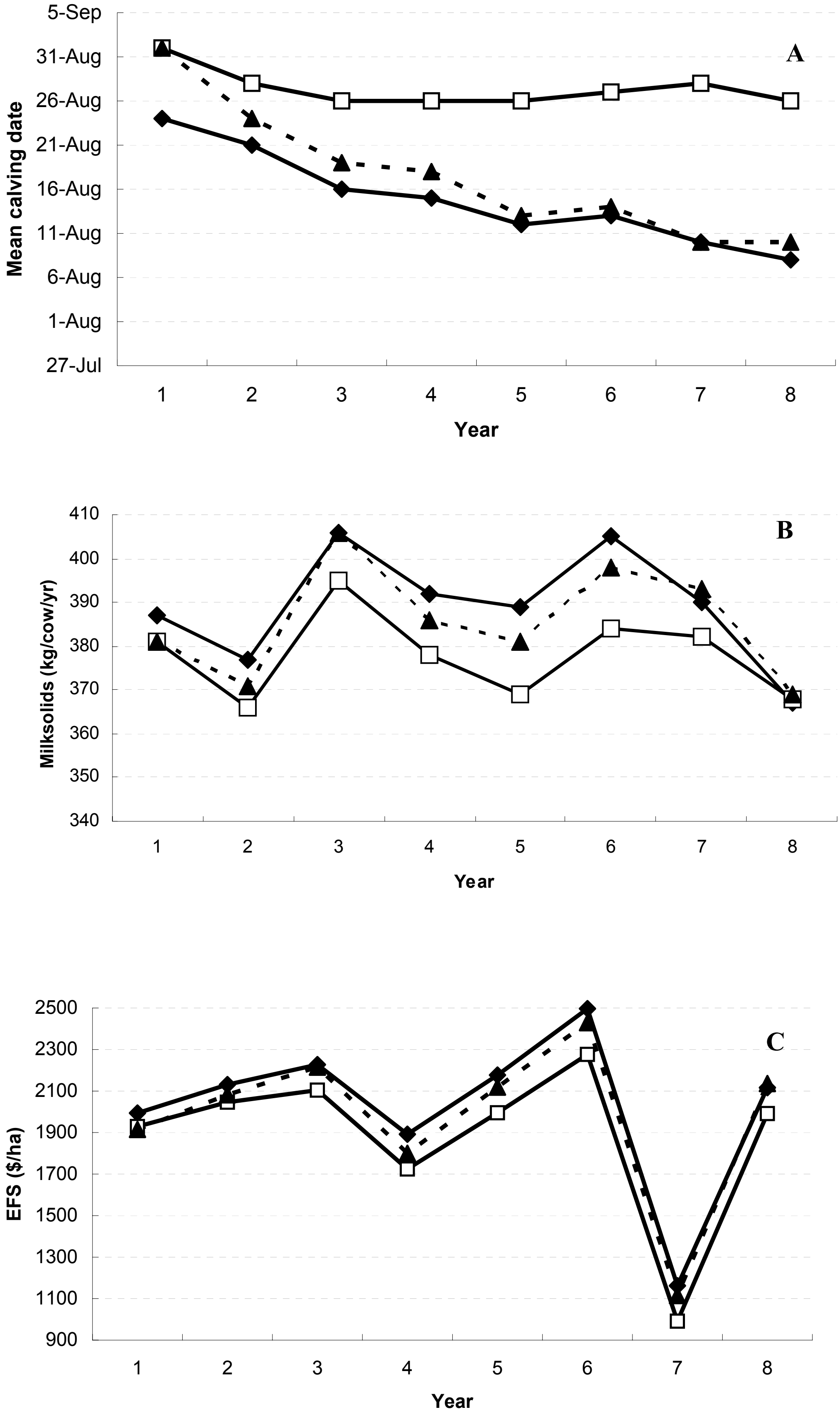
'No-Management' (with no inductions) showed an average EFS of $87/ha less than the 'Induction' strategy. The culling and replacement of 11% late-calvers in the 'Cull-and-Replace' strategy resulted in a larger proportion of the herd consisting of heifers. Feed demand was therefore lower compared with 'Induction' giving on average 1897 kg DM/ha silage surplus at the end of the year. The stocking rate for the 'Cull-and-Replace' strategy was raised from 3.65 to 3.82 cows/ha to utilise this extra feed. Over the five climate years the 'Cull-and-Replace' strategy with raised stocking rate showed an average EFS of $2,098/ha (SD 269), which was a significant improvement on the original 'Cull-and-Replace' strategy, but significantly less ($105/ha) than the 'Induction' strategy (Table 2).

Results of the multiple-year simulations confirmed the profitability of early inductions in a situation where calving was continuously spreading out, and feed was available to support the early-calving induced cows. It also showed that when the 'No-Induction plus Synchrony' strategy was implemented consistently for 5-8 years, assuming no change in the level of reproductive genetics and mating management in any scenario, there was a trend for mean calving date, per cow production and EFS to approach the levels achieved by the 'Induction' strategy (Figure 2).

DISCUSSION

This modelling exercise showed the value of condensed calving. The results support the findings of two previous modelling exercises illustrating the importance for farm profitability of, amongst others, per cow performance and an early and tight calving spread (Savage, 1996), and a high cull-and-replacement rate associated with a restricted breeding period (Gifford, 1994). Inductions (assuming no adverse effects on cows) were successful and profitable (by $100 to $200/ha) in condensing long calving spreads. The

FIGURE 2: Trend lines over eight climate years for (A) mean calving date (B) milksolids per cow (C) EFS for three calving strategies. 'Induction' = solid diamonds; 'No-Induction plus No-Synchrony' = open squares; 'No-Induction plus Synchrony' = solid triangles and broken line.



results confirm that farm systems with zero-inductions as part of the calving strategy will have profitability limited by not using inductions, unless a deliberate and consistent effort is implemented over a number of years to condense the calving spread by treating the causes rather than the effect.

With the 'No-Management' strategy, the savings from no inductions did not compensate for the lower production per cow as a result of fewer (eight) days in milk. With this strategy the feed demand was more in phase with the pasture supply in spring because of the extended calving spread. Milking cows required less silage and this improved their daily production. However, this cannot be regarded as a long term solution as the extended calving spread can be expected to disintegrate further and result in cascading negative impacts such as an increasing proportion of empty cows and labour issues when calving and mating start to overlap.

With the 'Cull-and-Replace' strategy the cost of buying in replacement heifers and the lower production potential of the larger proportion of heifers in the herd was greater than the saving from not inducing. 'Cull-and-Replace' with an increased stocking rate put greater pressure on feed supply and therefore increased the financial risk of the strategy (SD increased from $246 to $269/ha), but the average profitability was still significantly less ($105/ha) than for 'Induction'.

The effect of variability in climate on per cow performance and farm profitability can be seen in the results of the multiple-year simulations (Figure 2 B,C). Year 7 was an exceptionally poor year because of low rainfall in autumn, and pasture production was estimated at 15 t/ha compared with an average of 17.5 t/ha for the other years. Large demands were made on the silage reserves in all three strategies resulting in very low end reserves, and consequently all three strategies ran short of feed in the following year (Year 8), which explains the small differences in per cow performance (Figure 2 B). This shows that the payback on strategies aimed at condensing calving spread is greater in seasons and systems where cows are well fed in early spring. Alternatively a poor season can neutralize the benefits of a condensed calving spread developed over a number of years.

The 'No-Induction plus No-Synchrony' strategy showed that by only treating the symptoms of a herd calving progressively later every year, i.e. by culling the empties after a ten-week mating period, mean calving date was not advanced consistently, and over the timespan of this modelling exercise this strategy did not match the profitability of 'Induction' (Figure 2).

The trendline for the 'No-Induction plus Synchrony' strategy showed a consistent improvement in calving spread, i.e. the mean calving date was advanced to match that of the 'Induction' by Year 5 (Figure 2 A). The resultant increase in days in milk affected per cow performance that drifted upwards to match the 'Induction' level by Year 7 (Figure 2 B). The consequences of the poor year 7 were still evident in year 8, which renders conclusions about calving strategies and farm profitability a bit tentative towards the end of this simulation period. However, it does appear that the 'No-Induction plus Synchrony' strategy has the potential to match the farm profitability of the 'Induction' strategy after being consistently implemented for 5-8 years (Figure 2 C).

CONCLUSION

Immediate termination of inductions might cost a farmer in the order of $9/ha per 1% of the herd induced, which will only be recovered over time by diligently implementing a cull-and-replacement strategy that addresses the reproductive causes of an outward drifting mean calving date.

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