Economic and Reproductive Outcome of Programs Combining Timed Artificial Insemination and Estrous Detection Simulated with a Daily Markov-Chain Model

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Objective

⇒To compare the economic and reproductive performance of programs combining timed AI (TAI) and different levels of AI after estrus detection (ED) using a daily Markov-chain model.

Experimental Procedures

⇒ A dairy herd was represented by Markov-chains simulation of events with every cow following daily probabilistic events of aging, culling, mortality, pregnancy, abortion, calving, and starting a new lactation. Cows culled and dying were replaced to maintain herd size constant (Figure 1).

⇒ Daily milk yield was determined based on parity (1 to 9), DIM (1 to 750 d), and reproductive status (open vs. 1 to 282 d pregnant).

⇒ The daily probability of pregnancy depended on the combination of insemination risk and conception risk for each program. All open cows had a probability of pregnancy between the end of the voluntary waiting period (VWP) and a cut-off for breding at 300 DIM. After the cut-off, cows were labeled as "do not breed" (DNB) until their milk production was below a certain threshold when they were culled (Figure 1A).

⇒ A large algorithm (>2.5 million equations) was iterated until the number of cows in each specific state remained unchanged (steady state).

⇒ The value of a program was calculated daily for each cow as the sum of 5 factors: milk income over feed cost (IOFC), culling cost, mortality cost, income from newborns, and AI costs.

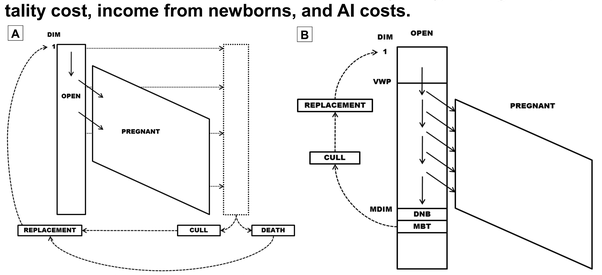

Figure 1. Panel A; Graphic representation of the involuntary culling and death process in the Markov-chain structure for one parity. DIM = days in milk. **Panel B;** Graphic representation of the breeding process in the Markov-chain structure for one parity. DIM = days in milk (d), VWP = voluntary waiting period (d), MDIM = cut-off DIM for breeding (d), DNB = do not breed, MBT = milk below threshold.

⇒ This model was used to compare the economic value of 19 reproductive management programs. Program 1 performed 100% TAI after synchronization with the Presynch-Ovsynch program for 1st service and Ovsynch Resynch for 2nd and subsequent TAI services. All other 18 programs combined the same synchronization protocol for TAI with different levels of estrus detection (ED; Table 1).

⇒ For TAI program 1 the VWP was 72 DIM. The VWP for ED in programs 2 to 19 was 50 DIM and first TAI occurred at 72 DIM. The interval between two successive TAI was 42 d in all programs.

⇒ The proportion of cows bred after ED in combined programs ranged between 30 and 80% and their CR ranged between 25, 30, and 35%. Because a different population of cows reached the TAI when ED was added it was expected that as the proportion of cows AI after ED increased the CR of TAI services decreased (Table 1).

Reproductive Programs Compared

Table 1. Input reproductive parameters used to calculate the reproductive performance for the 19 reproductive programs compared in the case study. [1]ED = estrous detection, [2]CR = conception rate.

Program	1st TAI			2nd and subsequent TAI		
	[1]ED before 1st TAI	[2]CR ED before 1st TAI	CR TAI	ED before TAI	CR ED before TAI	CR TAI
TAI 1	0	-	42	0	-	30
TAI + ED 2	30	25	40	30	25	30
TAI + ED 3	40	25	38	40	25	30
TAI + ED 4	50	25	36	50	25	30
TAI + ED 5	60	25	34	60	25	28
TAI + ED 6	70	25	32	70	25	28
TAI + ED 7	80	25	30	80	25	28
TAI + ED 8	30	30	40	30	30	30
TAI + ED 9	40	30	38	40	30	30
TAI + ED 10	50	30	36	50	30	30
TAI + ED 11	60	30	34	60	30	28
TAI + ED 12	70	30	32	70	30	28
TAI + ED 13	80	30	30	80	30	28
TAI + ED 14	30	35	40	30	35	30
TAI + ED 15	40	35	38	40	35	30
TAI + ED 16	50	35	36	50	35	30
TAI + ED 17	60	35	34	60	35	28
TAI + ED 18	70	35	32	70	35	28
TAI + ED 19	80	35	30	80	35	28

Economic Parameters for Reproductive Programs

Table 2. Economic parameters used for the 19 reproductive programs compared in the case study.

Item	Units	Value
Milk Price	($/kg)	0.45
Average Cost Feed	($/kg dry matter)	0.22
Average Calf Value	($/calf)	105
Heifer Replacement	($/heifer)	1200
Salvage Value	($/cow)	790

Results

Reproductive and Productive Parameters

Table 3. Reproductive parameters calculated by the model for the 19 reproductive programs compared in the case study. [1]20/17 = 21d-PR for 72 d VWP/21d-PR for 50 d VWP

Program	21d-PR (%)	Days Open	Calving interval	Average DIM	% of Herd Lactating
TAI 1	[1]20/17	129	13.7	187	89.1
TAI + ED 2	15	132	13.8	191	89.7
TAI + ED 3	14	134	13.9	193	89.9
TAI + ED 4	14	134	13.9	194	90.1
TAI + ED 5	13	134	13.9	196	90.3
TAI + ED 6	13	134	13.9	196	90.4
TAI + ED 7	13	134	13.9	196	90.4
TAI + ED 8	16	131	13.8	190	89.5
TAI + ED 9	15	131	13.8	191	89.6
TAI + ED 10	15	132	13.8	191	89.6
TAI + ED 11	15	131	13.8	192	89.8
TAI + ED 12	15	130	13.8	192	89.7
TAI + ED 13	16	129	13.7	191	89.7
TAI + ED 14	16	129	13.7	188	89.2
TAI + ED 15	16	129	13.7	188	89.2
TAI + ED 16	17	129	13.7	188	89.3
TAI + ED 17	17	128	13.7	188	89.3
TAI + ED 18	17	127	13.6	188	89.2
TAI + ED 19	18	125	13.6	187	89.1

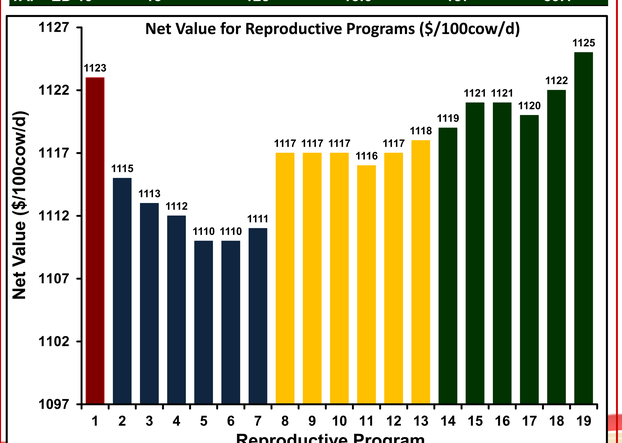

Figure 2. Net present value (NPV) per 100 cow per day for the 19 reproductive programs compared in the case study.

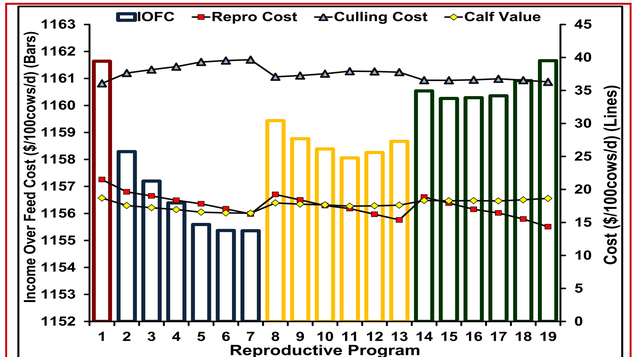

Figure 3. Income over feed cost (IOFC; bars), reproductive program cost, culling cost, and calf value (lines) per 100 cow per day for the 19 reproductive programs compared in the case study.

Table 4. Replacement heifer balance for 4 reproductive programs compared in the case study representing four different results scenarios. Cut-off DIM for AI was changed to increase/decrease culling in order to approximate heifers supply to requirements.

Program	Heifers Required	Heifers Supply	Excess/Need	New DIM Cut-off
TAI 1	38.0	43.4	5.5	250
TAI + ED 7	43.4	42.3	-1.1	325
TAI + ED 13	40.5	43.1	2.6	283
TAI + ED 19	38.3	43.4	5.1	243

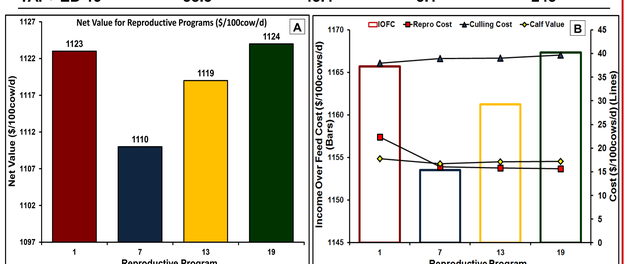

Figure 4. Net present value (NPV) per 100 cows per day or the 4 programs compared after changing cut-off DIM for AI (Panel A). Income over feed cost (IOFC), reproductive program cost, culling cost, and calf value per 100 cows per day for the four programs compared after changing cut-off DIM for AI (Panel B).

Summary

⇒ Adding ED to a 100% TAI Presynch-Ovsynch program with good reproductive performance is beneficial only when a significant proportion of the cows receive AI after ED and have a relatively good CR (35%).

⇒ Income over feed cost accounted for the major difference among programs. Culling cost, reproductive cost, and calf value were significantly lower than IOFC and showed less variation.

⇒ Changing the cut-off DIM to adjust culling to heifer supply improved the income over feed cost of programs with superior reproductive performance.

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