The Economics of Naturally Occurring Twinning in Dairy Cattle

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ABSTRACT
To determine the additional costs and returns of twin calvings in dairy cattle, an economic model was developed on the personal computer. Data used in the model were recorded on 33 farms over 6.5 yr and included 381 twin calvings. For missing information, assumptions were made from the literature. Additional calf returns turned out to be $2.96. Total additional cost were $71.47, consisting of $100.92 for milk reduction, $39.51 for increased premature culling, $19.25 for increased occurrence of abortion, $5.69 for increased therapy, and $6.09 for increased calving interval. Total losses were on average $171.47 − $62.69 = $108.51 per twin birth. Realistic changes in input variables could not change this negative outcome to a positive result. Therefore, it was concluded that it is not profitable to select to increase the number of twins in dairy cattle.
(Key words: dairy cattle, economics, twinning)

INTRODUCTION
Dairy farmers in The Netherlands have traditionally relied on both milk production and calf crop for their major sources of income. One potential method of adding income is to increase the incidence of twin calving. At present, selection for more twin births in dairy cattle results in deleterious effects on the dams (1, 2, 7). However, there is little, if any, data supporting this proposition, because economic losses from twin calvings in dairy cattle have not been estimated. In beef cattle, total costs per unit beef returns could be decreased 20 to 30% for cows producing twin instead of single calves. However, negative effects on fertility of the dam were also reported (3). Cow productivity for total calf weight at 100 d could be increased by 40%. Twin calves were lighter at birth but did not differ from single calves in postweaning gain (4).

The present economic study was primarily based upon the empirical results of research by Nielsen et al. (7), who concluded that twin births occurred infrequently, i.e., 3.2% in Dutch Black and White dairy cattle. Twin calvings increased when parity increased. Adjusted for mortality, calf production at 24 h of life was 1.62 for twins and .95 for singles. According to Nielen et al. (7), twin births increased during summer, and cows carrying twins produced 100 kg more milk at 100 DIM than the cows carrying single calves, but productivity was nearly the same at 270 DIM. After a twin birth, milk decreased 291 kg at 305 DIM with an additional drop of 295 kg if an abortion had occurred. Higher relative risks for the twinning group were found for intrauterine as well as for hormonal treatment. The relative risk of abortion was 3.5 times higher for twin pregnancies. Calving interval before a twin birth was shorter. Days open increased after calving, there were more retained placentas, and twin calving cows were more often culled for fertility reasons (7).

Economic calculations so far have been done only for beef cattle for which attention is centered on weight gain of the calves rather than milk production as in dairy cattle (3). In dairy cattle, not all quantitative data are avail-
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Parity 2 3 4
---- Reduced future income values for different
parities and periods within parity ----­

<table>
<thead>
<tr>
<th>Period within parity</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>348</td>
<td>336.15</td>
<td>299.15</td>
<td>327.2</td>
</tr>
<tr>
<td>2</td>
<td>522.4</td>
<td>451.38</td>
<td>377.5</td>
<td>386.13</td>
</tr>
<tr>
<td>3</td>
<td>539.73</td>
<td>443.65</td>
<td>353.48</td>
<td>358.15</td>
</tr>
<tr>
<td>≥4</td>
<td>374.68</td>
<td>259.08</td>
<td>162.88</td>
<td>161.64</td>
</tr>
</tbody>
</table>

Data Description

Briefly, there were 381 twin calvings in the original data set of 11,951 calvings. These calvings were recorded from January 1, 1982 to July 1, 1988 on 33 farms. The data were routinely collected from dairy herds, consisting mainly of Holsteins and Dutch Friesians, in the course of a routine herd health and production management program from the Veterinary Faculty in Utrecht. From this original data set, two subsets were generated: 1) the twin calving group of 381 calvings and 2) the control group of 1486 calvings. From this data set, highly improbable outliers were dropped, such as cows with a gestation length >300 d or cows with an interval for calving to conception >200 or <30 d. Additionally, in the twin calving group, data from cows that delivered twins more than once were excluded (32 cows delivered twins two or more times, 4 cows delivered twins three times). Data were available in period 1, the lactation before the twin calving, and in period 2, the lactation after calving.

TABLE 1. Default input values of the economic model.

<table>
<thead>
<tr>
<th>Price</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk, $/100 kg</td>
<td>37.00</td>
</tr>
<tr>
<td>Concentrates, $/100 kg</td>
<td>44.50</td>
</tr>
<tr>
<td>Male calves, $/kg of body weight</td>
<td>6.08</td>
</tr>
<tr>
<td>Female calves, $/kg of body weight</td>
<td>4.13</td>
</tr>
<tr>
<td>Antibiotics, $ per dosage</td>
<td>1.00</td>
</tr>
<tr>
<td>Lugol, $ per dosage</td>
<td>2.50</td>
</tr>
<tr>
<td>Prostaglandines, $ per dosage</td>
<td>1.25</td>
</tr>
<tr>
<td>Veterinary visit, $ per visit</td>
<td>16.00</td>
</tr>
<tr>
<td>Special veterinary handling, $ per handling</td>
<td>3.63</td>
</tr>
</tbody>
</table>

Data was routinely recorded on each farm. Accumulated milk production records were available on 100, 270, and 305 DIM.

The present economic study started with the assumption that cows in the twin group had a naturally occurring twin pregnancy and there-
fore had no embryo transplantation. Also, only the effects of twinning were considered; ignored were causes and risk factors and direct influences of twin births on feed consumption and on diseases other than reproductive problems of the dam. The influence of twinning on diseases within a month after calving was insignificant (7). Feed consumption was not included in the management program.

Returns

The additional income was completely based on the returns from the calves. The value of the calf was based on weight, sex, breed, mortality, and the price per kilogram of body weight. Because the weight of calves was not an available variable in the data set, the weight was assumed for a single female and a single male calf to be 36 and 39 kg, respectively, when the dam was parity 1, 39.75 and 42.83 when the dam was parity 2, and 41.45 and 44.53 when the dam was parity >2 (5). The twin calves were said to be weaker and smaller, although the available literature did not comment on the weight of twin calves (1). In the present economic study, the body weight of twin calves was assumed to be 10 kg lighter than for singles, as found for beef calves (4).

The prices of calves were on average $4.13/kg of body weight for male calves, $6.08/kg of body weight for female calves and $4.44 when the dam was parity >2 (5). The additional returns were calculated by Equation [1].

\[
\text{additional returns} = \sum_{i=1}^{a} \left( (WT_{sfi} \times pf + WT_{smi} \times pm) \times (1 - M_i) - (WT_{sfi} \times pf + WT_{smi} \times pm) \times .5 \times (1 - M_k) \times T_i \right)
\]

where

\[
WT_{sfi} = \begin{cases} 
\text{the body weight (kilograms) of a female twin calf with dam in parity } i \ (1, 2, >2), \\
\text{the price (dollars per kilogram of body weight) of a female calf,}
\end{cases}
\]

\[
WT_{smi} = \begin{cases} 
\text{the body weight (kilograms) of a male twin calf with dam in parity } i \ (1, 2, >2), \\
\text{the price (dollars per kilogram of body weight) of a male calf,}
\end{cases}
\]

\[
pf = \begin{cases} 
\text{the price (dollars per kilogram of body weight) of a female calf,}
\end{cases}
\]

\[
pm = \begin{cases} 
\text{the price (dollars per kilogram of body weight) of a male calf,}
\end{cases}
\]

\[
M_i = \begin{cases} 
\text{the mortality of twin calves within 24 h after birth,}
\end{cases}
\]

\[
WT_{sfi} = \begin{cases} 
\text{the body weight (kilograms) of a single female calf with dam in parity } i, \\
\text{the body weight (kilograms) of a male calf,}
\end{cases}
\]

\[
WT_{smi} = \begin{cases} 
\text{the body weight (kilograms) of a single male calf with dam in parity } i, \\
\text{the price (dollars per kilogram of body weight) of a single male calf,}
\end{cases}
\]

\[
M_s = \begin{cases} 
\text{the mortality of single calves within 24 h after birth (percentage),}
\end{cases}
\]

\[
T_i = \begin{cases} 
\text{the percentage of twin births in parity } i \ (i = 1, 2, >2), \\
1 \text{ (100%) if parity } >2
\end{cases}
\]

Because twin calving cows are on average older, this parity effect was corrected for by multiplying with the percentage of twin calving cows in parity i.

Costs

The cost factors considered were milk reduction, fertility losses, and increased premature culling.

Milk Reduction. In period 1 (the lactation before the twin calving), the cow carrying twins produced 100 kg more milk at 100 DIM. At 305 DIM, there was no significant difference in the productivity. An assumption was made that cows carrying twins had the ability to produce more milk than cows carrying single calves but that twin pregnancy affected production. The production ability of 100 kg more milk was considered as the minimal estimated loss from higher potential milk production. In the year after calving (period 2), cows calving twins produced 295 kg less milk than cows calving single calves at 305 DIM. Using the market price for milk would overestimate these losses, because less feed is necessary for milk production, and the milk price was reduced by this savings in costs based on data in the literature (5). In the basic situation, the default market price for milk was $37/100 kg (Table 1). The net milk price was calculated by Equation [2].
where
\[ p_c = p_m - 0.5p_f \]  \[2\]

where
\[ p_c = \text{the net milk price per kilogram}, \]
\[ p_m = \text{the market price for milk per kilogram}, \text{and} \]
\[ p_f = \text{the average concentrate feed price per kilogram}. \]

Milk losses were calculated by Equation [3]:
\[(MP_t + 100) \times p_c \]  \[3\]

where
\[ MP_t = \text{additional milk reduction in twinning cows at 305 DIM after calving (kilograms)}, \]
\[ p_c = \text{the net milk price per kilogram}. \]

Fertility. Abortion was defined in the data set as rejection of the fetus between 45 and 260 d of gestation. On a yearly basis, an abortion resulted in fewer calves, and the number of calves missed depended on the moment of abortion. A parameter for estimation was the calving interval over the whole period. On a yearly basis, .8 calves were missed, based on dividing the calving interval until an abortion by the total calving interval including an abortion. Here an assumption was made that the farmer expected a single calf rather than twins.

Abortion costs =
\[ [(MR_a \times p_c) + 0.8 \times (WT_f \times p_f)
\]
\[ + WT_m \times p_m) \times 0.5] (T - S) \]  \[4\]

where
\[ MR_a = \text{milk reduction because of abortion (kilograms)}, \]
\[ p_c = \text{net milk price (dollars per kilogram)}, \]
\[ WT_f = \text{the average body weight of a single female calf (kilograms)}, \]
\[ p_f = \text{the average price of a female calf (dollars per kilogram of body weight)}, \]
\[ WT_m = \text{average body weight (kilograms) of a single male calf}, \]
\[ p_m = \text{the average price of a male calf (dollars per kilogram of body weight)}, \]
\[ T = \text{percentage of twin calving cows with abortion, and} \]
\[ S = \text{percentage of single calving cows with abortion}. \]

The calving interval was determined by days open and the length of gestation. The optimal calving interval was taken as 1 yr. Deviations from this optimal interval decrease income, and those reductions in income, based on the literature (6), were multiplied by the percentage of cows in that calving interval, using Equation [5].

Calving interval costs =
\[ \sum_{i=1}^{n} \sum_{j=1}^{n} RED_{ij} \times (T_{ij} - S_{ij}) \]  \[5\]

where
\[ RED_{ij} = \text{reductions in annual income in parity } i \text{ (} i = 1, 2, >2 \text{) and calving interval } j \text{ (} j = 1, \ldots, 7 \text{)}, \]
\[ T_{ij} = \text{percentage of twinning cows in parity } i \text{ and calving interval } j, \text{ and} \]
\[ S_{ij} = \text{percentage of single cows in parity } i \text{ and calving interval } j. \]

In fertility treatment, a distinction was made between intrauterine therapy with antibiotics or lugol and hormonal therapy. Antibiotics were used to treat retained placenta or endometritis. Milk of cows treated with antibiotics was not allowed to be delivered for two consecutive milkings. This discarded milk could be fed to the calves, saving milk replacer. The antibiotics for retained placenta were generally administered by the farmer. All other medicines were administered by the veterinarian, which created additional costs for veterinary visits. Hormonal therapy consisted of dosage of progesterone (this was used only in a very few cases and therefore deleted), prostaglandins, releasing hormone, and FSH or LH (Prosolvinet®, Fertagyl®, and Nymfalon®, respectively, all three from Intervet, Boxmeer, The Netherlands).
RESULTS AND DISCUSSION

Basic Situation

Table 2 summarizes the total additional costs and returns of twinning when calculated.

Costs for therapy =
\[ \sum_{a=1}^{n} [(T_{ha} - S_{ha})(p_{h} + V_{ha}) \times n_{ha}] + \sum_{b=1}^{n} [(T_{1b} - S_{1b})(p_{1} + V_{1b} + ST_{1b} + M_{1b}) \times n_{1b}] \]

where

\[ T_{ha} = \text{percentage of twin births followed by hormonal treatment a,} \]
\[ S_{ha} = \text{percentage of single births followed by hormonal treatment a,} \]
\[ p_{h} = \text{average price of hormonal medicine for one dosage (dollars);} \]
\[ V_{ha} = \text{visiting costs of veterinarian for hormonal treatment a (dollars),} \]
\[ n_{ha} = \text{number of treatments for hormonal therapy a (dollars),} \]
\[ T_{1b} = \text{percentage of twin births followed by intrauterine treatment b,} \]
\[ S_{1b} = \text{percentage of single births followed by intrauterine treatment b,} \]
\[ p_{1} = \text{average price of intrauterine medicine (dollars),} \]
\[ V_{1b} = \text{visiting costs of veterinarian for intrauterine treatment b,} \]
\[ ST_{1b} = \text{special treatment costs of veterinarian for intrauterine treatment b,} \]
\[ M_{1b} = \text{costs of discarded milk for intrauterine treatment b,} \]
\[ n_{1b} = \text{number of treatments for intrauterine treatment b.} \]

From the literature, dystocia was defined as all calvings for which personnel assistance was needed, and dystocia depended on the size of the calf, its sex, and the age of the dam (8). The assumption was that an additional visit of the veterinarian was not needed for a twin calving, and, therefore, in the basic situation, no additional costs were calculated for dystocia.

In the data set, the consequences of endometritis were presented as a function of several other factors. Endometritis caused a lower conception rate at first conception, which led to a longer calving interval. Additional treatment costs were already involved. Therefore, the costs of endometritis were included in other factors.

Predisposition factors that have been suggested for retained placenta include food deficiency, fatness, age, dystocia, and twinning (8). In this large sample of observations, milk reduction because of retained placenta was insignificant and, consequently, ignored. If milk costs were present, they would be included in milk reduction and the additional costs of therapy in fertility treatment. The additional costs of culling because of retained placenta are considered in the cost factor culling and costs of a longer calving interval in the cost factor calving interval.

Culling. In this economic study, reduced future income values mentioned in the literature were used to calculate costs of culling (Table 1) (9). To include these costs, it was important to know the cow’s lactation number and relative within-herd production level. Assuming that the single calving cows produced at 100%, twin calving cows without dystocia also produced at 100% (2). Costs for premature culling were calculated by Equation [7].

Costs for premature culling =
\[ \sum_{i=1}^{n} \sum_{j=1}^{m} \text{RFI}_{ij} \times (T_{ij} - S_{ij}) \]

where

\[ \text{RFI}_{ij} = \text{reduced future income value in parity i and period j within parity i,} \]
\[ T_{ij} = \text{percentage of culled twin calving cows in parity i (1, 2, 3, ..., 16), and} \]
\[ S_{ij} = \text{percentage of culled single calving cows in parity i and period j within parity i.} \]
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because of more days open ($10.04). Total costs for calving interval, therefore, were $6.09. A shorter dry period before calving can reduce milk after calving, but those costs are already included in costs for milk reduction.

Total additional costs for culling were $39.51 and were higher for older cows (Figure 2). Within lactation, most of the additional costs occurred immediately after calving or at the end of lactation.

From the data it can be concluded that an abortion occurred late in lactation. In earlier months, an abortion could be missed when the cows are seen in estrus again. These costs were included in the calving interval factor. Costs of abortion consisted of costs for a missed calf ($12.88) and costs for additional milk reduction ($6.38). The total costs for milk reduction (including abortion) add $107.30, the major costs of twin calving.

It can be concluded from Table 2 that twins in dairy cattle are not favorable economically with total losses of $108 per twin birth.

To give an overview of the importance of each factor, the distribution of cost factors is also given in Table 2. Milk losses determined 59% of the total costs. The costs of therapy and calving interval did add slightly to the total costs.

Sensitivity Analysis

Using the economic model, several analyses were conducted directed toward calculating break-even points. Table 3 shows the results of

with the economic model. The total calf returns were $62.96. The major differences in calf income, when comparing twin calving cows with single calving cows, were seen in parity >2, because most twinning cows were in this parity group (Figure 1). Costs of milk reduction in the lactation before twin calving were $25.88 and $75.04 in the lactation afterward. Thus, total costs for milk reduction were $100.92 (Table 2). An assumption was made that a 1-kg milk reduction saves .5 kg of concentrate (5). The possibility exists that twin calving cows use additional feed to recover weight lost because of twin calving. Information on weight of cows and energy balances is necessary to quantify concentrate costs. Also, costs of additional feeding by the farmer during pregnancy were not included. In practice, however, most cases of twin pregnancy are not detected before calving.

Considering calving interval, losses resulted from 1) an advantage for the twin calving cows in period 1 from shorter gestation length (~$3.95) and 2) a disadvantage in period 2 because of more days open ($10.04). Total costs for calving interval, therefore, were $6.09. A shorter dry period before calving can reduce milk after calving, but those costs are already included in costs for milk reduction.

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TABLE 2. Total additional costs and returns for twin calving in US dollars and distribution of costs factors.

<table>
<thead>
<tr>
<th>Source</th>
<th>Costs</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Returns</td>
<td>+62.96</td>
<td>(100)</td>
</tr>
<tr>
<td>Calf returns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Costs</td>
<td>-171.47</td>
<td>4</td>
</tr>
<tr>
<td>Milk reduction</td>
<td>100.92</td>
<td>9</td>
</tr>
<tr>
<td>Fertility</td>
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<td></td>
</tr>
<tr>
<td>Dystocia</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Therapy</td>
<td>5.69</td>
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</tr>
<tr>
<td>Calving interval</td>
<td>6.09</td>
<td>4</td>
</tr>
<tr>
<td>Abortion</td>
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<td>11</td>
</tr>
<tr>
<td>Culling</td>
<td>39.51</td>
<td>23</td>
</tr>
<tr>
<td>Losses</td>
<td>-108.51</td>
<td></td>
</tr>
</tbody>
</table>
Importance of Assumptions

The cows carrying twins produced better at 100 DIM in period 1, and the cows carrying single calves produced better at 270 DIM, although the difference was not significant. At 100 DIM, there was little influence of the twin pregnancy. A significant level of difference at 270 and 305 DIM was probably not found because of missing records. The paramount reason for this was that 25% of the cows were heifers and, thus, not yet lactating in their first gestation. If cows carrying twins indeed have

**Changes in Cost Variables.** Even when milk reduction did not occur, there was still a loss of $7 per twin birth. Changing the production level of the twinning cows to 90% compared with single calving cows and setting the number of culled cows equal in both groups decreased the costs of $102.50 and the losses to $19.50. Lower production decreased costs for culling as reduced future income values decreased. With an equal number of culled cows for the twin calving and single calving groups, the costs of other factors might increase for the twinning cows. The conclusion of these sensitivity analyses is that a profitable result is difficult to obtain. This does not imply that an individual twin calving always costs more money than a single calving, but, considering all the calvings together, many negative contributing factors lead to an overall negative result.

**Importance of Assumptions**

The cows carrying twins produced better at 100 DIM in period 1, and the cows carrying single calves produced better at 270 DIM, although the difference was not significant. At 100 DIM, there was little influence of the twin pregnancy. A significant level of difference at 270 and 305 DIM was probably not found because of missing records. The paramount reason for this was that 25% of the cows were heifers and, thus, not yet lactating in their first gestation. If cows carrying twins indeed have

**Sensitivity Analyses.** Changes in Return Variables. When the difference in birth weight between twin calves and single calves was reduced to 5 kg, losses were $66.50 instead of $108.51. When the sensitivity analyses were conducted with the same weight for both twin calves and single calves, losses of $25.50 were still observed. To reach the break-even point, the weight of twin calves must be 45 and 48.5 kg for female and male calves, respectively. Heavy twin calves were observed in the data set of Nielen et al. (7) but were not common. When the calf mortality of twins was reduced to 5% (according to the level of the single calves), the returns increased from $62.96 to $109.50 per twin birth. The losses were reduced to $61.50, which was a reduction to 57% of the basic loss structure. From this analysis, it might be concluded that more care for twin calves in the 24 h after birth is needed.
the potential to produce at above average levels, the costs of milk reduction would increase and so would the costs of culling, which increased 78% compared with the basic level. The losses at that point would increase by 174%. The 100-kg milk reduction was considered a cost. However, it was not known whether more losses were incurred at 270 and 305 DIM because not enough records were available.

It was difficult to quantify the extra feed given by the farmer to achieve a better condition of the dam at calving. In retrospect, many twin pregnancies were not diagnosed; therefore, the assumption on which the calculations were based (the farmer did not give extra feed) was acceptable. From the sensitivity analyses, it could be concluded that body weight of the calves had greatest impact on the returns. Therefore, it is important to know the weight of calves.

CONCLUSIONS

There were many disadvantages because of twinning in dairy cattle, and these disadvantages did not offset the additional returns earned by the extra calves. In fact, this study shows that a twin birth costs the farmer $108 more on average than a single birth. This result did not indicate that in individual cases a twin birth always led to losses. From sensitivity results, it could be concluded that a reasonable change in the input variables of the returns could not lead to a positive result. In general, there were so many disadvantages that attempts to select for more twin calves in the dairy cattle herd should be discouraged.

REFERENCES