The cost of different types of lameness in dairy cows calculated by dynamic programming

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ABSTRACT

Traditionally, studies which placed a monetary value on the effect of lameness have calculated the costs at the herd level and rarely have they been specific to different types of lameness. These calculated costs are not particularly useful for farmers in making economically optimal decisions depending on individual cow characteristics. The objective of this study was to calculate the cost of different types of lameness at the individual cow level. This model would provide a more informed decision making process in lameness management for maximal economic profitability. We made modifications to an existing dynamic optimization and simulation model, studying the effects of various factors (incidence of lameness, milk loss, conception rate and treatment cost) on the cost of different types of lameness. The average cost per case (US$) of sole ulcer, digital dermatitis and foot rot were 216.07, 132.96 and 120.70, respectively. It was recommended that 97.3 percent of foot rot cases, 95.5 percent of digital dermatitis cases and 92.3 percent of sole ulcer cases be treated. This model affords versatility as it allows for parameters such as production costs, economic values and disease frequencies to be altered.

KEYWORDS

Lameness; Sole ulcer; Digital dermatitis; Foot rot; Cost; Dairy; Decision making; Dynamic programming

INTRODUCTION

Lameness has a detrimental effect on herd productivity, and is second only to mastitis in this respect. The objective of this study was to calculate the cost of different types of lameness (sole ulcer, digital dermatitis and foot rot). This would enable effective decision making of whether it may or may not be economically optimal for a cow to be kept in the herd, inseminated, culled or replaced. We did this by modifying an existing economic model.

MATERIALS AND METHODS

Lameness Categorization

Sole ulcer was chosen to represent the non-infectious lameness category and digital dermatitis is representative of the infectious lameness category. We categorized foot rot (interdigital phlegmon) separately, as it is less costly than digital dermatitis, generally rarer in occurrence, and treatment differs from other infectious types of lameness.

Replacing And Inseminations Optimization And Simulation Model

We modified an existing optimization and simulation model which was developed to study the cost of generic clinical mastitis in dairy cows (Bar et al., 2008a). The model was built using Multi Level Hierarchic Markov Process software as the application program interface (Kristensen, 2003), and was constructed as a 3-level hierarchic Markov process comprised of: the founder (parent) level containing state variables of permanent traits throughout the cow's life span, the child level divided into stages representing one whole lactation and the grandchild level divided into stages of one month. The possible actions that could be taken at this final level are: (1) replace the cow with a calving heifer, (2) keep the cow for another month without insemination (and treat if she has lameness) and (3) inseminate the cow for another month following the voluntary waiting period of 2 months (Bar et al., 2008a).
Model Parameters
Prices for milk, beef, variable costs, fixed costs and feed cost were taken from De Vries (2006) and Bar et al. (2008a). Milk loss values were taken from Warnick et al., 2001 and monthly risks (%) were taken from Booth et al., 2004. The conception rate was adjusted according to odds ratios detailed in Hernandez et al., 2001. Treatment costs adopted were from Greenough et al., 1997.

RESULTS

Lameness costs
The simulated herd results of lameness by type in the dynamic programming model are illustrated in Table 1. The average cost per case (US$) of sole ulcer, digital dermatitis and foot rot was 216.07 (26.36/0.122), 132.96 (9.44/0.071) and 120.70 (5.19/0.043), respectively. It was recommended that 92.3% of sole ulcer cases, 95.5% of digital dermatitis cases and 97.3% of foot rot cases be treated.

Table 1
The effects of different types of lameness (sole ulcer, digital dermatitis, foot rot) on net return, lameness cases, % of lameness treated, average cost of lameness and average cost per case, following an optimal replacement policy

<table>
<thead>
<tr>
<th>Net return in US$ per cow and year</th>
<th>Lameness cases in 100 cow years</th>
<th>% of lameness treated</th>
<th>Average cost of lameness</th>
<th>Average cost per case</th>
</tr>
</thead>
<tbody>
<tr>
<td>No lameness</td>
<td>426.05</td>
<td>23.5</td>
<td>94.1</td>
<td>41.74</td>
</tr>
<tr>
<td>All</td>
<td>384.31</td>
<td>12.2</td>
<td>92.3</td>
<td>26.36</td>
</tr>
<tr>
<td>Digital dermatitis and foot rot</td>
<td>410.67</td>
<td>7.1</td>
<td>95.5</td>
<td>9.44</td>
</tr>
<tr>
<td>Sole ulcer</td>
<td>393.75</td>
<td>4.3</td>
<td>97.3</td>
<td>5.19</td>
</tr>
<tr>
<td>Sole ulcer and foot rot</td>
<td>389.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digital dermatitis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foot rot</td>
<td></td>
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</tbody>
</table>

Exogenous factors affecting the cost of lameness
Milk loss contributed most to the total cost per case of sole ulcer (38%), followed by the effect of decreased fertility (33%) and treatment cost (28%) (Table 2). This was reversed in the case of digital dermatitis.

Table 2
The effect of milk loss, decreased fertility and treatment cost, on the average cost of a lameness case following an optimal replacement policy

<table>
<thead>
<tr>
<th>Lameness type</th>
<th>Average cost per case (in US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Milk loss</td>
</tr>
<tr>
<td>Sole ulcer</td>
<td>82.97</td>
</tr>
<tr>
<td>Digital dermatitis</td>
<td>35.41</td>
</tr>
<tr>
<td>Foot rot</td>
<td>33.54</td>
</tr>
</tbody>
</table>

Retention payoff of open healthy and lame cows
Retention payoffs under an optimal policy for hypothetically non-pregnant cows free of lameness and with different types of lameness, specific to a second lactation cow with average milk yield per 305 day lactation are shown in Figure 1. The optimal policy recommended by the model (keep, inseminate or replace) is also illustrated. A negative RPO indicates a cow should be culled. This was observed at month 12 for no lameness, month 11 for both digital dermatitis and foot rot, and month 9 for sole ulcer.
Fig. 1
Retention payoffs under an optimal policy for hypothetically non-pregnant cows free of lameness and with different types of lameness, specific to a second lactation cow with average milk yield per 305 day lactation (note: foot rot and digital dermatitis graphs overlap).

DISCUSSION AND CONCLUSION

Few studies have examined the cost of different types of lameness, and none have approached this problem at the individual cow level. In a study by Kossaibati and Esslemont (1997), the cost of lameness (converted from £ to US$ and adjusting for inflation US$ in 2009) per lame cow was 627.98, 342.74, 1,110.72 for digital dermatitis, interdigital dermatitis and sole ulcer, respectively. In contrast, a study by Enting et al. (1997) showed that the total cost (converted from NLG to US$ and adjusting for inflation US$ in 2009) per lame cow was 205.67/yr, and the total loss per average cow present in the herd was 44.71. This model allows for parameters such as production costs and disease frequencies to be altered providing farmers economically optimal guidelines specific to their individual cows suffering from different types of lameness.

REFERENCES