Reduction of Slaughter Value of Paratuberculosis-Infected Dairy Cows

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ABSTRACT

The aim of this study was to evaluate the effects of infection with Mycobacterium avium subsp. paratuberculosis (MAP) on slaughter weight and slaughter value of dairy cows. Two datasets were analyzed: 1) recordings from 1,031 cows in herds in a pilot-study to control MAP infections; and 2) recordings from 36,455 cows from herds participating in the Danish MAP control program. Carcass weight and meat quality data were obtained from all cows and the effect of stage of MAP infection was assessed by analysis of variance. MAP infection stage was based on repeated milk antibody ELISA in both datasets. Furthermore, repeated fecal culture and occurrence of enteritis and enteric edema found at slaughter were recorded in Dataset 1 and 2, respectively. Slaughter weight and value were reduced by 10% and 17%, respectively, in cows with positive ELISA at slaughter. If the cow was also positive in fecal culture, slaughter weight and value were reduced up to 15% and 31%, respectively. The slaughter weight and value were reduced an additional 20% and 31%, for cases with recorded enteritis or edema. Thereby, summarized weight losses up to 31% and value losses up to 48% occurred. Fecal culture negative cows only had reduced slaughter results if they were ELISA-positive in the last two tests. Losses at slaughter caused by MAP were much more severe than has previously been estimated, and these losses could be predicted by repeated milk-ELISA tests with or without confirmation with fecal culture.

KEYWORDS

Antibody profile, Mycobacterium avium subsp. paratuberculosis, slaughter weight, slaughter value

INTRODUCTION

Infection with Mycobacterium avium subsp. paratuberculosis (MAP) in cattle can cause reduced milk yield, intermittent diarrhea, weight loss and terminally devastating mortal diarrhea. Losses at slaughter associated with MAP infection have only been quantified in a few previous studies, with reduction of slaughter weight reported in some, and reduction in slaughter value in others. In addition to the weight of the animal at time of slaughter, slaughter value also includes the age of the animal and the price per kg, reflecting the quality of the meat. Compared to MAP culture negative cows, slaughter weight has been reported reduced by 10% in carcasses, where ileocecal lymph nodes, ileum, rectum or feces were MAP culture positive (Whitlock et al., 1985). Slaughter value has been reported reduced by 30% in cows with clinical symptoms (Benedictus et al., 1987). However, McKenna et al. (2004) found no relationship between body condition score and occurrence of MAP in the intestines or lymph nodes. Only animals that are unable to control the infection are expected to experience reduced weight caused by MAP infection. Loss of control is associated with occurrence of antibody-mediated immune reactions, which indicates progression of the infection. Our hypothesis was that specific MAP antibody profiles are associated with reduced weight and value at slaughter. The aim of this study was to assess the association between the slaughter weight and value and the MAP infection stage. MAP infection stages were estimated based on the repeated milk antibody ELISA (MAP antibody profile) alone or in combination with a) fecal culture results; or b) findings of enteritis or edema at slaughter as indicators of clinical disease.

MATERIALS AND METHODS

Animals, Herds, and Records

The study included two populations. Dataset 1 (sampled 1999 – 2003) included 1,031 Danish Holstein (Black and White) cows from 7 herds. Milk samples from monthly routine test-day recordings were repeated with a mean of 11 times per cow. Feces was sampled 4 times per year per herd, and resulted in a mean of 5.3 samples per cow. Dataset 2 was based on recordings from the Danish national voluntary control program on paratuberculosis (Nielsen, 2007) (2006 –2007) and a pilot study (2003-2005). In total, data from 28,733 Danish Holstein cows in 893 herds and 7,722 Jersey cows from 239 herds were included in Dataset 2. Fecal samples were not obtained, but milk sampling from all lactating cows was repeated every third month with a mean of 2.4 times per cow.
Diagnostic Tests
Milk samples were tested with a MAP specific antibody ELISA (Nielsen, 2002) and fecal samples were cultured using Herrold’s Egg Yolk Medium as described in Nielsen et al. (2004). Cows were divided into 6 different antibody groups based on the last 4 ELISA results. These groups were assigned to reflect different stages of infection, and have been described to be associated with differences in detectable MAP shedding and milk production (Nielsen, 2008; Nielsen et al., 2009). Group A0 has a minimum of two available tests, and all tests were negative. Group A1 has only one available test which was negative and this group was excluded from further analyses due to the limited information. In group A2 the last three tests were negative, but previously at least one test was positive. In group A3 the response is fluctuating between negative and positive, last test was negative. In group A4 the last test was positive, but previous tests were all negative. In group A5 the last two or more tests were positive. Groups A0 and A2 have a low risk of detectable bacterial shedding. Group A3 has an intermediate risk, whereas Groups A4 and A5 have a high risk (Nielsen, 2008). A cow was defined to be fecal culture (FC) positive if one or more fecal samples were positive.

Slaughter Recordings
Data on carcass weight, muscle mass classification (based on the E.U.R.O.P. system (Anon., 2004)) and registrations of signs of diseases (including enteric edema and enteritis) on the carcass was analyzed by analysis of variance, using the Mixed procedure in SAS®. The following initial model was set up using a random coefficient mixed model with two levels:

\[ Y_{ijklmno} = \beta_0 + \beta_1 + \beta_2 + \beta_3 + \beta_4 + \beta_5 + \beta_6 + \beta_7 + \beta_8 + \beta_9 + e_{ijklm} \]

where \( Y_{ijklm} \) = slaughter weight or slaughter value; \( DP_{jk} \) = days passed since first positive ELISA and until slaughter of the \( j \)th cow of the \( k \)th herd; \( DIM_{jk} \) = days in milk at slaughter of the \( j \)th cow of the \( k \)th herd; \( \beta_0 \) = overall mean of either the slaughter weight or slaughter value; \( \beta_1 \) = fixed effect of the \( j \)th antibody group, where \( j \) = A0, A2, A3, A4 or A5; \( \beta_2 \) = fixed effect of the \( m \)th fecal culture response where \( m \) = FC- or FC+; \( \beta_3 \) = fixed linear regression coefficient of DP; \( \beta_4 \) = fixed effect of category \( n \) of symptoms of chronic diseases found on the carcass; \( \beta_5 \) = fixed effect of the \( n \)th parity (categories 1, 2, and 3+); \( \beta_6 \) = fixed linear regression coefficient of DIM; \( H_k \) = random intercept of the \( k \)th herd; \( e_{ijklm} \) = random residual component assumed independent, identically distributed normal, \( N(0, \sigma^2) \). Dataset 1 was only analyzed for Danish Holstein. Dataset 2 was analyzed separately for Jerseys and Danish Holstein. All possible combinations of first-order interactions between all fixed effects were included initially besides the main effects. Models were reduced by backward elimination using the likelihood-ratio test at the 5% level as the cut-off for inclusion in the model.

RESULTS
The reduction in slaughter weight and value of cows with various antibody profiles compared to the slaughter weight/value of antibody negative cows is listed in Table 1. The last column shows the estimates of the additional effect of enteritis or edema on the slaughter weight in Dataset 2. This loss should be added to the loss associated to the antibody group, because there was no interaction between these variables. This

<table>
<thead>
<tr>
<th>Slaughter-</th>
<th>Data-</th>
<th>Breed</th>
<th>Fecal culture</th>
<th>Antibody group</th>
<th>Enteritis or enteric edema</th>
</tr>
</thead>
<tbody>
<tr>
<td>weight</td>
<td>set</td>
<td></td>
<td></td>
<td>A0</td>
<td>A2</td>
</tr>
<tr>
<td>1</td>
<td>Danish Holstein</td>
<td>Positive</td>
<td>-2.6%</td>
<td>-6.1%</td>
<td>-11.9%</td>
</tr>
<tr>
<td>1</td>
<td>Danish Holstein</td>
<td>Negative</td>
<td>0.0%</td>
<td>0.4%</td>
<td>-0.3%</td>
</tr>
<tr>
<td>2</td>
<td>Danish Holstein</td>
<td>Unknown</td>
<td>0.0%</td>
<td>1.9%</td>
<td>-3.8%</td>
</tr>
<tr>
<td>2</td>
<td>Jersey</td>
<td>Unknown</td>
<td>0.0%</td>
<td>-1.2%</td>
<td>-3.8%</td>
</tr>
<tr>
<td>Slaughter</td>
<td>value</td>
<td></td>
<td></td>
<td>A0</td>
<td>A2</td>
</tr>
<tr>
<td>1</td>
<td>Danish Holstein</td>
<td>Positive</td>
<td>-6.5%</td>
<td>-23.2%</td>
<td>-28.6%</td>
</tr>
<tr>
<td>1</td>
<td>Danish Holstein</td>
<td>Negative</td>
<td>0%</td>
<td>-1.3%</td>
<td>0.7%</td>
</tr>
<tr>
<td>2</td>
<td>Danish Holstein</td>
<td>Unknown</td>
<td>0%</td>
<td>-3.9%</td>
<td>-12.9%</td>
</tr>
<tr>
<td>2</td>
<td>Jersey</td>
<td>Unknown</td>
<td>0%</td>
<td>2.7%</td>
<td>-10.5%</td>
</tr>
</tbody>
</table>

** P < 0.01; ** P < 0.01; *** P < 0.001
means that a Danish Holstein cow in Group A5 with enteritis or edema at slaughter would have a total reduction of slaughter weight on 30%. The loss in monetary value reflects not only a lower weight but also a lower price per kilo due to age (> 42 months of age) and lower meat content and quality.

DISCUSSION AND CONCLUSION

MAP associated losses of slaughter value appeared to be twice the relative losses of slaughter weight. This underlines the importance of including meat quality in the estimation of the economic losses incurred to the farmer. Losses in slaughter weight and value caused by MAP were more severe than estimated in previous studies. Compared to presumably unaffected test-negative cows, slaughter weight and value were reduced by 10% and 17%, respectively for ELISA-positive cows. Slaughter weight and value were reduced 15% and 31%, respectively, for cows also testing fecal culture positive. Benedictus et al. (1987) estimated a total loss of slaughter value among clinical cows of 30%. In worst case, a total loss of 48% (17% loss due to being in antibody group A5 with unknown fecal culture and 31% due to clinical signs) could occur. The results show that losses in slaughter weight and slaughter value can be predicted by repeated milk-ELISA tests with or without confirmation with a fecal culture. ELISA-positive cows with findings of enteritis or enteric edema, or positive fecal culture, will experience the highest losses. Cows with repeated positive ELISA results (Group A5) had the biggest losses compared to ELISA negative cows (Group A0), but also cows with fluctuating antibody results (Group A3 + A4) could experience smaller, but still significant losses. There was a negligible difference in the slaughter weight results between Jerseys and Danish Holstein. Repeated milk ELISA testing gave a good prediction of potential losses in slaughter results, but when combined with fecal culture predictions were even better. Farmers using the regular milk-ELISA tests should pay increased attention to animals which have had their first positive ELISA. However, slaughter decisions should only be taken if the animal has had at least two positive ELISA results in a row. These cows have both a higher risk of a reduced slaughter weight, a reduced milk yield (Nielsen et al., 2009) and a higher risk of being infectious (Nielsen, 2008). If the farmer wants a confirmation of the diagnosis before slaughter, the ELISA can be supplemented with a fecal culture test. The results will be published in Kudahl and Nielsen (2009).

REFERENCES


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