Effects of Sarcocystosis on Milk Production of Dairy Cows

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ABSTRACT

Sixteen multiparous Holstein cows were allotted randomly to four groups of four cows each. Cows in 1 and 2 were uninfected. Those in 3 received 60,000 and those in 4 received 120,000 Sarcocystis bovicanis sporocysts per os approximately 30 days before the expected onset of lactation to produce nonclinical and clinical infections in 3 and 4, respectively. Combined stresses of infection, parturition, lactation, and high ambient temperatures caused all infected cows to develop clinical illness. Clinical signs included fever, anemia, glossitis, myositis, nasal discharge, hypersalivation, anorexia, and hind limb weakness; two cows died and two others were killed in extremis. Six cows in 3 and 4 developed high Sarcocystis-specific immunoglobulin G1 antibody. Uninfected control cows had no clinical signs and no rising concentrations of antibody against Sarcocystis antigen. When lactation began, cows were milked twice daily, and milk production was recorded for 70 consecutive days. All Sarcocystis-infected cows (3 and 4) decreased feed intake and milk production compared with uninfected controls. The Wisconsin Mastitis Test on milk samples at 1, 2, 4, 8, and 12 wk of lactation did not differ among groups.

INTRODUCTION

Experimentally induced infections of cattle with Sarcocystis bovicanis Heydorn, Gestrich, Mehlhorn, and Rommel 1975 (syn. Sarcocystis cruzi Hasselmann 1926) have provided detailed data on the morphology and location of the life cycle stages and on the pathology associated with this parasite in the bovine intermediate host (7, 8, 9, 11, 14). Based on these data, clinical sarcocystosis in cattle subsequently has been diagnosed and reported in the United States, Canada, England, and Norway (2, 3, 5, 12, 13, 15, 17, 19). In retrospect, several years before experimental data were available, an outbreak of a disease in a dairy herd was reported (4) that appears similar, if not identical, to acute experimental sarcocystosis. During this outbreak the following clinical signs were observed: fever, intermittent anorexia, nasal discharge, hypersalivation, emaciation, sloughing of the tip of the tail, abortion (10 of 17 pregnant cows), muscular tremors, drop in milk yield, and eventual cessation of lactation. The possibility that these cows were infected acutely with Sarcocystis and the knowledge that 75 to 98% of the cattle in the United States acquire Sarcocystis infections (16) led to this study to determine if clinical and subclinical experimental infections of cows with S. bovicanis affect milk production during early lactation, and if so, how production is affected.

MATERIALS AND METHODS

Sixteen pregnant multiparous Holstein cows ranging from 2 to 5 yr of age with similar milk production records were acquired from the dairy herd at the Beltsville Agricultural Research Center where they were raised, housed, and utilized in milk production studies. All cows were examined by a veterinarian and were pregnant and healthy with no evidence of mastitis at the beginning of the experiment. Cows were allotted randomly to four groups of four cows each. Groups 1 and 2 remained in the herd as uninfected controls. Groups 3 and 4 were transported to the Animal Parasitology Institute.
TABLE 1. Means (M), least squares means (LSM), and standard errors (SE) of variables during the first 10 wk of lactation of Holsteins infected with *Sarcocystis*.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Groups</th>
<th>Treatment</th>
<th>SE</th>
<th>P&lt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed intake, kg/day (LSM)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Initial weight, kg (M)</td>
<td>561</td>
<td>445</td>
<td>494</td>
<td>582</td>
</tr>
<tr>
<td>Body weight, kg (LSM)</td>
<td>493a</td>
<td>456a</td>
<td>503b</td>
<td>506b</td>
</tr>
<tr>
<td>Body weight loss, kg (M)</td>
<td>74</td>
<td>20</td>
<td>48</td>
<td>105</td>
</tr>
<tr>
<td>Milk, liters/day (LSM)</td>
<td>21.4a</td>
<td>19.6a</td>
<td>16.3b</td>
<td>12.3b</td>
</tr>
<tr>
<td>Milk protein, % (LSM)</td>
<td>3.79</td>
<td>4.17</td>
<td>4.21</td>
<td>4.08</td>
</tr>
<tr>
<td>Milk fat, % (LSM)</td>
<td>2.67</td>
<td>2.24</td>
<td>2.48</td>
<td>4.61</td>
</tr>
<tr>
<td>Body temperature, C (LSM)</td>
<td>39.4a</td>
<td>39.2b</td>
<td>39.7b</td>
<td>39.7b</td>
</tr>
<tr>
<td>Packed cell volume, % (LSM)</td>
<td>28.4a</td>
<td>30.2a</td>
<td>26.6b</td>
<td>27.2b</td>
</tr>
</tbody>
</table>

a,b Means with different superscripts differ (P<.05).

Institute 30 days before estimated parturition where each cow was isolated. Each cow in 3 received 60,000 sporocysts and each cow in 4 received 120,000 sporocysts of *S. bovicans* (Beltsville isolate SBDE) per os. An aqueous suspension of 20,000 sporocysts cleaned from dog feces was given daily for 3 or 6 consecutive days. The rationale for selecting these dosages was that: 1) 60,000 sporocysts had not produced clinical infection in unpublished laboratory studies and, thus, would provide information regarding the effect of subclinical infection on milk production; and 2) 120,000 sporocysts consistently produced clinical infection in studies and would provide information regarding the effect of clinical sarcocystosis on milk production. Two weeks after oral inoculation, cows in 3 and 4 were returned to the dairy where they were housed, fed, and milked with all other experimental cows. Feed intake was monitored daily. Cows were fed ad libitum a total mixed ration of 44% corn silage, 12% grass silage, and a 44% grain mix containing 21% crude protein.

For 3 consecutive days beginning at parturition, colostrum collected from infected cows in 4 was fed to calves from noninfected cows in 1 whereas calves in 2 and 3 nursed their dams to determine if *Sarocystis* could be transmitted via colostrum. Results of those trials are reported in (10). Thereafter, all cows were milked twice daily, and the weight of the milk was recorded for 70 consecutive days.

At weekly intervals for 10 consecutive wk, samples of milk from each quarter of the udder of each cow were analyzed for percent fat, protein, and total solids (21). Similar samples were subjected to the Wisconsin Mastitis Test (WMT) (20) on wk 1, 2, 4, 8, and 12 of lactation to determine if infection with *Sarocystis* affected frequency of mastitis. Readings of 10 or more in the WMT indicated mastitis.

Also at weekly intervals, cows were weighed, rectal temperatures were recorded, and jugular blood was collected into vacuum tubes containing the anticoagulant ethylenediaminetetraacetic acid (EDTA) and into vacuum tubes containing no anticoagulant. Packed cell volume was determined in microhematocrit tubes for blood containing EDTA. Serum was obtained from coagulated blood and examined for IgG1 antibodies specific to *Sarocystis bovicans* cyst organisms by enzyme linked immunosorbent assay (ELISA) to verify infectivity of the inoculum. Optical densities of the wells in the microtiter plates were determined by a Titertech Multiskan plate reader.

Statistical analysis of data was by analysis of variance (1). Mean differences between treatments were evaluated by Dunnett's test (6) when results were compared with those of cows in the uninfected control group 1.

RESULTS AND DISCUSSION

Although no cows had gross signs of sarco-
sarcocystosis. In addition, two cows in 4
became weak in the hind limbs, were unable to
rise, and were killed in extremis at 110 and 123
days after infection. One cow in 3 and another
in 4 became weak, were unable to rise, and died
on 106 and 74 days after infection. One of the
uninfected control cows from 1 became weak
and was killed 101 days after parturition. Post-
mortem examination showed a large abscess in
the coronary groove of the heart; all other
control cows remained healthy during the
experiment and had no signs resembling clinical
sarcocystosis.

Immunoglobulin G1 specific for S. bovicanis
antigen was elevated in all infected cows except
for one that died 74 days after infection and
another that had no detectable antibody
response (Figure 3). Immunoglobulin G1 was
highest between 70 and 120 days after infec-
tion. Similar high concentrations were not ob-
served for any uninfected control cows.

Feed intake, body weights, and milk produc-
tion data are listed in Table 1. Feed intake was
reduced (P<.01) in both Sarcocystis-infected...

Figure 1. Clear nasal discharge from cow with clini-
cal sarcocystosis.
TABLE 2. Number of milk samples from each experimental group at specific week of lactation with Wisconsin Mastitis Test of 10 or more.

<table>
<thead>
<tr>
<th>Group</th>
<th>Wk after lactation</th>
<th>Total milk samples indicating mastitis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>1a</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

aNo samples from one cow.
bNo samples from two cows.

TABLE 3. Average ambient temperature during experimental period and number of days over 32°C.

<table>
<thead>
<tr>
<th>Month</th>
<th>Average daily temperature (°C)</th>
<th>Days over 32°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>June</td>
<td>28.5</td>
<td>4</td>
</tr>
<tr>
<td>July</td>
<td>31.8</td>
<td>14</td>
</tr>
<tr>
<td>August</td>
<td>31.7</td>
<td>18</td>
</tr>
<tr>
<td>September</td>
<td>28.6</td>
<td>9</td>
</tr>
</tbody>
</table>

ELISA Test for IgG\textsubscript{1} Specific for Sarcocystis

Figure 3. Response of IgG\textsubscript{1} to inoculation with S. bovis. Range for all eight control cows in groups 1 and 2, shaded areas. Means for each of the eight cows in groups 3 and 4, solid or broken lines for individual cows. Results expressed at the optical density of serum samples at a 1:640 dilution in Dulbecco’s phosphate buffer saline with tween 20.

Milk production is influenced by both high and low ambient temperatures. Although feed intake should increase during lactation to meet the animals’ energy requirements, appetite and feed intake are reduced when ambient temperatures exceed 25°C (18). When maximum daily temperatures exceeded 27°C for 40 of the first 100 days of lactation, it was documented that gross efficiency (kg milk/Mcal/net energy)
for Holsteins in first lactation was 27% below cows exposed to 27°C or higher for only 0 to 20 days (18). The ambient temperature during our experiment was high, reaching or exceeding 32.3°C for 45 of the first 100 days (Table 3). Therefore, heat stress probably affected milk production for all cows. Heat stress may have had an additive effect on the cows in 3 and 4, accounting for the unexpectedly severe clinical manifestations of sarcocystosis and the production in these groups significantly lower than that of uninfected controls.

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REFERENCES