Effect of delayed exposure of cattle to *Mycobacterium avium* subsp *paratuberculosis* on the development of subclinical and clinical Johne’s disease

Luis A. Espejo, DVM, PhD; Noel Kubat, DVM; Sandra M. Godden, DVM, DVSc; Scott J. Wells, DVM, PhD

**Objective**—To evaluate the effect of delayed exposure of dairy cattle to *Mycobacterium avium* subsp *paratuberculosis* (MAP) on the incidence of those cows testing positive for MAP and developing clinical Johne’s disease (CJD).

**Animals**—79 cows not exposed to MAP as calves (unexposed cohort) and 260 cows exposed to MAP as calves (exposed cohort).

**Procedures**—Cows in the unexposed cohort were born into 5 MAP-uninfected herds and introduced at various ages into 5 MAP-infected herds where the exposed cohort cows were born and raised. Beginning when each cow was 24 months old, fecal and serum samples were collected annually from 2003 through 2006. Feces were cultured for MAP, and an ELISA was used to analyze serum samples for antibodies against MAP. Date and reason for culling were obtained from herd records. Incidence of positive culture and ELISA results and CJD was compared between unexposed and exposed cohort cows with Cox regression.

**Results**—Compared with exposed cohort cows, the hazard ratios for unexposed cohort cows having positive culture results, having positive ELISA results, and developing CJD were 0.12, 0.03, and 0.001, respectively, and those ratios increased by 2%, 6%, and 17%, respectively, for each month spent in an MAP-infected herd.

**Conclusions and Clinical Relevance**—Delayed exposure of cows to MAP resulted in lower incidences of positive culture and ELISA results and CJD in those cows, compared with incidences of cows exposed to MAP since birth. The hazard of testing positive for MAP or developing CJD increased with time, regardless of cohort. (Am J Vet Res 2013;74:1304–1310)

Paratuberculosis, or JD, is a chronic intestinal infection of ruminants caused by MAP. The incubation period for JD is long, and MAP-infected cattle rarely develop clinical signs of the disease before 2 years of age. Johne’s disease is one of the most economically important infectious diseases of dairy cattle because MAP-infected cows develop chronic diarrhea and progressive weight loss and have low milk production, which often results in those cows being culled from the herd prematurely. In a 2008 national survey conducted by the USDA, it was estimated that 68% of US dairy herds contain cattle infected with MAP. Investigators associated with a 1996 USDA survey conducted by the USDA, it was estimated that 68% of US dairy herds contain cattle infected with MAP. Investigators associated with a 1996 USDA survey estimated that JD costs the US dairy industry $200 million to $250 million annually.

For dairy herds with MAP-infected cattle, strategies to control JD focus on reducing transmission of MAP to susceptible cattle through fecal-oral routes and contaminated colostrum and milk and identifying and removing cattle that test positive for MAP.

**ABBREVIATIONS**

| CI | Confidence interval |
| JD | Johne’s disease |
| MAP | *Mycobacterium avium* subsp *paratuberculosis* |
| VJDHSP | Voluntary Johne’s Disease Herd Status Program |
Investigators of a meta-analysis\(^8\) that included 8 studies found consistent evidence that young calves are more susceptible to MAP infection than are older cattle. However, results of some studies\(^9\)–\(^12\) indicate that horizontal transmission of MAP among adult cattle does occur. Adult cattle that were experimentally inoculated with MAP developed histopathologic lesions consistent with JD, and MAP was isolated from tissue specimens of those cows.\(^9\)–\(^11\) Results of a study\(^12\) conducted by our laboratory group indicate that some cattle that are naturally exposed to MAP for the first time as adults have positive results for serum antibodies against MAP, as determined by an ELISA, and MAP isolated from feces by bacterial culture. Although results of those studies\(^9\)–\(^11\) suggest that cows exposed to MAP for the first time as adults may develop histopathologic lesions and test positive for MAP or antibodies against MAP, the incidence of clinical JD in those cows was rarely provided.

Transmission of MAP among cattle in infected herds has not been completely elucidated. Even if transmission of MAP between adult cattle may have been minimized, MAP transmission among adult cattle may have an important role in maintaining infection in herds with a low prevalence of MAP-infected cattle.\(^11\) However, the economic impact of MAP transmission to adult dairy cattle may be insubstantial because most of those cows are likely to be culled from the herd before their production is impaired by JD.\(^9\)

The current guide\(^1\) for JD risk assessments and management plans for dairy herds approved by the US Animal Health Association Joilhe’s Working Group and recommended for use by the USDA as part of the management component of the VJDHSP emphasizes the importance of reducing transmission of MAP to young replacement cattle because of the assumption that the risk of cattle becoming infected with MAP decreases as they mature. If that assumption is correct, then adult cattle should be fairly resistant to becoming infected with MAP and focusing on the prevention of MAP transmission to immature cattle is justified as an efficient and cost-effective approach to JD control. However, if that assumption is incorrect, adult cattle may become infected with MAP despite the implementation of currently recommended best management practices to minimize MAP transmission and JD control might never be achieved.

During a previous study\(^12\) conducted by our laboratory group, we identified a group of MAP-infected dairy cattle from herds classified at levels 3 and 4 of the VJDHSP (ie, herds with 98% and 99% probability, respectively, of not containing MAP-infected cows\(^5\)) was conducted through collaboration with the Minnesota Board of Animal Health in the summer of 2003. Data obtained from that survey indicated that 5 of 21 herds had sold cattle that were presumably uninfected with MAP to another 5 herds, which were known to contain MAP-infected cattle.

For the purpose of the study reported here, the cattle sold to the MAP-infected herds (n = 79) comprised the unexposed cohort, and those cows ranged in age from 9 to 87 months (mean \( \pm \) SD, 33.3 \( \pm \) 15.8 months; median, 26 months) at the time of purchase by the MAP-infected herds. Within each of the MAP-infected herds, each unexposed cohort cow was matched to 3 randomly selected cows (controls) on the basis of age, parity, and stage of lactation as described\(^12\); however, 23 additional cows were included in the exposed cohort to account for loss to follow-up in the unexposed cohort. In instances when 3 control cows with the same parity as that of the unexposed cohort cow were unavailable, control cows with a parity \( \leq 1 \) from that of the unexposed cohort cow were selected. The exposed cohort was comprised of control cows (n = 260). For all MAP-infected herds except 1 (herd 4), all exposed cohort cows were born and raised in that herd and considered to have been exposed to MAP since birth. When herd 4 was started, cows were purchased from other MAP-infected herds and those cows were also considered to have been exposed to MAP since birth.

Both cohorts were monitored for the 4-year period from 2003 through 2006. Prior to study initiation, all study procedures were approved by the University of Minnesota Institutional Animal Care and Use Committee, and consent to perform the study was obtained from managers of each of the MAP-infected herds.

Sample and data collection—Throughout the 4-year study period, each of the 5 MAP-infected herds was visited annually. From each cow in the unexposed and exposed cohorts \( \geq 24 \) months old, 10 g of feces for bacterial culture was obtained from the rectum by use of a plastic palpation sleeve and 9 mL of blood for determination of serum antibody titer against MAP was collected by venipuncture of the coccygeal vein.

All samples were submitted for diagnostic testing to the Minnesota Veterinary Diagnostic Laboratory, which achieved a passing score on the annual proficiency test for JD administered by the National Veterinary Services Laboratory throughout the study. Fecal samples were processed and cultured for MAP as described\(^8\) on Herrold’s egg yolk medium following 72 hours of sedimentation. A positive culture result was recorded when the mean number of MAP colonies per slant was \( > 0 \). Serum was obtained from each clotted blood sample and analyzed for the presence of antibodies against MAP by use of an ELISA.\(^8\) Results were interpreted in accordance with the manufacturer’s label, and a positive result was classified as a sample with a sample-to-positive ratio \( \geq 0.25 \).

Materials and Methods

Animals—During another study,\(^12\) a survey of Minnesota dairy herds classified at levels 3 and 4 of the VJDHSP (ie, herds with 98% and 99% probability, respectively, of not containing MAP-infected cows\(^5\)) was conducted through collaboration with the Minnesota Board of Animal Health in the summer of 2003. Data obtained from that survey indicated that 5 of 21 herds had sold cattle that were presumably uninfected with MAP to another 5 herds, which were known to contain MAP-infected cattle.

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Additionally, data for study cows regarding date of birth, herd of origin, purchase date, and culling dates and reasons were obtained from herd records throughout the study period. Cows that developed weight loss and chronic diarrhea that did not respond to treatment were classified as having clinical JD, and that classification was made at the herd manager's discretion. Two unexposed cohort cows with clinical signs of JD and a history of positive test results were culled from one of the study herds and submitted to the Minnesota Veterinary Diagnostic Laboratory for necropsy.

Statistical analysis—Outcomes of interest for each cohort included the number of cattle that had positive test results for culture of MAP from feces, had positive test results for serum antibodies against MAP, and age at culling for clinical JD. For each outcome, survival rate was compared between cows in the unexposed and exposed cohorts for each respective outcome by use of a 2-tailed z test.

Initially, Kaplan-Meier survival analysis was used to evaluate age at first positive result for culture of MAP from feces, age at first positive result for serum antibodies against MAP, and age at culling for clinical JD. Cox regression was used to evaluate the respective associations between cohort (unexposed or exposed) and first positive result for culture of MAP from feces, first positive result for serum antibodies against MAP, and culling for clinical JD. Robust sandwich estimates were incorporated into each model to account for clustering of cattle within herds. Age at introduction to a MAP-infected herd was included in each model, and for unexposed cohort cows, age at introduction to a MAP-infected herd was left truncated to account for the period that those cattle were not at risk of testing positive for MAP or developing clinical JD. For each of the 3 outcomes, visual evaluation of the Martingale and Schoenfeld residuals suggested that the data violated the proportional hazard assumption. Therefore, for each model, an interaction term between time spent in the MAP-infected herd (ie, time exposed to MAP) and cohort was included. The Martingale and Schoenfeld residuals were evaluated, and again it appeared that the data violated the proportional hazard assumption. As a result, an interaction term between time spent in the MAP-infected herd and age at introduction into an MAP-infected herd was evaluated in each of the models, and that interaction term was retained in the final multivariable model for a given outcome if it was significant (P < 0.05). Breslow approximation was used for instances where ≥ 2 cows had the same age to a given outcome (ie, for ties). Likelihood displacement was used to evaluate the data for outliers, and no influential outliers were found for any of the models. For each outcome, the hazard ratio was assumed to be constant after adjusting for time-dependent interaction terms. For each variable assessed in the Cox regression model, the hazard ratio (ie, hazard for unexposed cohort to hazard for exposed cohort) was calculated. All analyses were performed with statistical software, and values of P < 0.05 were considered significant.

Results

Herd—All study herds were located in central and southern Minnesota and contained primarily Holstein cows. At the beginning of the study, 4 of the 5 MAP-uninfected herds from which the unexposed cohort cows were purchased were classified at level 4 of the VJDHSP; the remaining herd was classified at level 3 of VJDHSP but was promoted to level 4 during the 4-year study period. The MAP-uninfected herds ranged in size from 35 to 100 cows (median, 61 cows), and cows were housed in free stall (n = 4) or tie stall (1) barns. The MAP-infected herds that purchased the unexposed cohort cows ranged in size from 30 to 536 cows (median, 128 cows), and cows were housed in free stall (n = 3) or tie stall (2) barns.

Cows—The age distribution for unexposed cohort cows at time of introduction for each MAP-infected herd was summarized (Table 1). During the 4-year study period, the incidence of positive results for culture of MAP from feces did not differ significantly (P = 0.25) between cows in the unexposed cohort (15/79 [19.0%]) and the exposed cohort (65/260 [25.0%]; Table 2). Similarly, the incidence of positive results for serum antibodies against MAP did not differ significantly (P = 0.74) be-

Table 1—Age distribution for 79 cows with delayed exposure to MAP (unexposed cohort) that were born into 5 Minnesota dairy herds classified at level 3 or 4 of the VJDHSP (98% and 99% probability, respectively, of not containing MAP-infected cows) at time of introduction into 5 MAP-infected dairy herds located in central and southern Minnesota during the 4-year period from 2003 through 2006.

<table>
<thead>
<tr>
<th>MAP infected herd</th>
<th>Herd size (No. of cows)</th>
<th>No. of unexposed cohort cows</th>
<th>Age (mo)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Minimum</td>
</tr>
<tr>
<td>1</td>
<td>306</td>
<td>19</td>
<td>9.0</td>
</tr>
<tr>
<td>2</td>
<td>38</td>
<td>8</td>
<td>38.0</td>
</tr>
<tr>
<td>3</td>
<td>536</td>
<td>24</td>
<td>19.0</td>
</tr>
<tr>
<td>4</td>
<td>50</td>
<td>11</td>
<td>26.0</td>
</tr>
<tr>
<td>5</td>
<td>128</td>
<td>17</td>
<td>16.0</td>
</tr>
<tr>
<td>Total</td>
<td>—</td>
<td>79</td>
<td>9.0</td>
</tr>
</tbody>
</table>

— = Not applicable.
tween cows in the unexposed cohort (13/79 [16.5%]) and the exposed cohort (47/260 [18.1%]). At the end of the study, 46 of 79 (58.2%) cows in the unexposed cohort had been culled, of which 5 were culled because of clinical JD, and 137 of 260 (50.4%) cows in the exposed cohort had been culled, of which 23 were culled because of clinical JD. The proportions of cows culled for any reason (P = 0.73) and cows culled for clinical JD (P = 0.44) did not differ significantly between cows in the unexposed and exposed cohorts. Of the 28 study cows culled because of clinical JD, only 2 cows had not had a positive culture or ELISA result prior to culling, whereas the remaining 26 cows had at least 1 positive culture or ELISA result prior to culling.

In 2006, 2 cows from the unexposed cohort in herd 1 that had signs of clinical JD were submitted to the diagnostic laboratory for necropsy. One of the cows was 28 months old when introduced into the herd and was culled 38 months later at 66 months old. In 2003 and 2004, feces and serum samples obtained from that cow yielded negative results for culture of MAP and antibodies against MAP, respectively. In 2005, both the culture of feces for MAP and serum ELISA for detection of antibodies against MAP yielded negative results in 2003 and 2004 and positive results in 2005. During necropsy, the ileal mucosa was thickened and had a mildly corrugated appearance. Culture of feces and sections of liver, spleen, ileum, ileocecal valve, and mediastinal lymph node resulted in growth of MAP.

Effect of delayed exposure to MAP for unexposed cohort cows on the incidence of those cows testing positive for MAP and developing clinical JD—Kaplan-Meier survival analyses indicated that the age at first positive result for culture of MAP from feces, age at first positive result for serum antibodies against MAP, and age at culling for clinical JD did not differ significantly between cows in the unexposed and exposed cohorts (Figure 1). Despite this lack of significance, visual evaluation of the Kaplan-Meier survival curves indicated that the proportion of cows in the unexposed cohort that had positive results for culture of MAP from feces and serum antibodies against MAP was less than that of cows in the exposed cohort until approximately 80 months of age (ie, approx 4 to 5 lactations). After 80 months of age, the survival curves for the unexposed and exposed cohorts intersected at least once.

For cows in the unexposed cohort, the hazards for first positive result for culture of MAP from feces, first positive result for serum antibodies against MAP, and being culled for clinical JD were 11.7% (95% CI, 6.0% to 22.6%), 3.1% (95% CI, 0.5% to 19.1%), and 0.1% (95% CI, 0.01% to 29.7%) lower, respectively, compared with those for cattle in the exposed cohort.

The results of the final multivariable Cox regression models for first positive result for culture of MAP from feces, first positive result for serum antibodies against MAP, and culling for clinical JD were summarized (Table 3). Age at introduction to an MAP-infected herd was not sig-

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Table 2—Number (percentage [ie, cumulative incidence rate]) of cows born into MAP-infected herds (exposed cohort) and unexposed cohort cows that had positive results for culture of MAP from feces, had positive results for serum antibodies against MAP were culled for any reason, and were culled for clinical JD in the herds of Table 1.

<table>
<thead>
<tr>
<th>Herd</th>
<th>Cohort</th>
<th>No. of cows</th>
<th>MAP cultured from feces</th>
<th>Serum antibodies against MAP*</th>
<th>Culled for any reason</th>
<th>Culled for clinical JD*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Exposed</td>
<td>76</td>
<td>16 (21.1)</td>
<td>11 (14.5)</td>
<td>53 (69.7)</td>
<td>8  (10.5)</td>
</tr>
<tr>
<td></td>
<td>Unexposed</td>
<td>19</td>
<td>4 (21.1)</td>
<td>4 (21.1)</td>
<td>12 (63.2)</td>
<td>3  (15.7)</td>
</tr>
<tr>
<td>3</td>
<td>Exposed</td>
<td>20</td>
<td>5 (25.0)</td>
<td>2 (10.0)</td>
<td>3 (15.0)</td>
<td>0  (0.0)</td>
</tr>
<tr>
<td></td>
<td>Unexposed</td>
<td>8</td>
<td>1 (12.5)</td>
<td>3 (37.5)</td>
<td>5 (62.5)</td>
<td>0  (0.0)</td>
</tr>
<tr>
<td>4</td>
<td>Exposed</td>
<td>33</td>
<td>7 (21.2)</td>
<td>4 (12.1)</td>
<td>6 (18.2)</td>
<td>1  (3.0)</td>
</tr>
<tr>
<td></td>
<td>Unexposed</td>
<td>11</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
<td>5 (45.5)</td>
<td>0  (0.0)</td>
</tr>
<tr>
<td>5</td>
<td>Exposed</td>
<td>56</td>
<td>17 (30.4)</td>
<td>13 (23.2)</td>
<td>45 (80.4)</td>
<td>7  (12.5)</td>
</tr>
<tr>
<td></td>
<td>Unexposed</td>
<td>17</td>
<td>6 (35.3)</td>
<td>3 (17.6)</td>
<td>11 (64.7)</td>
<td>0  (0.0)</td>
</tr>
<tr>
<td>Total</td>
<td>Exposed</td>
<td>260</td>
<td>65 (25.0)</td>
<td>47 (18.1)</td>
<td>157 (60.4)</td>
<td>23 (8.8)</td>
</tr>
<tr>
<td></td>
<td>Unexposed</td>
<td>79</td>
<td>15 (19.5)</td>
<td>13 (16.5)</td>
<td>46 (58.2)</td>
<td>5  (6.3)</td>
</tr>
</tbody>
</table>

*Clinical JD was defined as weight loss and chronic diarrhea that did not respond to treatment as determined by the herd manager.

Cows in the unexposed cohort were assumed to be unaffected with MAP at the time of introduction into the 5 MAP-infected dairy herds. Within each herd, each unexposed cohort cow was matched to 3 exposed cohort cows that had a parity ± 1 of that of the unexposed cohort cow. Additionally, 23 cows were included in the unexposed cohort to account for cows lost to follow-up in the unexposed cohort. From each study herd, a fecal sample for culture of MAP on Herrold’s egg yolk medium and a blood sample for detection of serum antibodies against MAP by use of a commercial ELISA were obtained annually from 2003 through 2006. A positive culture result was recorded when the mean number of MAP colonies per slant was > 0, and a positive result for ELISA was classified as a sample with a sample-to-positive ratio ≥ 0.25. Data regarding birthdates and culling dates and reasons were obtained from herd records.

See Table 1 for remainder of key.
significantly associated with any of the 3 outcomes but was retained in the respective models so that the interaction between time spent in an MAP-infected herd and age at introduction to an MAP-infected herd could be assessed. Cohort and the interaction between cohort and time spent in an MAP-infected herd were significantly associated with each of the 3 outcomes. After introduction into the MAP-infected herd, cows in the unexposed cohort had a lower risk of a positive result for culture of MAP from feces, a positive result for serum antibodies against MAP, and being culled because of clinical JD, compared with that for cows in the exposed cohort; however, the risk of cows developing each outcome increased 2.2% (95% CI, 0.1% to 4.3%), 6.2% (95% CI, 3.3% to 9.2%), and 17.4% (95% CI, 7.9% to 27.6%) for each additional month spent in an MAP-infected herd, respectively. For the outcome culling for clinical JD, there was also a significant association with the interaction between time spent in an MAP-infected herd and age at introduction to an MAP-infected herd; the magnitude of the association of age at introduction to an MAP-infected herd decreased by 0.5% (95% CI, 0.1% to 1.0%) for each additional month the cow spent in an MAP-infected herd. For cows in the unexposed cohort, the protective effect of being born and raised in an MAP-uninfected herd disappeared at 98.5 months of age (approx the seventh lactation) for having a positive result for culture of MAP from feces, 57.2 months of age (approx the third to fourth lactation) for having a positive result for serum antibodies against MAP, and 43.1 months of age (approx the second to third lactation) for being culled for clinical JD.

Discussion

Results of the present study suggested that dairy cattle that were first exposed to MAP at a median age of 26 months (ie, adult cattle) in a commercial herd setting could become infected and develop clinical JD. These findings are consistent with those of other studies in which experimental inoculation of adult cattle with MAP resulted in infection. In 1 study, IV inoculation of MAP to adult cows resulted in infection. In another study in which 7 adult cows were continuously exposed to an MAP-contaminated environment for 4 years, 1 cow developed clinical JD and MAP was isolated from lymphatic tissue specimens obtained from 4 cows, despite the fact that MAP was not consistently cultured from the feces of any of the 7 cows. Results of a study in which cattle of various ages were experimentally inoculated with MAP indicate that older cattle are more resistant to becoming infected with MAP than are 1-month-old calves; however, those adult cattle did develop an immune reaction against MAP and histopathologic lesions in the gastrointestinal tract consistent with MAP infection. Investigators of a meta-analysis, which included 8 studies that were conducted to evaluate the effect of age of cattle on the susceptibility to becoming infected with MAP, concluded that adult cattle can become infected with MAP when exposed to highly contaminated environments, but they are less likely to develop clinical JD, compared with cattle that are exposed to MAP as young calves.
In the present study, the incidence of cows not exposed to MAP at birth (unexposed cohort) that tested positive for MAP or developed clinical JD was compared with that of cows that were exposed to MAP since birth (exposed cohort). Although the cumulative incidences of positive results for culture of MAP from feces, positive results for serum antibodies against MAP, and culling for clinical JD did not differ significantly between cows in the unexposed and exposed cohorts, the culls in the exposed cohort did have a higher cumulative incidence, compared with that for the cows in the unexposed cohort for each of those outcomes. In fact, none of the unexposed cohort cows in 1 of the 5 study herds (herd 4) had positive test results for MAP or developed clinical JD, whereas, of 33 exposed cohort cows, 7 (21.2%) had positive results for serum antibodies against MAP and 1 (3.0%) was culled because of clinical JD. This was a 50-cow herd that was started in 2004 with the purchase of adult cows from multiple herds, and cows were housed in tie stalls.

Visual evaluation of the Kaplan-Meier survival curves for age at first positive result for culture of MAP from feces, age at first positive result for serum antibodies against MAP, and age at culling for clinical JD suggested that the risk of developing a given outcome was less for cows in the unexposed cohort, compared with that for cows in the exposed cohort, and that risk increased over time, regardless of cohort (unexposed or exposed). Similarly, when age at introduction to an MAP-infected herd and the interaction between time spent in an MAP-infected herd and cohort were controlled during Cox regression, the hazards for testing positive for MAP or developed clinical JD were less for cows in the unexposed cohort, compared with those for cows in the exposed cohort; however, the magnitude of the difference between those hazards for unexposed and exposed cohort cows decreased as the cows aged until approximately 48 months (ie, third lactation), at which time the hazards became equal for both cohorts. These findings may have been biased toward the null because of the criterion of matching exposed cohort cows with unexposed cohort cows on the basis of similar parity. In those instances when unexposed cohort cows with a parity > 1 were introduced into a herd, the exposed cohort cows matched to those cows may have been subject to survival bias (ie, because those exposed cohort cows had survived 1 or more parities, they might have had some innate resistance to MAP and been less likely to test positive for MAP or develop clinical JD).

In the present study, exposed cohort cows were matched to unexposed cohort cows on the basis of MAP-infected herd and similar parity in an attempt to ensure that both cohorts had similar environmental exposure to MAP. For the cows of the present study that were infected with MAP, the exact age at which they became infected was unknown. Because the unexposed cohort cows were purchased from herds that had a 98% to 99% probability of not containing MAP-infected cattle, it was assumed that those cows were not infected with and had not been exposed to MAP at the time they were introduced to the MAP-infected herds. Conversely, it was assumed that the exposed cohort cows had been continuously exposed to MAP since birth. Thus, the primary difference between the 2 cohorts was the amount of time exposed to MAP. A possible explanation for the convergence of hazards for cows in the unexposed and exposed cohorts as they aged is that a proportion of cows have negative results of testing for MAP throughout their lives because of insufficient exposure or innate resistance to MAP. Nonetheless, delaying exposure of cattle to MAP for as long as possible appears to be important from a herd management perspective because, even though adult cattle can become infected with MAP, it is likely they will be culled from the herd before they begin to shed MAP in their feces or develop clinical JD.14

The amount of MAP to which unexposed and exposed cohorts cows were exposed was not quantified in the present study and likely varied among herds. Therefore, the amount of MAP required to establish an infection in adult cows remains unknown. Results of the present study simply indicated that a proportion of cows initially exposed to MAP as adults shed MAP in their feces and developed serum antibodies against...
MAP clinical signs of JD, and histopathologic lesions consistent with MAP infection.

For consistency, the same laboratory performed the same MAP culture method and commercial ELISA throughout the study. Nevertheless, occasionally, culture or ELISA results were unavailable for each study cow because the cow was housed in an area where it could not be safely restrained for sample collection, an insufficient amount of sample was obtained, or fungal overgrowth prevented interpretation of results for bacterial culture of feces.

Many of the management practices currently recommended to decrease the incidence of MAP infection in dairy cattle are focused on minimizing exposure of calves and young heifers to MAP. Results of experimental studies12,13,14 and the present observational study indicate that horizontal transmission of MAP among adult cattle is possible, and its role in maintaining or propagating JD within a herd warrants further research. Investigators of a study13 in which simulation modeling was used to evaluate the persistence of MAP in commercial US dairy herds suggest that horizontal transmission of MAP among adult cattle may have an important role in maintaining JD within a herd, especially herds with a low prevalence of MAP-infected cows.

Results of the present study indicated that delaying exposure of dairy cows to MAP until they became adults did not prevent those cows from becoming infected; nonetheless, it did reduce the hazard of those cows having positive results for culture of MAP from feces, positive results for serum antibodies against MAP, or being culled for clinical JD, compared with the corresponding hazards for cattle that had been exposed to MAP since birth. The protective effect of delayed exposure to MAP decreased as cows got older and was essentially nonexistent after approximately the first 3 lactations. Although these findings suggested that horizontal transmission of MAP among adult dairy cattle does occur in a commercial herd setting and its role in maintaining JD within a herd warrants further research, the results of the present study do not negate or contradict current recommendations for control of JD within a herd, which focus on minimizing the exposure of calves and young heifers to MAP.

a. HerdChek, IDEXX Laboratories Inc, Westbrook, Me.

Reference