Where are we with Johne's Disease Control – Can we Eliminate?[a]

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Abstract

In the US, a major step forward in control of Johne's disease (JD) was the development and implementation of the JD Herd Risk Assessment and Herd Management Plan. Along with a major educational effort, many herds have joined the US JD Herd Control Program, though many others remain outside of control programs. The focus of this report is to address the issue of control and eradication of Johne's disease with evidence from scientific literature and experience primarily from US dairy cattle herds, identify knowledge gaps in our current understanding and identify a path forward towards national control.

Résumé

Aux États-Unis, une étape importante a été franchie dans la lutte contre la maladie de Johne avec la mise au point et en application d'un programme de conduite des troupeaux et d'évaluation des risques liés à la maladie de Johne. Grâce à un effort éducatif important, plusieurs troupeaux ont été inscrits au programme américain de lutte contre la maladie de Johne dans les troupeaux; toutefois, un grand nombre d'autres demeurent encore à l'extérieur de ces programmes. Le présent rapport s'intéresse particulièrement au problème de la lutte et de l'éradication de la maladie de Johne et apporte des preuves tirées de la documentation scientifique et de la pratique en provenance surtout de troupeaux laitiers aux États-Unis. On y souligne également les lacunes de notre compréhension actuelle et on y propose une voie à suivre pour étendre la lutte à l'échelle nationale.

Transmission in Dairy Herds

Risk factors associated with presence of Johne's disease (JD) in dairy herds include number of cows in the herd, geographic location, percent of cows born at other dairies, group housing for periparturient cows and group housing for preweaned calves.[21] *M. paratuberculosis* is usually introduced to dairy herds through the purchase of infected but clinically normal cattle,[19] an indication of the critical role of transmission from farm to farm through the introduction of purchased cattle. A key preventive measure for JD is the careful evaluation of purchased cattle (through screening the herd of origin) to avoid introducing *M. paratuberculosis* to the operation.

Early reports indicated that young calves are more susceptible than older cattle for infection with *M. paratuberculosis*.[8,11] A Minnesota study[7] indicates that heifers born and raised in test-negative herds and later introduced into infected herds just prior to first calving are less likely than herdmates to test positive later in life, though older cattle can become infected.

Most transmission of JD is thought to occur through fecal-oral transmission of the pathogen.[10] Fecal shedding by infected cattle can occur at very high concentrations, though the distribution of typical shedding concentrations is not well defined. The role of heavy fecal shedding cattle to the overall *M. paratuberculosis* bioburden and transmission of JD is likely to be considerable. The existence of passive shedding has been demonstrated in experimental studies in calves[18] and could serve as a method of transmission in youngstock. Theoretically, passive shedding could also occur in older cattle, and additional research is needed to clarify its significance.

In addition, *M. paratuberculosis* survives very well in the environment of many dairy farms, especially during cool and damp weather[15] and potentially for many months in shaded conditions.[22] Survival in bovine slurry at 41°F (5°C) has been demonstrated for over eight months.[5] This survival can lead to high levels of exposure of susceptible cattle in intensively managed cattle operations. The distribution of *M. paratuberculosis* in the environment of dairy cattle farms has been demonstrated in a recent study of Minnesota dairy herds.[13] The farm environment was culture-positive in 95% of herds with at least one positive pool of cow fecal samples.

While the most important route of JD transmission is generally considered to be through the ingestion

[a] Adapted from Wells SJ, 2005. The Prospects for Herd Level Control of Paratuberculosis - A Scientist's View. *Proc 8th International Colloquium on Paratuberculosis.*

of infective feces in the calf's environment, other potential sources of transmission include shedding (or post-harvest contamination) of *M. paratuberculosis* in colostrum or raw waste milk. One study reported that 27% of subclinically infected cows had culture-positive supramammary lymph nodes and 12% had culture-positive milk.[17] Another study reported that up to 22% of infected cows shed the organism in milk and colostrum.[16] Limited research to date suggests that the concentration of this pathogen in milk from hematogenous sources is much lower than the typical levels used in experimental studies, and suggests that pasteurization would be likely to eliminate this pathogen at this level. However the level of *M. paratuberculosis* in milk due to fecal contamination is unknown.

Finally, the prevalence and concentration of Map in surface water sources has not been evaluated. This may prove to be an important source of infection in certain situations in which standing water serves as primary drinking water source for cattle.

Control Strategy for use in Dairy Cattle Herds

Strategies to control JD within an infected herd are 1) to reduce transmission of the organism to susceptible animals and 2) to identify and remove animals known to test positive for the disease. Despite a general understanding of JD transmission, however, little information has previously been available regarding efficacy of specific herd control programs.

Herd Management

Very high exposure levels to replacement heifers are probable from contamination of feces from adult cattle in later stages of infection. Since this is likely to dominate the exposures received by young susceptible replacement cattle, recommended herd control measures focus on reduction of these exposures. Johne's disease control programs frequently stress management practices designed to prevent transmission of *M. paratuberculosis* to newborn calves and youngstock through fecal-oral routes as well as infective colostrum and milk.

One of the earliest potential postnatal exposures of dairy replacement heifers to contaminated fecal material from infected cows occurs in the first few hours of life within the maternity area. Because of the large potential risk, JD herd management plans place an emphasis on maternity pen management. Herd control plans for control of JD in dairy herds often include the use of individual calving pens cleaned between successive uses (versus calving cows in a group pen on a bedded pack).[14] Information from controlled clinical trials is not yet available, however, to substantiate this recommendation.

Another management recommendation designed to prevent transmission of *M. paratuberculosis* on infected farms is to raise youngstock segregated from cow feces in the environment. The practice of off-site heifer rearing, either by the owner or by a professional dairy heifer grower, is often recommended to help achieve this goal. Again, this has not yet been demonstrated in controlled clinical trials. Proper handling of infective fecal material is an important part of the herd management program.

The risk of transmission of JD from cow to calf through colostrum feeding is not fully understood, and some producers use results from individual cow testing for making colostrum feeding decisions. Limited research investigating the value of pasteurizing colostrum on pathogen control is available, though a clinical trial in Minnesota is underway. Another option for avoiding *M. paratuberculosis* transmission in colostrum is to instead feed a commercial colostrum substitute, and results from a clinical trial are expected soon.

One of the benefits of feeding a commercial milk replacer is to prevent transmission of *M. paratuberculosis*, as well as other important pathogens in potentially infective waste milk. Similarly, the recent introduction of commercial pasteurization equipment has offered dairy producers an economically attractive method to feed pasteurized waste milk while controlling pathogen transmission. Some concerns remain, however, that pasteurization may not effectively destroy all viable *M. paratuberculosis* present in waste milk, especially if present at high concentrations. Furthermore, even if some bacteria did survive the pasteurization process, it is not known if very low levels remaining in the milk are infective to cattle. Information is needed on the effect of commercial pasteurization of waste milk on the prevention of transmission of *M. paratuberculosis* under field conditions.

Despite lack of research documenting effects of specific herd management practices on control of JD, information has been gained from uncontrolled longitudinal herd studies. An Australian report[6] provides evidence that implementation of a herd control program in dairy herds does reduce clinical disease and test prevalence. In the US, results from analysis from Minnesota dairy and beef demonstration herds[2] show a similar reduction in clinical JD, after a period of four to five years. After six years of follow-up, there was a significant reduction in the incidence of seroconversion, fecal shedding, and cows with clinical signs of JD. Additional results from the National JD Demonstration Herd Program are expected soon.

These results indicate that motivated cattle producers can make progress in herd control, though it is impossible to separate the effects of herd management from those from removal of some test-positive cattle in these uncontrolled studies. Several clinical trials to evaluate the impact of specific herd management are currently underway in the US (feeding of colostrum vs. colostrum substitute to calves, individual cow maternity pens vs. group housing, segregated heifer rearing vs. calf rearing with adult cow contact), but results are not yet available.

In the US, a commercial vaccine is available for control of JD with State Veterinarian approval, and is adopted sporadically across the country. Evidence from a controlled clinical trial[9] showed that vaccination with whole-cell bacterin reduces incidence of clinical JD. Another study showed that vaccination is cost-effective due to reduction of culling of clinically affected cattle.[20] Longitudinal uncontrolled studies from several countries show reduction in clinical disease with whole-herd vaccination, but less consistent results are available regarding the effect of vaccination on fecal shedding. In a Wisconsin clinical trial underway (Patton *et al*, unpublished data), three moderately to heavily infected commercial dairy herds vaccinated every other heifer calf against JD, after previous implementation of a control program. After at least one test per cohort after first calving, cattle from the vaccinated cohort had significantly fewer positive fecal cultures than the non-vaccinated cohort, suggesting a protective role for JD vaccine in combination with management changes in moderate to heavily infected herds.

Eradication of JD in Dairy Cattle Herds

To date, limited information is available to address eradication of JD in cattle herds. Some dairy and beef cattle herds, however, are interested in eradication of JD from their operations and have financial incentive to do so, including a desire to reduce their liability from potentially selling infected cattle to other producers. For infected herds interested in disease eradication, both implementation of a management control program and additional testing is warranted to identify individual infected cattle for removal from the herd. Current tests do not identify all infected cattle. Infected cows can transmit infection to other cattle before showing clinical signs of disease or testing positive. Best estimates are that serum ELISA tests currently available detect less than 25% of subclinically infected adult cattle and falsely identify as positive up to 4% of uninfected cattle.[1] These assay errors indicate that many uninfected cattle in low prevalence herds may be culled in error, a cost of the eradication program. Cost-effectiveness of a test-and-cull program depends upon the specific herd situation, but test and removal has not been shown to be cost-effective for most dairy herds using one of the currently available serum ELISA tests.[4] Producers willing to make this investment should avoid re-introduction of JD through purchased cattle either by maintaining a closed herd or by purchasing cattle only from low risk herds.

An issue for further consideration, however, is the removal of late stage cattle with highest risk of transmission to susceptible young cattle (i.e., heavy fecal shedders). These cattle are at highest risk for contaminating the environment as well as shedding in the colostrum, milk and through the placenta. More research is needed to identify the importance of heavy fecal shedders in herd control and/or eradication programs.

Debate regarding the public health significance of JD continues, and if *M. paratuberculosis* is shown to be a human pathogen the costs of disease control will increase dramatically due to loss of market access and control program costs. Contingency planning is needed, utilizing risk assessment-based decision making. The goal of a program considering JD as a public health issue would be to reduce human exposure to *M. paratuberculosis* to reduce transmission. Potential routes of human exposure to *M. paratuberculosis* include oral ingestion of milk, water and infected or contaminated foods (meats, vegetables, fruits) and direct contact to infected fecal material, especially for those with occupational exposures like producers and veterinarians.

JD is worthy of our best control efforts, as well as continued research to better understand the efficacy of control options. Though complete information is not available, we have tools available today to reduce the within-herd prevalence of infection on dairy and beef cattle operations to minimize economic loss to cattle producers. Further information from clinical trials and other research will assist in fine tuning effective management programs. On the other hand, it is unclear whether we currently attain the knowledge needed to effectively eradicate JD from cattle herds. Eradication will be necessary if *M. paratuberculosis* is conclusively shown to be a public health risk, since control of JD will not be adequate to protect human health and satisfy public demands.

Today, we are at a key decision making point as a country. We have developed control programs that have been demonstrated to be successful, given several years of implementation, though the importance of specific components of the control program remains unknown. Federal funding has been available for the past several years to support the national program, yet future funding remains in doubt due to other animal health priorities. Questions that need to be addressed at this time include: What type of Johne's disease program do we want? What type of program does the dairy industry and beef cattle industry want? What roles should be played by key stakeholders (cattle producers, dairy and beef cooperatives, processors, interested states, and USDA-APHIS-Veterinary Services) in support of cattle producers? Our collective challenge will be to change national policy to match the needs of the affected industries while taking advantage of new information generated by research and control efforts.

References

1. Collins MT, Wells SJ, Petrini KR, Collins JE, Schultz RD, Whitlock RH: Evaluation of five antibody detection tests for diagnosis of bovine paratuberculosis. *Clin Diagn Lab Immunol* 12:685-692, 2005.
2. Ferrouillet C: Evaluation of the Johne's disease demonstration herd program in Minnesota for the potential control of *Mycobacterium avium* subsp *paratuberculosis* infections in dairy cattle and humans. MPH Thesis, University of Minnesota, 2006.
3. Godden S, Smith S, Feirtag J, Green L, Wells S, Fetrow J: Effect of on-farm commercial batch pasteurization of colostrum on colostrum and serum immunoglobulin concentrations in commercial dairy calves. *J Dairy Sci* 86:1503-1512, 2003.
4. Groenendaal H, Galligan DT: Economic consequences of control programs for paratuberculosis in midsize dairy farms in the United States. *J Am Vet Med Assoc* 223:1757-1763, 2003.
5. Jorgensen JB: Survival of Mycobacterium paratuberculosis in slurry. *Nord Vet Med* 29:267-270, 1977.
6. Jubb TF, Galvin JW: Effect of a test and control program for bovine Johne's disease in Victorian dairy herds 1992-2002. *Aust Vet J* 82:228-232, 2004.
7. Kovich D, Wells SJ, Friendshuh K: Evaluation of the value of the Voluntary Johne's Disease Herd Status Program for Cattle as a source of replacement cattle. *J Dairy Sci* 89:2366-3470, 2006.
8. Larson AB, Merkal RS, Cutlip RC: Age of cattle as related to resistance to infection with Mycobacterium paratuberculosis. *Am J Vet Res* 36:255-257, 1975.
9. Larson AB, Moyle AI, Himes EM: Experimental vaccination of cattle against paratuberculosis (Johne's disease) with killed bacterial vaccines: A controlled field study. *J Am Vet Med Assoc* 65-69, 1978.
10. National Research Council: National Research Council of the National Academies: Diagnosis and Control of Johne's Disease. National Academy of Sciences. National Academic Press. Washington, DC, 2003.
11. Payne JM, Rankin JD: A comparison of the pathogenesis of experimental Johne's disease in calves and cows. *Res Vet Sci* 2:175-179, 1961.
12. Quigley JD, Kost CJ, Wolfe TM: Absorption of protein and IgG in calves fed a colostrum supplement or replacer. *J Dairy Sci* 85:1243-1248, 2002.
13. Raizman EA, Wells SJ, Godden SM, *et al*: The distribution of *Mycobacterium avium* ssp *paratuberculosis* in the environment surrounding Minnesota dairy farms. J Dairy Sci 87:2959-2966, 2004.
14. Rossiter C, Hansen D: Critical management points for prevention and control of Johne's Disease in dairy cattle. Johne's Disease Information Article No. 2. AABP Food Safety Committee and the National Johne's Working Group, 2000.
15. Schroen CJ, Kluver PF, Butler KL, McDonald WL, Hope AF, Contron RJ: Factors affecting survival of *Mycobacterium avium* subsp *paratuberculosis* in soil. 7ICP 10-15, 2002.
16. Streeter RN, Hoffsis GF, Bech-Nielsen S, *et al*: Isolation of *Mycobacterium paratuberculosis* from colostrum and milk of subclinically infected cows. *Am J Vet Res* 56:1322-1324, 1995.
17. Sweeney RW, Whitlock RH, Rosenberger AE: *Mycobacterium paratuberculosis* cultured from milk and supramammary lymph nodes of infected asymptomatic cows. *J Clin Micro* 30:166-171, 1992.
18. Sweeney RW, Whitlock RH, Hamir AN, Rosenberger AE, Herr SA: Isolation of Mycobacterium paratuberculosis after oral inoculation in uninfected cattle. *Am J Vet Res* 53:1312-1314, 1992.
19. Sweeney RW: Transmission of paratuberculosis. *Vet Clin North Am Food Anim Pract* 12(2):305-312, 1996.
20. Van Schaik G, Kalis CHJ, Benedictus G, Dijkhuizen AA, Huirne RBM: Cost-benefit analysis of vaccination against paratuberculosis in dairy cattle. *Vet Rec* 139:624-627, 1996.
21. Wells SJ, Wagner BA: Herd-level risk factors for infection with *Mycobacterium paratuberculosis* in U.S. dairies and association between familiarity of the herd manager with the disease or prior diagnosis of the disease in the herd and use of preventive measures. *J Am Vet Med Assoc* 216(9):1450-1457, 2000.
22. Whittington RJ, Marshall DJ, Nicholls PJ, Marsh IB, Reddacliff LA: Survival and dormancy of *Mycobacterium avium* subsp *paratuberculosis* in the environment. *Appl Environ Micro* 70:2989-3004, 2004.