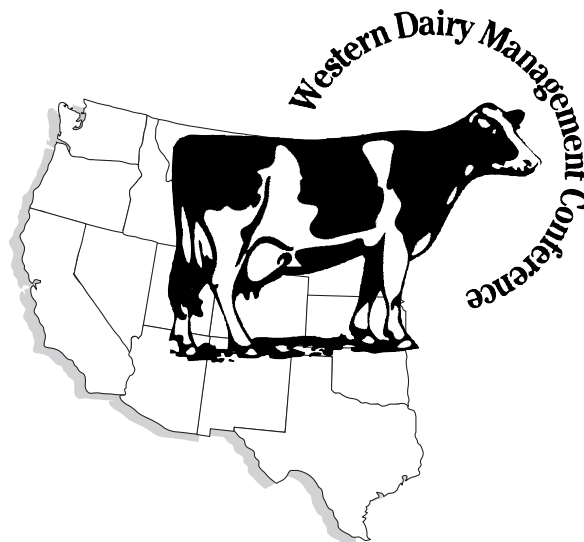


10 Myths About Johne's Disease: Information Dairy Producers Need To Consider

Franklyn Garry
Associate Professor, Integrated Livestock Management
Colorado State University
Department of Clinical Sciences
Fort Collins, CO 80523-1620
970-491-0371
fax 970-491-1275
fgarry@vth.colostate.edu



10 Myths About Johne's:

Information dairy producers need to consider

(Note: This article is modified from an earlier version that appeared in the November 1998 issue of the *Compendium of Continuing Education for the Practicing Veterinarian*.)

Johne's disease (JD, paratuberculosis) has become the focus of increasing attention across the country over the last several years. There are multiple reasons this livestock health problem has assumed much greater importance than before:

- 1.) Recent studies demonstrate a greater prevalence of the disease in dairy herds than was previously assumed.
- 2.) The economic impact of Johne's disease on affected herds appears to be much greater than previously assumed.
- 3.) Some recent litigation cases have focused on questions of responsibility for spread of the disease between herds.
- 4.) Some studies have suggested that the causative bacterium, *Mycobacterium paratuberculosis*, may also be associated with a human health problem, raising concerns that it is a zoonotic pathogen.

Most states have not had a well enunciated policy concerning JD. There is confusion about identification of affected animals and herds, and the prevailing attitude has been to ignore the problem. Most livestock producers are poorly informed about Johne's disease. In recent nationwide surveys only 17.7% of dairy producers and 2.4% of cow-calf producers claimed to be fairly knowledgeable about Johne's disease, while 37.1% and 5.4% additional dairy and beef producers knew some basics of the problem¹⁶.

Most dairy producers and veterinarians have a multitude of reasons why they choose to ignore JD. Unfortunately this decision is often based on partly or wholly inaccurate information and outmoded reasoning. It is time to reconsider this problem, and a good place to start is by examining some Johne's disease myths.

Myth #1 – Johne's disease is not an economically important disease of cattle.

Because Johne's disease is characterized by only a few cows with clinical disease in an infected herd at any one time, it has been easy to downplay the economic cost of the disease. Recent information from the National Animal Health Monitoring System (NAHMS) Dairy '96 Study, a national study of dairy health issues conducted by the USDA:APHIS:VS in 1996, estimates that the cost of Johne's disease can indeed be quite high¹⁶. The study showed that, in test-positive herds with at least 10% of cull cows with clinical signs consistent with Johne's disease, the average cost to dairy producers was \$227 per cow per year. The majority of this loss is due to reduced milk production. Other studies have similarly shown surprisingly high economic losses for infected herds^{15,31}. Clearly the losses will be lower for herds with lower disease prevalence, but then, most producers and most veterinarians haven't really evaluated disease prevalence, and cannot draw accurate conclusions for individual herds. It is critical to realize that a low prevalence herd today will become a high prevalence herd "tomorrow", thus losses will increase with time, unless effective intervention measures are used^{25,29}.

Myth #2 – Johne's disease is not a common problem, and it occurs mostly in the Northeast, rarely in the Western or Southern states.

Results from the NAHMS Dairy '96 Study show that about 22% of U.S. dairy herds have 10% or more cows infected with the *M. paratuberculosis* organism based on blood testing for antibody using a commercially available serum ELISA and clinical history¹⁶. Herd prevalence is related to herd size with about 40% of herds with at least 300 cows having similar 10% or greater infection rates. Only minor regional differences were noted indicating that dairy producers in all regions of the country need to consider implications and risks associated with this pathogen. It appears those regions of the country where JD has been considered less prevalent have as much or more occurrence of this problem as other areas¹.



The 10 Myths About Johne's Disease:

- #1 – JD is not an economically important disease of cattle.
- #2 – JD is not a common problem, and it occurs mostly in the Northeast, rarely in the Western or Southern states.
- #3 – JD is a dairy cow problem, not a concern to other livestock producers.
- #4 – The tests for JD identification are unreliable and worthless.
- #5 – If JD is identified in a herd, it will be reported to the State Veterinarian and the herd will be quarantined or otherwise penalized.
- #6 – Producers do not want to know about, nor deal with, JD in their herds.
- #7 – JD is a problem of older cows that does not spread much in the herd, and can be controlled by culling occasional affected cattle.
- #8 – If JD were present in my herd, I'd know it.
- #9 – Management for control of JD is complicated, ineffective, and a waste of effort.
- #10 – JD does not represent a real threat to the livestock industry.

Myth #3 – Johne's disease is a dairy cow problem, not a concern to other livestock producers.

A similar national study in beef cow/calf herds was conducted starting in the fall of 1997, and results are expected to be available soon. However, regional surveys of beef cattle have shown substantial infection rates^{1,32}. In addition, clinical Johne's disease has been reported from sheep, goats, deer, elk, bison, llamas and other ruminants indicating that this disease is not just a dairy cow or cattle problem²⁹.

Myth #4 – The tests for JD identification are unreliable and worthless.

Realistically, we need to remember that not a single test we use for disease identification in veterinary medicine is completely accurate. The tests we have used to eradicate brucellosis and tuberculosis from our cattle herds have been similarly flawed, and yet have been successfully employed in these efforts. It is true that our current tests for JD are not as good as we'd like at the detection of individual infected animals^{8,9,22}. But using a test for herd management of disease is different than using a test on an individual animal. The most commonly used tests for JD will miss some infected animals, but rarely produce a false-positive result for an uninfected animal. It is important to recognize

that herd sensitivity of a test is always greater than the sensitivity of the test applied to individuals.

Thus, by detecting some infected animals in a herd we can discover that the herd is infected and use that information in herd management, although some of the individuals will be missed. Further, an infection-free herd can be identified, providing compelling reason to work to keep the herd free of the disease, and an increased value of animals for sale. Valid and useful herd decisions can be made even when every single affected animal is not identified.

Fecal culture, serologic, and other diagnostic tests are available and can be effectively employed in disease control programs. Results from these tests are interpreted along with clinical signs of disease to provide management information on either an individual or herd level^{18,30}. A problem with diagnosis, particularly at the individual animal level, is lack of detection of some early infections since antibody development and heavy fecal shedding do not usually occur until late in the course of the disease. These facts result from the nature of the disease, not due to problems with the tests themselves. Generally the tests are quite good at confirming a diagnosis in clinically affected cows, but give negative results with increasing frequency

the earlier an animal is tested in the course of infection. Testing bred heifers, for example, will fail to detect the majority of infected animals, so this is a much weaker approach to screening incoming animals than testing older cattle in the herd of origin.

Myth #5 – If JD is identified in a herd, it will be reported to the State Veterinarian and the herd will be quarantined or otherwise penalized.

To this date, there have not been consistent state, national or industry-wide education or control programs in the U.S. In fact, a recent survey of state policies concerning JD showed only 7 states had JD herd certification programs, while only 6 had JD control programs. Only 6 states required reporting of ELISA positive tests, while 12 required reporting from fecal culture positive tests³³. Simply stated, it is important to contact your State Veterinarian to be sure what your state policy really is. Even more importantly, most states are looking for further input to develop a coherent policy. Many states are beginning to form State Johnes Disease Advisory Committees to help establish workable policies. Livestock producers and veterinarians need to be involved and help set priorities and direction for the future in this regard^{21,33}.

Myth #6 – Producers do not want to know about, nor deal with JD in their herds.

Realistically, most livestock producers know little enough about JD that their opinions, like those of many veterinarians, are based on limited information and on popular opinion or hearsay¹⁶. Producer education, based on accurate information, is a major and heavy responsibility of the veterinary community. While it is true that producers are not enthused about dealing with yet another disease problem, especially one like JD, it is clearly part of the duty of food animal veterinarians to help inform producers to a level where they can make informed choices regarding action on this disease. It is notable that the National Cattlemen's Beef Association, one of the nation's largest producer groups, sponsored an informational symposium on JD at their 1998 winter meeting. At the conclusion of the meeting, resolutions to address JD education for producers were adopted. Then at the summer 1998 meeting, the NCBA moved to incorporate producer education on JD into the Beef Quality Assurance program. In Colorado we have distrib-

uted information about JD to dairy producers via our dairy newsletter and producer education seminars. In response to a subsequent survey, over 75% of producers expressed concern about introducing JD into their herds, and a similar percent wanted more information and advice about managing to prevent or control the problem.

Many veterinarians need to reconsider the equation and ask whether they may be the ones least enthused about dealing with this disease, and if so, why? It is imperative that both producers and veterinarians become well educated about JD. Good decisions only result when based on sound knowledge. History shows that producers armed with information will indeed take action.

Myth #7 – Johne's disease is a problem of older cows that does not spread much in the herd, and can be controlled by culling occasional affected cattle.

It is true that the infectious organism is characterized by very slow growth, leading to chronic disease progression, with clinical signs typically developing only in mature or aged cattle^{16,30}. Young calves of less than six months old are most susceptible to infection²⁵. The problem has been likened to an iceberg where only the small portion of ice (symptomatic or advanced infection) above the water is visible. Many of our previous beliefs about disease transmission and its control have been challenged. In utero infection of calves appears to occur in 20%-40% of infected cows and about 9% of asymptomatic infected cows, contrary to earlier notions that fecal contamination of feed and water was the sole means of transmission^{20,25}. In addition, the bacteria can also be shed directly in milk and colostrum by both clinically affected and normal appearing infected cows even without fecal contamination. Under group housing conditions with high levels of exposure to the organism, JD can occur in cattle 16-27 months old^{16,18,30}. If management practices that limit the spread of the disease are not used, and only clinically affected cows are culled, the disease will slowly but surely continue to spread through the herd²⁵. This disease does not stand still, nor sporadically come and go like some other problems. Right now, due to lack of action to control JD, it is insidiously spreading to more herds and to more cattle within each affected herd.



Myth #8 – If JD were present in my herd, I'd know it.

Because of the information stated in the preceding comment, it is quite reasonable that JD in a herd can go unnoticed for a considerable time, especially if nobody is looking for it. Since subclinically affected cows will not show dramatic disease signs, and rather may simply perform poorly, they may be culled without any specific diagnosis³⁰. By the time a diagnosis of JD is made, many producers have allowed it to spread quite extensively through their herd⁸. The only ways to prevent such a problem are to specifically look for management risk factors that encourage disease introduction and spread, and to proactively evaluate and look for infected animals^{7,18}. In general, this disease will only catch attention once it is well entrenched and advanced.

Myth #9 – Management for control of JD is complicated, ineffective, and a waste of effort.

It is true that most farms require an individually designed program, because each operation has its own unique features^{7,18}. This effectively means that ideally a veterinarian should be involved in helping to design farm-specific plans. But the basic management practices needed to control JD are relatively simple, and program complexity depends on the desires and control targets of the individual producer⁷. The most important practices revolve on calf rearing, manure management, and introduction of new animals to the herd^{7,10,13,29}. Most importantly, the same practices that are used to control JD are also effective 'best management practices' for controlling other fecally transmitted, and neonatally contracted infectious problems^{7,18}. So management for Johne's disease is also management for other important infectious problems.

Myth #10 – Johne's disease does not represent a real threat to the livestock industry.

The four points made in the introductory paragraph outline why this disease is a very real threat to individual producers and the cattle industry as a whole. It is economically much more important than we have previously realized, its prevalence is higher than we have assumed, and it spreads from farm to farm with animal import. The disease is a particularly major threat to expanding dairy operations because of the rate of new animal introductions and the lack of identification of disease free

or low risk herds from which to purchase (7,16,17). The association of *M. paratuberculosis* with Crohn's disease in humans has substantial supportive evidence (2,5,6,11,12,19,28). Whether the problem is zoonotic, with spread from infected animals or their products to humans, has not been well investigated (4). Uncertainty about the potential risk to public health persists (3,4,14,24,27). USDA-ARS research on the effectiveness of pasteurization to kill the Johne's organism in milk indicates that commercial pasteurization does inactivate *M. paratuberculosis* in pasteurized milk (23), but concerns related to transmission through undercooked meat and water remain (26). The problems of negative publicity and consumer suspicion of the safety of animal products alone represent real threats to the food animal industry, even if later evidence disproves any connection between JD and human health problems. The livestock industries, and the professionals who work with them, are obliged to take meaningful action against Johne's disease.

Where Do We Go From Here?

There are several key actions we can take to benefit our livestock industries:

Step 1: Education. Producers and practitioners need to be well informed about the disease and the various pros and cons of different surveillance and management techniques, in order to formulate a farm-specific approach. Veterinarians have a major role in assuring that their own information is accurate, and they need to help inform and educate producers. Producer decisions should be based on knowledge - even a producer who chooses to do nothing about the disease should be aware of their options and realistic outcomes of their choices. Here are some important facts about paratuberculosis that herd owners should understand:

- a.) Paratuberculosis decreases milk production of subclinically infected cows as early as first lactation.
- b.) Paratuberculosis shortens the productive herd-life of cattle.
- c.) Young cattle are more susceptible than are older animals. The critical window of susceptibility is roughly the first six months of life.
- d.) *Mycobacterium paratuberculosis* is principally transmitted by the fecal/oral route, but

can also be transmitted in utero and from milk of infected cows, more so in cows with late-stage infections. Because of this, calves born to infected cows have higher likelihood of becoming infected than do calves born to noninfected cows.

- e.) Because cattle herds are usually closed self-replicating populations, unless something is done to intervene, the *M. paratuberculosis* infection rate in the herd will increase with time.
- f.) Control of paratuberculosis takes time and requires management changes to minimize the chances of infecting calves, and culling of *M. paratuberculosis*-infected adults from the herd. Culling only clinically ill cows with paratuberculosis is not sufficient to control spread of the infection.

Step 2: Consider State Policies and Regulations. Each state needs to have a coherent policy that supports JD identification and control. Ideally, programs should be voluntary and propelled by the benefits that would derive from reducing or eliminating the disease in a herd. If your state does not currently have a well defined program, there are opportunities to become involved in helping to establish one.

Step 3: Begin to Work with Herds. For those accustomed to ignoring JD, this may be a very challenging task. But it is unquestionably an important one. We cannot justify inactivity in this regard. The alternatives of waiting for a governmental agency to mandate action, for consumers to demand action, or producers to seek help only after JD problems are well advanced, are not desirable options. If we can make reasonable progress with steps 1 and 2, this step will follow.

Not all producers will need to, nor be willing and able to deal with JD at the same level. Furthermore, it is generally unproductive to approach each herd with the same program or with testing as the main activity. A reasonable approach to a herd Johne's disease program includes:

- a.) Assess Herd Management. Special emphasis should be placed on risk factors for acquiring and spreading the disease - thus manure management, maternity pen management, calf rearing practices, and new herd additions.
- b.) Determine Likely Need and Ability to

Change. This requires evaluation of many factors unique to each operation. What are the management capabilities of the owner? What are their long term goals? What is their financial status? What is the nature of their facilities?

- c.) Determine Herd Infection Status. This can be done crudely by close observation for clinical disease signs, but is more accurately performed with testing.
- d.) Establish A Herd Management Plan. Management to control or prevent Johne's disease is also good management to control other infectious diseases. The program needs to be specific to the farm, consistent with the goals and capabilities of the owner, and based on the findings from steps 2 and 3.

Ultimately it is producers who will control this disease. Veterinary practitioners must be key players in this effort. And therefore it is important that you are well informed not only about the disease and its identification and control, but also about what is happening at the state and national level and about how you can get additional information when you need it.

How Do We Get Started?

Where Do We Look For Help?

The main purpose of this article has been to highlight some of the misconceptions that have stymied development of positive, progressive actions directed at controlling and eradicating Johne's disease. Education is the first, most important step we need to take. While numerous sources of information are available, several stand out for their ready accessibility and comprehensive coverage of this topic. The reader is strongly encouraged to explore the following sources, all of which help debunk these 10 Johne's disease myths:

- Your state Johne's Disease Committee, if formed
- Paratuberculosis (Johne's disease) Veterinary Clinics of North America-Food Animal Practice July 1996
- Johne's disease on U.S. dairy operations, USDA-APHIS-VS, 1997, found on the internet at <http://www.aphis.usda.gov/ceah/cahm>, under dairy
- Johne's Information Center on the internet at <http://www.vetmed.wisc.edu/pbs/johnes/index.html>



• National Johnes Working Group, Education Subcommittee Chair, Dr. Don Hansen, Oregon State University, 541-737-6533, or hansedon@ccmail.orst.edu

For information on what some others think about the possibility of a human health threat from Johnes's disease, visit the web site for Paratuberculosis Aggressive Research Association (PARA) at <http://members.aol.com/ParaTBweb/>

Another very thorough site is that of Alan Kennedy, a Crohn's disease patient, at <http://iol.ie/~alank/CROHNS/welcome.htm>

The National Johnes Working Group

The National Johnes Working Group (NJWG) is a subcommittee of the Johnes Disease Committee of the U.S. Animal Health Association. Its many and diverse members are veterinarians, state and federal representatives, academicians, industry personnel (dairy and beef) and others. Its goal is to develop and coordinate implementation of a voluntary, producer driven, national Johnes program. The NJWG has recently developed and distributed a model plan for a herd status program to help identify sources of replacement animals with low

risk of JD infection. This plan has been distributed to the states.

The three co-chairs of the NJWG are Robert Whitlock, DVM, PhD, University of Pennsylvania; John Adams, National Milk Producers Federation; and Gary Weber, National Cattlemens Beef Association. The objectives for the NJWG are:

- a.) Evaluate information suggesting *M. paratuberculosis* is a zoonotic pathogen; assess the likelihood that animals serve as a reservoir of infection.
- b.) Evaluate the potential for the organism to contaminate foods of animal origin.
- c.) Identify and encourage research for control and herd certification.
- d.) Evaluate domestic and international economic impacts of Johnes disease and update currently suggested good management practices to prevent entry and spread of infection in livestock.
- e.) Develop a set of policy objectives and goals to enhance development and implementation of Johnes disease control and herd certification program.

References:

1. Braun RK, Buergelt CD, Littell RC, et al. Use of an enzyme-linked immunosorbent assay to estimate prevalence of paratuberculosis in cattle in Florida. *J Am Vet Med Assoc* 196: 1251-1254, 1990.
 2. Chiodini, RJ. Crohn's disease and the mycobacterioses: A review and comparison of two disease entities. *Clin Microbiol Rev*, 2:90-117, 1989.
 3. Chiodini, RJ, J Hermon-Taylor. The thermal resistance of *Mycobacterium paratuberculosis* in raw milk under conditions simulating pasteurization. *J Vet Lab Diagn*, 5:629-631, 1993.
 4. Chiodini RJ, CA Rossiter. Paratuberculosis: A potential zoonosis? In: Sweeney, RW.(ed), *Paratuberculosis (Johnes's disease)*, *Veterinary Clinics of North America - Food An Pract*, W.B. Saunders Co, Philadelphia, 1996 pp 457-468.
 5. Chiodini RJ, HJ VanKruiningen, RS Merkal, et al. Characteristics of an unclassified *Mycobacterium* species isolated from patients with Crohn's disease. *J Clin Microbiol*, 20:966-971, 1984.
 6. Chiodini RJ, HJ Van Kruiningen, WR Thayer et al. The spheroplastic phase of mycobacteria isolated from patients with Crohn's disease. *J Clin Microbiol*, 24:357-363, 1986.
 7. Collins MT. Clinical approach to control of bovine paratuberculosis. *J Am Vet Med Assoc* 204: 208-210, 1994.
 8. Collins MT. Diagnosis of paratuberculosis. In: Sweeney, RW. (ed), *Paratuberculosis (Johnes's disease)*, *Veterinary Clinics of North America - Food An Pract*, W.B. Saunders Co, Philadelphia, 1996 pp 357-372.
 9. Collins MT, DC Sockett. Accuracy and economics of the USDA licensed enzyme-linked immunosorbent assay for bovine paratuberculosis. *J Am Vet Med Assoc* 203:1456-1463, 1993.
 10. Collins MT, DC Sockett, WJ Goodger, et al. Herd prevalence and geographic distribution of, and risk factors for, bovine paratuberculosis in
-

- Wisconsin. *J Am Vet Med Assoc* 204:636-641, 1994.
11. Dell'Isola B, C Poyart, O Goulet, et al. Detection of *Mycobacterium paratuberculosis* by polymerase chain reaction in children with Crohn's disease. *J Infect Dis*, 169:449-451, 1994.
 12. Fidler HM, W Thurrell, NM Johnson, et al. Specific detection of *Mycobacterium paratuberculosis* DNA associated with granulomatous tissue in Crohn's disease. *Gut*, 35:506-510, 1994.
 13. Goodger WJ, MT Collins, KV Nordlund, et al. Epidemiologic study of on-farm management practices associated with prevalence of *Mycobacterium paratuberculosis* infections in dairy cattle. *J Am Vet Med Assoc* 208:1877-1881, 1996.
 14. Grant IR, HJ Ball, MT Rowe. Inactivation of *Mycobacterium paratuberculosis* in cow's milk at pasteurization temperatures. *Appl Environ Microbiol*, 62:631-636, 1996.
 15. Hutchinson LJ. Economic impact of paratuberculosis. In: Sweeney, RW. (ed), *Paratuberculosis (Johne's disease)*, Veterinary Clinics of North America - Food Anim Pract, W.B. Saunders Co, Philadelphia, 1996 pp 373-382.
 16. NAHMS, *Johne's Disease on U.S. Dairy Operations*, Report from USDA:APHIS:VS, CEAH, National Animal Health Monitoring System, Dairy '96 Study, Fort Collins, CO. #N245.1097, 1997.
 17. NAHMS, Parts I-III, *Management Practices on U.S. Dairy Operations*, Report from USDA:APHIS:VS, CEAH, National Animal Health Monitoring System, Dairy '96 Study, Fort Collins, CO. 1997.
 18. Rossiter CA, WS Burhans. Farm-specific approach to paratuberculosis. In: Sweeney, RW. (ed), *Paratuberculosis (Johne's disease)*, Veterinary Clinics of North America - Food An, W.B. Saunders Co, Philadelphia, 1996 pp 383-416.
 19. Sanderson JD, MT Moss, ML Tizard, et al. *Mycobacterium paratuberculosis* DNA in Crohn's disease tissue. *Gut*, 33:890-896, 1992.
 20. Seitz SE, LE Heider, WD Hueston, et al. Bovine fetal infection with *Mycobacterium paratuberculosis*. *J Am Vet Med Assoc*, 194:1423-1426, 1989.
 21. Sockett DC. *Johne's disease eradication and control:Regulatory implications*. In: Sweeney, RW. (ed), *Paratuberculosis (Johne's disease)*, Veterinary Clinics of North America - Food An, W.B. Saunders Co, Philadelphia, 1996 pp 431-440.
 22. Spangler E, S Bech-Nielsen, LE Heider. Diagnostic performance of two serologic tests and fecal culture for subclinical paratuberculosis, and associations with production. *Prev Vet Med* 13:185-195, 1992.
 23. Stabel JR, Steadham EM, Bolin CA . Heat inactivation of *Mycobacterium paratuberculosis* in raw milk: Are current pasteurization conditions effective? *Appl Envr Micro* 63:4975-4977, 1997.
 24. Streeter RN, GF Hoffsis, S Bech-Nielsen, et al. Isolation of *Mycobacterium paratuberculosis* from colostrum and milk of subclinically infected cows. *Am J Vet Res*, 56:1322-1324, 1995.
 25. Sweeney RW. Transmission of paratuberculosis. In: Sweeney, RW. (ed), *Paratuberculosis (Johne's disease)*, Veterinary Clinics of North America - Food Anim Pract, W.B. Saunders Co, Philadelphia, 1996 pp 305-312.
 26. Sweeney, RW, RH Whitlock, AE Rosenberger. *Mycobacterium paratuberculosis* cultured from milk and supramammary lymph nodes of infected asymptomatic cows. *J Clin Microbiol*, 30:166-171, 1992.
 27. Taylor, AK, CR Wilks, DS McQueen. Isolation of *Mycobacterium paratuberculosis* from the milk of a cow with *Johne's disease*. *Vet Rec*, 109:532-533, 1981.
 28. Van Kruiningen HJ, RJ Chiodini, WR Thayer, et al. Experimental disease in infant goats induced by a *Mycobacterium* from a patient with Crohn's disease. *Dig Dis Sci*, 31:1351-1360, 1986.
 29. Whitlock R. *Johne's disease*. In: Smith BP (ed), *Large Animal Internal Medicine*, 2nd ed. Mosby Year-Book Inc., St. Louis, 1996, pp 899-904.
 30. Whitlock RH, C Buergett. Preclinical and clinical manifestations of paratuberculosis. In: Sweeney, RW. (ed), *Paratuberculosis (Johne's disease)*, Veterinary Clinics of North America - Food Anim Pract, W.B. Saunders Co, Philadelphia, 1996 pp 345-356.
 31. Wilson DJ, C Rossiter, HR Han, et al. Association of *Mycobacterium paratuberculosis* infection with reduced mastitis, but decreased milk production and increased cull rate in clinically normal dairy cows. *Am J Vet Res* 54:11-16, 1993.
 32. Wren G. Is Johnes disease sneaking into beef herds? *Bov Vet*, January, pp 4-8, 1995.
 33. Wren G. Will you take on Johnes disease? *Bov Vet*, February, pp 13-16, 1998.