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REVIEW

Prevalence and Prevention of Paratuberculosis in North America

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Abstract

The United States of America (U.S.) has made several attempts over the years to develop a producer accepted voluntary program. The focus of the U.S. Voluntary Bovine Johne's Disease Control Program (VBJDCP) is to provide producers with the tools to control Johne's disease on their farms and identify herds with a low risk for the presence of *Mycobacterium avium* subspecies *paratuberculosis* (MAP) infection. The VBJDCP includes an evaluation of producers' operations to identify practices that could allow the transmission of MAP among animals or between premises. Once risky practices have been identified, a herd management plan is developed to assist the producer in correcting risky practices. In addition to management changes, vaccination is a control tool allowed in the U.S. because it reduces the clinical signs of Johne's disease and the shedding of MAP. Testing is used in addition to management changes. While the classification component of the VBJDCP dictates the amount and type of testing herd owners are required to conduct, the education and management components of the VBJDCP does not specify testing protocols. The testing for control is intended to fit the needs and resources of producers and can be quite flexible. Management changes on the farm remain the key to control and programs cannot replace well thought out plans by producers that are specific to their resources, facilities, and operation.

Keywords: control, paratuberculosis, prevalence, United States

Introduction

Paratuberculosis (Johne's disease) has been known to exist in the United State of America (U.S.) since the early 1900's. Dr. Leonard Pearson first published a description of a Pennsylvania dairy cow with clinical sign in 1908.[12] Since then, the U.S. has made several attempts over the years to develop both voluntary and involuntary programs. In 1993, a model Johne's disease certification program created by U.S. Animal Health Association (USAHA) was adopted.[24] Due

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to cost and other program issues, it was not embraced by the industry. The next attempt was in 1998 with the U.S. Voluntary Johne's Disease Herd Status Program for Cattle (VJDHSP).[2] The focus of the VJDHSP was to identify herds with a low risk for the presence of *Mycobacterium avium* subspecies *paratuberculosis* (MAP) infection, instead of certifying herds as free. This led to the creation of the Uniform Program Standards for the Voluntary Bovine Johne's Disease Control Program (VBJDCP) by industry, State, and Federal personnel. The new VBJDCP was approved by United States Department of Agriculture Animal and Plant Health Inspection Service (APHIS) in April 2002.[17] There are three major components of the VBJDCP: producer education, herd management and herd classification. In 2010, the approach to herd classification in the VBJDCP was revised to allow flexible testing protocols.

The perception of Johne's disease among producers has contributed to the current U.S. situation. Unlike diseases such as Salmonella or E. coli scours, Johne's disease is a slow progressing malady. This leads to the misperception that there is no direct cause and effect with practices done today causing disease not seen until years later. Without the immediate connection, producers tend not to understand the results of their management practices. Also the lack of immediate economic loss contributes to slow corrections to risky management. Unlike the loss of calves from scours or the loss of milk from mastitis, paratuberculosis does not affect the producer until well after exposure. The producer often sees a productive cow having calves and producing milk but it unaware of the decreases in milk production until late in progression of the disease.[9] In the end the producer sees the clinical animal with rapid weight loss and the need to replace the animal but the connection to allowing calves to comingle with a clinically suspect animal four years ago is lost.

National prevalance

Most work in the U.S. regarding prevalence rates has been done within the dairy industry. In order to get a handle on the prevalence APHIS, through its National Animal Health Monitoring System (NAHMS), conducted the first national prevalence study in 1996. Blood samples were randomly collected from 25 to 40 milk cows depending on the size of the herd and tested by enzyme-linked immunosorbent assays (ELISA). The objective was to have a 90 percent confidence that if a herd had a 10 percent actual within-herd prevalence that at least one positive sample would be detected. Based on the results of this study, a conservative estimate was made for the national dairy herd prevalence at 21.6 percent.[15] In 2007, NAHMS conducted a follow up study. However, instead of using the same methodology, environmental fecal samples were used. Six environmental samples were collected from six different adult cow areas from each farm including common pens or alleyways, manure pits, holding pens or exits ways from milk parlors, gutter cleaners and manure spreaders. MAP was isolated using Herrold's egg yolk agar from at least one environmental sample from 68.1 percent of the operations. In the largest dairies ($>=$ 500 cows) 95 percent of the farms returned positive isolates.[19] The differences between the methodologies make the results not directly comparable. However, in either case given the sensitivities of the test used, the reported prevalences are likely less than the true values.

Fewer studies have been carried out looking at beef populations. Only one national level attempt has been made to assess U.S. beef operations. In 1997, the NAHMS group conducted a national beef study in an attempt to come up with a national beef prevalence using the same methodology as the 1996 NAHMS Dairy study. However the results were not weighted and cannot be considered a national prevalence estimate. Results from the study

include blood samples collected from 10,372 cows in 380 cow-calf herds in 21 States. Only 0.4 percent of the cows and 7.9 percent of the herds tested positive for MAP.[5] Because within-herd apparent prevalence was likely lower than 10 percent in many herds, the 1997 NAHMS Beef Cow-Calf study probably failed to identify a number of infected herds with low within-herd prevalence.

More recently work done in Texas looked at purebred beef operations in which 50 of 115 herds (43.8 percent) had at least one seropositive animal.[13] That study performed ELISA on up to 50 cattle per herd, and follow-up fecal culture testing was performed on seropositive cattle only. Nine of the 50 seropositive herds (18 percent) had at least one animal with a positive fecal culture. Given the low confirmation by fecal culture, some of the positive results may have been false positives caused by mycobacteria other than MAP.[13] It should also be noted that purebred herds might be more likely to have more positive cattle than commercial herds because of practice of using dairy cows to nurse orphan beef calves or using dairy cows as embryo transfer recipients.

Another study done in 2002–2003 in Alberta, Canada beef herds found that 28.5 percent of herds had at least one seropositive animal.[22] Like this study, most point prevalence surveys are done using ELISAs to determine MAP prevalence in beef herds. However, testing methods are not consistent, so it is difficult to compare results across studies. The best available MAP prevalence estimate of beef herds in the U.S. remains that of the 1997 NAHMS Beef Cow-Calf study (7.9 percent). However, because of limitations in the study design, herd prevalence in the beef industry is likely higher.

Producer education

The education component of the VBJDCP is intended to enlighten livestock producers about the costs of paratuberculosis (from the loss of production and disease management) and to provide information about management strategies to prevent, control, and eliminate the disease. For the on-farm interaction, the program uses certified accredited veterinarians to work directly with producers. To be a Johne's disease certified veterinarian (JCV), training is given to ensure that each veterinarian knows how to conduct proper risk assessments and design herd management plans in addition to providing information about available tests and appropriate testing strategies.

In addition to training veterinarians, APHIS funds a National Johne's Education Initiative through a grant with the National Institute of Animal Agriculture. The initiative develops and prints educational material for States to distribute when interacting with producers. Distribution takes place through mailings, handouts at producer meetings and through one-on-one visits to farms.

The impact of educational activities is hard to gauge since changes in management practices cannot be easily measured. Survey results are typically used to measure results. In an attempt to evaluate producer perceptions of Johne's disease, APHIS included questions about level of knowledge in the 1997 NAHMS Beef Cow-Calf study. In 1997, 7.8 percent of operations knew some basics about Johne's disease.[16] This percentage increased to 31.3 percent when the study was repeated in 2007. While this data shows that the educational efforts were increasing the awareness about Johne's disease, the number of producers testing for Johne's disease only increased from 0.7 percent in 1997 to 3.2 percent in 2007. Additionally only 1.4 percent of beef cow-calf operations participated in any programs to control Johne's disease or to document a low risk herd status in the 5 years prior to 2007.[20]

In contrast to the beef industry, 94 percent of dairy producers considered themselves fairly knowledgeable or knew the basics about Johne's disease in 2007. This was an increase from the

54.8 percent estimate from the 1996 NAHMS Dairy study, showing significant gains in dairy producer's understanding of this disease. Dairy producers also responded to the increased awareness by increasing testing. Thirteen percent of dairy producer tested in 1996. This rose to 35 percent by 2007. In 2007, 31 percent of U.S. dairy producers participated in a Johne's disease control or certification program, an increase from 1 percent in 1996 and 11 percent in 2002.[19] Interestingly, only about 10 percent are officially enrolled in the VBJDCP, indicating that more producers are doing something about paratuberculosis control than are officially recognized.

Herd management

Risk Assessment and Herd Management Plans

The management component of the VBJDCP includes an evaluation of producers' operations to identify practices that could potentially allow the transmission of MAP among animals or between premises. A workbook provides a systematic walk-through of all aspects of the operations, starting with the calving and calf management area and ending with the adult cattle areas and farm biosecurity. Specific questions are asked about each management group on the premises and a score is assigned to each response in an attempt to quantify levels of risk. Questions include exposure to fecal material in food or water, multiple animal use of a calving area or multiple age groups housed together, access to stored manure and recent herd additions.

Once risky practices have been identified, a herd management plan is developed using the outline provided in workbooks. This creates a step by step process which producers and veterinarians can work through together. To increase compliance with the new or revised herd management plan, only a few targeted changes are expected each year. This allows the producer to focus on priorities that would have the greatest impact on disease transmission. By designing the herd management plan to include not only Johne's disease but other diseases as well, it creates a situation where a producer can see a more immediate impact to changes they make. When targeting any disease transmitted by the fecal oral route in addition to Johne's disease, this gives producer a chance to monitor the results of the changes without having to wait 3 years to see the effects on the herd Johne's disease prevalence.

Data collected by the University of Minnesota shows that the risk assessment and herd management plan approach does work. In a retrospective study of beef and dairy herds enrolled in the Minnesota Johne's Disease Control Program (MJDCP), a steady increase in voluntary program participation by Minnesota cattle producers was observed from 1998 to December 2006.[23] Dairy and beef herds in the management component of the MJDCP reduced their on-farm risk assessment scores during the program, translating to a risk reduction for the transmission of MAP on the farm. On average, dairy herds in the management program reduced on-farm risk assessment scores by 18.1 points for the first 2 years of participation in the control program.[23] These assessment score reductions were maintained throughout the enrollment period. Beef herds showed similar results. However, while the reduction of risk of transmission within the herd was a positive step, the risk of introducing MAP continued without significant change through introduction of cattle from other herds.

Rather than adopting the VBJDCP as is, the New York State Cattle Health Assurance Program (NYSCHAP) uses a slightly different approach. The NYSCHAP is built upon a core of best management practices such as animal identification, record keeping, and general herd health with a Johne's disease module as a component. Enrollment in the program is around 700 producers. In 2005, a survey done by the New York State's Comptroller looked at producer's perceptions of the NYSCHAP as part of an audit

to determine the value of the State's program. The audit team surveyed both enrolled producers and producers who had dropped out of the program. Of the 92 enrolled producers that responded, 76 percent felt that they had better herd health, 30 percent saw more milk production, and 35 percent felt that they increased profits by being in the program. The conclusion of the audit team was that the program is beneficial.[11]

The National Johne's Disease Demonstration Herd Project (NJDDHP) in the U.S. was initiated to evaluate the effectiveness of management-related practices designed to control Johne's disease on dairy and beef cattle operations.[18] The NJDDHP was started in 2003 with the last year of data collection in 2010 and included 19 beef and 58 dairy operations in 17 states. All participating herds had MAP confirmed on the operation by fecal culture and risk assessments and herd management plans were completed along with testing on an annual basis.

The risk assessment followed the same basic outline as the workbooks for the VBJDCP including the six main management areas: calving area, pre-weaned heifers, post-weaned heifers, bred heifers, cows and bulls, and additions/replacements. For dairy herds, addition/replacement management and pre-weaned heifer areas appeared to be most important with regard to risk of cattle being fecal-culture positive for MAP. Specific pre-weaned heifer and additions/replacement factors associated with a greater risk for cattle to be MAP-positive included: feeding pooled colostrum to calves (16.6% of cattle expected to be positive when risk was moderate/high and 8.2% positive when risk was zero/low, $p < 0.01$); possible manure contamination of milk or colostrum (14.7% positive for moderate/high risk vs. 9.3% positive for zero/low risk, $p < 0.01$); and additions (13.7% positive when additions obtained from non-tested herds vs. 10.0% when additions obtained from herds known to be test negative, $p = 0.03$).[7] These results suggest that placing more emphasis on pre-weaned calf management and increased caution in obtaining herd additions can aid in management of MAP on dairy operations.[7]

For beef cattle, the results from the NJDDHP suggest that keeping cow-calf pairs separate from Johne's clinical or suspect animals, limiting manure contamination of water for pre-weaned heifers, and limiting cow access to accumulated or stored manure are the most important control point to reducing MAP prevalence on beef operations.[7] Beef herds in the project showed a reduction of ELISA positive animals from 6.4% to 2.4% prevalence by the end of the study.[19] Since the number of beef herds enrolled in the project were limited, it is difficult to determine if all the changes are a result of the management changes or a change in culling practices.[7]

Vaccination

In addition to management changes, vaccination is a control tool allowed in the program because it reduces the clinical signs of paratuberculosis and there is evidence that it can reduce the shedding of MAP.[8] The current U.S. licensed vaccine product does not prevent infection.[6] While it is allowed in the program, its use is not widely encouraged due to the killed MAP bacterium's ability to cause cross-reactions on tests for other mycobacteria. This can cause an increase in false-positive responses to the caudal fold tuberculin (CFT) test for tuberculosis among vaccinated animals.[10] Determining that a positive CFT response is caused by exposure to mycobacteria other than *Mycobacterium bovis* can be made using the comparative cervical test, but this does increase resources needed to follow up each with false positive.

Overall the endemic rate of Johne's disease has not been a problem for the national tuberculosis surveillance system since that program is based on surveillance targeting visible lesions at slaughter. Given the low prevalence of Johne's disease in beef cattle, vaccination is currently not used in any beef herds and does not present an issue. It is questionable whether

whole dairy herd vaccination impacts tuberculosis testing given that most dairies are already exposed to MAP from the environment. Work in California has shown there is an association between CFT test responders and the MAP status of an animal. The odds of a CFT reactor versus a CFT non-reactor being Johne's disease serum ELISA positive or fecal culture positive were 4.7 and 5.6, respectively.[1] Similar false positive responses would be expected in Johne's disease vaccinated herds. When a vaccinated herd is tested by CFT test, variable false positive CFT rates have been seen, anywhere from 5 to 50 percent based on antidotal experience (Patton, Elizabeth, Madison WI, Brignole, Thomas, Tumwater WA. personal communications. December 7, 2010). Clearly this needs to be investigated further in the U.S. before widespread use of MAP vaccination can be encouraged.

Because of the concern for interference with tuberculosis surveillance, MAP vaccination is only allowed on premises where MAP has been identified by organism detection test. Each herd undergoes a whole herd tuberculosis test prior to the start of MAP vaccination as well. The vaccine is limited to calves under 35 days of age to reduce the chances that a false positive result would be seen later in the animal's life. Each vaccinated animal is also identified with an official eartag and a tattoo in the left ear and a record of the vaccination is recorded at the State animal health department.

Twenty-one States allow the use of vaccination. The majority of vaccinations conducted in Iowa and Wisconsin. Roughly 31,000 calves have been vaccinated each year since 2003 with an upward trend (Fig. 1). Since 2003, over 280,000 calves have been vaccinated for MAP. Clearly only a very small portion of the U.S. annual calf crop is vaccinated.

Testing

A second tool is testing to identify potential carriers of MAP. The classification component of the program dictates the amount and type of

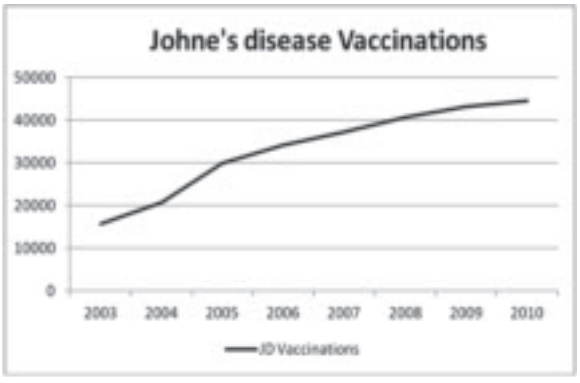

Fig. 1. Johne's disease calfhood vaccinations by year.

testing herd owners are required to conduct, but the management component of the VBJDCP does not specify testing protocols. In general, most herd owners participating in the management component incorporate some kind of testing in their herd management plans. The testing for control is intended to be a "best fit" according to the needs and resources of producers and can be quite flexible. To assist producers and veterinarians with identifying an appropriate testing strategy, APHIS supported a project to develop a testing strategy document. The final report was published in 2006 and provided a simplified set of recommendations for veterinarians and producers that were categorized by cattle type (beef or dairy) and by the goal of the testing. Examples of possible testing goals include estimates of biological burden, eradication, control, and disease confirmation.[4]

Testing has varied in the U.S. over the past decade depending on to the amount of federal funding that supported individual animal testing. From 2003 to 2010, over 3,100,000 dairy cattle and 692,000 beef cattle were tested by serum ELISA. Positive samples ranged from 5.0 to 6.6 percent per year for dairy cows and 2.1 to 3.6 percent for beef herds (Tables 1 and 2). While in 2010 approximately 131,000 milk ELISA tests were reported for program testing, the numbers from Dairy Herd Improvement Association (DHIA) testing laboratories indicate double that number of milk ELISA tests being performed.

Table 1. Serum ELISA Testing Numbers

Year	Dairy Animals Tested	Dairy Animals Tested Positive	Beef Animals Tested	Beef Animals Tested Positive	Dairy Percent Positive	Beef Percent Positive
2003	251,298	14,416	24,428	887	5.7%	3.6%
2004	424,717	26,536	113,750	3,810	6.2%	3.3%
2005	580,882	36,171	127,384	3,707	6.2%	2.9%
2006	629,199	37,604	153,575	3,467	6.0%	2.3%
2007	436,894	26,084	127,630	2,701	6.0%	2.1%
2008	378,271	24,904	81,599	2,129	6.6%	2.6%
2009	213,148	13,389	34,001	914	6.3%	2.7%
2010	188,903	9,539	30,007	929	5.0%	3.1%

Table 2. Milk ELISA Testing Numbers

Year	Dairy Animals Tested	Dairy Animals Tested Positive	Dairy Percent Positive
2005	672	2	0.3%
2006	25,479	1,572	6.2%
2007	41,728	2,206	5.3%
2008	97,417	5,567	5.7%
2009	129,448	6,483	5.0%
2010	131,334	5,267	4.0%

Either way, both reported testing and DHIA numbers indicate that milk ELISA testing continues to increase.

From 2003 to 2010, approximately 514,000 dairy and 67,000 beef cattle were tested by MAP organism detection test (fecal cultures or fecal polymerase chain reaction), with the percent of positive tests ranging from 7.2 to 14.1 percent for dairy and 2.8 to 16.9 percent for beef (Table 3). It must be noted that program testing does not represent randomly collected samples. These animals and herds are tested because of concerns for MAP or for herd classification. Therefore, these numbers cannot be used as a national estimate of prevalence.

As the testing numbers show, testing continues to decrease reflecting the reducing levels of federal funding made available to support the State programs. Most States either provided free or subsidized testing to producers while receiving federal funding. The only variance to these trends is the milk ELISA testing done through the DHIA laboratories. Milk ELISA testing has not received any Federal or State subsidies in recent years and yet has continued to grow in numbers of tests run each year. This shows that although producers may not have an interest in enrolling in the national program, they are still interested in monitoring the disease situation on their own.

Herd classification

The VBJDCP included a herd classification component to the program in 2002 to provide producers with information identifying low risk herds or low prevalence herds.[17] The classification component used the guidance outlined by the VJDHSP and recommendations from "Minimum Recommendations for Administering and Instituting State Voluntary Johne's Disease Programs for Cattle."[3] Classification was based on the fact that it would require multiple years of testing to ensure a reasonable level of confidence that program herds were a low threat for being affected by MAP.

In 2010, APHIS revised the program in order to allow greater flexibility in testing options available to producers. The new program

Table 3. Organism Detection Tests (fecal polymerase chain reaction and culture) Testing Numbers

Year	Dairy Animals Tested	Dairy Animals Tested Positive	Beef Animals Tested	Beef Animals Tested Positive	Dairy Percent Positive	Beef Percent Positive
2003	31,632	2,288	2,307	64	7.2%	2.8%
2004	84,173	9,064	11,163	411	10.8%	3.7%
2005	115,482	13,353	13,009	907	11.6%	7.0%
2006	116,868	11,720	17,433	1,014	10.0%	5.8%
2007	73,035	7,701	13,452	713	10.5%	5.3%
2008	50,715	4,792	5,760	685	9.4%	11.9%
2009	17,142	2,415	3,014	412	14.1%	13.7%
2010	25,655	3,613	1,753	297	14.1%	16.9%

Table 4. Voluntary Bovine Johne's Disease Control Program Enrolled Herd Summary Data

Fiscal Year[a]	Total Enrolled Herds	Enrolled Dairy Herds	Enrolled Beef Herds	Total Classified Herds	Classified Dairy Herds	Classified Beef Herds
2000[b]	1,952	NA	NA	390	NA	NA
2001[b]	1,925	NA	NA	514	NA	NA
2002[b]	3,254	NA	NA	631	NA	NA
2003	4,722	NA	NA	543	NA	NA
2004	5,732	4,265	1,467	993	660	333
2005	8,046	6,397	1,649	1,459	1,006	744
2006	8,736	6,634	2,102	1,779	1,054	725
2007	8,818	6,797	2,021	1,651	978	673
2008	7,273	5,511	1,762	1,397	772	625
2009	5,675	4,282	1,393	891	481	410
2010	4,611	3,671	940	412	223	189

[a]Fiscal year = October 1st through September 30th of each year.
[b]Year that herds enrolled under State programs.

eliminated the separate test-negative and test-positive components and adopted a gradient approach to the classification levels.[21] This approach classifies herds based on a 95% confidence that herds within a given level would be at less than a specified prevalence (15% for level 1, 10% for level 2, 5% for level 3, and 2% for level 4 and greater).[14] Based on assumptions for test sensitivity and specificity, a table was created to estimate the true prevalence range based on the test used and the number of test-eligible animals, and used that estimate to classify the herd. This revised classification method will allow a more rapid inclusion of new test methods after the proposed test's diagnostic sensitivity and specificity are estimated and validated.

In FY 2010, States reported there were 4,611 enrolled herds (3,671 dairy and 940 beef) of which 412 were classified herds (223 dairy and 189 beef). This represents 8.4 percent of the licensed dairy herds and 0.1 percent of the beef

operations enrolled in the program. This is a significant decrease from previous years (Table 4). The high point for herd enrollment was 2007 with 8,818 enrolled herds (6,797 dairy and 2,021 beef). For the dairy industry this represents an overall continuing decline in most categories.

Conclusion

Although the U.S. has had regulations regarding paratuberculosis, they have never been extremely strong and the U.S. has instead focused on voluntary control. Without a strong regulatory component of a program, there are few economic drivers and industry adoption of a voluntary certification program has been limited. Over the past decade, the cattle industry, State animal health agencies and APHIS have continued to modify the program to best meet the needs of the industry and encourage participation. Although producer participation is a common measure of program success, the program's true value lies in the changes that producers make in their management scheme and this impact to disease control is easily overlooked. To this end, significant resources have been invested for education and outreach to producers for the control of Johne's disease. National or state programs cannot replace well thought out plans by producers that are specific to individual farms, resources, facilities, and management practices. The key to paratuberculosis control remains management practices instituted on the farm.

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