Evaluation of the caudal fold tuberculin (CFT) test as a screening test for bovine TB in small herds in control regions with low prevalence

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ABSTRACT

After bovine tuberculosis was identified in one State in 11 cattle herds over a 3 year period, a TB control region was proposed which would require annual whole-herd testing of all 300 herds. In order to estimate the risk of bovine TB leaving the region through infected yet undetected cattle, a model was constructed taking into account movement frequency, herd size, and test parameters. Because of the presence of a wildlife reservoir and the potential for exposure to cattle herds, the model demonstrated that it is possible for infected cattle to leave the control region despite annual whole-herd testing.

KEYWORDS

Tuberculosis, Regionalization

INTRODUCTION

In the United States, the State and Federal Cooperative Bovine Tuberculosis (TB) Eradication Program has been underway since 1917 and has been successful in reducing the prevalence of *M. bovis* infections in humans and cattle. However, the intermittent finding of bovine TB in livestock continues to occur. Identification of bovine TB in livestock herds can result in a reduction in accreditation status for the entire State which imposes additional testing requirements and movement restrictions and can be costly for producers in the State. Bovine TB has also recently been identified in free-ranging white-tailed deer in two States, providing additional risk of exposure to cattle in those areas.

Bovine TB was detected in 11 cattle herds over a 3 year period in one State. Subsequent testing identified infection in nearby white-tailed deer and a 17,740 sq km (6,850 sq mi) control region was delineated. The region would contain all known infected cattle and wildlife and have a reduction in accreditation status, while the area of the State outside the region would not be subject to the additional restrictions. Regionalization (or zoning) is one control strategy for containing outbreaks of bovine TB, particularly when a wildlife reservoir is identified. Regionalization is applied when a subpopulation with a distinct health status is contained in a geographic area to minimize the impact to the rest of the country (OIE, 2008). For regionalization to be effective, the pathways for *M. bovis* to leave the control region must be identified and mitigated so populations outside of the region are not at risk of exposure or infection.

The objective of this project was to determine the likelihood of *M. bovis* leaving the control region through cattle movement after all 300 herds were tested annually with a caudal fold tuberculin (CFT) screening test. This likelihood is based on the probability of a herd testing falsely negative and the probability of an infected animal moving out of a false-negative herd (USDA, 2008).

METHODS

To better estimate the expected number of false-negative herds from a whole herd test, a stochastic simulation model was developed using a spreadsheet (Excel, Microsoft Corp.) and simulation software (@Risk, Palisade Corp.). In order to estimate the probability of having at least one shipment containing at least one infected undetected animal, the following formula was used:

Equation 1

$$1-\left(1-P_{herd}\left(1-\left(1-\frac{p(1-Se)}{p(1-Se)+(1-p)Sp}\right)^{n}\right)\right)^{k}$$

where:
C=the event of interest
The probability of at least one shipment containing at least one infected animal is:
k=the number of shipments
n=the number of animals in a shipment
P_{herd}=the probability of a herd being declared not infected, when it was truly infected (probability of the herd being false negative)
p=the within-herd prevalence
Se=sensitivity
Sp=specificity

Herd prevalence was estimated from the previous number of affected herds identified annually in the TB control region (Pert(0,2,5)/300). Within herd prevalence was based on the number of animals confirmed culture positive out of the total number of animals in the 11 affected herds (3%). Apparent within herd prevalence was based on CFT parameters (sensitivity and specificity), the true prevalence if the herd were infected, and herd size (randomly drawn from herd size distribution where mean=84). The CFT sensitivity used for an individual animal was 82% and specificity was 96%. The likelihood of an infected animal leaving the TB control region from a false-negative herd was modeled from trace investigation data from the 11 affected herds to randomize the shipment size and frequency of animals leaving the region. This analysis did not account for animals going to slaughter or the age of cattle in a shipment, hence all animals were considered test-eligible and eligible for shipment to populations outside the control region (USDA, 2008).

RESULTS

Based on results from 5,000 iterations, the mean number of false-negative herds expected was less than one herd (mean=0.82, 95% confidence interval (CI)=0 to 3 herds). The mean likelihood of missing at least one herd with infected animals was 0.48. The mean likelihood at least one infected, undetected animal leaving the control zone was 0.13, 95% CI=0.01 to 0.30. This implies that a 13% possibility exists for at least one infected animal to leave the proposed TB control region, assuming *M. bovis* transmission is still active in cattle and wildlife.

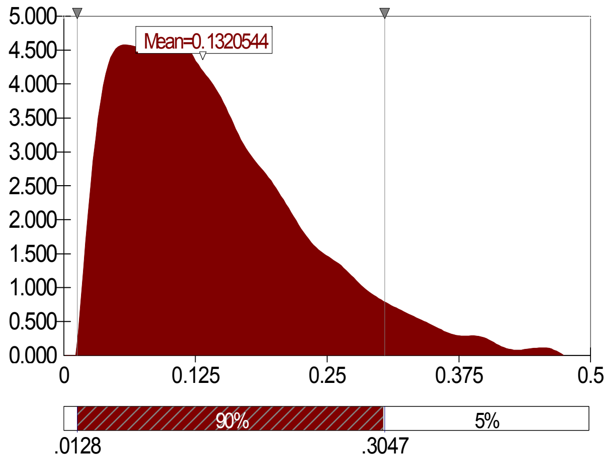

Figure 1 Distribution of probability of at least one infected undetected animal leaving the control region

CONCLUSION

A negative whole herd test for *M. bovis*, using the CFT, would suggest the herds were truly negative. However, applying a screening test of low sensitivity for a low prevalence disease in small herds increases the risk of obtaining false-negative results given the dependence of herd sensitivity on test sensitivity and within-herd prevalence. Therefore, when developing a control region, knowledge of test performance in that population allows for more accurate assessment of the effectiveness of control efforts and can direct development of additional mitigation measures and surveillance activities.

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