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Spatial analysis of *Mycobacterium bovis* infection in white-tailed deer (*Odocoileus virginianus*) in Michigan, USA

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Abstract

The wild white-tailed deer (*Odocoileus virginianus*) population in Michigan, USA, has endemic *Mycobacterium bovis*. We determined whether there were spatial clusters of retrospective TB cases in white-tailed deer in northeastern Michigan and identified specific factors associated with the spatial clusters.

Data from hunter-harvested deer (age, gender, TB status, and geographic section) were collected by the Michigan Department of Natural Resources (MDNR) during TB surveillance from 1995 to 2002. Land cover (vegetation, land-use) and land type (soil types and drainage characteristics, landforms) described potential deer habitats. Specific locations of large-scale supplemental feeding sites were collected from the MDNR aerial surveillance program from 1997 to 2002. Analyses were conducted using principal components derived from environmental data (and other risk factors) on spatial clusters of disease (identified by the spatial scan statistic). Spatial effects were incorporated into the multivariable analyses by using a neighborhood approach.

A total of 420 deer with *M. bovis* infection were identified from 1995 to 2002, out of 39,451 harvested deer from 3216 TRS units, and spatial clusters of cases were identified. A total of seven principal components of environmental data were generated. Clusters were associated with the presence of large expanses of deciduous forests on moraine ridges separated by low areas of forested wetlands, and the presence of many small lakes. Factors that promoted congregation of deer for extended periods of time (natural cover, access to water, and less human contact) appeared to be associated with increased odds of TB

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positivity. This suggests that there are specific areas where interventions can be implemented to reduce congregation of animals and disrupt the cycle of infection transmission.

Keywords: Tuberculosis; *Mycobacterium bovis*; Epidemiology; White-tailed deer; *Odocoileus virginianus*; Spatial analysis; Principal components analysis

1. Introduction

Bovine tuberculosis (TB) caused by infection with *Mycobacterium bovis* was recognized in wild white-tailed deer (*Odocoileus virginianus*) in northeastern Michigan, USA, in 1994, in a hunter-harvested buck (Schmitt et al., 1997). Subsequent investigation revealed that the deer population had endemic *M. bovis*. Ongoing research has been focused on identifying factors unique to the area that might be associated with the support of endemic bovine tuberculosis in wild deer.

Initially, the Michigan Department of Natural Resources (MDNR) established a specific deer-management unit (DMU 452) around the index case, and surveillance focused on this 650 km^2 TB 'core' area. Since 1995, surveillance has increased to cover the entire State of Michigan. The prevalence of *M. bovis* infection decreased in DMU 452 after control measures were implemented by the MDNR in 1997, and has remained relatively stable at approximately 0.2 cases per 100 deer tested (O'Brien et al., 2002). From 1995 to 2000, a negative association was seen between TB prevalence and distance from the core area where the index case was found (Hickling, 2002). Most TB cases in free-ranging white-tailed deer (95%) have been in a five-county area surrounding DMU 452. Only isolated cases of TB in deer have been found in other counties in the state.

Localized conditions conducive to transmission of the infection might include: (1) environmental conditions associated with deer habitat, particularly areas of natural congregation (''yarding'' areas); (2) ecological conditions which support survival of *M. bovis*; (3) human activities which induce deer to cluster (e.g., large-scale winter supplemental feeding and activity by hunters). If associations can be found between specific habitats or environmental conditions and disease clusters, this information can be of use in TB control efforts.

However, several factors can produce apparent clustering when none actually exists: bias in selection of areas and cases/populations, errors in disease ascertainment, and misclassification of exposures (Elliot and Wakefield, 2000). We conducted this study to address the hypotheses: (a) that there are distinct spatial clusters of cases of *M. bovis* infection in free-ranging white-tailed deer in northeastern lower Michigan; (b) that there are environmental- and human-activity factors associated with patterns of cases of *M. bovis* in free-ranging white-tailed deer in Michigan.

2. Materials and methods

2.1. Study design

Our retrospective study was conducted in the northeastern corner of the Lower Peninsula of Michigan, USA, in the counties of Alcona, Alpena, Montmorency, Oscoda, and Presque Isle, adjacent to Lake Huron.