Habitat Modeling of the Black-Legged Tick: Reducing the Risk of Lyme disease at a Military Installation in the United States

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Abstract

The black-legged tick (*Ixodes scapularis*) is the principal vector of Lyme borreliosis in the eastern United States. Military personnel and their family members, working and living on military installations are at risk of Lyme borreliosis where this tick species occurs. A study was conducted to determine which habitat variables determined distribution and density of the black-legged tick at the Edgewood Area, Aberdeen Proving Ground, Maryland, USA. Shrub density was found to be a significant predictor of the distribution and density of the black-legged tick at the Edgewood Area with higher resolution than previous published predicted models of the black-legged tick ($1m^2$ p<0.001). At the Edgewood Area, the enlisted personnel family housing area was adjacent to a high risk area. With good communication and inter-agency cooperation integrated vector management can be use to prioritize areas to have tick reduction. This information can be used by public health leadership at Edgewood to be proactive and reduce the risk for Lyme borreliosis and other tick-borne diseases to military personnel and their families.

Keywords: *Borrelia, Ixodes*; Acari; Epidemiology; Geographic Information System

Introduction

Borrelia burgorferi is the etiologic agent of Lyme borreliosis, also known as Lyme disease. Lyme borreliosis is found in Asia, Europe and the USA, primarily in forested habitats [1]. Lyme disease is transmitted through the bite of an infected tick, most often in the genus *Ixodes*. Immature black-legged ticks (*I. scapularis*) are usually infected with *B. burgdorferi* when they feeding on a warm-blooded vertebrate, such as deer mice, *Peromyscus* species. Once engorged with a blood meal, the infected tick will drop off, molt to the next stage, quest for a new host, then feed upon and infect another host, including humans. Lyme borreliosis has a significant impact on public health in the United States. According the Centers for Disease Control and Prevention, about 30,000 cases are reported annually, with reports of cases in Maryland among the top 10% [2]. In addition to *B. burgdorferi*, the blacklegged tick is also a vector of *Anaplasma phagocytophilum* (human granulocytic anaplasmosis), *Babesia microti* (babesiosis), and *Borrelia miyamotoi* (a relapsing fever Borrelia), and deer tick virus.

Military personnel and their families can be at risk from vector-borne diseases at military installations. For example, high risk areas for *Yersinia pestis*, the etiologic agent of bubonic plague, were identified at the United States Air Force Academy installation, with some high risk sites adjacent to family housing on the base [4]. Lyme borreliosis poses a significant risk to military personnel and their families. In 2015, over 1,000 ticks tested by the Army Public Health Command, were positive for *B. burgdorferi*; 21% of I. scapularis ticks were positive and all *I. pacificus* ticks were negative [5]. Because of the importance of *I. scapularis* in the transmission of Lyme diseases, the present study was conducted to identify factors affecting the distribution and density of this tick species at the Edgewood Area military installation, Aberdeen Proving Ground, Maryland.

Methods and Results

There are approximately 1,000 people living on Edgewood Area, Aberdeen Proving Ground, with nearly 15,000 people working both areas of Aberdeen Proving Ground. Nearly 20,000 retirees and their families use the recreational facilities at Edgewood [6]. Data from 300 sample points was collected from oak forest, pine forest, and ecotone. Ticks (N=344) were collected using a one-meter square cloth tick drag, at 10m intervals. Trees were counted by transect using a 2m pole; shrub, fern, monocot, and dicot plant density were estimated using a 4m plastic square. Data was analyzed using Statistica software and ArcGIS. Shrub density was provided the best predictive variable with high resolution, p< 0.001 at $1m^2$ (Table 1). Density and distribution of black-legged ticks varied geographically (Figure 1).
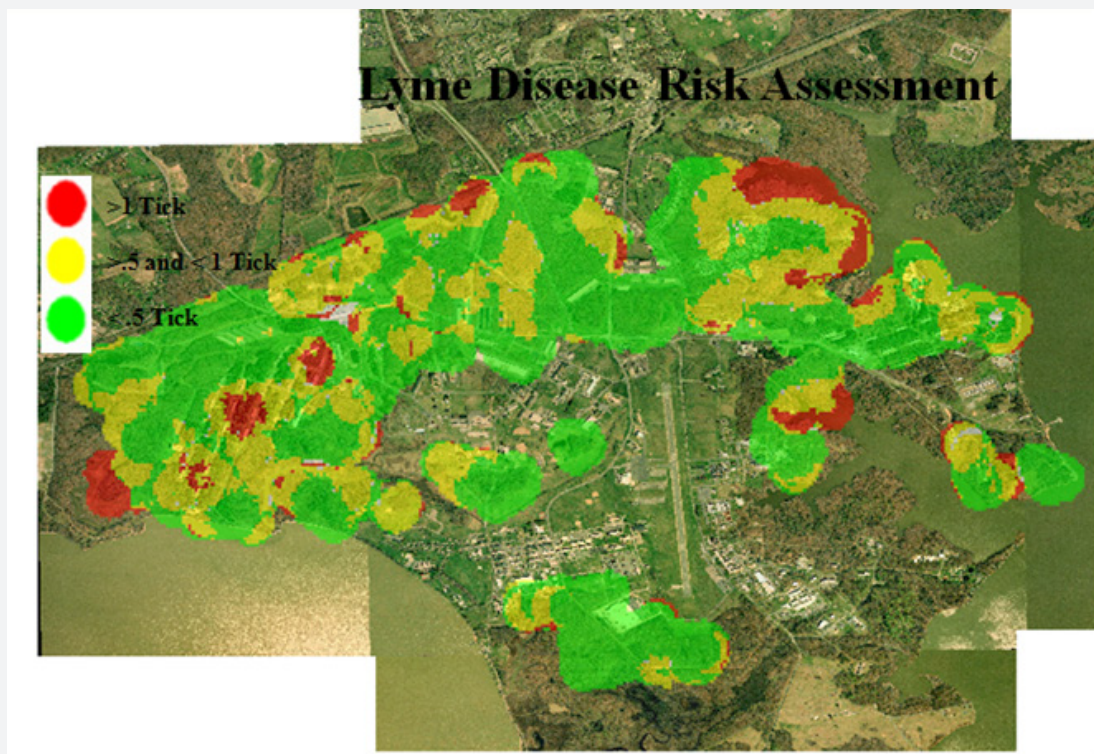
Figure 1: Risk Assessment of Lyme borreliosis based on predicted distribution of the black-legged tick (*Ixodes scapularis*) per square meter at Edgewood Area, Aberdeen Proving Ground.

Table 1: Regression summary for the number of black-legged ticks (*Ixodes scapularis*) and abiotic and biotic variables; R=0.97, R2=0.93, F(11.8)=10.18, p<0.05, SE Estimate: 0.77, significant factors yellow highlight.

Intercept	Beta	p-level
Elevation	-2.11	0.22
Habitat Type	0.04	0.77
Percent Canopy	0.21	0.12
Tree Density	-0.05	0.75
Shrub Density	0.89	0.001
Monocot Density	-0.35	0.84
Dicot Density	0..3	0.82
Fern Density	-0.04	0.78

Discussion

Several abiotic and biotic factors influence the distribution and density of *I. scapularis*, e.g. precipitation, elevation, host composition, and vegetative land cover [7,8]. In the present study, density of shrubs was identified as the most important factor of the variables studied for determining presence and density of the black-legged tick. The model also provided higher resolution with higher predictability than other published models of *I. scapularis.* For example, a predictive model for *I. scapularis* had a resolution of $30m^2$ when using land cover data [8].

Demographic factors can also play a role in determining risk of becoming infected with vector-borne diseases. For example, poor and minority neighborhoods can be at higher risk of West Nile virus [9]. Military officers and enlisted personnel often live at different housing areas on military installations and they and their families. Housing areas on military bases may differ in the risk from Lyme borreliosis. At Edgewood, officer quarters are located in the southwest and enlisted quarters are located in the northeast. In a previous study at the Edgewood Area, enlisted family housing appeared to be at higher risk of West Nile virus than officer family housing due to variation in abiotic and biotic between sites [10]. Further investigations to determine risk vector-borne diseases based on geographic and demographic factors on military installations is suggested.

Military public health officials should incorporate peridomestic tick surveillance as part of the installation integrated vector management plan. The black-legged tick is often found in peridomestic habitats where Lyme borreliosis is highly endemic [3]. Additional investigation into demographic, social and behavioral factors and the risk of Lyme borreliosis at military installations should be investigated. Leadership from public health officials is required for any successful IVM efforts, however this leadership is not always provided. As an example, previous leadership at Edgewood Area were informed that the enlisted personnel housing area was adjacent to a high

risk area for Lyme disease and recommendations for control methods were suggested. Unfortunately, at that time, no plan of action was taken to reduce the risk of Lyme borreliosis to the military personnel and their families living near the high risk area. The justification provided by the former leadership, was the department did not have good working relationship with the agency having the responsibility for vector control. The information provided in this model can assist public health leadership at Edgewood, by being proactive with the objective of reducing the risk for Lyme borreliosis and other tick-borne diseases to military personnel and their families. Identifying the risk of vector-borne diseases and implementing integrated vector management at Edgewood and other military installations is of significant public health value. Once the risk of an infectious disease is determined, medical and preventive measures can be taken to reduce the threat to military personnel and their families.

Acknowledgement

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