



Understanding Pennsylvania Tick Population and Tick-borne Disease Dynamics: A Retrospective Analysis of Archived Databases from 2008-2020



Nishi Natalia, Julia Sendatch, Heidi St. John, Richard Stewart, Marcie L. Lehman, Christina Farris, and Alison Luce-Fedrow

Biology Department of Shippensburg University

United States Naval Medical Research Center

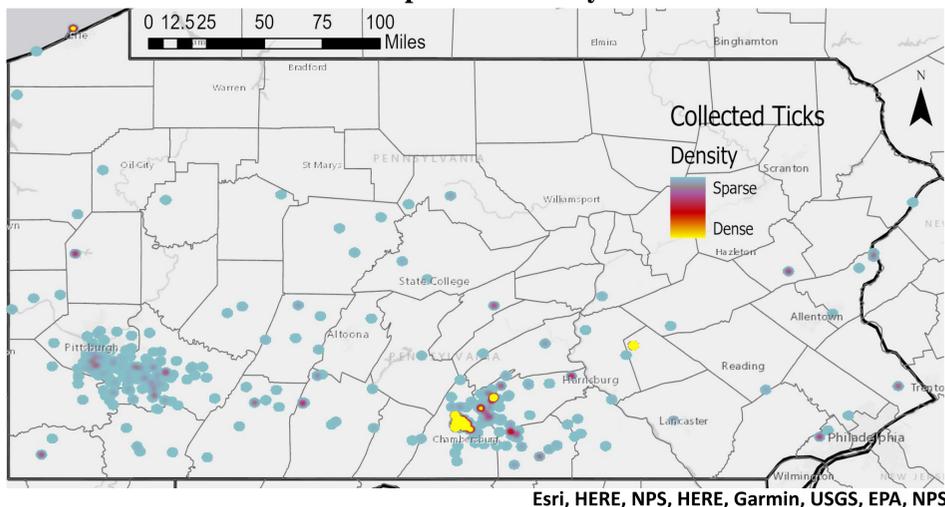
Introduction

Ticks have been widely studied for their importance in disease transmission. In Pennsylvania, four different ticks (associated with human diseases) are commonly encountered: (1) *Dermacentor variabilis* (Rocky Mountain Spotted Fever); (2) *Ixodes scapularis* (Lyme disease); (3) *Amblyomma americanum* (Ehrlichiosis); and (4) *I. cookei* (possible Powassan). In addition to the commonly occurring tick species, approximately 25 species have been identified in the state. *I. scapularis*, which was once primarily found in Central and Eastern PA, can now be found in all counties in PA. In recent years, PA has had the highest confirmed numbers of Lyme disease cases in the United States. The increasing abundance and prevalence of ticks known to vector human pathogens has prompted public health concerns and further research. Despite the devastating consequences, and potentially fatal outcomes of tick-borne diseases, the local/regional distribution of ticks in Pennsylvania is under-investigated with regards to changes in tick populations and tick-borne disease dynamics.

Methods

- Compiled individual databases from 2008-2020 into one master database
 - Date of collection, location, method of collection, species, sex, life stage, engorgement status, and molecular status
- Quantitative analysis and mapping (ArcGIS Pro version 2.7.3 (Esri, Redlands, CA)) used to conduct comparative analysis of changing geographical distributions, seasonal distribution, and tick life stage
- Tick-borne microbes (*Rickettsia*, *Ehrlichia*, *Anaplasma*, and *Borrelia*) were compared for ticks collected from 2008-2016.

Sample Site Density



- Further investigation will examine host association of tick species and the molecular status of ticks that are positive or negative for these pathogens from 2016-2020

Conclusions

- I. scapularis* and *D. variabilis* have been present in PA since 2008.
- A. americanum* and *Haemaphysalis* species are emerging species in the state.
- Rickettsia* and *B. burgdorferi* are most prevalent among the species of ticks tested.
- E. chaffeensis* and *A. phagocytophilum* are hypothesized to increase in prevalence.

Implications

- Application in the medical field: provide insight on tick-borne illness prevalence in PA
- Provide pertinent background information for future researchers and epidemiologists

Future Research

- Molecular testing of ticks from 2016-2020
- Further expanded surveying of ticks in Pennsylvania

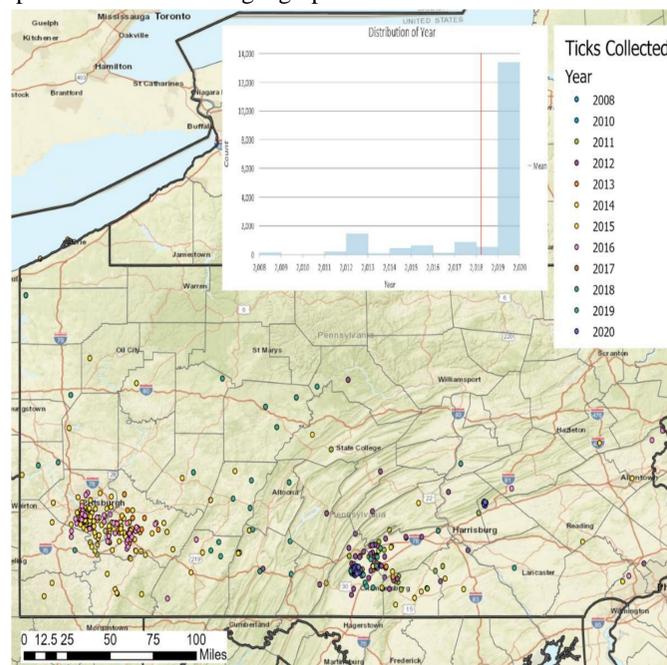
REFERENCES

- Steere, A.C., J. Coburn, and L. Glickstein. *The emergence of Lyme disease*. J Clin Invest. 2004.
- USACHPPM. *Just the facts...Lyme Disease*. 2006 April 2006 [cited 2012].
- CDC.gov. *Notifiable diseases/deaths in selected cities weekly information*. MMWR. 2009.
- Adams, D., et al., *Summary of Notifiable Diseases — United States, 2011*. MMWR. 2013.
- Gardner, S.L., et al., *National surveillance for the human ehrlichioses in the United States, 1997-2001, and proposed methods for evaluation of data quality*. Ann N Y Acad Sci. 2003.
- Paddock, C. and J.E. Childs. *Ehrlichia chaffeensis: a prototypical emerging pathogen*. Clin Microbiol Rev. 2003.
- CDC.gov. *Ehrlichiosis*. 2011 [cited 2012].
- Chen, S., et al., *Identification of a granulocytotropic Ehrlichia species as the etiologic agent of human disease*. J Clin Microbiol. 1994.
- Hall-Baker, P., et al., *Summary of Notifiable Diseases - United States, 2009*. MMWR. 2011.
- Barker TL, et al., *Serosurvey of Borrelia burgdorferi infections among U.S. military personnel: A low risk of infection*. Am. J. Trop. Med. Hyg., 2001.
- Courtney JW, et al., *Molecular characterization of Anaplasma phagocytophilum and Borrelia burgdorferi in Ixodes scapularis ticks from Pennsylvania*. J. Clin. Microbiol., 2003.
- Steere, A., *Lyme Disease*. N Engl J Med. 2001. 345(2): p. 115-125.
- Treviso, R., et al., *Evaluation of a two-test serodiagnostic method for community assessment of Lyme disease in an endemic area*. Am. J. Trop. Med. Hyg., 2001.
- CDC.gov. *Lyme Disease*. 2012 5 April 2012 [cited 2012].
- Magnarelli, L., *Global importance of ticks and associated infectious disease agents*. Clin Microbiol Newsletter. 2001.
- Fornadel, C.M., et al., *High rates of Rickettsia parkeri infection in Gulf Coast ticks (Amblyomma maculatum) and identification of "Candidatus Rickettsia andeanae" from Fairfax County, Virginia*. Vector Borne Zoonotic Dis. 2011.
- Jiang, J., et al., *Development of a quantitative real-time polymerase chain reaction assay specific for Orientia tsutsugamushi*. Am. J. Trop. Med. Hyg., 2004.
- Jiang, J., et al., *Molecular detection of Rickettsia amblyommii in Amblyomma americanum parasitizing humans*. Vector-Borne and Zoonotic Diseases. 2010.
- Smith, M.P., et al., *Bacterial pathogens in ixodid ticks from a Piedmont County in North Carolina: prevalence of rickettsial organisms*. Vector Borne Zoonotic Dis. 2010.
- Courtney, J.W., et al., *Multiplex real-time PCR for detection of anaplasma phagocytophilum and Borrelia burgdorferi*. J Clin Microbiol. 2004.
- Jiang, J., et al., *Phylogenetic analysis of a novel molecular isolate of spotted fever group Rickettsiae from northern Peru: Candidatus Rickettsia andeanae*. Ann N Y Acad Sci. 2005.

Results

Total Ticks Collected by Year		
<u>2008</u>	<u>2013</u>	<u>2017</u>
131 ticks	72 ticks	875 ticks
<u>2010</u>	<u>2014</u>	<u>2018</u>
2 ticks	138 ticks	521 ticks
<u>2011</u>	<u>2015</u>	<u>2019</u>
188 ticks	633 ticks	6512 ticks
<u>2012</u>	<u>2016</u>	<u>2020</u>
1442 ticks	93 ticks	6855 ticks
<u>Total</u>		
17,507 ticks		

Table 1 and Figure 1. A total of 17,507 ticks were collected. Major collecting years included 2012 (n = 1,442), 2019 (n = 6,512), and 2020 (n = 6,855), with concentrations centered around western and central Pennsylvania, but a presence in statewide geographical distribution



Tick Species	Percentage of Total Ticks Collected
<i>I. scapularis</i>	6884/17,507 (39.32%)
<i>D. variabilis</i>	2119/17,507 (12.10%)
<i>A. americanum</i>	6868/17,507 (39.23%)
<i>Haemaphysalis spp.</i>	112/17,507 (0.64%)

Table 2. Major species collected included *Ixodes scapularis* (39.32%), *Amblyomma americanum* (39.23%), and *Dermacentor variabilis* (12.10%). Emergence of two previously rare/unknown ticks in Pennsylvania, *A. americanum* (2017) and *Haemaphysalis* (2015), with significant prevalence from 2018-2020.

Pennsylvania 2008-2020	
Pathogen	qPCR positive ticks
<i>Rickettsia</i>	169/793 (21.31%)
<i>B. burgdorferi</i>	108/852 (12.68%)
<i>E. chaffeensis</i>	59/802 (7.36%)
<i>A. phagocytophilum</i>	15/550 (2.73%)
<i>Borrelia spp.</i>	143/377 (37.93%)

Table 3. Molecular testing (qPCR) of ticks from 2008-2016 demonstrated *Rickettsia* (21.31%) and *Borrelia burgdorferi* (12.68%) as the most commonly detected tick-borne microbes.

The views expressed in this article are those of the author and do not necessarily reflect the official policy or position of the Department of the Navy, Department of Defense, the U.S. Government, nor the Henry M. Jackson Foundation for the Advancement of Medicine, Inc. (HJF). Authors, as employees of the U.S. Government (CMF), conducted the work as part of their official duties. Title 17 U.S.C. §105 provides that 'Copyright protection under this title is not available for any work of the United States Government.' Title 17 U.S.C. §101 defines a U.S. Government work as a work prepared by an employee of the U.S. Government as part of the person's official duties. The study protocol was approved by the Shippensburg University Institutional Animal Care and Use Committee (Shippensburg University IACUC protocol #R02-03-19) in compliance with all applicable federal regulations governing the protection of animals and research.