

Dermacentor variabilis and Its Associated Rickettsiae in Southeastern Virginia; the Potential Role of Pathogen Spillover from Local Sympatric Tick Species

Alexandra Cumbie^{1,2}, Holly Gaff², and Wayne Hynes²

¹Department of Entomology, Virginia Tech, Blacksburg, VA

²Department of Biological Sciences, Old Dominion University, Norfolk, Virginia

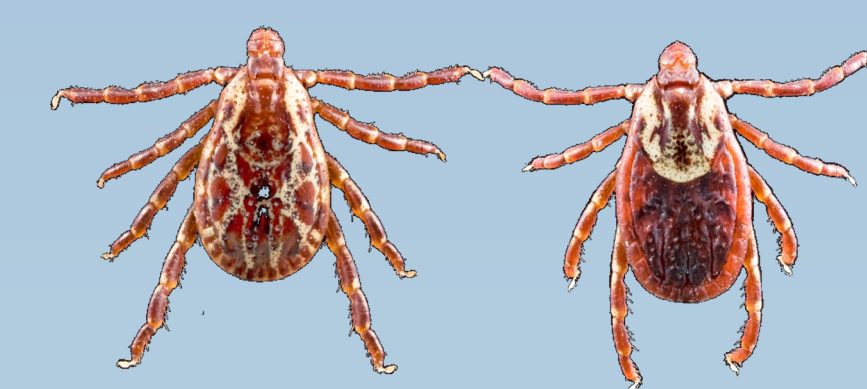


#ODUTickTeam

Abstract

Hard-bodied ticks are the most medically important group of arthropods in the United States (US). *Dermacentor variabilis*, the American dog tick, is a common vector in the US with its geographic range expanding across the eastern and western portions of the country. This tick is the historical vector of *Rickettsia rickettsii*, the causative agent of Rocky Mountain Spotted Fever and has been reported to harbor other spotted fever group rickettsiae anecdotally. In Virginia, spotted fever group rickettsiosis cases range between 300-400 per year based on passive surveillance data which do not often identify the rickettsial agent to species. There are a variety of rickettsial species reported in Virginia which include *R. rickettsii*, *R. amblyommatis*, *R. montanensis*, and *R. parkeri*. Each rickettsia can be detected in multiple tick species, but are typically transmitted by a single vector; all of which are sympatric with *D. variabilis*. The purpose of this study was assess current *D. variabilis* populations in Virginia and their associated rickettsiae. From 2012 to 2018 as part of a long-term active surveillance project, adult *D. variabilis* were collected using standard flagging methods and their immatures were collected using small mammal trapping. The presence of rickettsiae was detected using real-time PCR and confirmed using Sanger sequencing. *Dermacentor variabilis* in Virginia were observed to harbor *R. montanensis*, *R. parkeri*, and *R. amblyommatis*, with the most common rickettsial species being *R. montanensis*. No samples had detectable levels of *R. rickettsii* infection. The occurrence of pathogen spillover among sympatric tick species appears to be common in *D. variabilis* under select pressures (i.e. when other tick species are dominant in the same area). Once that pressure is removed, *R. montanensis*, the common endosymbiont of *D. variabilis*, becomes the predominant rickettsia detected.

BACKGROUND AND INTRODUCTION



Dermacentor variabilis

Pathogen: *R. rickettsii*¹

Endosymbiont: *R. montanensis*¹

Life History: adults active in summer; juveniles active all year, but mostly winter²



Amblyomma maculatum

Pathogen: *R. parkeri*³

Life History: all life stages active in summer³



Amblyomma americanum

Endosymbiont and potential pathogen: *R. amblyommatis*⁴

Life History: all life stages active in summer⁴

- ❖ Spotted fever group rickettsioses are among the most commonly reported tick-borne diseases in the US
- ❖ Each tick species is a vector of one or more rickettsial pathogens
- ❖ Life history traits and questing behavior allow for pathogen spillover between these tick species

RESEARCH OBJECTIVES

- ❖ Determine the prevalence of various rickettsial species in field collected *D. variabilis*
- ❖ Determine potential pathogen spillover of *R. parkeri* and *R. amblyommatis* into *D. variabilis* immature ticks from small mammal collections

MATERIALS & METHODS

- ❖ Ticks collected over a 7-year period from vegetation using flagging and from small mammals using live trapping
- ❖ Ticks were identified either morphologically or via real-time PCR using the ITS2 gene⁵
- ❖ *Rickettsia* spp. were identified using real-time PCR assays for the *ompB* gene⁶ and sequence confirmed using a portion of the *ompA* gene⁷

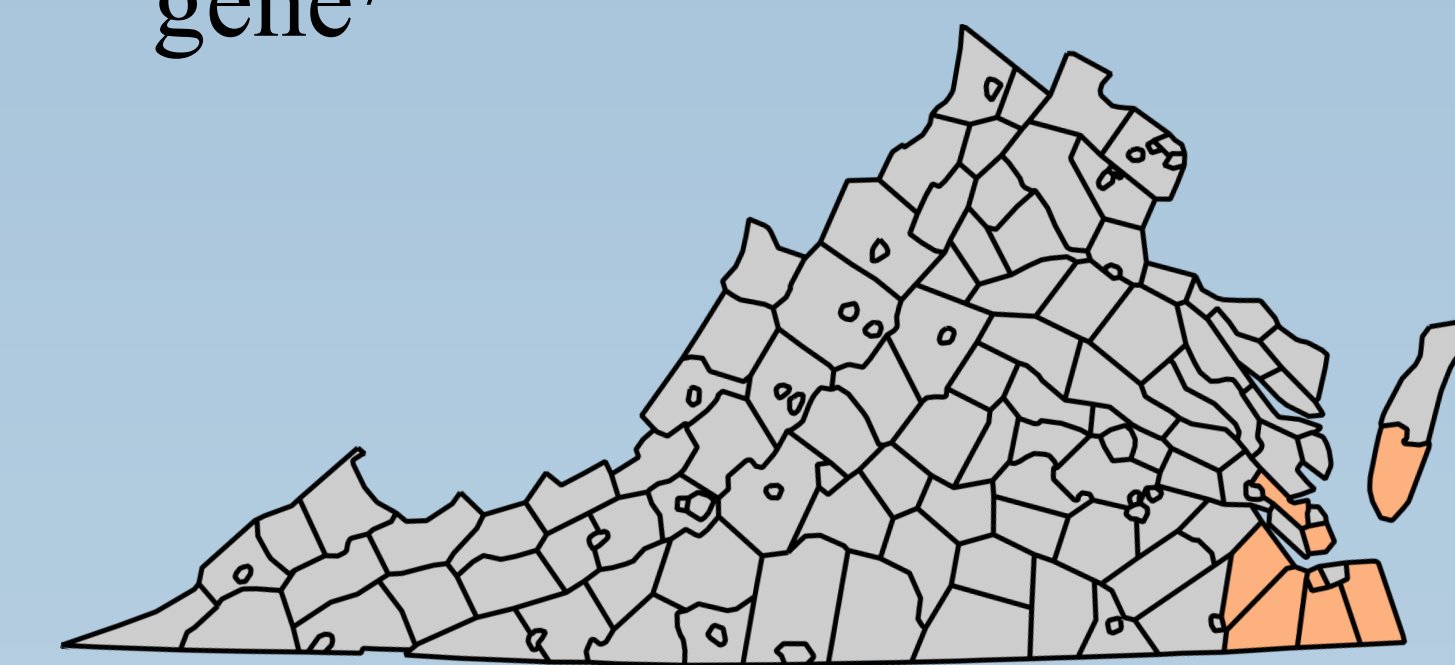


Figure 1. Commonwealth of Virginia. Orange highlighted counties were areas where we collected ticks from vegetation and include Chesapeake, Isle of Wight, Northampton, Newport News, Portsmouth, Suffolk, Virginia Beach, and York.



Figure 2. (A) Example of flagging vegetation for *D. variabilis*. (B) Example of white-footed mouse capture during live trapping for *D. variabilis*.

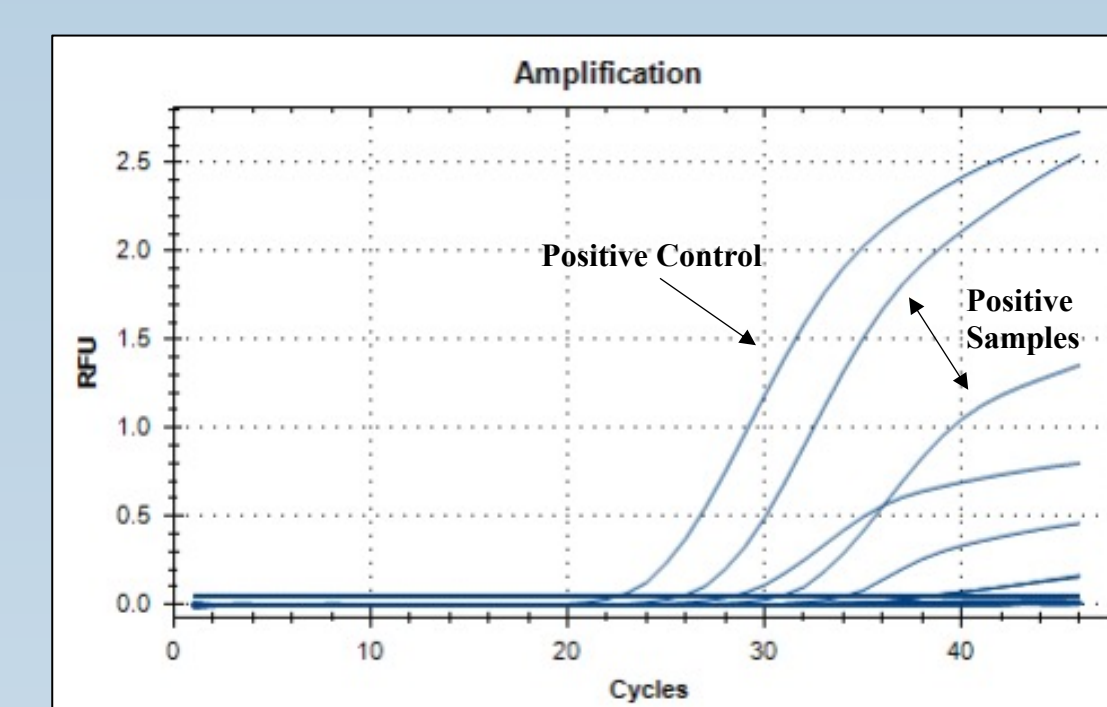


Figure 3. Example of rickettsial 17kDa real-time PCR output. The x-axis represents number of cycles during amplification and the y-axis represents relative fluorescent units (RFUs). Positive samples are indicated by peaks and negative samples are indicated by flat lines.

RICKETTSIA RESULTS

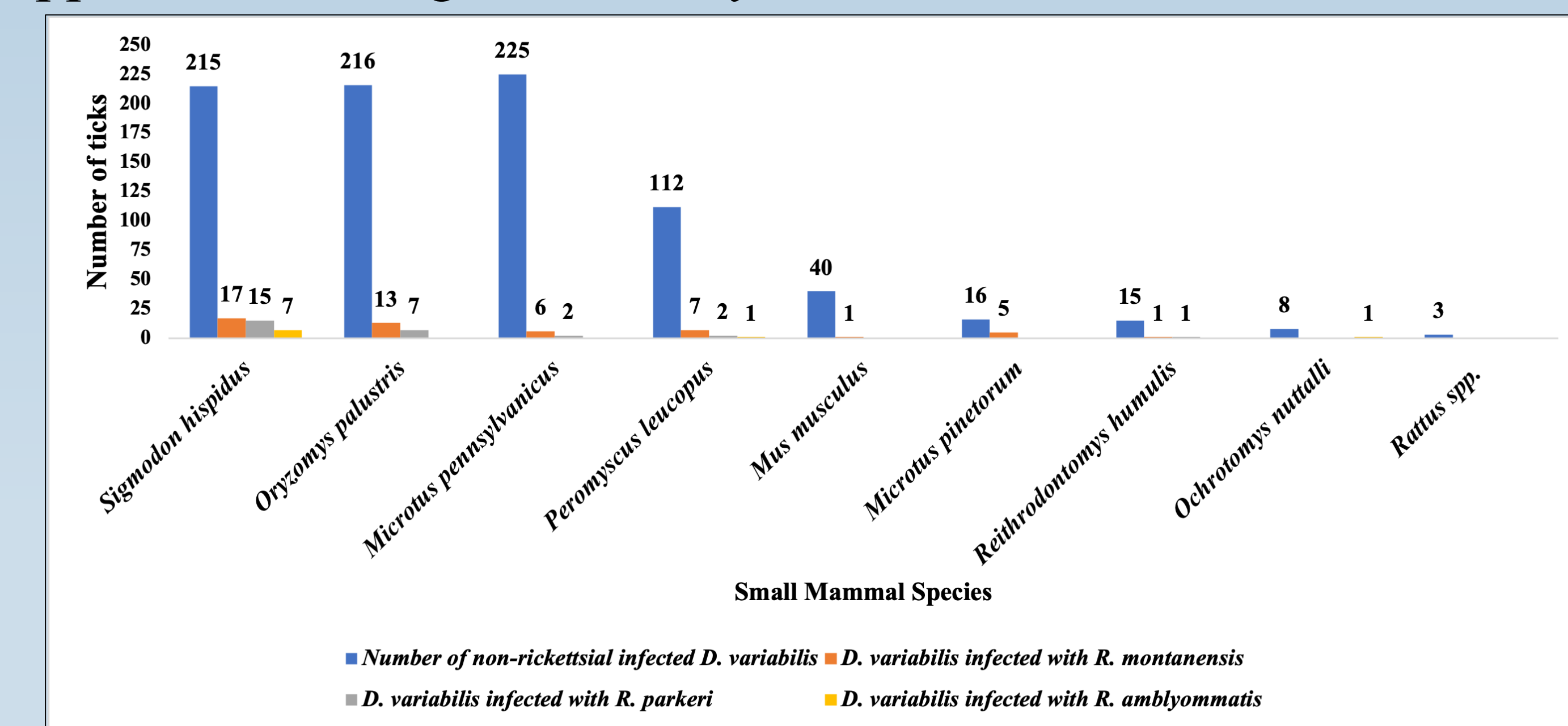
Table 1. Prevalence (percentages) of *Rickettsia* spp. present in *D. variabilis* across all sites and analyzed separately by year. Adults were tested in pools and prevalence was determined using maximum likelihood estimation using the R package binGroup⁸. Juveniles were tested individually.

Year	# of ticks	<i>R. montanensis</i>		<i>R. amblyommatis</i>		<i>R. parkeri</i>	
		Adult	Juveniles	Adults	Juveniles	Adults	Juveniles
2012	657	0.47%	0.41%	0.00%	0.83%	0.00%	4.56%
2013	630	1.41%	11.2%	0.00%	2.39%	1.71%	5.58%
2014	268	1.23%	12.3%	0.60%	0.00%	0.00%	0.00%
2015	298	1.79%	3.25%	0.57%	0.00%	0.00%	0.00%
2016	227	1.27%	1.45%	0.00%	0.00%	0.61%	0.00%
2017	287	6.33%	0.00%	0.00%	0.00%	0.00%	0.00%
2018	336	3.36%	0.00%	0.00%	0.00%	0.34%	0.00%

- ❖ *Rickettsia montanensis* and *R. parkeri* were the dominant rickettsial species found in all life stages of *D. variabilis*
- ❖ *Rickettsia amblyommatis* was rarely detected; *R. rickettsii* was not detected in any samples

SMALL MAMMAL RESULTS

Figure 4. Immature *D. variabilis* harbored various *Rickettsia* spp. while feeding on a variety of small mammal hosts.



TICK COLLECTION RESULTS

- ❖ *Dermacentor variabilis* collected from vegetation: 1572 ticks
- ❖ *Dermacentor variabilis* collected from small mammals: 936 ticks

SIGNIFICANCE

- ❖ As adults, *Dermacentor variabilis* harbor multiple rickettsial species including common rickettsia also found in *A. maculatum* and *A. americanum*. The sharing many large and meso-mammal hosts is probably facilitating the transmission each rickettsial pathogen.
- ❖ Small mammals play a primary role in Virginia as hosts to juvenile *D. variabilis* and *A. maculatum*. Further investigation into their role as reservoirs of *R. parkeri* is necessary. Additionally, prevalence of *R. parkeri* may change in local *D. variabilis* populations with an abundance of certain host species acting as reservoirs needs to be followed.
- ❖ Simply harboring rickettsial agents does not necessarily mean that *D. variabilis* is a competent vector, but further investigation of their potential for horizontal transmission is warranted as these sympatric populations have the ability to acquire and maintain these agents.

References & Recognition

1. Piesman and Gage, 1996 Univ. Press of CO
 2. Sonenshine et al., 1966 Ann Entomol Soc Am.
 3. Paddock et al. 2004. Clin Infect Dis.
 4. Jiang et al. 2010 Vector Borne Zoonotic Dis.
 5. Zemtsova et al. 2014. J Med Entomol.
 6. Jiang et al. 2012. Vector Borne Zoonotic Dis.
 7. Blair et al. 2004. J Clin Microbiol.
 8. Zhang et al. 2018. Package 'binGroup'
- We would like to thank our funding in part from an NIH grant 1R01AI136035 as part of the NIH-NSF-USDA Ecology and Evolution of Infectious Diseases program. Many thanks to ODU Tick Team with specific thanks to Robyn Nadolny, Christina Espada, and Alexis White. Tick photo credit: Graham Snodgrass, US Army Public Health Command