

The efficiency of 4-poster tick management stations on three tick species populations within Brookhaven National Laboratory.

Taylor Gosselin

Department of Wildlife, Fisheries, and Conservation

University of Maine

Orono, ME 04469

Tim Green

Environmental Protection Division

Brookhaven National Laboratory

Upton, New York 11973

Abstract

*Increased risk of contracting Lyme Disease and other tick related illnesses has led to many research and management projects being conducted throughout the United States. In 2013, Brookhaven National Laboratory (BNL) set up fourteen 4-poster tick management systems in an effort to control populations of three tick species: blacklegged (deer) tick (*Ixodes scapularis*), American dog tick (*Dermacentor variabilis*), and lone star tick (*Amblyomma americanum*). An increase in the deer population in 2014 resulted in four additional systems being added. In 2015, when the deer population decreased, three systems were removed. Each station, filled with corn to bait deer, has four rollers coated in 10% permethrin which kills ticks attempting to feed on treated deer. Camera traps are present at all stations to determine usage and assist in determining the BNL deer population. Tick populations are determined by flagging, where a 0.46 by 0.76 meter flag is dragged across vegetation 30 times for 1 minute each at every site. Captured ticks were then identified and recorded. Other 4-poster studies show an overall decrease in tick populations, with significant results showing after the third year of treatment. One such study has been carried out on Shelter Island and Fire Island, with results supporting the use of 4-poster devices as a means to control the tick populations. Although this was the third year of the study at BNL, percent control was less than expected, with the highest control at 59% for *A. americanum* males.*

Introduction

Lyme disease, a vector-borne illness, is one of the most commonly reported illnesses of its kind within the United States. Between 1992 and 2011, 87,588 cases were reported within New York alone, 12,871 of those cases reported from Suffolk County. New York also holds a spot within the top fourteen states that account for 95% of all Lyme disease cases reported in the United States (CDC 2015). In addition to Lyme disease ticks can carry an array of other diseases, the transmission of which depending on what species is attached and feeding. On Long Island possible illnesses includes Ehrlichiosis, Southern tick-associated rash illness (STARI), Tularemia, Rocky Mountain spotted fever (RMSF), Lyme disease, Anaplasmosis, and Babesiosis. Tick species present on Long Island that transmit these diseases include the blacklegged (deer) tick (*Ixodes scapularis*), lone star tick (*Amblyomma americanum*), and the dog tick (*Dermacentor variabilis*). During the ticks' larval and nymph stage, they attach to birds and small mammals, and can be infected if feeding on a reservoir competent host (animal

infected by a parasite that serves as a source of infection for other species) (Stafford 2004; Stafford n.d.). After the larval and nymph stages, non-infected ticks are less likely to be infected as they feed on larger hosts such as the white-tailed deer (*Odocoileus virginianus*) that are not competent hosts. White-tailed deer not only serve as a meal to ticks, but also assist in tick reproduction and transport into new areas, leading to the relation between the deer population and the abundance and distribution of ticks (Stafford n.d.).

The 4-poster passive acaricide application system was developed and patented in 1994 as a way to apply “acaricide to the head, neck and ears of a deer as they feed”, controlling the free-living populations of ticks in the process (Pound et. al 2000; Curtis et. al 2011). Before the 4-poster device was implemented for tick control, the only methods available were not able to control the free-living tick population. These methods included, but were not limited to, biological controls, chemical applications, “pesticide treatment of small mammals”, habitat modification, and reduction in available hosts (Pound, Lemeilleur et. al 2000). After its initial development and testing, the 4-poster system was further tested in a variety of tick population control studies, many of which reached the conclusion that these systems have a significant impact on controlling free-living tick populations and reducing the risk of tick-borne diseases (Brei et. al 2009; Carroll et. al 2009; Curtis et. al 2011; Pound et. al 2000; Pound, Lemeilleur et. al 2000). With this in mind, Brookhaven National Laboratory (BNL) began using the 4-poster tick management systems. This paper compares the first year’s tick population to that of the third year, where significant results have typically been found.

Methods

Study Area

BNL covers 5,265 acres within Suffolk County, Long Island, NY. The diverse habitat (lawns, roadside, forests, etc.) result in significant edge habitat where deer tend to thrive. In addition, BNL has historically had no deer management, resulting in a large deer population on site (BNL 2009) that has ranged from 50 – 100 deer/mi². A variety of other animals besides deer utilize the 4-posters as well, and include wild turkey (*Meleagris gallopavo*), grey squirrels (*Sciurus carolinensis*), Canada geese (*Branta canadensis*), groundhogs (*Marmota monax*), and raccoons (*Procyon lotor*).

4-Posters

In 2013, fourteen 4-poster devices were deployed throughout the BNL property. In 2014, due to light use at some sites, three devices were removed and set up as duplicates at sites 3, 4, and 11 where use was heavy in 2013; and four additional devices were added in areas of high deer presence. In 2015, duplicates at sites 4 and 11 were removed after the deer population was reduced, leaving a total of fifteen devices in operation throughout BNL. Each device has a central bait bin filled with corn which dispenses on either side to a feeding trough to attract deer. Each feeding trough has two permethrin-treated paint rollers which coat the deer's head, neck, and ears as they feed (Pound et. al 2000; Pound, Lemeilleur et. al 2000; Curtis et. al 2011). Due to decreased usage, devices were serviced once per week in 2015 instead of on a twice per week schedule as in previous years. Corn was refilled to maintain a 200 lb supply and the amount consumed between each refilling was recorded. The rollers were initially treated with 40mL of

permethrin, and subsequently with an additional 1.25mL applied via a hand gun applicator for every 1.5lbs of corn consumed.

Each 4-poster device was monitored for usage by wildlife using a Wildgame Innovations infrared digital camera (model W5EGC) or Moultrie model D-333 camera set up adjacent to the device. Memory cards for each camera were replaced every two weeks and sorted into one of five categories: deer, raccoon, turkey, other animals, and no animals. Deer took priority as they were the target species, and any picture with deer, regardless of the presence of other animals, was categorized as deer. After deer the order of importance was as follows: raccoon, turkey, other animals, no animals. Any picture containing a human or vehicle was placed into the 'No Animals' category.

Tick Sampling

A 0.46 x 0.76 meter flag was dragged across vegetation and leaf litter to sample the tick population. The flag consisted of a cream-colored corduroy material, allowing for ticks to easily cling to it. In 2014, the flag was reduced to approximately half its original size, resulting in timed samples changing from 30 30-second samples, as was done in 2013, to 30 one-minute samples for comparability. After each one-minute sample, the flag was checked for any ticks. If ticks were present, the species was identified as one of three: *A. americanum*, *I. scapularis*, or *D. variabilis* and recorded. Life stage (larvae, nymph, or adult) and gender, if adult, were also recorded for each collected tick. The ticks were then removed from the flag using a sticky-tape lint roller and disposed of. The vegetation of the one-minute sample was also recorded and consisted of any mix between wooded, grassy, herbaceous, and shrubby vegetation. Tick population sampling was conducted in July of 2013, and June-July in 2014 and 2015.

Analysis

The Kruskal-Wallis H test was used to compare differences between *A. americanum* adult male, adult female, nymph, and *I. scapularis* nymph populations from July 2013, 2014, and 2015. As the data collected was nonparametric, this test was chosen because comparisons could be made between several years unlike the Mann-Whitney U test which can only compare two years. Percent control was calculated between each focus life stage in 2013-2015 and 2014-2015 using a modification of Henderson's method where: percent control = $100 - [(T / U) \times 100]$, where *T* and *U* are mean after treatment and mean before treatment respectively (Schulze et al. 2007). Insignificant numbers of *I. scapularis* adults and larvae and all life stages of *D. variabilis* resulted in no statistical analysis being conducted.

Results

Tick Sampling

The Kruskal-Wallis H test showed significant results in differences between population means of *A. americanum* adult males (P=0.0392), adult females (P=0.0202), and nymphs (P<0.0001), but no significant difference in *I. scapularis* nymphs (P=0.995) throughout the three sampling years. Comparing 2013 to 2015, adult male *A. americanum* had the highest percent control (59.0%) followed by adult females (55.8%), and nymphs (0.5%) (Table 1). *I. scapularis* nymphs was the only life stage to have a negative percent control (-7.3%). Five of the eleven sites had 100% control in at least one of the three life stages of *A. americanum* evaluated, while six sites had at least one negative percent control in one of the four categories (*A. americanum* adults (male, female) and nymphs and *I. scapularis* nymph). Between 2014 and 2015, adult female *A. americanum* had the highest percent control (51.6%), followed by adult males (7.6%) (Table 2). Both *A. americanum* and *I. scapularis* nymphs had a negative percent control

(-137.0% and -38.6% respectively). Like the 2013-2015 comparison, five of the eleven sites had 100% control in at least one of the three life stages of *A. americanum*. Unlike the 2013-2015 comparison, eight of the eleven sites in the 2014-2015 comparison had a negative percent control in at least one of the four categories.

Discussion

Tick Sampling

Of the sampled species and life stages, only the *A. americanum* adult males, adult females, nymphs, and *I. scapularis* nymphs showed significant results, and thus were the focus stages of the study. Very little or no data was found for the remaining life stages of the focus species, and thus were not viable to use in population estimates. Larvae were sampled at sites, but are most abundant in August. Due to the high numbers of *A. americanum* larvae, abundance of larvae captured was estimated, making the data collected unreliable in calculating a true larval population. Although little to no data was found previously, there was an increase in adult male and female *D. variabilis* at several sites during the July 2015 sampling.

An overall comparison of the three years of conducting the study indicated a significant difference within *A. americanum* adult male ($P=0.0392$), adult female ($P=0.0202$), and nymph ($P<0.0001$) populations, but no significant difference was found in *I. scapularis* nymph ($P=0.995$) populations (Figure 1). The inability to detect a difference within the *I. scapularis* nymph population may be due to the small number of nymphs actually detected throughout the sites, whereas the *A. americanum* was numerous and abundant at all sites. One factor that may result in the finding of more *A. americanum* than *I. scapularis* is the hosts they feed on. The *A. americanum* is very aggressive and non-specific when seeking hosts. They can be found on people, small and large mammals (white-footed mice and white-tailed deer), and wild turkeys

(Holderman and Kaufman 2013), all of which are found on the BNL site. Unlike *A. americanum*, *I. scapularis* are very specific in their selection of hosts, depending on the life cycle stage they are at, and with a low probability of ever finding one due to only crawling short distances, starvation is a major cause of mortality (Patnaude and Mather 2000; Ginsberg and Zhioua 1996). In addition, *I. scapularis* is more susceptible to desiccation, and therefore tend to be in areas with higher moisture or humidity.

Several sites saw multiple increases in tick populations in both the 2013-2015 and 2014-2015 percent control comparisons (Tables 1 & 2). This is most likely due to the habitat composition and “microclimatic factors such as temperature and humidity” (Ginsberg and Zhioua 1996; Burks et. al 1996). Variations in temperature can influence the success rate of ticks finding hosts to feed from. Along with humidity, these two factors influence tick behavior and activity, and may result in an increase or decrease in mortality rates (Ogden et. al 2005). *I. scapularis* host questing is affected by relative humidity within the area. Schulze (et. al 2001) found *I. scapularis* questing early in the morning when temperatures were low and humidity was at its peak. This humidity could determine the height the ticks may quest at away from the leaf litter layer, and increase or decrease chances of finding a host (Ogden et. al 2005).

The amount of shade available, or lack thereof, due to canopy cover and other vegetation, may also be a factor in site tick abundance and species variation. Canopy cover, unlike grassy/herbaceous areas, would provide shade and a lower temperature than exposed areas, appealing to species ticks feed upon. Forest type (coniferous/deciduous) also contributes to the distribution of *I. scapularis* and *A. americanum* throughout the sites. It is not clear however as to what type of forest *I. scapularis* prefers. Some studies have stated that greater abundance would be found in coniferous forests rather than deciduous, while others state the opposite. *A.*

americanum however, primarily occupy not only woods of both types, but also the woody edges and grassy habitats too (Ginsberg and Zhioua 1996). At sites where grassy areas had more coverage than forests, *A. americanum* was more likely to be found, and with potential researcher bias this may have been a cause of error. If during one year of the study, the grassy areas were sampled more than the forests, there may be an increase in *A. americanum*, while researchers who favor forests may see less.

Although this study has shown an overall decrease in tick numbers, it is not to the extent expected (Table 1; Figure 1). This could be due to numerous factors, including abiotic and unintentional error on the researchers' part. During the winter months, ticks burrow into the soil and leaf litter, a period known as overwintering. High amounts of snow fall during this period will insulate them, decreasing the winter mortality, whereas cold, dry winters would reduce survivability (Hayes et. al 2015; Nearing 2015). This past winter (2014-2015), snowfall for the month of March was absurdly high (23.9 inches), and maintained a 20.6 in. average between the months of January - March (Newsday 2015). The months of January - March of 2013-2014 also had unusual amounts of snowfall (19.7 inches) compared to previous records, and may be the cause of limited percent control of free-living tick species observed during the study. Another area of possible error is the length of 4-poster deployment. In this study, the 4-posters were in use from mid-April to late September or early October. Other studies with longer periods of 4-poster use also had significant results in controlling the tick population (Carroll et. al 2009; Curtis et. al 2011; Pound et. al 2000). This may suggest that the 4-poster devices were pulled too early to have the level of impact that we were expecting.

Regardless of the level of control, it is evident that the 4-poster devices are able to control the free-living *A. americanum* and *I. scapularis* populations, and thus decrease the risk of human

illness. With BNL efforts to reduce the deer population to below 30 deer/mi. sq., the tick population is expected to decrease, as lower deer densities theoretically decrease the potential of deer as final hosts. Comparing data of high deer densities with 4-posters to that of lower densities with 4-posters may have a significant effect on tick populations. However, due to unforeseen factors such as severity and length of winter months and 4-poster deployment, the efficiency the 4-posters can provide still remains uncertain. Keeping a record of snowfall and tick abundances may assist in determining levels of control following particularly snowy or lengthy winters, and further validate the 4-poster system as a means of tick control.

Acknowledgments

I would like to thank my mentor, Tim Green, for his help and guidance throughout this study. Thanks to Jennifer Higbie and Kathy Schwager as well for giving help when needed. This project was supported in part by the U.S. Department of Energy, Office of Science, Office of Workforce Development for Teachers and Scientists (WDTS) under the Science Undergraduate Laboratory Internships Program (SULI).

Bibliography

- BNL. www0.bnl.gov,. 2009. Natural Resource Management, Environmental Protection Division (EPD), Brookhaven National Laboratory, BNL. <<http://www0.bnl.gov/esd/wildlife/Deer.asp>>.
- Brei, B., J. Brownstein, J. George, J. Pound, J. Miller, T. Daniels, R. Falco, K. Stafford, T. Schulze, T. Mather, J. Carroll, and D. Fish. 2009. Evaluation of the United States Department of Agriculture Northeast Area-Wide Tick Control Project by Meta-Analysis. *Vector-Borne and Zoonotic Diseases* 9:423-430.
- Burks, C., R. Stewart, G. Needham, and R. Lee. 1996. The role of direct chilling injury and inoculative freezing in cold tolerance of *Amblyomma americanum*, *Dermacentor variabilis* and *Ixodes scapularis*. *Physiological Entomology* 21:44-50.
- Carroll, J., D. Hill, P. Allen, K. Young, E. Miramontes, M. Kramer, J. Pound, J. Miller, and J. George. 2009. The Impact of 4-Poster Deer Self-Treatment Devices at Three Locations in Maryland. *Vector-Borne and Zoonotic Diseases* 9:407-416.

- CDC. cdc.gov,. 2015. Data and Statistics| Lyme Disease | CDC.
<<http://www.cdc.gov/lyme/stats/index.html>>.
- Curtis, P., S. Walker, and D. Gilrein. 2011. Shelter Island and Fire Island 4-Poster Deer and Tick Study.
- Ginsberg, H., and E. Zhioua. 1996. Nymphal survival and habitat distribution of *Ixodes scapularis* and *Amblyomma americanum* ticks (Acari: Ixodidae) on Fire Island, New York, USA. *Exp Appl Acarol* 20:533-544.
- Hayes, L., J. Scott, and K. Stafford. 2015. Influences of weather on *Ixodes scapularis* nymphal densities at long-term study sites in Connecticut. *Ticks and Tick-borne Diseases* 6:258-266.
- Holderman, C., and P. Kaufman. 2013. lone star tick - *Amblyomma americanum* (Linnaeus).
Entnemdept.ufl.edu. <http://entnemdept.ufl.edu/creatures/urban/medical/lone_star_tick.htm>.
- Nearing, B. 2015. Snow protects infected ticks. Cary Institute of Ecosystem Studies.
<<http://www.caryinstitute.org/newsroom/snow-protects-infected-ticks>>.
- Newsday,. 2015. Long Island weather: Snowfall totals since 1947. <<http://data.newsday.com/long-island/data/weather/snowfall-history/>>.
- Ogden, N., M. Bigras-Poulin, C. O'Callaghan, I. Barker, L. Lindsay, A. Maarouf, K. Smoyer-Tomic, D. Waltner-Toews, and D. Charron. 2005. A dynamic population model to investigate effects of climate on geographic range and seasonality of the tick *Ixodes scapularis*. *International Journal for Parasitology* 35:375-389.
- Patnaude, M., and T. Mather. 2000. blacklegged tick or deer tick - *Ixodes scapularis* Say.
Entnemdept.ufl.edu. <http://entnemdept.ufl.edu/creatures/urban/medical/deer_tick.htm>.
- Pound, J., J. Miller, and J. George. 2000. Efficacy of Amitraz Applied to White-Tailed Deer by the '4-Poster' Topical Treatment Device in Controlling Free-Living Lone Star Ticks (Acari: Ixodidae). *Journal of Medical Entomology* 37:878-884.
- Pound, J., J. Miller, J. George, and C. Lemeilleur. 2000. The '4-Poster' Passive Topical Treatment Device to Apply Acaricide for Controlling Ticks (Acari: Ixodidae) Feeding on White-Tailed Deer. *Journal of Medical Entomology* 37:588-594.
- Stafford, K. 2004. Tick management handbook. Connecticut Agricultural Experiment Station, New Haven, Conn.
- Stafford,. n.d. Management of Host Animals. 1st edition. The Connecticut Agricultural Experimentation Station.
- Schulze, T., R. Jordan, C. Schulze, S. Healy, M. Jahn, and J. Piesman. 2007. Integrated Use of 4-Poster Passive Topical Treatment Devices for Deer, Targeted Acaricide Applications, and Maxforce TMS Bait Boxes to Rapidly Suppress Populations of *Ixodes scapularis* (Acari: Ixodidae) in a Residential Landscape. *Journal of Medical Entomology* 44:830-839.
- Schulze, T., R. Jordan, and R. Hung. 2001. Effects of Selected Meteorological Factors on Diurnal Questing of *Ixodes scapularis* and *Amblyomma americanum* (Acari: Ixodidae). *Journal of Medical Entomology* 38:318-324.

Figures & Tables

Table 1. Percent control between 2013 and 2015 at each 4-poster device between species/life stage. Negative percentages indicate an increase in ticks at the site. Negative signs (-) indicate an unquantifiable increase from zero.

2013-2015				
	A. americanum		I. scapularis	
	Male	Female	Nymph	Nymph
4P-2	75.0%	80.0%	98.3%	68.4%
4P-3	100.0%	100.0%	66.7%	-140.0%
4P-4	-	-200.0%	-152.9%	-
4P-5	75.0%	100.0%	77.3%	85.0%
4P-6	100.0%	100.0%	94.4%	66.7%
4P-7	0.0%	85.7%	-182.6%	0.0%
4P-10	57.1%	40.0%	75.2%	-300.0%
4P-11	80.0%	80.0%	-48.3%	80.0%
4P-12	61.5%	78.6%	-171.6%	-
4P-13	100.0%	50.0%	53.2%	0.0%
4P-14	0.0%	100.0%	96.2%	60.0%
Average	59.0%	55.8%	0.5%	-7.3%

Table 2. Percent control between 2014 and 2015 at each 4-poster device between species/life stage. Negative percentages indicate an increase in ticks at the site. Negative signs (-) indicate an unquantifiable increase from zero.

2014-2015				
	A. americanum		I. scapularis	
	Male	Female	Nymph	Nymph
4P-2	0.0%	0.0%	-30.0%	45.5%
4P-3	100.0%	100.0%	35.5%	-50.0%
4P-4	-150.0%	-	-72.0%	-
4P-5	-	100.0%	-55.6%	-50.0%
4P-6	100.0%	100.0%	80.3%	63.2%
4P-7	33.3%	0.0%	-712.0%	-300.0%
4P-10	-200.0%	25.0%	28.6%	-300.0%
4P-11	-	0.0%	-266.7%	66.7%
4P-12	-	57.1%	-550.0%	0.0%
4P-13	100.0%	85.7%	18.2%	100.0%
4P-14	100.0%	100.0%	16.7%	0.0%
Average	7.6%	51.6%	-137.0%	-38.6%

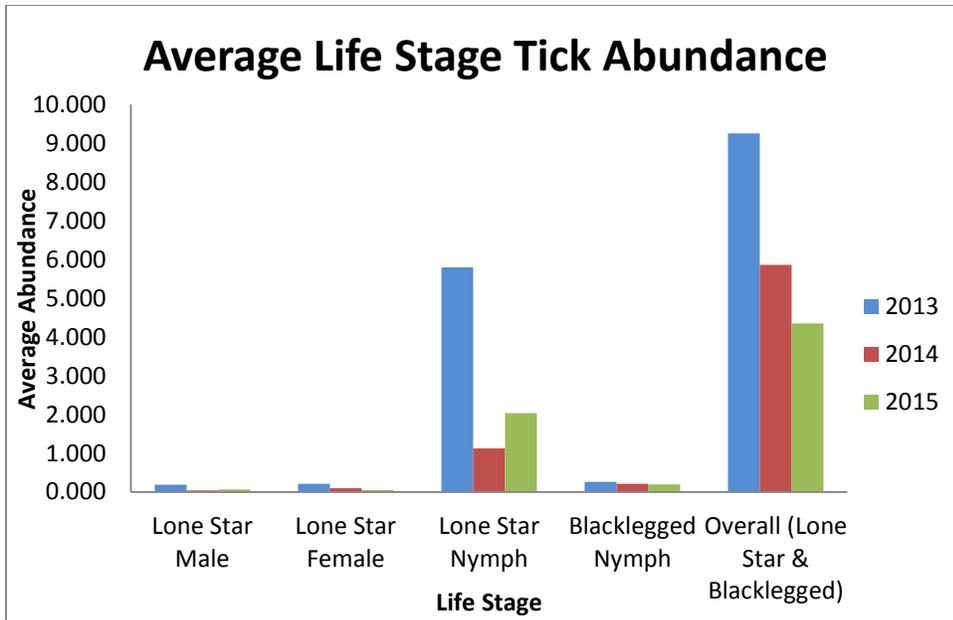


Figure 1. Average abundance of lone star (*A. americanum*) and blacklegged tick (*I. scapularis*) life stages throughout the three-year study. Pooled tick abundance is also compared among the three years.

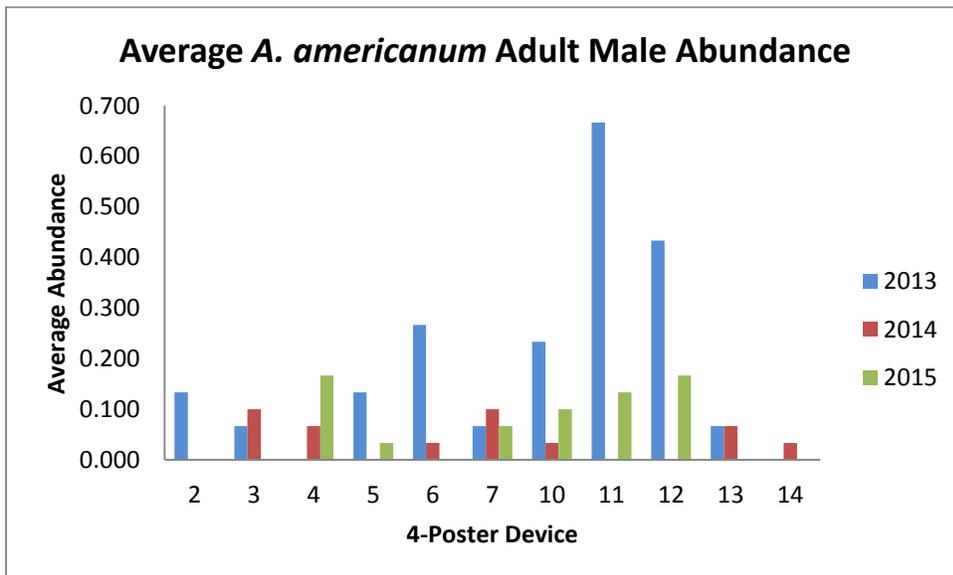


Figure 2. Average *A. americanum* males captured by flagging at 4-Poster sites from July 201, 2014, and 2015.

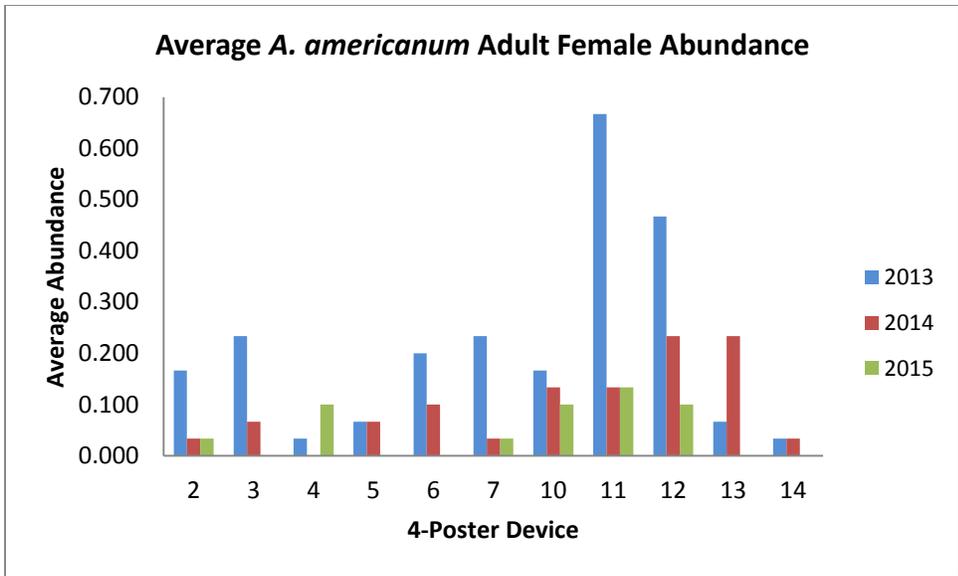


Figure 3. Average *A. americanum* females captured by flagging at 4-Poster sites from July 201, 2014, and 2015.

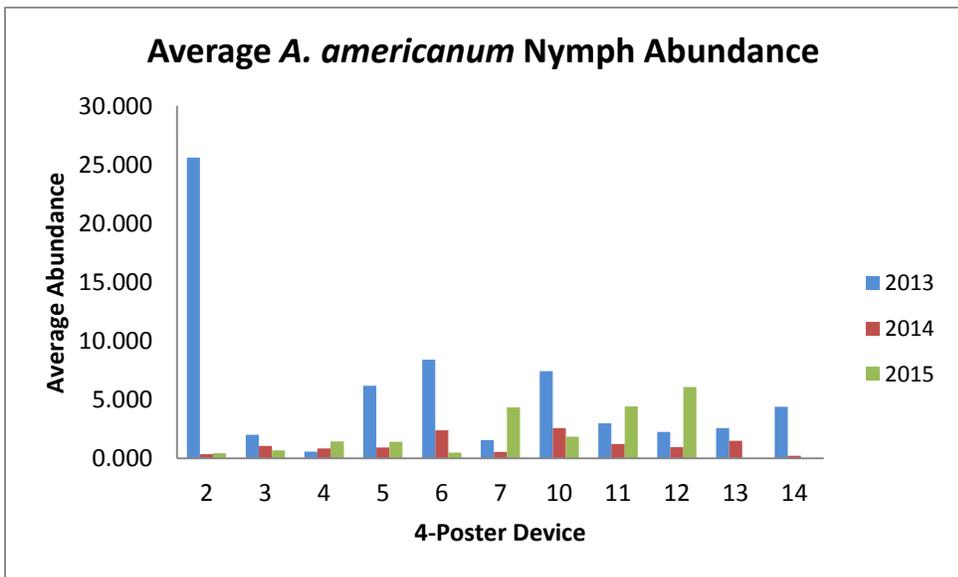


Figure 4. Average *A. americanum* nymphs captured by flagging at 4-Poster sites from July 201, 2014, and 2015.

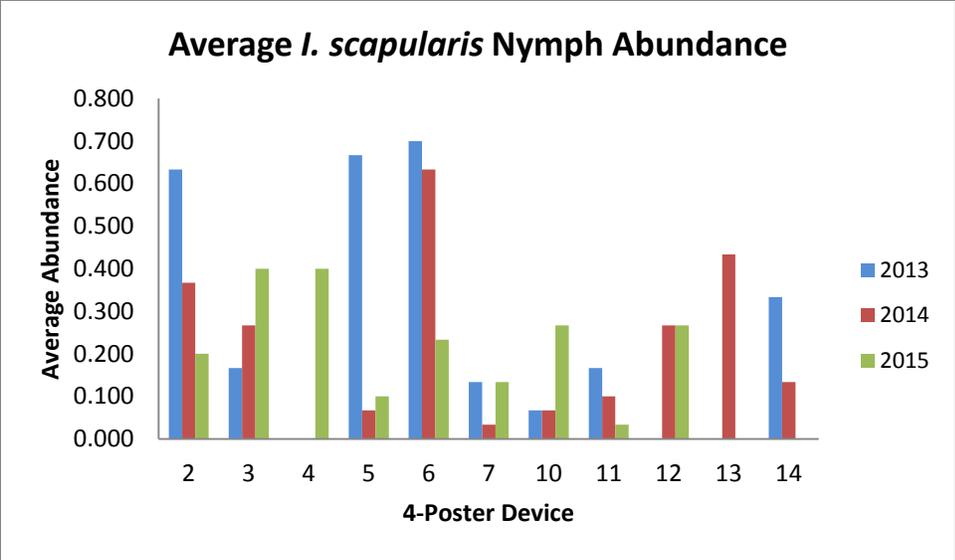


Figure 5. Average *I. scapularis* nymphs captured by flagging at 4-Poster sites from July 201, 2014, and 2015.