The effectiveness of the 4-Poster tick management system in controlling three tick species at Brookhaven National Laboratory

Dulaney Miller
Wildlife Conservation & Biology, University of New Hampshire, Durham, New Hampshire 03824

Tim Green
Environmental Protection Division, Brookhaven National Laboratory, Upton, New York 11973

Abstract

In 2013, Brookhaven National Laboratory (BNL) set out fourteen 4-Poster deer treatment devices within its campus to determine their effectiveness in managing blacklegged ticks (Ixodes scapularis), lone star ticks (Amblyomma americanum), and American dog ticks (Dermacentor variabilis). Four additional devices were added in 2014. Each station, equipped with four rollers treated with 12% Permethrin solution were applied to feeding white-tailed deer (Odocoileus virginianus)—primary hosts of ticks—to reduce tick populations, thus diminishing tick-borne disease at BNL. Flagging to define tick populations at each of the 4-Poster devices occurred during the month of July, 2013 and in June and July, 2014. A 0.7 by 1.0 meter flag was dragged 30 times for one minute at each 4-Poster station and ticks located on the substrate were counted from each flagging and recorded. A comparison of samples between July 2013 and July 2014 showed a decrease of 52%, 37%, and 68% in A. americanum males, females, and nymphs, respectively; as well as a 24% reduction in I. scapularis densities Previous studies revealing significant reductions of >90% in tick densities were detected only three to five years after deployment, suggesting the study must continue in order to show effectiveness.

Introduction

There have been 12,871 confirmed cases of Lyme disease (LD), according to the Centers for Disease Control and Prevention (CDC), in Suffolk County, NY between 1992 and 2011 (CDC 2013). Lyme disease has become an epidemic in the Northeastern and mid-Atlantic United States, but LD is not the only life-threatening tick-borne disease found on Long Island. Other diseases include human anaplasmosis, babesiosis, human ehrlichiosis, Powassan (POW) virus, Rocky Mountain spotted fever (RMSF), and southern tick-associated rash illness (STARI), among others (Adams et al. 2011; CDC 2014b) Blacklegged ticks (*Ixodes scapularis*) and American dog ticks (*Dermacentor variabilis*) are established on Long Island, and in 1991, it was reported that lone star ticks (*Amblyomma americanum*) are now distributed widely on eastern Long Island (Ginsberg et al. 1991; Mixson et al. 2004). Ticks can become infected with such diseases when they take a blood meal from a competent host such as small rodents and birds. Larger hosts that do not become infected with disease when bit by a tick are called incompetent hosts, and function more as a vector- transporting ticks into human adopted areas. White-tailed deer (*Odocoileus virginianus*) populations have been directly correlated with tick density within the deer's range; and tick densities have directly correlated to incidence of Lyme disease among humans in the corresponding area (Hartfield et al. 2010). Targeting *O. virginianus* via removal, topical acaricide application, internal treatment, etc. to diminish tick populations in an area is a commonly practiced method.

The 4-Poster deer topical self-treatment device was patented by the Agricultural Research Service in 1994 to administer acaricide to deer while bypassing the issue of contaminated meat and interference with hunting seasons (Pound et al. 2009). It is designed to dispense corn into two depressions on either side of the 4-Poster. Two Permethrin treated rollers surround each cavity to disperse the solution topically onto the head and ears, an area of high tick abundance, of white-tailed deer as they consume the corn. This system has been used previously in New York, but requires a permit through the New York State Department of Environmental Conservation (DEC). Part 189 of Title 6 of the Codes, Rules and Regulations of the State of New York restricts the feeding of deer and moose. However the DEC has extended permits for scientific research with 4-Poster devices at Shelter Island, Fire Island, and more recently BNL (Curtis et al. 2011). This paper compares the results of two years post-deployment of the 4-Poster system throughout the BNL property to reduce tick populations and the human-wildlife associated risks of tick-borne disease, and justifies continuation of the study to further control ticks within the area.

Materials and Methods

Study Site

BNL is 5,265 acres located in Suffolk County, Long Island, NY. Hunting has been banned from the property, thus there is an abundance of white-tailed deer, wild turkey

(*Meleagris gallopavo*), raccoons (*Procyon lotor*), groundhogs (*Marmota monax*), and grey squirrels (*Sciurus carolinensis*). BNL is sited in the western end of the Central Pine Barrens of Long Island. Tree species include pitch pine, white oak, and red maple. Shrubs and herbaceous plants include Japanese barberry (*Berberis thunbergii*), lowbush blueberry (*Vaccinium pallidum*), sweetfern (*Comptonia peregrine),* bracken fern (*Pteridium aquilinum*), spinulose wood fern (*Dryopteris carthusiana*), and bull thistle.

4-Poster System

Eighteen 4-Poster devices were set up at various locations on BNL property. Three of the locations from the previous year that experienced light use were relocated to create extra coverage at 4-Poster stations 3, 4 and 11 where there was heavy usage. Four additional stations were also added to new locations from the previous years' fourteen locations. Bi-weekly 4-Poster devices were serviced to maintain 200 lbs of corn in the bin and apply Permethrin applied to each of the rollers. Each new roller is initially treated with 40 ml Permethrin solution at the beginning of the study and when replaced. 0.25 ml Permethrin treatment was applied to each roller per 1.5 lb corn added to the 4-Poster device each time they were serviced. The amount of corn and Permethrin solution added to each station was recorded.

A Wildgame Innovations infrared digital scouting camera (Model W5EGC) was set up adjacent to each 4-Poster to record wildlife presence. Memory cards were changed every week to two weeks. Photos were downloaded and sorted into five categories: deer, raccoon, turkey, no animal, and other animal. In cases where both deer and raccoons are present in one photo, they were sorted into the "Deer" folder because they are the target species. Total number of photos in each category by station was recorded and summary statistics included in annual reports were sent to the DEC.

Flag Sampling

A 0.66 x 1.02 meter white corduroy flag was used to perform flag sampling to determine tick densities surrounding each site. White corduroy material allowed for the most visibility of ticks on the flag, and the corduroy texture enabled ticks to cling to the flag securing their presence during sampling. The drag sampling method consists of pulling a cloth flag throughout vegetation and leaf litter to capture ticks while repeatedly checking the flag for target species. The flag used for sampling was approximately one half the area of the flags used the previous year, therefore the duration of sampling doubled from 30 thirty-second samples to 30 one-minute samples for comparability. After each one-minute sample, ticks were identified on the flag and either collected or released back into the environment. Identifications were recorded as male, female, nymph, or larvae of species *A. americanum*, *I. scapularis*, or *D. variabilis*. Areas where two 4-Poster devices occur (3, 4, and 11) were flagged as one station. The vegetation of each individual sample was also recorded as any combination of grassy, herbaceous, shrubby, or wooded. If the vegetation was wet or damp, flag sampling was not conducted until the weather permitted. Sampled areas were within ≈200 m of each 4-Poster device in vegetation that appeared habitable for tick species. Flagging of 4-Poster areas occurred during mid-July of 2013. All plots including additional 4-Posters were sampled again in late-June 2014 and mid-to-late-July 2014. Multiple methods for tick density assessment have been utilized but a study on the comparison of methods for sampling blacklegged ticks in 1992 determined that drag sampling was the most reliable method (Falco and Fish).

Statistical Methods

The Mann-Whitely U test was used to compare the differences between A.americanum adult male, adult female, nymph, and I. scapularis nymph populations from July 2013 to July 2014. This method was chosen because the data was non-parametric. This test also allowed for testing uneven sample sizes, which was necessary when comparing the data sets with stations 15-18 samples included for the July 2014 collection. Percent difference was calculated between each focus life stage using: percent difference = $[(T - U)/ U] \times 100$, where T and U are the mean of the previous sample/ mean of the current sample, respectively. All statistical tests were performed using Excel.

Results

Percent differences between July 2013 and July 2014 stations 1-14 samples for *A. americanum* adult males, adult females, and nymphs were -52.17% (P-0.002), -37.18% (P-0.002), and -67.82% (P-0.000), respectively. Percent difference for *I. scapularis* nymphs was -24.07% (P-0.478). Adding 4-Poster stations 15-18 that existed in July 2014 into the comparison with the July 2013 data yielded percent differences for *A. americanum* adult males, adult females, and nymphs of -49.37% (P-0.004), -33.31% (P-0.004), and -37.45% (P-0.000), respectively. Percent difference for *I. scapularis* nymphs was -36.02% (P-0.093). Between June 2014 and July 2014 samples for *A. americanum* adult male and adult female percent differences were -88.26% (P-0.000) and -72.97% (P-0.000), respectively. During the course of the study no *I. scapularis* males, *D. variabilis* nymphs, or *D. variabilis* larvae were found.

Discussion

The most significant data collected was of *A. americanum* adult males, adult females, nymphs, and of *I. scapularis* nymphs; thus these are the focus life stages of the study. Little or no data was found on the other life stages of the species observed; therefore, conclusions could not be made based upon their populations. Sampling data for larvae was trivial because according to a tick's life cycle stage, larvae will not reach considerable abundance until August.

A comparison of samples from 4-Poster stations 1-14 from July 2013 to July 2014 determined that there was an overall decrease in the focus life stages over time (Table 1). When the sampling data from stations 15-18 were added into comparison, percent difference between 2013 and 2014 was less than that of only stations 1-14. 4-Poster's 15-18 were recently added prior to 2014 samplings and had not been in effect for long; thus, added data from untreated areas had a negative effect on the declining trend in tick densities.

Some individual 4-Poster stations did not follow the declining trend. In July of 2013, there was an average of 0.07 *A. americanum* males, 0.17 females, and 0.60 nymphs per flagging discovered at station 9. In July of 2014, there was an average of 0.43 *A. americanum* males, 0.50 females, and 6.80 nymphs per flagging at station 9 (Figure 1, 2, 3). This is a 550%, 200%, and 1033% increase from 2013 to 2014 at station 9, respectively. Randolph (2000) showed that moisture is a parameter that can heavily influence tick habitat. The increase in *A. americanum* ticks in this particular area may be due to climate or humidity differences during the particular days flagging occurred in 2013 and 2014 Station 9 is also one of the stations that had a device removed in 2014 due to lack of use.

It is also important to note the habitual clustering of both *A. americanum* and *I. scapularis* species. Studies indicate that both species are frequently found in clusters as opposed to a uniformed spatial distribution, which decreases the likelihood of a tick occurrence by area (Goddard 1992; Jackson 1996; Goddard 1997). Averages should also be taken into consideration with standard error because many of the samples include 0 or 1 (Figure 1-4).

A comparison of sampling from June 2014 and July 2014 showed a prominent decrease in *A. americanum* adult males and adult females, as expected. This is concurrent with the life cycle stages of ticks, when adults will release larvae and decline at the end of June (CDC 2014a).

The overall decrease in tick densities shows the 4-Poster system has been effective, but not to the desired extend. Previous studies revealing significant reductions of >90% in tick densities were detected only three to five years after deployment, suggesting the study must continue in order to show greater effectiveness (Carroll 2009; Pound 2009; Schulze 2009). A study on the effectiveness of 4-Poster topical treatment devices documented success in years following device retrieval, adding further value to this treatment method (Schulze et al. 2009).

Modifications may be made to this study in order to maintain consistent and accurate data collection. Weights could be added to the bottom of the flag to keep it from folding over while sampling vegetation. The flag frequently gets twisted and looses full surface area while flagging, preventing full coverage during each sample. Weights would work to keep the corners separated and detangled, exposing more surface area to collect ticks.

It would also be beneficial to erect transects at each station for sampling. The current sampling method may have bias, as one can choose where to sample and may choose areas that would harbor more tick species, such as deer runs. From year-to-year vegetation types may not be sampled consistently. If one year more leaf litter areas are sampled than the next, the data might show a greater decrease in *I. scapularis*; but, habitat was sampled inconsistently and populations did not necessarily decrease. Non-random sampling can create errors in the data, therefore the transect method could be established to promote accuracy.

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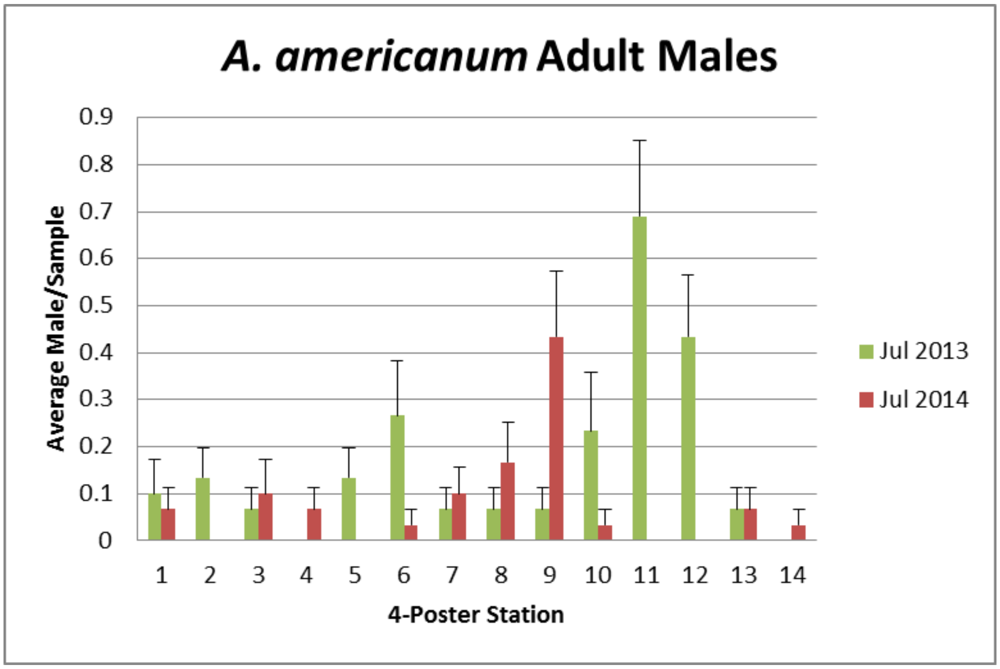

Figure 1. Mean estimate and standard error of numbers of A. americanum males captured by flagging at 4-Poster sites 1-14 from July 2013 and July 2014.

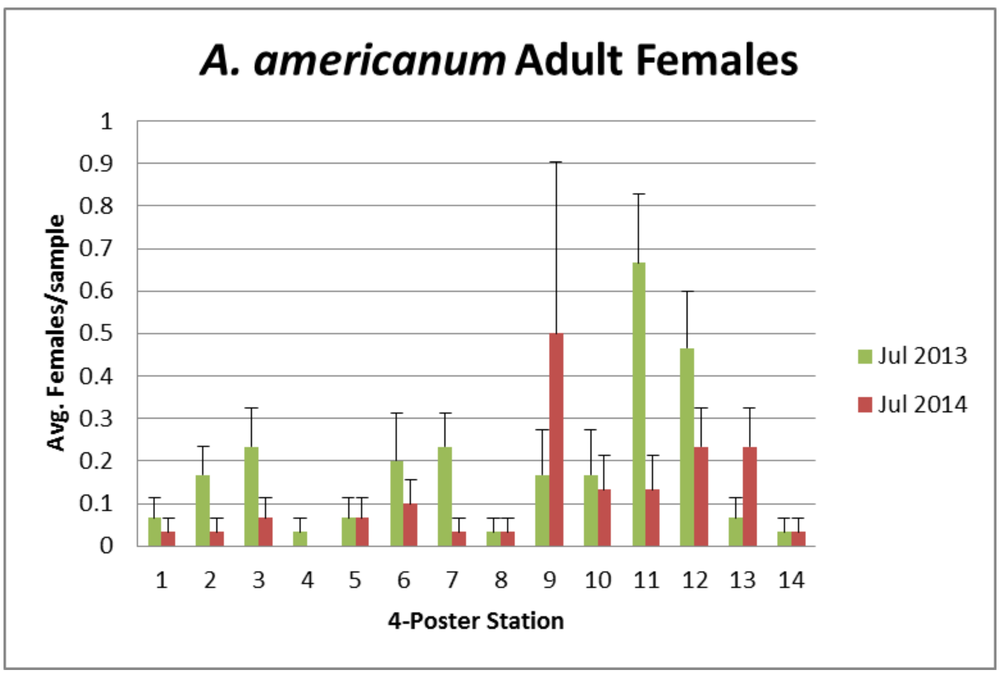

Figure 2. Mean estimate and standard error of numbers of A. americanum females captured by flagging at 4-Poster sites 1-14 from July 2013 and July 2014.

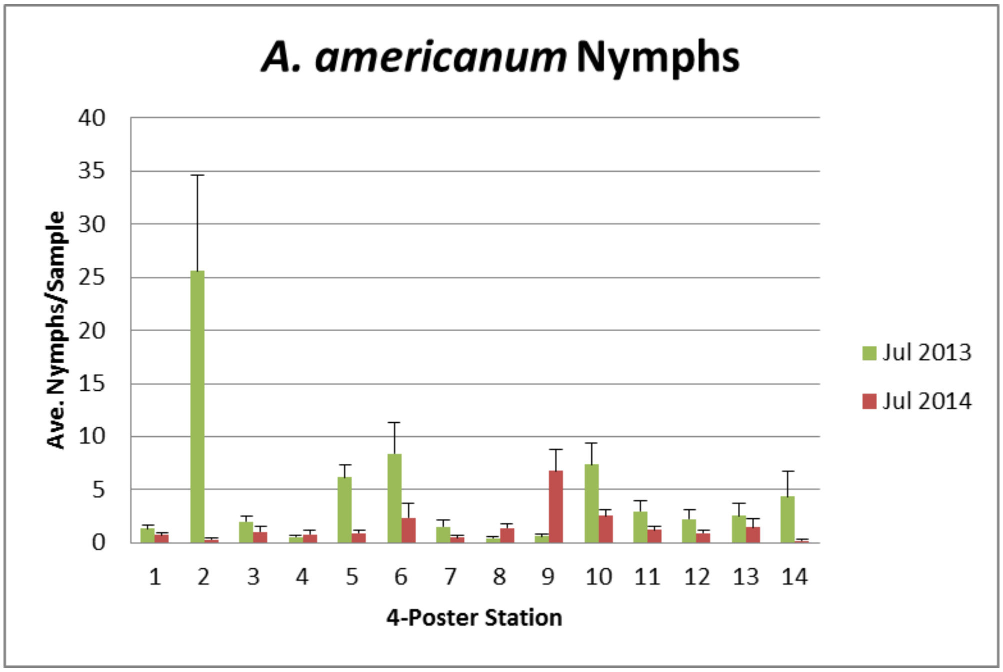

Figure 3. Mean estimate and standard error of numbers of A. americanum nymphs captured by flagging at 4-Poster sites 1-14 from July 2013 and July 2014.

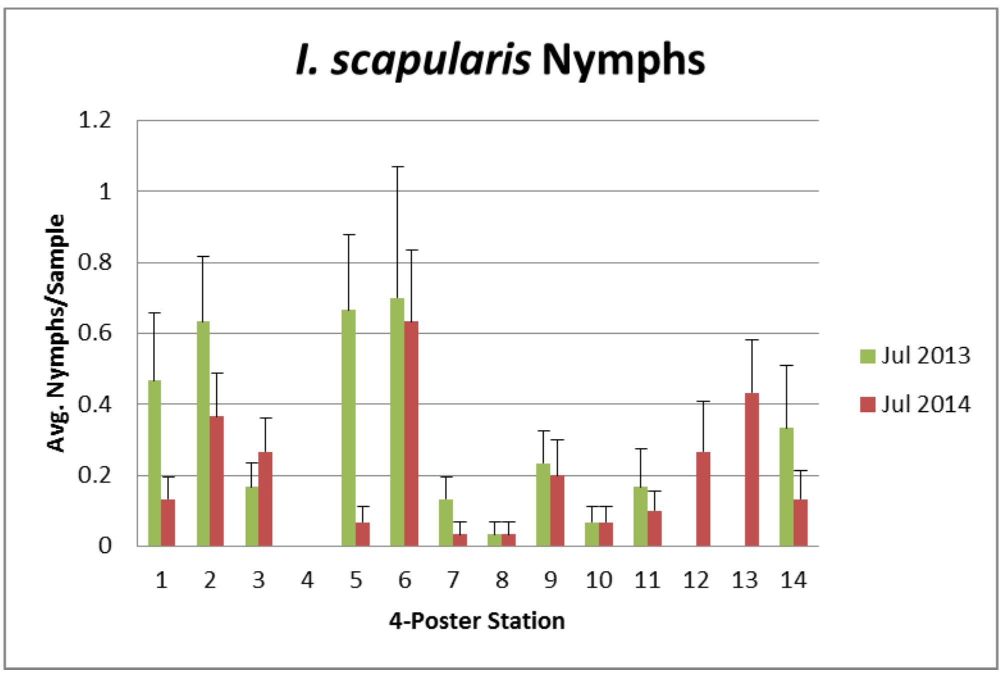

Figure 4. Mean estimate and standard error of numbers of I. scapularis nymphs captured by flagging at 4-Poster sites 1-14 from July 2013 and July 2014.

Table 1. Percent differences (%) between tick species/life stage densities at 4-Poster stations 1-14 between 2013 and 2014.

	Lone Star			Blacklegged
	Adult Male	Adult Female	Nymph	Nymph
4P-1	-33.3%	-50.0%	-46.3%	-71.4%
4P-2	-100.0%	-80.0%	-98.7%	-42.1%
4P-3	50.0%	-71.4%	-48.3%	60.0%
4P-4	+	-100.0%	47.1%	0.0%
4P-5	-100.0%	0.0%	-85.4%	-90.0%
4P-6	-87.5%	-50.0%	-71.8%	-9.5%
4P-7	50.0%	-85.7%	-65.2%	-75.0%
4P-8	150.0%	0.0%	223.1%	0.0%
4P-9	550.0%	200.0%	1033.3%	-14.3%
4P-10	-85.7%	-20.0%	-65.3%	0.0%
4P-11	-100.0%	-80.0%	-59.6%	-40.0%
4P-12	-100.0%	-50.0%	-58.2%	+
4P-13	0.0%	250.0%	-42.9%	+
4P-14	+	0.0%	-95.4%	-60.0%
Total	**-52.20%**	**-37.18%**	**-67.82%**	**-24.07%**

+ indicates an unquantifiable increase from zero