TICK CONTROL IN STATE PARKS

JEROME GODDARD
Mississippi Department of Health, PO Box 1700, Jackson, MS 39215 USA

Abstract - A three-stage study was initiated to evaluate ways to use precision-targeting of insecticides for lone star tick (LST) control in Mississippi State parks. The first stage involved an evaluation of the residual effects of three commercially available pyrethroids against the LST, with the purpose of choosing a candidate product for use in parks. Live ticks were placed in the grass on three dates over a 15-day period inside artificially constructed tick enclosures which had been previously sprayed with the pyrethroids. Two of the insecticides, Permanone7 10 percent EC and Suspend7 SC, provided 100% tick control for the entire 15-day period. The third product, Saga7 WP, provided 100% control for the first seven days. The second phase of the project, conducted at a wildlife management area, carefully documented LST clustering in relation to shade and soil moisture. Results of this study showed clear patterns of LST clustering, especially of nymphs, in association with shade and soil moisture. Ticks were only collected in areas with > 23% soil moisture. Only three ticks out of 221 were collected in 10% or less shade. The average percentage shade for areas where all adult LSTs were caught was 63% in lane one and 43% in lane two. The third phase constituted an attempt to identify spots of LST clustering along nature trails in a Mississippi State park and to spot-treat those areas with Suspend7 SC. Only a minimal amount of insecticide was applied with a backpack sprayer in sites of clustering. For comparison, appropriate control areas (where no treatments were applied) along the same nature trails were also sampled for ticks. Spot treatment provided tick control of 72.7 B 100% for two months (with two exceptions). For the entire first month after spraying there was an average 88.1% control.
Key words - Ticks, tick control, acaricides, recreation areas

INTRODUCTION

In addition to having nuisance effects, tick bites may result in disease transmission to humans. Accordingly, tick control is a desirable goal for public health departments. One objective of the entomology program at the Mississippi Department of Health is to explore ways of reducing the number of cases of tick-borne disease, especially with methodologies that involve limited use of traditional pesticides. With the broader plan of setting up large-scale tick control projects in the Mississippi State Parks, several small initial studies were undertaken to test insecticide efficacy against ticks and to identify ways to precision-target insecticides (i.e. to exactly place the chemical only in spots where pests occur). Precision targeting of insecticides for tick control is possible because ticks are not evenly distributed in nature. The spatial arrangement of ticks in nature may be uniform (under-dispersed), random, or aggregated (over-dispersed), depending upon tick species and ecology of the host (Korch, 1994). Hard ticks attach to a vertebrate host for several days. Host specificity varies by tick species; some ticks feed on almost any vertebrates, whereas others are closely associated with a particular rodent, bird, reptile, etc. Since engorged ticks are most likely to fall off wherever their hosts spend the most time, the presence of ticks in the environment is largely a function of host activity. Previous tick studies in Mississippi have indicated clustering or clumping of at least two hard-tick species. A study of the ecology of adult *Ixodes scapularis* in a privately owned wildlife management area demonstrated clustering patterns (Goddard, 1992). Another study, 200 miles north of the first, revealed clumping of adult *Amblyomma americanum*, or lone star ticks (LST) (Jackson *et al.*, 1996). The lone star tick is an extremely aggressive pest species occurring primarily in the southeastern and south-central United States, and up the eastern seaboard to approximately New York. All three motile life stages bite humans, pets, domestic and wild animals. These three field studies were designed to determine: a suitable candidate insecticide for use in parks; whether lone star tick clustering in nature is real and predictable; and whether the phenomenon can be exploited for control purposes. Results of the first two studies have been previously published and are included here with permission of the National Environmental Health Association (Goddard, 1997, 1998).

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MATERIALS AND METHODS

Study one

Holding pens were created in an outdoor area, each sprayed with a different product, and then ticks were systematically released into the pens at intervals to evaluate how long each product would continue to kill ticks. The only limiting factor in this study was the availability of live ticks. Two shipments, each of approximately 400 lone star ticks (equal numbers of male and female), were received from Dr. Matt Pound and co-workers at the U.S. Department of Agriculture (USDA) Livestock Insects Laboratory in Kerrville, Texas. The ticks were subdivided into separate vials containing 20 ticks each for release into the tick pens. Twelve tick pens 1 square meter (m^2) each were constructed with thick, clear plastic in an area of high grass (Figure 1). At the bottom of each pen the plastic was tucked inside and held down by large nails driven into the ground. Three insecticide products and one control were randomly assigned to the plots. This pattern was replicated three times, yielding a total of 12 plots. The products evaluated were Permanone 10 % EC (active ingredient permethrin), Saga WP (active ingredient tralomethrin), and Suspend7 SC (active ingredient deltamethrin Deltaguard™). These products are commercially available to pest control operators. On May 5, 1996, each insecticide was mixed according to label directions and sprayed with a handheld 1-gallon sprayer in each assigned plot. Sufficient solution was applied to thoroughly wet the grass. Nothing was done to the three control plots. This was the only insecticidal treatment. Plots were open to sun, wind, and rain the entire time. The first batch of live ticks (20 per plot) was placed in the plots 24 hours later. Another 24 hours later, each plot was sampled for ticks with a 1 m^2 white flannel cloth. Sampling consisted of two careful swipes over the grass within each pen. The cloth was then examined for live ticks. Numbers for all three replicates were combined for each treatment and the control. This release/sample process was repeated on day 7/8 and again on day 14/15. Each time, the sampling occurred 24 hours after tick release. The number of ticks collected indicated product effectiveness. Accordingly, no ticks collected indicated a lethal residual effect.

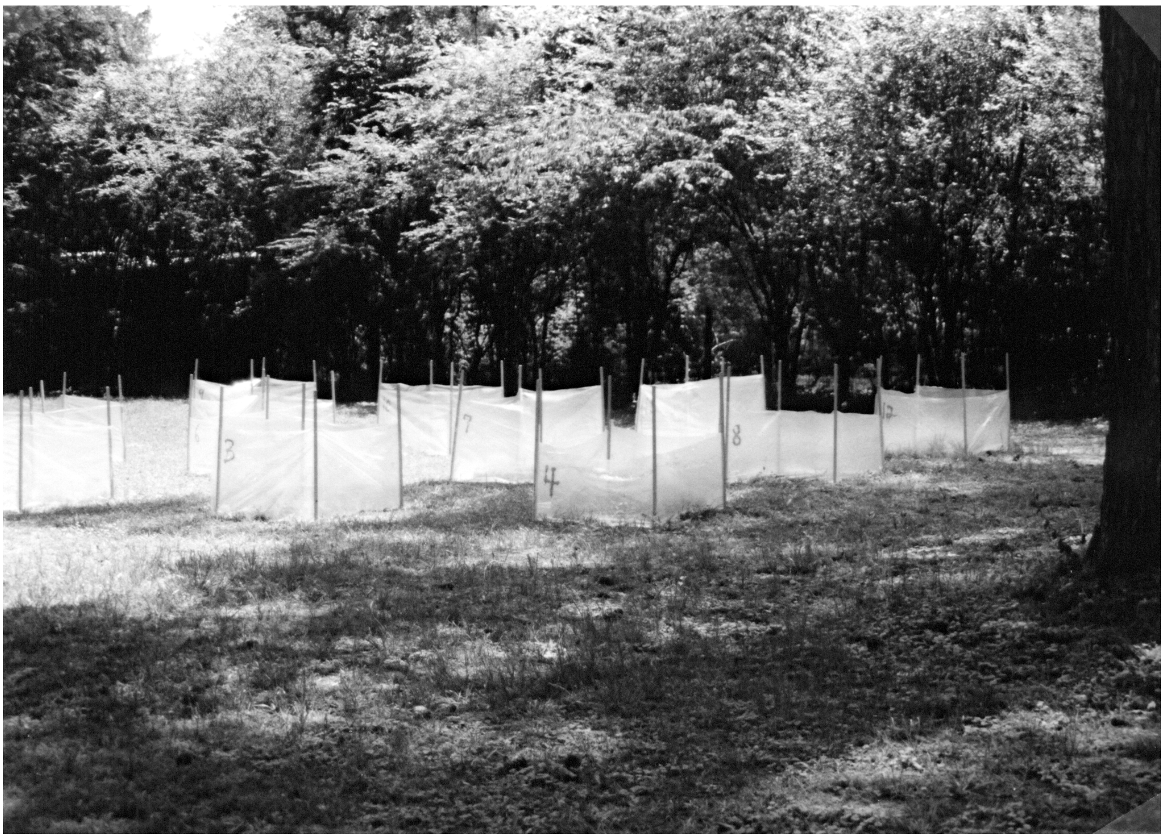

Figure 1. Artificial enclosures, or tick pens, constructed to estimate the residual effects of pyrethroid insecticides.

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Study two

Ticks were collected in two field plots over a period of seven months and their location within the plots studied in relation to soil moisture and shade. In late winter, 1994, two lanes 620 meters long by 2 meters wide were bush-hogged through the woods at the Copiah County Game Management Area in central Mississippi. The narrow lanes were bush-hogged to facilitate careful sampling and exact numbering of each lane into 10-meter sections. The two lanes were located 1.6 kilometers apart. Each lane crossed several types of habitat (open field; creek bottoms; and forests of oak, hickory, and pine). From April 1, 1994, to October 31, 1994, each lane was sampled for ticks on a weekly basis: a 1-square -meter piece of white flannel cloth was dragged up one side of the lane all the way to the end and back down the other side. The cloth was examined for ticks every 10 meters. Spots were marked on a map drawn to scale wherever lone star ticks (adults or nymphs) were captured. Except for voucher specimens, all ticks were returned alive to the plots. Percent shade for each 10-meter section of lane was visually estimated three times during the season (May 15, July 15, and September 15) and averaged to yield a shade value for each section. Percent soil moisture was determined (using an OSK soil moisture meter from Forestry Suppliers of Jackson, Mississippi) on the same three dates and averaged to yield a moisture value for each 10-meter section.

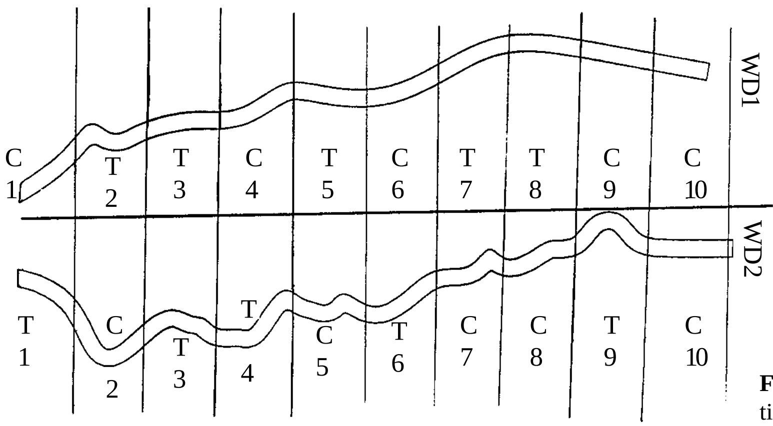

Figure 2. Two 640m trails chosen for tick study, divided into 10 - 64m subsections designated T (treatment) or C (control).

Study three

Spots of lone star tick clustering along nature trails at a state park were identified and spot treated with an insecticide to see if minimal use of insecticide could be efficacious. In late winter, 1997, two 640 meter by 2 meter wide sections of trails were marked at Wall Doxey State Park in northern Mississippi. These two plots (actually, linear sections of hiking trails) were mapped carefully, making drawings of them to scale. Each plot was subdivided into ten, 64-meter subsections: five were randomly assigned as treatments and five were controls (Figure 2). Beginning the first week of April, each plot was sampled for ticks with a 1-square-meter white drag cloth. The cloth was dragged down the trail and examined for ticks every 10 meters. Any lone star ticks (adults or nymphs) on the cloth were identified, their location noted on the scale map, and released near their capture point. Thus, pre-counts were made, but, more importantly, exact spots were noted on the plot maps where ticks were found. As time progressed, the plot maps showed spots of tick clustering. The first week of May, 1997, treatments were made using a backpack sprayer (fan nozzle) with deltamethrin (Suspend SC) mixed at the rate of 1.5 ounces per gallon of water. This was the standard label rate recommended for tick control. Spraying was limited to 2 gallons of finished spray per 640 meter plot. This was not a label restriction; only our self-imposed pesticide limit. Even in treatment areas, only spot treatments were made at spots of clustering as revealed by the plot maps. Most of the trails, treatments and controls, received no pesticide applications. For 9 weeks after treatment, tick sampling was continued as before, keeping record of tick numbers and plotting location of ticks on the plot maps.

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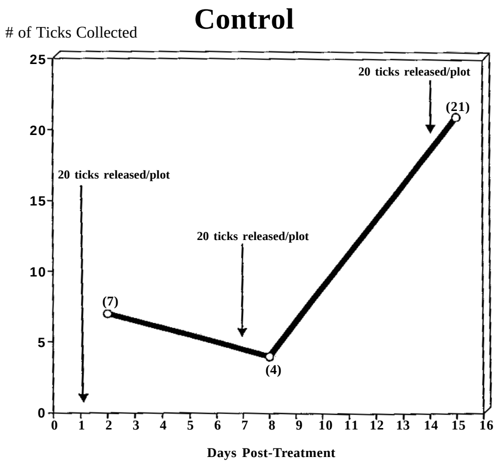

Figure 3. Number of live ticks collected in control pens (number from all replicates combined).

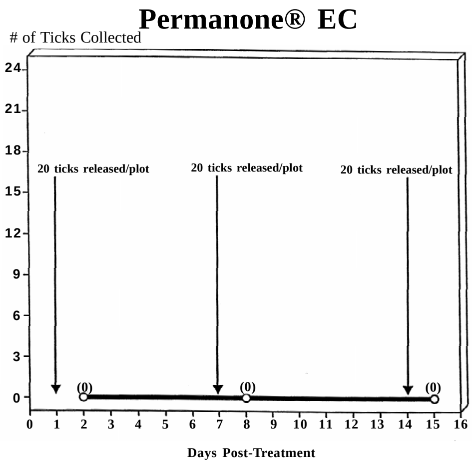

Figure 4. Number of live ticks collected in Permanone7 10 Percent EC pens (number from all replicates combined).

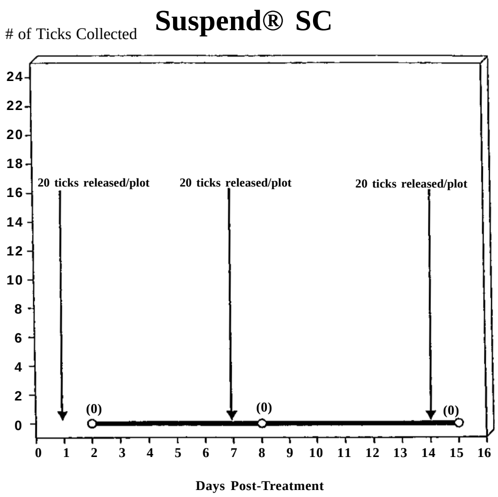

Figure 5. Number of live ticks collected in Suspend7 SC pens (number from all replicates combined).

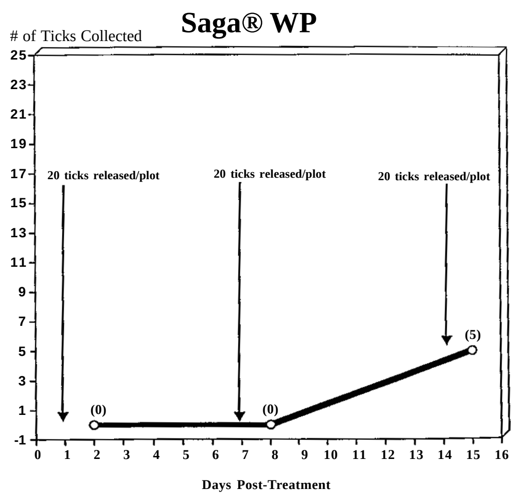

Figure 6. Number of live ticks collected in Saga7 WP pens (number from all replicates combined).

RESULTS AND DISCUSSION

Study one

It rained on the plots two times during the 15-day study B approximately 0.10 inch on May 9 and 0.50 inch on May 11. Weather on the other days consisted of varying amounts of sunshine and mild temperatures (range 49° to 88 °F), typical for mid-May in Mississippi. Ticks seemed to survive well in the control pens during the study period and could easily be observed on grass or leaves inside all three of those pens. Ticks were collected in control plots during each sampling period (Figure 3). Not one live tick was collected during the 15-day study period from the Permanone 10 % EC and Suspend SC test plots, even though 20 ticks were released three different times into each plot (times three replicates, for a total of 180 ticks) (Figures 4 and 5). This result indicates complete tick control by the residual effect of these products. Saga WP began to lose effectiveness somewhere between day 8 and day 15 (Figure 6).

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Study two

Overall, 221 LSTs were collected - 64 in site one and 157 in site two. Breaking down by life stage, 31 adults and 33 nymphs were collected in site one, whereas 44 adults and 113 nymphs were collected in site two. Seasonally, the peak of adult ticks in site one was June 15; the peak in site two was June 8. More nymphs were collected on May 31 and June 8 than any other date in site one, and on June 8 in site two.

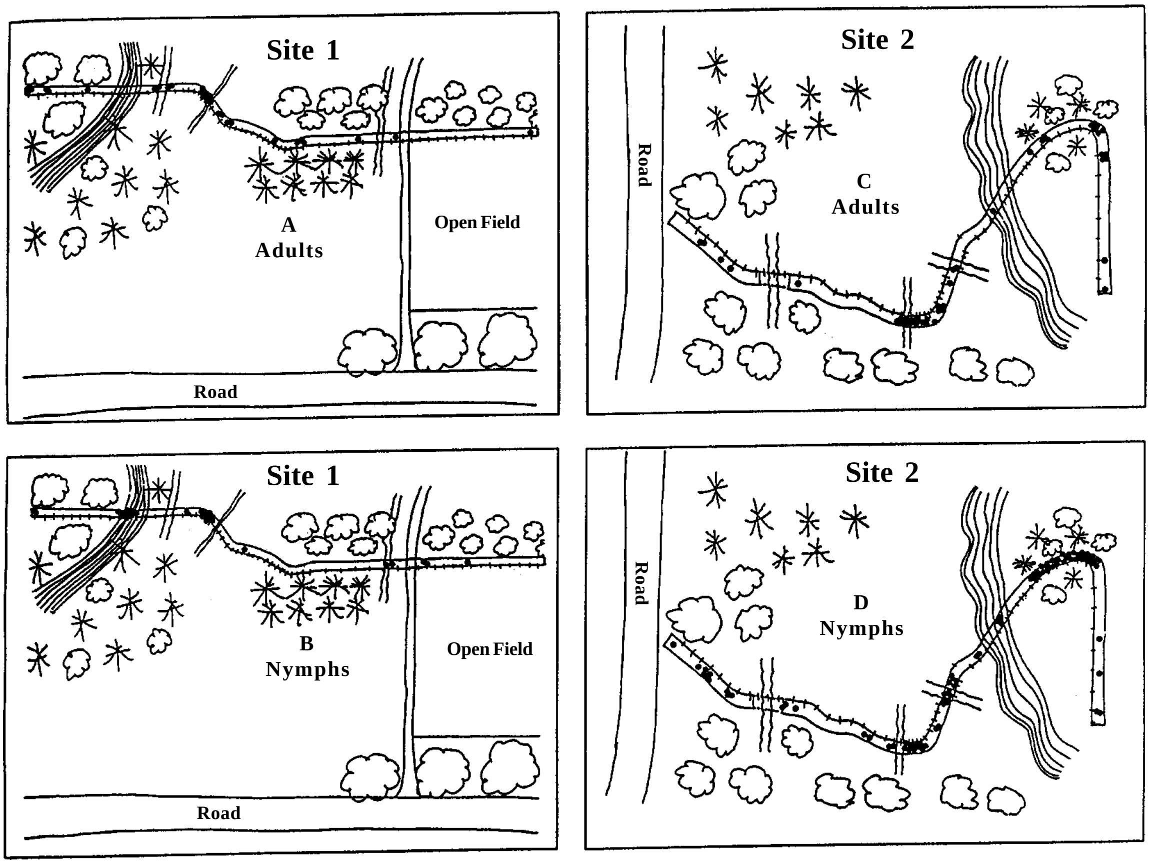

Figure 7. Distribution of ticks collected from study sites, Copiah County Game Management Area, showing clustering effect. Each dot represents one or more tick collections.

Lone star ticks were clustered in the lanes (Figure 7). This was most obvious in site two (especially the nymphs, see Figure 7 D). In fact, if one calculates the area where most ticks were found and divides by total area (times100), the percentage of area where ticks were found is quite small (Table 1). This was most striking for nymphs in site one where 73% were collected in 9.7 % of the lane. Approximately 70% of LSTs were found in 10-20% of the geographic area.

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Table 1. Clustering of LSTs in study sites.

Site	Tick Stage	% of Area Where Majority Ticks Found
1	Adult	17.7
1	Nymph	9.7
2	Adult	14.5
2	Nymph	25.8

Table 2. Percent shade in places where the majority of LSTs were collected.

Site	Tick Stage	Amount LSTs Collected	% Shade
1	Adult	21/31 (68%)	71
1	Nymph	24/33 (73%)	65
2	Adult	31/44 (70%)	45
2	Nymph	81/113 (72%)	71

Table 3. Percent soil moisture in places where the majority of LSTs were collected.

Site	Tick Stage	Amount LSTs Collected	% Soil Moisture
1	Adult	21/31 (68%)	38
1	Nymph	24/33 (73%)	37
2	Adult	31/44 (70%)	52
2	Nymph	81/113 (72%)	53

Percentage shade in the lanes ranged from 0 - 90% in both sites. Ticks were collected mostly from shaded areas. Only three ticks out of 221 were collected in 10 percent or less shade. This may be due to LST inability survive hot dry environments. Lancaster (1957) reported that LST eggs reared in an environment of <75 percent humidity would not hatch. The average percentage shade for areas where all adult LSTs were caught was 63% in site one, and 43% in site two. The average percentage shade for areas where all nymphs were collected was 61% in site one and 46 percent in site two. If one further breaks down the collection data into only the areas where most LSTs were collected the percentages are higher (Table 2). Soil moisture in the lanes ranged from 20-66 percent in site one and from 27-88 percent in site two. Overall, site two was a wetter site. Interestingly, site two produced 30 percent more ticks than site one. This may relate to moisture needs by lone star ticks for survival. Ticks were collected where soil moisture was >23 percent, with most collected where it was 37% or higher (Table 3).

Study three

A total of 220 lone star ticks were collected; 130 from plot one and 90 from plot two (Tables 4, 5). Plot one produced 44% more ticks than plot two. Seasonally, the peak of ticks in both plots was May 1. Lone star ticks were clustered. Spot treatment of clustering sites provided tick control of 72.7-100% for two months (with two exceptions). For the entire first month , both plots combined, there was an average 88.1% control. Statistical analysis comparing the two group means (treatment vs control) per week revealed no significant differences during all five pre-spray weeks, but significant differences ($p< .05$) in six out of the nine ensuing post-spray weeks (Table 6).

Table 4. Lone star ticks collected at Wall Doxey Park (#1, Old Roadbed Trail), 1997.

Date	Status	No. LSTs Treatment[1]	No. LSTs Control[1]	% Control[2]
3 Apr 97	5 wk pre-spray	0	0	-
8 Apr 97	4 wk pre-spray	2	1	-
17 Apr 97	3 wk pre-spray	0	0	-
23 Apr 97	2 wk pre-spray	3	2	-
1 May 97	1 wk pre-spray	9	15	-
16 May 97	1 wk post-spray	2	14	85.7%
22 May 97	2 wk post-spray	3	18	83.3%
28 May 97	3 wk post-spray	4	16	75.0%
2 Jun 97	4 wk post-spray	0	3[3]	100%
12 Jun 97	5 wk post-spray	1	6	83.3%
19 Jun 97	6 wk post-spray	1	8	87.5%
27 Jun 97	7 wk post-spray	0	3	100%
1 Jul 97	8 wk post-spray	3	5	40%
8 Jul 97	9 wk post-spray	8	3	-

[1]Five replicates of treatment and controls; numbers combined.
[2]Difference between treatment and control divided control X 100.
[3]Raining on this day.

Table 5. Lone star ticks collected at Wall Doxey Park (#2 , Hiking Trail), 1997.

Date	Status	No. LSTs Treatment[1]	No. LSTs Control[1]	% Control[2]
3 Apr 97	5 wk pre-spray	2	2	-
8 Apr 97	4 wk pre-spray	4	2	-
17 Apr 97	3 wk pre-spray	4	3	-
23 Apr 97	2 wk pre-spray	9	4	-
1 May 97	1 wk pre-spray	12	6	-
16 May 97	1 wk post-spray	0	1	100%
22 May 97	2 wk post-spray	0	7	100%
28 May 97	3 wk post-spray	3	11	72.7%
2 Jun 97	4 wk post-spray	0	0[3]	-
12 Jun 97	5 wk post-spray	1	7	85.7%
19 Jun 97	6 wk post-spray	2	4	50.0%
27 Jun 97	7 wk post-spray	0	5	100%
1 Jul 97	8 wk post-spray	0	1	100%
8 Jul 97	9 wk post-spray	3	0	-

[1]Five replicates of treatment and controls; numbers combined.
[2]Difference between treatment and control divided by control x100.
[3]Raining on this day.

Although limited in size and scope, these three studies indicate that precision-targeting of insecticides for tick control is tenable. The first study showed that at least two commercially available insecticides are sufficiently lethal to provide 100% control in the natural environment for at least two weeks during late spring. Spraying for ticks will be effective for at least two weeks. The second study indicated that lone star tick clustering in nature is real and somewhat predictable. Clearly definable spots in the study sites consistently produced ticks, whereas others did not. Almost no ticks were collected in open areas with full sunlight. Approximately 70% of ticks were collected in 10 to 20% of the geographic area. The third study demonstrated that the clustering phenomenon can be exploited for control purposes. If the 10 to 20% of area containing ticks is spot-treated with insecticides in the spring, then tick numbers can be significantly reduced for 4-8 weeks.

Table 6. Statistical analysis of tick numbers in Treatment vs Control Sections of Old Road and Hiking Trail, Wall Doxey State Park, 1997.

Week #	Status	T value	P value
1	5th wk pre-spray	.0000	.5000
2	4th wk pre-spray	.8783	.1957
3	3rd wk pre-spray	.2683	.3957
4	2nd wk pre-spray	.8581	.2011
5	1st wk pre-spray	.0000	.5000
6	1st wk post-spray	-1.6180	.0615
7	2nd wk post-spray	-1.9165	.0357
8	3rd wk post-spray	-2.9925	.00390
9	4th wk post-spray	-2.4804	.0116
10	5th wk post-spray	-2.4804	.0116
11	6th wk post-spray	-1.9237	.0352
12	7th wk post-spray	-2.4495	.0124
13	8th wk post-spray	.0000	.5000
14	9th wk post-spray	1.3631	.0948

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