Pesticide Use by Licensed Applicators for the Control of *Ixodes scapularis* (Acari: Ixodidae) in Connecticut

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ABSTRACT To assess the use of insecticides for tick control by commercial applicators in Connecticut, a questionnaire was mailed to 897 individuals and businesses with ornamental and turf pesticide applicator licenses. In total, 348 completed surveys were returned (38.8%). The majority of the respondents considered themselves lawn care (41.1%), landscape (31.3%) or tree care (12.6%) providers. Tick control services were offered by 16.4% (n = 57) of the respondents, all of whom apply insecticides for tick control, mainly for *Ixodes scapularis* Say. Over half (n = 33) also treat for the American dog tick, *Dermacentor variabilis* (Say). Most respondents (66.7%) began applying pesticides for the control of *I. scapularis* during the period from 1990 to 1996. The principal acaricide used for tick control was cyfluthrin (n = 21), with chlorpyrifos 2nd (n = 18), carbaryl 3rd (n = 12), and fluvalinate (n = 4) 4th. When asked about what other pesticides were used for tick control, the top 3 chemicals also were the principal alternatives. Past success with a product was the dominant factor in selecting a pesticide, but information provided by the Connecticut Agricultural Experiment Station (New Haven), Cooperative Extension (University of Connecticut, Storrs), and scientific studies were important. Half of the respondents (49.1%) indicated that their tick control business had increased slightly or dramatically since 1991, although tick control comprises <5% of their overall business for 63.1% of these applicators. Residential properties comprised 90% of the business for half of those treating for ticks, and the median charge for 0.4 ha was $180. Many respondents (43.8%) also indicated that they planned to expand their tick control services. Tick control represents a small but growing business in Connecticut.

KEY WORDS *Ixodes scapularis*, control, insecticides, Lyme disease, ticks, survey

LYME DISEASE IS the leading arthropod-associated disease in the United States, and the prevalence of this illness has increased dramatically in recent years (Dennis 1995). From 1982 through 1995, nearly 83,000 human cases have been reported to the Centers for Disease Control and Prevention. Lyme disease, caused by the spirochete *Borrelia burgdorferi* Johnson, Schmid, Hyde, Steigerwalt & Brenner, was recognized in 1975 as a distinct clinical syndrome from a cluster of cases in southeastern Connecticut (Steere et al. 1977, Burgdorfer et al. 1982, Johnson et al. 1984). Today, Connecticut has the highest rate of reported Lyme disease in the United States (CDC 1995, 1996).

The blacklegged tick, *Ixodes scapularis* Say, is the principal vector of *B. burgdorferi* sensu stricto in the northeastern and midwestern United States. The majority of *I. scapularis* are associated with forests, wooded suburban landscapes, and woodland edge (ecotone), but ticks also are found on lawns and ornamental plantings (Maupin et al. 1991, Carroll et al. 1992, Stafford and Magnarelli 1993, Fish 1995). Much of the research on the control of this tick has focused on the use of personal protective measures, host management, vegetative management, biological control, and the use of acaricides (Wilson and Deblinger 1993). On a practical basis, reducing the risk of tick bite, and consequently Lyme disease, has been limited to personal protection measures and the use of pesticides. An early-summer application of carbaryl has been shown to control *I. scapularis* nymphs in the lawn and adjacent woodland areas around the home, and a fall application of carbaryl or diazinon has been shown to reduce adult *I. scapularis* populations in an oak-dominated forest for 1 yr (Schulze et al. 1987, Stafford 1991a). Liquid and granular formulations of cyfluthrin were effective in reducing *I. scapularis* in a wooded habitat (Solberg et al. 1992). One application of carbaryl, cyfluthrin, or chlorpyrifos to lawns and wooded margins has reduced nymphal *I. scapularis* by 67.9–97.4% (Curran et al. 1993). Granular materials also appear to be effective (Schulze et al. 1991).

Properly certified lawn care providers and arborists may apply pesticides to control a variety of ornamental and turf pests, which now includes *I. scapularis*. Some pest control operators have begun offering tick control services once they are certified to offer lawn care or are certified in public health control, with chlorpyrifos, cyfluthrin, or carbaryl in 2 annual applications being recommended (Guyette 1993). However, little is known about what tick control services are being offered commercially, how many certified applicators have elected to offer tick control services, or how frequently and what type of insecticides are being applied to suppress tick populations around the home. A survey of Lyme disease knowledge, attitudes, and behaviors in Connecticut found that well-informed people at risk for acquiring the disease were more likely to take personal precautions to prevent Lyme disease, but the use of insecticides was not addressed (Brown et al. 1992). A subsequent survey of residents in southeastern Connecticut found that only 45% of the respondents favorably viewed the use of pesticides to control the tick (M. L. Cartter, Connecticut Department of Public Health, Hartford, unpublished data). The purpose of this study was to examine the use of insecticides for tick control by licensed pesticide applicators in Connecticut. Information from the survey can help assess the role of pesticides in Lyme disease prevention programs, determine research needs, and target tick control education programs.

Materials and Methods

A 4-page, self-administered questionnaire was used to collect the sample data on pesticide usage and on other issues related to tick control by the commercial industry in Connecticut. Questionnaire is available from the author upon request. The survey was approved by the Connecticut Agricultural Experiment Station's Use of Humans in Research Committee. The protocol is on file at the Experiment Station. With 35 dichotomous, multiple-choice, and open-end type of questions (Mendenhall et al. 1971), the questionnaire requested information about the business, type of chemicals used to control ticks, amount of material applied, fees for service, use of alternative tick control strategies, and trends in overall requested service. The first 8 questions were about the business in general, and the remaining information requested was to be filled out by those individuals or businesses that do apply pesticides for tick control. Specific details on the chemicals applied in 1994 and 1995, their formulation, the application equipment used, amount of acaricide applied, rate of application, and other details were requested in questions.

A listing of commercial applicators who are licensed to treat for ticks in the suburban landscape was compiled from information provided by the Pesticide Management Division of the Connecticut Department of Environmental Protection (Hartford). In Connecticut, these are individuals in the state with Ornamental and Turf (category 3A) pesticide applicator licenses. In 1994, there were 897 listings that included addresses in New York, Massachusetts, and Rhode Island. In Connecticut, the number of licenses in each county were: Hartford (n = 260), Fairfield (n = 239), New Haven (n = 158), Litchfield (n = 49), Middlesex (n = 39), New London (n = 20), Tolland (n = 18), and Windham (n = 17). Because not all applicators were expected to respond to the survey and the listing of certified applicators changes every year, the survey was sent to all 897 certified applicators with a cover letter explaining the questionnaire. To determine who had returned a survey and also ensure confidentiality of the individual responses, each self-addressed, stamped return envelope was given a number corresponding to the respondent on the mailing list. Returned surveys were checked off and the envelope was thrown away. Each returned survey was considered 1 record and constituted 1 sample of certified applicators.

Most of the data generated by the survey is descriptive and provides an estimate of the proportion of commercial applicators providing a service, using an insecticide, and so forth. Because there can be >1 entry for some questions and not all questions may be answered within a record, the results of some of the questions are based upon the number of responses. However, unless specified otherwise, the proportion of applicators that provided a specific response is based upon the total number of applicators sampled. Several statistical tests were used to analyze some of the survey results depending upon the type of data produced and comparison of interest (SYSTAT 1996). As a measure of survey response, the distribution by county of completed questionnaires was compared by a chi-square test with the number of expected records based upon the county distribution of certified applicators (Snedecor and Cochran 1967). The Mann–Whitney test was used to compare the number of towns serviced for those treating and not treating for ticks and to compare sources of information used for selecting a pesticide. The distribution of employee size for companies treating for ticks was compared by a chi-square test with the number of expected employees based upon the expected distribution of those who do not treat for ticks. The number of residential or commercial clients serviced for ticks in 1994 and 1995 were compared by a t-test on transformed ($\log x + 1$) counts to normalize the data.

Results

Survey Response. Of the nearly 900 surveys mailed, 348 (38.8%) were completed and returned. An additional 93 either could not be delivered and were marked to be returned to sender or the addressee indicated they were no longer in business. If these 93 listings are removed from the list, the survey response rate increases to 43.3%. Fairfield County had the most Connecticut businesses responding to the survey (32.1% of 305), followed by Hartford (23.0%), New Haven (21.3%), Litchfield (7.9%), Middlesex (6.9%), Windham (3.9%), Tolland (3.3%), and New London (1.6%) counties.

Table 1. Type of businesses indicated by the respondents of the pesticide use assessment survey by those who do and do not treat for ticks

Type of business	No. businesses		
	Do not offer tick control	Offer tick control	Total
Lawn care	107	36	143
Tree service	18	26	44
Landscape service	90	19	109
Municipal and utilities	23	0	23
Golf course and clubs	16	1	17
Retail garden centers	19	0	19
Cemeteries	6	0	6
Other	43	3	46
Total	322	85	407

Because of multiple entries, the number of responses does not equal the number of records (n = 348). There were 52 records with multiple answers for type of business that do not offer tick control services (n = 291 total records) and 22 records with multiple answers for type of business that do treat for ticks (n = 57 total records).

There was no significant difference between the county distributions for the completed records and the surveys that were sent out (χ^2 = 10.739, df = 7, P = 0.150), indicating that the survey sample was not geographically biased. Records also were received from 9 companies in New York or Rhode Island with a Connecticut pesticide license. There were 57 completed records that did not provide a county of business, indicated that they had moved, or listed multiple counties in or out of state.

Nearly half (41.1%) of those returning the survey considered themselves a lawn care provider (Table 1). Landscapers comprised 31.3% of the operations and arborists 12.6%. However, one-fifth (n = 74) of the records indicated multiple categories for their operation. Many of the respondents listed golf courses, municipalities, schools, utilities, cemeteries, nurseries, and garden centers as their type of business. The majority of the applicators (61.5%) indicated they were the owners of the business. One-third (34.1%) of the businesses had 1–5 employees, whereas nearly half had >5 employees (Table 2).

Tick Control Service Business Profile. Most of those sampled (73.6%) indicated that they treated for insects and other pests. However, only 16.4% (n = 57) offered tick control services as well. Within Connecticut, Fairfield County had the most businesses offering tick control services (50.0% of 52), followed by Hartford (21.2%), New Haven (15.4%), Litchfield (3.9%), Windham (3.9%), Middlesex (1.9%), New London (1.9%), and Tolland (1.9%) counties. Although a greater proportion of Fairfield County businesses treated for ticks than would be expected from the distribution of returned surveys (32.1%), there was no significant difference in overall distribution by county for those treating for ticks compared with all sampled responses (χ^2 = 4.353, df = 7, P = 0.360). Two survey respondents located in Westchester County, New York, and 3 in Kent County, Rhode Island, also treated for ticks. Companies that treated for ticks tended to be large. The employee profiles for those who treat and do not treat for ticks were significantly different (χ^2 = 12.265, df = 4, P = 0.015), with few single person businesses indicating they treat for ticks (Table 2). These responding businesses also serviced significantly more towns than those that do not offer tick control services (Mann–Whitney U = 1239.5, P < 0.001) with 43.2% covering ≥10 towns (Table 3). In contrast, businesses that do not treat for ticks served an average of ≈5 towns, 25% served only 1 town, and only 2.0% served ≥10 towns.

Table 2. Number of employees indicated by the respondents in the pesticide use assessment survey by businesses who do and do not treat for ticks

Number of employees	Do not offer tick control	Offer tick control	Total
Self only	67	3	70
1–5	89	20	109
5–10	42	14	56
10–15	28	9	37
>15	38	10	48

Tick Control Services. All of the respondents that treat for ticks apply insecticides for tick control, mainly for the control of *I. scapularis* (87.7%). Over half (57.9%) also treat for the American dog tick, *Dermacentor variabilis* (Say). Two-thirds of the licensed applicators began applying insecticides for the control of *I. scapularis* during the period from 1990 to 1994, although 5 indicated they began during the period 1986 to 1989 (Fig. 1). Half the applicators (50.8%) offer a formal tick control program. Treatment of residential properties comprised the significantly greater proportion of the business (90.1%) for those offering tick control services than commercial properties (9.9%) (Mann–Whitney U = 410.0, P = 0.001) (Table 4). The number of residential properties treated per respondent increased from an average of 25 in 1994 to an average of 41 in 1995 (t = −17.280, df = 1,140, P < 0.0001). Six commercial applicators treated ≥100 properties in 1995.

The principal pesticide listed for tick control was cyfluthrin (36.8%), with chlorpyrifos 2nd (31.6%), carbaryl 3rd (21.0%), fluvalinate 4th (7.0%), and diazinon 5th (3.5%) (total percentage >100 because of multiple answers). When asked about what other pesticides were used for tick control,

Table 3. Number of towns serviced by the respondents in the pesticide use survey by those who do and do not treat for ticks

Respondents	n[a]	mean (SEM)	Median	Range
Do not offer tick control	184	5.1 (0.36)	4.0	1–45
Offer tick control	44	13.1 (1.71)	8.0	1–50
Total	228	6.6 (0.49)	5.0	1–50

[a] Number of respondents.

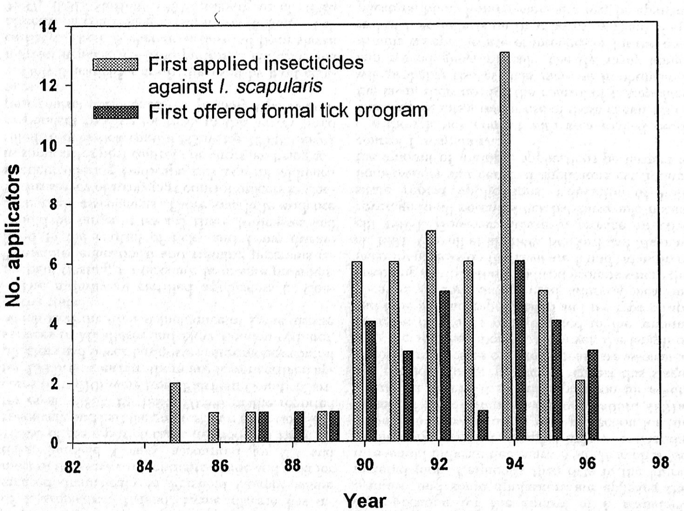

Fig. 1. Number of respondents applying acaricides for the control of ticks and offering a formal tick control program for the first time, 1982–1996 (n = 51 responses).

several respondents (15.8%) indicated permethrin-treated cotton balls (Damminix, EcoHealth, Boston, MA), which kill ticks on white-footed mice, *Peromyscus leucopus* (Rafinesque). However, carbaryl, cyfluthrin, or chlorpyrifos were the principal alternatives (71.3% of 87 multiple entries). More specific information requested on the insecticides used, their formulations, and amount of material applied in 1994 and 1995 is presented in Table 5. There was little difference between 1994 and 1995 in the chemicals, formulations, or application methods used for tick control. In many of the records, insecticides were listed by general brand name (i.e., Sevin, Dursban) without specifying the actual product used. A specific label was indicated or could be determined for cyfluthrin, fluvalinate, insecticidal soap, permethrin, and cyhalothrin (see Table 5).

An emulsifiable concentrate applied with a high-pressure sprayer was the most common formulation used by the 57 sampled applicators. In 1994, 70.2% indicated an emulsifiable concentrate and 64.4% preferred a high-pressure sprayer. Similarly in 1995, 52.6% used an emulsifiable concentrate and 57.9% used a high-pressure sprayer. Some type of spreader for granular material, mainly chlorpyrifos, was the 2nd most common application method listed (17.5% for both 1994 and 1995). The 3rd method of application was a backpack mist blower (14.0 and 12.3% for 1994 and 1995, respectively). Wettable powder (12.3% both years), microencapsulated and flowable products were other formulations listed. The permethrin-treated cotton balls are dispersed manually in cardboard tubes. Most of the applications were made to the lawn–wood border (60–62% of applications),

Table 4. Number and type of clients serviced by the respondents treating for ticks in the pesticide use assessment survey

Client type	Year	n[a]	Total no. (%)	Mean (SEM)	Median	Range
Residential	1994	33	865 (34.0)	25.8 (7.67)	10.0	1–200
Commercial	1994	13	151 (5.9)	12.4 (7.44)	4.0	1–100
Residential	1995	35	1,446 (56.9)	41.3 (10.23)	14.0	1–255
Commercial	1995	13	80 (3.1)	6.7 (2.28)	3.5	1–25

[a] Number of responses from 57 respondents (57 records) that treat for ticks.

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Table 5. Name and formulations of acaricides used in 1994 and 1995 as reported by the respondents of the pesticide use assessment survey

Active ingredient[a]	Formulation[b]	No. (%) responses
Carbaryl	EC	19 (15.3)
	WP	2 (1.6)
	F	7 (5.6)
	UN	2 (1.6)
Chlorpyrifos[c]	EC	11 (8.9)
	WP	7 (5.6)
	G	14 (11.3)
Cyfluthrin[d]	EC	33 (26.6)
	WP	3 (2.4)
	M	1 (0.8)
Diazinon	EC	1 (0.8)
	G	3 (2.4)
Fluvalinate[e]	F	7 (5.6)
Insecticidal soap[f]	LC	2 (1.6)
Lamda cyhalothrin[g]	EC	1 (0.8)
Permethrin[h]	CB	8 (6.4)
Malathion	UN	1 (0.8)

[a] Sevin, Dursban, and Diazinon were usually used generically for carbaryl, chlorpyrifos, and diazinon, respectively, by the respondents. Full label brand names were rarely given. Name, manufacturer, and percentage active ingredient (AI) for specific products identifiable in the survey are given in the footnotes.

[b] EC, emulsifiable concentrate; WP, wettable powder; G, granules; F, flowable; M, microencapsulated; CB, cotton balls (Damminix); LC, liquid concentrate; UN, unknown.

[c] DursbanPro (23.5% AI), DowElanco, Indianapolis, IN, listed in 3 of 62 responses.

[d] Tempo 2 (20% AI), Tempo 50W (50% [AI]), Bayer Agricultural Division, Kansas City, MO; Optem PT600 (6% [AI]), Whitmire Research Laboratories, St. Louis, MO.

[e] Mavrik Aquaflow and Yardex (22.3% AI), Sandoz Crop Protection, Des Plaines, IL.

[f] M-Pede (49% [AI]), Mycogen, San Diego, CA.

[g] Scimitar (9.7% [AI]), Zeneca Ag Products, Wilmington, DE.

[h] Damminix (7.4% [AI]), EcoHealth, Boston, MA.

but a quarter or more of the respondents treated the entire lawn.

Over half of those offering tick control services (61.4%) treat for ticks only when requested rather than on a regular schedule (26.3%). Most of these applicators (63.2%) indicated that they treat for both nymphs and adults, but only 10 respondents noted that they treat once each tick season for nymphs or adults of *I. scapularis*. When the question on treatment frequency was rephrased to inquire about the frequency of summer applications for control of nymphal *I. scapularis*, most respondents (66.7%) treated ≥ 2 times during the summer tick season. Half the respondents (50.7%) said that they survey for the presence of ticks before treating. There was considerable variation in the charge per acre (0.4 ha) of residential property for a single tick control service, ranging from as little as \$40 (n = 1) to as much as \$400 (n = 2). The average charge per acre was \$192.67 ± 14.90 (mean ± SEM) with a median of \$180. Over three quarters of the applicators charged <\$150. When ranked by \$50 intervals for a "typical" residential treatment, 26.3% charged \$50–100, 33.3% charged \$101–150, 10.5% charged \$151–200, and 7.0% charged >\$200 (22.8% did not answer the question). Charges for treating a commercial property were higher (χ^2 = 11.896, df = 3, P = 0.008) than residential service with 38.5% (of 26 responses) charging >\$200.

Table 6. Methods used and rankings of 10 methods of acaricide selection by respondents of the pesticide use assessment survey

Methods used	No. placements within indicated rank[a]			
	1st	2nd	3rd	Total (1–3)
Advertisements	0	0	0	0
Article in trade magazine	1	1	3	5
Salesperson recommendation	4	4	2	10
Another licensed applicator	3	4	4	11
Experiment Station information[a]	9	4	1	14
Dealer recommendation	3	3	0	6
Cooperative Extension information[b]	6	3	2	11
Past success with product	6	9	5	20
Report in scientific paper	5	6	3	14
Characteristic of product	4	5	5	14

[a] Only the top 3 (1st, 2nd, 3rd) and total top 3 rankings are given (most important, 1; least important, 10) (n = 57 records).

[b] Connecticut Agricultural Experiment Station, New Haven.

[c] University of Connecticut, Storrs.

Ten possible sources of information were listed in the questionnaire for choosing the acaricide used for tick control (Table 6). When ranked in importance from most important (1) to least important (10), it was clear that some sources of information were significantly more important to commercial applicators than others in making their selection (Kruskal–Wallis K = 104.00, df = 8, P < 0.0001). Connecticut Agricultural Experiment Station information was ranked 1st the most often, followed by Cooperative Extension and past success with the product as the basis for selecting an acaricide. Overall, however, past success with the product was the strongest factor, dominating the top 3 rankings as the most important method in choosing an acaricide. Advertisements or articles in trade magazines were the least significant factors in selecting a chemical insecticide for tick control.

Half of the 57 respondents (49.1%) indicated that their tick control business had increased slightly or dramatically since 1991, whereas 28.1% said it remained the same. None indicated their tick control business had decreased slightly, 1 said it decreased dramatically, and 12 did not answer the question. Only 2 respondents (3.5%) indicated that tick control services comprised >50% of their business. For most of the replies (63.1%), these services comprised <5% of the overall business (78.3% of the 46 answering the question). However, 43.8% of the respondents indicated that they plan to expand their tick control services, primarily by advertising (71.4% of the 21 responses). A few (24.6%) applicators offered alternatives to area-applied insecticides for tick control. These alternatives frequently included host-targeted permethrin (Damminix), but cutting grass, clearing brush, and guinea hens were also mentioned. However, more than half the respondents (35.1%) said they received requests for an alternative to insecticides for tick control.

Discussion

Tick control represents a small but growing part of the lawn care professional's business. The application of acaricides for the control of *I. scapularis* is a relatively recent service; most companies began service between 1990 and 1995. This corresponds to an increase in tick abundance and an increase in the number of reported human Lyme disease cases in the state. The abundance of nymphal *I. scapularis* in southeastern Connecticut increased dramatically between 1990 and 1992 (unpublished data). The number of cases reported to the Connecticut Department of Public Health increased 69% in 1991 over that in 1990 and 48% in 1992 over that in 1991 (CDC 1991, CDC 1993). The greatest number of human cases were reported in 1994 (2,030 cases) with a rate of 62/100,000 population (CDC 1995). This is the year when the greatest number of applicators begin applying pesticides for the control of *I. scapularis*. Because most applicators treat for ticks upon request by their customers, this study suggests that they were responding to an increased demand for the control of *I. scapularis*. Indeed, Lyme disease has increased dramatically in Fairfield County, where most of the survey respondents reside and treat for ticks. Fairfield County accounted for 2.8 and 16.2% of the reported cases in 1985 and 1988, respectively, and had the greatest rate increase (Cartter et al. 1989). By 1994, 20.2% of the reported cases ($n = 610$) were from Fairfield County (Cartter 1995). In contrast, there are fewer certified applicators and fewer businesses offering tick control services in Middlesex and New London counties, which have the highest incidence of Lyme disease in the state.

The majority of certified applicators in Connecticut treating for ticks are lawn care providers. Therefore, educational and training programs related to the control of ticks and Lyme disease should be targeted toward these businesses and their trade associations. There was little evidence in this survey of many pest control officers in Connecticut offering landscape tick control, although in some states pest control operators are being certified to offer tick control (Guyette 1993). Only 1 respondent treating for ticks in this survey listed pest control operator as the primary type of business.

Only 3 acaricides are being used by most commercial applicators—chlorpyrifos, cyfluthrin, and carbaryl. These 3 chemicals have all been shown effective in controlling *I. scapularis* (Schulze et al. 1987, 1991; Stafford 1991; Solberg et al. 1992; Curran et al. 1993). Product success was one of the most important factors in selecting a chemical. However, studies in the scientific literature and information provided by experiment station or extension staff also were important in the selection of compounds by the commercial applicators. Chlorpyrifos, cyfluthrin, and carbaryl also have broad labels for many ornamental and turf insects, making these materials easy to use as part of an overall pest control program. Conversely, the narrow market for tick control could be a disincentive for other promising materials to be registered for use against *I. scapularis* or developed specifically for this market. Interestingly, permethrin-treated cotton balls used to kill ticks on white-footed mice are still used by a number of applicators despite reports of its ineffectiveness in a residential setting or areas of ≤4 ha (Daniels et al. 1991; Stafford 1991b, 1992). Substantially higher charges for tick control services by some respondents may reflect the use of Damminix with its associated material and labor costs. Fees for a particular product or total amount of revenue from tick control services was not specified in the survey. Nevertheless, a rough estimate on costs can be made from the data available. If a "typical" property is assumed to average 0.4 ha at $192.67 each, then residential clients paid $166,660 in 1994 and $278,600 in 1995 for tick control services by the 57 applicators responding to this survey.

There was no consistent pattern in the frequency of application for the control of *I. scapularis* nymphs, and some applicators are applying the material more frequently than data in the literature would indicate necessary. A single application in the spring against nymphal ticks in residential setting can provide up to 97% protection for the period of peak nymphal activity (Stafford 1991a, Curran et al. 1993). A fall application for adults can provide similar protection against this stage, although most cases of Lyme disease are associated with the summer months. However, the length of effective control is probably tied to the amount and type of landscape treated and the type of application or formulation used. Most applications are being made at the woodland ecotone where the majority of ticks on the lawn are found (Maupin et al. 1991, Carroll et al. 1992, Stafford and Magnarelli 1993). However, failure to provide effective coverage in all potential tick habitats could necessitate repeat applications. Education of both homeowners and certified applicators can reduce the amount of multiple applications performed to control *I. scapularis*.

Although tick control with area-applied pesticides represents a minor use of these chemicals on the lawn, their use for the control of *I. scapularis* will probably rise as ticks increase in abundance and spread geographically. Clearly, many homeowners accept the use of insecticides for the control of *I. scapularis* on their lawns by licensed applicators. Many homeowners also may be applying their own pesticides for tick control. The few alternative tick control strategies available (i.e., exclusion of white-tailed deer, use of parasitic wasps) are less effective and less economical than chemical control or remain speculative. Until new approaches for reducing the abundance of ticks are developed, insecticides will continue to offer the most effective and economical method to control ticks at individual residences. However, the application of these chemicals needs to be integrated with treatments for other ornamental and turf pests and to incorporate other tick reduction strategies, such as landscape modifications, to reduce ticks around the home.

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References Cited

Brown, S. W., M. L. Cartter, J. L. Hadler, and P. F. Hooper. 1992. Lyme disease knowledge, attitudes and behaviors—Connecticut, 1992. Morb. Mortal. Wkly. Rep. 41: 505–507.

Burgdorfer, W., A. G. Barbour, S. F. Hayes, J. L. Benach, E. Grunwaldt, and J. P. Davis. 1982. Lyme disease—a tick-borne spirochetosis? Science (Wash. D.C.) 216: 1317–1319.

Carroll, M. C., H. S. Ginsberg, K. E. Hyland, and R. Hu. 1992. Distribution of *Ixodes dammini* (Acari: Ixodidae) in residential lawns on Prudence Island, Rhode Island. J. Med. Entomol. 29: 1052–1055.

Cartter, M. L. 1995. Lyme disease Connecticut, 1994. Conn. Epidemiol. 15: 13–16.

Cartter, M. L., P. Mshar, and J. L. Hadler. 1989. The epidemiology of Lyme disease in Connecticut. Conn. Med. 53: 320–323.

[CDC] Centers for Disease Control. 1991. Lyme disease surveillance—United States, 1989–1990. Morb. Mortal. Wkly. Rep. 40: 417–421.

1993. Lyme disease—United States, 1991–1992. Morb. Mortal. Wkly. Rep. 42: 345–348.

1995. Lyme disease—United States, 1994. Morb. Mortal. Wkly. Rep. 44: 459–462.

1996. Lyme disease—United States, 1995. Morb. Mortal. Wkly. Rep. 45: 481–484.

Curran, K. L., D. Fish, and J. Piesman. 1993. Reduction of nymphal *Ixodes dammini* (Acari: Ixodidae) in a residential suburban landscape by area application of insecticides. J. Med. Entomol. 30: 107–113.

Daniels, T. J., D. Fish, and R. C. Falco. 1991. Evaluation of host-targeted acaricide for reducing risk of Lyme disease in southern New York State. J. Med. Entomol. 28: 537–543.

Dennis, D. T. 1995. Lyme disease. Dermatol. Clinics 13: 537–549.

Fish, D. 1995. Environmental risk and prevention of Lyme disease. Am. J. Med. 98: 2S-9S (suppl. 4A).

Guyette, J. E. 1993. Lyme disease: epidemic or problem under control? Pest Control 61: 52–54.

Johnson, R. C., G. P. Schmid, F. W. Hyde, A. G. Steigerwalt, and D. J. Brenner. 1984. Borrelia burgdorferi sp.nov.: etiologic agent of Lyme disease. Int. J. Syst. Bacteriol. 34: 496–497.

Maupin, G. O., D. Fish, J. Zultowsky, E. G. Campos, and J. Piesman. 1991. Landscape ecology of Lyme disease in a residential area of Westchester County, New York. Am. J. Epidemiol. 133: 1105–1113.

Mendenhall, W., L. Ott, and R. L. Scheaffer. 1971. Elementary survey sampling. Duxbury, Belmont, CA.

Schulze, T. L., W. M. McDevitt, W. E. Parkin, and J. K. Shisler. 1987. Effectiveness of two insecticides in controlling *Ixodes dammini* (Acari: Ixodidae) following and outbreak of Lyme disease in New Jersey. J. Med. Entomol. 24: 420–424.

Schulze, T. L., G. C. Taylor, R. A. Jordan, E. M. Bosler, and J. K. Shisler. 1991. Effectiveness of selected granular acaricide formulations in suppressing populations of *Ixodes dammini* (Acari: Ixodidae): short-term control of nymphs and larvae. J. Med. Entomol. 28: 624–629.

Snedecor, G. W., and W. G. Cochran. 1967. Statistical methods. Iowa State University Press, Ames.

Solberg, V. B., K. Neidhardt, M. R. Sardelis, F. J. Hoffman, R. Stevenson, L. R. Boobar, and H. J. Harlan. 1992. Field evaluation of two formulations of cyfluthrin for control of *Ixodes dammini* and *Amblyomma americanum* (Acari: Ixodidae). J. Med. Entomol. 29: 634–638.

Stafford, K. C., III. 1991a. Effectiveness of carbaryl applications for the control of *Ixodes dammini* (Acari: Ixodidae) nymphs in an endemic residential area. J. Med. Entomol. 28: 32–36.

1991b. Effectiveness of host-targeted permethrin in the control of *Ixodes dammini* (Acari: Ixodidae). J. Med. Entomol. 28: 611–617.

1992. Third-year evaluation of host-targeted permethrin for the control of *Ixodes dammini* (Acari: Ixodidae) in southeastern Connecticut. J. Med. Entomol. 29: 717–720.

Stafford, K. C., III, and L. A. Magnarelli. 1993. Spatial and temporal patterns of *Ixodes scapularis* (Acari: Ixodidae) in southcentral Connecticut. J. Med. Entomol. 30: 762–771.

Steere, A. C., S. E. Malawista, D. R. Snydman, R. E. Shope, W. A. Andiman, M. R. Ross, and F. M. Steele. 1977. Lyme arthritis: an epidemic of oligoarticular arthritis in children and adults in three Connecticut communities. Arthritis Rheum. 20: 7–17.

SYSTAT. 1996. Systat 6.0 for windows: statistics. SPSS, Chicago.

Wilson, M. L., and R. D. Deblinger. 1993. Vector management to reduce the risk of Lyme disease, pp. 126–156. *In* H. S. Ginsberg [ed.], Ecology and environmental management of Lyme disease. Rutgers University Press, New Brunswick, NJ.

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