Metropolitan Mosquito Control District
IXODES SCAPULARIS DISTRIBUTION STUDY
2003

Abstract

A black legged tick (*Ixodes scapularis*) distribution study designed to detect any changes in *I. scapularis* distribution over a many year period was conducted in the seven county metropolitan area by the Metropolitan Mosquito Control District. Small mammal sampling was used to collect ticks from 100 wooded areas that have all been sampled since 1990 or 1991. The number of sites where at least one *I. scapularis* was collected decreased to 39 in 2003 from 56 in 2002, but we did tabulate two positive Ramsey County sites (an additional Shoreview Township site, near Roseville) for the first time. South of the Mississippi River our positive sites were restricted to Dakota County and the total decreased down to 6 from 12 in 2002 (typical is 3-4 sites). A total of 477 *I. scapularis* were removed from 1226 mammals for an overall season mean of .389 *I. scapularis* per mammal, lower than our elevated 2000 - 2002 averages (all ≥ .806) and comparable to our 1994 (.325), 1998 (.406), and 1999 (.390) averages. The Anoka County sites accounted for 71% of the total *I. scapularis* collections (215L; 124N) with our Washington County sites contributing an additional 22% (96L; 8N) of the total. The highest average number of *I. scapularis* per mammal (1.237) was calculated for Anoka County, followed by Ramsey County (.472). Ramsey County's season mean surpassed Washington County's (.419) season mean for the first time. Townships maintaining the highest (all ≥ 1.0) *I. scapularis* per mammal averages were Saint Francis (4.429), Coon Rapids (3.344), Ham Lake (1.846), Blaine (1.656), and Ramsey (1.111) of Anoka County and Grant (2.0) and Afton (1.565) townships of Washington County, while averaging ≥ .500 *I. scapularis* per mammal were Burns, Andover, and East Bethel of Anoka County and May Township of Washington County. Our 1990-2003 *I. scapularis* per mammal township averages (all > 1.0) include Hugo, New Scandia and May of Washington County and Coon Rapids, East Bethel and Blaine of Anoka County. *Peromyscus leucopus* has consistently been the predominant yearly mammal species collected. We observed no apparent major shifts in the diversity of our small mammal or immature tick collections and obtained an average (12.26) yearly small mammal collection level per site. Examining human tick-borne disease case numbers (Lyme 473 and ehrlichiosis 78), the Minnesota Department of Health tabulated a decrease from their highest recorded tabulations of 2002 (Lyme 867 and ehrlichiosis 152) but results are similar to their previous all-time high case totals of 2000 and 2001. Our overall 2003 decrease in *I. scapularis* collections can be attributed to an almost three-fold decrease in the number of *I. scapularis* larvae collected; our total nymph count (140) was in the hundreds for only the third time. We postulate that the unusually low volume of snow cover during the winter of 2002-2003 may have adversely affected overwintering *I. scapularis*, adults perhaps to a greater degree than nymphs, which in turn reduced 2003 egg production and the larval cohort. Although our collections were lower, our data also provides some evidence of a continued high *I. scapularis* population level via the high nymph count, the detection of *I. scapularis* near the city of Roseville, and continuing to tabulate higher than typical number of positive sites (6) south of the Mississippi River. Our 2003 results seem to indicate that the *I. scapularis* population is no longer at its 2000-2002 elevated level, but it remains higher than levels we had detected prior to 1998.

Introduction

In 1990 the Metropolitan Mosquito Control District initiated a Lyme Disease Tick Surveillance Program to determine the distribution and prevalence of *Ixodes scapularis* and *Borrelia burgdorferi* within the Minneapolis- Saint Paul metropolitan area. District re-structuring in 1996 integrated the former tick surveillance program activities into the District's overall field processes. Small mammal trapping has been the primary sampling method used, with examination of road-killed mammals and dragging flannel cloth along vegetation each used as secondary collection methods in the past.

A total of 545 sites were sampled from 1990 through 1992, including 100 sites that had been selected for repetitive sampling prior to the 1991 or 1992 field season. Baseline *I. scapularis* distribution data for our area was determined from the 1990 and 1991 studies with most of the ticks collected north of the Mississippi River in Anoka, Washington, and northern Ramsey counties. The 1992 study was designed to inspect areas that had not been sampled as intensely in the past, with emphasis on locations south and west of the Mississippi River, but the majority of *I. scapularis* collections continued to be obtained in the northeastern counties.

Since 1993, our distribution study has focused on the re-sampling of 100 sites to detect any potential changes in *I. scapularis* distribution over time. Seventy-five of these sites were re-sampled beginning in 1991 and were selected from the previous study based on three criteria: representative habitat of an area, locations that were unlikely to be developed, and areas where small mammal collections had been sufficient in the past. An additional twenty-five sites were selected from Dakota, Hennepin, Scott, and Carver counties in 1992 to increase our data collections south of the Mississippi River. We plan to monitor these sites indefinitely and may intensify our sampling effort in areas that have shown potential *I. scapularis* range expansion.

Two additional sites were sampled from 1995-1997; section 7 of New Market township in Scott County (where a single adult *I. scapularis* tick had been collected in 1995) and section 19 of West Saint Paul township in Dakota County (Dodge Nature Center- to foster improved relations through providing a general risk assessment). Sampling at these two locations was discontinued in 1998 since zero *I. scapularis* had been collected in either location in that three-year period.

Materials and Methods

Of the 100 repeat sites, 56 are located north of the Mississippi River in Anoka (28 sites), Washington (25 sites), and Ramsey (3 sites) counties. The 44 repeat sites located south of the Mississippi River are distributed throughout the counties of Dakota (15 sites), Hennepin (14 sites), Scott (8 sites), and Carver (7 sites).

Sampling was initiated on April 21, 2003 and ended on October 23, 2003 with small mammal trapping used as the primary sampling method. As in past years, the twenty-seven week study was divided into three nine-week sampling periods, and all sites were sampled for twenty-one trap nights (7 traps x 3 consecutive nights) per period. Weeks of site visitation were randomly selected within each sampling period.

One three-hundred foot transect was established at each sampling location and Sherman live traps (H. B. Sherman Traps, Inc., Tallahassee, Fla.), baited with peanut butter and oats, were placed along these transects at fifty foot intervals. We euthanized all small mammals caught in the traps, removed any ticks found, and stored the ticks in alcohol for later identification.

Results

- **2003 Study (Repeat Sites):**

We found at least one *I. scapularis* at 39 of 100 sampling sites, with 33 of these positive sites located north of the Mississippi River in Anoka (19 sites positive/28 sites sampled), Washington (12 sites positive/25 sites sampled), and Ramsey (2 sites positive/3 sites sampled) counties. Six additional positive sites were detected south of the river in Dakota County. Zero *I. scapularis* were collected in Hennepin, Scott, or Carver counties in 2003.

Overall, 1226 mammals (Figure 1 and 2003 results in Table 2) were inspected: 558 from north of the Mississippi River and 668 from south of the river and a total of 477 *I. scapularis* (Figure 2 and 2003 results in Table 3) were collected from them. The Anoka County sampling locations accounted for 71% (215 larvae; 124 nymphs) of the total, with the majority of collections occurring in Blaine (80 larvae; 26 nymphs) and Coon Rapids (43 larvae; 64 nymphs) townships. We collected an additional 22% of the total (96 larvae; 8 nymphs) from Washington County, with most of the collections occurring in Afton (31 larvae; 5 nymphs), May (30 larvae), and Grant (27 larvae; 1 nymph) townships.

The overall season mean number of *I. scapularis* collected per mammal in 2003 was .389 (larvae: .275, nymphs: .114). The mean increases to .986 (larvae: .696, nymphs: .289) when all sites negative for *I. scapularis* are excluded (see 2003 results in Figure 6). The highest average number of *I. scapularis* per mammal was calculated for Anoka County, which had a season mean of 1.237 compared with Ramsey (.472) and Washington (.419) counties season means (see 2003 results in Figure 3). Townships in Anoka County averaging $\geq$ 1.0 *I. scapularis* per mammal in 2003 were Saint Francis (4.429), Coon Rapids (3.344), Ham Lake (1.846), Blaine (1.656), and Ramsey (1.111), with Burns (.833), Andover (.708), and East Bethel (.500) all averaging $\geq$ .500 *I. scapularis* per mammal. In Washington County, Grant (2.0) and Afton (1.565) townships averaged $\geq$ 1.0 *I. scapularis* per mammal in 2003 while May township (.625) maintained an average $\geq$ .500 *I. scapularis* per mammal (Figure 4).

- **Compiled 1990-2003 Results (Repeat Sites):**

The 1990-2003 mean number of *I. scapularis* collected per mammal is .363, with the highest averages continuing to occur north of the Mississippi River. Anoka County has maintained the highest yearly county season mean since 1998, while Ramsey County's season mean was higher than Washington County's mean for the first time in 2003 (Figure 3). Washington County (.680) still maintains the highest 1990-2003 overall season mean (no figure). The 1990-2003 township averages for Hugo, New Scandia, May (Washington County), Coon Rapids, East Bethel and Blaine (Anoka County) townships are > 1.0 *I. scapularis* per mammal, while the averages for Linwood, Ham Lake, and Saint Francis of Anoka County, as well as Afton, Grant, and Lakeland townships of Washington County are > .500 *I. scapularis* per mammal (Figures 4A and B—inserts on Figure 4).

I. scapularis status at the 100 repeat sampling locations is shown on Figure 5. The status has changed at 72 of the sites since 1990 or 1991 (see 2003 results in Table 1). While the number of sites where *I. scapularis* is detected every year has decreased since 1992, we continue to detect *I. scapularis* at several new sampling locations each year (Table 1).

Table 1: Comparison of *I. scapularis* Presence/Absence Status at 100 Repeat Sampling Locations: 1992 - 2003

	1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
No. sites changing status	26	34	38	40	47	53	58	59	61	66	69	72
Ticks found:												
all years	21	19	17	16	11	6	5	5	5	5	4	3
most years	5	15	15	15	19	27	27	31	31	34	35	37
least	21	19	23	25	28	26	31	28	30	32	34	35
(not found)	53	47	45	44	42	41	37	36	34	29	27	25

Our positive sites have been primarily located north of the Mississippi River in Anoka and Washington counties, with one consistently positive Ramsey County site (northern Shoreview Township). In 2003 we tabulated two positive Ramsey County sites (both of our Shoreview Township sites) for the first time. South of the river we typically tabulate 3-4 positive sites each season. Except for 1991 when several *I. scapularis* were collected at one site each in Scott and Carver counties, positive sites from south of the river were located only in Dakota County from 1990 through 1997. In 1998 we first detected *I. scapularis* in Hennepin and Scott counties[1] and in 2000 we tabulated a total of seven sites (6 Dakota; 1 Hennepin) south of the river. Our tabulation increased to ten in 2001 (7 Dakota; 2 Hennepin; 1 Scott) and then to twelve in 2002 (8 Dakota; 3 Hennepin; 1 Scott). In 2003 our southern positive site total decreased down to six sites and was restricted to Dakota County locations.

Comparing our 2003 small mammal and immature *I. scapularis* collection results with past study efforts, both small mammal (Table 2) and immature tick (Table 3) species diversity appears comparable to past years. *P. leucopus* consistently has been the predominant mammal species collected each year with some variability in the total percentages collected[2] (Figure 1 and Table 2). The 2003 average number of mammals collected per site (12.26) appears to represent an average yearly collection level. Our compiled average small mammal collection success level per site for 1990 through 2003 is 13.90 (1991-2003 average of 13.21 for 100 repeat sites only), with results ranging from the low of 7.28 mammals collected per site in 1997 to the high of 20.61 (23.54 at the 100 repeat sites only) in 1991. Our overall season mean of .389 *I. scapularis* per mammal is a decrease from our

[1] *I. scapularis* was collected previously in Hennepin County in a collaborative study with Dr. R. Johnson of the University of Minnesota and in very small numbers in Scott and Carver counties (one site each) in our 1991 study effort. In 1995 District staff performing pest mosquito activities inadvertently found a single adult tick in Scott County's New Market Township but no additional *I. scapularis* were detected there in a 3 year sampling effort. Staff or the public have continued to occasionally turn in adult *I. scapularis* from Scott County, especially from New Market Township, since 1995.

[2] see the discussion sections in the 1993 (*I. scapularis* population estimates) and 1994 (graph handout-mammal density equality across sites) *I. scapularis* distribution study reports.

recent elevated averages (2000 - 2002 averages were ≥ .806), but comparable to our 1994 (.325), 1998 (.406), and 1999 (.390) averages (Figures 3 and 6). We collected fewer *I. scapularis* larvae (an almost three-fold decrease) in 2003 compared with 2002, while our total *I. scapularis* nymph count was in the hundreds (140) for only the third time since inception of this study (Table 3).

Discussion

Our results seem to indicate that *I. scapularis* populations are established within northeastern Anoka and northern Washington counties while remaining localized or nonexistent in areas south of the Mississippi River. Although our study was not designed to specifically answer the question of tick establishment, we feel that our relative *I. scapularis* density estimates are accurate enough for a general risk assessment. Given the consistency of our results, where greater numbers of *I. scapularis* continue to be collected in the northeastern metropolitan area each season, we believe that the greatest Lyme disease risk continues to occur in the northeastern metropolitan area[3].

Although our 2003 data does provide some evidence of a continued high level of *I. scapularis*[4] , our results seem to indicate that *I. scapularis* populations have decreased from their 2000 – 2002 elevated levels. Although comparable to our 1994 (.325), 1998 (.406), and 1999 (.390) averages, our 2003 overall season mean of .389 *I. scapularis* per mammal is a decrease from our elevated averages of 2000 - 2002 (all ≥ .806). We also tabulated fewer positive sites (white boxes on Figure 3) overall, and, south of the Mississippi River, from a more restricted geographic area (Dakota County only) when compared to recent years. An examination of Table 3 indicates that this overall decrease in *I. scapularis* collections can be attributed to an almost three-fold decrease in the number of *I. scapularis* larvae collected[5].

We postulate that the unusually low volume of snow cover recorded during the winter of 2002-2003 may have adversely affected overwintering *I. scapularis*, perhaps the adult stage to a greater degree than the 2003 nymphal stage, which in turn reduced egg production and the 2003 larval cohort. To explain, the winter of 2002-2003 was unusual in the very low volume of snow cover which allowed for lower than normal soil frost depths (and the unusually high occurrence of many frozen septic systems[6]). The 119 year cumulative snowfall average from the November through January period is 25.1 inches of snowfall[7], with a 1987-2003 average of 32.6 inches (range 9.5 – 58.6 inches). Only 9.5 inches fell during this period in the winter of 2002-2003, which is the lowest recorded November – January cumulative snowfall amount in the 16 year period tabulated.

Contrary to this hypothesis are several items, and there have always been fluctuations both up and down in our year-to-year *I. scapularis* collections, but we do believe that the low snow cover volume hypothesis does appear to have validity. However, we do not believe that snow cover volume is a completely independent variable. We believe it is, at least in part, a predictor of the amount of insulation available that will protect the ground and overwintering *I. scapularis*. For example, examining additional years and the variable of cumulative November – January snowfall only, we continued to collect fewer *I. scapularis* (rather than more, if using only snowcover volume) in both 1996 and 1997 despite each previous winters' accumulation of greater than the 32.6 inch average snowfall amounts. The second-lowest cumulative November through January snowfall total (16.9

[3]Yearly metro human exposure case totals vary from 1 case per year occurring sporadically in Scott and Carver counties to double-digit amounts (typically teens to twenties) for both Anoka and Washington counties (personal communication MN Dept Health).

[4]total nymph count in the hundreds (140) for only the third time since 1990, *I. scapularis* collected near the city of Roseville in Ramsey County (a wooded corridor that connects to a residential park) for the first time, still higher than typical number of sites (6) tabulated south of Mississippi River.

[5]Concepts in this and following paragraphs were presented in the discussion sections of the 1998 - 2002 *I. scapularis* distribution study reports.

[6]according to various newspaper articles and septic system company employees. For example see **S-s-septic s-s-systems are feeling winter chill** BY KERMIT PATTISON Pioneer Press Sat, Feb. 08, 2003 at www.twincities.com/mld/twincities/5133694.htm?1c or **Catastrophic winter for septic, waterlines** By CHARLES RAMSAY Mesabi Daily News Sat, March 15th, 2003 at www.virginiamn.com/placed/index.php?story_id=135404&view=text

[7]See the Twin Cities Monthly and Seasonal Snowfall Totals (inches) 1884 – 2003 at www.climate.umn.edu/text/historical/mspsnow.txt

inches) fell during the winter of 1994-1995 and we saw a similar reduction in our 1995 collection results[8] compared with our high 1994 collections (see Figure 6 and Table 3), but this lower, but double-digit, snow accumulation did not create the deep soil frost depth that occurred in the winter of 2002-2003. Perhaps there were other factors than simple lack of snow accumulation (such as infrequent timing of snowfalls leading to more days with bare ground) that lead to the deeper soil frost depth, but the lack of insulation as shown by deeper freezing of soil ultimately could have led to higher than normal *I. scapularis* mortality over the winter. No other year in the 16 year period was found to have accumulated snowfall in the single digits. Further, it was the subjective opinion of septic system employees that in up to 50 years of service to their communities they could not recall another year with so many frozen septic systems to contend with. Another weather variable, a dry spell created by lower than normal precipitation beginning in July 2003[9], could have impacted our *I. scapularis* collections, but an analysis of previous distribution study results determined that we collected more larvae in the fall of 2003 than some fall periods in previous distribution studies.

Another contrary factor is, as Table 3 depicts, that we collected a large number of *I. scapularis* nymphs in 2003, which on the surface does not appear to support high overwintering mortality as a prominent factor in reducing our *I. scapularis* collections. We thought of several possibilities to explain this apparent divergence. First, we had collected the largest number of larvae in 2002 of any year since 1990 so there were great numbers of what would become the 2003 nymphal cohort available to overwinter. It could be that these 2002 larvae exhibited an increase in overwintering mortality at a similar percentage to other 2002 stages but the sheer volume of individual ticks overwintering made detection of high mortality less noticeable. Or, perhaps some other difference such as higher energy reserves of the 2002 larvae compared to adult *I. scapularis* led to higher overwintering mortality for the adults, or at least the mated female *I. scapularis.* Mated females could have had fewer energy reserves available, or were somehow otherwise differently affected, from the process of egg production, making them more vulnerable to adverse conditions. Since we do not collect adult *I. scapularis* we are unsure what the overwintering success status of the high levels of 2002 nymphs was.

While we can't definitively make a conclusion, we did collect a high number of nymphs in 2003 and collected a lower number of larvae in 2003 than had been collected in recent years. Examining human tick-borne disease case numbers (Lyme 473 and ehrlichiosis[10] 78), the Minnesota Department of Health also tabulated a decrease from their highest recorded tabulations of 2002 (Lyme 867 and ehrlichiosis 152) but results are similar to their previous all-time high human case totals of 2000 and 2001. Although a combination of known as well as unknown variables which affect *I. scapularis* populations are continuously at play, as shown in the year-to-year variation in the number of *I. scapularis* we collect and as has been discussed in previous reports, we have argued in past reports that warmer than typical weather conditions could have led to an increase in the *I. scapularis* population. It does not seem unreasonable to conclude now that the unfavorable weather conditions of lack of snow accumulation and low soil frost depths over the winter of 2002-2003 may have negatively impacted *I. scapularis*. Regardless, our 2003 results seem to indicate that the *I. scapularis* population is no longer at its 2000-2002 elevated level, but it remains higher than levels we had detected prior to 1998.

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[8] We collected roughly half the numbers of *I. scapularis* larvae in 1995 as we had in 1994.

[9] Based on compilation of 2003 MMCD precipitation network rain gauge data, or see www.climate.umn.edu/doc/journal/dry_spell_200307-200404.htm

[10] MDH uses the technically correct term "human anaplasmosis" rather than the former term "ehrlichiosis" which we and the Centers for Disease Control continue to use, at least for now. The District is maintaining the term "ehrlichiosis" to remain consistent with listings in its public education materials. Metro 2003 Lyme case totals were 50 (238 total residents diagnosed), with 7 HGE infections (21 total residents diagnosed) pers. comm. MDH.

ADDITIONAL UPDATES/RESEARCH:

CONTINUING STUDIES FOR 2004.

- ***Ixodes scapularis* distribution study** (sites unchanged from 1993).

ADDITIONS FOR 2004.

- **Cooperative studies with Dr. Russell Johnson (University of Minnesota-Mpls).**

A cooperative study regarding the distribution and prevalence of *Borrelia burgdorferi* and the HGE agent in the metropolitan area resumed after a several year break and was added in May.

Re-sampling North Oaks (Ramsey County-2 sites) and Elm Creek Park Reserve (Hennepin County-1 site).

Background:

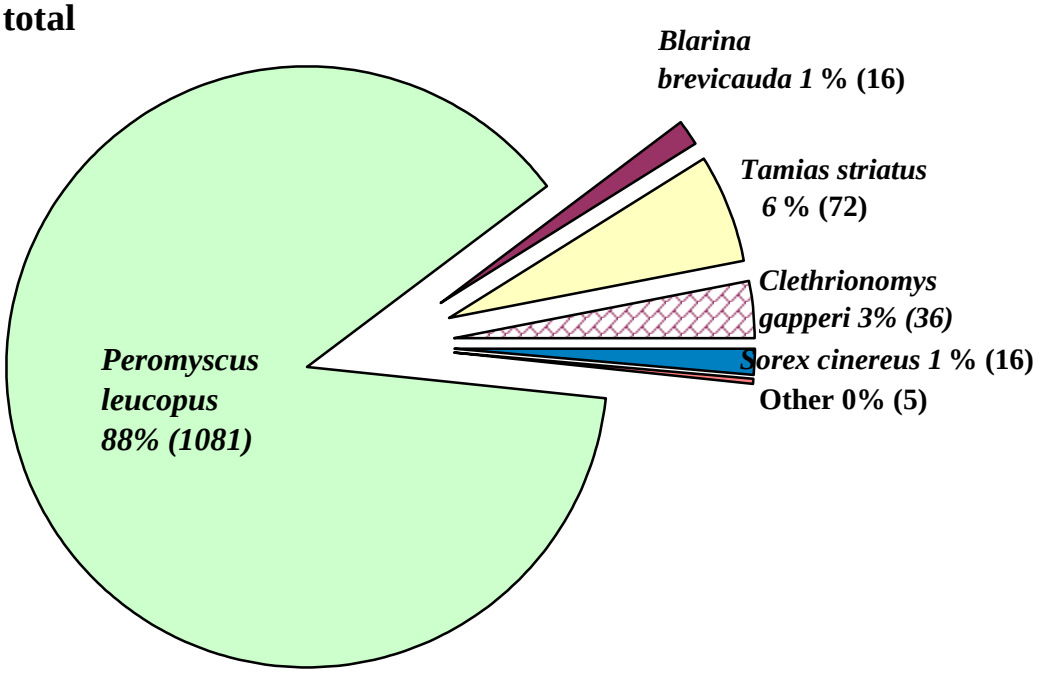
North Oaks
is a residential community in Ramsey county that was extensively examined by the District and Dr. Russell Johnson (UM-Mpls) from 1992 – 1997 and again in 2000. It is parceled into larger acreage lots; those located on the eastern half of the community consisting generally of woody-stemmed vegetation (trees and bushes), with the western side tending towards a more open vegetative environment. Past research results found a *B. burgdorferi* small mammal infection rate ranging overall from 4.5% - 15% (rates seemingly site specific and localized). Most of the *I. scapularis* collections as well as higher *B. burgdorferi* infection rates were found on the eastern side of North Oaks. Surveys regarding Lyme disease in North Oaks residents performed by the Minnesota Department of Health also seemed to establish a pattern of higher risk in the eastern side of the community.

Elm Creek Park Reserve
is a large acreage nature park comprising of fragmented wooded and open habitats in Dayton, Maple Grove, and Champlin Townships of Hennepin County. A northwest area in Dayton Township was selected for sampling in 1992 as a representative non-endemic site as part of an overall study to demonstrate the presence of *B. burgdorferi* within the seven-county metropolitan area. The 1992 research results for Elm Creek indicated that a small percentage of small mammals were infected with *B. burgdorferi*, and *I. scapularis* were also found in limited numbers at this site.

Since this area was initially sampled over a decade ago and since the District's surveillance sampling in recent years has detected an elevated *I. scapularis* population, we wanted to re-sample Elm Creek to determine whether any increases in small mammal infection rates or numbers of ticks could be detected. Sampling in North Oaks and at Elm Creek Park Reserve began May 10 and is scheduled to end mid to late October 2004.

Small Mammals Collected
2003: 1226 total

Figure 1



Ticks, by Species and Stage, Removed from Small Mammals
2003: 1293 total

Figure 2

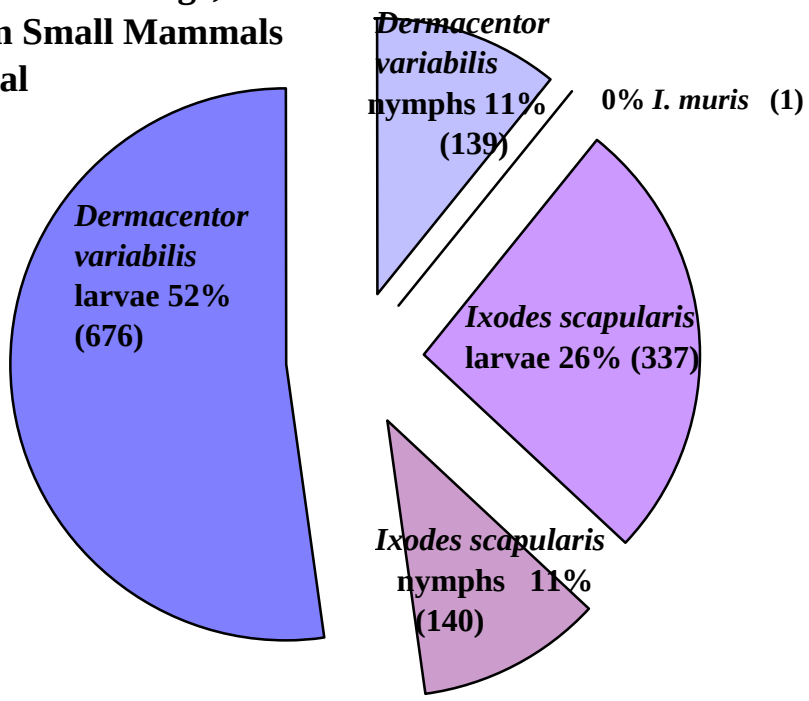
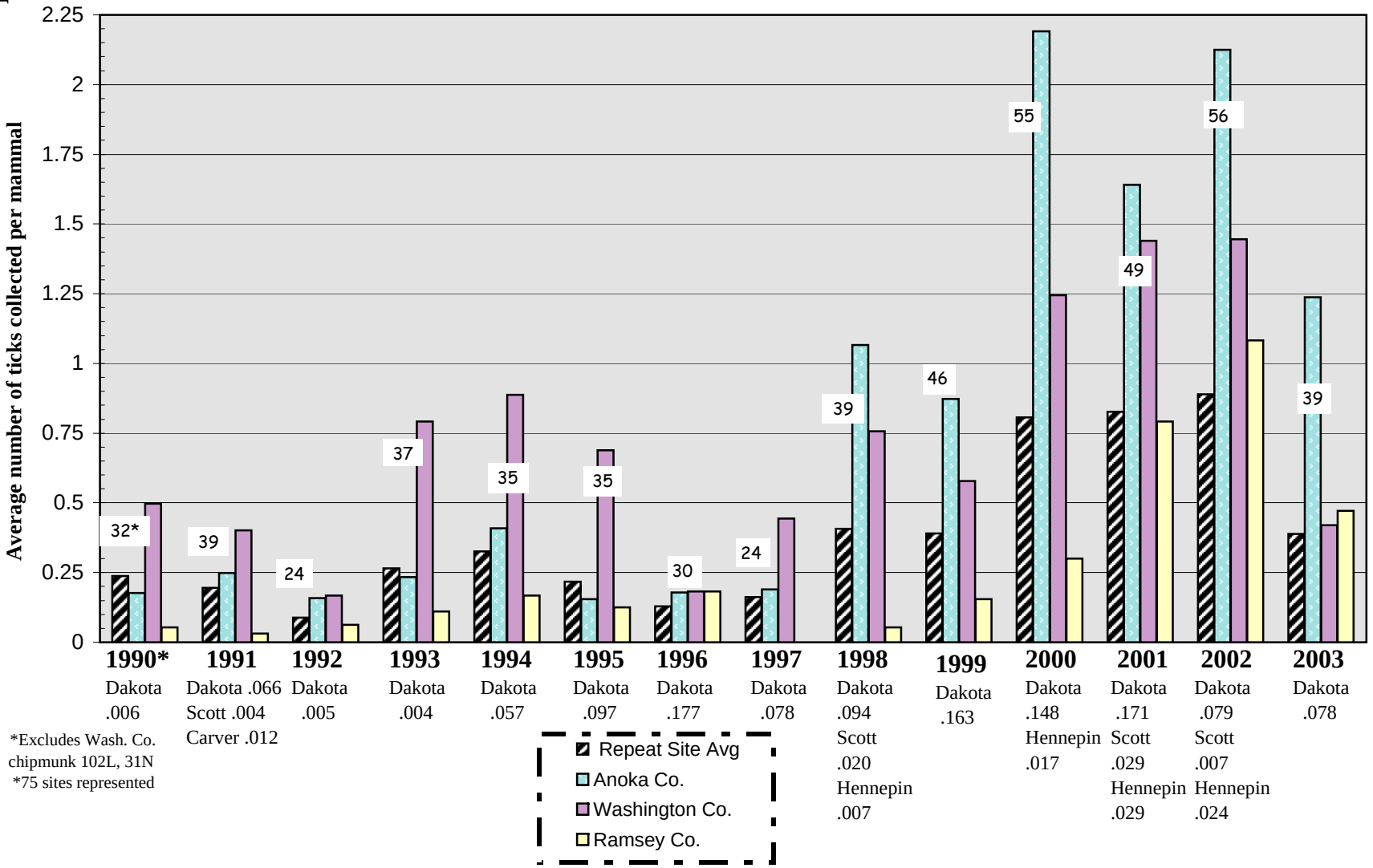


Figure 3

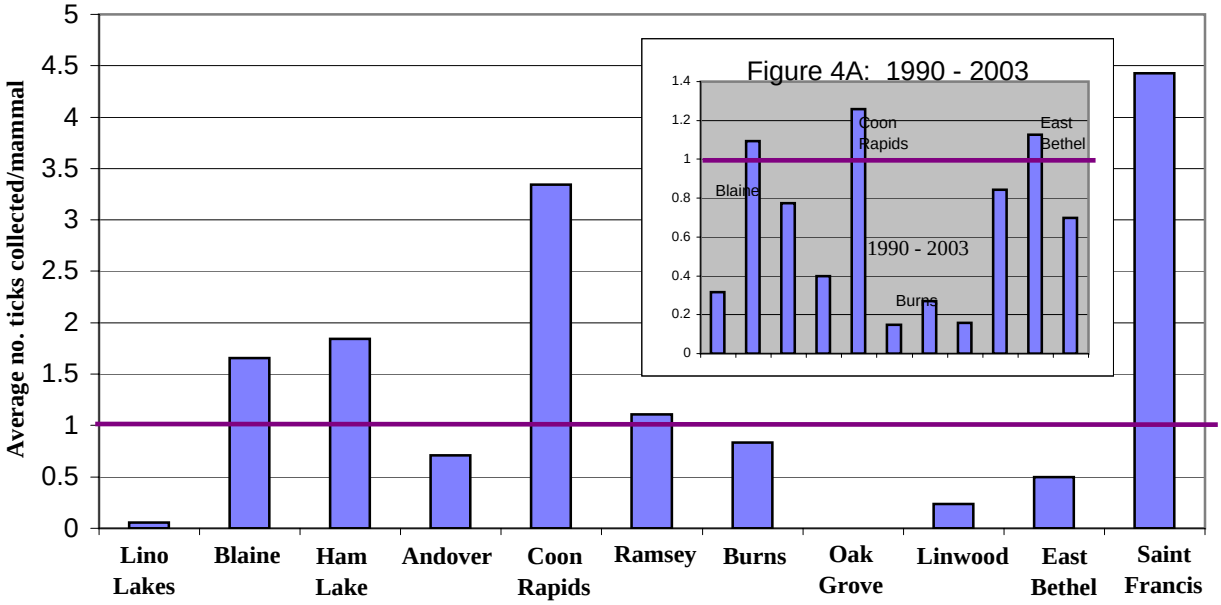
Average number of *I. scapularis* collected per mammal at 100 sampling locations in Anoka, Washington, and Ramsey counties: 1990 - 2003 (white box shows the total number of sites where at least one *I. scapularis* was found: by year)



*Excludes Wash. Co. chipmunk 102L, 31N
*75 sites represented

Figure 4

Average number of *I. scapularis* collected per mammal in Anoka county (by township):2003 results



Average number of *I. scapularis* collected per mammal in Washington county (by township):2003 results

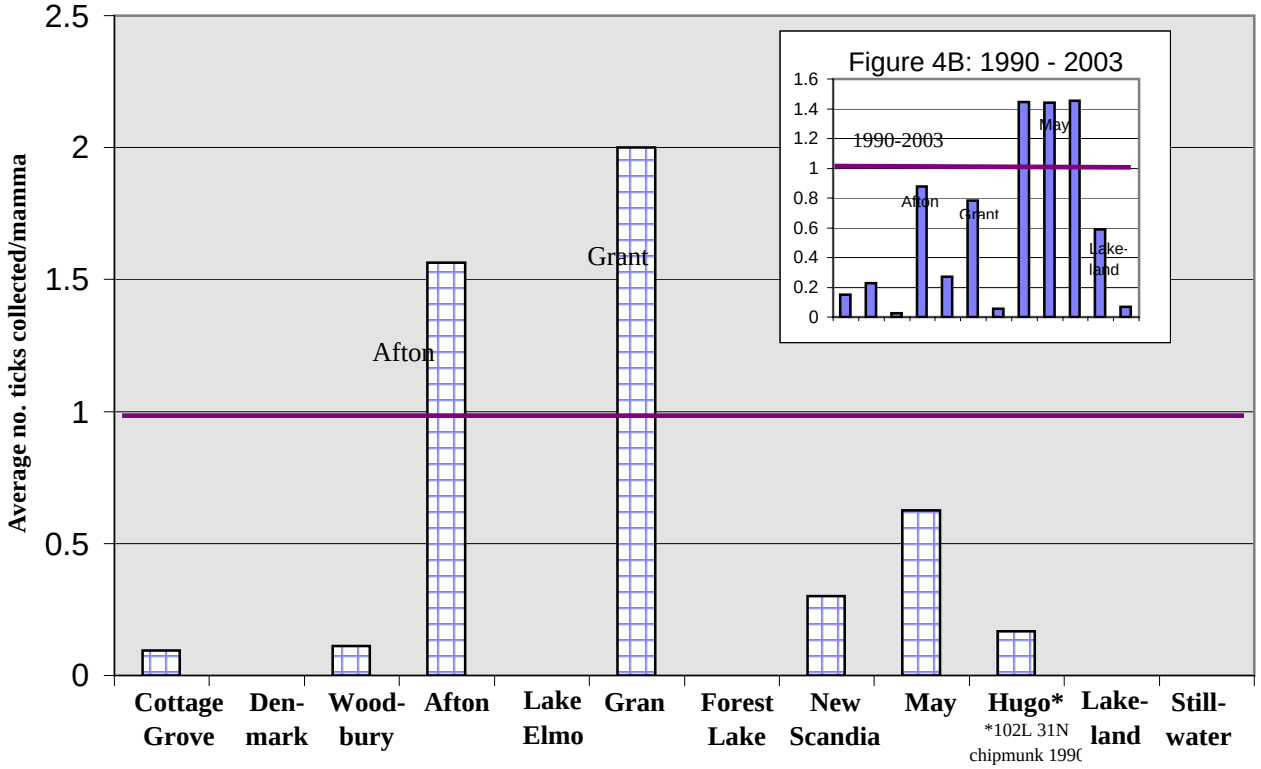
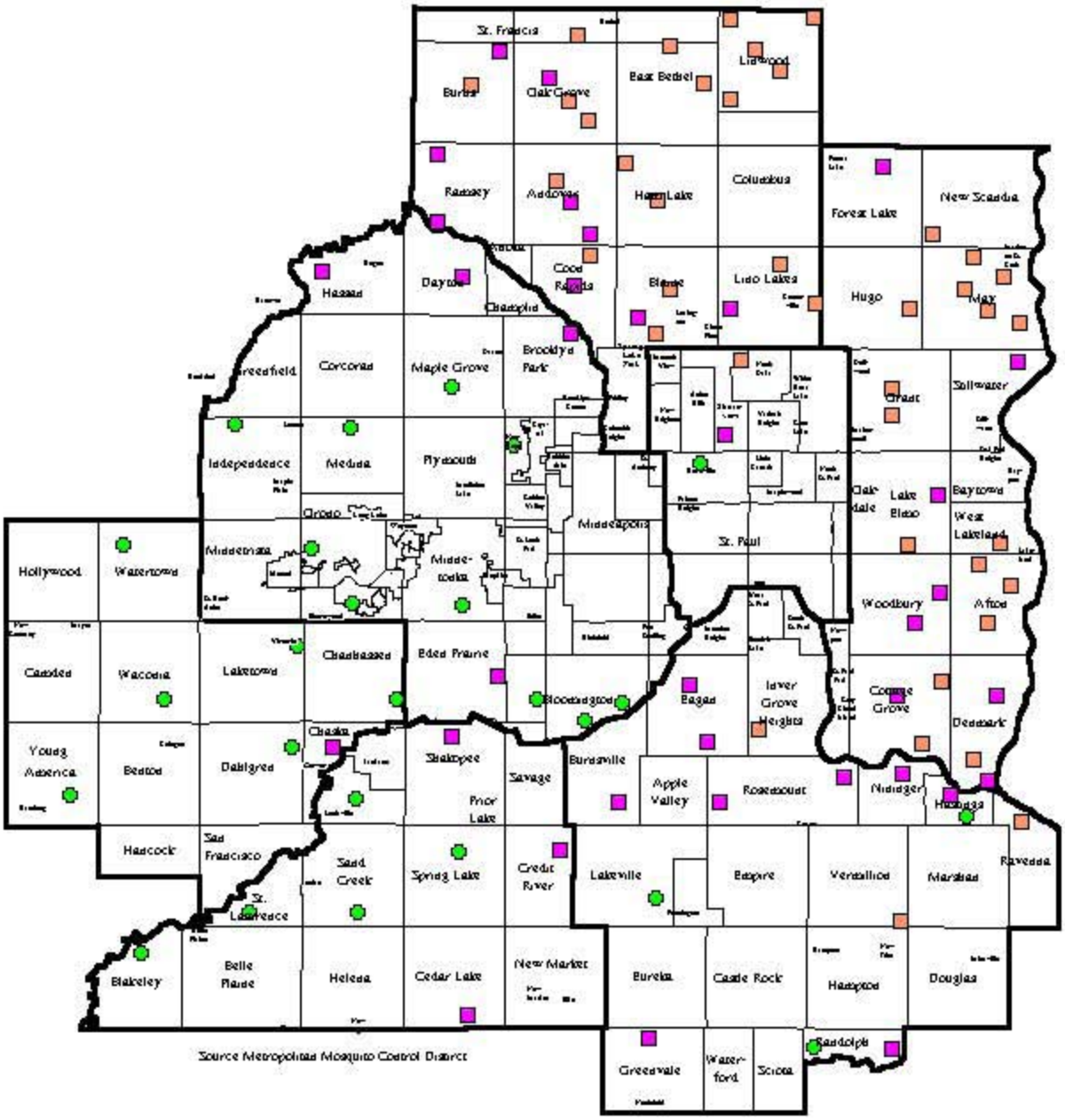


Figure 5

Ixodes scapularis **Presence/Absence status: 1990 - 2003**

(present if at least one I. scapularis is collected during a year)



At least one tick found during:

- all/most years (40)
- at least one year (35)
- (not found) (25)

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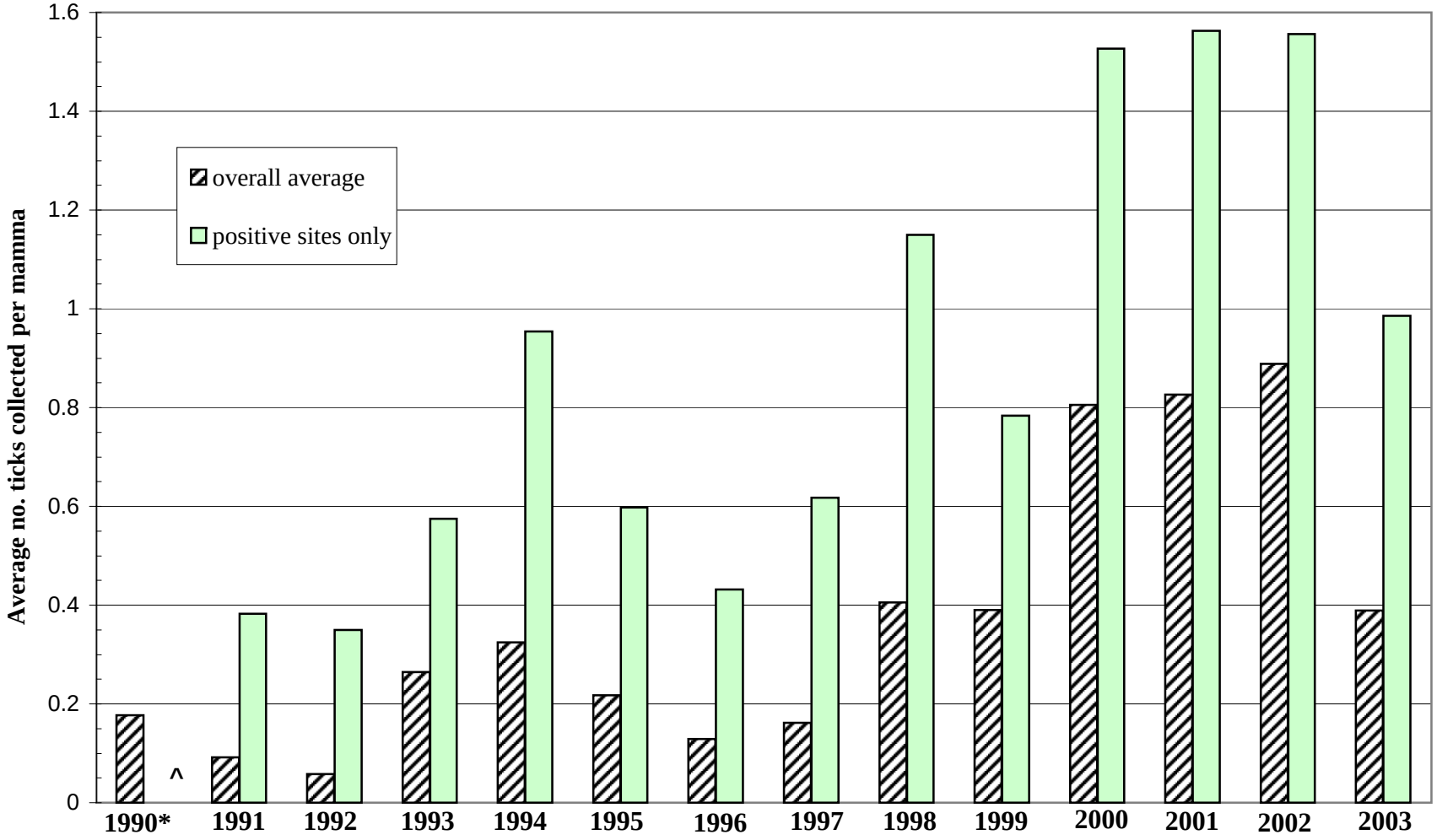
Figure 6

Average number of *I. scapularis* collected per mammal at 100 repeat sampling locations 1990-2003: overall vs. sites where at least one *I. scapularis* was collected (positive sites)



*75 sites

^data unavailable

Table 2. Numbers and Percentages of Small Mammals Collected by Year

Year	No. sites	Total mammals collected	Avg collected per site and [100 repeat sites only]	*Peromyscus leucopus* percent (n)	*Tamias striatus* percent (n)	*Clethrionomys gapperi* percent (n)	*Blarina brevicauda* percent (n)	Other* percent (n)
[a] 1990	250	3651	14.6 [17.15 @75 sites]	80% (2921)	6% (224)	7% (240)	4% (155)	3% (111)
1991	270	5566	20.61 [23.54]	77% (4308)	7% (395)	5% (264)	7% (402)	4% (197)
1992	200	2544	12.72 [12.68]	71% (1804)	9% (223)	4% (103)	13% (329)	3% (85)
1993	100	1543	[15.43]	81% (1243)	4% (69)	7% (101)	7% (107)	1% (23)
1994	100	1672	[16.72]	78% (1309)	10% (171)	5% (79)	5% (76)	2% (37)
1995	100	1406	[14.06]	79% (1115)	11% (156)	4% (55)	4% (61)	1% (19)
1996	100	791	[7.91]	79% (628)	11% (84)	3.5% (29)	3.5% (28)	3% (22)
1997	100	728	[7.28]	71% (515)	13% (98)	3% (24)	10% (71)	3% (20)
1998	100	1246	[12.46]	84% (1041)	4% (51)	3% (42)	6% (72)	3% (40)
1999	100	1627	[16.27]	85% (1376)	7% (108)	3% (46)	4% (63)	1% (9)
2000	100	1173	[11.73]	83% (968)	7% (86)	5% (55)	2% (28)	3% (36)
2001	100	897	[8.97]	80% (719)	6% (58)	7% (63)	4% (39)	2% (18)
2002	100	1236	[12.36]	87% (1074)	6% (73)	3% (42)	2% (27)	2% (19)
2003	100	1226	[12.26]	88% (1081)	6% (72)	3% (36)	1% (16)	2% (21)

*Other includes *Microtus pennsylvanicus, Spermophilus tridecemlineatus, Zapus hudsonius, Mustela erminea, Tamiasciurus hudsonicus, Glaucomys volans, Sorex arti* *Sorex cinereus* , and several ground-feeding bird species.

Table 3. Numbers and Percentages of Tick Species Collected by Stage and Year

Year	No. sites	Total ticks collected	*Dermacentor variabilis* L[b] percent (n)	*Dermacentor variabilis* N[c] percent (n)	*Ixodes scapularis* L[b] percent (n)	*Ixodes scapularis* N[c] percent (n)	Other species[d] percent (n)
[a] 1990	250	9957	83% (8289)	10% (994)	6% (573)	1% (74)	0% (27)
1991	270	8452	81% (6807)	13% (1094)	5% (441)	1% (73)	0% (37)
1992	200	4130	79% (3259)	17% (703)	3% (114)	1% (34)	0% (20)
1993	100	1785	64% (1136)	12% (221)	22% (388)	1% (21)	1% (19)
1994	100	1514	53% (797)	11% (163)	31% (476)	4% (67)	1% (11)
1995	100	1196	54% (650)	19% (232)	22% (258)	4% (48)	1% (8)
1996	100	724	64% (466)	20% (146)	11% (82)	3% (20)	1% (10)
1997	100	693	73% (506)	10% (66)	14% (96)	3% (22)	0% (3)
1998	100	1389	56% (779)	7% (100)	32% (439)	5% (67)	0% (4)
1999	100	1594	51% (820)	8% (128)	36% (570)	4% (64)	1% (12)
2000	100	2207	47% (1030)	10% (228)	31% (688)	12% (257)	0% (4)
2001	100	1957	54% (1054)	8% (159)	36% (697)	2% (44)	0% (3)
2002	100	2185	36% (797)	13% (280)	42% (922)	8% (177)	0% (9)
2003	100	1293	52% (676)	11% (139)	26% (337)	11% (140)	0% (1)

[a] 1990 data exludes one *Tamias striatus* with 102 larval & 31 nymphal *I. scapularis*

[b] L = larvae

[c] N = nymphs

[d] Other species mostly *Ixodes muris* 1999-2nd adult *I. muris* collected