

Metropolitan Mosquito Control District

Ixodes scapularis DISTRIBUTION STUDY

2005

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 positive sites, sites where at least one *I. scapularis* was collected, increased to 53 from 46 in 2004, and we continued to tabulate higher than typical positive sites from counties south of the Mississippi River (7 Dakota, 2 Scott, and 1 Hennepin). A total of 1139 *I. scapularis* were removed from 965 mammals for an overall season mean of 1.180 *I. scapularis* per mammal. This is the 1st year an overall average of > 1.0 has been tabulated but we currently consider it comparable with our elevated 2000 – 2002 and 2004 averages (all $\geq .806$). The Anoka County sites accounted for 59% of the total *I. scapularis* collections (628L; 46N), and were primarily collected from two townships (236L; 14N Blaine, 138L; 4N Coon Rapids). Our Washington County sites accounted for an additional 32% of the total (324L; 36N). South of the Mississippi River we collected 79L and 3N. The highest county average number of *I. scapularis* per mammal (2.740) was calculated for Anoka County and was followed by Washington (1.714) and Ramsey (1.095) counties. Townships maintaining the highest (all ≥ 1.0) *I. scapularis* per mammal averages included 7 of 11 Anoka County townships (range 1.267 to 9.286) and 8 of 12 Washington County townships (range 1.0 to 3.318). Shoreview Township (1.769) of Ramsey County and Inver Grove Heights Township of Dakota County (7.125) also averaged ≥ 1.0 *I. scapularis* per mammal. Likely due to the extreme number of townships averaging ≥ 1.0 *I. scapularis* per mammal in 2005, few townships averaged $\geq .500$ *I. scapularis* per mammal and included only East Bethel (Anoka County), Hassan (Hennepin County), and Vermillion (Dakota County) townships. Zero Washington County townships $\geq .500$ were tabulated. Anoka County maintained the highest 1990-2005 overall season mean (.828), followed by Washington County (.742). Our compiled 1990-2005 *I. scapularis* per mammal township averages (all > 1.0) include May, Hugo, New Scandia, and Grant (Washington Co.) and Blaine, Coon Rapids, East Bethel, and Saint Francis (Anoka Co.). South of the Mississippi River, the highest 1991-2005 averages (> .500 *I. scapularis* per mammal) occurred in Inver Grove Heights and Vermillion townships of Dakota County. Both small mammal and immature tick species diversity in 2005 appeared comparable to past years, although for the 2nd consecutive year we tabulated the highest percentage of *I. scapularis* to date (58% in 2005). As in past years, *Peromyscus leucopus* was the predominant mammal species collected, and the 2005 average number of mammals collected per site (9.65) appears to represent a lower than average yearly small mammal collection level. Examining human data, the MN Dept Health recorded their 2nd highest Lyme disease case total (918) and their highest human anaplasmosis case total (186) in 2005. The Twin Cities metro case totals have also risen over time but not as dramatically as the recent elevated state-wide totals. Our 2005 results seem to provide continued evidence of an elevated *I. scapularis* population, signs of which we feel we began to detect in 1998. We believe that the Twin Cities metro *I. scapularis* population is continuing to build.

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 25, 2005 and ended on October 27, 2005 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

➤ 2005 Study (Repeat Sites):

We found at least one *I. scapularis* at 53 of 100 sampling sites, with 43 of these positive sites located north of the Mississippi River in Anoka (22 sites positive/28 sites sampled), Washington (19 sites positive/25 sites sampled), and Ramsey (2 sites positive/3 sites sampled) counties. Ten additional positive sites were detected south of the river in Dakota County (7), Scott County (2), and Hennepin County (1). Zero *I. scapularis* were collected in Carver County in 2005.

Overall, 965 mammals (Figure 1 and 2005 results in Table 2) were inspected: 477 from north of the Mississippi River and 488 from south of the river and a total of 1139 *I. scapularis* (Figure 2 and 2005 results in Table 3) were collected from them. The Anoka County sites accounted for 59% of the total *I. scapularis* collections (628 larvae; 46 nymphs), with 374L and 18N collected from two townships (236L 14N Blaine Township and 138L 4N from Coon Rapids Township). We collected an additional 32% of the total (324L 36N) from our Washington County sites, with most of the collections occurring in May (131L 15N) Township. South of the river we collected an overall total of 79L and 3N.

The overall season mean number of *I. scapularis* collected per mammal in 2005 was 1.180 (larvae: 1.092, nymphs: .088). The mean increases to 2.292 (larvae: 2.121, nymphs: .171) when all sites negative for *I. scapularis* are excluded (see 2005 results in Figure 6). The highest average number of *I. scapularis* per mammal was calculated for Anoka County, which had a season mean of 2.740 compared with Washington County's season mean of 1.714 (see 2005 results in Figure 3).

Townships¹ maintaining the highest (all ≥ 1.0) *I. scapularis* per mammal averages were Ham Lake (9.286), Blaine (6.098), Saint Francis (4.714), Coon Rapids (3.641), Oak Grove (2.875),

¹ Prior to 2005, township averages south of the river were not tabulated. Inver Grove Heights Township first averaged $> .500$ in 1998 (.800). Yearly averages from 1999-2004: 1999 (2.421), 2000 (.857), 2001 (1.833), 2002 (.250), 2003 (.538), 2004 (0). Vermillion Township averaged .630 in 1991. Yearly averages from 1992-2004: 1992 (0), 1993 (.053), 1994 (.176), 1995 (.429), 1996 (1.727), 1997 (2.0), 1998 (0), 1999 (.063), 2000 (.667), 2001 (.778), 2002 (.308), 2003 (.118), 2004 (2.048). 2005 was the first year that Hassan Township had an average $\geq .500$ *I. scapularis* per mammal. Inver Grove Heights Township has maintained a compiled 1991-current year average of $> .500$ *I. scapularis* per mammal since 1999 while Vermillion's first compiled 1991-current year average $> .500$ *I. scapularis* per mammal occurred in 2004.

Andover (1.643), and Linwood (1.267) of Anoka County and May (3.318), Grant (2.385), Cottage Grove (2.345), New Scandia (2.167), Afton (2.136), Lakeland (1.667), Hugo (1.333), and Lake Elmo (1.0) townships of Washington County. Shoreview Township (1.769) of Ramsey County and Inver Grove Heights Township of Dakota County (7.125 with *I. scapularis* collected from 8 of 8 mammals examined) also averaged ≥ 1.0 *I. scapularis* per mammal. Likely due to so many townships averaging ≥ 1.0 *I. scapularis* per mammal in 2005, fewer townships than typical averaged $\geq .500$ *I. scapularis* per mammal and included only East Bethel (.833) of Anoka County, Hassan Township (.714) of Hennepin County, and Vermillion Township (.588) of Dakota County. For the 1st time, zero Washington County townships $\geq .500$ were tabulated (Figure 4).

➤ **Compiled Results (Repeat Sites) from 1990 - 2005 or 1991 - 2005:**

The 1990-2005 mean number of *I. scapularis* collected per mammal is .429, with the highest averages continuing to occur north of the Mississippi River. Washington County maintained the highest yearly county season means from 1990-1997 and Anoka County has maintained the highest yearly county season means since 1998 (Figure 3). The highest compiled 1990-2005 overall season mean was tabulated for Anoka County (.828), followed closely by Washington County (.742). The 1990-2005 township averages (all > 1.0) include May, New Scandia, Hugo, and Grant of Washington County and Blaine, Coon Rapids, East Bethel, and Saint Francis of Anoka County, while the averages for Ham Lake, Linwood, and Andover of Anoka County and Afton and Lakeland townships of Washington County are $> .500$ *I. scapularis* per mammal (Figures 4A and B—inserts on Figure 4). In compiled results from south of the Mississippi River, both Inver Grove Heights (.789) and Vermillion (.552) townships of Dakota County maintained 1991-2005 averages $> .500$ *I. scapularis* per mammal (no figure).

I. scapularis status at the 100 repeat sampling locations is shown on Figure 5. The status has changed at 76 of the sites since 1990 or 1991 (see 2005 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	1994	1996	1998	2000	2001	2002	2003	2004	2005
No. sites changing status	26	38	47	58	61	66	69	72	75	76
Ticks found:										
all years	21	17	11	5	5	5	4	3	1	1
most years	5	15	19	27	31	34	35	37	38	41
least	21	23	28	31	30	32	34	35	37	35
(not found)	53	45	42	37	34	29	27	25	24	23

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 and the 2nd Shoreview Township site was positive for *I. scapularis* again in 2005. South of the river it had been typical to 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 were located only in Dakota County from 1990 through 1997. In 1998 we first detected *I. scapularis* in Hennepin and Scott counties² 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

²*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.

2002 (8 Dakota; 3 Hennepin; 1 Scott) before decreasing back down to six in 2003 (all Dakota County locations). In 2004 we tabulated nine sites (8 Dakota; 1 Scott), and in 2005 we tabulated ten sites (7 Dakota; 1 Hennepin; and 2 Scott), including one new Scott County site located in Blakeley Township.

Comparing our 2005 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, although we tabulated the highest percentage of *I. scapularis* (58%) since the inception of this study. This is the 2nd consecutive year that a record high *I. scapularis* collection percentage has been tabulated and is only the 3rd time that *I. scapularis* has comprised $\geq 50\%$ of our overall collections (Table 3). Our overall season mean of 1.180 *I. scapularis* per mammal is also the highest tabulated average to date but we regard it as comparable to our elevated averages (all $\geq .806$) of 2000 - 2002 and 2004 (Figures 3 and 6) when our lower 2005 small mammal collection total is considered. *P. leucopus* consistently has been the predominant mammal species collected each year with some variability in the total percentages collected³ (Figure 1 and Table 2). The 2005 average number of mammals collected per site (9.65) appears to represent a lower than average yearly small mammal collection level. Our compiled average small mammal collection success level per site for 1990 through 2005 is 13.58 (1991-2005 average of 12.86 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.

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 area⁴.

We believe that we continue to detect new signs that the metro *I. scapularis* population is continuing to build. Since 1998 we have detected *I. scapularis* from a broader geographic area, most notably south of the Mississippi River, and we continue to tabulate new “highs” in various categories each year. In 2005 we tabulated the highest percentage of *I. scapularis* (58%) in our overall collections since the inception of this study, which is important since other than 2002 (50%) and 2004 (55%), the majority of ticks we have collected each year have actually been *Dermacentor variabilis* rather than *I. scapularis* (Table 3). Our 2005 *I. scapularis* per mammal average of 1.180 is the highest since inception of the study (Figures 3 and 6) and 2005 is also the first year that we have tabulated an overall *I. scapularis* per mammal average of > 1.0 , but as stated previously we currently view it as comparable to our elevated averages (all $\geq .806$) of 2000 - 2002 and 2004 (Figures 3 and 6), particularly when our lower 2005 small mammal collection total is considered. Not surprisingly, we also compiled the highest season mean number of *I. scapularis* collected per mammal for an individual county in 2005 (2.740 for Anoka County), although Anoka County had maintained comparable averages in 2000 (2.192), 2002 (2.125) and 2004 (2.333). A new category that shows a striking increase (doubled to tripled compared with years past) is the total of 17 townships in 2005 that maintained a season average of ≥ 1.0 deer tick per mammal. This surpasses the previous high of 12 townships that had been tabulated in 2004. In past years, the total number of townships ranged from 0 - 4 between 1990 and 1997 (average of 2 per year) and from 7 - 11 between 1998 and 2003 (average of 8 per year).

³ 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.

⁴ 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).

Apart from a drop to 39 in 2003⁵, our total number of tabulated positive sites (white boxes on Figure 3) has ranged between 46 - 56 since 1999, compared to the years 1990 – 1998 when yearly positive site totals ranged from 24 - 39. As with finding *I. scapularis* comprising $\geq 50\%$ of our overall seasonal tick collections, all three of our positive site totals tabulated in the 50's have occurred in the period between 2000 – 2005. South of the Mississippi River, beginning in 1998 we began to find *I. scapularis* in small numbers in Scott and Hennepin counties in addition to our usual Dakota County locations, and the overall number of positive Dakota County sites increased as well. In 2004 the overall Dakota County *I. scapularis* per mammal average increased to .367 and the average remained similar (.355) in 2005 (Figure 3, below graph).

Examining human tick-borne disease case numbers, the Minnesota Department of Health (MDH) has been consistently tabulating record-setting tick-borne disease statewide case totals since 2000. In 2005 they recorded their 2nd highest statewide Lyme disease case total (918). The MDH all-time high statewide Lyme disease tabulation occurred in 2004 (1023 cases) with the Lyme case totals of 2000 (463 cases), 2001 (465 cases), and 2003 (473 cases) being comparable. They had recorded 867 Lyme cases for 2002. Their human (granulocytic) anaplasmosis (HGA) case totals have increased also. They recorded an all-time high HGA case total of 186 in 2005, with cases ranging from 78 to 152 from 2000 - 2004 compared with an average of roughly 15 cases per year through 1999. In compiled Twin Cities by-county exposure data, the Twin Cities metro tick-borne disease case totals have also risen since 1991 but not as dramatically overall. The range for metro-exposed Lyme cases for all seven counties combined was 15 to 43 from 1991 – 1999 and 40 to 69 from 2000 – 2005⁶. Lyme exposures in a county located south of the Mississippi River exceeded single digits for the 1st time in 2005 (Dakota County-10 cases). Although HGA had been detected in small mammals in MMCD's collaborative research beginning in 1995⁷, human HGA metro-exposed cases were not documented by MDH until 2000. As has been the case with our small mammal serology research results, human HGA cases have been low overall but documented from some unexpected locations compared to our *I. scapularis* study results. The majority of metro Lyme exposures continue to occur in Washington and Anoka counties at numbers roughly similar to past years. The majority of metro-exposed HGA cases have been recorded from Washington and Anoka counties as well but have also been recorded from some Ramsey, Hennepin, and Carver County locations where *I. scapularis* has not been detected in our study or via samples turned in by the public or staff.

While there is no current supporting evidence, it is theoretically possible that some future Twin Cities metro *I. scapularis* population threshold could be met that causes increased human encounters with locally-infected *I. scapularis* and greater numbers of diagnosed metro-exposed cases than is currently being detected. For now, we think it is feasible that we have seen signs that the *I. scapularis* population is building in the metropolitan area but will feel more confident of this evaluation if our 2006 results also show a high *I. scapularis* per mammal average along with other signs such as continued high numbers of positive sites. At a minimum, our *I. scapularis* collections in 2005 seem to reflect the elevated population levels of 2000 – 2002 and 2004 along with our lower (but mixed) results of 2003.

⁵ A sharp drop in IS larval collections occurred in 2003. Evidence of a continued high level of *I. scapularis* in 2003 included a high total nymph count, *I. scapularis* collected for the first time near the city of Roseville in Ramsey County (a wooded corridor that connects to a residential park), & still higher than typical number of sites (6) tabulated south of the Mississippi River. Evidence of a lowering population included fewer larvae collected, tabulating fewer positive sites overall, &, south of the Mississippi River, from a more restricted geographic area (Dakota Co. only) when compared to 2000 - 2002.

⁶ Metro 2005 Lyme case exposure totals were 64 (399 total residents diagnosed), with 7 HGA infections (52 total residents diagnosed). For the 1st time, Lyme disease exposures in a county located south of the Mississippi River exceeded single digits (Dakota County-10 cases in 2005). pers. comm. MDH.

⁷ Serology studies have been performed since 1995 using both distribution-study collected small mammals and small mammals collected at different sites. A map showing the results of our 1995 and 1997 efforts is available on our website (http://www.mmcd.org/tick_links.html). The 1995 work has been published--Walls, J. J., B. Greig, et al. (1997). "Natural Infection of Small Mammal Species in Minnesota with the Agent of Human Granulocytic Ehrlichiosis." *Journal of Clinical Microbiology* **35**(4): 853-855. Additional unpublished studies have been performed in collaboration with Dr. Russell Johnson, UM Microbiologist. Serology results of the later distribution study serology efforts are similar overall to the 1995 and 1997 work shown on the website map.

ADDITIONAL UPDATES/RESEARCH:

CONTINUING STUDIES FOR 2006.

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

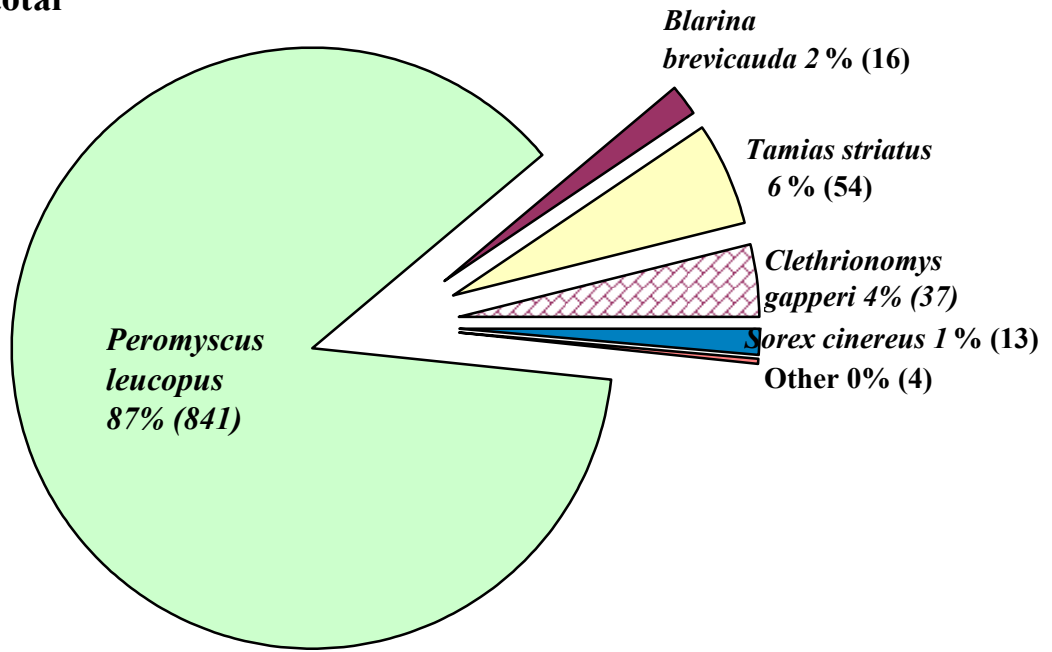
ADDITION FOR 2006.

- **Cooperative studies with David Neitzel and Melissa Kemperman (MN Dept Health).**

MMCD is collecting questing *I. scapularis* in one Anoka and one Washington County site (five 100-meter transects at each site) via dragging with drag cloths of a “finger drag” design (design and manufacturing instructions had been graciously provided to MMCD by Dr. Uriel Kitron and Roberto Cortinas of the University of Illinois in 2001. MMCD later provided MDH a sample finished product and the manufacturing instructions). Any *I. scapularis* collected from the drag or the human sampler will be tested to determine the infection rate status for Lyme disease, HGA, and babesiosis. A total of four sampling dates was planned, with a start date of May 9 and anticipated end date of June 26, 2006. MDH began this study in northern Minnesota last year (2005) with a goal of obtaining one-year samples from across the entire state of Minnesota over time. MDH collected ticks from additional locations outside the Twin Cities metropolitan area in 2006.

**Small Mammals Collected
2005: 965 total**

Figure 1



**Ticks, by Species and Stage,
Removed from Small Mammals
2005: 1974 total**

Figure 2

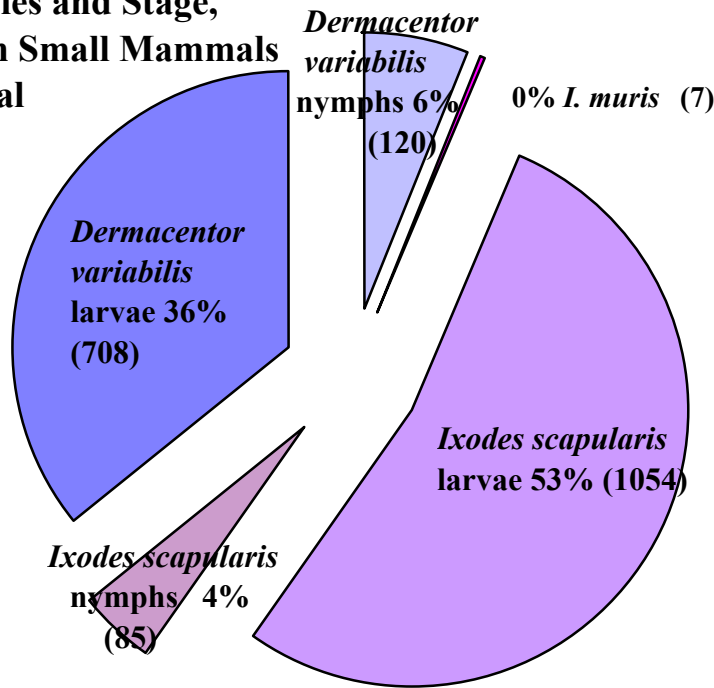


Figure 3

Average number of *I. scapularis* collected per mammal at 100 sampling locations in Anoka, Washington, and Ramsey counties: 1990 - 2005
(white box shows the total number of sites where at least one *I. scapularis* was found: by year)

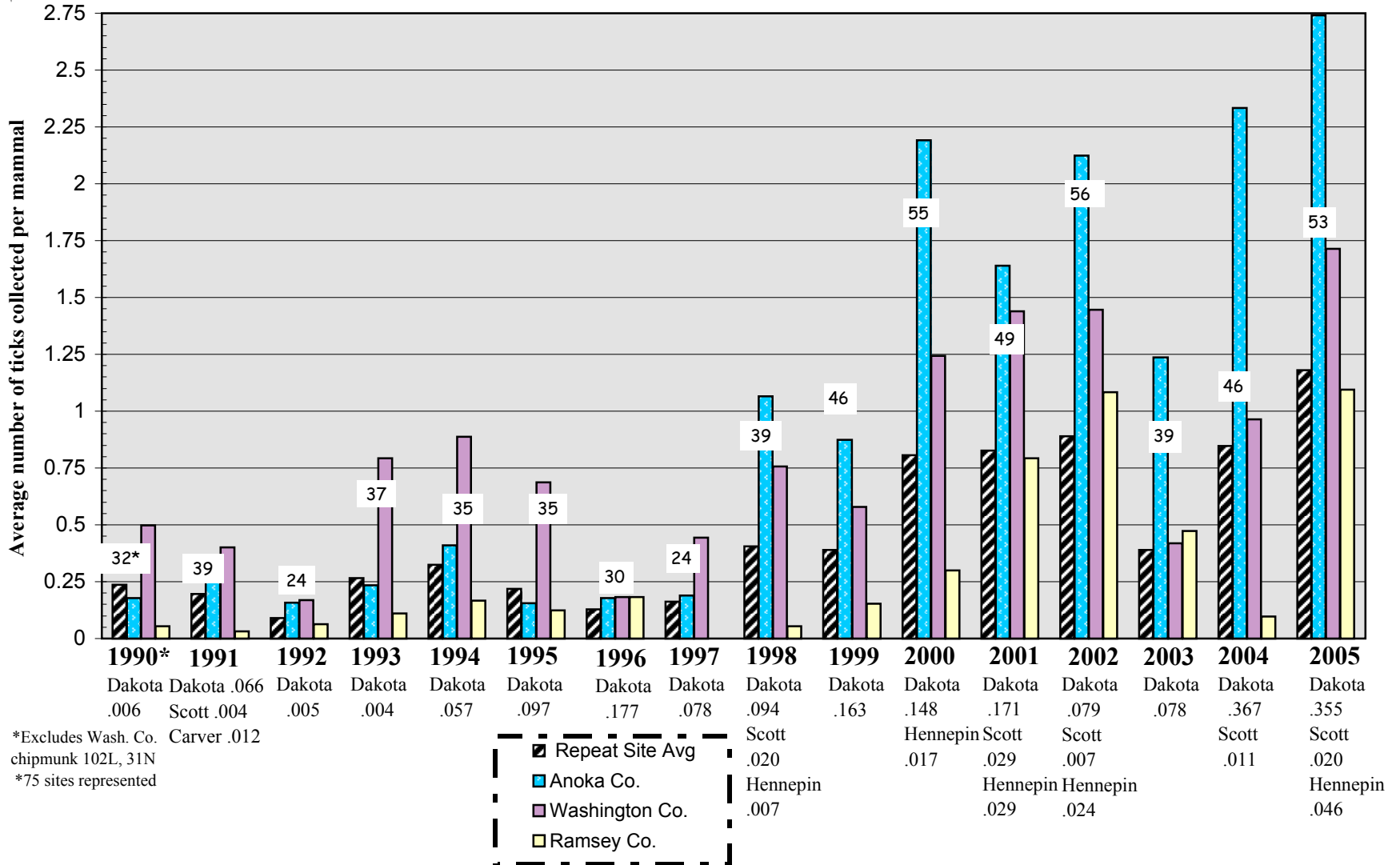
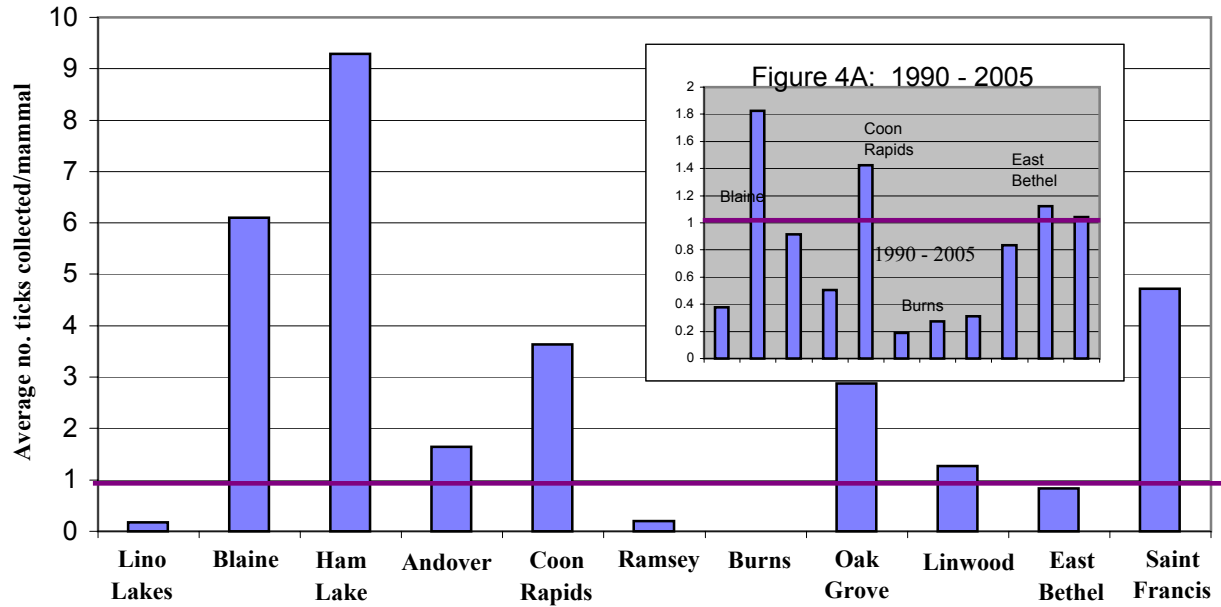


Figure 4

Average number of *I. scapularis* collected per mammal in Anoka county (by township):2005 results



Average number of *I. scapularis* collected per mammal in Washington county (by township):2005 results

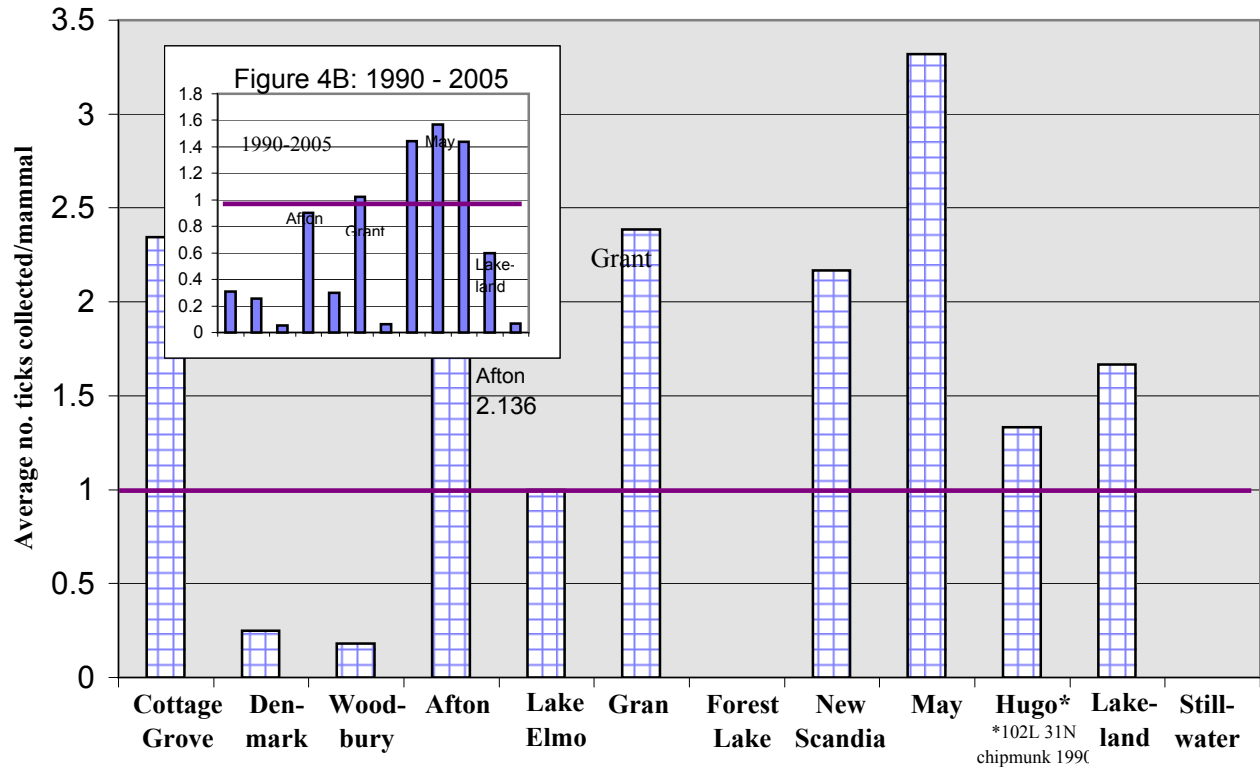


Figure 5

Ixodes scapularis Presence/Absence status: 1990 - 2005

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

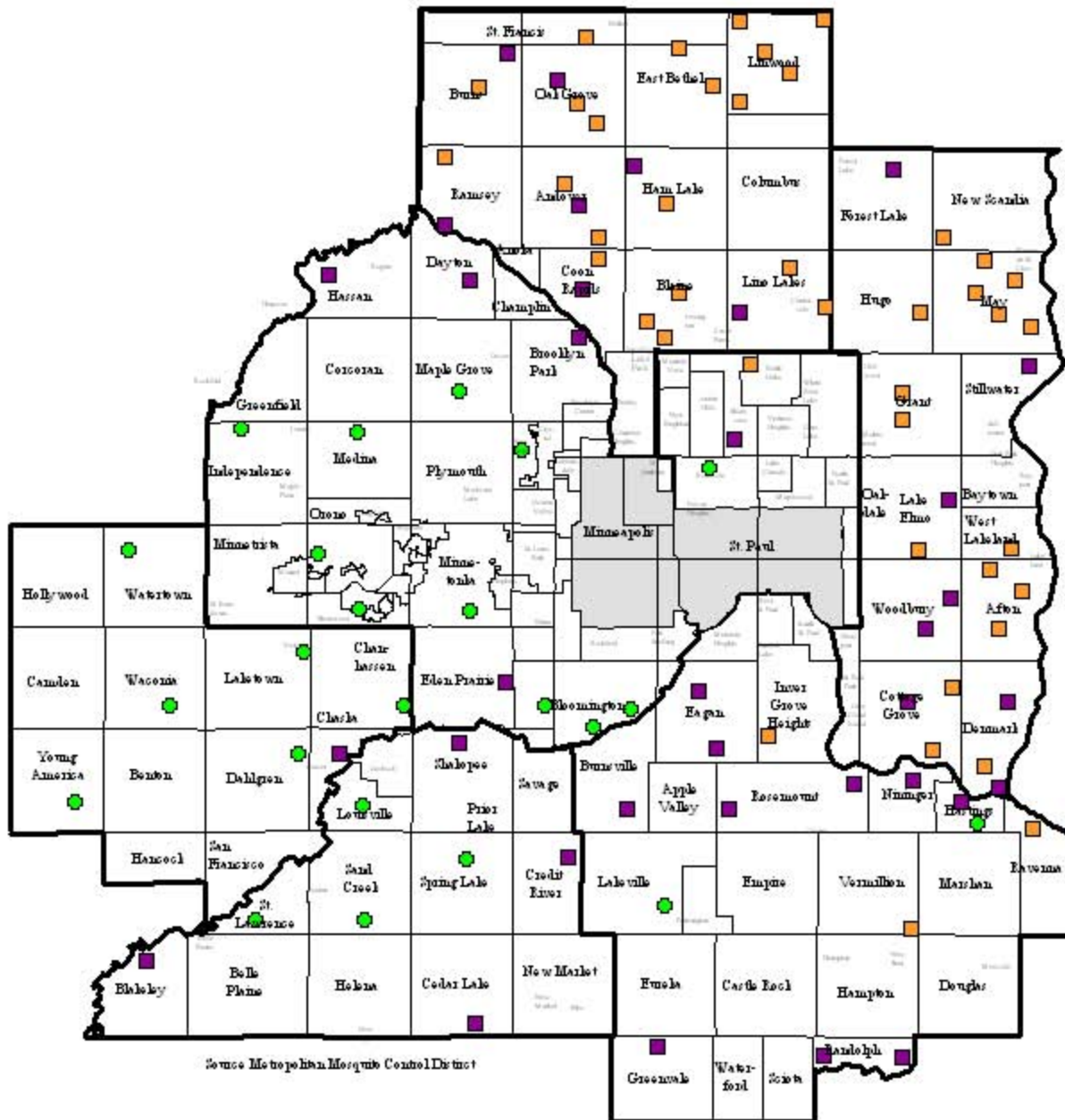
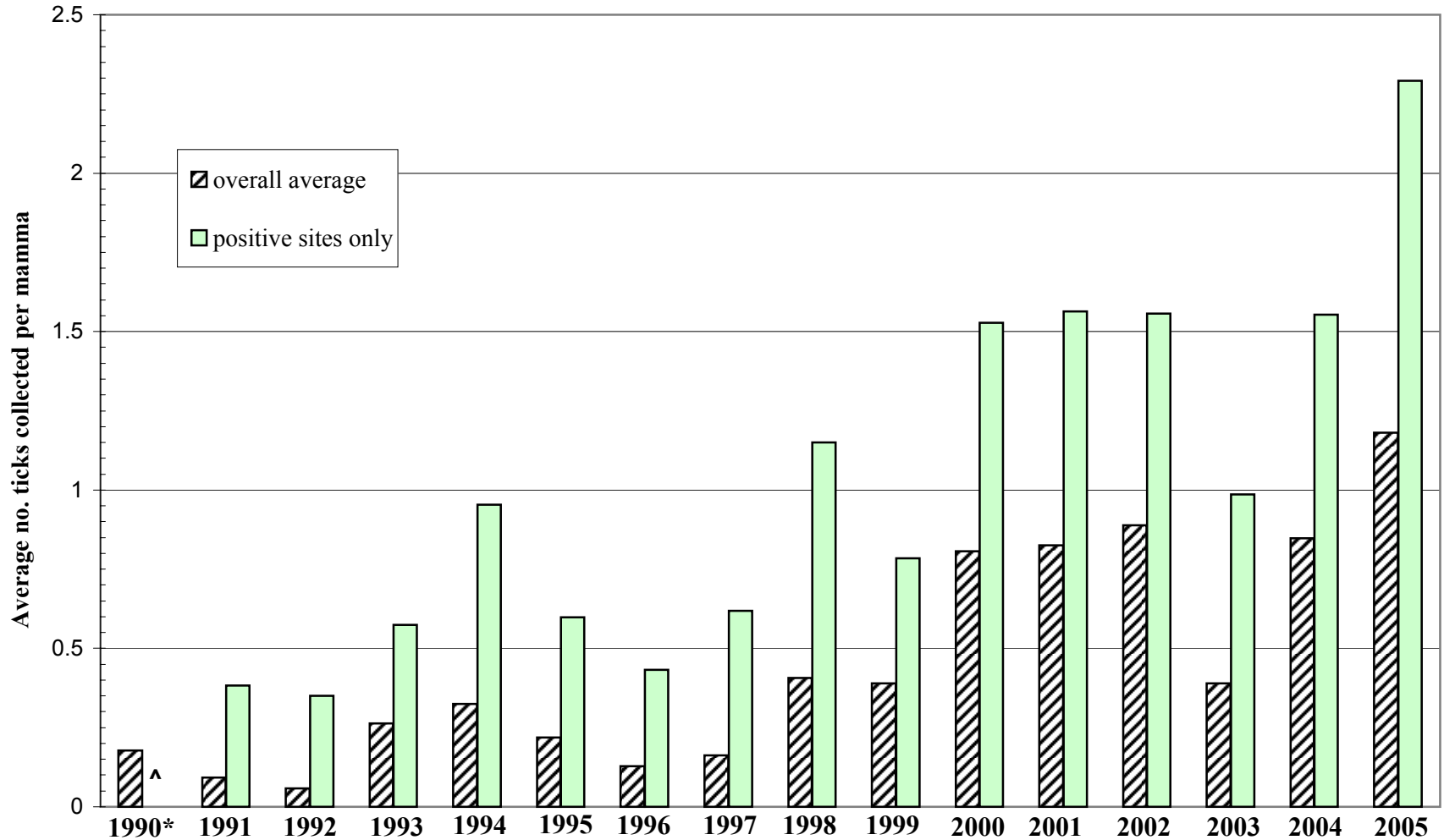


Figure 6

Average number of *I. scapularis* collected per mammal at 100 repeat sampling locations 1990-2005: 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]	<i>Peromyscus leucopus</i> percent (n)	<i>Tamias striatus</i> percent (n)	<i>Clethrionomys gapperi</i> percent (n)	<i>Blarina brevicauda</i> 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)
2004	100	1152	[11.52]	87% (1007)	6% (71)	3% (40)	2% (20)	1% (14)
2005	100	965	[9.65]	87% (841)	6% (54)	4% (37)	2% (16)	2% (17)

^aOther includes *Microtus pennsylvanicus*, *Spermophilus tridecemlineatus*, *Zapus hudsonius*, *Mustela erminea*, *Tamiasciurus hudsonicus*, *Glaucomys volans*, *Sorex arcticus*, *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	<i>Dermacentor variabilis</i> L ^b percent (n)	<i>Dermacentor variabilis</i> N ^c percent (n)	<i>Ixodes scapularis</i> L ^b percent (n)	<i>Ixodes scapularis</i> 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)
2004	100	1773	37% (653)	8% (136)	51% (901)	4% (75)	0% (8)
2005	100	1974	36% (708)	6% (120)	53% (1054)	4% (85)	0% (7)

^a 1990 data excludes 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