Metropolitan Mosquito Control District
IXODES SCAPULARIS DISTRIBUTION STUDY
2015

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 locations that have all been sampled since 1990 or 1991. Except for 2011, since 2007 we have collected *I. scapularis* from at least one site in all seven counties that comprise our service area. Our overall positive site total for 2015 was 81, a new record high and surpassing 2014's previous high of 75. From counties south of the Mississippi River, our 2015 positive site total of 30 equals 2014's record high and surpasses our previous highs recorded for 2012, 2011, and 2010 (27, 26, 24 respectively). We collected a total of 1733 *I. scapularis* removed from 1195 mammals for an overall season mean of 1.450 *I. scapularis* per mammal; a new record but comparable to our averages since 2000 (2000, 2001, 2002, 2004, 2005, 2007, 2009, 2010, 2012 and 2014 were all $\geq$ .806). Our Anoka County sites accounted for the majority (42%) of our 2015 collections with an additional 24% obtained from Washington County. Dakota County accounted for another 17% of our overall collections. Townships maintaining *I. scapularis* per mammal averages $\geq$ 1.0 included Afton, May, Grant, Oakdale/Lake Elmo, Hugo, New Scandia and Lakeland of Washington County (range 1.0 – 5.481), Coon Rapids, Linwood, Blaine, East Bethel, Ham Lake, Saint Francis, Lino Lakes, Andover, and Oak Grove of Anoka County (range 1.0 – 10.222), Shoreview (6.444) of Ramsey County, Burnsville, Vermillion, Inver Grove Heights, and Nininger (range 1.0 – 10.778) of Dakota County, and Eden Prairie (2.857) of Hennepin County. Cottage Grove, Stillwater, and Denmark (Washington),Burns (Anoka), Ravenna (Dakota), Sand Creek, Blakely (Scott), Victoria/Laketown (Carver), Bloomington and Hassan (Hennepin) townships all averaged $\geq$ .500 *I. scapularis* per mammal. Anoka County maintained the highest 1990-2015 overall season mean (1.049), followed by Washington County (.945). Our compiled 1990-2015 township averages (all > 1.0) north of the Mississippi River include May, Hugo, Afton, New Scandia, and Grant of Washington County and Coon Rapids, Blaine, Saint Francis, Ham Lake, East Bethel and Linwood of Anoka County. Shoreview of Ramsey County maintained a compiled 1990-2015 average of .851. South of the river, the highest 1991-2015 averages (> .500 *I. scapularis* per mammal) occurred in Burnsville, Inver Grove Heights, Vermillion and Ravenna townships of Dakota County (range .518 – 1.824) and Eden Prairie Township (.541) of Hennepin County. Both small mammal and immature tick species diversity in 2015 appeared comparable to past years although in 2015 a record setting 81% of our overall collections were *I. scapularis*. As in past years, *Peromyscus leucopus* was the predominant mammal species collected. As of April 14, 2016 the MN Dept Health (MDH) did not have 2015 tick-borne disease case totals prepared but there had been 896 Lyme and 448 human anaplasmosis cases in 2014. Our results continue to indicate that a Twin Cities resident's risk of encountering *I. scapularis* locally is now greater than it once was and that this risk has risen over time in counties south of the Mississippi River.

Introduction

In 1990 the Metropolitan Mosquito Control District initiated a Lyme Disease Tick Surveillance Program to determine the distribution and prevalence of *I. 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 flagging (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 to track areas that have shown potential *I. scapularis* range expansion.

Periodically, additional sites have been sampled:
From 1995-1997 two additional sites were sampled; 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 the three-year period.

From 2007-2009 several park sites were sampled and results compared to our 1990 results. Although we are still sampling a limited number of parks today, in 1990 a larger number of our sites had been selected inside metropolitan parks to provide a primitive assessment of park user risk to potential *I. scapularis* encounters. Included were Joy Park in North Saint Paul (62-08-01) and a location near Pigs Eye Lake in St Paul (62-13-02). In 1990 *I. scapularis* had not been collected at either park in three rounds of sampling. We re-sampled both parks, for two rounds only, as extra sites in 2007 and 2008. The 2007-08 Pigs Eye site was moved over one section, to section 3 while the 2007-08 Joy Park site was in the same (square mile) section, but east of our 1990 location. Unlike 1990, we detected *I. scapularis* in both parks in both years. In 2009 Joy Park and a previously unsampled Ramsey County location, Priory Preserve (62-04-24), were both sampled for three rounds and *I. scapularis* was found again at Joy Park. Zero mammals were collected at Priory Preserve.

In 2010 Joy Park and Priory Reserve were sampled for two rounds and a new site, section 18 of Laketown Township in Carver County (a single adult *I. scapularis* had been collected in late July 2009), was sampled for all three rounds. *I. scapularis* was not found at Joy Park in 2010 but was detected at both Priory Reserve and Laketown Township.

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 20, 2015 and ended on October 22, 2015. Small mammal trapping was 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. http://www.earth-pics.com/gallery/10most/the-most-amazing-ice-formations

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

- **2015 Study (Repeat Sites):**

Except for 2011, since 2007 and again in 2015 we collected *I. scapularis* from at least one site in all seven counties that comprise our service area. Specifically, we found at least one *I. scapularis* at 81 of our 100 sampling sites, with 51 of these positive sites located north of the Mississippi River in Anoka (25 sites positive/28 sites sampled), Washington (23 sites positive/25 sites sampled), and Ramsey (3 sites positive/3 sites sampled) counties. Thirty additional positive sites were detected south of the river in Dakota (13), Hennepin (8), Scott (6) and Carver (3) counties (Figure 5A).

Overall, 1195 mammals (Figure 1 and 2015 results in Table 2) were inspected: 476 from north of the Mississippi River and 719 from south of the river and a total of 1733 *I. scapularis* (Figure 2 and 2015 results in Table 3) were collected from them. The Anoka County sites accounted for 42% of the total *I. scapularis* collections (572L; 154N) with the highest numbers collected in Linwood (233L; 57N), Blaine (99L; 35N), and Coon Rapids (80L; 17N) townships. Washington County accounted for another 24% of our total *I. scapularis* collections (357L; 66N), with the highest numbers collected in Afton (134L;14N) and May (107L; 6N) townships. An additional 17% of the total (282L; 19N) were collected from our Dakota County sites, with the highest collections occurring in Burnsville (190L; 4N) Township.

The overall season mean number of *I. scapularis* collected per mammal in 2015 was 1.450 (larvae: 1.207, nymphs: .244). The mean increases to 1.815 (larvae: 1.510, nymphs: .305) when all sites negative for *I. scapularis* are excluded (see 2015 results in Figure 6). The highest average number of *I. scapularis* per mammal was calculated for Anoka County (3.490), followed by Ramsey (3.441), Washington (1.808) and Dakota (1.249) counties (see 2015 results in Figure 3). North of the Mississippi River, townships in Washington County averaging $\geq$ 1.0 *I. scapularis* per mammal in 2014 were Afton (5.481), May (3.229), Grant (2.862), Oakdale/Lake Elmo (1.444), Hugo (1.143), New Scandia (1.0), and Lakeland (1.0), in Anoka, Coon Rapids (10.222), Linwood (5.800), Blaine (5.583), East Bethel (4.500), Ham Lake (4.273), Saint Francis (3.250), Lino Lakes (1.579), Andover (1.292) and Oak Grove (1.0) townships, and in Ramsey County, Shoreview Township (6.444). Averaging $\geq$ .500 *I. scapularis* per mammal were Cottage Grove (.829), Stillwater (.714), and Denmark (.571) of Washington County and Burns (.556) township of Anoka County (Figure 4). South[1] of the Mississippi River (no figure), townships maintaining averages $\geq$ .500 *I. scapularis* per mammal were Burnsville (10.778), Vermillion (3.500), Inver Grove Heights (1.0), Nininger (1.0) and Ravenna (.778) of Dakota County, Sand Creek (.737) and Blakely (.615) of Scott County, Victoria/Laketown (.571) of Carver County, and Eden Prairie (2.857), Bloomington (.814), and Hassan (.571) of Hennepin County.

- **Compiled Results (Repeat Sites) from 1990 - 2015 or 1991 - 2015:**

The 1990-2015 mean number of *I. scapularis* collected per mammal is .589, with the highest averages continuing to occur north of the Mississippi River. Washington County maintained the highest yearly county season means from 1990-1997, 2010 and 2012 while Anoka County maintained the highest yearly county season means from 1998-2009, 2011, 2014 and 2015. In 2013, Ramsey County had the highest county season mean (.842) for the first time (Figure 3). Anoka County's compiled 1990-2015 overall season mean is 1.049 and is followed by Washington County (.945). The 1990-2015 township averages (all > 1.0), north of the Mississippi River include May, Afton, Hugo, Grant, and New Scandia of Washington County and Coon Rapids, Blaine, Saint Francis, Ham Lake, East Bethel and Linwood of Anoka County, while the averages for Andover, Oak Grove and Lino Lakes of Anoka County and Lakeland and Lake Elmo townships of Washington County are > .500 *I. scapularis* per mammal (Figures 4A and B—inserts on Figure 4). Shoreview of Ramsey County maintained a compiled 1990-2015 average of .851. In compiled results from south of the Mississippi River (1991 – 2015), Burnsville (1.824), Inver Grove Heights (.969), Vermillion (.920), and Ravenna (.518) townships of Dakota County and Eden Prairie (.541) of Hennepin County maintained 1991-2015 averages > .500 *I. scapularis* per mammal[2] (no figure).

I. scapularis status at the 100 repeat sampling locations is shown on Figure 5. The status has changed at 95 of the sites since 1990 or 1991 (see 2015 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).

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). We tabulated two positive Ramsey County sites (both of our Shoreview Township sites) for the first time in 2003. These two sites were positive for *I. scapularis* again in 2005, 2006, 2008, 2010, 2013, 2014 and 2015. In fact, since 2013 our Roseville site has also been positive, making 2015 the third consecutive year that all three of our Ramsey County sites were positive. South of the river from 1990 – 1999 it had been typical to tabulate a maximum total of 3-4 positive sites each season. Except for

[1] Prior to 2005, township averages south of the river were not tabulated. See footnote 1 (and the report text) in the 2005 report for detailed yearly averages for positive townships south of the Mississippi River through 2005. In brief, Inver Grove Heights Township first averaged > .500 in 1998 while Vermillion Township first averaged > .500 in 1991. 2005 was the first year that Hassan Township (Hennepin County) had an average $\geq$ .500.

[2] 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.

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 counties[3] and in 2000 we began to tabulate more sites south of the river than in past years. In 2014 we tabulated 30 positive sites south of the river; a new record, surpassing the former record high of 27 positive sites in 2012 (Table 1A).

Comparing our 2015 small mammal and immature *I. scapularis* collection results with past study efforts, small mammal (Table 2) and immature tick (Table 3) species diversity appears comparable to past years. As in past years, *Peromyscus leucopus* was the predominant mammal species collected. In our tick collections, since 2002 and including 2015 *I. scapularis* has comprised $\geq$ 50% of our overall collections 10 times. This compares to the 16 times that *Dermacentor variabilis* has comprised the majority, including for the first 12 years of this study. The total number of ticks collected in 2015 (*D. variabilis*, *I. scapularis*, and *I. muris* combined) was 2,154 (Table 3). As Figures 3 and 6 show, our 2015 overall season mean of 1.450 *I. scapularis* per mammal is a new record high, surpassing our previous record high of 1.213 from 2012 but similar to the averages we have come to expect in recent years (2000 – 2002, 2004, 2005, 2007, 2009, 2010, 2012, 2014 and 2015 were all $\geq$ .806). *P. leucopus* consistently has been the predominant mammal species collected each year with some variability in the total percentages collected[4] (Figure 1 and Table 2). The 2015 average number of mammals collected per site (11.95) is an average yearly small mammal collection total (Table 2). Our compiled average small mammal collection success level per site for 1990 through 2015 is 12.57 (1991-2015 average of 11.93 for100 repeat sites only), with results ranging from 2013's low of 5.96 mammals collected per site 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 Anoka and Washington counties and are now established or establishing in locations 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. While it remains our view that the greatest Lyme disease risk continues to occur in the northern metropolitan area[5], we believe greater *I. scapularis* exposure opportunities and therefore higher tick-borne disease risk is occurring now across our seven county service area.

In 2015 we surpassed previous highs that had just been set the year previous, in 2014. Our tabulation of 81 positive sites surpasses our previous record high of 75 from 2014 and is the first time we have tabulated a positive site total in the 80's. The first time we had ever tabulated a positive site total in the 70's was in 2010, with a tabulation of 70 sites (Figure 3). Our average number of *I. scapularis* collected per mammal (1.450) in 2015 is another new record high, although it is still comparable to the averages we have come to expect in recent years (2000 – 2002, 2004, 2005, 2007, 2009, 2010, 2012, and 2014 were all $\geq$ .806). We also found that 78% of the 2,217 ticks we collected were *I. scapularis* which is also a new record. Our previous highest percentage of *I. scapularis* was 72%, in 2010.

[3] *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.

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

[5] 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).

Whether our record setting year was temperature related is unknown, but we did have an early beginning to tick season in 2015. *I. scapularis* quest at temperatures generally 40°F or above and average monthly temperatures for March were two to four degrees above normal across much of Minnesota. Numerous high temperature records were set during the second week of March[6]. We documented our first *I. scapularis* adult on March 13, our first *Dermacentor variabilis* adult April 11, and our first *I. scapularis* nymph April 25. From 2001-2015 we documented our first *I. scapularis* adult in March three times, in April nine times, and in May three times.

Minnesota human case data for 2015 is not yet available (as of April 14, 2016) but as shown in Table 4, in 2014 there had been 896 Lyme and 448 human anaplasmosis (HA) cases. The statewide Lyme case totals from 1992-1999 were roughly 250 Lyme cases per year and the MDH had been compiling an average of roughly 15 HA cases per year statewide from 1997 to 1999. Cases had begun to rise in 2000. When the MDH had been separating metro residents from people who reside elsewhere in the state for their statewide data, they had consistently documented that metro residents comprised roughly half of the Lyme cases tallied[7].

Although metro-exposed case tallies have not been available since 2008, the metro case totals had also been rising over time, but not as dramatically as the statewide totals. The last available (2007) totals had been at all-time highs (80 Lyme, 9 HA). Comparatively, the range for metro-exposed Lyme cases was 15 to 43 from 1991 – 1999 and 40 to 69 from 2000 – 2006 for all seven counties combined. Although HA had been detected in MMCD collaborative research in metro-collected small mammals beginning in 1995[8], locally acquired human HA cases were not documented by MDH until 2000. From 2000 – 2007 the MDH typically tabulated a few metro-exposed HA cases each year (range 0-9). Case totals obviously would be higher if using metro resident data, not just people who were exposed in the metro.

Metro residents north of the Mississippi River have been used to encounters with *I. scapularis* but south of the river these encounters have changed over time from extremely infrequent to commonplace. The risk of metro tick encounters is higher than it used to be and is based both on our collections of more *I. scapularis* overall as well as from a broader geographic area (south of the Mississippi River) now than in years past.

[6] http://www.dnr.state.mn.us/hydroclim/hc1504.html

[7] Slide 37 www.health.state.mn.us/divs/idepc/diseases/**lyme**/**lyme**slide.ppt

[8] Several 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:

STUDIES/PROJECT UPDATES AND PLANS FOR 2016.

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

- **Discontinued, Additional projects: Bot Flies.** From 2009-2015, MMCD had provided samples to Dr. Roger Moon (UM – St Paul), to further the knowledge of the rodent bot fly (Genus *Cuterebra*). From 2013-2015 pupae were collected to be reared out to the adult stage. Dr. Moon managed to successfully induce adults to emerge, at least some of them after having been in forced diapause (frozen) for a period of time.

- **Collecting ticks from grooming shops.** Dogs make great tick collectors and some dogs get groomed. A sub-set of these dogs have ticks on them that the groomer removes and tick vials are kept at a lot of shops. In 2015 we had collected an adult *Amblyomma americanum* using this method. For 2016 at least one facility will drop a vial at a groom shop and later the ticks will be identified and documented. This idea had originated with Dr. Moon.

POSTING AT DOG PARKS.

Since the initial suggestion of the Technical Advisory Board (TAB) in 2010, we have visited dog parks and vet offices as part of our outreach. Signs have been posted in at least 21 parks with additional signs posted in active dog walking areas. In 2015 we had posted a total of 41 signs at over 36 locations throughout the metro with most signs removed in winter. Signs have been re-posted in spring 2016.

DISTRIBUTING MATERIALS TO TARGETED AREAS

In 2016 brochures, tick cards, and/or posters were dropped at roughly 292 locations (city halls, libraries, schools, child care centers, retail establishments, vet clinics, parks) across the metro as well as distributed at fair booths and city events, with many more mailed upon request. We have continued materials distribution in spring 2016.

AMBLYOMMA AMERICANUM

Amblyomma americanum (lone star tick) records are significant because these ticks vector human monocytic ehrlichiosis, they are an aggressive human biter, and their range is known to be moving northward. Though found here since 1990 on a rare, sporadic basis, Minnesota is not within their historic range. In 2009 there were several *Amblyomma* collections (one adult, submitted to the MDH, one nymph, submitted to MMCD) in one year; an unusual event. This trend continued in 2010, with *Amblyomma* submitted to MMCD from Eagan, Mound, and the Orono/Lake Minnetonka areas of the metro. In 2011 the MDH had submissions of adults from Shakopee, Lindstrom, and Hennepin Co (unconfirmed location) and in 2012, three more *Amblyomma* were submitted to the MDH: Eden Prairie or Burnsville, Bloomington, and Rice County. MMCD did not receive any *Amblyomma* in 2011 or 2012. In 2013, the MDH did not receive any reports but MMCD received 3 *Amblyomma* (Afton, Scandia and Western Wisconsin). We notified the Wisconsin Department of Health of the Western Wisconsin detection and mailed the tick to them per their request. In 2014 MMCD did not receive any reports but the MDH received one report from the Zumbrota, MN area. In 2015 MMCD received 1 adult male and 1 nymph from the Elk River area and one additional adult female (unknown location) was collected by a dog groomer in collaboration with the Jordan facility.

BORRELIA MAYONII, A NEW NORTH AMERICAN LYME DISEASE GENOSPECIES

A new *Borrelia burgdorferi* sensu lato genospecies has been found to cause Lyme disease. This is the first additional one to *B. burgdorferi* sensu stricto that has been detected in North America.

Identification of a novel pathogenic *Borrelia* species causing Lyme borreliosis with unusually high spirochaetaemia: a descriptive study *Bobbi S Pritt, Paul S Mead, Diep K Hoang Johnson, David F Neitzel, Laurel B Respicio-Kingry, Jeffrey P Davis, Elizabeth Schiffman, Lynne M Sloan, Martin E Schriefer, Adam J Replogle, Susan M Paskewitz, Julie A Ray, Jenna Bjork, Christopher R Steward, Alecia Deedon, Xia Lee, Luke C Kingry, Tracy K Miller, Michelle A Feist, Elitza S Theel, Robin Patel, Cole L Irish, Jeannine M Petersen* ***Lancet Infect Dis*** **2016 (p 1-9).**
Published Online February 5, 2016 http://dx.doi.org/10.1016/S1473-3099(15)00464-8

Mayo researchers tested samples from 2003-2014.

- *B. mayonii* found in 6 of 100,545 patient samples
  - all 6 from 2012 or later
  - all were WI, MN, & ND (ND likely MN exposure)
  - 3 had neurological CNS symptoms & 2 were hospitalized

Some of the symptoms the same as for *B. burgdorferi* but each genospecies also has unique clinical features (underlined).

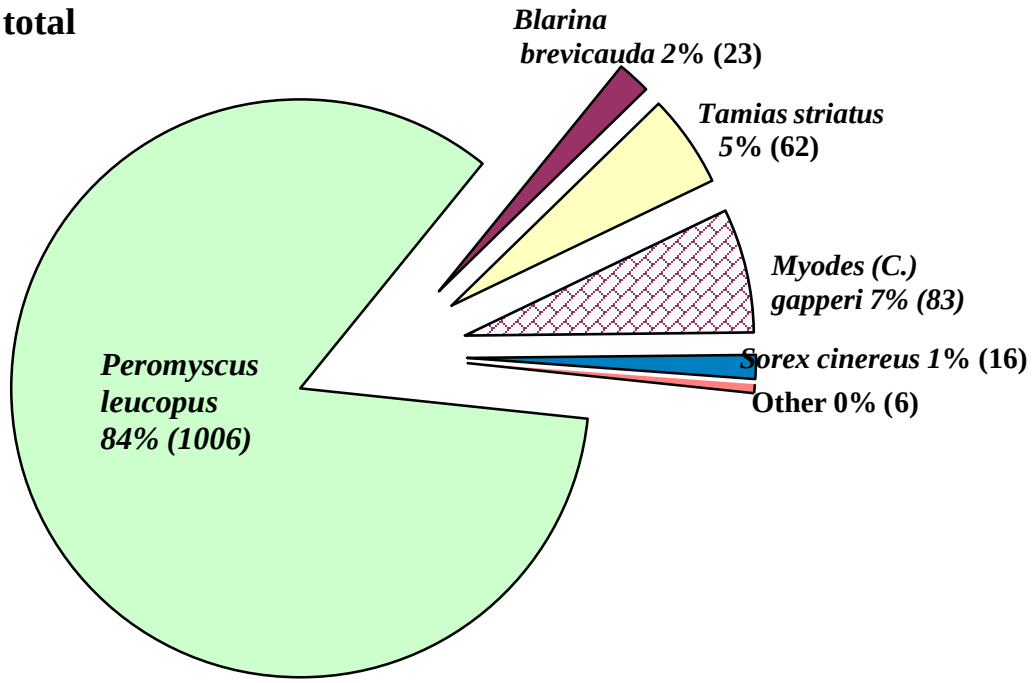
- substantially raised spirochaetemia!
  - Median 180x higher than B. burgdorferi sensu stricto
- 5 fever, headache
- 4 diffuse or focal macular rash
- 4 nausea or vomiting, fatigue, myalgia
- 1 knee pain and swelling

B. mayonii tick infection rate:

- 19+ (2.9%) of 658 *Ixodes scapularis* ticks
- Prevalence similar in nymphs and adults
  - Unlike *B. burgdorferi* sensu stricto - lower infected nymph rate compared with adults
  - Larvae were not tested
- tick infection rate of 1-3% found in different ticks, tested by MN Dept Health

Small Mammals Collected
2015: 1195 total

Figure 1



Ticks, by Species and Stage, Removed from Small Mammals
2015: 2154 total

Figure 2

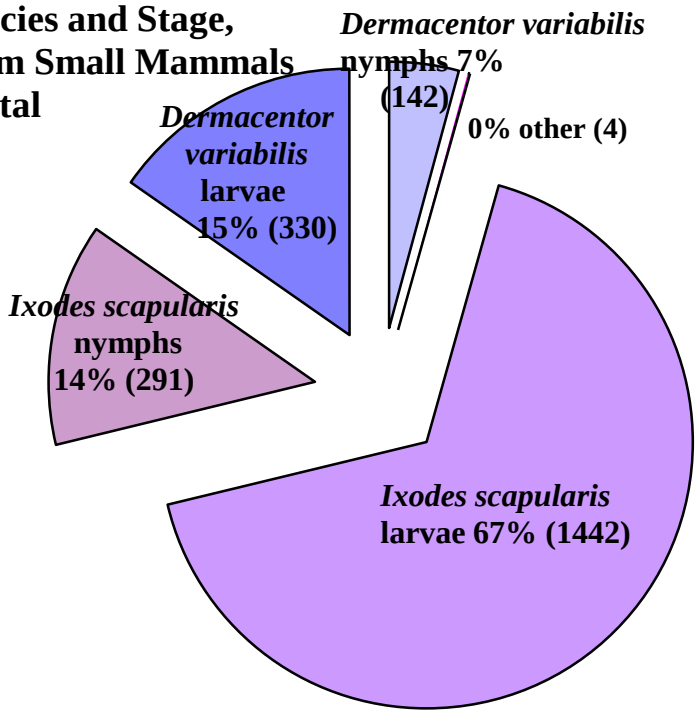
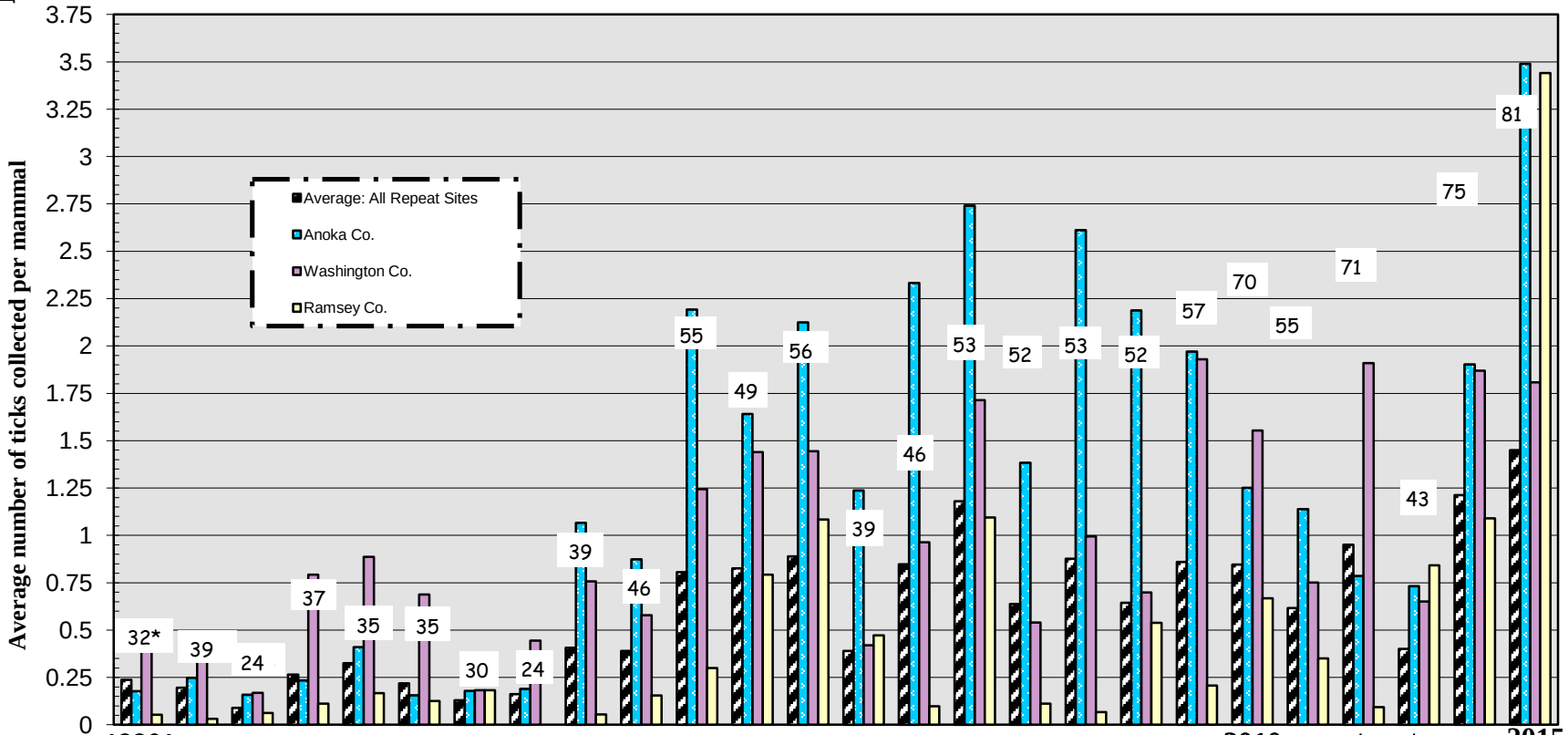


Figure 3

Average number of *I. scapularis* collected per mammal at 100 sampling locations in Anoka, Washington, and Ramsey counties: 1990 - 2015
(white box shows the total number of sites where at least one *I. scapularis* was found: by year)



1990*
Dakota
.006

*1990 Excludes Wash. Co. chipmunk 102L, 31N
*75 sites represented

1995
Dakota
.097

2000
Dakota
.148

Hennepin
.017

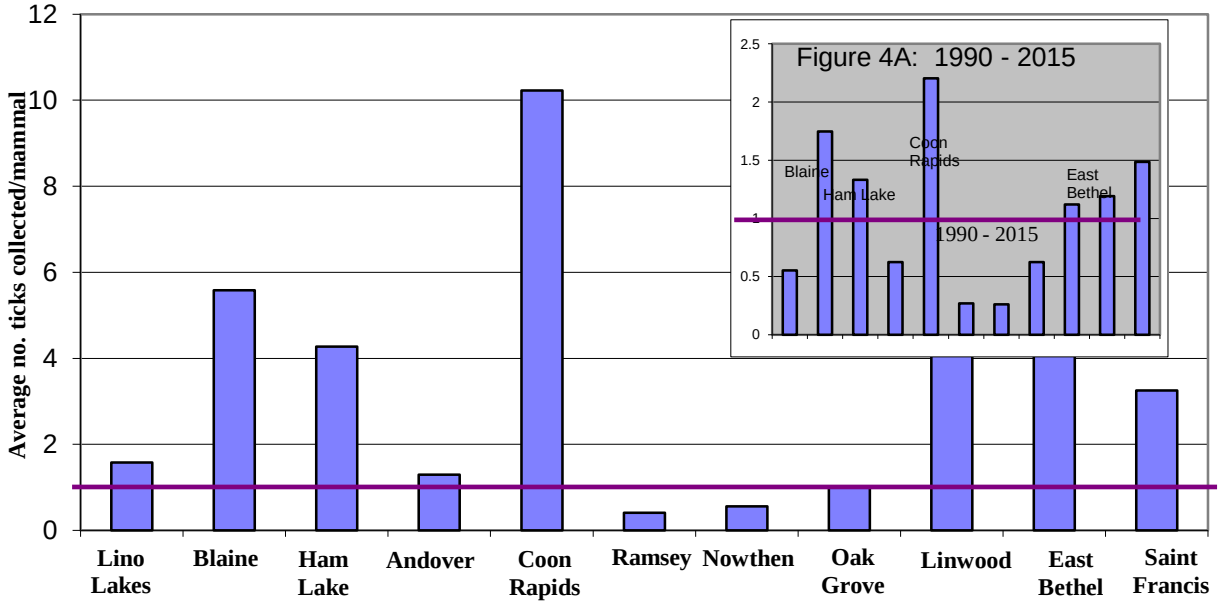
2005
Dakota
.355
Scott
.020
Hennepin
.046

2010
Dakota
.913
Scott
.215
Hennepin
.216
Carver
.045

2015
Dakota
1.249
Scott
.351
Hennepin
.475
Carver
.173

Figure 4

Average number of *I. scapularis* collected per mammal in Anoka county (by township): 2015 results



Average number of *I. scapularis* collected per mammal in Washington county (by township): 2014 results

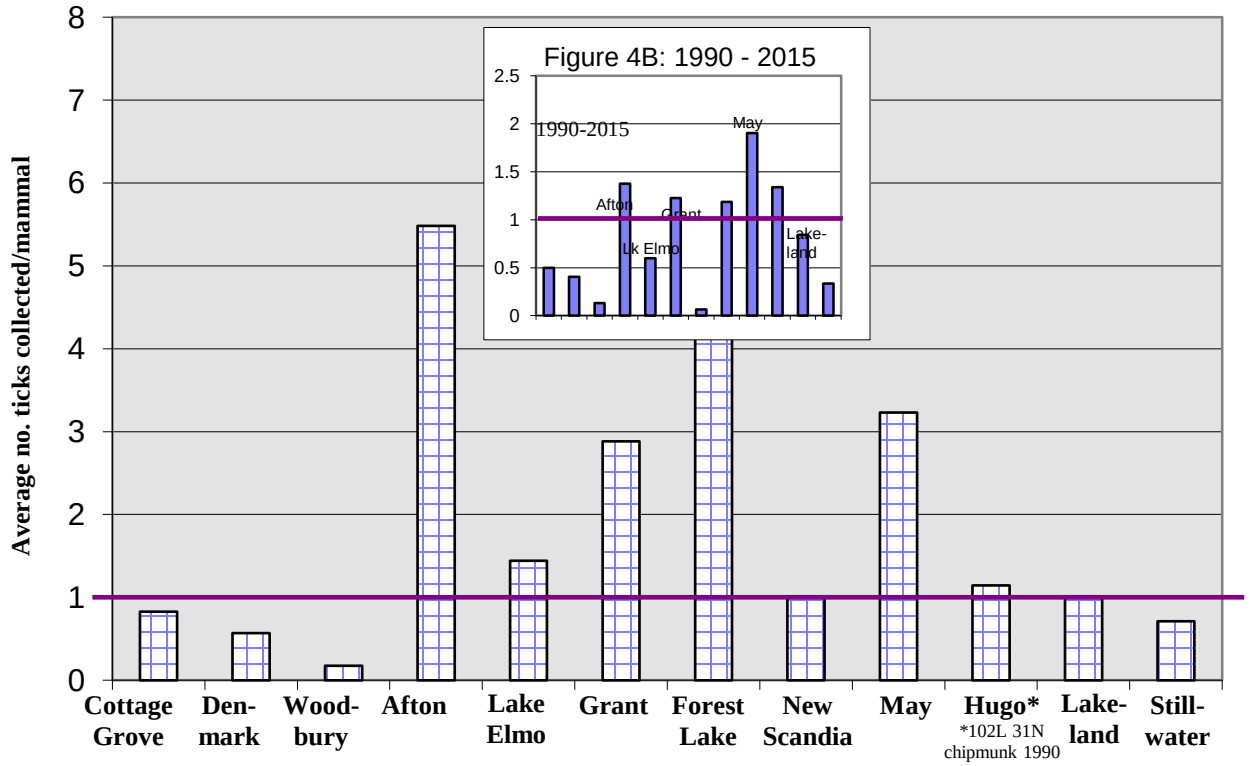
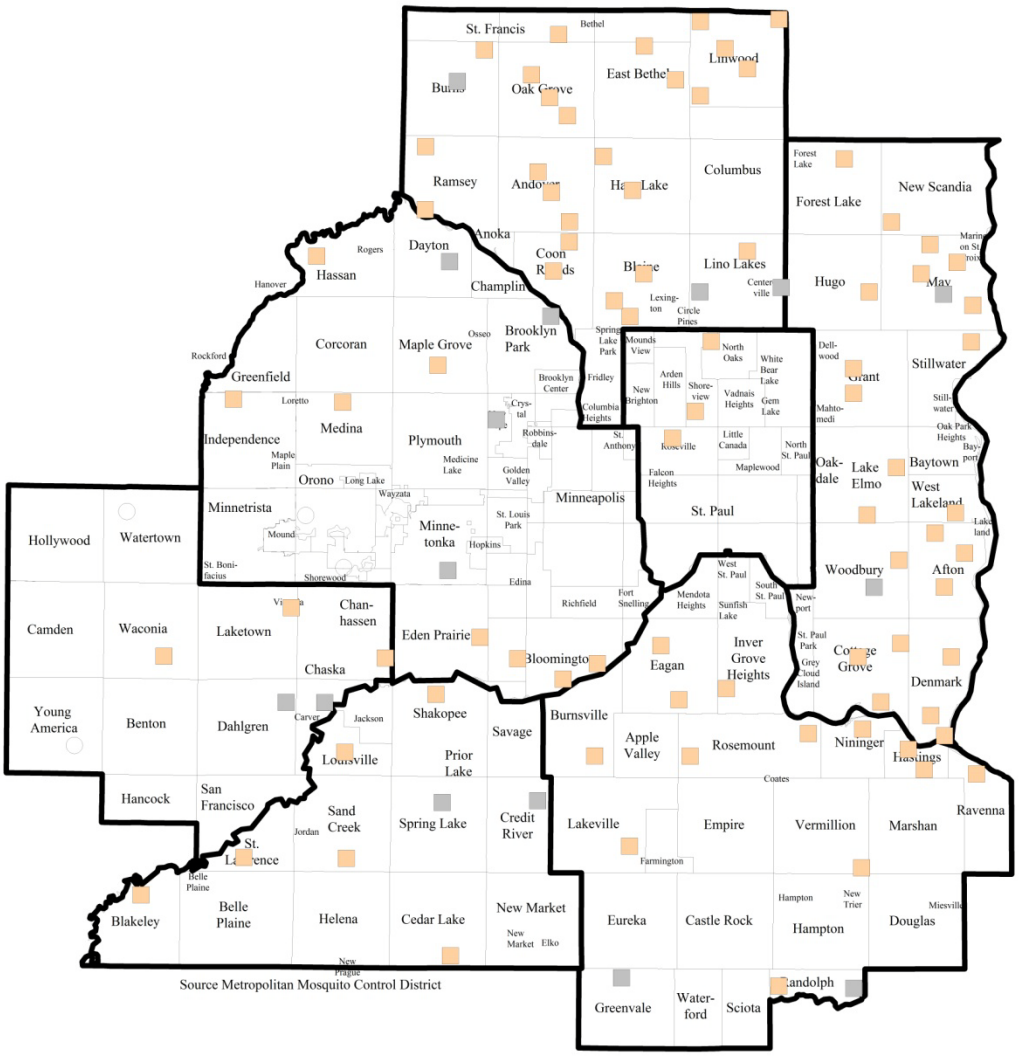


Figure 5A

Ixodes scapularis Presence/Absence status: 2015

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



Source Metropolitan Mosquito Control District

Status 2015

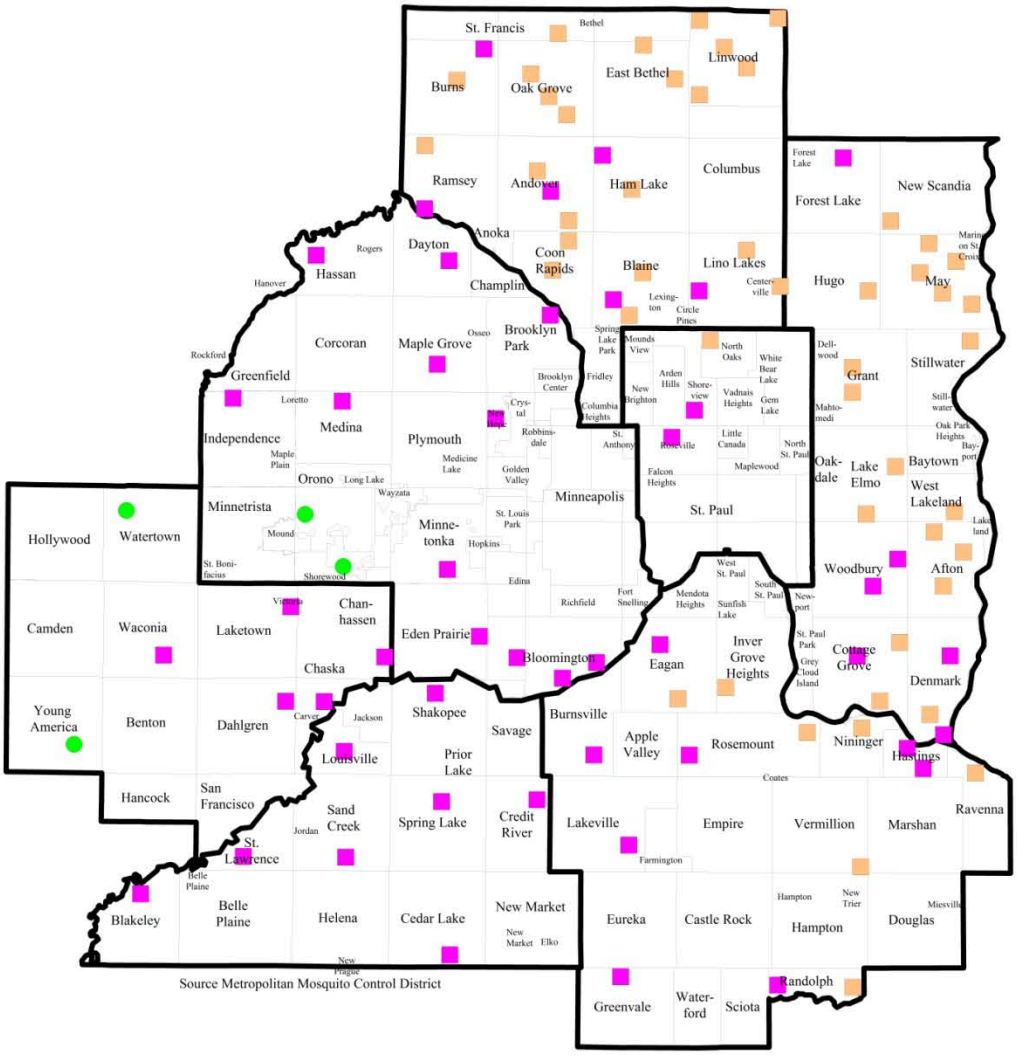
present	(81)
absent this year	(15)
not found 1990-2015	(4)

2015 Ixodes scapularis Distribution Study Report-
Metropolitan Mosquito Control District

Figure 5

Ixodes scapularis Presence/Absence status: 1990 - 2015

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



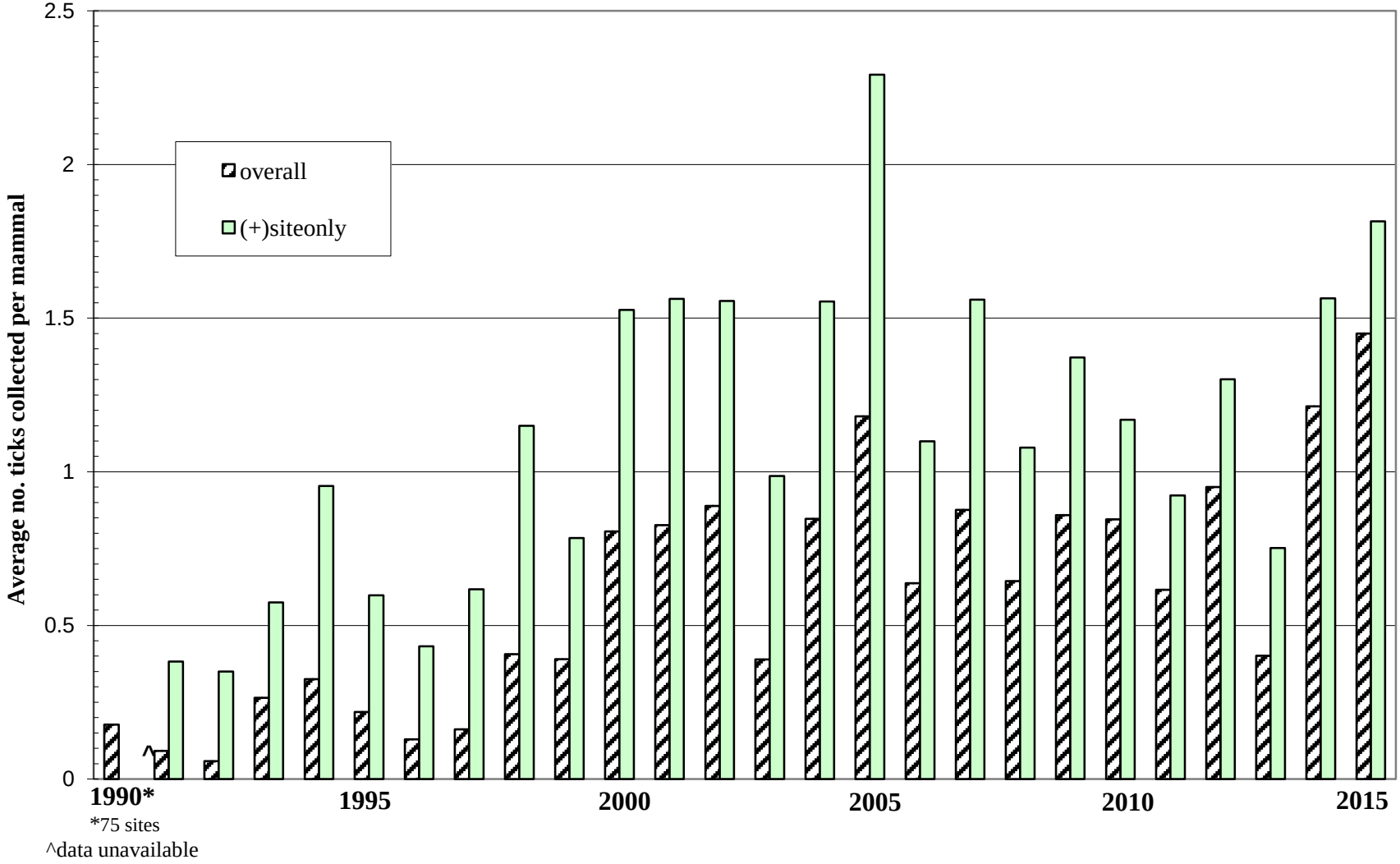
At least one tick found during:

- all/most years (49)
- at least one year (47)
- (not found) (4)

2015 Ixodes scapularis Distribution Study Report-
Metropolitan Mosquito Control District

Figure 6

Average number of *I. scapularis* collected per mammal at 100 repeat sampling locations 1990-2015 overall vs. sites where at least one *I. scapularis* was collected (positive sites)



*75 sites

^data unavailable

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

No. sites	1992	1994	1996	1998	2000	2002	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
changing status	26	38	47	58	61	69	75	76	78	80	81	83	88	90	91	92	94	95
Ticks found:																		
all years	21	17	11	5	5	4	1	1	1	1	1	1	1	1	1	1	1	1
most years	5	15	19	27	31	35	38	41	41	45	42	44	44	44	45	45	45	48
least	21	23	28	31	30	34	37	35	37	35	39	39	44	46	46	47	49	47
(not found)	53	45	42	37	34	27	24	23	21	19	18	16	11	9	8	7	5	4

Table 1A: Number of Sites South of the Mississippi River Positive for *I. scapularis*

	1992	1994	1996	1998	2000	2002	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total sites south of river	*1	2	4	4	7	12	9	10	12	16	19	19	24	26	27	15	30	30
By county:																		
Dakota	*1	2	4	2	6	8	8	7	9	10	12	11	10	11	13	9	11	13
Hennepin	*0	0	0	1	1	3	0	1	2	3	3	3	6	9	7	4	8	8
Scott	*0	0	0	1	0	1	1	2	1	2	2	3	6	6	4	1	7	6
Carver	*0	0	0	0	0	0	0	0	0	1	2	2	2	0	3	1	4	3

*This count includes only our current site network. However, despite our intensive 1992 effort, the overall total was only 2 (both Dakota County).

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)	*Myodes (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% (1114)	11% (156)	4% (56)	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)	2% (34)
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% (20)
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)
2006	100	1241	[12.41]	85% (1056)	4% (54)	8% (94)	0% (2)	3% (35)
2007	100	849	[8.49]	85% (721)	8% (71)	5% (42)	1% (5)	1% (10)
2008	100	702	[7.02]	80% (560)	8% (53)	6% (45)	4% (29)	2% (15)
2009	100	941	[9.41]	86% (809)	4% (40)	5% (47)	1% (14)	3% (31)
2010	100	1320	[13.20]	82% (1084)	4% (55)	6% (78)	5% (70)	3% (33)
2011	100	756	[7.56]	73% (549)	8% (62)	11% (81)	6% (43)	3% (21)
2012	100	1537	[15.37]	86% (1322)	3% (49)	7% (103)	2% (31)	2% (32)
2013	100	596	[5.96]	80% (474)	5% (31)	9% (56)	3% (18)	3% (17)
2014	100	1396	[13.96]	85% (1192)	5% (69)	7% (101)	2% (23)	1% (11)
2015	100	1195	[11.95]	84% (1006)	5% (62)	7% (83)	2% (22)	2% (22)

*Other includes *Microtus pennsylvanicus, Spermophilus tridecemlineatus, Zapus hudsonius, Mustela erminea, Tamiasciurus hudsonicus, Glaucomys volans, Sorex articu* *Sorex cinereus* , *Mus musculus* 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)
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)
2006	100	1353	30% (411)	10% (140)	54% (733)	4% (58)	1% (11)
2007	100	1700	47% (807)	8% (136)	33% (566)	10% (178)	1% (13)
2008	100	1005	48% (485)	6% (61)	34% (340)	11% (112)	1% (7)
2009	100	1897	48% (916)	9% (170)	39% (747)	3% (61)	0% (3)
2010	100	1553	21% (330)	7% (101)	65% (1009)	7% (107)	0% (6)
2011	100	938	40% (373)	10% (97)	28% (261)	22% (205)	0% (2)
2012	100	2223	25% (547)	9% (211)	59% (1321)	6% (139)	0% (5)
2013	100	370	24% (88)	11% (42)	40% (147)	25% (92)	0% (1)
2014	100	2427	24% (580)	6% (149)	67% (1620)	3% (74)	0% (4)
2015	100	2217	15% (390)	4% (91)	67% (1442)	14% (291)	0% (3)

[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 2007-collected 7 *I. marxi* nymphs

Table 4: Minnesota human Lyme and anaplasmosis case totals, 2000-2014

Year	Lyme	anaplasmosis
2014	896	448
2013	1,431 (record)	627
2012	911	512
2011	1,201	782 (record)
2010	1,293	720
2009	~1,065	317
2008	1,050	278
2007	1,239	322
2006	914	177
2005	918	186
2004	1023	139
2003	473	78
2002	867	152
2001	465	93
2000	463	79

Source data: MN Dept Health