

THE BLACKLEGGED TICK (*IXODES SCAPULARIS*) IN INDIANA: A REVIEW

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ABSTRACT. In 1987, the first recently confirmed specimens of *Ixodes scapularis* Say (the blacklegged tick) were collected from hunter-harvested deer in four Indiana counties. These specimens provided the first evidence that blacklegged ticks had become re-established in Indiana after many years of apparent absence. Through periodic sampling over a 20 year period, it has been determined that *Ixodes scapularis* had spread to at least 59 of Indiana's 92 counties by 2007. It is postulated that the re-establishment and rapid spread of this species is a direct result of the re-introduction and population management of white-tailed deer herds that were extirpated by 1900. Evidence and experience suggest that *Ixodes scapularis* will eventually become established throughout the state. Potential implications for public health are discussed.

Keywords: Blacklegged tick, *Ixodes scapularis*, Lyme disease, Indiana

This report describes collections of the blacklegged tick, *Ixodes scapularis* Say, in Indiana from its rediscovery in 1987 through the end of 2007. The blacklegged tick is a former resident of Indiana, having been previously recorded in the state 100 years ago in 1908 (Banks 2008). But, the species is believed to have become extirpated early in the 20th century along with the white-tailed deer (*Odocoileus virginianus*), the primary vertebrate host for its adult stage. Although it was occasionally re-introduced into Indiana by travelers and their pets, it failed to become re-established until recently (Demaree 1986; Wilson 1961). The present establishment of *Ixodes scapularis* in more than two-thirds of Indiana's 92 counties is a direct result of Indiana's re-introduction and subsequent management of the white-tailed deer as a game animal. The re-establishment and proliferation of blacklegged tick populations in Indiana have important public health implications for the residents of Indiana because of the tick's ability to transmit several human diseases including Lyme disease, human anaplasmosis, and babesiosis.

BACKGROUND AND REVIEW OF LITERATURE

Blacklegged tick in Indiana before 1987.—The first record of *Ixodes scapularis* in Indiana was that of Banks (1908). This suggests that the species had a historical presence in the state. However, in subsequent years, neither Cooley

& Kohls (1945) nor Bishopp & Trembley (1945) recorded *I. scapularis* in Indiana. The closest records reported in proximity to Indiana during this time were from Tennessee (Cooley & Kohls 1945). Wilson (1961) did not find *I. scapularis* in spite of examining more than 4300 ticks from Indiana mammals. He concluded, "I do not believe that *Ixodes scapularis* occurs within the state as a permanent resident at the present time, although occasionally it may be introduced from farther south on domestic animals or man" (Wilson 1961).

Two more recent studies, one by Whitaker (1982) and the other by Demaree (1986), also failed to confirm *I. scapularis* as a member of the recent tick fauna in Indiana. [Between 1962 and 1978, Whitaker collected ticks from 54 species of mammals (including deer (*Odocoileus virginianus*) and white-footed mice (*Peromyscus leucopus*), two of the most favored hosts of *I. scapularis*) and reported no *I. scapularis*.] Demaree (1986), who examined 12,377 tick specimens between 1982–1986, stated that "*Ixodes scapularis* is not an established species in Indiana but is frequently removed from people and pets returning from southern vacation trips" (Demaree 1986). Finally, an examination of the Purdue Entomological Research Collection, housed in the Department of Entomology at Purdue University, West Lafayette, Indiana in 2006, revealed only a single vial of *I. scapularis*; these had been collected in Georgia in 1946.

Lyme disease renews interest in ticks.—Toward the end of the 1970s, interest in ticks increased dramatically nation-wide following the discovery and description of Lyme disease in Connecticut (Steere et al. 1977) and the subsequent revelation that this disease was transmitted by ticks (Steere et al. 1978, 1979; Wallis et al. 1978). The tick species responsible for transmitting Lyme disease was described as a new species, *Ixodes dammini* (Spielman et al. 1979). It was given the common name, Damm-in's northeast deer ixodid, a name that was soon shortened to "deer tick." In the process of developing their species description, Spielman and coworkers examined tick specimens from other states, including one collected by W.S. Blatchley in Indiana in 1939, which they identified as a male *I. scapularis*.

By 1993, a preponderance of scientific evidence indicated that *I. dammini*, was a junior synonym of *Ixodes scapularis* Say (Oliver et al. 1993). Therefore, in literature published between 1979 and 1993 this species is reported either as *I. scapularis* (the blacklegged tick) or *I. dammini* (the deer tick).

The realization that the Lyme arthritis of Connecticut and the tick-associated skin rashes (erythema migrans) reported in Wisconsin (Scrimanti 1970) and in California (Naversen & Gardner 1978) were manifestations of the same disease, stimulated interest among medical entomologists to begin looking for the newly-described tick vector in other states.

Tick studies at Ball State, 1982–2006.—Tick studies began at Ball State University in 1982. Initially, these studies were funded internally, and their focus was to identify ticks submitted from around the state and to test them for Rocky Mountain spotted fever. Beginning in 1983 and continuing through 2001, the Rocky Mountain spotted fever tick-testing program was funded by the Indiana State Department of Health. Initially, Indiana's program was modeled after one at the Ohio State Department of Health's Vector-borne Disease Unit. Ticks were solicited from Indiana's veterinarians, sanitarians and nurses in local health departments and field personnel of the Indiana Department of Natural Resources. As word of the program spread, ticks began to arrive from private citizens, clinics, hospital laboratories, and even other states.

Specimens received during the first years of the program were made available to Herald

Demaree (Indiana State Department of Natural Resources) and were included in his publication *Ticks of Indiana* (Demaree 1986). During the early years of the program, almost all of the ticks submitted were American dog ticks (*Dermacentor variabilis*). In 1984, we received a tick which Herald Demaree identified as *I. scapularis*, but the tick had been attached to a Henry County resident who had just returned from Sarasota County, Florida. Through 1986, there was no direct evidence that a population of blacklegged ticks was established in Indiana.

Lyme disease in Indiana.—In spite of our inability to detect the presence of blacklegged ticks in Indiana in the early 1980s, cases of Lyme disease were diagnosed in the State. The first two cases were reported in Marion County (Indianapolis) in 1983 (Pinger et al. 1989). Tick exposure for one of these cases was possibly out-of-state; the other case was not able to be completed because a travel history was not obtained. The third reported case of Lyme disease in Indiana occurred in 1985, in a Jasper County resident. A search for ticks at the residence of this case immediately following the report failed to detect the presence of *I. scapularis* (Michael J. Sinsko, Indiana State Department of Health, pers. commun.). Five more probable and confirmed cases of Lyme disease were reported in Indiana in 1987, but at least two of these were imported (Pinger et al. 1989). Since 1987, cases of Lyme disease have been reported annually to the Indiana State Department of Health (James F. Howell, Epidemiology Resource Center, ISDH, pers. commun.). An annual average of 27 cases was reported during 1993–2006 (Centers for Disease Control and Prevention 2008).

Blacklegged ticks discovered in Indiana.—The first specimens of the blacklegged tick that were undeniably from populations established in Indiana were recovered from deer in 1987 (Pinger & Glancy 1989). That year, an informational letter and a tick mailing kit were sent to each official deer checking station requesting that any ticks found on deer be sent to our laboratory, the Public Health Entomology Laboratory, at Ball State University. In the ensuing weeks, four blacklegged ticks were sent to our lab from deer hunters or checking stations, one each from LaPorte, Marshall, Parke, and Porter counties. A fifth blacklegged tick, removed from a dog by a veterinarian,

arrived from Wabash County. But because of the dog's travel history, this tick was considered to have been imported.

The same procedure was followed in 1988 and 1989. No additional blacklegged ticks were submitted in 1988, but nine specimens were submitted in 1989, three from deer, three from dogs and three from humans. These specimens came from Marshall and Porter counties again, and also from Lake, Madison, Pike, St. Joseph, and Vigo counties.

In 1990, the first of our annual surveys of hunter-harvested deer was conducted. With the help of personnel from the University of Notre Dame, Indiana State University, Franklin College, and the Indiana State Department of Health, 729 hunter-harvested deer were examined for ticks at deer checking stations. Ticks were found on 13 of these deer. Infested deer were found in Newton, Porter, and Vigo counties. The highest infestation rate occurred at Willow Slough Fish and Wildlife Area in Newton County where 10 of 64 (16%) deer examined were infested with blacklegged ticks. One of these ticks was found to be infected with *Borrelia burgdorferi*, the spirochete that causes Lyme disease (Pinger et al. 1991). This was the first isolation of the Lyme disease agent in Indiana.

That same year, 16 additional specimens of *I. scapularis* were among the 1249 ticks submitted to Ball State as part of the Rocky Mountain Spotted Fever Tick Testing and Lyme Disease Surveillance Program. This brought the total number of blacklegged ticks collected in 1990 to 41. While most of these came from the counties previously mentioned, ticks were also received from Morgan, Starke, and Warren counties. By the end of 1990 there was evidence that the blacklegged tick, unreported before 1987, was present in 13 counties, most of which were located in the northwest quadrant of the state (Fig. 1).

Discovery of an established population of blacklegged ticks.—Through 1992, no immature *I. scapularis* had been collected in Indiana; all the records to this point were those of adult ticks. During the winter of 1992–1993, a vial of blacklegged ticks arrived from the person in Jasper County who had been diagnosed as Indiana's third case of Lyme disease in 1985. An investigation the following May resulted in the discovery of numerous adults and nymphs of *I. scapularis* in a wooded area immediately

south of the residence of this Lyme disease patient. An examination of the ticks from this site in May–June 1993 revealed that 33% of the adults and 9% of the nymphs were infected with spirochetes. Subsequently, 16 of 17 isolates were confirmed as *B. burgdorferi* by the CDC using PCR techniques (Pinger et al. 1996). In July and August, rodent trapping revealed that 82% of white-footed mice (*Peromyscus leucopus* Rafinesque) and 80% of the short-tailed shrews (*Blarina brevicauda* (Say)) were infested with ticks. Of the 522 ticks removed from these mammals, 503 were *I. scapularis*. Lyme disease spirochetes were isolated from 6% of the white-footed mice, but from none of the shrews.

Our experience has shown that examining deer for adult blacklegged ticks (deer checking during the hunting season) is the most efficient way to detect the presence of this species of ticks in an area. Deer checking was carried out annually from 1990 through 2001, the last year of state funding for the Rocky Mountain spotted fever tick testing and Lyme disease surveillance program at Ball State University. During this period, new county distribution records for the blacklegged tick were established each year. In addition, the percentage of deer harboring ticks and the number of ticks found on infested deer increased. Beginning in 1993, deer reduction hunts were initiated in selected state parks. Some years, deer were examined for ticks during these deer reduction hunts, as well as at official deer checking stations. By the end of 2001, the number of counties with records of blacklegged tick-infested deer was 36. During this same period (1991–2001), participants in the Rocky Mountain spotted fever tick testing and Lyme disease surveillance program continued to submit ticks to our laboratory. When these ticks are included with those collected through deer checking the total number of counties with a record of at least one blacklegged tick by 2001 was 48 (Fig. 2).

Following 2001, funding to support tick testing and active surveillance at deer checking stations was lost; and tick surveillance, including the checking of deer for ticks, became irregular. Additional county records were established as follows: Adams (2004); Carroll, Martin, Shelby, Steuben, Switzerland and Wayne (2005); Benton, Daviess, Jefferson and Lawrence (2006); and Union and Whitely



Figure 1.—Indiana counties with a record of the blacklegged tick, *Ixodes scapularis*, in 1990.

(2007). Some of these records were established by Keefe (2008). As of October 2008, records of the blacklegged tick have been established in 65 of Indiana's 92 counties. A map of Indiana's counties showing the year the first blacklegged tick was found in each county is presented in Fig. 3.

DISCUSSION

Over the past 80 years, Purdue University entomologists and the State Entomologist have reported numerous entomological invasions that have threatened plant and animal health and the State's economy. Examples include



Figure 2.—Indiana counties with a record of the blacklegged tick, *Ixodes scapularis*, in 2001.

invasions by the European corn borer, the face fly, the Gypsy moth and the emerald ash borer. Occasionally, pests that affect human health have also been introduced: the German yellow jacket, the Asian tiger mosquito, and more recently, the mosquito, *Aedes japonicus*.

Although the re-establishment of the blacklegged tick in Indiana may not have a direct impact on Indiana's economy, it may have a

significant effect upon the health of its citizens. Through 2007, more than 400 suspected or confirmed cases of Lyme disease have been reported in Indiana residents (James Howell, Indiana State Department of Health, pers. commun.), including 55 cases in 2007 (CDC 2008). Many more cases have undoubtedly occurred but have not been reported. The incidence rate for Lyme disease in Indiana in

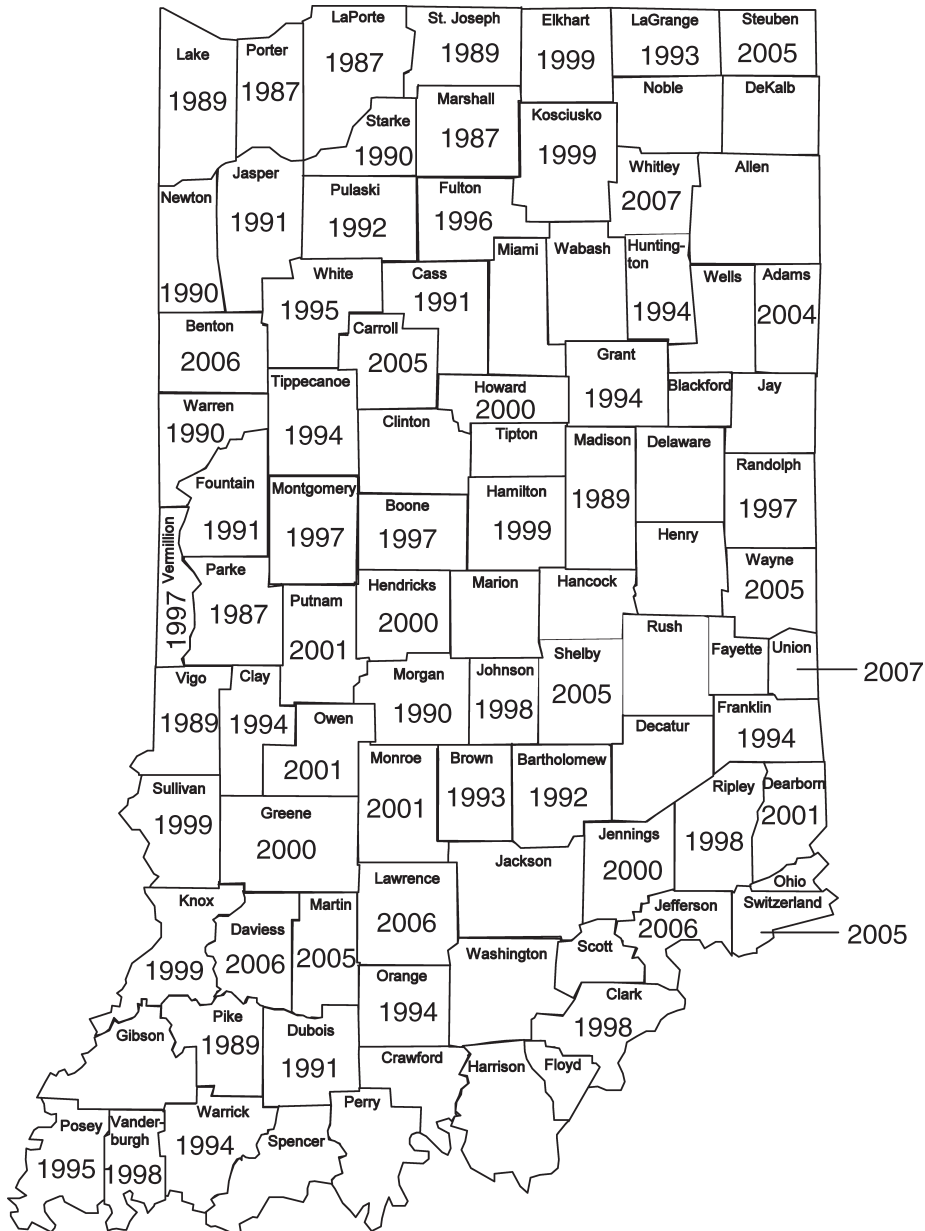


Figure 3.—Establishment of the presence of the blacklegged tick, *Ixodes scapularis*, in Indiana by county and by year, through 2007.

2007 was 0.9 cases per 100,000—more than double the 2006 rate of 0.4 cases per 100,000 (CDC 2008).

While there is little reason to believe that the incidence of Lyme disease in Indiana will reach the levels experienced in Connecticut (87.3 cases per 100,000) where the disease was first discovered, neither is it safe to assume that case

rates will decline in the near future. For comparison, the incidence rates in adjacent states are 1.2 per 100,000 in Illinois and 0.3 per 100,000 in Ohio (CDC 2008).

The presence of ample deer populations throughout most of Indiana suggests that *I. scapularis* will eventually be found in all of Indiana’s 92 counties. In some counties, such as

Pulaski County, both deer and tick populations are already quite high. Examination of 40 hunter-harvested deer checked at Jasper-Pulaski Fish and Wildlife Area in 2005 revealed that 33 of them (82.5%) were infested with blacklegged ticks (unpubl. data). At nearby Tippecanoe River State Park in 2004 *Borrelia burgdorferi*-infection rates of adult blacklegged ticks were well above 50% (Steiner et al. 2008). As the blacklegged tick becomes better established, the day may come when virtually all hunter-harvested deer are infested with blacklegged ticks. The spread of these ticks is further enhanced when hunters carry their infested deer carcasses home.

Finally, it should be noted that, in addition to transmitting Lyme disease, *I. scapularis* transmits human babesiosis (Spielman et al. 1985) and human anaplasmosis (Magnarelli et al. 1995; Pancholi et al. 1995; Telford et al. 1996). Although none of the *I. scapularis* collected in Indiana and examined during a recent study were found to harbor *Babesia microti* (the agent of human babesiosis) and, as far as is known, no human cases of babesiosis have been reported in Indiana, 5% of the ticks collected in Pulaski county were positive for *Anaplasma phagocytophilum* (the agent of human anaplasmosis) (Steiner et al. 2008). The first two cases of human anaplasmosis in Indiana were reported in 2002 (James Howell, Indiana State Department of Health, pers. commun.).

It is important that both scientific and health care provider communities become aware of the health risks posed by the expanding distribution of *I. scapularis* in Indiana. This article is a contribution to the effort to increase that awareness.

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