

Lone Star Ticks (*Amblyomma americanum*):

An Emerging Threat in Delaware

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Abstract

Public health messaging in the eastern United States has historically underemphasized the risks posed by lone star ticks (*Amblyomma americanum*), focusing instead on blacklegged ticks (*Ixodes scapularis*). This gap persists despite mounting evidence that lone star ticks also play an important role in disease ecology as confirmed vectors for a wide variety of tick-borne pathogens. These pathogens include several distinct bacterial agents that cause ehrlichiosis and tularensis in humans and dogs, a protozoal agent that causes cytauxzoonosis in cats, and emerging viruses such as Heartland, Bourbon, and Tacaribe. Lone star ticks are additionally linked to Rocky Mountain spotted fever, southern tick-associated rash illness, and alpha-gal syndrome, a condition marked by immune reactions to ingestion of mammalian meat. Moreover, their distribution in North America is expanding due to changing climatic factors and land use patterns. Lone star ticks are the most commonly encountered tick in Delaware, especially in Sussex and Kent Counties, and make up the vast majority of ticks collected in the first two years of the state's tick surveillance program. Given the magnitude of lone star ticks' medical and veterinary import, it is vital for healthcare professionals and health educators to devote more attention to this emerging threat.

Introduction

Lone star ticks (*Amblyomma americanum*) have long been noted as aggressive human biters whose bites leave irritating, itchy wounds, but their greater importance in public health has been historically underrecognized. They are the most common human-biting ticks in Delaware and in the United States as a whole.¹ Lone star ticks are associated with bacterial, viral, and protozoal pathogens as well as a newly recognized allergy to mammalian products (alpha-gal syndrome). Nonetheless, they are often overshadowed by blacklegged or "deer" ticks (*Ixodes scapularis*) in the public health sphere. This dearth of attention has resulted in a shortage of effective control methods for this species and may contribute to incorrect diagnoses and/or substandard treatment for associated diseases.

In contrast to ticks that use an ambush strategy (i.e., lying in wait for a host to move by), lone star ticks actively seek hosts, attracted by carbon dioxide and vibrations from host movement.² To complete their life cycle, lone star ticks must take three blood meals, each from a different individual host; all three motile stages (larvae, nymphs, and adults) will readily feed on humans in addition to other vertebrate hosts. Each blood meal represents a possible exposure to pathogenic agents. Generally, the bite of a larval tick is considered less dangerous than the bite of a nymphal or adult tick because the larvae are feeding for the first time and thus have not had

prior exposure to infected hosts. There is an increasingly recognized possibility, however, that some larvae may be infected by transovarial transmission of pathogens from the mother tick, irrespective of fed versus unfed status^{1,3}; thus, all stages of lone star ticks should be considered possible threats to humans and other hosts.

The first lone star tick specimen collected in Delaware was reported 75 years ago.⁴ At that time, it was not considered established in the state (i.e., there was no documentation of populations surviving year-round), and Virginia was considered the northernmost extent of its normal range. In the intervening decades, however, they have invaded, established, and supplanted blacklegged ticks and American dog ticks (*Dermacentor variabilis*) as the most commonly encountered tick species in the state. This range expansion is attributed to changing climatic factors such as shorter, milder winters, as well as the increasing abundance of preferred hosts like the white-tailed deer (*Odocoileus virginianus*), which in turn is facilitated by reduced predation pressure and changing land use patterns (e.g., forest fragmentation, suburbanization, and increased availability of edge habitat).²

Lone star ticks are abundant in the southeastern and south-central United States, and within Delaware they are more common in the southern counties than in New Castle County. Despite their widespread presence, they are underappreciated as a threat to human and veterinary health. Much of our public health messaging (e.g., signage at state parks and other public lands, as well as in clinics and veterinary clinics) pertains to blacklegged ticks and specifically the risk of acquiring Lyme disease. This focus on blacklegged ticks has heretofore been justified by the fact that Lyme disease is the most common tick-borne infection in the country, and lone star ticks are unable to vector the Lyme disease-causing spirochete and thus do not play an appreciable role in that disease cycle.⁵ Although Lyme disease remains the most common tick-associated disease in Delaware,⁶ this focus on one tick species and one disease suggests that other tick species and tick-borne pathogens are unimportant, when in fact they are associated with serious health outcomes.

Medical Significance of Lone Star Ticks

Bacterial agents

The association between ehrlichiosis and lone star ticks was discovered in 1990. Prior to this recognition, lone star ticks were considered nuisance biters but of generally low public health importance.⁷ Ehrlichiosis is a catch-all term for disease caused by infection with *Ehrlichia* bacteria. Lone star ticks are capable vectors of at least three known pathogenic species in this genus: *E. chaffeensis*, *E. ewingii*, and “Panola Mountain” *Ehrlichia*.⁸ Reported ehrlichiosis cases have steadily increased since reporting began in 1999.⁹ Symptoms include fever, chills, headaches, muscle aches, nausea, and vomiting. A subset of patients, particularly those who are older or immunocompromised or those who do not receive adequate antibiotic treatment in early stages, may experience more severe illness marked by neurological complications, respiratory failure, and organ failure, which can result in death.⁹ The non-specific presentation of ehrlichiosis can delay or complicate diagnosis. Importantly, some antibiotics that are prescribed for Lyme disease are not effective against ehrlichiosis, and prophylactic use of antibiotics is not recommended for the latter.¹⁰

Another bacterial infection associated with lone star ticks is tularemia. Along with other tick species and some mosquito and biting fly species, lone star ticks can transmit the causative

agent, *Francisella tularensis*. This pathogen merits further scrutiny as a possible agent of bioterrorism, and presents with a wide range of clinical signs and symptoms, from fever and enlarged lymph nodes to skin lesions, sepsis, and meningitis.¹¹ Lone star ticks are specifically linked to Type A1, the most virulent strain, based on geographic distribution data.¹²

Lone star ticks are capable of transmitting *Rickettsia rickettsii*, the causative agent of Rocky Mountain spotted fever, in a laboratory setting.¹³ Whether they can do so in nature remains unconfirmed, but some recent authors consider it a strong possibility.^{14,15} Indeed, infection rates of lone star ticks with *R. rickettsii* have been recorded as higher than those in American dog ticks, long considered the major vector of this pathogen.¹⁴ Rocky Mountain spotted fever is considered among the most severe tick-associated illnesses globally because of its mortality rate.¹⁴ Clinical signs and symptoms include fever, aches, nausea, and a distinctive rash.¹⁶

Other *Rickettsia* species have been isolated from lone star ticks, including *R. parkeri*, the agent of Tidewater spotted fever, which is more typically associated with Gulf Coast ticks (*Amblyomma maculatum*).¹⁷ In places where both of these tick species occur (which includes Delaware), spillover of *R. parkeri* from Gulf Coast ticks feeding on the same hosts as lone star ticks could infect the latter and further increase the risk of transmission to humans.¹⁷ Lone star ticks have the ability to transmit *R. parkeri* transovarially (i.e., female ticks can lay already-infected eggs, meaning that even the bite of a larval tick could transmit the pathogen).³ Lone star ticks are also frequently infected with *R. amblyommatis*, another member of the spotted fever group rickettsiae. While some authors refer to this species as non-pathogenic, there are reports that it can cause clinical illness, with symptoms resembling those of other spotted fevers.¹⁸ If its pathogenic status is confirmed, an additional concern for this species is that it can be transovarially transmitted.¹

Lone star ticks are the presumptive vector for a condition called southern tick-associated rash illness (STARI). This disease occurs in the southern United States and bears a resemblance to Lyme disease, especially with regard to the appearance of an erythema migrans or “bull’s-eye” rash, although STARI is noted to have milder symptoms.¹⁹ The etiologic agent has not yet been identified (although it is suspected to be a species of *Borrelia*, given the similarities to Lyme disease) and thus it has not been conclusively linked to a vector species, but the distribution of STARI cases closely overlaps with the geographic range of lone star ticks and case data indicate that patients reported tick bites prior to the onset of symptoms. Due to the absence of a confirmed agent, diagnosis of STARI depends on clinical signs and symptoms, geography, and exposure to tick bite.¹⁹

Viral agents

Bourbon virus and Heartland virus are emerging diseases whose causative agents are vectored by the lone star tick.²⁰ Symptoms for both viral infections include fever, fatigue, headaches, and joint or muscle aches.²¹ An additional virus, Tacaribe, has also recently been isolated from lone star ticks, although its pathogenicity to humans is unknown.²² These viruses belong to three different families (Orthomyxoviridae, Phenuiviridae, and Arenaviridae, respectively), indicating that lone star ticks are capable of carrying a wide variety of viral agents. These viruses have not yet been detected in Delaware; Tacaribe was detected in Florida, whereas Heartland and Bourbon occur in the Midwest, however, ticks’ movement via wildlife hosts, especially migratory birds, means that ticks infected with novel pathogens could be introduced into a given area at virtually any time, so vigilance needs to be consistent.²³ There are no specific treatments

or vaccines available for these viruses; medical providers' options are limited to treating the symptoms to make the patient more comfortable.²¹

Alpha-gal syndrome

Alpha-gal syndrome (AGS) is distinct from other tick-associated illnesses because it does not involve an infectious agent. The clinical illness is not induced by infection with a pathogen, but by an immune reaction to the presence of alpha-gal (a sugar) in the bloodstream. Alpha-gal, or more accurately, galactose-alpha-1,3-galactose, is naturally found in mammals except for humans and other catarrhine primates (i.e., apes, Old World monkeys).²⁴ Lone star ticks that feed on a mammalian host may subsequently contain trace amounts of alpha-gal in antigens in their salivary glands, which is then injected into hosts.

In AGS patients, the immune system reacts to alpha-gal in the bloodstream as though it were a foreign invader: with an IgE-mediated allergic response, which varies in presentation from patient to patient. In milder cases, it may present as itching; pruritus is the most commonly reported symptom. More severe symptoms range from gastrointestinal distress to anaphylaxis. Even patients that have an extensive history of consuming and tolerating meat prior to the sensitizing event (i.e., tick bite) can develop this sensitivity.²⁵ Some patients additionally experience allergic reactions to dairy foods and pharmaceutical products that contain gelatin and other mammalian products. A key example is the cancer-fighting drug cetuximab; patients' adverse reactions to this drug were the initial event that launched investigations into AGS. By 2011, the link between ticks and AGS was established. Unlike some other food allergies, in which reactions occur more or less immediately, reactions to alpha-gal typically occur several hours after ingestion. Not every exposure to alpha-gal results in an allergic reaction.²⁵ Delayed diagnosis of this condition presents serious risks as this allergy can manifest as serious reactions. At this time, there is no treatment for AGS; clinical guidance includes avoiding mammalian products, carrying an epinephrine injectable device, and taking antihistamines as needed.²⁶

Lone Star Tick Activity in Delaware

The newly established statewide tick program within the Delaware Department of Natural Resources and Environmental Control, Division of Fish and Wildlife, Mosquito Control Section has collected lone star ticks at each of the 20 sites that were surveilled in 2019-2020. Lone star ticks were collected in each month from April-November, with an adult activity peak in June, a nymphal activity peak in July, and a larval activity peak in August. This species made up 94.7% of total ticks collected in 2020 as of early December. Of those, 92.1% were in the larval stage. Larvae typically cluster in dense aggregations, colloquially called "tick bombs." During the months lone star ticks were active, the mean densities of questing lone star ticks were numerically higher in Sussex and Kent Counties (552.9 ticks/km and 450.1 ticks/km, respectively) than in New Castle County (97.4 ticks/km).

Between 1998 and 2019, 430 ticks from Delaware were submitted to the Army Public Health Center's Tick-Borne Disease Laboratory (TDBL) in Aberdeen Proving Grounds, Maryland for pathogen testing.²⁷ Lone star ticks were the most common species submitted, making up 62.3% of total ticks. Four (1.5%) ticks tested positive for pathogens; two were positive for *Ehrlichia ewingii*, one for *Ehrlichia chaffeensis*, and one for *Borrelia* sp. They were submitted each month between March and October, with a peak in June (32% of lone star ticks submitted that month). The majority (75.3%) were submitted from Kent County, where Delaware's only military base,

Dover Air Force Base, is located; the TDBL serves Department of Defense personnel and their dependents.²⁷ Most (51.3%) were in the nymphal stage. Nymphs are noticeably smaller than adults and thus harder to detect; adults are more likely to be seen or felt and removed before they bite or before they transmit pathogens. Larvae, in turn, are even smaller than nymphs; they are small enough to avoid detection even after engorging with blood, and additionally present the lowest risk of pathogen transmission, thus explaining why nymphs comprise the majority of submitted ticks.

Lone star ticks were also the most frequently-submitted tick species from Delaware at the University of Massachusetts tick-testing lab (69.7% of total ticks submitted from January 2008-September 2020).²⁸ Lone star ticks were submitted in each month from March to October; June was the peak month for submission, followed by July and September. Most (73%) were submitted from Sussex County, and most (85.9%) were in the nymphal stage. Relatively few (2.17%) of submitted ticks were infected; 2 of 126 ticks tested positive for *Borrelia lonestari*, a spirochete in the relapsing fever group, and 1 of 110 ticks tested positive for *Ehrlichia ewingii*.²⁸ Although overall incidence of infection is low in submitted ticks thus far, their sheer abundance and proclivity to bite humans renders them a significant threat as a vector. The most common attachment sites for human-biting lone star ticks submitted from Delaware include the upper leg (19.2%), groin (19.2%), lower leg (11.5%), back (11.5%), and armpit (6.2%).²⁸

Veterinary Significance of Lone Star Ticks

Some of the pathogens of medical concern listed above are also of veterinary importance. *Francisella tularensis* causes tularemia or “rabbit fever” in dogs. *Ehrlichia chaffeensis* and *E. ewingii* cause ehrlichiosis in dogs (canine ehrlichiosis), as does *E. canis*.²⁹ Ehrlichiosis is reportedly more severe in certain breeds (e.g., German Shepherds) and can be marked by lethargy, weakness, bleeding disorders, nervous system involvement, and bone marrow damage.²⁹ Lone star ticks also carry the protozoan parasite *Hepatozoon americanum*, causing hepatozoonosis; dogs become infected not when bitten by the tick, but if they ingest the tick (i.e., while grooming). Hepatozoonosis is characterized by muscle weakness, muscle atrophy, and nerve damage.²⁹ Lone star ticks usually attach to dogs ventrally, on the abdomen, axillary, or inguinal regions. They made up 19.1% of total ticks collected from dogs in the U.S.,³⁰ however, in Delaware they appear to be a greater threat. These ticks comprised 40% of the ticks submitted to the state surveillance program collected from dogs in 2019 and 55% in 2020, as of early December.

In cats, lone star ticks usually attach ventrally at the tail and perianal region.³⁰ An agent of feline disease vectored by lone star ticks is the protozoan parasite *Cytauxzoon felis*, which causes cytauxzoonosis. Clinical signs of this disease include lethargy, loss of appetite, dehydration, fever, enlarged spleen, and enlarged liver; the mortality rate is high but treatment with antimalarial drugs can be effective.³¹ Lone star ticks comprised 38.5% of ticks collected from U.S. cats³⁰; they made up 42.5% of the ticks collected from cats in Delaware in 2019 and 80% in 2020, as of early December.

Lone Star Tick Ecology and Control Options

Lone star ticks are thriving in the southern and Mid-Atlantic states partly because of their host and habitat preferences. Their preferred hosts (white-tailed deer, wild turkeys, red foxes, gray foxes, coyotes, raccoons, and opossums) all occur in Delaware, and most are species that have

benefited from increased suburbanization and forest fragmentation. Lone star ticks prefer second-growth forest, which is abundant throughout their reported range. Although they are currently more common in Sussex and Kent Counties, it is likely that they will become more established in New Castle County as well in the coming decades. They have a broader habitat range than blacklegged ticks and are more tolerant of lower humidity. Modeling indicates they will continue spreading northward and westward.³²

Many of the best-known tick control methodologies were developed to control blacklegged ticks and are not effective in controlling lone star ticks. For example, interventions that target rodents, such as acaricide-treated “tick tubes” and rodent bait boxes, are ill-suited to control lone star ticks because these ticks do not preferentially feed on rodents.³³ An additional challenge is posed by lone star ticks developing resistance to acaricides.³³ An alternative method that may be better suited to control this species is the use of traps baited with carbon dioxide as an attractant. Although these traps have typically been used for surveillance and research purposes rather than control and thus are not commercially available, a homemade version can be assembled using coolers, dry ice, and double-sided carpet tape.³⁴

Some of the personal protective measures initially developed for other tick species or other arthropods are effective against lone star ticks. Permethrin-treated clothing and application of sprays containing DEET as an active ingredient provide protection against lone star ticks in the field.^{35,36} Removing leaf litter from yards, particularly in the areas most frequented by people and pets, can also reduce lone star ticks’ survival rates over winter, as they rely on humid microclimates, although impacts on non-target, beneficial arthropods should be considered.³³

Outreach for Tickborne Diseases in Delaware

During 2017-2019, Delaware Division of Public Health (DPH) received federal grant funding dedicated to education and prevention outreach for tickborne diseases. Modeled after a program in Connecticut,³⁷ the Delaware BLAST Lyme Disease Campaign officially kicked off in May 2018. The intention of the BLAST Lyme Disease Campaign was to increase awareness of ticks and tickborne diseases while also promoting prevention strategies to keep Delawareans healthy. A health educator traveled throughout all three Delaware counties to schools, kids camps, libraries, community centers, and health fairs to promote the BLAST campaign (Bathing after coming indoors, Looking for ticks on your body by doing frequent tick checks, Applying repellent, Safeguarding your yard against ticks to help reduce tick habitats, and Treating your pets against tickborne diseases). As noted above, these personal protective measures are effective against lone star ticks as well as other common human-biting tick species. During the two years the outreach was implemented, the program reached over 3,000 Delawareans ranging in age from kindergarteners to residents of senior living facilities. “BLAST” received positive feedback from local and state media. Requests for outreach and presentations far exceeded available capacity. One of the most frequently asked questions during presentations pertained to lone star ticks and rumors of a “red meat allergy” (i.e., alpha-gal syndrome), indicating that the public is concerned about the risks associated with this tick species. “BLAST” provided a forum to explain the serious health complications of tickborne illnesses, such as alpha-gal syndrome. All around, recipients of the educational services reported substantial increase in knowledge and a greater likelihood to practice prevention strategies, according to program surveys. Unfortunately, due to competing interests, federal grant funding was not received after 2019.

Impact of COVID-19 and Conclusions

Tick-borne infections in general are an ever-increasing threat in the United States, and the COVID-19 pandemic has indirectly contributed to this threat, making 2020 an especially challenging year in this regard. Delays in diagnosis and treatment of tick-borne infections have resulted from COVID-19-related issues,³⁸ and stay-at-home orders and reduced access to indoor recreational outlets have likely contributed to more people spending time outdoors compared to past years.³⁹ Additionally, public health agencies that typically help to control and manage ticks and tick-associated illnesses have seen a diversion of personnel and funding to cope with the COVID-19 crisis instead.⁴⁰ It is important to find ways to respond to the coronavirus pandemic without diminishing vigilance for tick-borne infections and our preparedness to handle them as they arise.

The apparent attitude towards lone star ticks among the public and within the medical community often borders on nonchalance. Tick bite victims and/or their healthcare providers may be more concerned about blacklegged/“deer” ticks and feel relatively unconcerned about other species. Unfortunately, this dismissive stance is not supported by evidence. A growing body of research, summarized above, indicates that lone star ticks are associated with a wide range of health threats, some with possibly severe outcomes. As lone star ticks become further established in Delaware and more people and pets come into contact with them, it is imperative that we raise awareness of the serious risks they pose.

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