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Range Expansion of Native and Invasive Ticks: A Looming Public Health Threat

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Abstract

Native and invasive tick species pose a serious public health concern in the United States. Range expansion of several medically important tick species has resulted in an increasing number of communities at risk for exposure to ticks and tick-borne pathogens.

Keywords

tick; tickborne pathogens; invasion; range expansion; public health

Native and invasive tick species are serious public health concerns in the United States (US). The range expansion of medically important ticks (blacklegged tick, *Ixodes scapularis*; lone star tick, *Amblyomma americanum*; Gulf Coast tick, *Amblyomma maculatum*) has placed new communities at risk for tick exposure [1], and novel pathogens associated with these ticks have been discovered in recent decades [2, 3]. The number of reported tickborne disease (TBD) cases increased from 22 527 in 2004 to 50 865 in 2019, for a total of 649 628 [4], but the actual case number is undoubtedly higher. Most TBD cases are associated with *I. scapularis*, the primary vector of *Borrelia burgdorferi* and *Borrelia mayonii* (Lyme disease), *Borrelia miyamotoi* (*B. miyamotoi* disease), *Anaplasma phagocytophilum* (anaplasmosis), *Ehrlichia muris eauclairensis* (ehrlichiosis), *Babesia microti* (babesiosis), and Powassan virus (Powassan virus disease) [2, 3]. Climate warming, anthropogenic environmental changes, and increases in populations of key animal hosts, particularly white-tailed deer,

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which were decimated in the northern part of the eastern US in the 1800s and early 1900s but then rebounded in the last half century, have allowed *I. scapularis* and other tick species to proliferate and expand their ranges [5]. Additionally, human encroachment on tick habitat has led to increased human–tick contact.

Accelerated trade, international travel, and wildlife transport provide increasing opportunities for exotic ticks and pathogens to invade the US. The invasive Asian longhorned tick, *Haemaphysalis longicornis*, was discovered in 2017 to be present in New Jersey and has since been documented in 17 mostly eastern states, with established populations as far north as Connecticut [6, 7] (Figure 1). As this species survives in an expansive range of climatic conditions, has a wide host range, and can reproduce parthenogenetically, it will likely spread to and establish populations across a large portion of the US. Human bites by *H. longicornis* have been recorded in the US [7], but it remains to be seen how frequently this species will infest humans.

Haemaphysalis longicornis has been documented to be infected with a wide range of viral, bacterial, and parasitic disease agents in Asia, but its vector potential remains unclear for many of these pathogens. In the US, genetic materials from *B. burgdorferi*, *A. phagocytophilum*, *B. microti*, and Bourbon virus have been detected in field-collected host-seeking *H. longicornis* [8–10] (Molaei, unpublished data). Experimental studies indicate that *H. longicornis* is a vector of *Rickettsia rickettsii*, the Rocky Mountain spotted fever agent, but is unlikely to serve as a vector of *B. burgdorferi* or *A. phagocytophilum*, as these pathogens appear not to survive the molt from one life stage to the next in sufficient numbers for transmission to occur during a subsequent blood meal [11–13]. However, there is evidence for frequent partial bloodmeals in host-seeking *H. longicornis*, which potentially could lead to pathogen transmission during a secondary partial bloodmeal in the same life stage if the first partial bloodmeal came from a pathogen-infected host (Molaei, unpublished data). For viral pathogens, experimental acquisition and transmission by *H. longicornis* was demonstrated for Heartland virus, which is primarily transmitted by *A. americanum* [14].

Amblyomma maculatum occurs along the Atlantic coast and Gulf of Mexico. Established populations have recently been identified in states well north of the historically recognized range from the mid-1900s, including in Arkansas, Illinois, Kentucky, North Carolina, several mid-Atlantic states (Virginia, Maryland, and Delaware), and more recently in Connecticut and New York [1, 15, 16] (Figure 1). Judging by low genetic variation and high levels of gene flow among expanding populations of *A. maculatum*, these northward range expansions are likely recent. Immature *A. maculatum* are commonly associated with birds and adults with white-tailed deer, facilitating continued range expansion [15]. This tick, which can bite humans in all life stages, is the primary vector of *Rickettsia parkeri*, a newly discovered pathogen causing an eschar-associated rickettsiosis comparable to but milder than Rocky Mountain spotted fever [2, 3, 15].

Amblyomma americanum has a wide distribution, ranging from the Atlantic coast west to central Texas and Oklahoma, eastern Kansas and Nebraska, and north to the southern parts of Iowa, Illinois, and Indiana, with occasional reports also from Ohio, Pennsylvania, and Wisconsin [2]. By the early 1990s, its northern range had expanded to southern New

Jersey, Long Island, and Fire Island, New York [1, 17, 18]. Moreover, breeding populations were reported from the Northeast, including Suffolk County, New York, in 1971; Newport County, Rhode Island, in 1986; Somerset and Middlesex Counties, New Jersey, in 2017; Fairfield and New Haven Counties, Connecticut, in 2018 and 2019, respectively; and Barnstable, Nantucket, and Dukes Counties, Massachusetts, in 2019 [18] (Figure 1). The northward expansion likely represents the tick reclaiming the historical range before its favored host, white-tailed deer, was decimated in the Northeast in the 1800s and early 1900s.

Amblyomma americanum is an aggressive human biting tick associated with a growing list of human diseases and medical conditions, including ehrlichiosis (*Ehrlichia chaffeensis*, *Ehrlichia ewingii*, and Panola Mountain *Ehrlichia*), Heartland virus disease, Bourbon virus disease, and red meat allergy (α-gal syndrome [AGS]) [2, 3]. Cases of the emerging tick bite–induced food allergy AGS were first reported in 2009 in the US, and the number of confirmed cases increased to 34 000 by 2019. It is estimated that nearly 3% of the US population might have AGS [19]. Moreover, *A. americanum* is likely an occasional vector of *Francisella tularensis* (tularemia) as well as *R. rickettsii* and *R. parkeri* [3]. This tick has also been found to be infected with *Rickettsia amblyommatis*, a spotted fever group *Rickettsia* species of still undetermined importance as a human pathogen [3]. *Amblyomma americanum* can be highly abundant locally, leading to individuals receiving numerous bites, which can be highly irritating, even in the absence of pathogen transmission or allergic reactions.

The ongoing range expansion and establishment in new areas of *H. longicornis*, *A. maculatum*, and *A. americanum,* coupled with the persistent and expanding threat posed by *I. scapularis*, highlights the increasing public health challenges associated with ticks and TBDs. The convergence of medically important ticks in new areas, overlapping ranges of ticks and their associated pathogens, and the recognition of novel tick-borne pathogens (6 of the 15 human pathogens transmitted by hard ticks in the US were described in the past 2 decades) poses an elevated risk for human infections and coinfections with tick-borne pathogens in areas where pathogen transmission was previously absent or rare. Hospitable environmental conditions combined with abundant hosts serving as blood meal sources and/or pathogen reservoirs set the stage for native ticks to continue to proliferate and exotic ticks to succeed in establishing populations, if introduced.

To monitor changes in the distribution, abundance, and phenology of native and invasive ticks, and the presence and prevalence of tickborne pathogens, in 2018, the Centers for Disease Control and Prevention (CDC) introduced a national tick-based surveillance program [3]. This program aims to provide current and accurate information to clinicians, the public, and public health authorities on when and where persons are at risk for exposure to ticks and tick-borne pathogens, and to identify tick species–specific local risks to aid in diagnostic decisions and prevention recommendations [20,21]. Evaluation of tick behavior, host interactions, and vector competency for novel or recently introduced tickborne pathogens is also needed.

Rigorous inspection of imported goods, livestock, and companion animals is critical for prompt interception and identification of invasive ticks at ports of entry to the US. Because

exotic tick species, each associated with a unique suite of pathogens, may be misidentified as native species, it is important to improve national capacity for accurate detection and identification of exotic ticks and pathogens. To expand medical entomology expertise, the CDC established regional centers of excellence in vectorborne diseases [22]. Rapid implementation of effective control measures is critical to prevent the establishment of exotic ticks. The likelihood of success is greatest for species with narrow host ranges, particularly domestic animals, where ticks can be targeted on their main hosts. Tick species infesting a variety of wild animals, such as *H. longicornis*, may prove very challenging to eliminate once they have spread from the initial invasion location(s), but control within heavily used limited settings should be attainable.

Across native human biting species, evidence bases are inadequate for either tick bite prevention measures or environmental control methods to reduce TBD cases [23,24]. Deer-targeted approaches have potential to control both *I. scapularis* and *A. americanum* at a community-wide scale, but their use is limited by logistical and regulatory issues [24,25]. Consequently, the second iteration of the CDC-funded regional centers of excellence in vectorborne diseases (to be funded starting in 2022) will focus on tick bite prevention and tick control. Additionally, a unified pathway, akin to the pipelines used to develop vaccines and therapeutics, is needed to develop safe, effective, and acceptable tick control products for use in strategies proven to reduce human tick bites and TBDs [24]. For now, it is critical to remain aware of the changing risks of TBDs across the US and to continue to recommend and practice tick bite prevention, such as use of Environmental Protection Agency–registered repellents, daily tick checks, and avoidance of tick-infested areas.

References

1. Sonenshine DE. Range expansion of tick disease vectors in North America: implications for spread of tick-borne disease. Int J Environ Res Publ Health 2018; 15:478.
2. Eisen RJ, Kugeler KJ, Eisen L, Beard CB, Paddock CD. Tick-borne zoonoses in the United States: persistent and emerging threats to human health. ILAR J 2017; 58:319–35. [PubMed: 28369515]
3. Eisen RJ, Paddock CD. Tick and tick-borne pathogen surveillance as a public health tool in the United States. J Med Entomol 2021; 58:1490–502. [PubMed: 32440679]
4. Centers for Disease Control and Prevention. Tickborne disease surveillance data summary. Available at: https://www.cdc.gov/ticks/data-summary/index.html. Accessed 24 March 2022.
5. Paddock CD, Yabsley MJ. Ecological havoc, the rise of white-tailed deer, and the emergence of *Amblyomma americanum*–associated zoonoses in the United States. Curr Top Microbiol Immunol 2007; 315:289–324. [PubMed: 17848069]
6. Schappach BL, Krell RK, Hornbostel VL, Connally NP. Exotic *Haemaphysalis longicornis* (Acari: Ixodidae) in the United States: biology, ecology, and strategies for management. J Integr Pest Manage 2020; 11:21.
7. Molaei G, Little EAH, Williams SC, Stafford KC. First record of established populations of the invasive pathogen vector and ectoparasite *Haemaphysalis longicornis* (Acari: Ixodidae) in Connecticut, United States. J Med Entomol 2021; 58: 2508–13. [PubMed: 34185871]
8. Price KJ, Graham CB, Witmier BJ, et al. *Borrelia burgdorferi* sensu stricto DNA in field-collected *Haemaphysalis longicornis* ticks, Pennsylvania, United States. Emerg Infect Dis 2021; 27:608–11. [PubMed: 33496234]
9. Price KJ, Ayres BN, Maes SE, et al. First detection of human pathogenic variant of *Anaplasma phagocytophilum* in field-collected *Haemaphysalis longicornis*, Pennsylvania, USA. Zoonoses Publ Health 2022; 69: 143–8.

10. Cumbie AN, Trimble RN, Eastwood G. Pathogen spillover to an invasive tick species: first detection of bourbon virus in *Haemaphysalis longicornis* in the United States. Pathogens 2022; 11:454. [PubMed: 35456129]
11. Breuner NE, Ford SL, Hojgaard A, et al. Failure of the Asian longhorned tick, *Haemaphysalis longicornis*, to serve as an experimental vector of the Lyme disease spirochete, *Borrelia burgdorferi* sensu stricto. Ticks Tick Borne Dis 2020; 11: 101311. [PubMed: 31640938]
12. Stanley HM, Ford SL, Snellgrove AN, et al. The ability of the invasive Asian longhorned tick *Haemaphysalis longicornis* (Acari: Ixodidae) to acquire and transmit *Rickettsia rickettsii* (Rickettsiales: Rickettsiaceae), the agent of Rocky Mountain spotted fever, under laboratory conditions. J Med Entomol 2020; 57:1635–9. [PubMed: 32338290]
13. Levin ML, Stanley HM, Hartzer K, Snellgrove AN. Incompetence of the Asian longhorned tick (Acari: Ixodidae) in transmitting the agent of human granulocytic anaplasmosis in the United States. J Med Entomol 2021; 58:1419–23. [PubMed: 33590859]
14. Raney WR, Perry JB, Hermance ME. Transovarial transmission of Heartland virus by invasive Asian longhorned ticks under laboratory conditions. Emerg Infect Dis 2022; 28:726–9. [PubMed: 35202534]
15. Paddock CD, Goddard J. The evolving medical and veterinary importance of the Gulf Coast tick (Acari: Ixodidae). J Med Entomol 2015; 52: 230–52. [PubMed: 26336308]
16. Molaei G, Little EAH, Khalil N, Ayres BN, Nicholson WL, Paddock CD. Established population of the Gulf Coast tick, *Amblyomma maculatum* (Acari: Ixodidae), infected with *Rickettsia parkeri* (Rickettsiales: Rickettsiaceae), in Connecticut. J Med Entomol 2021; 58:1459–62. [PubMed: 33458776]
17. Rochlin I, Egizi A, Lindström A. The original scientific description of the lone star tick (*Amblyomma americanum*, Acari: Ixodidae) and implications for the species' past and future geographic distributions. J Med Entomol 2022; 59:412–20. [PubMed: 35024845]
18. Molaei G, Little EAH, Williams SC, Stafford KC. Bracing for the worst—range expansion of the lone star tick in the northeastern United States. N Engl J Med 2019; 381: 2189–92. [PubMed: 31800982]
19. Sharma SR, Karim S. Tick saliva and the alpha-gal syndrome: finding a needle in a haystack. Front Cell Infect Microbiol 2021; 11:680264. [PubMed: 34354960]
20. Fleshman AC, Graham CB, Maes SE, Foster E, Eisen RJ. Reported county-level distribution of Lyme disease spirochetes, *Borrelia burgdorferi* sensu stricto and *Borrelia mayonii* (Spirochaetales: Spirochaetaceae), in host-seeking *Ixodes scapularis* and *Ixodes pacificus* ticks (Acari: Ixodidae) in the contiguous United States. J Med Entomol 2021; 58: 1219–33. [PubMed: 33600574]
21. Foster E, Burtis J, Sidge JL, et al. Inter-annual variation in prevalence of *Borrelia burgdorferi* sensu stricto and *Anaplasma phagocytophilum* in host-seeking *Ixodes scapularis* (Acari: Ixodidae) at long-term surveillance sites in the upper midwestern United States: implications for public health practice. Ticks Tick Borne Dis 2022; 13:101886. [PubMed: 34929604]
22. Petersen LR, Beard CB, Visser SN. Combatting the increasing threat of vector-borne disease in the United States with a national vector-borne disease prevention and control system. Am J Trop Med Hyg 2019; 100:242–5. [PubMed: 30499427]
23. Eisen L Personal protection measures to prevent tick bites in the United States: knowledge gaps, challenges, and opportunities. Ticks Tick Borne Dis 2022; 13:101944. [PubMed: 35364518]
24. Eisen L, Stafford KC. Barriers to effective tick management and tick-bite prevention in the United States (Acari: Ixodidae). J Med Entomol 2021; 58:1588–600. [PubMed: 32372075]
25. Stafford KC III, Williams SC. Deer-targeted methods: a review of the use of topical acaricides for the control of ticks on white-tailed deer. J Integr Pest Manage 2017; 8: 19: 1–5.

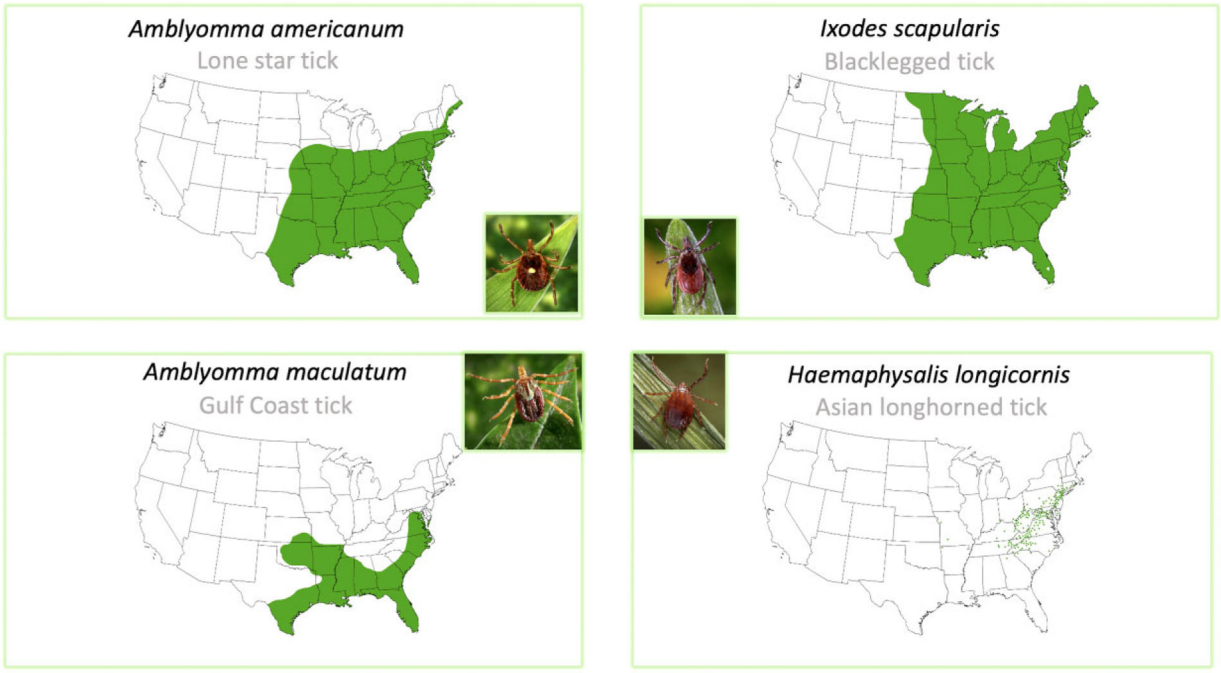

Figure 1.

Generalized distributions of human-biting tick species with expanding ranges in the eastern United States (US) in recent decades. Following range expansion in recent decades, the blacklegged tick (top right) can now be found throughout the eastern US. The ranges of the lone star tick (top left) and the Gulf Coast tick (bottom left) are currently expanding northward in the eastern US. The invasive Asian longhorned tick (bottom right) appears to be spreading north, west, and south after its discovery in New Jersey in 2017. Because surveillance data are insufficient to outline a generalized tick distribution, dots are used to indicate counties with collection records for this species (data kindly provided by the US Department of Agriculture). Tick images were provided by the Centers for Disease Control and Prevention (see https://www.cdc.gov/ticks/geographic_distribution.html).