# Burden of Tick-borne Infections on American Companion Animals

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This review examines the biology of ticks and tick-borne infections in the United States. The most common tick-borne diseases in dogs and cats are discussed. We demonstrate that there is much interest in tick-borne infections at the level of the lay public (pet owners), describe trends in the distribution and prevalence of tick-borne infections in the United States, summarize some issues in understanding the degree of ill health due to tick-borne infections, and suggest some avenues for research that would clarify these issues.


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More pathogens have been associated with ticks than any other bloodsucking arthropod but mosquitoes. Companion animals have always suffered from tick infestations. As veterinary medicine advances, signs and symptoms of disease that may have been missed before are now being detected. In addition, given the current trends of pet ownership and indeed treating companion animals as one of the family, there is more interest in the possible effects of tick infestation. Burden is an epidemiological concept that is based on the combination of prevalence and capacity of an infection to impact the health of a group of individuals. Therefore, we review the potential burden of tick-borne infections on companion animals and, in particular, those that affect dogs in the United States.

## Tick Biology

Hard ticks (ixodids) are so named because of the hardened dorsal shield or scutum. In female hard ticks, the scutum is on the anterior third of the body, with the remainder consisting of pleated, leathery cuticle that allows for tremendous expansion during bloodfeeding. In male hard ticks, which may or may not feed at all, the scutum extends the length of the body. In contrast, soft ticks have no scutum; their entire body is leathery. Soft ticks (argasids) are transient feeders and will only rarely be found attached. We focus our discussion on hard ticks because soft ticks rarely achieve great population densities and do not comprise a burden. (The spinose ear tick, *Otobius megnini*, may occasionally infest individual dogs in numbers that may cause dermatoses, but these ticks are restricted to small foci in the south-central United States and are not broadly encountered.) Hard ticks require several days to complete their bloodmeal; the number of days depends on the species and stage of the tick. Deer ticks (*Ixodes dammini*) will feed 3 days as a larva, 4 days as a nymph, and 7 days as the female. In the last day, usually in the last 3 or 4 hours of the bloodmeal, the tick takes what has been termed "the big sip," removing a large volume of whole blood, then detaching and dropping from the host.

Because they must remain attached for days, hard ticks secrete a complex mixture of anticoagulant, antiinflammatory, and antihemostatic agents that temporarily disable a host's local inflammatory response,[1] which might inhibit its feeding. Hosts that have never been exposed to ticks will not realize that a tick is attached. In contrast, soft ticks are similar to mosquitoes in their feeding, spending tens of minutes to no more than a few hours feeding, usually as their host is sleeping.

Tick life cycles have an extended duration, usually months or years. Deer ticks, for example, take 2 years to go from egg to egg. For this reason, there is generally no risk associated with hard ticks engorging and dropping off of a companion animal within a patient's home. The engorged tick will not feed again and will take weeks to molt or lay eggs, and, in the interim, usually the relative humidity within the house is too low for extended survival of the tick. Many of the pest tick species have very specific microhabitat requirements, including the need for high relative humidity and thus are found mainly in sites with dense grassy or herbaceous vegetation with a leaf litter understory. Brown dog ticks (*Rhipicephalus sanguineus*) are very resistant to heat and moisture deficits,[2] but require warmer temperatures for their complete life cycle. They are the only hard tick in which a complete life cycle may occur indoors, particularly within kennels.

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## Ticks Commonly Infesting Dogs and Cats in the United States

There are 800 described tick species globally, and 87 of these have been reported from North America (of which nearly half are hard ticks of the genus *Ixodes*). However, relatively few are common pests in the United States. Virtually all ticks found on dogs or cats are brown dog ticks (*Rhipicephalus sanguineus*), American dog ticks (*Dermacentor variabilis*), Rocky Mountain wood ticks (*D. andersoni*), Western dog ticks (*D. occidentalis*), Lone Star ticks (*Amblyomma americanum*), Gulf Coast ticks (*A. maculatum*), deer ticks (*I. dammini*), blacklegged ticks (*I. scapularis*), and woodchuck ticks (*I. cookei*). With the exception of *Dermacentor* spp (in which the subadults infest only rodents), all 3 stages (adult, nymph, larva) of the other common species may infest dogs. Good photographs are available online and may help identify a specimen to species. However, when ticks are partially fed or engorged, many of the easy morphologic features become obscured. The need for identification is not axiomatic: if dogs or cats are frequently infested, the owner would want to act to reduce infestation regardless of species. Although most concern relates to infectious agents, note that the vast majority of host-seeking ticks are not infected. Other than for the agent of Lyme disease in New England deer ticks (in which prevalence of spirochetal infection is commonly 35% to 65% in adult ticks,[3] typical infection rates for the agents of spotted fever, ehrlichiosis, tularemia, or babesiosis in their tick vectors is on the order of 0.1% to 1%. Accordingly, it might be useful to distinguish dog ticks from deer ticks in New England, if only to be alert for signs or symptoms of Lyme disease. Otherwise, tick identity would not affect a decision to try to reduce risk, either at the level of the individual (a topical formulation for pets, personal protection for the owner) or at the level of yards or neighborhoods (habitat management, judicious use of acaricidal spraying). Although focused on deer ticks, a good source for modes of prevention for any tick may be found at http://www.ct.gov/CAES/lib/caes/documents/special_features/TickHandbook.pdf.

## Ticks as Vectors

Ticks are notorious vectors for a diverse array of infections. The vectorial capacity of a bloodsucking arthropod depends on focusing bites on relevant hosts, and competence in sustaining the development of a pathogen and the density of the arthropod.[4] Tick vectorial capacity is a function of (1) the extended duration of their feeding and large amount of blood ingested, thereby concentrating minute amounts of pathogen circulating within the vertebrate vasculature, and (2) the great densities of infestations that might result from environmental perturbation. In addition, very host-specific ticks that feed throughout their life cycle on the same individual animal or at most on a single species of animal efficiently maintain pathogen life cycles by not wasting bites on irrelevant species. Ticks that are more indiscriminate in their feeding habits have many opportunities to transfer potential pathogens between species, thereby serving as "bridge vectors." Ticks have long been known as important veterinary pests and sources of infection. Indeed, the seminal report of the life cycle of the agent of Texas cattle fever (*Babesia bigemina*) by Smith and Kilborne in 1893 served to start the field of medical and veterinary entomology.

## Significance of Tick Infestation for Companion Animals

Ill health from tick infestation is due to (1) repeated infestation and engorgement of dozens of adult ticks at a time, promoting anemia or immune suppression, (2) tick paralysis induced by a toxin secreted in the saliva of certain ticks, (3) effects of sensitization or secondary bacterial infection of bite sites, causing granulomatous dermal reactions or pyogenic lesions, and (4) disease resulting from infection transmitted by a tick. Although occasional low-level tick infestations of dogs or cats are arguably harmless and should not incite panic, repeated identification of attached ticks should prompt preventive measures to at least reduce the likelihood of direct injury. Anemia or tick granulomas would be more likely with dense tick infestations, something that few companion animal owners should tolerate.

## Tick-borne Infections of Companion Animals

Dogs and cats may become ill because of infection by arboviruses (arthropod-borne viruses), bacteria, and protozoa transmitted by ticks. Good reviews of the biology and clinical features of these infections are available,[5,6] and we provide only a brief overview. The most burdensome of the tick-borne infections for dogs are ehrlichiosis and babesiosis, and for cats, cytauxzoonosis (a form of babesiosis). Canine ehrlichiosis due to *Ehrlichia canis* and canine babesiosis due to species complexes of *Babesia gibsoni* and *B. canis* have been known since the early 20th century. Both significantly contribute to the ill health of dogs across the New World and Old World tropics because of infestations of brown dog ticks. Infections may progress to a chronic disease resulting in immunosuppression and pancytopenia (tropical canine pancytopenia due to *E. canis*) or severe hemolysis and shock due to multiorgan ischemia (babesiosis). Fortunately, severe babesiosis is rare in American dogs, even though *B. gibsoni*-like complex parasites are endemic in some states.[7] Most cases are detected in dogs that were adopted from Latin America, or from small outbreaks in kennels that had kept such dogs. Interestingly, dog bites appear to be an important mode of exposure for canine babesiosis in the United States, undoubtedly because of transfer of parasitized red cells.[8]

Less severe forms of ehrlichiosis due to *Ehrlichia canis* are common in the United States. Although the agent is now classified as *Anaplasma phagocytophilum*, and "human granulocytic ehrlichiosis" is erroneously referred to as "human anaplasmosis,"[9] the disease is indistinguishable from that known as canine granulocytic ehrlichiosis due to *E. ew-*