

# LYME DISEASE IN CALIFORNIA

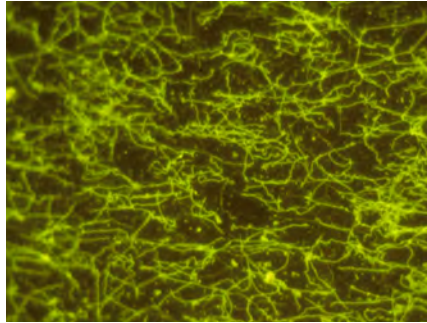
*Integrated Pest Management for Homes, Gardens, and Landscapes*

Lyme disease is a potentially serious disease, and can be localized or affect multiple body systems. In the United States, the disease is caused almost exclusively by the spirochete *Borrelia burgdorferi*, a corkscrew-shaped bacterium (Figure 1). Five additional species of Lyme disease-group spirochetes have been described from California, but only one of them, *Borrelia bissettii*, has been found to occasionally infect people.

Lyme disease spirochetes are transmitted to humans and other animals by the feeding activities of certain ticks. Of the 48 tick species established in California, 6 species attach to humans with some regularity, but only nymphs (an immature tick life-stage) and adult females of the western blacklegged tick, *Ixodes pacificus*, transmit *Borrelia burgdorferi* to people (Figures 2, 3 and 6). A closely related tick species, the blacklegged or deer tick (*Ixodes scapularis*), transmits *B. burgdorferi* in eastern North America, but that tick does not occur in California.

*Ixodes pacificus* has been reported in 56 out of 58 counties in the state. This tick has a broad host range and, as of 2007, has been recorded feeding on 108 species of lizards, birds, and mammals within the state. Moreover, it attaches to humans more frequently than any other tick species.

In northern California areas where Lyme disease occurs, usually about 1–2% of the adult *Ixodes pacificus* ticks and 2–15% of the nymphal ticks, on average, are infected with *Borrelia burgdorferi*. The risk of encountering infected nymphs varies spatially within a property and from year to year. Circumstantial evidence suggests that most persons infected with *Borrelia burgdorferi* acquire their infections following exposure to nymphs rather than adult ticks.



**Figure 1.** The causal agent of Lyme disease, *Borrelia burgdorferi*, shown in culture and magnified about 500X.



**Figure 2.** Nymph of the western blacklegged tick (*Ixodes pacificus*).

First recognized in the United States as an emerging disease in the mid-1970s in Lyme, Connecticut, Lyme disease has been reported in Canada and in many European and Asian countries. The first Lyme disease case in California was reported from Sonoma County in 1978. Lyme disease was designated a reportable disease in California and the United States in 1989 and 1991, respectively. Since 1989, more than 2,600 cases have been documented in California through 2014. The number of confirmed cases reported to state health authorities ranged from 57 to 97 per year between 2005 and 2014 (Figure 4, next page). Typical of all disease surveillance systems, the number of Lyme disease cases may be under-reported or misclassified (i.e., disease due to another cause).



**Figure 3.** Two adult males and an adult female of the western blacklegged tick in host-seeking posture before feeding.

Assuming these conditions apply across the United States, it is clear that the incidence of Lyme disease in California is much less than it is in highly endemic areas of the northeastern and upper midwestern United States. Overall, the incidence of Lyme disease in California is usually only 0.2 cases per 100,000 persons per year.

Nonetheless, certain California counties pose a much higher risk of contracting Lyme disease than others. For example, the highest average incidence from 2005 to 2014 occurred in the northwestern counties of Trinity (4.5), Humboldt (3.9), and Mendocino (3.9), as well as in the northern Sierra-Nevada counties of Sierra (3.2) and Nevada (2.7) (Figure 5). These county estimates vary slightly due to year-to-year variation in reporting, but the patterns of risk remain similar.

## PEST NOTES

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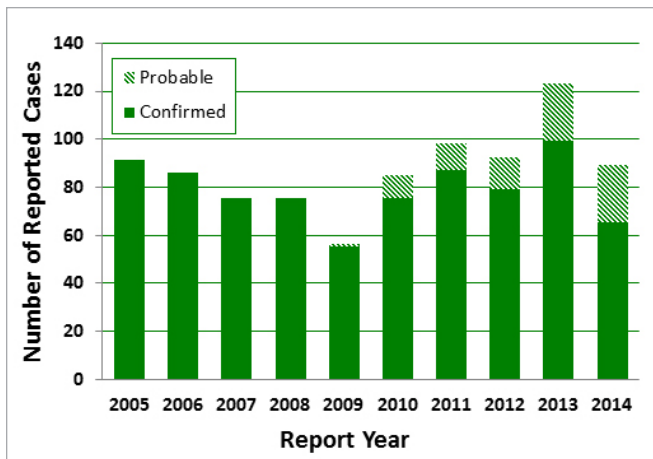


Figure 4. Confirmed and probable cases of Lyme disease reported to the California Department of Public Health, 2005-2014.

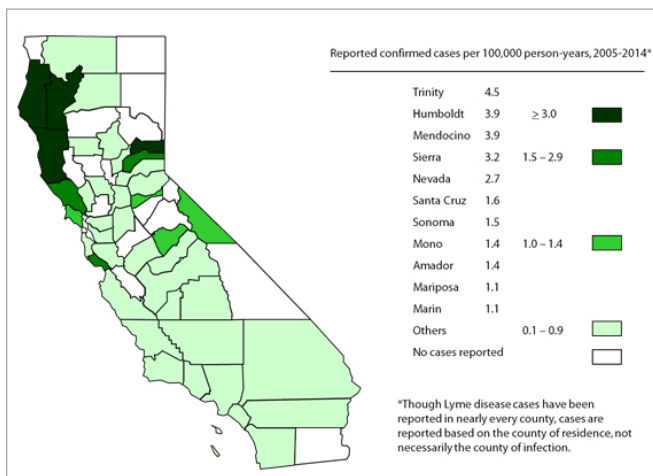


Figure 5. Incidence of confirmed Lyme disease cases by county and year of report, California, 2005-2014.

### TICK LIFE CYCLE AND BIOLOGY

There are two major families of ticks: the slow-feeding hard ticks (Ixodidae) and the rapid-feeding soft ticks (Argasidae). These have significantly different life histories. The hard ticks comprise roughly 80% of the 900-plus species of ticks described so far. Globally, four species of hard ticks in the genus *Ixodes* serve as primary vectors of *Borrelia burgdorferi* or closely related spirochetes to people.

All hard ticks have four life stages: the egg, and three parasitic stages that suck the blood of vertebrates, including two immature stages (larva and nymph) and the adult stage (Figures 3 and 6). After an immature or adult female feeds, protein digested from the blood meal is used by larvae or nymphs to complete metamorphosis to the next stage (larva to nymph, nymph to adult) or by female ticks to produce hundreds or thousands of eggs.

*Ixodes pacificus*, like all hard ticks, possesses plate-like body armor. Larvae and nymphs feed on birds, small mammals,

and especially lizards, for up to several days, whereas the adult females feed on medium- or large-sized mammals for about a week. Female ticks develop and eventually deposit 900-1,000 eggs in soil or litter areas.

The life cycle takes three years to complete, from the egg stage to egg-laying females, in the Hopland area of north-western California, but it may take less or more time than that throughout the broad geographical distribution of this tick in far-western North America.

### TICK IDENTIFICATION AND HABITAT

#### Know How to Recognize the Western Blacklegged Tick

In its unfed state, the nymph is about the size of a poppy seed or 1/25 inch long (Figures 2 and 6). It has eight legs, a dark brownish-black plate on its back, and a light-colored, translucent abdomen. Attached nymphs are especially prone to be overlooked because of their small size and somewhat reduced feeding time compared with adult female ticks.

The unfed adult female is about 1/8 inch long, has elongate, forward-projecting mouthparts, brownish-black legs, a dark brownish-black plate that covers the anterior half of her back, and a reddish-orange abdomen (Figures 3 and 6). Attached females feeding on a host become bloated, expanding to 3/8 inch in length or longer. While feeding, adult females increase their initial body weights 100-fold or more.

At 1/10 inch, adult males are smaller than females, oval-shaped, and brownish-black. Males attach to people infrequently compared to adult females, imbibe small quantities of blood, and therefore hardly increase in size. Adult ticks also have eight legs, whereas the pinhead-sized larvae have only six legs and do not commonly attach to people.

#### Know Where the Ticks Occur

The western blacklegged tick is the most widely distributed and abundant of the 48 tick species in California. Five additional species of *Ixodes* ticks have been found infected

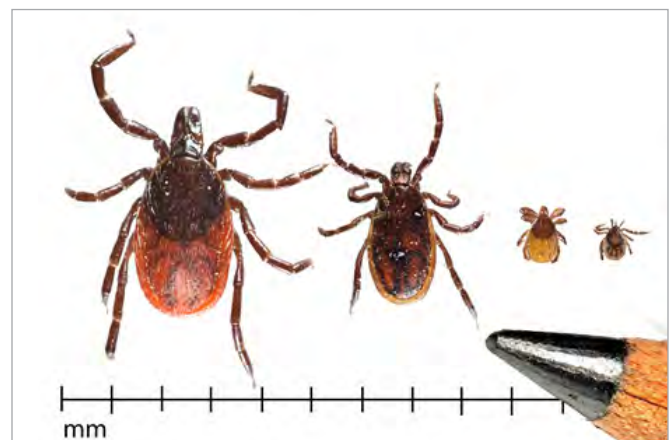


Figure 6. Parasitic life stages of the western blacklegged tick.

naturally with Lyme disease-group spirochetes in the state, but all of them infrequently or never attach to people.

**Nymph Habitat.** Nymphs of the western blacklegged tick may be encountered in a variety of habitats, but they are most accessible and plentiful in certain types of dense woodlands or forests such as those harboring oak, Pacific madrone, or Douglas fir trees. The nymphs abound in hardwood forests or woodlands carpeted with leaf litter or fir needles, but they are much less abundant and accessible in more open habitats such as grassland.

Unlike adult ticks, the nymphs usually do not ascend grasses or shrubs while host-seeking. Instead, they seek their hosts within or atop litter on the forest floor, or on branches, logs, and the basal portions of tree trunks up to a height of 3 to 4 feet. Any activity that places people in direct contact with shed leaves, fir needles, or wood (e.g., gardening, gathering firewood, picnicking, sitting on logs or against tree trunks, and woodcutting) may increase one's risk of encountering nymphs and possibly contracting Lyme disease.

Nymphs have a decided host preference for lizards. Research has demonstrated that in certain woodlands more than 90% of the nymphs attach to lizards, versus birds or mammals. In the laboratory, when nymphs were offered a choice of different hosts, they preferred western fence lizards versus a bird or two species of rodents. After feeding fully, nymphs drop off the host and molt to the adult stage weeks to months later.

In California, approximately 5% of the landscape is covered by forest. Six counties—four in the northwest (Humboldt, Lake, Mendocino, Trinity), Santa Cruz County on the central coast, and Nevada County in the northeast—are more than 10% covered by forests that may entail high risk of exposure to nymphs.

**Adult Habitat.** Adult female and male ticks climb low-lying vegetation in grassland, woodland-grass, or brush, where they lie in wait for hours or days for potential hosts, including medium- to large-sized mammals, such as black

bears, coyotes, deer, foxes or jack rabbits, to brush against them. Once adult ticks contact a suitable host, female ticks begin to search for a suitable attachment site. In contrast, male western blacklegged ticks mainly seek vertebrate hosts to locate receptive females for mating purposes.

*Ixodes pacificus* adults are commonly encountered by humans in open grassland or chaparral (brushlands), along the margins of trails (especially the uphill vegetative borders of hillside hiking trails) in parklands and wildlands, in semirural communities, and in some suburban areas that support populations of deer and other wildlife, particularly in coastal counties and the foothills of the Sierra Nevada Mountain range.

They also are common in areas where two habitat or vegetational types merge (e.g., where grassland abuts either brush or forest), and on southern-versus northern-facing slopes. In one study, 85% of adult ticks that contacted the clothing of subjects walking in grassland were detected between the ankle and knee. Hence, staying in the center of trails and avoiding contact with grass or brush will greatly reduce one's exposure to adult ticks.

The California Department of Public Health maintains an interactive Web site displaying locations where some public health agencies have collected adult or nymphal western blacklegged ticks and tested them for the agent that causes Lyme disease (See the REFERENCES section).

### **Know When Ticks Occur**

In northwestern California, *Ixodes pacificus* nymphs can be found from January through October in different localities, though they are most active from March to July and usually reach peak abundance in mid- to late spring. However, people are most likely to be bitten in spring and early summer when the nymphs are abundant in forests carpeted with leaf or fir-needle litter.

In central and southern California, nymphs are difficult to collect in woodlands during the daytime, so their seasonal activity period has not been well-defined except for a few sites in

Los Angeles and Santa Barbara counties. Host-seeking activity by nymphs there was truncated and spanned February to early May or early June.

Adult ticks generally seek their hosts from late fall through spring but are most active during winter in the north coast (Mendocino County) and Sierra Nevada foothills (Yuba County). In central and southern California, adult ticks quest from late November until late April or early May. On clear, warm days, people are more apt to be exposed to adult ticks in early morning or late afternoon because adult tick activity is highest when relative humidity is high and temperatures are cool.

Lyme disease cases in California residents having no travel history and exhibiting the expanding rash associated with early-stage *Borrelia burgdorferi* infection (called erythema migrans) peak from May to July following the maximum abundance of *Ixodes pacificus* nymphs (April to June). Even in heavily populated metropolitan areas, such as Alameda County in the San Francisco Bay region where the Lyme disease incidence is quite low, isolated woodland pockets exist where the hazard of confronting spirochete-infected nymphs is elevated.

## **DAMAGE**

### **Lyme Disease Signs and Symptoms**

Lyme disease begins in up to 60 to 80% of patients as a slowly expanding reddish rash known as "erythema migrans" (Figure 7), typically 3 to 32 days after the bite of an infectious tick. This rash, which may not be apparent on dark-skinned people, usually begins at the location where the tick attached and expands slowly to several inches in diameter before disappearing within 3 to 4 weeks. Antibiotic treatment reduces the duration of the rash to about a week. Many patients experience fatigue, headache, fever, chills, and other flulike symptoms during the initial stage of illness.

Without treatment, other signs or symptoms may occur days to months later. These can involve the skin (multiple secondary rashes), musculoskeletal system (migratory pain in joints, tendons,

muscles, or bones), neurologic system (severe headache, facial palsy, memory loss), and enlarged lymph nodes. More rarely, inflammation of the heart or eyes, or liver damage, may ensue, too.

People with untreated late-stage Lyme disease may begin to experience signs or symptoms months or years after infection, which may result in arthritic, neurologic, or further skin manifestations. Deaths attributable to Lyme disease are rare events: sudden cardiac deaths linked to Lyme carditis (inflammation of the heart) were reported during a 9-month period in 2013 for three young adults who resided in the north-eastern United States.

**Lyme Disease in Pets.** Dogs are susceptible to Lyme disease and may develop arthritis or lameness, lethargy, loss of appetite, enlarged lymph nodes, or other clinical conditions. Consult a veterinarian if you suspect your dog has Lyme disease. Cats, horses, and livestock also may become infected but rarely develop clinical signs.

## MANAGEMENT

Preventing exposure to ticks is the best way to reduce the risk of getting Lyme disease. Know how to recognize the western blacklegged tick and the areas and times of year where and when this tick occurs. Always inspect clothing, exposed skin, and pets for ticks when outdoors in tick habitats, and oneself for several days afterward to ensure that one or more nymphs may not have been overlooked.

### Prevention

If you spend time outdoors in tick-infested areas, you can significantly reduce the risk of exposure to *Ixodes pacificus* and other human-biting ticks by taking a few simple precautions.

**Dress Appropriately.** Ticks tend to climb upward, so wearing full-length pants and a long-sleeved shirt, tucking your shirt into your pants, and tucking pant legs into socks will help keep ticks off your skin.

**Consider Acaricides or Repellents.** As an added precaution, commercially available acaricides or repellents can be sprayed on skin or clothing. Products



**Figure 7.** “Erythema migrans” rash on forearm two weeks after removal of a tick.

containing permethrin as the active ingredient are highly effective for personal protection against both immature and adult ticks when applied to clothing. Permethrin is highly toxic to ticks at very low dosages. It should not be applied directly to the skin because it can cause irritation, though it is of low toxicity to humans.

Other products containing 20%–30% DEET as the active ingredient are effective against a wide range of blood-sucking ticks and insects and may be applied to either clothing or skin. Follow the manufacturer’s instructions carefully. Water or perspiration can wash repellents off your skin, so they may need to be reapplied after swimming, bathing, or perspiring heavily.

**Perform Tick Checks.** While outdoors in tick habitats, frequently inspect your clothing or exposed skin to detect and remove ticks before they have a chance to attach. Ticks may attach anywhere on the body, but on fully clothed persons they often attach to the scalp, behind an ear, or to an arm or leg. Pay particular attention to these areas as well to pant and bare legs when examining yourself or others.

Further, examine your bedding for the next several days for the presence of detached, fed ticks. Nymphs of *Ixodes pacificus*, once attached to human skin, are easily overlooked because of their small size and sometimes hidden feeding sites such as the scalp. Fully satiated nymphs detach from people during the night within as few as 3 days after tick exposure, and they are much easier to detect in a bloated state while digesting

their blood meal among bedclothes, including one’s pillow.

**Shower and Heat Clothing.** Research has demonstrated that showering within two hours of exposure to ticks offers protection against Lyme disease. Moreover, subjecting clothes worn outdoors to a one-hour dryer cycle at high heat will kill any ticks that crawled onto them.

**Check Your Pets.** After they have been outside, dogs and cats can transport ticks indoors. Most ticks will not survive indoors for very long, but unfed ticks that have recently wandered off pets onto bedding, floors, or furniture may attach to people who remain unaware of their presence. Ask your veterinarian about the latest products registered for controlling ticks that infest dogs or cats. Lyme disease vaccines are available for protecting dogs in California.

**Reduce Tick Abundance.** In California, about half of the reported cases are contracted around the home in semirural environments. Good landscape management can reduce tick densities in such areas. Some of the same management practices used to make the landscape less hospitable for ticks in the northeastern United States, for example, clearing leaf litter or creating woodchip barriers between lawns and adjacent woodlands, may prove useful in California’s semirural residential settings, or in private or public gardens adjoining natural areas inhabited by wildlife.

For an excellent, comprehensive overview of tick management strategies, organic land-care practices, personal protective measures, and chemical control methods, refer to the state of Connecticut’s *Tick Management Handbook* (see REFERENCES). Although the ecology of Lyme disease in Connecticut and California differs markedly, this handbook nonetheless is a good read for pertinent information on the subject.

For information about managing rodents, deer, lizards, and other potential tick hosts, see UC IPM’s list of vertebrate Pest Notes (see REFERENCES).

### Tick Removal

If you find an attached tick, remove it immediately. Prompt removal of

infected ticks can prevent Lyme disease and other tick-borne illnesses. Research demonstrated that *I. pacificus* nymphs require more than one day of attachment to begin transmitting *B. burgdorferi* to rodents. However, the minimum time it takes experimentally infected adult ticks to transmit spirochetes to an animal model has not been evaluated.

Since *I. pacificus* males seldom attach to people and consume small quantities of blood, we speculate that they rarely, if ever, infect humans with *B. burgdorferi*. In contrast, certain tick-borne agents like those causing Colorado tick fever and Rocky Mountain spotted fever may be transmitted within the first day.

Grasp the tick as close to the skin as possible with a pair of tweezers. If tweezers are unavailable, use fingers protected with gloves or tissue paper whenever possible. Be careful not to squash a fed or partially fed tick because some tick-borne agents may be transmitted through broken or possibly even unbroken skin.

Slowly and steadily pull the tick straight out. Remove any mouthparts that break off in the wound, and consult a physician if necessary. The mouthparts may be contaminated with other bacteria that sometimes cause secondary infections, but the mouthparts alone will not transmit Lyme disease spirochetes.

Do not jerk or twist the tick as you extract it. Do not apply alcohol, fingernail polish, heat from a lit match, or petroleum jelly to the tick. These methods are ineffective and therefore ill-advised.

Clean the wound with soap and water. Apply a mild antiseptic such as rubbing alcohol or povidone-iodine, if available.

### Tick Identification and Testing

It may be helpful to save a removed tick for identification. Specialists at governmental agencies (e.g., state and local health departments, mosquito and vector control districts) or universities may be available to assist you with tick identification.

Nevertheless, testing a tick that has bitten you is not recommended for medical decision-making because:

- Testing may take considerable time to complete.
- There is a potential for false positive and false negative test results.
- The tested tick may not reflect what an undiscovered, concurrently or previously attached tick might have been carrying.
- A tick sometimes may carry more than one disease agent.

Ticks can be submitted to certain commercial laboratories or governmental agencies for testing for presence of *Borrelia burgdorferi* or other disease agents. Check with your local testing agency or laboratory about whether the ticks should be submitted alive or preserved in isopropyl alcohol.

### Treatment

Consult a physician promptly if you or a family member experiences a flu-like illness or a rash after having been in areas where ticks may be found. Most people who contract Lyme disease or other tick-borne diseases become ill within 1 to 2 weeks after having been bitten. Commonly used antibiotics usually cure Lyme disease. If treatment is delayed, the disease may progress to arthritic, neurologic, or cardiac problems weeks to months later.

A vaccine to protect against Lyme disease was approved for human use in December 1998, but decreasing sales, high cost, litigation, and other factors resulted in its withdrawal from the commercial market by early 2002. Research aimed at developing another human Lyme disease vaccine has continued to the present, but a second-generation commercial vaccine has not reached the marketplace yet.

### Other Tick-Transmitted Disease Agents

Besides the bacteria that cause Lyme disease, the western blacklegged tick can transmit bacteria that cause human granulocytic anaplasmosis, which rarely may be fatal, and hard tick-borne relapsing fever (*Borrelia miyamotoi* disease).

Other species of hard or soft ticks in California can transmit at least six additional microbial disease agents, such as those causing human babesiosis, Colorado tick fever, relapsing fever, Rocky Mountain spotted fever, tularemia, and Pacific Coast tick fever caused by the recently described bacterium, *Rickettsia philipii*. Insofar as is known, the latter microbe is transmitted solely by the Pacific Coast tick (*Dermacentor occidentalis*). It usually causes a painful scab at the site of the tick bite that cannot be confused with erythema migrans (Figure 7). We make this distinction here because *I. pacificus* bite reactions rarely may present as a scab-like lesion.

Consult the Web sites of the California Department of Public Health and the United States Centers for Disease Control and Prevention (see REFERENCES) for additional information about ticks, Lyme disease, and other tick-borne diseases.

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