

# LYME DISEASE IN CALIFORNIA

Integrated Pest Management for Home Gardeners and Landscape Professionals

Lyme disease is a potentially serious disease, and can be localized or affect multiple bodily systems. In the United States, the disease is caused by a spirochete, *Borrelia burgdorferi*, a corkscrew-shaped kind of bacterium. The spirochete is transmitted to humans and other animals by the feeding activities of certain ticks. Of the 47 tick species established in California, 6 species attach to humans with any regularity, but only the western black-legged tick, *Ixodes pacificus*, is thought to be responsible for transmitting the spirochete to people (Fig. 1). *Ixodes pacificus* has been reported in 56 out of 58 counties in the state, and it attaches to humans more frequently than any other tick. In one study, about 60% of 967 ticks that had attached to people were identified as western black-legged ticks. A recent compilation revealed that 108 species of lizards, birds, or mammals have been recorded as hosts of this tick in California. A different but closely related tick species, the deer tick (*Ixodes scapularis*), transmits *Borrelia burgdorferi* in eastern North America, but that tick does not occur in California.

In most areas of northern California where Lyme disease occurs, only about 1 to 2% of the adult *Ixodes pacificus* ticks and 2 to 15% of the nymphal ticks, on average, are infected with *Borrelia burgdorferi*. However, Lyme disease transmission risk can be highly localized. In one woodland site in Mendocino County, for example, 41% of the nymphs were found to contain Lyme disease bacteria.

First recognized in the mid-1970s in Lyme, Connecticut, Lyme disease has been reported in the United States,

Canada, and in many European and Asian countries. The first report of the disease in California appeared in 1978. Lyme disease was designated a reportable disease in California and the United States in 1989 and 1991, respectively. Since 1989, approximately 2,145 cases have been reported in California through 2006. Considerable year-to-year variation occurs in the number of cases reported to state health authorities (Fig. 2). The highest incidence per 100,000 persons per year from 1997 to 2006 occurred in the northwestern counties of Trinity (18.5), Humboldt (7.8) and Mendocino (6.6).

## LIFE CYCLE

All ticks have four life stages: the egg and three parasitic stages that feed on the blood of vertebrate, two immature stages (larva and nymph), and the adult stage. In California, only the nymph and the adult female of *Ixodes pacificus* are important in transmitting *Borrelia burgdorferi* to humans. In northern California, people appear to be most at risk in spring until about midsummer, especially from April through July, when the nymphs are abundant. In southern California, the seasonal activity period of the nymphs has not been defined. It may occur earlier in the year, especially in hot, dry climatic zones, because the nymphs are highly susceptible to drying out. Therefore, nymphs may seek their hosts in late winter/early spring when weather tends to be cooler and relative humidity higher. The tiny nymphs, which are about the size of a poppy seed (Fig. 1), readily attach to people.

**Nymphal Habitat.** Nymphs may be encountered in a variety of habitats,

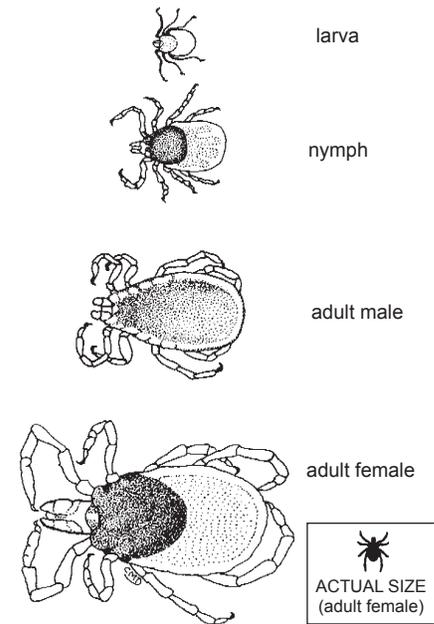


Figure 1. Western black-legged tick.

but they are particularly accessible and plentiful in leaf- and fir-needle litter areas in certain types of dense woodlands, for example oak/madrone forests. Unlike the adult ticks, the nymphs do not climb onto low vegetation while seeking a blood meal. Instead, they live within litter on the forest floor, and they climb on logs and the basal portions of tree trunks up to a height of about 3 to 4 feet, so any activity that places people in direct contact with shed leaves, fir needles or wood (such as gardening, gathering firewood, picnicking, sitting on logs or against tree trunks, woodcutting) may elevate the risk of contracting Lyme disease. Nymphs are especially attracted to lizards but also feed on birds or small mammals. Once they attach to a person, the nymphs feed for several days before they de-

tach and drop off. They molt to the adult stage weeks or months later.

**Adult Habitat.** Adult ticks seek their hosts from late fall to spring, but are most active during winter. They climb low vegetation, such as grass or brush, and lie in wait for hours or days while seeking their preferred medium- to large-sized hosts, such as rabbits, dogs, or deer. Consequently, humans incidentally encounter adult ticks during recreational activities or working in various types of grassland or brushland habitats. In one study, about 85% of the adult ticks that infested the clothing of people walking through grassland did so between the ankle and the knee. Therefore, when outdoors, individuals should frequently inspect their pant legs to detect and remove ticks before they have a chance to attach to skin. After attaching to a host, adult females ingest blood for about a week, engorging up to nearly four times their original bodily length. They then drop off the host and eventually deposit about 900 to 1,000 eggs in soil or litter. Adult males rarely attach to people, feed little, and therefore are unimportant as transmitters of disease organisms to humans or other animals.

**LYME DISEASE MANIFESTATIONS**

For light-skinned persons, Lyme disease begins in up to 60 to 80% of patients as a slowly expanding, reddish rash known as erythema migrans 3 to 32 days after the bite of an infectious tick. The rash, if present, may not easily be seen on dark-skinned patients. However, 50% or more of Lyme disease patients do not recall having been bitten by a tick. Attached nymphal ticks are particularly prone to be overlooked because of their smaller size and reduced feeding time as compared with adult female ticks. The rash typically begins at the location the tick attached, and it may expand slowly to several inches in diameter before disappearing within 3 to 4 weeks. Antibiotic treatment hastens disappearance of the rash, which with treatment may vanish in about a week. Many victims experience fatigue, headache, fever, chills, and other flulike symptoms during the initial stage of illness.

Days to weeks later, a variety of other clinical manifestations may occur singly or in combination. 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), lymphatic system, heart, eyes, liver, respiratory system, or kidneys.

Finally, untreated late (disseminated) Lyme disease normally begins months or years after infection, and may result in arthritic, neurologic, or further skin manifestations.

**Protect Your Dog.** Dogs are susceptible to Lyme disease and may develop arthritis or lameness, lethargy, loss of appetite, disease of the lymph nodes, or other clinical conditions after being infected. Other animals including cats, horses, and livestock can become infected with *Borrelia burgdorferi*, but rarely develop clinical signs. Consult a veterinarian if you suspect that your dog has Lyme disease, or if you wish to consider protecting your dog(s) with one of the commercially available canine Lyme disease vaccines. Highly effective pesticide-impregnated tick collars also are available to protect dogs that are exposed to tick-infested environments.

**Other Tick-Transmitted Diseases.** Besides the bacteria that cause Lyme disease, various ticks in California occasionally transmit at least eight other microbial disease agents, such as those causing relapsing fever, Rocky Mountain spotted fever, tularemia, Colorado tick fever, or babesiosis. Mounting evidence indicates that the western black-legged tick is the primary transmitter of the bacteria that cause another emerging disease, human granulocytic anaplasmosis, which sometimes is fatal. Thus, if a tick is tested for presence of *Borrelia burgdorferi* and is found to be uninfected, the possibility still exists that it could have been infected with another disease agent. See the Centers for Disease Control and Prevention Web site for more information on other tickborne diseases: <http://www.cdc.gov/ticks>.

**Treatment**

Consult a physician promptly if you or a family member experience an ill-

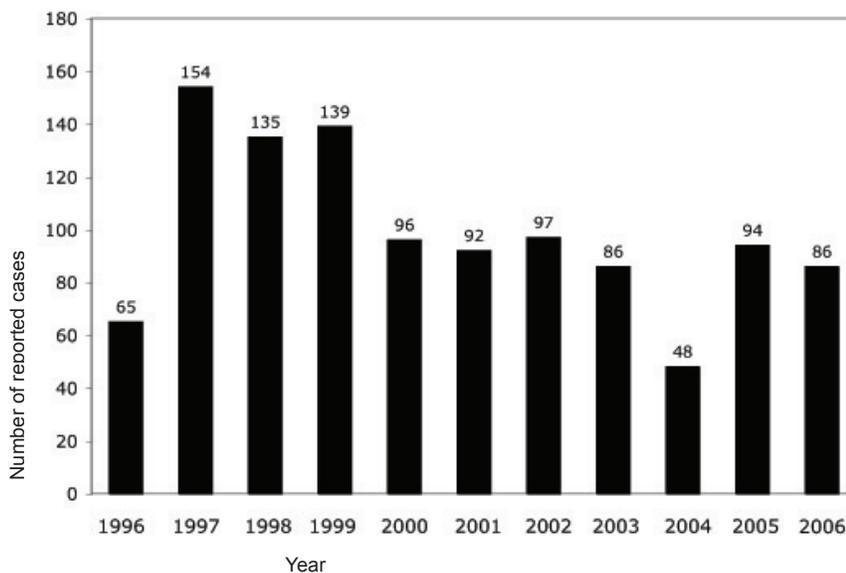


Figure 2. Lyme disease cases reported to the California Department of Public Health, 1996–2006.

ness that might be compatible with a diagnosis of Lyme disease. Commonly used antibiotics usually cure Lyme disease if administered within the first few weeks of infection. 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.

### PREVENTION

If you spend much time outdoors in tick-infested areas, you can significantly reduce the risk of disease by taking a few simple precautions.

**Know How to Recognize the Western Black-Legged Tick.** In its unfed state, the nymph is about the size of a poppy seed ( $\frac{1}{25}$  inch long). It has four pairs of legs, a dark brownish-black plate on its back, and a light-colored, translucent abdomen. The unfed adult female is about  $\frac{1}{8}$  inch long, has long mouthparts, brownish-black legs, a dark brownish-black plate that covers the anterior half of its back, and a reddish-orange abdomen. Attached females feeding on a host may expand to  $\frac{3}{8}$  inch in length, or longer. At  $\frac{1}{10}$  inch, adult males are smaller than females, somewhat oval shaped, and brownish black.

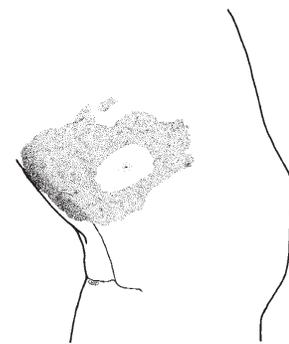
**Know Where the Ticks Occur.** The western black-legged tick is the most widely distributed of the 47 species of ticks known to be established in California. The nymphs abound in hardwood forests or woodlands carpeted with leaf litter or fir needles, but they are much less abundant or accessible in more open habitats such as grassland. The adults are commonly encountered in open grass or chaparral (brushlands), and along the margins of trails (especially the uphill vegetative borders of hillside trails) in parklands and wildlands, in semirural communities, and in some suburban areas that support surrounding domestic populations of deer and other wildlife, particularly in coastal coun-

ties and the foothills of the Sierra Nevada Mountain Range. A recent study concluded that 5.4% of the landscape of California, and more than 10% of 4 northwestern counties (Humboldt, Lake, Mendocino, Trinity), Santa Cruz County on the central coast, and Nevada County in the northeast are covered by forests that may entail high risk of exposure to *Ixodes pacificus* nymphs.

**Know When Ticks Occur.** People are more apt to be exposed to the adult ticks at certain times of day (e.g., early morning/late afternoon on clear, warm days) because adult tick activity is positively associated with relative humidity and negatively associated with temperature; in fringe areas where two vegetational types merge (e.g., where grassland abuts with either brush or forest); and, in hilly areas, on low vegetation bordering the uphill versus the downhill margins of hiking trails, and occasionally on southern versus northern-facing slopes. Thus, simply minimizing or avoiding prolonged contact with either grass or brush when these conditions apply will greatly reduce one's exposure to the adult ticks.

**Dress Appropriately.** Wear full-length pants and a long-sleeved shirt in tick-infested areas. Ticks are easier to spot against light-colored clothing. Tuck your blouse or shirt into your pants, and tuck pant legs into boots or socks.

**Consider Repellents.** As an added precaution, commercially available repellents or pesticides can be sprayed on skin or clothing. Products containing permethrin as the active ingredient are particularly effective for personal protection against both immature and adult ticks when applied to clothing. Permethrin should not be applied directly to the skin. Other products containing DEET (N,N-diethyl-m-toluamide) as the active ingredient are effective against a wide range of bloodsucking ticks and insects, and may be applied to either clothing or skin. Follow the manufacturer's instructions carefully. Water or perspiration can wash repellents from your



**Figure 3.** Erythema migrans, the skin rash common in the early stage of Lyme disease, is shown here developing in the knee area.

skin, so they may need to be reapplied after swimming or perspiring heavily.

**Perform Tick Checks.** Inspect your clothing and exposed skin for ticks often when outdoors in likely tick habitats. 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 when examining yourself or others. Furthermore, examine your bedding for up to several days after exposure to tick-infested habitats for presence of detached, fed ticks. Nymphs of the western black-legged tick, once attached to human skin, are easily overlooked because of their small size and sometimes hidden feeding sites (such as the scalp). However, fully satiated nymphs have been observed to detach from people during the night within as few as 3 days after exposure to ticks, and they are much easier to detect in a bloated state while digesting their blood-meal among bedclothes, including one's pillow.

**Check Your Pets.** After they have been outside dogs and cats can carry ticks indoors. To protect your pets, use a commercially available tick collar or consult your veterinarian about some of the latest pesticides registered for controlling ticks that infest dogs or cats.

**Reduce Tick Abundance.** Landscape management practices can be employed to reduce tick densi-

ties and populations of vertebrates (e.g., rodents or deer) that host such ticks. In the northeastern United States, most human cases of Lyme disease are contracted around the home in suburban areas, whereas in California, most cases are acquired in rural areas or around the home in semirural environments. Some of the same management practices used to make the landscape less hospitable for ticks in the Northeast, such as clearing leaf litter or creating woodchip barriers between lawns and adjacent woodlands, could prove useful in California's semirural residential settings or in 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, the interested reader is referred to the state of Connecticut's *Tick Management Handbook*, available online at <http://www.ct.gov/caes>.

### Tick Removal

If you find an attached tick, remove it immediately. Prompt removal of infected ticks can prevent Lyme disease and other tickborne diseases. Although research suggests that *Ixodes pacificus* nymphs require about 2 or more days of attachment to begin transmitting *Borrelia burgdorferi* to a host, other tickborne agents (such as Colorado tick fever, 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 your fingers, but protect them with tissue paper. Be careful not to squash a fed or partially fed tick because some tickborne agents may be transmitted through broken skin.

Slowly and steadily pull the tick straight out. Remove any mouthparts that break off in the wound (consult a physician if necessary). The mouthparts may be contaminated with other bacteria that occasionally 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 completely ineffective.

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

**Testing Ticks for Disease.** Whenever an attached tick is removed from a person, it should be saved for later identification in case the person experiences an illness within a month. Most people who contract Lyme disease or other tickborne diseases usually become ill within 1 to 2 weeks after having been bitten. Acarologists (scientists who study ticks and other mites), entomologists, or public health biologists employed by governmental agencies (e.g., state and local health departments, mosquito and vector control districts) or universities may be available to assist you with tick identifications. Ticks also can be submitted to certain commercial laboratories or governmental agencies for testing for presence of *Borrelia burgdorferi*. Depending on the specific test performed (e.g., IFA, PCR) in a given laboratory, ticks may have to be submitted either alive or preserved in isopropyl alcohol.

### REFERENCES

- California Dept. of Public Health. 2007. Vector-borne Diseases in California, 2007 Annual Report. Vector-Borne Disease Section, Sacramento, CA. Available online, <http://ww2.cdph.ca.gov/programs/vbds/Documents/VBDSAnnualReport07.pdf>
- Eisen, R. J., R. S. Lane, C. L. Fritz, and L. Eisen. 2006. Spatial patterns of Lyme disease risk in California based on disease incidence data and modeling of vector-tick exposure. *Am. J. Trop. Med. Hyg.* 75:669-676.
- Fritz, C. L., and A. M. Kjemtrup. 2003. Lyme borreliosis. *J. Am. Vet. Med. Assoc.* 223:1261-1270.

Furman, D. P., and E. C. Loomis. 1984. The ticks of California (Acari: Ixodida). *Bull. Calif. Insect Surv.* 25:1-239.

Lane, R. S. 1989. Treatment of clothing with a permethrin spray for personal protection against the western black-legged tick, *Ixodes pacificus* (Acari: Ixodidae). *Exp. Appl. Acarol.* 6:343-352.

Lane, R. S., D. B. Steinlein, and J. Mun. 2004. Human behaviors elevating exposure to *Ixodes pacificus* nymphs and their associated bacterial zoonotic agents in a hardwood forest. *J. Med. Entomol.* 41:239-248.

Piesman, J., and L. Eisen. 2008. Prevention of tick-borne diseases. *Annu. Rev. Entomol.* 53: 17.1-17.21.

Steere, A. C. 2006. Lyme borreliosis in 2005, 30 years after initial observations in Lyme Connecticut. *Wien. Klin. Wochenschr.* 118/21-22:625-633.

### SUGGESTED READING & ADDITIONAL SOURCES FOR INFORMATION

- Effectiveness of personal protective measures to prevent Lyme disease. 2008. M. Vásques, C. Muehlenbein, M. Cartter, E. B. Hayes, S. Ertel, and E. D. Shapiro. *Emerg. Infect. Dis.* 14:210-216.
- Lyme borreliosis: Biology, epidemiology and control.* 2002. J. O. Gray, R. S. Lane, and G. Stanek. CABI Publishing, New York, NY.

*Tick Management Handbook.* Bulletin 1010. 2007. K. C. Stafford, III. The Connecticut Agricultural Experiment Station, New Haven, CT. Available online (This large 66-page document loads slowly.) <http://www.ct.gov/caes/lib/caes/documents/publications/bulletins/b1010.pdf>.

Members of the Vector-Borne Disease Section of the California Department of Public Health (formerly the California Department of Health Services) have contributed a wealth of educational materials on ticks, Lyme disease, and other tickborne diseases. This body of useful information, which includes brochures on Lyme disease

in California (in English and Spanish), descriptions of common human-biting ticks, counties in which spirochete-infected ticks have been detected, questions and answers about tick-testing methods, epidemiological facts about Lyme disease, and accounts of preventive measures, can be accessed online, <http://www.cdph.ca.gov/HealthInfo/discond/Pages/LymeDisease.aspx>.

Additionally, the minutes of a state-mandated, educationally focused, Lyme Disease Advisory Committee, which meets annually at the California Department of Public Health, are posted on the same Web site.: <http://www.cdph.ca.gov/services/boards/ldac/Pages/default.aspx> ❖

For more information contact the University of California Cooperative Extension in your county. See your telephone directory for addresses and phone numbers.

**AUTHOR:** R. S. Lane, Environmental Science, Policy and Management, UC Berkeley  
**TECHNICAL EDITOR:** M. L. Flint  
**COORDINATION & PRODUCTION:** P. N. Galin  
**ILLUSTRATIONS: Figs. 1, 3:** C. M. DeWees;  
**Fig. 2:** Calif. Dept. of Public Health

Produced by UC Statewide IPM Program, University of California, Davis, CA 95616

**This Pest Note is available on the World Wide Web ([www.ipm.ucdavis.edu](http://www.ipm.ucdavis.edu))**



This publication has been anonymously peer reviewed for technical accuracy by University of California scientists and other qualified professionals. This review process was managed by the ANR Associate Editor for Urban Pest Management.

To simplify information, trade names of products have been used. No endorsement of named products is intended, nor is criticism implied of similar products that are not mentioned.

This material is partially based upon work supported by the Extension Service, U.S. Department of Agriculture, under special project Section 3(d), Integrated Pest Management.

**ACKNOWLEDGEMENTS**

The information contained in this *Pest Note* is based on many years of research by the writer and his various co-workers including undergraduate students, graduate students, postdoctoral researchers, technicians, and colleagues at other institutions. Though too numerous to single out individually, sincere thanks are extended to all of them for their invaluable contributions. Anne M. Kjemtrup, California Department of Public Health, is gratefully acknowledged for her helpful comments on the manuscript, and Yvette A. Girard and Esther Omni-Olsen, University of California, Berkeley, are thanked for their technical assistance. Finally, the research upon which most of the foregoing information is based was funded in part by grants to the author from the National Institutes of Health, cooperative agreements from the Centers for Disease Control and Prevention, and state or federal funds administered through the Agricultural Experiment Station, University of California.

**WARNING ON THE USE OF CHEMICALS**

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in the original labeled containers in a locked cabinet or shed, away from food or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Pesticides applied in your home and landscape can move and contaminate creeks, rivers, and oceans. Confine chemicals to the property being treated. Avoid drift onto neighboring properties, especially gardens containing fruits or vegetables ready to be picked.

Do not place containers containing pesticide in the trash or pour pesticides down sink or toilet. Either use the pesticide according to the label or take unwanted pesticides to a Household Hazardous Waste Collection site. Contact your county agricultural commissioner for additional information on safe container disposal and for the location of the Household Hazardous Waste Collection site nearest you. Dispose of empty containers by following label directions. Never reuse or burn the containers or dispose of them in such a manner that they may contaminate water supplies or natural waterways.

The University of California prohibits discrimination or harassment of any person on the basis of race, color, national origin, religion, sex, gender identity, pregnancy (including childbirth, and medical conditions related to pregnancy or childbirth), physical or mental disability, medical condition (cancer-related or genetic characteristics), ancestry, marital status, age, sexual orientation, citizenship, or service in the uniformed services (as defined by the Uniformed Services Employment and Reemployment Rights Act of 1994: service in the uniformed services includes membership, application for membership, performance of service, application for service, or obligation for service in the uniformed services) in any of its programs or activities. University policy also prohibits reprisal or retaliation against any person in any of its programs or activities for making a complaint of discrimination or sexual harassment or for using or participating in the investigation or resolution process of any such complaint. University policy is intended to be consistent with the provisions of applicable State and Federal laws. Inquiries regarding the University's nondiscrimination policies may be directed to the Affirmative Action/Equal Opportunity Director, University of California, Agriculture and Natural Resources, 1111 Franklin Street, 6th Floor, Oakland, CA 94607, (510) 987-0096.