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FACT SHEET

The Prevention of Tick Bite and Tick-Borne Disease: Tick Checks and the Use of Insect Repellents

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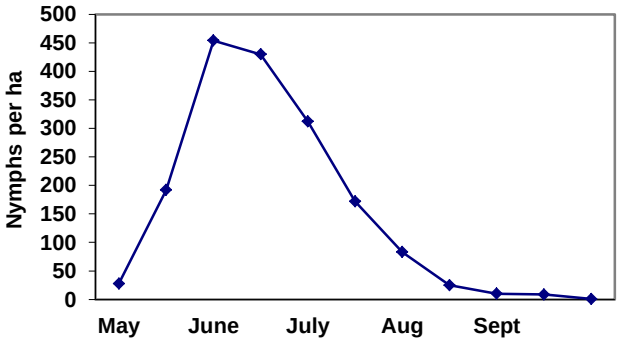
The prevention of tick bites and the prompt detection and removal of attached ticks can reduce the chance of tick-associated diseases. The pathogens that cause Lyme disease, human babesiosis, human granulocytic anaplasmosis, a relapsing fever *Borrelia*, and Powassan virus (i.e., deer tick virus) are spread by the bite of the blacklegged tick, *Ixodes scapularis* (commonly called the deer tick). The American dog tick, *Dermacentor variabilis*, can transmit the agents of Rocky Mountain spotted fever and tularemia, and can cause tick paralysis. The lone star tick, *Amblyomma americanum*, has long been considered mainly a nuisance pest and locally, the tick can be extremely abundant. This tick is the vector for three *Ehrlichia* agents, primarily *Ehrlichia chaffeensis*; has been associated with southern tick-associated rash illness (STARI) and a red meat allergy; is possibly a vector for spotted fever rickettsioses and tularemia; and is probably the vector for the Hartland and Bourbon viruses, new pathogens associated with severe febrile disease recently recognized from initial cases in Missouri and Kansas.

All active stages (larva, nymph and adult) of the blacklegged tick and lone star tick will feed on people and pets. Each stage of a tick feeds only once and slowly; requiring several days to ingest the blood meal. Most

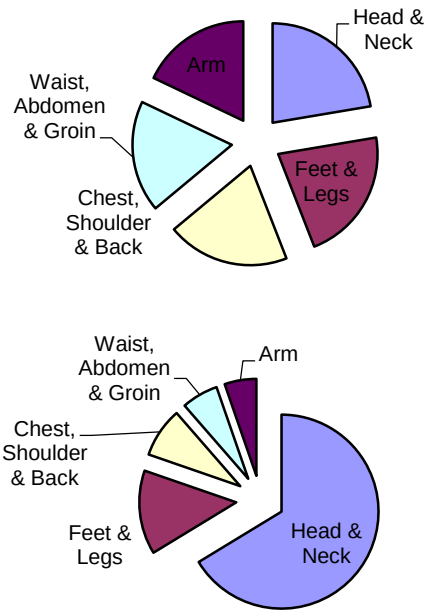


Lyme disease, babesiosis, and anaplasmosis cases are associated with the bite of the nymphal stage of *I. scapularis*. Nymphs are small (about the size of a pinhead), difficult to spot, and are active during the late spring and summer months when most people are outdoors (see graph of relative activity). Adults of *I. scapularis* are associated with fewer cases of Lyme disease. Adult female ticks are larger, easier to spot, and are active in the fall, warmer days in the winter, and in the spring when outdoor activity may be more limited. Male blacklegged ticks do not require a blood meal and are rarely found attached, but may be found crawling on the body. Blood engorged female *I. scapularis* may be confused in the spring with the American dog tick. Only the adult stage of the American dog tick feeds on people and pets and adult ticks are active during the months from April through August. All the stages of *A. americanum* are active in the summer months.

Dress appropriately and check for ticks . . . Ticks do not jump, fly or drop from trees, but grasp passing hosts from the leaf litter, tips of grass, etc. Most ticks are probably picked up on the lower legs and then crawl up the body seeking a place to feed. Adult *I. scapularis* will seek a host higher in the vegetation (i.e., shrub layer) as deer are the primary host. Wear light-colored clothing with the pants tucked into socks. Repellents can substantially increase the level of protection.

Photos courtesy Pfizer Central Research

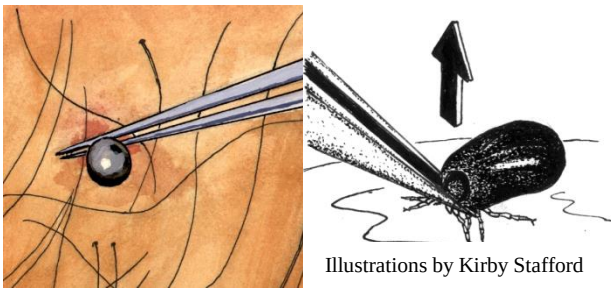
On returning home, remove and wash and dry the clothing. Many ticks can survive a warm or hot water wash, but cannot withstand 1 hour in a hot dryer. Carefully inspect the body and quickly remove any attached ticks (Above: an engorged nymphal *I. scapularis* with straight pin and a unfed and engorged female tick on dime to illustrate size). Tick bites are usually painless and, consequently, many people may be unaware that ticks are or have been attached. Also, carefully inspect children and pets. As an age group, children have a higher rate of reported Lyme disease than many adults. Ticks may attach anywhere on the body (Figure 3), but most are initially picked up on the lower extremities. A case control study found that checking for ticks within 36 hours of time spent in the yard or bathing within 2 hours was protective against Lyme disease. Pets can bring ticks into the home, resulting in a tick bite without the person being outdoors. A tick bite does not necessarily mean a person will develop Lyme disease (see risk of transmission). Most cases of Lyme disease result from an undetected tick and about 75% of ticks are acquired in activities around the home.



Proportion of *Ixodes scapularis* (Top) and *Dermacentor variabilis* (Bottom) submitted to the Connecticut Agricultural Experiment Station recovered from various regions of the body. While ticks were recovered anywhere on the body, the distribution of the blacklegged tick was more uniform, while most American dog ticks were removed from the head and neck region.

Remove ticks promptly . . .

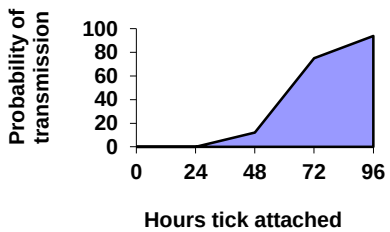
Use thin-tipped tweezers or forceps to grasp the tick as close to the skin surface as possible. Pull the tick straight upward (see illustration) with steady even pressure. This should remove the tick with the mouthparts intact. If the mouthparts break off, it will not



Illustrations by Kirby Stafford

affect the chance of getting Lyme disease. Disinfect the area; a topical antibiotic may also be applied. Save the tick for identification and evidence of tick bite. A dead tick can be saved dry in a small sealable bag or vial, particularly if it is to be tested for several tick-borne pathogens by DNA techniques (if available). Note the site and date of the bite. Other methods of tick removal (e.g. petroleum jelly to suffocate the tick) are not effective. Use of heat from matches to make the tick back out or gasoline or other chemicals are unacceptable. Watch for signs and symptoms of Lyme disease. Although an average of only 25% of the nymphs in Connecticut is infected with *B. burgdorferi*, this can vary from about 10-40% in any given year or location.

Risk of Transmission…



The risk of transmission of *B. burgdorferi* from an infected feeding nymph of *I. scapularis* increases dramatically after 48 hours of attachment. Early removal of an attached tick will reduce the chance of Lyme disease. During the first 24 hours of tick attachment, there is no transmission. By 48 hours of feeding, the transmission rate in one study was only 12.5% and then by 72 hours the transmission rate increases to 75%. Transmission by an infected tick is almost 100% after 4 days and full engorgement. Studies on the prophylactic use of antibiotics upon a detected tick bite found that the risk of Lyme disease in the placebo groups was around 5% or less. It also takes at least 24 hours for the agents of babesiosis and anaplasmosis to be transmitted by the tick. By contrast, the Powassan virus can be transmitted in as little as 15 minutes after tick attachment.

Topically Applied Insect Repellents…

Insect (and tick) repellents applied to skin and/or clothing can be broadly grouped as synthetic-chemical or botanical chemical-based compounds**.** There are about 150 repellent products registered with the U.S. Environmental Protection Agency (EPA) for use on human skin. The National Pesticide Information Center has an insect repellent locator (http://npic.orst.edu/). These are general guidelines as studies have shown that the response to various repellents varies between tick species and stages of the tick (or type of mosquito).

The formulation can also influence efficacy and acceptance and use by the consumer. An ideal repellent would provide complete protection for several hours under different environmental conditions, protect against all biting arthropods, be non-toxic, non-irritating, be harmless to clothing, be

cosmetically acceptable with no unpleasant odor or oily feel to the skin, be easy to apply and inexpensive.

DEET: The primary active ingredient in most insect/tick repellents today is DEET (N,N-diethyl-3-methylbenzamide or N,N-diethyl-m-toluamide). DEET is the most effective, broad-spectrum repellent ever discovered. The EPA estimates that over one-third of the U.S. population will use a DEET-based product. Products range in concentration from 4% to nearly 100% DEET and are available as an aerosol can, pump spray bottle, stick, lotion, cream, or towelette for application to skin or clothing. DEET is only effective for one to several hours and must be reapplied periodically. The effectiveness of DEET on the skin is influenced by the concentration of DEET, absorption through the skin, evaporation, sweating, air temperature, wind, and abrasion of the treated surface by rubbing or washing. Higher concentrations up can provide longer protection; 10% DEET may last 2 hours while 30% DEET may last up to 5 hours. However, a concentration greater than 30% doesn't provide much extra protection. Several controlled-release, extended duration products with DEET have been developed which decrease skin absorption and increase protection time. All active ingredients and their concentrations are listed on the product label.

DEET and ticks: DEET will repel ticks and decrease the chances of tick bite, but depending upon the concentration, it may not provide total protection and can vary between tick species. Concentrations of DEET that might prevent tick attachment may not deter a tick from walking across the skin to unexposed and untreated areas. For blacklegged ticks, DEET concentrations around 20 to 30% applied to clothes are about 86-92% effective in preventing tick bites in earlier studies. When applying a repellent against ticks, particular attention should be given to the shoe tops, socks, and lower portion of pants.

Safe Use of DEET: The Environmental Protection Agency (EPA) completed a review of DEET and concluded that normal use of DEET does not present a health concern to the general population when following label directions. The EPA established new labeling requirements for directions, precautions, and claims. A new repellent awareness graphic in 2016 will provide easily viewed information on what is repelled by the product and for how long it should be effective. The EPA has a repellent selection search tool available at http://cfpub.epa.gov/oppref/insect/ .

DEET has been used by millions of Americans for over 40 years and has an excellent safety record. The incidence of adverse reactions is low. However, some allergic, toxic, and neurological reactions to DEET have been reported in medical literature. Repeated applications have occasionally produced tingling, mild irritation or contact dermatitis. Some individuals may be particularly sensitive to chemicals. Toxic reactions are rare, but have occurred with applications to the skin, particularly with children. Reported cases often involved ingestion of DEET, applications of high concentrations of DEET and over application of product contrary to label directions. Therefore, it is prudent to minimize the use of high concentrations (no more than 30%) on the skin and follow the directions and precautions given on the repellent label. The American Academy of Pediatrics (AAP) recommends not more than 30% DEET be used on children and none on infants younger than 2 months of age. The AAP also does not recommend products combining DEET or other

repellents with sunscreen as sunscreen is applied more frequently, increasing exposure to DEET and studies have shown that sun screen may increase absorption of DEET through the skin. Apply DEET sparingly to exposed skin, and spray on clothing when possible. However, DEET will harm some synthetic fabrics (rayon and spandex), plastics (watch crystals and eyeglass frames), and car and furniture finishes. If you suspect a reaction to DEET (or any other repellent), stop using the product, wash the treated skin, and call the poison control center (CT 1-800-343-2722).

Picaridin (KBR2030): Picaridin-based insect repellents became available in 2005. There are several brands (Sawyer, Off!, Natrapel) available in the United States labeled for protection against biting flies, chiggers, fleas, gnats, mosquitoes, no-see-ums, and ticks. It has more pleasant cosmetic properties than DEET. Several published studies of the use of picaridin repellents against mosquitoes has shown the compound to be as effective or slightly more effective than similar concentrations of DEET, depending on the mosquito species. Products with 20% picaridin were reported by Consumer Reports to be effective against ticks 6-8.5 hours. Lower concentrations of picaridin were not evaluated. It has been available in Europe and Australia under the Autan® or Bayrepel® brands since 1988. Unlike DEET, this repellent has fewer adverse effects on plastics and synthetic fabrics, but can stain leather and vinyl.

Oil of lemon eucalyptus (p-menthane-3,8-diol): This compound occurs naturally in the oil of the lemon eucalyptus plant and the synthesized oil is the sole active ingredient in some newer products. Oil of lemon eucalyptus provides protection against mosquitoes similar to or better than lower concentrations of DEET. In one study, products containing oil of eucalyptus or its primary compound provided the most protection against mosquitoes with protection ranging from 60 to 217 minutes, better than 7-15% DEET. A recent report by Consumers Union found 30% oil of lemon eucalyptus (Repel®) to keep mosquitoes and ticks away for 7-8 hours. The EPA recognizes general use of p-Mentane-3,8-diol as safe for both children and adults. However, the label states it should not be used on children under the age of three.

IR3535®: Classified by the EPA as a biopesticide (it is structurally very similar to the amino acid B-alanine), this synthetic compound has been used as an insect repellent in Europe for 20 years with no notable adverse effects and was approved for use in the United States in 1999. Several formulated products with IR3535, including a spray, an aerosol, a towelette, and a lotion and spray with sunblock (SPF30 & SPF15), are currently available in the United States. They are labeled for use against mosquitoes, ticks, and several other biting flies. The EPA recognizes general use of IR3535 as safe for both children and adults. It is not a skin irritant or sensitizer, but IR3535 is a strong eye irritant. There is little published information on the efficacy of IR3535® against the blacklegged tick and other ticks. Industry-sponsored evaluations of IR3535 against *I. scapularis* suggested that 15% IR3535 is as effective as 30% DEET and 30% IR3535 is as effective as 60% DEET against the blacklegged tick. After 2 hours, >85% repellency was observed with both 15% IR3535 and 60% DEET on treated human fingers. Another study showed 7.5% IR2535 lotion provided about 3 hours protection against blacklegged ticks. However, Consumer Union's evaluation of two products with 20% IR2535 found it generally less effective than 20% picaridin, 30% oil of lemon eucalyptus, or DEET.

Clothing Repellent - Permethrin: Repellents containing permethrin are for use only on clothing or other fabrics such as

mosquito netting or tents. A synthetic pyrethroid insecticide rather than a traditional repellent, permethrin works primarily by killing ticks on contact with the clothes, although it also has some contact repellency. It can provide very high levels of protection against ticks (and chiggers and mosquitoes). Products are formulated as an aerosol spray or pump with a concentration of 0.5% and distributed mainly in lawn and garden centers or sports and camping stores. It will provide at least 2 weeks of protection with one treatment of the clothing as the spray will bind to the fabric and last through several washings. The clothing should be laundered before retreating. For proper application, the products are applied per label directions to clothing in a well-ventilated outdoor area and allowed to dry for 2 hours (4 hours with high humidity). Follow precautions on the label. Wash thoroughly with soap and water after handling. Permethrin has low mammalian toxicity, is poorly absorbed through the skin and is rapidly inactivated by the body. Skin reactions have been uncommon. Nevertheless, avoid contact with face, eyes or skin. Several companies (e.g., Columbia Insect Blocker™, Orvis Bugsaway®, Insect Shield®) offer clothing already impregnated with permethrin, which remain effective after 100 washings. For additional protection against mosquitoes and ticks, these permethrin products may be used in conjunction with an insect repellent labeled for use on skin.

Botanical or "Herbal"-based Repellents: Botanical, herbal or natural-based repellents include one or several plant essential oils. Some new products are refinements of these essential oils or synthetic versions of the active ingredient in the natural oil. These oils are considered safe by the EPA at the concentrations used, but most provide a more limited duration of protection against biting pests. There is some, but limited published data on the efficacy of plant-based repellents against ticks and most are not labeled for use against ticks. Citronella is often the principal and sometimes only active ingredient in a number of plant-based insect repellents. There is little published data on repellency for many of the other oils incorporated into repellent products and these botanical repellents are reported to provide only short-term protection with a mean protection time of around an hour or less against mosquitoes, often 3 to 20 minutes, although longer protection times were noted against *I. scapularis* by Consumer Reports. Other essential oils used in these natural-product based repellents include peppermint, lemongrass, lavender, cedar, canola, rosemary, pennyroyal, geranium and cajeput among others. In summary, many plant-derived repellents are not labeled for ticks and are unlikely to provide much protection against ticks.

Addendums to Factsheet

Table 1. List of Repellents
Table 2. EPA repellent recommendations
Selected References

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Table 1. List of insect repellents by active compound for The Prevention of Tick Bite and Tick-Borne Disease: Tick Checks and the Use of Tick Repellents Factsheet.

Active Ingredient	Concentration Protection Time	Brands or formulations	Characteristics
DEET	5-98% Lasts 2-5 hours depending on concentration	Many brand names and formulations available from several manufacturers (~230 products); major drug store chains also carry their own labels.	Cheap, good safety record, broad-spectrum efficacy, but oily, can damage plastics
DEET	33% Lasts 8-12 hours	3M Ultrathon™ (polymer-based) Sawyer Controlled Release (microencapsulated)	Controlled release formulations
Picaridin KBR3023	5-30% Lasts 2-10 hours depending on concentration	Available US in 1999 (since 1970s as Bayrepel® or Autan® in Europe). Brands incl. Sawyer, Avon Skin-so-Soft, Cutter® , KBR30123, Natrapel	Safe, some labels not registered for ticks. ≥ 20% conc. effective against ticks. No oily or greasy feel.
p-menthane-3,8-diol	10-40% Lasts 2-8 hours	Oil of Lemon Eucalyptus; brands include Coleman Botanicals, Cutter®, Off! and Repel® formulations	Repellent to ticks
IR3535® Merk3535	7-35% Lasts 2-8 hours depending on concentration	Avon® Skin-so-Soft, Sawyer®, Coleman, Bug Repel®, and Bullfrog are major brands, sometimes combined with sunscreen	≥ 20% conc. as effective as DEET against ticks.
2-undecanone	7.75% Lasts 2 hours ticks, longer for mosquitoes	BioUD®, Registered US in 2007. Active ingredient derived from wild tomato plants	Repellent to ticks, but less effective than alternatives.
Other essential oils	Varies, generally < 1.0 hour	Citronella (4.2%), soybean oil, catnip oil Most are not registered for ticks	Less effective than alternatives
Permethrin	0.5% Lasts about 2 weeks	Repel® Permanone, Sawyer® Clothing Repellent, Cutter® Outdoorsman Gear Guard, 3M™ Clothing and Gear Insect Repellent, Expel. Available in pre-treated clothing.	Toxicant for use on clothing only; not applied to skin.

Get specific medical information about the active ingredients in repellents and other pesticides by calling the National Pesticide Information Center (NPIC) at 1-800-858-7378. NPIC operates from 6:30 a.m. to 4:30 p.m. (Pacific Time),9:30 a.m. to 7:30 p.m. (Eastern Time), 7 days a week. The NPIC Web site is http://npic.orst.edu/ and their insect repellent locator is http://pi.ace.orst.edu/repellents/.

Table 2. U.S. Environmental Protection Agency (EPA) recommendations when using insect repellents for The Prevention of Tick Bite and Tick-Borne Disease: Tick Checks and the Use of Insect Repellents Factsheet.

- Follow the directions and precautions given on the repellent label.
- Apply repellents only to exposed skin and/or clothing (as directed on the product label). Do not use under clothing.
- Never use repellents over cuts, wounds, or irritated skin.
- Do not apply to eyes and mouth, and apply sparingly around ears. When using sprays do not spray directly onto face; spray on hands first and then apply to face.
- Do not allow children to handle the products, and do not apply to children's hands. When using on children, apply to your own hands and then put it on the child.
- Do not spray in enclosed areas. Avoid breathing a repellent spray, and do not use it near food.

- Use just enough repellent to cover exposed skin and/or clothing. Heavy application and saturation is generally unnecessary for effectiveness; if biting insects do not respond to a thin film of repellent, then apply a bit more.
- After returning indoors, wash treated skin with soap and water or bathe. This is particularly important when repellents are used repeatedly in a day or on consecutive days. Also, wash treated clothing before wearing it again. If you suspect that you or your child is reacting to an insect repellent, discontinue use, wash treated skin, and then call your local poison control center. If/when you go to a doctor, take the repellent with you.

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The material in this fact sheet is provided for informational purposes only. Mention of a repellent product does not constitute an endorsement by The Connecticut Agricultural Experiment Station (CAES). The list of repellents is not meant to be comprehensive and brands are subject to change. Not all products may be registered in all states.