

## **Personal Protection from Ticks**

The information presented here is a chapter taken, with permission, from the *Tick Management Handbook*, published by the Connecticut Agricultural Experiment Station. The complete handbook is available at:

<http://www.ct.gov/caes>.

## Personal Protection

### Tick Bite Prevention

Personal protection behaviors, including avoidance and reduction of time spent in tick-infested habitats, using protective clothing and tick repellents, checking the entire body for ticks, and promptly removing attached ticks before transmission of *Borrelia* spirochetes can occur, can be very effective in preventing Lyme disease. While surveys and the continuing incidence of disease suggest that few people practice these measures with sufficient regularity, studies suggest that tick checks are the most effective method for the prevention of tick associated disease. Preventive measures are often considered inconvenient and, in the summer, uncomfortable. Despite the efficiency of tick repellents, particularly with DEET applied to skin and permethrin applied to clothing, they are under-utilized.

***Checking for ticks and prompt removal of attached ticks is probably the most important and effective method of preventing infection!***

Important points to consider in tick bite prevention and checking for ticks include:

#### Tick Behavior & Risk of Exposure

- Most (about 98%) Lyme disease cases are associated with the bite of the nymphal stage of the blacklegged tick, of which 10-36% may be infected with Lyme disease spirochetes.
- Nymphal blacklegged ticks are very small (about the size of a pinhead), difficult to spot, and are active during the late spring and summer months when human outdoor activity is greatest. The majority (about 75%) of Lyme disease cases are associated with activities (play, yard or garden work) around the home.
- Adult blacklegged ticks are active in the fall, warmer days in the winter, and in the spring when outdoor activity and exposure is more limited. They are larger, easier to spot, and therefore associated with fewer cases of Lyme disease (even though infection rates are higher).
- 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 ticks will, however, seek a host (i.e., deer) in the shrub layer several feet above the ground, about or above the height of children.
- Children 5-13 years of age are particularly at risk for tick bites and Lyme disease as playing outdoors has been



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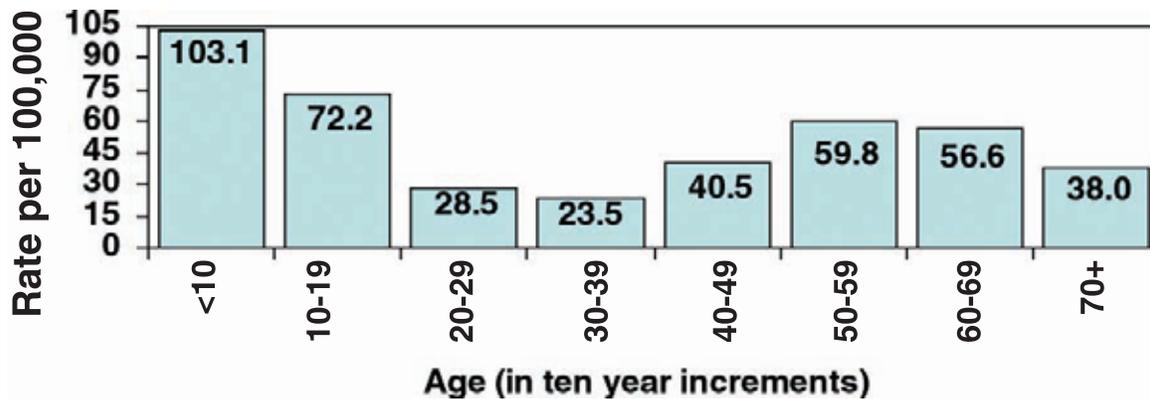


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identified as a high-risk activity. Take notice of the proximity of woodland edge or mixed grassy and brushy areas from public and private recreational areas and playing fields. While ticks are unlikely to be encountered in open fields, children chasing balls off the field or cutting through woods to school may be entering a high-risk tick area.

- Pets can bring ticks into the home, resulting in a tick bite without the person being outdoors. A veterinarian can suggest methods to protect your pets. Engorged blacklegged ticks dropping off a pet will not survive or lay eggs in the house, as the air is generally too dry.

*Lyme disease incidence (per 100,000 population) by ten year age groups for Connecticut, 2006. The pattern has been consistent each year. The incidence of Lyme disease is highest in children and middle-aged adults, related to outdoor activity and exposure to ticks (CT DPH).*



### Prevention

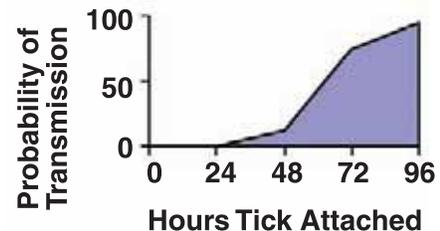
- Wear light-colored clothing with long pants tucked into socks to make ticks easier to detect and keep them on the outside of the clothes. Unfortunately, surveys show the majority of individuals never tuck their pants into their socks when entering tick-infested areas. It is unclear just how effective this prevention measure is without the addition of a repellent. Larval and nymphal ticks may penetrate a coarse weave sock. Do not wear open-toed shoes or sandals.
- DEET or permethrin-based mosquito and tick repellents may be used, which can substantially increase the level of protection (see section on repellents). This approach may be particularly useful when working in the yard, clearing leaves, and doing other landscaping activity with a high risk of tick exposure. A separate set of work or gardening clothes can be set aside for use with the permethrin-based clothing tick repellents.
- When hiking, keep to the center of trails to minimize contact with adjacent vegetation.
- Carefully inspect the entire body and remove any attached ticks (see below). Ticks may feed anywhere on the body. Tick bites are usually painless and, consequently, most people will be unaware that they have an attached tick without a careful check. Also, carefully inspect children and pets. A hypersensitivity reaction to a tick bite may aid detection in a few individuals, but most people will be unaware that a tick is attached and feeding.



- Unattached ticks brought in on clothing can potentially result in a later tick bite. Blacklegged ticks can survive for many days in the home depending upon the humidity. In the laboratory, nymphal *I. scapularis* can survive for over 6 months at 93-100% relative humidity (RH), but over half will die in less than 4 days at 65% RH. On returning home, remove, wash and dry the clothing. Many blacklegged ticks and lone star ticks can survive a warm or hot water wash, but they cannot withstand one hour in a hot dryer.

### Transmission

- It takes 36-48 hours or more for transmission of *B. burgdorferi* or *B. microti* to occur from an attached tick and not all ticks are infected. Therefore, a tick bite does not necessarily mean a person will get infected. Prompt removal of an attached tick will reduce the chance of infection. However, transmission of the agent of ehrlichiosis can occur within 24 hours.
- The probability of transmission of Lyme disease spirochetes increases the longer an infected tick is attached (0% at 24 hours, 12% at 48 hours, 79% at 72 hours, and 94% at 96 hours in one recent study). The estimated average time for attachment before detection and removal was 30 hours for nymphs and 10 hours for adult ticks, nymphal ticks were twice as likely as adult ticks to be partially engorged.
- Lyme disease may result from an unrecognized tick rather than the tick that was detected and removed, as the primary Lyme disease rash is sometimes found at a different location than the detected tick. It is not unusual to have more than one tick attached at one time.
- In some areas, tick-testing services for the presence of Lyme disease spirochetes may be available from a government or commercial laboratory. The detection of spirochetes in a tick does not necessarily indicate transmission and an estimate of risk is difficult without a measure or estimate of length of attachment.



### Tick Removal

To remove a tick, use thin-tipped tweezers or forceps to grasp the tick as close to the skin surface as possible. Pull the tick straight upward with steady even pressure. This should remove the tick with the mouthparts intact. Commercial tick removal devices have been shown to vary widely in their efficacy for removing nymphal blacklegged ticks: some worked in every attempt, some failed in every attempt, some were in between. Tick removal devices that have been shown to successfully remove *I. scapularis* nymphs attached for 48 hours in all attempts in a recent study include #4 forceps, Original Tick Kit (Tick Kit, Inc.), Pick-Tick (Encepur, Chiron), Pro-Tick Remedy (SCS, Ltd.), and the Nick Nipper (Josyln Designs, Inc.).

The mouthparts of larval and nymphal ticks will seldom be left in the skin. With proper removal, they usually come out intact. Adult ticks are more difficult to remove intact because of the longer mouthparts. If the mouthparts break off, it will not change the chance of getting Lyme disease. Spirochetes in the



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mouthparts or cement plug, and therefore the feeding lesion, means the tick was removed too late and transmission has already occurred. Do not use other methods of tick removal (e.g. petroleum jelly to suffocate the tick, heat from matches to make the tick back out or gasoline or other chemicals); they are not effective and may potentially increase the risk of pathogen transmission.

#### After removing the tick:

- Disinfect the area with rubbing alcohol or another skin disinfectant; a topical antibiotic also may be applied.
- Save the tick for reference and, in some cases, testing (if available). A live tick can be placed in a crush proof container with a blade of grass to keep it alive (a sealable plastic bag also will work). A small plastic vial is best. Dead ticks are tested by DNA methods and should be held dry in a crush proof container. For long-term storage, ticks are held in 70-80% ethyl alcohol (rubbing alcohol will work). Avoid placing ticks in black film containers or using cellophane tape to mount the tick to paper, a note card or a slide if it needs to be identified or tested. Ticks under cellophane tape are difficult to handle. If the tick is removed by a health professional, ask to keep the tick for future reference or testing.
- Note the site and date of the bite.
- Watch for signs and symptoms of Lyme disease or other tick-associated diseases for 30 days or consider prophylactic treatment if the tick is engorged or infection rates are high (see below). Watch for evidence of secondary infection.

Localized tick bite reactions develop rapidly and can sometimes resemble a small Lyme disease rash, but these transient reactions generally disappear in 24-48 hours and do not continue to expand like a characteristic erythema migrans rash. Mouthparts left in the skin may cause irritation as the body attempts to absorb or reject the foreign tick tissue (analogous to a minute splinter that is difficult to remove) with a slight risk of secondary bacterial infection. A foreign body granuloma may persist for weeks, especially if the mouthparts remain. A physician should be consulted if there is evidence of infection.

### Tick Bite Prophylaxis

The prophylactic use of antibiotics following a tick bite has not generally been recommended by most medical authorities in the U.S. as the chance of Lyme disease from a known tick bite with *I. scapularis* appears low (< 5%; 0% with flat ticks, 10% with engorged ticks in one study). Only 14-32% of patients diagnosed with Lyme disease remember a feeding tick.

#### *Factors against prophylactic treatment:*

- Tick bites in endemic areas are very common.
- Local infection rates in nymphal ticks may be low (< 20%) with a low risk of infection (<5%) from a detected, attached tick (most people who get Lyme disease do not notice the tick).



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- The infection status and degree of engorgement of the tick, and therefore the risk of infection, are generally not known. Routine testing of unengorged (flat) ticks attached < 24-36 hours is not necessary.
- Not infrequently, ticks submitted for identification or testing turn out not to be a tick (i.e., a scab, beetle, spider, etc.) or a tick that is not a vector for Lyme disease (better training of physicians or clinic staff to recognize major tick species is important).
- There may be a risk of an adverse reaction to the antibiotic.
- The value of antibiotic prophylaxis for HGA or babesiosis is unknown.

*Factors in favor of prophylactic treatment:*

- A single 200 mg dose of doxycycline within 72 hours for adults or children  $\geq 8$  years of age (4 mg/kg up to 200 mg) following a tick bite can prevent Lyme disease. A single dose is less likely to stain teeth in children or produce adverse reactions.
- For a partly or fully engorged blacklegged tick, the risk of infection may be high. It can equal the prevalence of infection in the tick, which may be > 30% for a nymphal tick and greater than 60% for an adult tick (though usually lower).
- Patient reports on the period of attachment usually underestimate actual time of attachment.
- If a tick is infected (determined by testing at a proficient laboratory) and the tick is engorged, infection by Lyme disease spirochetes is highly likely and treatment may be seriously considered. However, results from tick testing may not be available in time for prophylactic treatment or Lyme disease symptoms may already be evident.

## **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. The effectiveness of a repellent against mosquitoes does not indicate how effective a product will be against ticks, but may provide a broad indication of repellency potential as data for efficacy against ticks are limited. 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.

Insect repellent compounds currently in use include:

- DEET (N,N-diethyl-m-toluamide, also known as N,N-diethyl-3-methylbenzamide).
- IR3535 (Ethyl Butylacetylaminopropionate or 3-[N-Butyl-N-acetyl]-aminopropionic acid, ethyl ester).
- Picaridin (1-piperidinecarboxylic acid, 2-(2-hydroxy)ethyl-, 1-methylpropylester).
- MGK-326 (di-n-propyl isocinchomeronate), used in conjunction with DEET in composite formulation.
- MGK-264 (N-octyl-bicycloheptene dicarboximide), used in conjunction with DEET in composite formulation.
- Oil of Lemon Eucalyptus (PMD; p-Mentane-3,8-diol).
- Citronella, Soybean, Peppermint, and other plant essential oils.

## DEET

The primary active ingredient in most insect/tick repellents today is DEET (N,N-diethyl-3-methylbenzamide, also known as N,N-diethyl-m-toluamide). DEET is the most effective, broad-spectrum repellent ever discovered, effective against mosquitoes, biting flies, chiggers, fleas and ticks. The U.S. Environmental Protection Agency (EPA) estimates that over one-third of the U.S. population will use a DEET-based product. There are approximately 230 products containing DEET registered with the EPA (e.g., *Cutter, Off, Repel, Muskol, Ben's, Sawyer, and others*). Products range in concentration from 5% to 100% DEET and are available as an aerosol can, pump spray bottle, stick, lotion, cream, or towelette for application to skin or clothing. For any repellent, all active ingredients and their concentrations are listed on the product label.

DEET is effective for one to several hours and must be reapplied periodically. There are few firm guidelines on the concentration a consumer should use. The effectiveness of DEET on the skin is influenced by the concentration of DEET, absorption through the skin, evaporation, sweating, air temperature, wind, abrasion of the treated surface by rubbing or washing and the arthropod for which protection is desired. Higher concentrations generally provide longer protection, but increasing the concentration does not proportionally increase protection time. A recent study comparing the efficacy of insect repellents against bites of the mosquito *Aedes aegypti* found that a 23.8% DEET formulation provided an average of 5 hours of complete protection, while 6.65% DEET provided slightly under 2 hours of protection. Several controlled-release or extended-release DEET formulations have been developed which decrease skin absorption and increase protection time. These products may provide longer protection similar to products with a higher concentration of DEET.

### 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 against the blacklegged tick. Not all products with DEET are labeled for ticks. Little is known about the effectiveness of different concentrations of DEET against *I. scapularis*. Concentrations of DEET that might prevent tick attachment may not deter a tick from walking across the skin to unexposed and untreated areas. Some protection against tick attachment appears to come from the oily nature of some products. When applied to clothes, 30% and 20% DEET were found to be 92% and 86% effective against *I. scapularis*, respectively, but skin applications were reported to be only 75 to 87% effective against crawling ticks in a second study. These studies suggest that, for blacklegged ticks, DEET concentrations around 30 to 40% may be necessary for adequate protection, although the effectiveness of higher (>50%) and lower (<20%) concentrations against *I. scapularis* needs to be examined more closely. Concentrations above 50% will probably provide the user with little additional protection. When applying a repellent against ticks, particular attention should be given to the shoe tops, socks, and lower portion of pants.

### Composite DEET Repellents with MGK-326 and MGK-264

The MGK Repellent 326 and MGK Repellent 264 are only used together with DEET in composite repellent formulations for human use in the United States. Composite repellents are labeled for use against biting flies, fleas, chiggers, and ticks. The EPA has determined that MGK-326 poses no unreasonable adverse effect on human health when properly used, but MGK-326 was classified as a probable human carcinogen in 1993. To mitigate risk, the EPA has limited total production and use of MGK-326, set a maximum concentration of 2.5% in repellent products, and the label may limit the number of applications per day of MGK-326 on children twelve and under to limit overexposure in young children.

## Permethrin-based Repellents

Several products contain 0.5% permethrin (e.g., *Duranon Tick Repellent*, *Repel Permanone*, *Cutter Outdoorsman Gear Guard*, *Sawyer's Permethrin Tick Repellent*, *Sawyer's Clothing Insect Repellent*, *3M Clothing and Gear Insect Repellent*, *No Stinkin' Ticks*), which is 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 has some repellency. It can provide high levels of protection against ticks (and chiggers and mosquitoes). Permethrin is available as an aerosol spray or pump, mainly in lawn and garden centers or sports and camping stores. Permethrin has a relatively low mammalian toxicity, is poorly absorbed through the skin and is quickly metabolized and excreted by the body, although the EPA does list it as a potential carcinogen. Permethrin can cause mild skin and eye irritation, but reactions appear uncommon. Important points in the safe use of a permethrin repellent include:



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- Follow the directions and precautions given on the repellent label.
- Apply to CLOTHING ONLY. Do not apply to skin. Immediately wash with soap and water if you get material on the skin.
- Do not apply to clothing while it is being worn. Apply before you put the clothing on.
- Apply in a well-ventilated area outdoors protected from the wind.
- Lightly moisten the fabric, do not saturate. Allow drying for 2 hours (4 in humid conditions).
- Allow clothing to dry prior to before wearing.
- Do not treat the clothing more than once every two weeks. Launder treated clothing at least once before retreating.
- Permethrin can be used in conjunction with an insect repellent labeled for use on skin for additional protection.

## IR3535 and Picaridin

Classified by the EPA as a biopesticide (it is structurally very similar to the amino acid B-alanine), the synthetic compound IR3535 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 varying concentrations of IR3535, including a spray, an aerosol, a towelette, and a lotion and spray with sun block, are currently available in the United States (e.g., *Skin-So-Soft Bug Guard Plus Insect Repellent*). They are labeled for use against deer ticks, mosquitoes, and several other biting flies. IR3535 is not a skin irritant or sensitizer, but it is a strong eye irritant. There is some information on the efficacy of IR3535® against the blacklegged tick and other ticks. Industry-sponsored evaluations of IR3535 against *I. scapularis* suggest 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 a 7.5% IR2535 lotion provided protection against blacklegged ticks for about 3 hours.

The Centers for Disease Control and Prevention (CDC) recently added a Picaridin-based insect repellent and oil of lemon eucalyptus-based repellent (see below) to DEET as recommended repellents for the prevention of mosquito bites. 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. It is claimed to have more pleasant cosmetic properties than DEET. The chemical name for picaridin is 1-piperidinecarboxylic acid, 2-(2-hydroxyethyl)-, 1-methylpropyl ester. It is also known as KBR2030 or Bayrepel® (a trademark of Bayer AG) and has been available in Europe and Australia under the Autan® brand

(S.C. Johnson and Sons, Inc.) since 1988. There is one brand currently available in the United States at two concentrations (5.75 and 7%) (*Cutter® Advanced*) and others should become available. Picaridin is labeled for protection against biting flies, chiggers, fleas, gnats, mosquitoes and no-see-ums, but is not labeled for use against ticks. One study against nymphs of an African *Amblyomma* tick species found that 20% KBR2030 was much less effective than 20% DEET. Unlike DEET, this repellent has no adverse affect on plastics and synthetics.

### **Botanical, Herbal, and Natural-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 low concentrations used, but provide a limited duration of protection against mosquitoes (< 3 hours). There is virtually no 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 many plant-based insect repellents. Oil of lemon eucalyptus, soybean oil or geraniol is the sole active ingredients in some products. Available in several brands or formulations, oil of lemon eucalyptus provides protection against mosquitoes similar to low concentrations of DEET. Two 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. The compound p-menthane-3,8-diol occurs naturally in the oil of the lemon eucalyptus plant. It was originally isolated from waste distillate of lemon eucalyptus oil extract, but the synthetic compound is used. The EPA recognizes general use of p-Mentane-3,8-diol as safe for both children and adults as the toxicity of p-Mentane-3,8-diol is very low. However, the label states it should not be used on children under the age of three. At least one brand is labeled for use against ticks and some repellency has been reported against the tick *I. ricinus*, the vector for Lyme disease in Europe. A 2% soybean oil-based repellent has been reported to provide an average of 1.5 hours of protection against mosquito bites, while other botanical repellents tested provided only short-term protection with a mean protection time of only 3 to 20 minutes. There are no published data on repellency against mosquitoes for many of the other oils incorporated into repellent products. 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, most plant-derived repellents are not labeled for ticks and are unlikely to provide much protection against ticks.

### **Safe Use of DEET**

DEET has been used by millions of Americans for at least 40 years and has a remarkable safety record. The incidence of adverse reactions is extremely low with fewer than 50 cases of serious effects documented in the medical literature since 1960. The Environmental Protection Agency (EPA) conducted a review of DEET and believes that normal use of DEET does not present a health concern to the general population when used according to label directions (Reregistration Decision document available from the EPA). Some allergic, toxic, and neurological reactions to DEET have been reported in medical literature, but toxic encephalopathic reactions are rare. Reported adverse reactions appear to have involved high concentrations of DEET, over application of product contrary to label directions, or ingestion of product. Repeated applications have occasionally produced tingling, mild irritation or contact dermatitis. Important points in the safe use of DEET include:

- Follow the directions and precautions given on the repellent label.
- Apply DEET sparingly to exposed skin, and spray on clothing when possible.
- Do not use DEET under clothing or over cuts, wounds, or irritated skin.
- Use the lowest concentration necessary for protection and estimated time of needed

protection. Minimize the use of higher concentrations on the skin. Lower concentrations, such as 10% DEET, will provide approximately 2 hours of protection (but may be less effective against ticks), while a concentration of 24% will provide about 5 hours of protection.

- A concentration of DEET up to 30% for adults and children over 2 years of age is the maximum concentration currently recommended by the American Academy of Pediatrics (AAP).
- The AAP does not recommend the use of DEET on children under 2 months of age. Apply sparingly to small children.
- AAP precautions suggest DEET should not be used in a product that combines the repellent with a sunscreen as sunscreens are often reapplied periodically. DEET is not water-soluble and will last many hours. Reapplications of DEET may increase the possibility of a toxic reaction to DEET.
- Apply the product to a child yourself. Repellent on a child's hands can end up in the eyes or mouth.
- Wash the hands with soap and water after applying DEET.
- People with certain skin conditions should be cautious about the use of DEET.
- Wash off the repellent with soap and water when returning indoors.
- DEET generally won't harm cotton, wool or nylon. DEET can damage some synthetic fabrics (acetate, 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 a poison control center (CT 1-800-222-1222) or contact your physician.

### Other Repellent Options

Avon's moisturizing Skin-So-Soft bath oil has been widely touted as a mosquito repellent, but provides less than 10-30 minutes of protection against mosquitoes and is unlikely to offer any protection against ticks. Ingested compounds like garlic and vitamin B1 and ultrasonic sound devices do not repel mosquitoes and probably do not repel ticks. Wrist-bands impregnated with either DEET or citronella provided no protection against mosquitoes and would not protect against ticks either. Protection is provided only around where the repellent is actually applied.

### Medical and safety information about the active ingredients in an insect repellent is available from:

National Pesticide Information Center by telephone (1-800-858-7378) from 6:30 a.m. to 4:30 p.m. Pacific Standard Time or 9:30 a.m. to 7:30 p.m. Eastern Standard Time, 7 days week, except holidays. Additional information is available at their website (<http://npic.orst.edu/>).

### Human Lyme disease vaccine

The Food and Drug Administration (FDA) approved a human Lyme disease vaccine, LYMERix (GlaxoSmithKline), which contained recombinant outer-surface protein A (OspA) of *B. burgdorferi*, in December 1998. However, the manufacturer took the vaccine off the market in February 2002 because of declining sales. In clinical trials, vaccine efficacy was 49% after 2 doses for those with definite Lyme disease and 76% after the third dose. Protection in an immunized individual was provided when levels of antibody to OspA in the blood were high enough to neutralize the spirochetes inside a feeding tick before transmission occurred. Protection in vaccinated individuals will wane after a year or two, so protection against Lyme disease in previously vaccinated people will be nonexistent.