

# EWG'S GUIDE TO BETTER BUG REPELLENTS

**ENVIRONMENTAL  
WORKING GROUP**

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#### About EWG

The mission of the Environmental Working Group (EWG) is to use the power of public information to protect public health and the environment. EWG is a 501(c)(3) non-profit organization, founded in 1993 by Ken Cook and Richard Wiles.

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# WHICH IS WORSE, BUG BITES OR BUG REPELLENT?

BY DAVID ANDREWS, PH.D., RENEE SHARP, M.A.,  
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CHOOSING THE RIGHT BUG REPELLENT CAN MAKE A HIKE, PICNIC OR OUTDOOR EVENT A PLEASURE INSTEAD OF A PAINFUL, ITCHY EXPERIENCE THAT MAY HAVE SERIOUS CONSEQUENCES.

West Nile virus, carried by mosquitoes, infected more than 5,674 Americans last year and 286 of them died, according to the federal [Centers for Disease Control and Prevention](#) (CDC 2013C).

The incidence of Lyme disease, spread by ticks, has more than doubled over the last 15 years, with 24,364 [confirmed cases recorded](#) in 2011 (CDC 2013A, CDC 2013B).

Both these illnesses, and other pest-borne diseases, can have serious and occasionally life-altering consequences. Many experts expect to see more cases in the future as the warming climate expands the habitat of species that spread pathogens.

Yet many people are understandably concerned about the possible drawbacks of common repellents such as DEET. At EWG, we certainly were. So we spent 18 months digging into the question: **what are the safest and most effective ways to prevent bug bites and the diseases they may transmit?**

The conclusions of our fact-finding investigation surprised and in some ways disappointed us.

**The bad news:** there's no sure, completely safe way to prevent bug bites. All bug repellents have pros and cons.

**The good news:** some repellents are effective and relatively low in toxicity -- provided you take precautions when using them, particularly on children.

**The surprising news:** among the four repellent

chemicals EWG found to be top picks is DEET, which is widely used but much maligned. DEET's safety profile is better than many people assume. Its effectiveness at preventing bites is approached by only a few other repellent ingredients.

DEET isn't a perfect choice nor the only choice. But weighed against the consequences of Lyme disease and West Nile virus, we believe it is a reasonable one.





## WHAT TO LOOK FOR IN A BUG REPELLENT

No repellent works every place against every pest. You should research the diseases carried by mosquitoes and other insects and ticks where you plan to spend time outside and consider the best bets for yourself and your family. The repellent you might choose for a Lyme disease-infested area or a backcountry trip in Alaska could be different from the one that might suffice for a picnic on the beach.

According to the available scientific literature, when you really need protection, your best bets are products made with active ingredients that have been registered with the U.S. Environmental Protection Agency and approved by the CDC. When a company registers a bug repellent, it must provide EPA with technical information that shows that the chemical is effective against mosquitoes or ticks or both. EPA must approve any marketing claims that assert that the repellent works for a particular length of time.

**Tests have found that these four registered and approved repellent chemicals offer a high level of protection from a variety of biting insects and ticks and have good safety profiles:**

- **Picaridin**
- **IR3535**
- **DEET**
- **Oil of Lemon Eucalyptus and its synthetic derivative PMD**

Beware when using any of these repellent chemicals: you **must** follow basic guidelines to avoid

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*“Research the diseases carried by mosquitos and other insects and ticks where you plan to spend time outdoors.”*

overexposure. These are strong chemicals. Some should not be used on infants and young children.

If you hesitate to try a new bug repellent, start with the backyard, neighborhood and places you go regularly. If one product fails to deter biting bugs as you had hoped, next time out try a different formulation with a higher percentage of the repellent chemical you think best for your outing, or a product with another active ingredient.

## WHAT ABOUT BOTANICALS?

Products based on botanical extracts may be worth trying if bug-borne diseases are not known to be a problem where you are going. But many of these products contain allergens in highly concentrated forms. Effectiveness varies widely. The Environmental Protection Agency does not require registration and testing of these botanicals for effectiveness or safety, so there is not much data to confirm or contradict their advertising claims. Consumers have no assurance that the product actually works. That is why the only botanically-derived ingredient the CDC recommends is Oil of Lemon Eucalyptus/PMD, which has been registered with the EPA and undergone efficacy testing.

**Here is a guide to common brands that feature the four recommended active ingredients.** (EWG does not recommend products that combine repellent and sun protection.)

Repellent chemical	Common Brands
Picaridin	Avon Skin-So-Soft Bug Guard Plus Picaridin Cutter Cutter Advanced Natrapel 8-hour OFF! Active OFF! FamilyCare Walgreens Light & Clean
IR3535	Coleman Skin Smart
DEET	Bug Off Buzz Off Cutter OFF! Active OFF! Family Care OFF! Deep Woods Repel Ultrathon
Oil of Lemon Eucalyptus with enhanced PMD concentration	Coleman Botanicals Citrapel Fite Bite Repel Essential
PMD	OFF! Botanicals



## BEFORE YOU GRAB FOR THE BOTTLE REPELLENTS SHOULD BE A LAST CHOICE

### FIRST:

**Give bugs a smaller target.** Cover up with light-colored clothing. In bug country, wear long-sleeved shirts with high collars and bandanas. When walking in tall grass or brush, tuck pants into socks to keep ticks and chiggers off your body. Use nets and or fans over outdoor eating areas and place nets over strollers and baby carriers. Send your kids to camp with mosquito netting for their bunks.

**Get rid of mosquito breeding grounds.** Drain standing water around your home. If you live in a place with a high tick concentration, make a wood chip barrier between your yard and wooded areas, mow the lawn, clean up brush regularly and follow the [CDC's guidelines](#) for reducing your yard's tick population.

## KNOW YOUR ENEMY

If you are in a place that presents few risks for pest-borne diseases and don't mind getting a few bug bites, your choice of repellent may not be that critical. On the other hand, if you need to protect yourself from Lyme disease, West Nile or other serious mosquito- and tick-transmitted diseases, your repellent and other preventive actions are serious decisions. It is vital that you research the common pest-borne diseases in your area (or where you are headed) so that you can match your choices to your risks.

Lyme disease cases are highly concentrated in 13 Northeastern and Mid-Atlantic states, from Virginia to Maine, and the upper Midwest, mostly in Wisconsin and Minnesota (CDC 2013A). You are most likely to contract Lyme disease between late April and mid-July.

West Nile cases have been found in almost every state, with the highest numbers reported in Texas, California, Illinois, Louisiana, Michigan, Mississippi and Oklahoma (CDC 2013E). According to the CDC, infections from mosquitoes carrying West Nile virus occur primarily in the summer months, peaking in August (CDC 2012B).

Much more information is available on the websites of the [CDC](#) and the [World Health Organization](#).

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# EWG'S DO'S AND DON'TS FOR AVOIDING BUG BITES

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## DO:

- Wear pants, socks, shoes and long sleeves, especially when venturing into heavy brush with likely bug infestations.
- Take extra precautions to avoid bug bites if you are in a high-risk area for Lyme disease, West Nile virus or other mosquito- and tick-borne illnesses.
- Use nets and/or fans over outdoor eating areas and place nets over strollers and baby carriers.
- Read labels to learn about safe usage and protection from bug species known to infest your area.
- Choose a repellent concentration rated for the time span you're outdoors, but not longer.
- Use products with the lowest effective concentration of repellent chemicals, particularly on children.
- Consult a physician if you are traveling out of the U.S. or need to use bug repellent daily for prolonged periods.
- Take extra care with kids. Keep repellents away from young children to reduce risk of accidental swallowing.
- Send kids to camp with netting for bunks.
- When using repellent on a child, apply it to your own hands and then rub them on your child. Avoid eyes and mouth and use repellent sparingly around ears. Do not apply repellent to children's hands because they sometimes put their hands in their mouths.
- Use products in lotion, pump or towelette form.
- Try repellents on a small patch of exposed skin before slathering all over. Check for ticks thoroughly after returning indoors and remove ticks properly.
- Wash clothing and repellent-coated skin when your kids come indoors or at the end of the day.

## DON'T USE:

- Oil of Lemon Eucalyptus/PMD on children younger than 3 years old.
- More than 30 percent DEET on anyone.
- Any bug repellents on children under 6 months.
- Outdoor "fogger" insecticides. They contain more toxic ingredients than repellents applied to skin.
- Candles. They may not be effective. They emit fumes that could trigger respiratory problems.
- Aerosol sprays in pressurized containers. You'll inhale chemicals, and you could get sprayed in the eyes and face.
- Repellent mixed with sunscreen. When you reapply sunscreen every two hours as advised, you overexpose yourself to repellent.
- Bug zappers and treated wristbands.

# REPELLENT CHEMICALS

## PICARIDIN

Picaridin, developed by Bayer AG in the 1980s and sold in the U.S. since 2005, is not known to irritate skin and eyes, does not have a pungent odor like DEET and does not dissolve plastics (EPA 2005). It evaporates from the skin more slowly than DEET or IR3535 and may repel bugs for longer periods (Debboun et al. 2007).

In efficacy testing it performs like DEET, appearing to repel a wide range of pests (Badolo 2004, Barnard 2004, Carroll 2010, Consumer Reports 2010). The World Health Organization recommends Picaridin, along with DEET and IR3535, for protection against mosquitoes that carry diseases (WHO 2012). EPA registration data indicate that Picaridin at a concentration of 20 percent is effective against mosquitoes and ticks for 8 to 14 hours and for 3.5 to 8 hours at a concentration of 10 percent.

Picaridin does not carry the same neurotoxicity concerns as DEET but has not been tested as much over the long term. Overall, EWG's assessment is that Picaridin is a good DEET alternative with many of the same advantages and without the same disadvantages.

## IR3535

IR3535, whose full chemical name is 3-[N-Butyl-N-acetyl]-aminopropionic acid, ethyl ester, is structurally similar to the naturally occurring amino acid B-alanine. Merck & Co., Inc., developed IR3535 in the mid-1970s. It has been used in Europe for more than 20 years but was not registered for use in the U.S. until 1999 (EPA 1999).

IR3535 can be very irritating to the eyes but poses few other safety risks. European authorities have received no reports of health problems caused by this chemical. Like DEET, IR3535 may dissolve or damage

plastics. The manufacturer recommends avoiding contact with plastics other than polyethylene and polypropylene.

Merck recommends formulations with 10 to 30 percent IR3535 to repel biting insects and ticks (Merck 2013). *Consumer Reports* tests found that 20 percent IR3535 was slightly less effective than 15 to 30 percent DEET in repelling *Aedes* mosquitoes that sometimes carry yellow fever, dengue and encephalitis. *Consumer Reports* found that it performed as well as DEET against deer ticks and *Culex* mosquitoes that sometimes carry West Nile virus (Consumer Reports 2010).

This chemical is often found in products sold as sunscreens and repellents. We recommend avoiding these products because sunscreen should be reapplied every 2 hours. Following those instructions would over-exposed the user to bug repellent.

In sum, IR3535 is a good DEET alternative with many of the same advantages and fewer disadvantages.

## DEET

DEET, registered for public use in 1957, is the most common mosquito and tick repellent. It is rated as very effective in repelling a wide range of mosquitoes, ticks and other bugs. DEET has been used billions of times and is a reasonable, if imperfect, choice.

On the plus side, if used as directed, DEET is considered safe by many public health organizations, including the Environmental Protection Agency, the Centers for Disease Control, the American Academy of Pediatrics and World Health Organization (AAP 2005, CDC 2013D, EPA 1998, Schutze 2013, WHO 2012). DEET is among those chemicals recommended by WHO for protection against disease-carrying mosquitoes and is the only repellent recommended by the CDC to protect against Lyme disease (CDC 2013D, WHO 2012).

In 1998 the EPA reviewed the first 40 years of public usage of DEET along with the known toxicity information and concluded that "the normal use of DEET does not present a health concern to the



general U.S. population.” The agency found “no toxicologically significant effects in animal studies” (EPA 1998).

When we started our research, we were particularly concerned about the potential downsides of DEET. We still are. We urge consumers to handle DEET with caution. It is known to irritate the eyes and in intense doses may induce neurological damage (Abdel-Rahman et al 2001, ATSDR 2004, Corbel et al. 2009). In very rare cases DEET has been reported to impair the nervous system, with symptoms including seizures, tremors and slurred speech, most often after exposure to high concentrations of the chemical (ATSDR 2004, Briassoulis 2001). In addition, DEET gives off a distinct odor and can damage plastic, rubber and vinyl on a variety of gear including clothing, backpacks, glasses, watches and cameras (Schutze 2013).

In 1998, after reviewing case reports of seizures, the EPA concluded that the rate of adverse reactions appeared to be very low -- on the order of 1 per 100 million persons. The agency instructed manufacturers to provide additional instructions for minimizing overexposure to DEET. It authorized DEET for use by children but banned marketing claims that DEET products are “safe for children” (EPA 1998). EPA said it had “no evidence that would lead [it] to believe that DEET is uniquely toxic to infants and/or children,” but it added that its personnel still had “concerns regarding these seizures, especially for children who are more susceptible to seizures in general and who receive a higher dose of DEET due to a greater surface area to body weight ratio” (EPA 1998).

Laboratory studies conducted since the 1998 EPA review have suggested that DEET exposure can affect the nervous systems of rats (Abdel-Rahman et al 2001, Corbel et al. 2009). People who use DEET daily have reported suffering symptoms including rashes, dizziness, difficulty concentrating and headaches (ATSDR 2004). Studies using DEET alongside the pesticide permethrin have raised concerns that DEET could cause neurological damage and epigenetic changes (Abdel-Rahman et al 2001, Manikkam et al 2012).

Still, after reviewing the evidence, EWG has concluded that DEET is generally safer than many people assume and remains a viable option for people in areas infested with disease-carrying pests. As rates of Lyme disease and other bug-borne illnesses rise, people need bug repellents that work well when it counts.

The EPA allows U.S. sales of repellents with up to 100 percent DEET, but increasing concentration does not increase efficacy. Longer protection times can be achieved by time-release products. We think it makes sense to follow Canadian government recommendations limiting DEET to 30 percent in any product and even weaker concentrations for young children (Canada 2012). The Canadian government’s advice conflicts with the CDC’s recommendation to use a product containing 20 to 50 percent DEET for adult protection against Lyme disease, and a product containing 20 to 30 percent DEET for children’s protection. Consumers must make their own decisions about which advice to follow when it comes to using DEET on children in areas with high risk of Lyme disease.

### Health Canada Recommendations for DEET Usage

Age	Recommendations
0 to 6 months	No DEET
6 to 24 months	Only when bug risks are high 5-10% DEET products Limit to 1 application per day
2 to 12 years	5-10% DEET Limit to 3 applications per day. Avoid prolonged use
General population	No more than 30% DEET allowed in products



The oil of the lemon eucalyptus tree repels insects.

## OIL OF LEMON EUCALYPTUS /PMD

**Oil of Lemon Eucalyptus** is the trade name for the repellent that originated as an extract of the eucalyptus tree native to Australia. The tree extract is refined to intensify the concentration of the naturally occurring substance *para*-menthane-3,8-diol, also known as PMD, from 1 to 65 percent. The resulting oil is very different from unprocessed tree oil.

Most Oil of Lemon Eucalyptus products on the market are made by Spectrum Brands and sold under the brand names Repel and Cutter. These have concentrations of 30 percent Oil of Lemon Eucalyptus and 20 percent PMD. Some testing has shown that concentrations of 20 to 26 percent PMD may perform as well as 15 to 20 percent DEET against both mosquitoes and ticks (Barnard 2004, Consumer Reports 2010). PMD's maximum protection time against mosquitoes and ticks is shorter than DEET's, according to EPA documents.

The [Repel website](#) does not recommend Oil of Lemon Eucalyptus/PMD when the risk of West Nile

virus is high or against sand flies or the biting midges known as no-see-ums.

Refined Oil of Lemon Eucalyptus is classified as a biochemical pesticide, which the EPA defines as a naturally occurring ingredient that controls pests by non-toxic mechanisms. Ingredients in this category can qualify for EPA approval with less safety testing than synthetic chemical pesticides. However, unlike botanicals, these products have to submit tests showing effectiveness.

Because the dangers to children have not been thoroughly explored, products with Oil of Lemon Eucalyptus and PMD have labels that warn, "Do not use on children under the age of 3" (NY 2002). The CDC also advises not to use on children under three years of age (CDC 2013F). Citronellol and other chemicals in the extract are known allergens.

Synthetic PMD can be found in some repellent products at a concentration of 10 percent. These products provide only a few hours of protection and warn against use on children younger than 3. They present less risk of allergic skin reaction than natural PMD.

Scientists do not know enough to determine differences between PMD and Oil of Lemon Eucalyptus, but one study found that Oil of Lemon Eucalyptus provided longer protection than the equivalent concentration of synthetic PMD.

We conclude that Oil of Lemon Eucalyptus has disadvantages and is not appropriate for all situations but is a good choice for people who want a botanically-based bug repellent.

# BOTANICAL REPELLENTS

EWG research indicates that botanically based bug repellents are not often the best choice. The most common contain castor oil, cedar oil, citronella oil, clove oil, geraniol oil, lemongrass oil, peppermint oil, rosemary oil and soybean oil. While effectiveness varies, and there may be a few exceptions, most botanicals repel bugs for a short time, if at all.

There are few data available on botanicals because the EPA has classified them as “minimum risk” pesticides, meaning, they are exempt from registration and efficacy testing. But “minimum risk” does not mean safe. Products based on these botanical ingredients generally contain known human allergens – often at much higher concentrations than personal care products.

The EPA recently convened a Science Advisory Panel meeting to discuss the possibility of requiring efficacy testing for all skin-applied repellents, including botanicals. If the agency mandates such testing, it could produce solid evidence to support – or refute – advertising claims by botanical repellent makers.

EWG recommends that consumers who are in high-risk areas for bug-borne disease or need long-lasting, effective bug protection avoid botanically based bug repellents, aside from Oil of Lemon Eucalyptus. In other cases, you may find it worth your while to try botanical repellents to identify one that works well for you. To determine if a product might cause an allergic reaction, EWG suggests testing it on a small patch of skin before slathering all over.

Botanical oil	Likely to contain these known human allergens**
Castor oil	none
Cedar oil	none
Citronella oil	geraniol*, citronellol*, limonene*, linalool*, farnesol*
Clove oil	eugenol*
Oil of Lemon Eucalyptus (PMD 65%)	citronellol, pinene, caryophyllene
Geraniol oil	geraniol*, citronellol*, linalool*, limonene*
Lemongrass oil	geraniol*, citral*, citronellol*, limonene*
Peppermint oil	menthol, caryophyllene, limonene*, pinene
Rosemary oil	pinene, camphor, caryophyllene, limonene*, terpineol, linalool*
Soybean oil	none

\*In Europe, cosmetics applied to the skin must disclose these ingredients when the concentration exceeds 0.001 percent (SCCS 2003).

\*\* Known human allergens identified by the European Commission Scientific Committee on Consumer Safety (SCCS 2011).

# EWG Repellent Guide: Top Choices

Repellent Chemical	General Effectiveness*	Pros*:	Cons*:
Picaridin	A 5-10% concentration can provide short protection time of 1-2 and up to 4 hours against ticks and mosquitoes. A 20% concentration product provides all-day protection from mosquitoes and ticks.	<ul style="list-style-type: none"> <li>• Safer risk profile than DEET</li> <li>• Odorless</li> <li>• Non-irritating</li> <li>• Does not melt plastic</li> </ul>	<ul style="list-style-type: none"> <li>• Approved by EPA in 2005, less surveillance of rare adverse effects</li> <li>• Shorter protection time against DEET in some studies</li> </ul>
IR3535	A 20% concentration can provide 8 hours of mosquito protection and 6 to 12 hours of tick protection.	<ul style="list-style-type: none"> <li>• Structurally similar to amino acid alanine</li> <li>• Long experience in Europe</li> <li>• Good safety profile</li> </ul>	<ul style="list-style-type: none"> <li>• Concentrations weaker than 10% may not be effective</li> <li>• Avoid brands with added sunscreen</li> <li>• Serious eye irritant</li> <li>• Melts some plastic and damages some fabrics</li> </ul>
DEET	DEET at less than 10% concentration can provide 1-2 hours of protection against ticks and mosquitoes. A 20-30% concentration product provides all-day protection from mosquitoes and ticks.	<ul style="list-style-type: none"> <li>• Effective against wide range of pests</li> <li>• Widely used with few serious adverse reactions</li> <li>• Concentrations of 10 to 30% provide lasting protection against many species.</li> </ul>	<ul style="list-style-type: none"> <li>• Limit concentration used on children</li> <li>• Strong eye irritant</li> <li>• Melts some plastic and damages some fabrics</li> <li>• In a few cases neurological symptoms have been reported</li> <li>• Avoid products with more than 30% DEET, try time-release products when you need multi-hour protection</li> </ul>

Oil of Lemon Eucalyptus with enhanced PMD concentration	30% concentration (19% PMD) provides up to 6 hours of protection against mosquitoes and ticks	<ul style="list-style-type: none"> <li>• Most effective botanical ingredient</li> </ul>	<ul style="list-style-type: none"> <li>• Not for use on children 3 and younger</li> <li>• Can irritate lungs</li> <li>• Possible allergens</li> </ul>
PMD	10% provides 2 hours of protection against mosquitoes and ticks	<ul style="list-style-type: none"> <li>• Lower allergen concern than botanical based product</li> </ul>	<ul style="list-style-type: none"> <li>• Not for use on children 3 and younger</li> <li>• Can irritate lungs</li> <li>• No higher concentration on the market</li> </ul>

\* The general effectiveness, pros and cons columns in the table refer generically to products formulated with the ingredient listed and do not make explicit claims on the quality or performance of any specific product. Effectiveness estimates are drawn from peer-reviewed literature and EPA registration approvals for labeling at <http://cfpub.epa.gov/oppref/insect/>. Actual protection time varies in field tests. Experiment to see which products work for you to repel bugs in your area.

# OTHER OPTIONS

Repellent Chemical	General Effectiveness*	Pros*	Cons*
2-undecanone (Methyl Nonyl Ketone)	7.5% concentration offers 4 hours of mosquito and 2 hours of tick protection	<ul style="list-style-type: none"> <li>• Effective as DEET in some tests</li> </ul>	<ul style="list-style-type: none"> <li>• Hard to find</li> </ul>
Citronella	4.2% concentration provides 1 hour of mosquito and tick protection	<ul style="list-style-type: none"> <li>• Botanical ingredient</li> </ul>	<ul style="list-style-type: none"> <li>• Less effective than other repellent ingredients</li> <li>• Frequent application may be necessary</li> <li>• May cause allergic skin reactions</li> <li>• Ineffective against Asian tiger mosquitoes</li> </ul>
Catnip oil	7% and 15% concentrations offer 7 hours of mosquito protection, no tick protection	<ul style="list-style-type: none"> <li>• Botanical ingredient</li> </ul>	<ul style="list-style-type: none"> <li>• Hard to find</li> </ul>
Botanical blends	Little testing data; many tested do not repel Asian tiger mosquito and other aggressive species	<ul style="list-style-type: none"> <li>• Botanical ingredient</li> <li>• Some geranium oil and soybean oil mixtures shown to provide lasting bug protection</li> </ul>	<ul style="list-style-type: none"> <li>• Exempt from EPA registration and testing</li> <li>• Effectiveness varies depending on mosquito species</li> <li>• Frequent reapplication necessary</li> <li>• May cause allergic skin reactions</li> </ul>

\* The general effectiveness, pros and cons columns in the table refer generically to products formulated with the ingredient listed and do not make explicit claims on the quality or performance of any specific product. Effectiveness estimates are drawn from peer-reviewed literature and the EPA registration approvals for labeling at <http://cfpub.epa.gov/oppref/insect/>. Actual protection time varies in field tests. Experiment to see which products work for you for the bugs in your area.

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## USE WITH CAUTION

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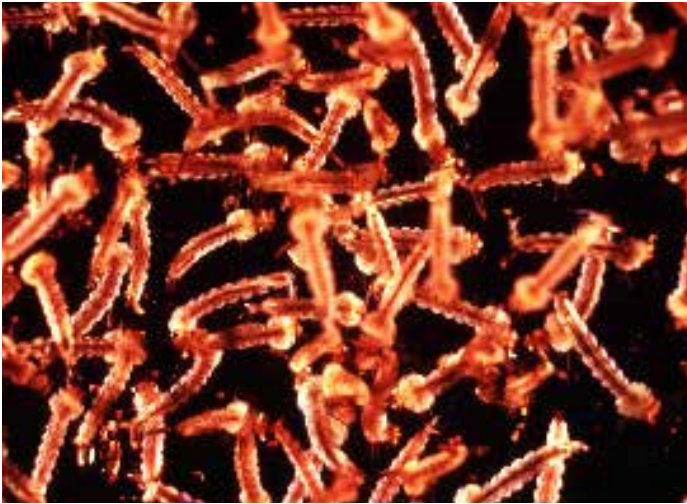
Permethrin-treated clothing	<ul style="list-style-type: none"><li>• Doesn't require direct application to skin</li><li>• Useful in areas infested with mosquito and ticks, high disease risks and where other repellents are ineffective</li></ul>	<ul style="list-style-type: none"><li>• Chemical is more toxic than skin-applied repellents</li><li>• Safe handling necessary for treated clothing</li><li>• Home application of permethrin can lead to overexposure</li></ul>
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## AVOID TOXIC OR INEFFECTIVE OPTIONS

Product	Why?	Try instead
Bug zappers	Are ineffective and expensive, may attract more mosquitoes to the area and kill beneficial bugs	Drain standing water, check window screens, stay indoors when insects swarm. Use repellent as needed on exposed skin
Yard bug treatments	Don't provide lasting protection, require more pesticides than skin repellents	
Clip-on repellents, Insecticide fans	Inhalation hazard, ingredients metofluthrin and allethrin more toxic than skin products	Ceiling or standing fans can keep mosquitoes from landing on people
Repellent candles	Inhalation hazard, less effective than skin or clothing treatments	Cover up with light colored clothes. Use repellent as needed on exposed skin
Pure essential oils	Can cause serious irritation and allergy	Use products formulated for skin use. Test on small area before applying widely

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Mosquito larvae, called “wigglers,” breed in stagnant water.

## WHAT DISEASES DO BUGS TRANSMIT?

### MOSQUITOES

The primary mosquito-borne disease threat in the U.S. is West Nile virus. Travelers to tropical regions and some other places could encounter malaria, dengue fever, yellow fever and a few other diseases.

The most common diseases carried by mosquitoes are:

Mosquito genus	Diseases
Aedes	Dengue fever, Rift Valley fever, yellow fever, chikungunya
Anopheles	Malaria, lymphatic filariasis
Culex	West Nile fever, Japanese encephalitis, lymphatic filariasis

Source: World Health Organization, 2012

**West Nile virus** struck 5,674 Americans last year. Half those cases were complicated with neuroinvasive disease such as meningitis, encephalitis or acute flaccid paralysis, according to the CDC. Symptoms can be high fever, headache, stupor, tremors, convulsions and neurological damage.

Between 1999 and 2008, 64 different mosquito species tested positive for West Nile virus.

According to the CDC, infections from mosquitoes carrying West Nile virus occur primarily in the summer months, peaking in August. West Nile cases have been found in almost every state in the nation, with the highest numbers reported in Texas, California, Illinois, Louisiana, Michigan, Mississippi and Oklahoma.

**Malaria** can cause fever, chills, headache, vomiting, diarrhea and in severe cases, organ failure, coma and death. According to the World Health Organization, more than 125 million travelers annually visit the 100 countries or areas where malaria has been reported.

Some 30 to 40 of the 3,500 species within the Anopheles genus transmit malaria. These species are widespread throughout the world.

The CDC recommends DEET, Picaridin, IR3535 and Oil of Lemon Eucalyptus/PMD to repel mosquitoes that transmit malaria. The WHO recommends DEET, IR3535 and Picaridin.

### WHAT TESTS TELL US – AND WHAT THEY DON'T

Repellents are not tested against all mosquito species. The most common mosquito used in tests is the *Aedes aegypti* mosquito, because it is very sensitive to repellents and easy to cultivate in laboratories. Other *Aedes* mosquito species require higher doses and more frequent reapplication of repellents (Badolo 2004).

One repellent may not always protect a person from all the different mosquito species, nor from other pests.



# TICKS

Diseases carried by ticks are rare but can be severe. EWG recommends prudent tick prevention methods to anyone who spends time in tick-infested areas.

Seven tick species in the U.S. may carry disease:

**Lyme disease**, carried by the blacklegged tick and Western blacklegged tick, is the most prevalent tick-borne disease in the U.S., with [24,364 known and 8,733 probable cases reported in 2011](#), the latest year for which data are available.

Most cases occur from Virginia to Maine and the upper Midwest, mostly Wisconsin and Minnesota (CDC 2013F).

Adult blacklegged ticks are about the size of a sesame seed. Most Lyme disease is transmitted via bites from immature nymphs that feed during the spring and summer. You are most likely to contract tick-borne Lyme disease between late April and mid-July.

The lone star tick, found in the eastern half of the U.S., carries Southern tick-associated rash illness, an infectious disease similar to Lyme disease.

Tick	Disease(s)	Symptoms
Blacklegged tick, also known as deer tick	Anaplasmosis	Anaplasmosis: fever, headache, chills and muscle aches  Babesiosis: varies from none to flu-like and life-threatening
	Babesiosis	
	Lyme disease	
Western blacklegged tick	Anaplasmosis	Lyme disease: bull's eye rash, fatigue, chills, fever, headache, aches, swollen lymph nodes
	Babesiosis	
	Lyme disease	
American dog tick	Rocky Mountain spotted fever	Rocky Mountain spotted fever: fever, headache, vomiting, muscle pain and in some cases death
Brown dog tick	Rocky Mountain spotted fever	
Gulf Coast tick	Rickettsiosis	Rickettsiosis: fever, scabs, rash
Lone star tick	Ehrlichiosis	Ehrlichiosis: fever, headache, chills, malaise, muscle pain, nausea/vomiting/diarrhea, confusion, red eye, rash
Rocky Mountain wood tick	Rocky Mountain spotted fever	Rocky Mountain spotted fever: fever, headache, vomiting, muscle pain and in some cases death  Tulameria: Skin ulcer with regional lymph node swelling
	Tularemia	

Source: CDC 2010



Adult deer tick, *Ixodes scapularis*.

**Rocky Mountain spotted fever** can cause fever, headache, vomiting, muscle pain and in some cases death. It can be transmitted to humans by bites of the American dog tick, Rocky Mountain wood tick and brown dog tick. The disease has been reported throughout the lower 48 states; most cases occur in North Carolina, Oklahoma, Arkansas, Tennessee and Missouri. The incidence rate has increased over the past 20 years to about 2,000 cases annually. But the fatality rate has greatly decreased over the past 50 years from 5 to 10 percent to less than 0.5 percent (CDC 2012A).

## DO REPELLENTS STOP TICKS?

No single chemical completely repels important American ticks. Do not rely on any product to keep ticks away. Perform tick checks at the end of the day or when returning indoors.

To help protect from Lyme disease, the CDC recommends that people use a product with at least [20 percent DEET or Permethrin-coated clothing](#) (CDC 2011). In lab studies DEET stops 3 of every 4 ticks. Researchers test tick repellents by timing how long it takes for a tick to walk over a volunteer's repellent-coated skin. The effectiveness of tick repellents can vary according to species and lifecycle stage of the tick.

The EPA has approved Picaridin, IR3535 and Oil of Lemon Eucalyptus/PMD for use as tick repellents

with a protection time greater than two hours (EPA 2013). There are few peer-reviewed scientific studies of the efficacy of these chemicals against deer ticks. Two studies indicate that IR3535 repels deer ticks as well as or better than DEET (Bissinger 2009, Carroll 2005). Direct evidence of Picaridin efficacy is limited, but Consumer Reports gave it top marks (Consumer Reports 2010).

In one study, three repellents – 33 percent DEET, 20 percent Picaridin and 20 percent IR3535 – repelled lone star ticks for some hours, but 10 percent IR3535 did not (Carroll 2005).

## DOES TREATED CLOTHING KEEP TICKS AWAY?

ExOfficio BugsAway products, sold at outdoor stores like REI, L.L. Bean, and Cabela's, are pretreated with permethrin, which is not a repellent but an insecticide meant to kill ticks on contact.

This chemical is neurotoxic and has been classified by EPA as a likely human carcinogen. It is highly toxic to the environment, especially to fish and other aquatic life. But a 2009 EPA review said that "permethrin factory-treated clothing is unlikely to pose any significant acute or chronic hazard to people," including toddlers, pregnant women and nursing mothers (EPA 2009, EPA 2012).

Use permethrin products with caution, read labels, and wash all treated clothing separate from other clothing.

ExOfficio claims that the bug-killing effect of its clothing lasts for 70 washings (ExOfficio 2013). Efficacy testing indicates a higher level of protection than that offered by repellents applied to the skin (Miller et al. 2011). In a pilot study, 16 North Carolina state employees in outdoor occupations chose between treated clothing or repellents. The group that used repellents received 62 tick bites. Among the group who wore treated clothing, one person had one tick bite (Vaughn & Meshnick 2011).

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