



How to Repel Mosquitoes Safely

With summer approaching, and the insects coming out in full force, along with some very itchy arms and legs, avoiding mosquitoes becomes a high priority. It is not too early this spring to fight the bite first and foremost by practicing prevention. Remove any standing water where mosquitoes can breed around your home and schoolyard, such as plant pots, leaky hoses, clogged gutters, empty buckets, toys, and old tires. Trim back overgrown vegetation, and encourage natural predators like bats, birds, dragonflies, and frogs.

Protect yourself from mosquitoes by wearing long-sleeved, loose, light colored clothing. When sitting outside, use an oscillating fan, a screened area, or even a pop-up shelter. Burning citronella candles outside may also help repel mosquitoes. As a last line of defense, employ least-toxic mosquito repellents (but with the understanding that no acceptable repellent will provide complete protection from bites). Many common mosquito sprays contain harmful ingredients, so it is important to read labels carefully before buying and using repellents.

Least-Toxic Mosquito Repellents:

Registered Repellents: Although many essential oil insect repellents are registered by the U.S. Environmental Protection Agency (EPA), only the following active ingredients in repellents are evaluated by EPA for health risks and product effectiveness, and also considered least-toxic by Beyond Pesticides. With any repellent, read the directions and follow the label carefully, and be sure to avoid contact with sensitive areas like the eyes and open wounds. These materials are all alternatives to the hazardous ingredient DEET. (See DEET hazards on next page.)

Oil of Lemon Eucalyptus (OLE)

****Best Choice!****

The U.S. Centers for Disease Control and Prevention (CDC) recommends OLE repellents as an effective alternative to DEET. OLE masks both carbon dioxide and lactic acid exhalations that alert mosquitoes to our presence, hiding humans from detection. Only formulated, refined OLE is registered by the agency as a repellent; note that “pure” lemon eucalyptus oil is registered for safety, but not repellent effectiveness by EPA. A synthetic version of the active ingredient in OLE,

p-Menthane-3,8-diol, is also on the market, but Beyond Pesticides suggests considering the refined, natural extract. Protection times are similar to DEET-based repellents.

- **Cautions:** Do not apply to children less than 3 years of age.
- **Product Examples:** Repel Lemon Eucalyptus Insect Repellent, Cutter Lemon Eucalyptus Insect Repellent.
- **Estimated Time of Effectiveness:** 3-7 hours in areas with aggressive mosquito populations, up to 12 hours in other areas.

Picaridin (Icaridin, or KBR 3023)

A synthetic version of the piperine compound in pepper, picaridin is a relatively new insect repellent that can be used as a least-toxic alternative to DEET. Although there is limited data available on this product, particularly concerning long-term toxicity, evidence does suggest that it has low potential for human harm if used as directed. Picaridin is synthetic, so those seeking a natural repellent should consider OLE.

- **Cautions:** Do not apply to children less than 2 months of age.
- **Product Examples:** Avon Skin So Soft Bug Guard Plus Picaridin, Sawyer Pre-

mium 20% Picaridin Insect Repellent.

- **Estimated Time of Effectiveness:** Based on picaridin concentration: 3-6 hours at concentrations below 20%; up to 8 hours at concentrations of 20%.

IR3535

Insect repellent 3535 is a synthetic repellent that was registered by EPA in 1999, after 20 years of use in Europe, with no reports of adverse effects in the scientific literature. Despite its synthetic make-up, IR3535 is registered as a biochemical pesticide because it is functionally identical to the molecular structure of beta alanine, a naturally occurring amino acid, and the end groups formed through its production are not likely to contribute to toxicity. Still, those looking for a natural repellent should consider OLE.

- **Cautions:** Eye irritant, avoid contact in or around eyes.
- **Product examples:** Avon Skin So Soft Bug Guard Plus IR 3535 Expedition, Coleman Skin Smart DEET-Free Pump Spray Insect Repellent.
- **Estimated Time of Effectiveness:** Based on IR3535 concentration: Around 2 hours at concentrations below 20%; up to 8 hours at concentrations of 20%.



Federally Registered Repellents: Unless determined to be minimum risk and exempt from registration, repellents must undergo EPA's formal registration process, which includes a scientific assessment of the active ingredient that is included in pesticide products. Repellents with a public health claim (such as, 'protects against mosquitoes carrying West Nile virus'), must be evaluated by EPA for product effectiveness.

Unregistered Repellents (List 25(b) – Federally Exempt Minimum Risk Products): Minimum risk repellents and pesticides under section 25(b) of the *Federal Insecticide, Fungicide and Rodenticide Act* (FIFRA) are not required to undergo the federal registration process if their ingredients are "demonstrably safe for its intended use."

Unregistered Repellents (25b–see box): Essential oil repellents are considered minimum risk, and are evaluated by EPA for safety concerns. Although EPA has not evaluated them for effectiveness, some independent data does suggest a varying degree of efficacy with certain essential oil repellents. All are considered least-toxic by Beyond Pesticides, but some can cause contact dermatitis, so apply to a small area of skin, such as the arm or leg first, before using on the rest of your body. With all essential oil bug repellent products, use caution around infants and toddlers, and always read the label.

Soybean Oil

Many bug repellents are formulated with soybean oil, an extract of soybeans. Although soybean oil repellents have not been tested for efficacy by EPA, Health Canada recommends these products as an acceptable mosquito repellent. The agency also does not prescribe any frequency or age limitations to the use of soybean oil repellents.

- **Cautions:** Avoid contact with eyes, follow label directions.
- **Product examples:** Buzz Away products, Bite Blocker Organic Extreme.
- **Estimated Time of Effectiveness:** 1.5 to 4 hours, depending upon formulation.

Citronella Oil

The classic all-natural mosquito repellent may not be as effective as word of mouth

would have it. Although there is evidence that burning citronella candles and incense reduces backyard mosquitoes, spray-on products primarily made of citronella oil are not reported by many to be the most effective way to repel mosquitoes. For example, Natrapel products containing 10% citronella oil showed one hour efficacy under EPA tests, but now have been reformulated with picaridin. Natural products, such as the ones listed below, which contain citronella, but not as the active ingredient, have increased repellency.

- **Cautions:** Citronella can contain human allergens and should not be applied to infants and toddlers.
- **Product example:** All-Terrain Herbal Armor DEET-Free Natural Insect Repellent.
- **Estimated Time of Effectiveness:** 30 minutes to 3 hours, depending upon formulation.

Other Essential Oils

Many of the products listed above also contain essential oils, such as lemongrass oil, castor oil, catnip oil, geraniol oil, cedarwood oil, peppermint oil, clove oil and others. There is limited data on the efficacy for many of the essential oils as stand-alone mosquito repellents. However, catnip oil shows the greatest promise. No essential oils should be applied to infants or toddlers. Beyond Pesticides suggests that you consider one of the many DEET-free formulated repellents.

Be Sure to Avoid:

Pesticide-Impregnated Clothing

Although clothing pre-treated with the insecticide permethrin, the only pesticide approved for this use, is less available in the marketplace, many companies nonetheless sell spray cans of permethrin intended to be applied to clothing. Beyond Pesticides strongly discourages the use of permethrin on clothing. Permethrin is classified as "likely to be carcinogenic" by EPA, and studies have linked childhood permethrin exposure to leukemia. Permethrin shows evidence of endocrine disruption and neurotoxicity,^{1,2} and research has also linked pesticides in the pyrethroid class, which permethrin is a part of, to behavioral and emotional problems in children.³

DEET

Although recent scientific data calls into question evidence that DEET results in seizures in children, Beyond Pesticides suggests that people consider least-toxic repellents such as OLE and the others listed in this article be used in place of DEET. In humans, symptoms of acute exposure to DEET include headache, exhaustion and mental confusion, together with blurred vision, salivation, chest tightness, muscle twitching and abdominal cramps. Researchers have noted significant concerns related to the use of DEET, including nervous system disorders, adverse developmental effects, and neurotoxicity in children. One study found that DEET inhibits cholinesterase activity crucial for regulating nerve impulses.⁴ Another study associated pregnant women's exposure to insect repellents, such as DEET, during their first trimester to an 81% increased chance of male children developing "hypospadias," a condition where the urinary opening is at the bottom rather than the tip of the penis.⁵

Studies have also shown synergistic effects as a result of combining DEET and permethrin together.⁶ Scientists link the combined effect of these two chemicals to poor sensorimotor performance and brain damage. This is especially important when considering the widespread use of permethrin in mosquito spray programs, where governments may concurrently advise the use of DEET.

DEET labels are required to include the following directions: "Do not apply over cuts, wounds, or irritated skin; Do not apply to hands or near eyes and mouth of young children; Do not allow young children to apply this product; Use just enough repellent to cover exposed skin and/or clothing; Do not use under clothing; After returning indoors, wash treated skin with soap and water; Wash treated clothing before wearing it again; and, Use of this product may cause skin reactions in rare cases."



Endnotes

1. Elwan, MA et al. 2006. Pyrethroid pesticide-induced alteration in dopamine transporter function. *Toxicology and Applied Pharmacology*. 211(3):188-97. Epub 2005 Jul 11.
2. Kim, I. Yet al. 2004. Assessing estrogenic activity of pyrethroid insecticides using in vitro combination assays. *Journal of Reproduction & Development*. 50(2):245-255. ISSN: 0916-8818.
3. Youssef Oulhote and Maryse F Bouchard. 2013. Urinary Metabolites of Organophosphate and Pyrethroid Pesticides and Behavioral Problems in Canadian Children. *Environmental Health Perspectives*. DOI:10.1289/ehp.1306667
4. Corbel, Vincent et al. 2009. Evidence for inhibition of cholinesterases in insect and mammalian nervous systems by the insect repellent deet. *BMC Biology*. 2009, 7:47 doi:10.1186/1741-7007-7-47
5. Dugas, J. et al. 2009. Use of biocides and insect repellents and the risk of hypospadias. *Occupational and Environmental Medicine*. doi:10.1136/oem.2009.047373
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Citations

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BEYOND PESTICIDES

701 E Street SE • Washington DC 20003
 202-543-5450 phone • 202-543-4791 fax
info@beyondpesticides.org • www.beyondpesticides.org