There are a number of similarities in the issues between the use of ‘green’ pesticides for the control of two obligate blood feeders: ticks and bed bugs.

**REVIEW OF THE “NATURAL” PRODUCT MINEFIELD FOR BED BUG CONTROL**

Kirby C. Stafford III, Ph.D.
Chief Scientist, State Entomologist
Department of Entomology
Center for Vector Biology & Zoonotic Diseases
Connecticut Agricultural Experiment Station
New Haven, CT

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**Bed Bug Treatments and 25b Compounds**

- Pest management professional (PMP) applied EPA-registered synthetic acaricides or insecticides continues to be the primary and most efficacious method of bed bug and tick control for homeowners with increasing interest in ‘green’ products, botanically-based or other all "natural" products for controlling pests. The big question is are they effective under natural conditions?
- Increased interest by companies as products can be exempt from registration under minimum risk exemption regulations. Quick to market vs 10 years from lab bench to registered and marketed product.
- Many homeowners self treat for bed bugs with a glut of unregulated, off the shelf, internet available products. Some PMPs use 25b materials for organic tick control. Some 25b products do have EPA registration numbers.
- The internet is all too often an easy source of misinformation, directing those who have or think they have bed bugs to prevention methods that are ineffective and potentially harmful, underscoring the need for improving science-based tick-borne disease prevention communication.
- Misuse or poor application can result in poor bed bug control and deleterious health consequences (for example, toxic human exposures to pesticides).

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**EPA registered products mainly pyrethriods, neonicinoids, etc.**

Examples – 370 products listed for bed bugs for CT on Kelly Solutions

- CrossFire = clothianidin + methofluthrin + piperonyl butoxide
- Temprid SC = imidacloprid + β-cyfluthrin
- Suspend SC = deltamethrin
- Demand CD = λ-cyhalothrin

Interest in alternatives due to resistance or tolerance to pyrethriods by bed bugs and increased demand by the public for "green" products
What are 25b Compounds?
Also listed whether for non-food or food use

**Active Ingredient (examples)**
- Cedarwood oil
- Cinnamon
- Citric acid
- Citronella
- Eugenol
- Garlic & garlic oil
- Geraniol
- Lauril sulfate
- Lemongrass oil
- Peppermint & peppermint oil
- Rosemary & rosemary oil
- Sesame & sesame oil
- Sodium chloride
- Sodium lauryl sulfate
- Thyme & thyme oil

**Inert Ingredient (examples)**
- Almond huls, oil, shells
- Beeswax
- Bentonite
- Calcium citrate
- Cellulose
- Coffee grounds
- Diatomaceous earth
- Fish meal & oil
- Gum arabic
- Isopropyl alcohol
- Lard
- Lysine oil
- Milk
- Mineral oil
- Silica, amorphous
- Silica gel
- Urea
- Wintergreen oil

Look at an EPA registered product
Diatomaceous earth & silica on EPA's minimum risk inert list, but **not** on minimum risk active ingredient list, hence EPA registration Would not qualify as a wholly 25b product;
Other ingredients do not have to be listed
• Diatomaceous earth dust is a non-chemical method using insecticides composed of amorphous silicon dioxide, harmful to human health by inhalation.
• Silica, amorphous, fumed (crystalline free), precipitate, and gel are on minimum risk inert ingredient list; not the active ingredient list so can’t be used as wholly 25b product.
• Risks with inhaled products with repeated exposure include silicosis, lung cancer, and nonmalignant respiratory disease (particularly if material contains high percentage of crystalline silica).
• Tolerance to silica-based dusts has been reported for bed bugs.

Note: Behavioral responses of bed bugs to insecticide dusts could influence their efficacy; bed bugs avoid some insecticide dusts, but some also can provide rapid killing effect with brief contact.

A minimum risk product must meet the six conditions listed below. A product that meets all of these six conditions then is exempted from regulation under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), i.e., the pesticide product does not need to be registered with EPA. However, states may require registration under state laws.

• **Condition 1:** The product’s active ingredients must only be those that are listed in 40 CFR 152.230(f)(1)
• **Condition 2:** The product’s inert ingredients may only be those that have been classified by EPA as:
  - listed in 40 CFR 152.230(f)(2)
  - commonly consumed food commodities, animal feed items, and edible fats and oils as described in 40 CFR 180.355(a), (b), and (c); and
  - certain chemical substances listed under 40 CFR 180.355(c).
• **Condition 3:** All of the ingredients (both active and inert) must be listed on the label. The active ingredient(s) must be listed by label display name.
• **Condition 4:** The product must not bear claims either to control or mitigate organisms that pose a threat to human health, or insects or rodents carrying specific diseases.
• **Condition 5:** The name of the producer or the company for whom the product was produced and the company’s contact information must be displayed prominently on the product label.
• **Condition 6:** The label cannot include any false or misleading statements.

### Condition 3: Ingredients Listed on Label

• All of the ingredients in an exempted product (both active and inert) **must** be listed on the label:
  - All active ingredients must be listed by label display name* and percentage (by weight).
  - All inert ingredients must be listed by label display name*.

*Pursuant to the final rule published on **December 28, 2015**, the compliance date for the requirement to label ingredients with a label display name is **February 26, 2019**.
Condition 4: Health-Related Claims

- The label cannot state or imply that the product can or will control or reduce organisms that pose a threat to human health, or insects or rodents carrying specific diseases.
- Claims Linking Pest to Specific Diseases
- Minimum risk pesticide labels may not bear claims to control rodent, insect or microbial pests in a way that links the pests with any specific disease. The label claim may only be for the pest, as a pest, and not as a disease vector. For example:
  - The label may not say:
    - “controls ticks that carry Lyme disease;” or
    - “controls mosquitoes that can transmit malaria, encephalitis, West Nile virus or the Zika virus.”
  - But can say:
    - “controls ticks;” or
    - “controls mosquitoes.”

Bed bugs fall through the cracks (pun intended) on claims, don’t transmit any disease pathogens, but can be a health issue.

Detergent & surfactant 3.0%
Salt 1.0%
Citric Acid 0.2%

A diversity of products can be found on the shelf; most EPA registered, but some not. What is available over the internet for self-treatment is a real concern.

And labels can be more than just false or misleading, but really illegal! Federal agencies like the FDA, USDA, and EPA take a really dim view of use of their logos.
State Requirements for CT

- Commercial use - 25b products same as EPA registered products (must be state registered).
- The same rules apply for commercial applications of these products. The products must have state registration, commercial applicators must be licensed and business registered, they must pre-notify registered abutters, they must post outdoor treatments, they must maintain records of applications.
- No essential oil-based products for bed bugs found registered in CT on Kelly Solutions (just silicon dioxide products like CimeXa, n = 28 products, last updated 1/13/19).

Essential Oils

- Derived from various aromatic plants that are composed of complex mixtures of chemicals
- Composed of different functional groups: phenols, aldehydes, acids, hydrocarbons, terpenoids, etc.
- For example, cedarwood oil can come from diversity of tree species from different genera and localities with different chemical components.
- Concentrations of essential oils in products very low and “unlikely to be lethal to bed bugs when used alone”.... Other factors besides the active ingredients must have accounted for the high efficacy of some essential oil-based pesticides. Singh et al. 2014. J. Econ. Entomol. 107(6):2163-2170.

Screen of Essential Oils Against Bed Bugs

Zha et al. (2018) Environ. Ent. 11:170-177

- Cedarwood Virginian
- Cedarwood Cherokee
- Cedarwood Himalayan
- Cedarwood Texas & Atlas
- Palmarosa (Geraniol)

Note: these results are from a topical bioassay

EcoRaider
1% geraniol, 1% cedarwood, 2% sodium laurel sulfite
Company wouldn’t disclose cedarwood used in product
efficacy, combination and special formulating technique?

Cedarwood oil from 4 regions, extracted from 6 tree species, with different main constituents
Keep a Perspective

<table>
<thead>
<tr>
<th>Essential oil component</th>
<th>LD₅₀ ug/mg body weight (95% limits)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carvacrol</td>
<td>27.5 (25-30.5)</td>
</tr>
<tr>
<td>Thymol</td>
<td>32.5 (29.5-35)</td>
</tr>
<tr>
<td>Geraniol</td>
<td>ND (&lt;30% mortality, LD₅₀ not determinable)</td>
</tr>
<tr>
<td>Bifenthrin (positive control)</td>
<td>0.000345 (~72,000 times more potent)</td>
</tr>
</tbody>
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“More than a dozen [dozens!] essential oil-based products are available commercially for indoor use, but only two products have been found effective for bed bug control…Therefore need for conducting comparative baseline toxicity studies…using major components or constituents of different plant essential oils.”

“Carvacrol and thymol were the most active compounds in topical application bioassays [italics added]…are not present in any of the essential oil-based products available for bed bug control.”

Summary Issues “Natural” Products

- Essentria IC-3 active ingredients: 10% rosemary oil, 5% geraniol, 2% peppermint oil
- Other ingredients: Wintergreen Oil, White Mineral Oil, Vanilllin, Polyglyceryl Oleate
- Blocks octopamine, a neurotransmitter, neurohormone or neuromodulator in invertebrates
- Larval packet tests multiple strains R. microplus
- Among AIs, only geraniol exhibited larvicial properties (no activity bed bugs)
- Rosemary oil and peppermint oil failed dose-mortality response
- High response to commercial product attributed to synergism among the principal ingredients and other components present in the product

- No or limited efficacy data, especially under real world field conditions (most published studies are topical bioassays).
- Exempted from testing for toxicity, some may be toxic at higher doses, irritants, or allergens.
- Variable composition of essential oils depending on source plant species (may or may not be known or released by manufacturer), extraction method, etc.
- Volatility and lack of persistence, requiring frequent applications.
- Efficacy oil vs. specific components of the plant extract or oil Laboratory (topical, direct spray) vs. field evaluations (i.e., residual activity - bed bugs in cracks, crevices, etc.; ticks under leaf litter).
- Formulation may make a huge difference because any activity likely due to synergism or interaction of multiple ingredients.
From red-bugs and bed-bugs,  
from sand-flies and land-flies,  
Mosquitoes, gallinippers and fleas,  
From hog-ticks and dog-ticks,  
from hen-lice and men-lice,  
We pray thee, good Lord, give us ease.

An old prayer, circa 1856