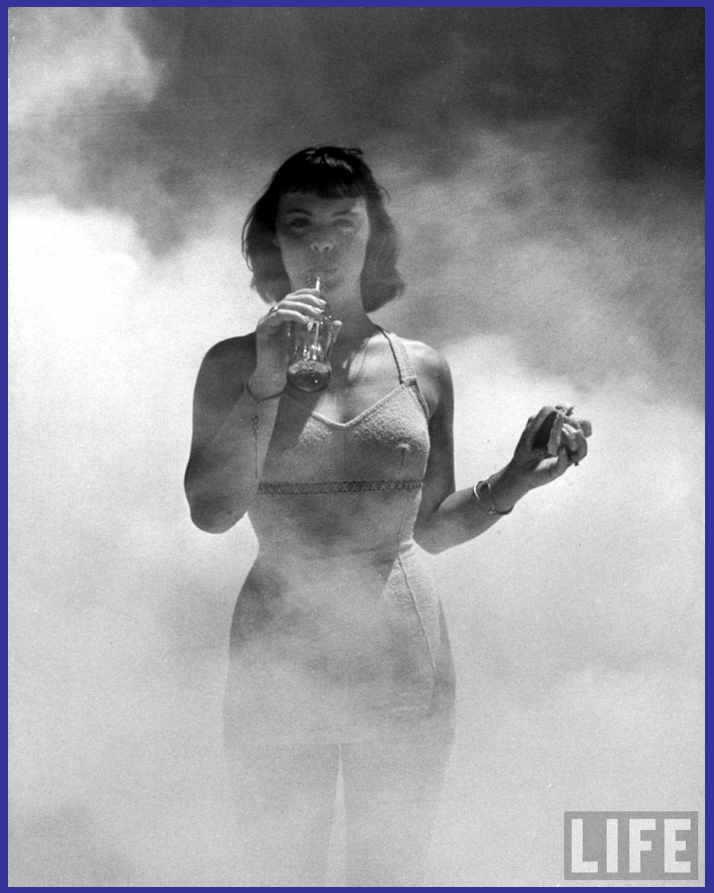
Pesticides for managing bed bugs

Richard S. Cowles

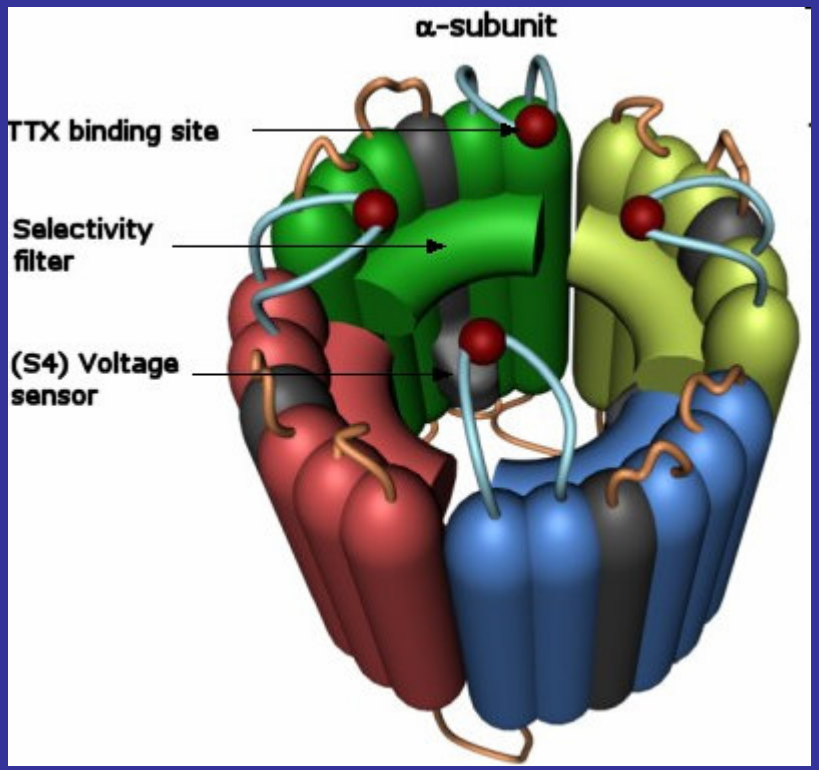
Connecticut Agricultural Experiment Station, Valley Laboratory
Windsor, CT

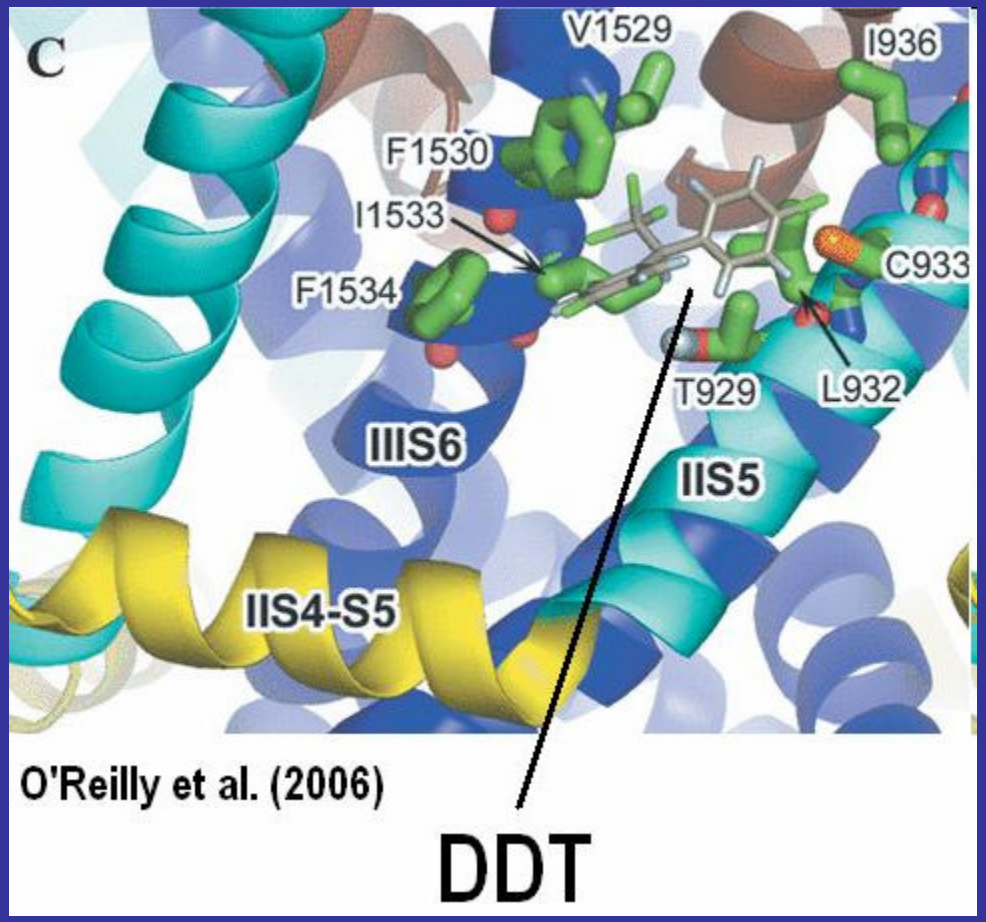
http://women4hope.files.wordpress.com/2009/04/female-bedbug.jpg

DDT saved many soldiers and civilians' lives during WWII.



Era of public acceptance led to virtual eradication in U.S. of bed bugs.





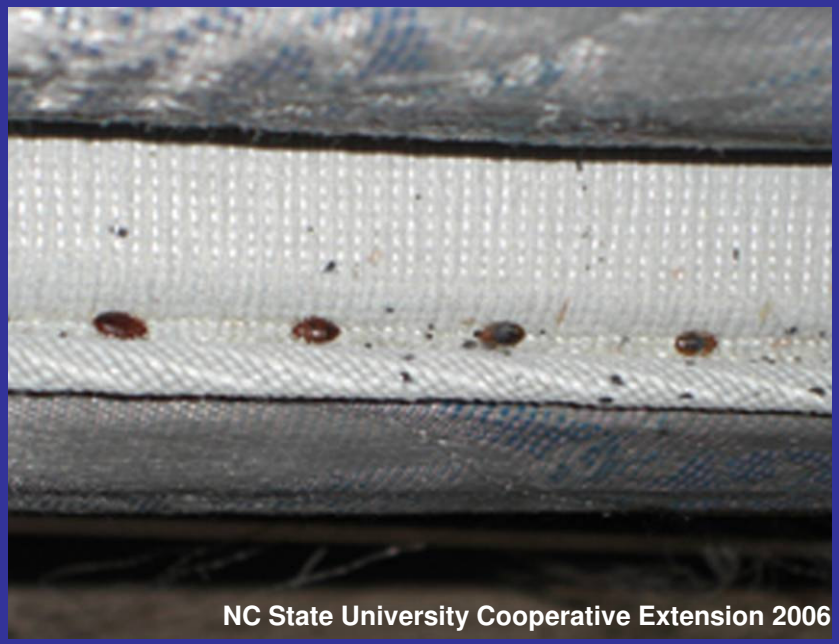
Selection with DDT could have led to pre-adaptation to survive exposure to pyrethroids.

Residual insecticides registered for control of bed bugs on surfaces other than on mattresses

lambda-cyhalothrin
permethrin
bifenthrin
fenvalerate
propoxur *
(s)-hydroprene
chlorfenapyr

* Crack and crevice only, bed bugs not on label.

Insecticides Registered for Control of Bed Bugs on Mattresses


NC State University Cooperative Extension 2006

Residual Chemicals

deltamethrin

cyfluthrin

silica aerogel dust + pyrethroid

ground limestone

permethrin

pyrethrins

Contact Chemicals

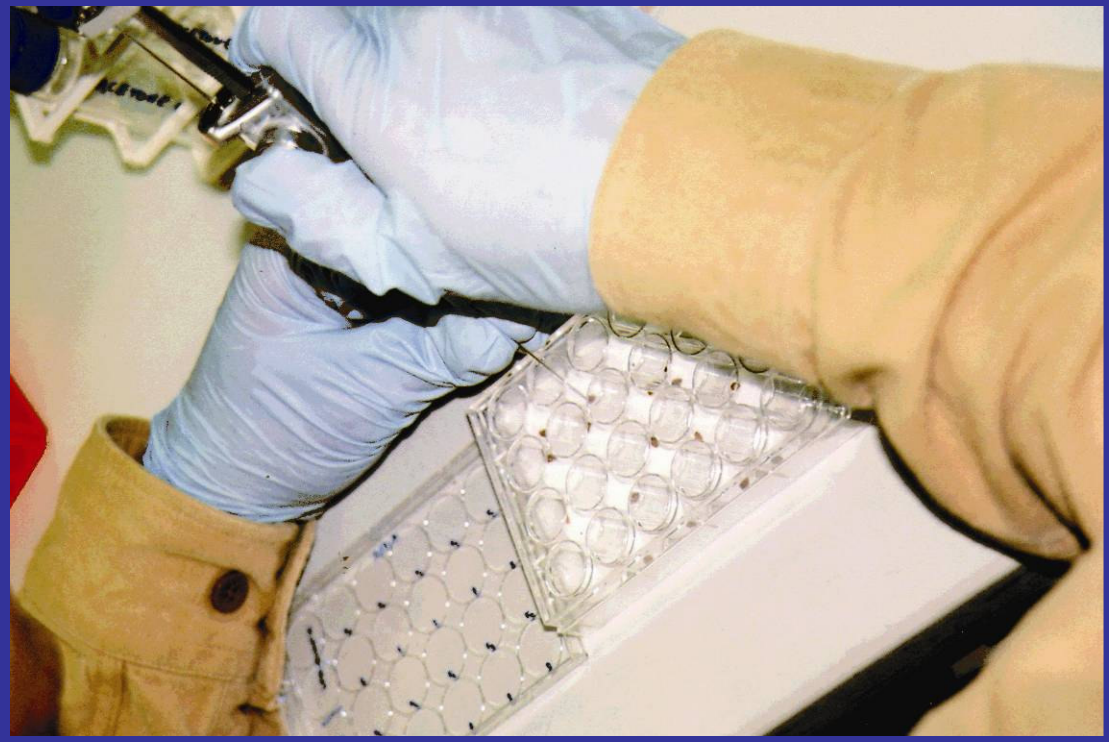
pyrethrins

d-phenothrin

alcohols

Application of Pyrethroids to Bed Bugs

Assembling the Hamilton Repeating Dispenser

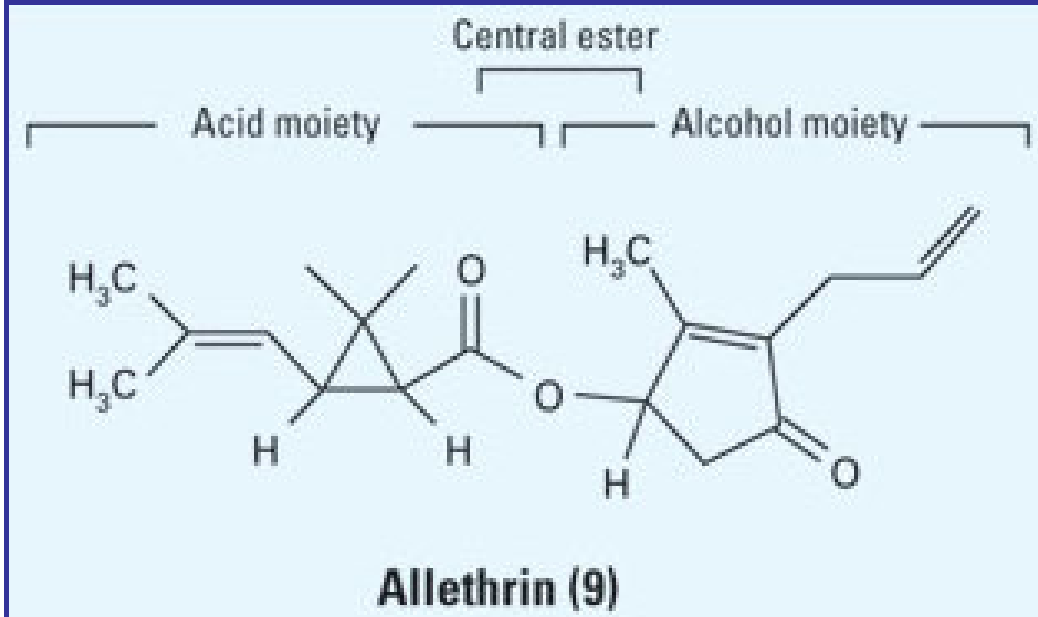


Placing a small drop of a pyrethroid insecticide on a bed bug

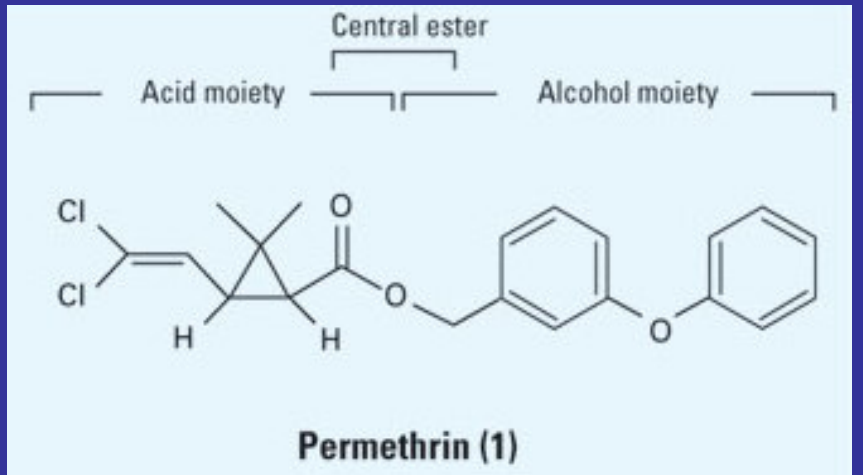
Pyrethrum Daisy (*Tanacetum cinerariaefolium*)

Synthetic products are called pyrethroids

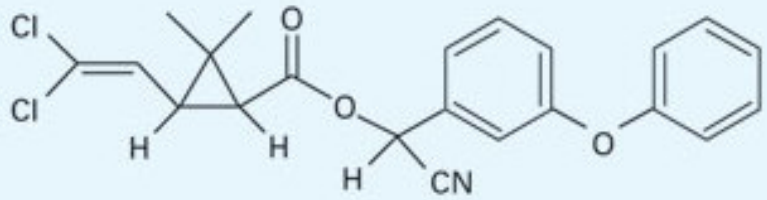
Natural products are called pyrethrins



Allethrin (9)



Permethrin (1)



Cypermethrin (3)

Mortality of Bed Bugs after 72 Hours Exposure to 1 µg of Insecticide

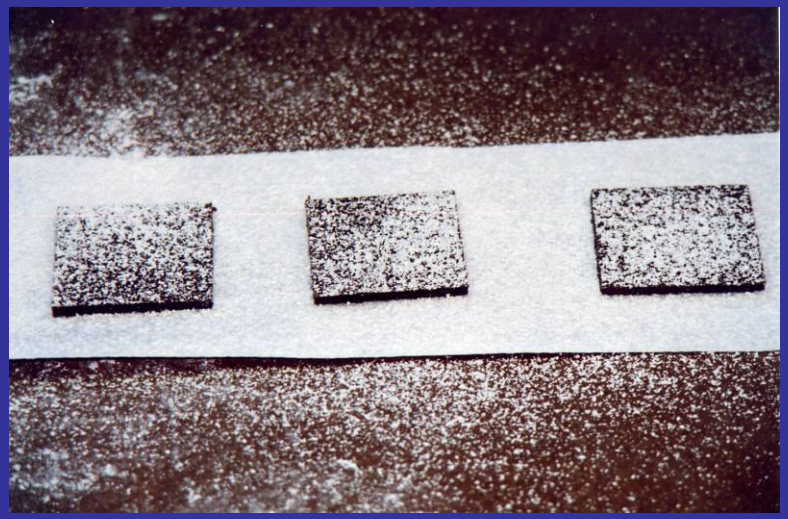
Class*	Common Name	% Mortality
I	D-Phenothrin	5
I	Pyrethrins	5
I	d-Trans Allethrin	5
I	Tetramethrin	5
I	Permethrin	0
I	Resmethrin	5
II	Lambda cyhalothrin	95
II	Trans-cypermethrin	35
II	Cis-cypermethrin	80
II	Fenvalerate	5
II	Fenpropathrin	10
II	Cyfluthrin	80
II	Deltamethrin	90
Negative Control	Acetone	0

Liquid and Dust Formulations of Insecticides Tested against Bed Bugs

Formulation	Trade Name	Common Name
Liquid	Bedlam	D-Phenothrin
	D-Force HPX	Deltamethrin
	Cyonara 9.7	Lambda cyhalothrin
Dust	Delta Dust	Deltamethrin
	Drione	Pyrethrins
	Tempo Dust	Cyfluthrin
	Syloid Silica Gel	None

Applying Residual Chemicals to Filter Papers, Hardboards, and Mattress Covers

Applying Drione to a soil sieve



Hardboards treated with Drione

Applying D-Force

Percent Mortality of Bed Bugs
Note: 13 days of continuous exposure

Surface	Age of D-Force HPX when bed bugs first exposed (days)					
	1	15	35	56	112	168
Filter Paper	100	73	77	50	50	23
Hardboard	93	27	37	17	43	13
Mattress Cover	90	27	10	7	40	3

Percent Mortality of Bed Bugs

Surface	Age of Drione residue when bed bugs first exposed (days)					
	1	15	35	56	112	168
Filter Paper	100	100	100	100	100	100
Hardboard	100	100	100	100	100	100
Mattress Cover	100	100	100	100	100	100

Percent Mortality of Bed Bugs

Surface	Age of Syloid Silica Gel dust when bed bugs first exposed (days)				
	1	15	35	56	112
Filter Paper	100	100	100	100	100
Hardboard	100	100	100	100	100
Mattress Cover	100	100	100	100	100

What about behavioral effects?

Percent Mortality of Bed Bugs
Note: 13 days of continuous exposure

Surface	Age of D-Force HPX when bed bugs first exposed (days)					
	1	15	35	56	112	168
Filter Paper	100	73	77	50	50	23
Hardboard	93	27	37	17	43	13
Mattress Cover	90	27	10	7	40	3

Behavioral Responses of the Bed Bug to Insecticide Residues

Alvaro Romero, Michael F. Potter, and Kenneth F. Haynes

Journal of Medical Entomology 46(1): 51-57. 2009

In two-choice tests, grouped insects and individual insects avoided resting on filter paper treated with deltamethrin. Insects did not avoid surfaces treated with chlorfenapyr. Harborages, containing feces and eggs and treated with a deltamethrin-based product, remained attractive to individuals from a strain resistant to pyrethroids. Video recordings of bed bugs indicated that insects increased activity when they contacted sublethal doses of deltamethrin.

Pyrethroid summary

Target site insensitivity
Behavioral avoidance
Reduced penetration through cuticle
Metabolic detoxification

Do not expect pyrethroids to have any utility for killing bed bugs

Non-pyrethroid bed bug insecticides

Phantom = chlorfenapyr

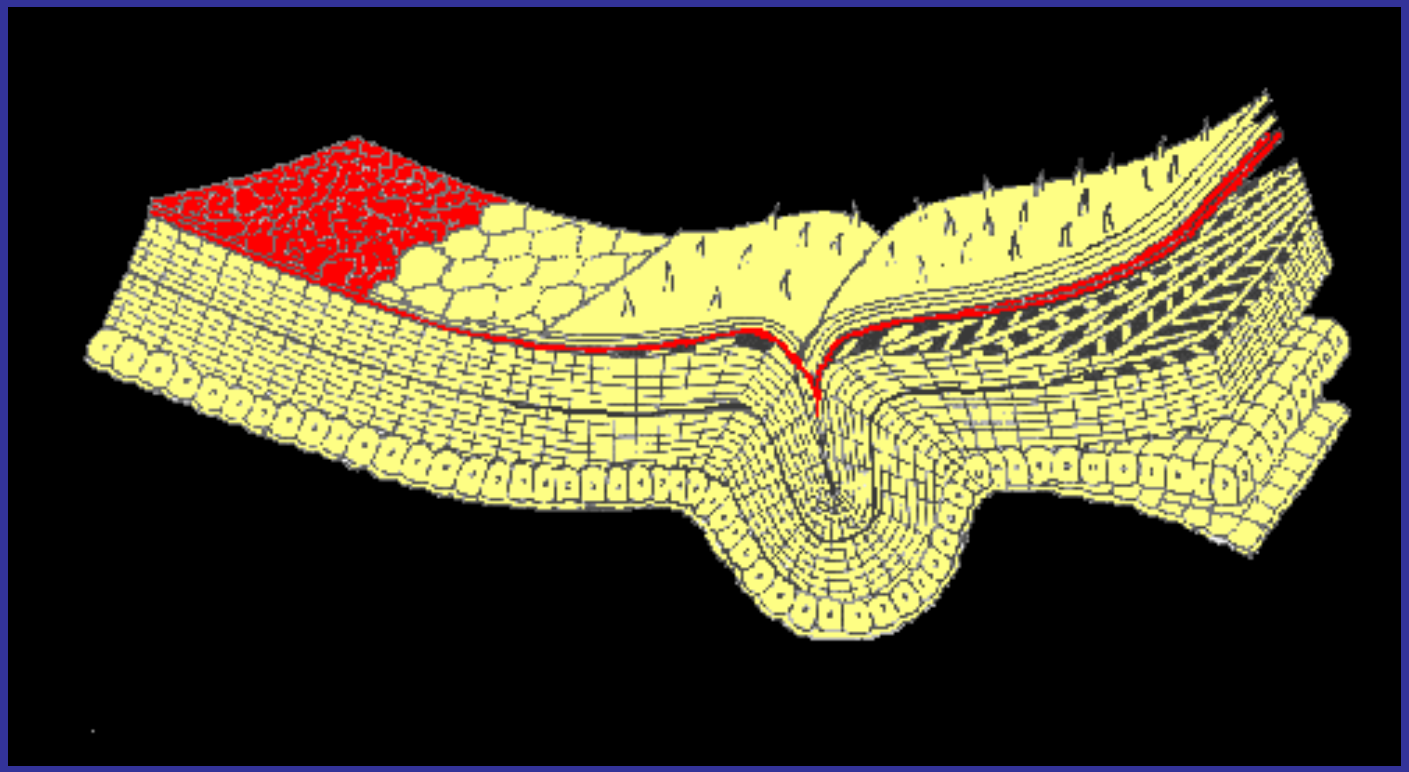
TC 269, Alpine dust = dinotefuran
Multicide 295511 = phenothrin + imidacloprid
Transport = bifenthrin + acetamiprid

Gentrol, RF9707 = hydroprene
TER-CX1 = neem oil

Dusts

The oldest insecticide

Lipid barrier is only 0.25 μm thick



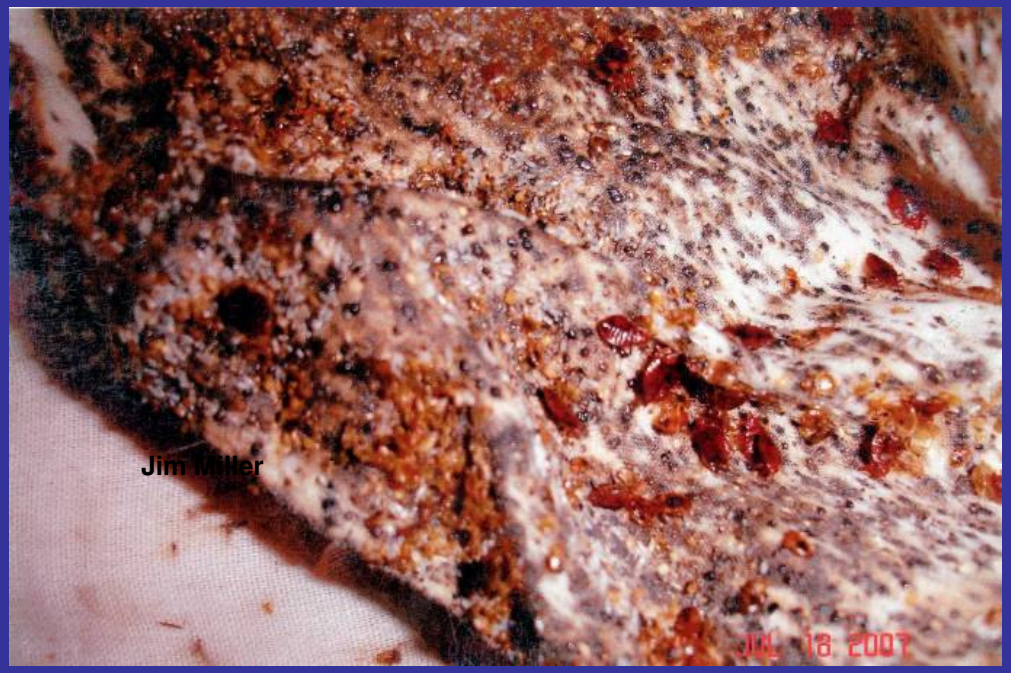
Emptying wax canals by sorption of wax at the surface leads to rapid desiccation

All three effective measures desiccate bugs

Dusts
Heat treatment
Alcohol spray

Bed bugs have extremely high surface to volume ratio, and so are especially susceptible to desiccation.

Bed bugs are unlikely to evolve resistance to desiccants!



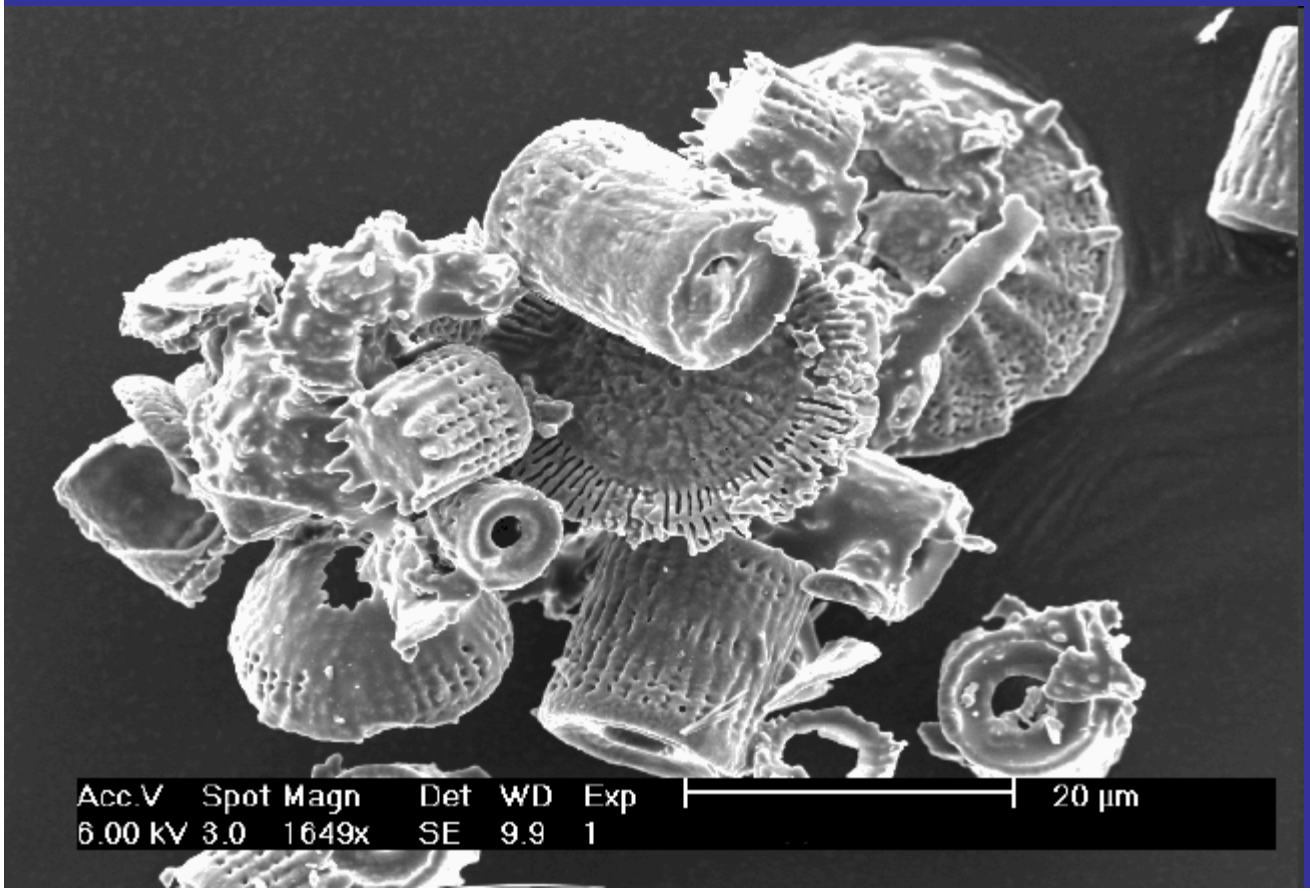
White sheet on bed

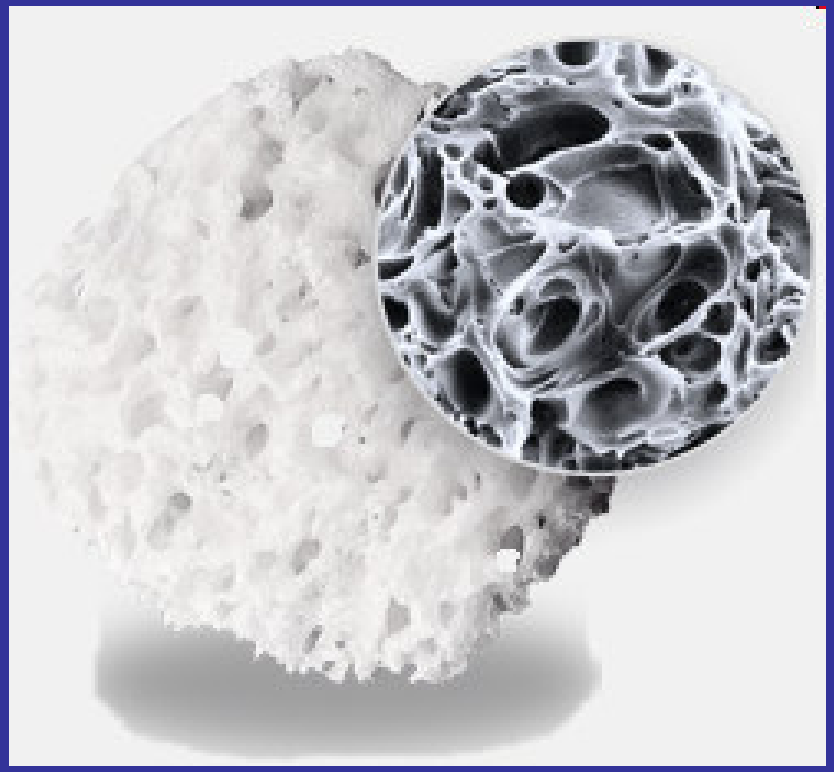
Aggregation behavior may be an adaptation to avoid desiccation

Bed bugs in refrigerator

Diatomaceous earth

Similar in principle to silica aerogel
May contain some crystalline silica
(risk of silicosis if inhaled)





W. R. Grace

Surface area can reach 300 m^2 per gram

(Ebeling, W. 1971. Annu. Rev. Entomol.)

Pure silica gel dust is now available

Least risk to humans

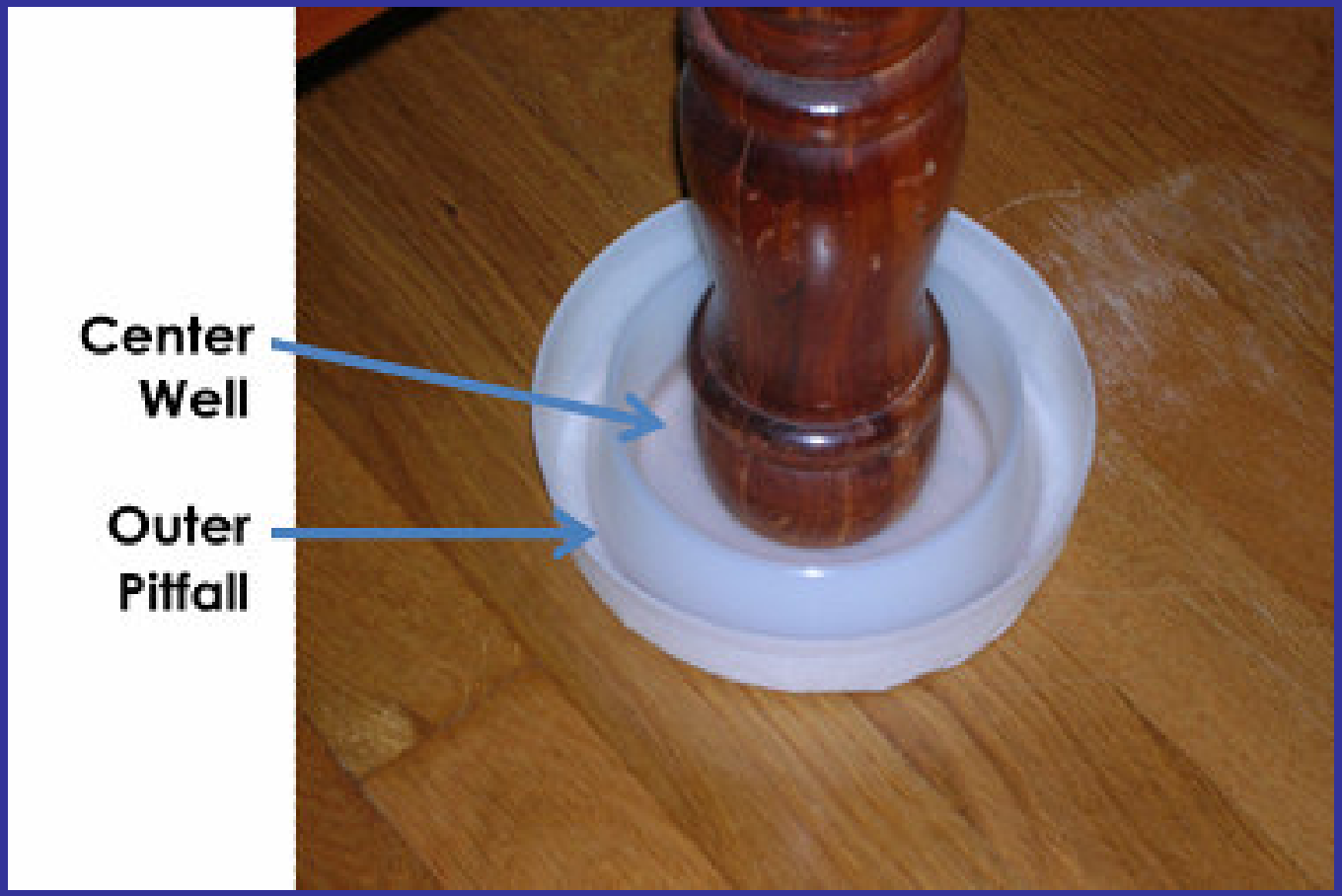
Suitable for DIY

Putting it all together:
practical management for infestations

How dusts may be used /
The sleeping human as bait

Susan McKnight's Invention

"CLIMBUP Insect Interceptor"



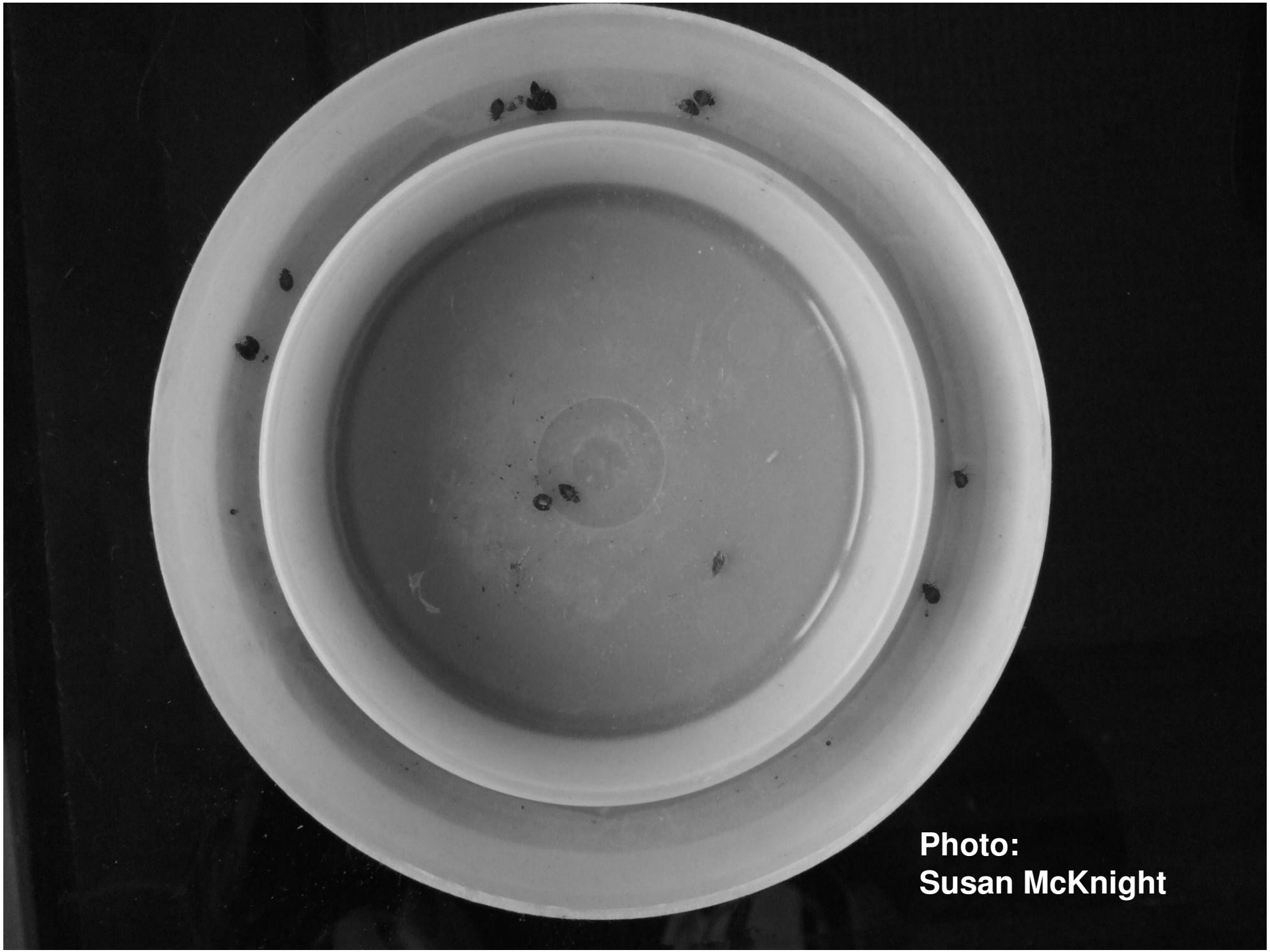


Photo:
Susan McKnight

Exclusion from bedding

Covers for box springs and mattresses can isolate bed bugs so that they cannot escape from within, and will eventually starve.

Best practices to get rid of bed bugs:

Don’t spray pyrethroids!
Use dusts as crack/crevice treatment
Use interceptor traps
Enclose mattress/box springs with cover
Prevent contact of bed clothes with floor