Current Bed Bug Technologies

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Outline

- Identification, quick facts, and biology with respect to humans
- Control Technologies – Historical and currently used options

Who’s sleeping with you tonight?

Well, good night, sleep tight, and don't let the bed bugs bite.

Family Cimicidae

~ 91 species

bat hosts – 13 genera, 61 species

bird hosts (swallows and swifts), 26 species

mammals and birds – 2 species

hosts unknown – 2 species

Cimex lectularius

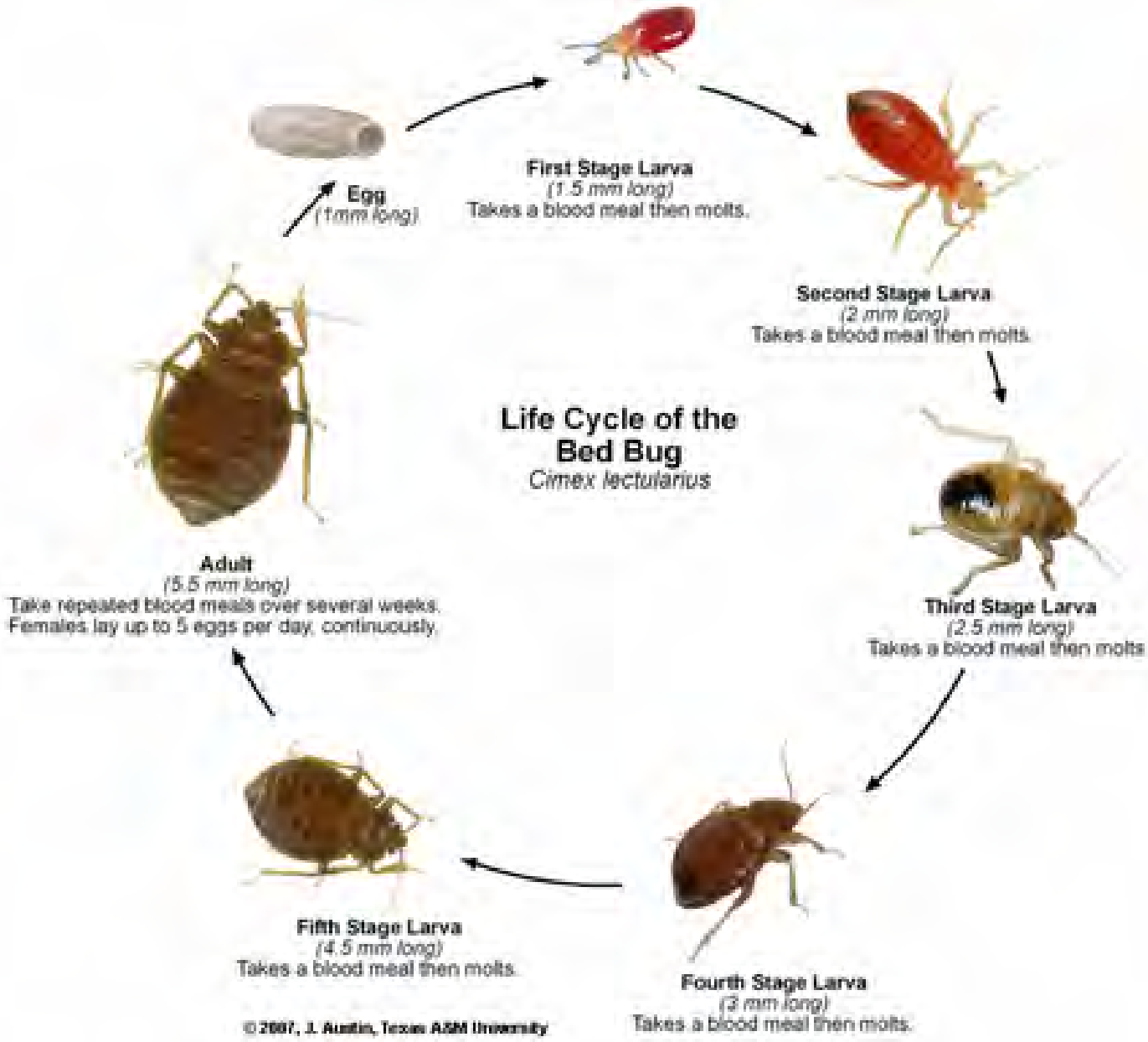
Quick Facts…

- The human bed bug (*Cimex lectularius*) and its relatives (Cimicidae) form a small group of bloodsucking insects.
- It has never been demonstrated that bed bugs transmit any human disease; more to follow
- Because of the different habits of the various bed bugs, proper identification determines where to direct controls to be most effective.
- The bite of these bugs often is painless, but a toxic saliva injected during feeding will later cause severe itching and an inflamed welt. However, individuals may vary widely in sensitivity to these bites. Often, a series/line of two to three welts are produced in close proximity following feeding by bed bugs.
- “True bugs” – 3 part segmented beak; 4 part segmented antennae, and a scent gland.
- Bed bugs have a short broad head, broadly attached to the prothorax, and an oval body.

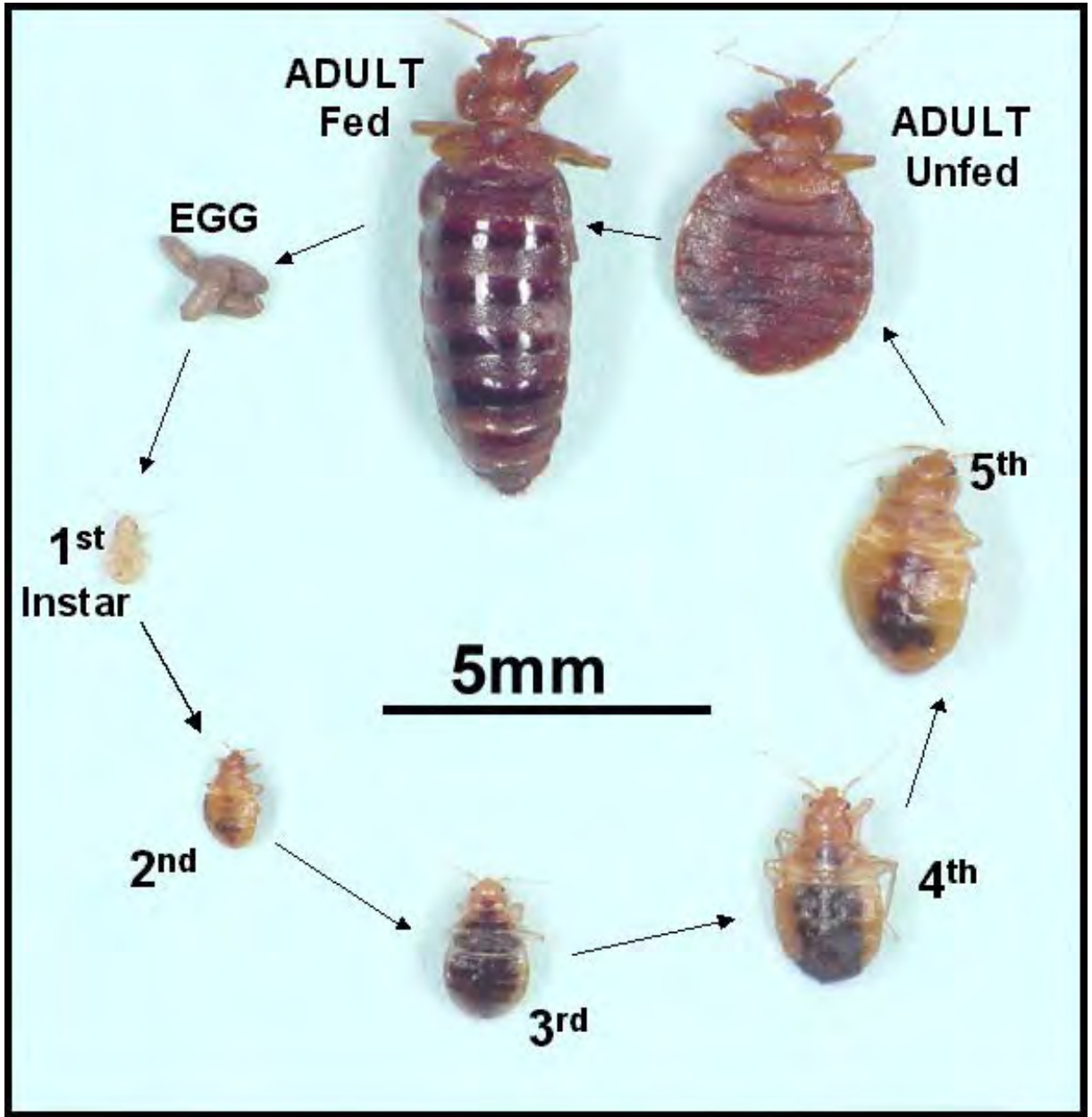
Why the Increase?

- International Travel/Commerce
- Changes in pesticides registered for their control have been lost in Canada and US
- Transported easily in luggage, clothing, bedding, furniture, computers and other hiding places
- Frequently found in locations that have a high rate of occupant turnover
- Cyclic
- Infestations are not reflective of poor hygiene/bad housekeeping but seem to occur in these types of locations
- Delayed physical response/reaction to the bed bug bite which may not correlate to the current location
- * This is not an all inclusive list of potential reasons *

Lifecycle


Egg
(1mm long)
First Stage Larva
(1.5 mm long)
Takes a blood meal then molts.
Second Stage Larva
(2 mm long)
Takes a blood meal then molts.
Life Cycle of the
Bed Bug
Cimex lectularius
Third Stage Larva
(2.5 mm long)
Takes a blood meal then molts
Adult
(5.5 mm long)
Take repeated blood meals over several weeks.
Females lay up to 5 eggs per day, continuously.
Fifth Stage Larva
(4.5 mm long)
Takes a blood meal then molts.
Fourth Stage Larva
(3 mm long)
Takes a blood meal then molts.
©2007, J. Austin, Texas A&M University

Lifecycle



Doggett, 2012

Biology

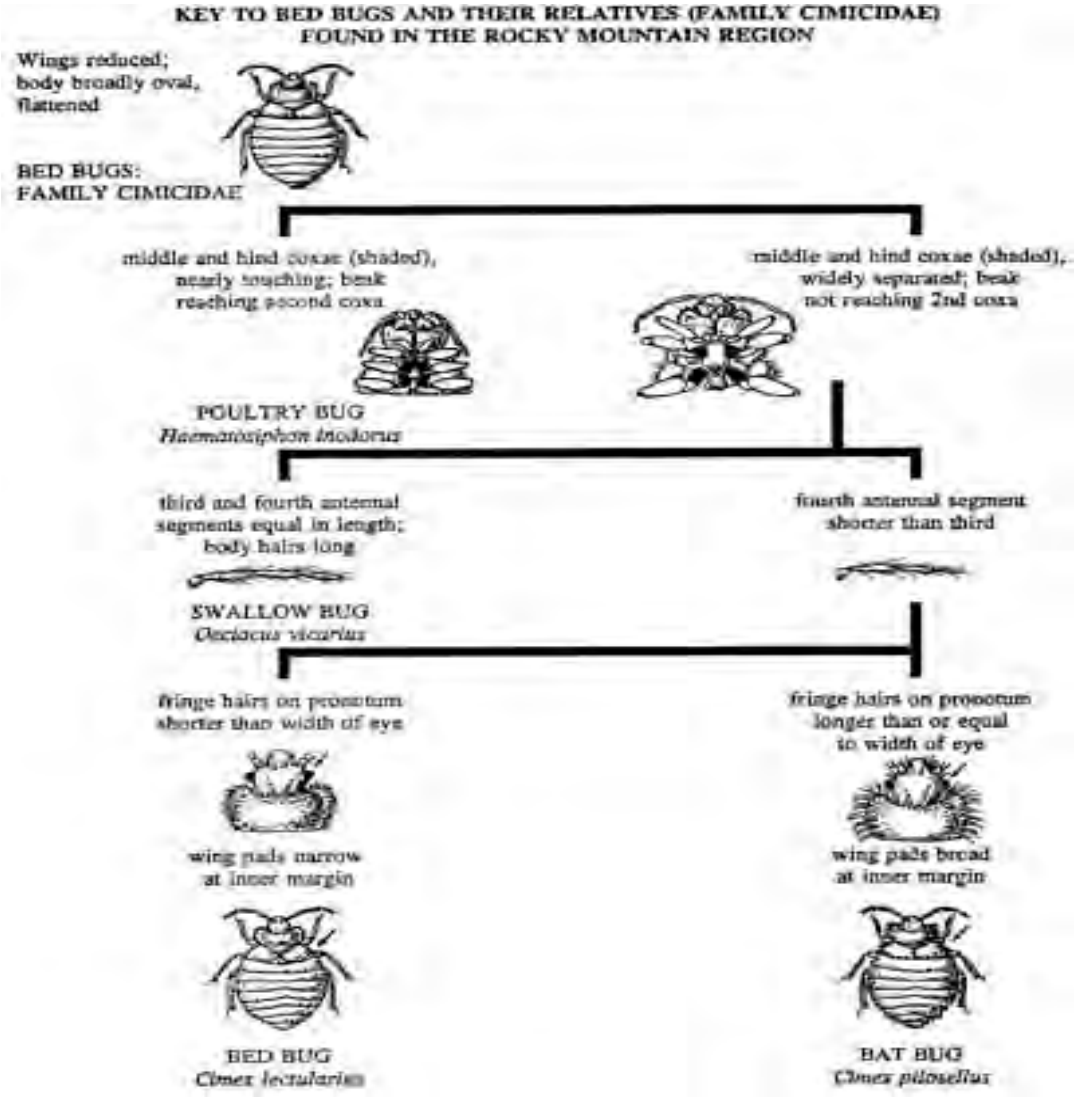
Life Cycle

- Females can lay ~200 over her lifetime; in some cases up to 500 eggs
- Eggs hatch in 1-2 weeks
- Nymphs start to feed immediately
- Nymphal stages are 14-30 days
- Entire life cycle is 4-9 weeks
- Adults can survive, conditions dependent, up to 12-18 months, or longer, without feeding
- Average adult life span approx 80 days
- May migrate if it ‘senses’ a potential food source

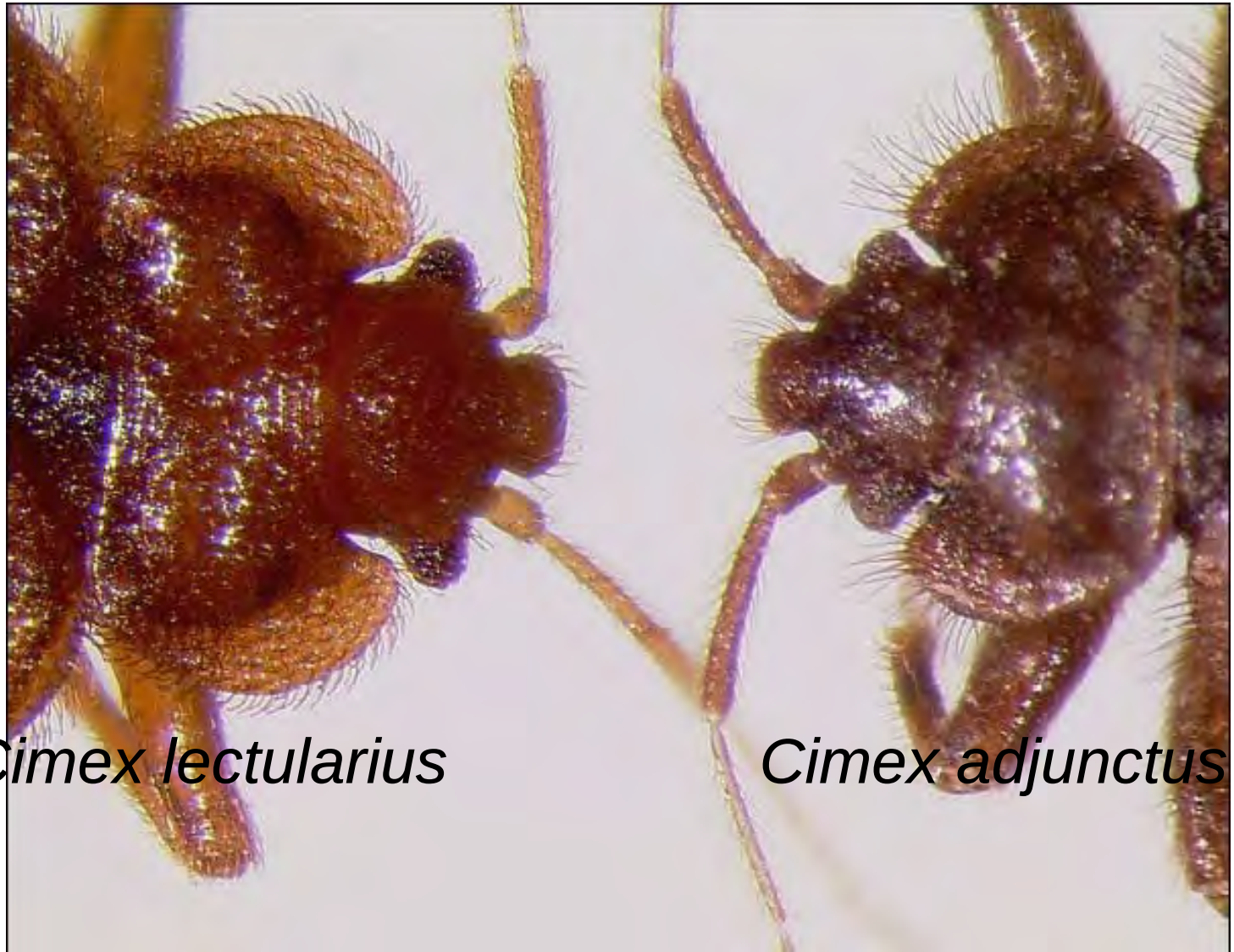
Medical Importance

- Naturally infected with >45 human pathogens
- Never proven to transmit any human disease but the presence of the pathogens have been detected in all body parts including excretions
- Mechanic transmission has also been removed as a route as pathogens cannot live for very long outside the body
- Serious social stigma to “having” an infestation, stress, anxiety, sleeplessness, phobias etc
- Secondary infection from itching/scratching can occur
- Not currently in the Canadian Public Health Act

Biological Key



Speciation




Conundrum #4 – Bat Bugs
Cimex pipistrelli or
Cimex dissimilis?

Human Attraction Cues

- Sense carbon dioxide and heat plumes via their antennae and receptors
- Get ‘excited’ when body temperatures are higher when we are sleeping
- Follow carbon dioxide plume and increased body temperature gradient
- Blood is food/energy source

Fed vs Unfed

1st Instar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Feeding

- Adults/Nymphs feed ‘usually’ at night, depends on when the host is present, can feed and be active during the day
- Nymphs – 3 min average for 1st instar; Nymphs variable; Adults – 10 to 15 min
- Saliva causes the allergic reaction
- Digest blood meal; molts and feeds again when its ready or ‘waits’ until a host is present
- They do not stay on the host longer than it takes to get a blood meal
- “Bites” – usually in two to three spatially close welts

Feeding

R Naylor, 2011

Historical Controls

- 1690 – European Exterminators (Tiffin and Son of London)
- 1730 - John Southall, who published a 44-page treatise on bed bugs in 1730. The manual contained information on bed bug habits, prevention and control based on his experiences
- Southall also gained notoriety for his “Nonpareil Liquor,” a supposedly terrific bed bug killer which he obtained from a native while traveling in Jamaica. The formula for the liquid has been lost, but may have been derived from quassia wood, a tropical tree with insecticidal properties (Busvine 1976)
- Worst advice for killing bed bugs was published in The Compleat Vermin-Killer (1777), instructing readers to fill the cracks of the bed with gunpowder and light it on fire…..
- 1800s. As noted earlier, bed bugs became plentiful in North America with the coming of European settlers. As a deterrent, beds were often made from sassafras wood and the crevices doused with boiling water, arsenic and sulfur. This provided only temporary relief. Go to jail today…
- mid-1800s, bed bugs had become a particular problem in poor, overcrowded areas with low standards of cleanliness. Wealthy households with an abundance of domestic help discovered that bed bugs could be kept in check with vigorous housecleaning, especially with respect to beds. Washing bedding, breaking down beds, and dousing the slats, springs and crevices with boiling water or grease from salt pork or bacon proved helpful (USDA Report of the Commissioner of Agriculture, 1875)
- 1900s. Bed bugs received a big reproductive boost in the early 1900s, when central heating of buildings became common. By the turn of the century, cast iron radiators were delivering warm air to every room in the house, a process made even easier in the 1930s by electricity, fans and forced air heating. This enabled the bugs to thrive year-round, whereas before that, populations followed a more seasonal trend, increasing as the weather warmed

From PCT, 2009, M. Potter

Historical Controls

- 1930s and ’40s, bed bugs became a community-wide problem like rats and mosquitoes. Infestation was worse in poorer, overcrowded neighborhoods, although wealthy households had problems as well
- War years, bed bugs were transported on bedding into many public air-raid shelters. They also feasted on sleeping soldiers in barracks and battlefront trenches, and were spread on belts, backpacks, canteens and helmets. One interesting account from World War I states, “In the East African campaign the bugs invaded the cork lining of the sun helmets of the soldiers. As the helmets were piled together at night, all soon became infested and the soldiers complained of bugs attacking their heads.” (Medical Entomology, 1932).
- Bed bugs also occupied warships and the nooks and crannies of submarines. Besides the usual places, bed bugs were common years ago in laundries, dressing rooms, factories and furniture upholstery shops. Theaters had big problems and sometimes had to tear out entire rows of seats and install new ones. Coat rooms and lockers in schools were commonly infested, as is happening again today
- Bed bug epidemic during the first half of the 20th century prompted a great deal of research by universities and government agencies. Studies were conducted on bed bug biology and habits, risk of disease transmission, and management. Much of what we know about bed bugs was discovered during this period (1900-1950). **Notably, no simple solution was discovered other than “eternal vigilance”** (C. L. Marlatt, USDA publication, 1916)

From PCT, 2009, M. Potter

Other Historical Controls

- 1800s and early 1900s also included arsenic and mercury compounds prepared by the druggist. The poisons were mixed with water, alcohol or spirits of turpentine and applied with a brush, feather, syringe, eyedropper or oil can wherever bed bugs were found. Mercury chloride, better known as corrosive sublimate or “Bed Bug Poison,” was a common remedy used by both exterminators and householders. One way to apply it was with the whites of an egg, beaten together and laid with a feather (Good Housekeeping, 1888). Unfortunately, Bed Bug Poison also killed some people, accidentally or by intent
- mid-1800s was pyrethrum, prepared from dry Chrysanthemum flowers; other compounds were used such as rotenone, phenol, cresol, naphthalene and Lethane 384, an organic thiocyanate which also had activity against bed bug eggs but there was no residual effects so bed bugs could return
- until the mid-1940s Turpentine, gasoline, kerosene, benzene and alcohol (an ingredient in Sterifab)
- Zyklon B pellets, 100% kill but extremely dangerous as the gas kills people just as fast
- Fumigants: Early bed bug fumigation often involved burning sulfur, sometimes called the “fire and brimstone” method
- The gold standard for fumigation during the first half of the 20th century was hydrocyanic acid (cyanide) gas. Fumigating with cyanide was highly effective, but costlier and far more dangerous than previously mentioned methods. As with modern-day fumigations, the entire building had to be vacated, which was not always necessary when burning sulfur
- DDT (Dichloro-diphenyl trichloroethane) applied as a 5-percent oil-based spray or 10-percent powder was so effective that all the bed bugs in a room could eventually be eliminated by thoroughly treating the bed and nowhere else, since the bugs eventually had to crawl onto the bed to feed. Resistance and other issues….
- 1950s to 1970s to control occasional infestations of bed bugs included diazinon (when the bugs became resistant to malathion), lindane, chlordane and dichlorvos (DDVP). Mattresses were sprayed and aired as part of the overall treatment.

From PCT, 2009, M. Potter

Current Canadian Toolbox

Product Class	**Insect Resistance Action Committee Group:** Active Ingredient(s)	# Products
Domestic	**3A:** D-Phenothrin, Tetramethrin	22*
	3A: Permethrin	14
	3A: D-Phenothrin, Prallethrin **Synergist:** N-Octyl bicycloheptene dicarboximide, Piperonyl butoxide	3
	3A: D-Trans allethrin **Synergist:** N-Octyl bicycloheptene dicarboximide, Piperonyl butoxide	2
	3A: Pyrethrins, Tetramethrin **Synergist:** N-Octyl bicycloheptene dicarboximide, Piperonyl butoxide	1
	3A: D-Trans allethrin **Synergist:** Piperonyl butoxide	17
	3A: D-Trans allethrin, Pyrethrins **Synergist:** Piperonyl butoxide	1
	3A: D-Trans allethrin, Tetramethrin **Synergist:** Piperonyl butoxide	1
	3A: Permethrin, Pyrethrins **Synergist:** Piperonyl butoxide	8
	3A: Pyrethrins **Synergist:** Piperonyl butoxide	56
	3A: Pyrethrins, Tetramethrin **Synergist:** Piperonyl butoxide	2
	3A: Pyrethrins **Unassigned:** Silicon dioxide **Synergist:** Piperonyl butoxide	2
	Unassigned: D-Limonene	1
	Unassigned: Silicon dioxide	18

Current Canadian Toolbox

Commercial	**1A:** Carbaryl†	6
	3A: Cyfluthrin	1
	3A: Lambda-cyhalothrin	1
	3A: Permethrin	6
	3A: D-Phenothrin **Synergist:** N-Octyl bicycloheptene dicarboximide	1
	3A: Pyrethrins **Synergist:** N-Octyl bicycloheptene dicarboximide, Piperonyl butoxide	3
	3A: D-Trans allethrin **Synergist:** Piperonyl butoxide	2
	3A: Pyrethrins **Synergist:** Piperonyl butoxide	34
	3A: Pyrethrins **Unassigned:** Silicon dioxide **Synergist:** Piperonyl butoxide	2
	Unassigned: Boric acid†	1
	Unassigned: D-Limonene	1
	Unassigned: Liquid carbon dioxide	1**
	Unassigned: Silicon dioxide	5

Notes on the Canadian Toolbox

- *One end-use product is discontinued with an expiry date of 2015-03-01
- **The end-use product is discontinued with an expiry date of 2016-09-04
- †All registered bed bug uses for products containing these active ingredients are proposed for phase-out as a result of re-evaluation (see PRVD-2009-14, Carbaryl and PRVD 2012-03, Boric Acid and its Salts (Boron)).

Note: As of Nov 20th, 2013 Boric Acid and its salts should remain as available until the end of 2014.

This list excludes one commercial end-use product containing the active ingredient bendiocarb and one domestic end-use product containing d-phenothrin and tetramethrin. These products are discontinued and expire on December 31, 2013.

US Product Toolbox

- Over 300 products are registered in the US as compared to 212 currently in Canada.
- Most are domestic labels approved by the EPA (PMRA here). Most products are Class 3 – Pyrethroids/Pyrethrum/Permethrin
- There are no lists for the number of ‘Organic or Organically Based’ products
- Issue – We need to recommend that self treatments NOT be done, need to educate the public on this. Require a PMP to treat an infestation

US General Product Toolbox

- Pyrethroids – deltamethrin, permethrin, phenothrin, resmethrin, tetramethrin, bifenthrin, lambda-cyhalathrin, cyphenothrin, esfenvalerate, zeta-cypermethrin, cyfluthrin, beta-cyfluthrin, prallethrin, imiprothrin, bioallethrin, gamma-cyhalthrin. Certain products have the synergist PBO and MGK 264 with it.
- Neonicotinoids - actamiprid, imidacloprid, dinotefuran. Neonicotinoids are usually mixed with pyrethroids/permethrins to increase efficacy.
- Pyrroles - new class, stomach/contact poison; chlorfenpyr.
- IGR's - hydroprene, ethofenpox, pyriproxyfen, neem oil. Usually mixed with other products
- Organophosphates – only DVVP strips (dichlorvos 18.6%)

US General Toolbox

- Desiccants - Boric acid, silica gel, diatomaceous earth (DE)
- Fumigants - sulfuryl fluoride, carbon dioxide
- Organics – no list of products was found from the EPA

IPM

- Integrated Pest Management is:

  A decision making process that uses a combination of techniques to suppress pests and that must include but is not limited to the following elements:

IPM Components

- planning and managing ecosystems to prevent organisms from becoming pests;
- identifying potential pest problems;
- monitoring populations of pests and beneficial organisms, pest damage and environmental conditions;
- using injury thresholds in making treatment decisions;
- reducing pest populations to acceptable levels using strategies that may include a combination of biological, physical, cultural, mechanical, behavioural and chemical controls;
- evaluating the effectiveness of treatments

Current Methods

- Most US and Canadian companies use chemical control, mostly pyrethroids with alternative methods.
- Many use IPM methodology and the CPMA and NPMA best management guide for Bed Bug control
- Success is heavily dependant on the Pest Management Professional.

Current Industry Methods

- Chemical Treatments (>99%)
- Mattress encasements (~86%)
- Laundering (~86%)
- Vacuuming (~43%)
- Disposal of infested items (when/where required) (~62%)
- Steaming (~43%)
- Fumigation (~16%)
- Whole house, apartment, condo heat treatment (~5%)
- Alternative or Organic treatments (unknown)

- Survey percentages from the end of 2011, Potter

Current Alternative Methods

- Earlier the detection and identification of BB’s the higher the success rate.
- PMP is key in the success of control program.
- Room Preparation
- Process – licensed, trained, IPM techniques

Room Prep Themes

Dear Customer/Tenant:

We have been engaged by the Management of this building to carry out a routine pest control service program in the premises occupied by you. This service is being performed to eliminate (or prevent) BEDBUG infestations.

Company X will be treating your premises on, 20___ at _____ AM/PM. It will be necessary for you to vacate your premises until .

In order to enable our Pest Management Professionals to apply an effective treatment, we require your cooperation in carrying out the following instructions:

1. Remove all food, dishes and cooking utensils from countertops, stoves and tabletops and place in cupboards or in fridge.
2. Furniture in all rooms should be moved at least 2 feet away from the walls, to allow access to the baseboard perimeters.
3. Remove all sheets and blankets from all beds. Wash the bedding right after removing from the bed(s). Leave the box spring and mattress on the bed frame but allow enough room for them to be propped up against the wall. Don't install a new mattress in the room until after treatment. Mattress and box spring encasements are strongly recommended to be used. Dust covers on box springs will be removed for treatment.
4. Do not place items on couches, as they may also need to be treated.
5. All closets and dresser drawers should be completely emptied, including hanging clothes. All clothing should be washed in hot water, dried in hot dryer and placed in garbage bags until infestation is gone.
6. Birds and pets must be removed from the premises for 4 to 6 hours. Fish tanks must be covered, and the pumps turned off. Remove pet dishes.
7. All plants must be removed or covered.
8. Remove the electrical outlet switch plate covers, this includes, phone jack plates and light switch covers.
9. Vacuum all floors (carpets/wood/tile) especially around baseboards, cracks/crevices and remove vacuum bag, seal it in a plastic bag and place in garbage. Bed bugs can survive being vacuumed up.
10. Remove the front panel from heating/air conditioning units, if applicable.
11. Everyone must leave the premises for at least 4 to 6 hours. Anyone who has allergies, asthma, is pregnant, children under the age of 4, or anyone with respiratory problems should leave the premises for 12 to 24 hours.

Room Prep Themes

CO-OPERATION IS ESSENTIAL FOR BED BUG CONTROL AND FOLLOW-UP TREATMENTS WILL BE REQUIRED AFTER FIRST TREATMENT

1. Use clean sheets and blankets on all beds and a sheet should be placed on the couch after treatment for one week. Vacuum carpets especially around baseboards daily.
2. All furniture should be vacuumed daily (i.e. mattress, box spring, couches, chairs and ottoman).
3. This is not an instant kill; the products do not kill bed bug eggs. The eggs will hatch and young bed bugs will have to cross the product in order to die, this may take 10 to 14 days.
4. HOTEL/MOTEL rooms may be required to be out of commission for 7 days after treatment, depending on infestation and technician recommendations.

Please note that it is the responsibility of the landlord or building owner to notify all tenants that may be affected by the above treatment.

Non-Chemical Monitoring

(not an all inclusive list of monitoring tools)

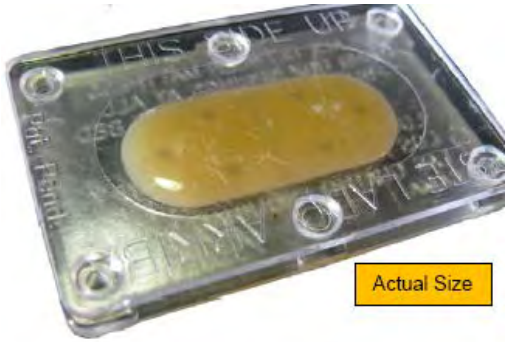
- Sticky Traps/Double sided tape
- Mattress encasements – Allerzip, Mattress Safe, etc
- Bed posts in BB Cans, Pitfall Trap, Moats
- Vacuum with hepa filter; use often with strong suction
- Use a scrub brush/edge of vacuum along the seams of mattresses
- Diatomaceous earth (limited locations for use)
- Bed Bug dogs
- CDC 3000/Nightwatch – $CO_2$and heat attractant
- Clear View – monitoring credit card for mattresses and other discreet locations

Pitfall Trap/Bed Moat

Pit Fall Trap and Clutter

Clear View

- Can capture 2nd instar to adults
- Discreet for use in hotels, hospitals, retail locations
- Option with sticky tape/traps



Active Monitors

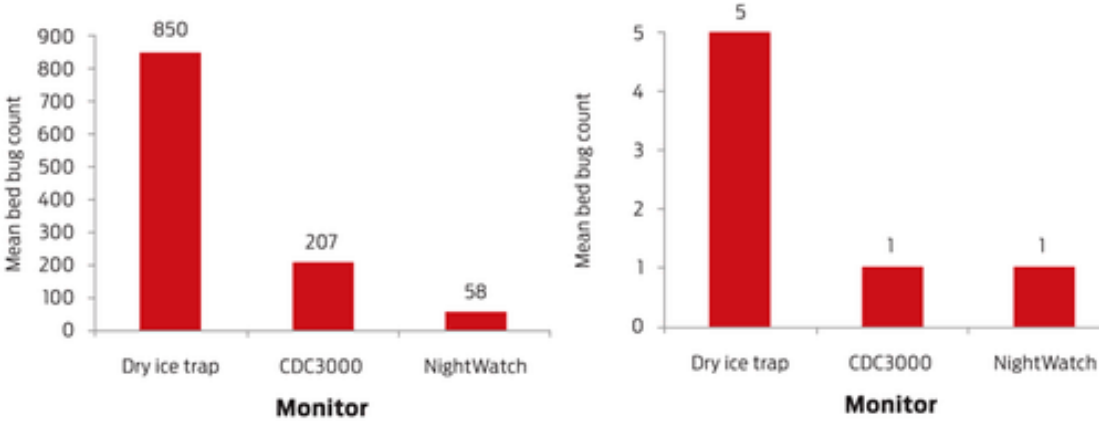


Figure 2. Effectiveness of three bed bug monitors in detecting bed bugs in apartments with heavy infestation (left) and light infestation (right).

Non-chemical control

(not an all inclusive list of tools)

- Heat (>120°F/50°C) put items in heat boxes, rooms, buildings etc) heat units. Not a complete ‘Chemical Free’ option.
- Heat clothes/toys etc in dryer for 15-20 min; will kill all stages including eggs (>120°F/50°C)
- Hot steam along baseboards, wallpaper, cracks etc. May become an issue with mold when over used. Direct control – No depth
- Cryonite – direct control, no depth
- Expose bugs to ‘cold temperatures’ below 32°F/0°C

Generally **Does Not Work**

- Chilling period must be maintained for many days (adults) greater than -20°C; colder than most freezers
- Eggs – Generally NOT an effective control option

Heat Treatment Technology

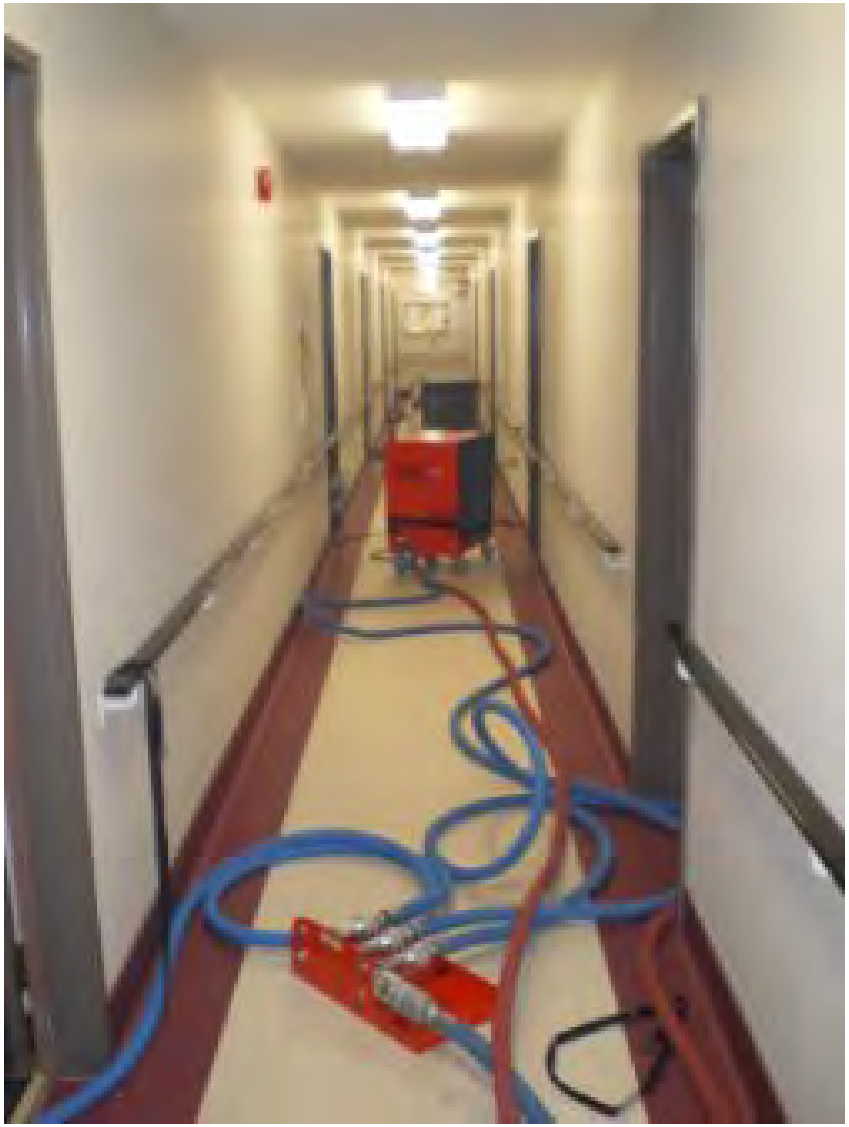
Poulin's, 2012


CAUTION


INSPIRON mini
3/17/2010 4:12:17 PM
Alarm OFF
Logging Active
Disk OK
Printer OFF
About
ShutDown
Sensors
Graph
Project
Grid
1 Sensor1 Online 140.3
2 Sensor2 Online 138.0
3 Sensor3 Online 130.9
4 Sensor4 Online 136.3
5 Sensor5 OffLine 0.0
6 Sensor6 Online 138.3
7 Sensor7 Online 135.8
8 Sensor8 Online 132.8
9 Sensor9 Online 136.5
10 Sensor10 Online 134.4
11 Sensor11 Online 130.4
12 Sensor12 Online 129.2
13 Sensor13 Online 124.9
14 Sensor14 Online 134.3
15 Sensor15 Online 133.8
16 Sensor16 Online 137.1
17 Sensor17 Online 131.4
18 Sensor18 Online 130.4
19 Sensor19 Online 135.9
20 Sensor20 Online 134.8
21 Sensor21 Online 138.5
22 Sensor22 Online 139.6
23 Sensor23 Online 131.2
24 Sensor24 Online 135.4
Stop Logging
Log Time: 05:15:37
Log Count: 64
Print Report
Help
Setup
BELKIN
DELL

Heat Treatment Technology

Monarch Pest Control, 2012



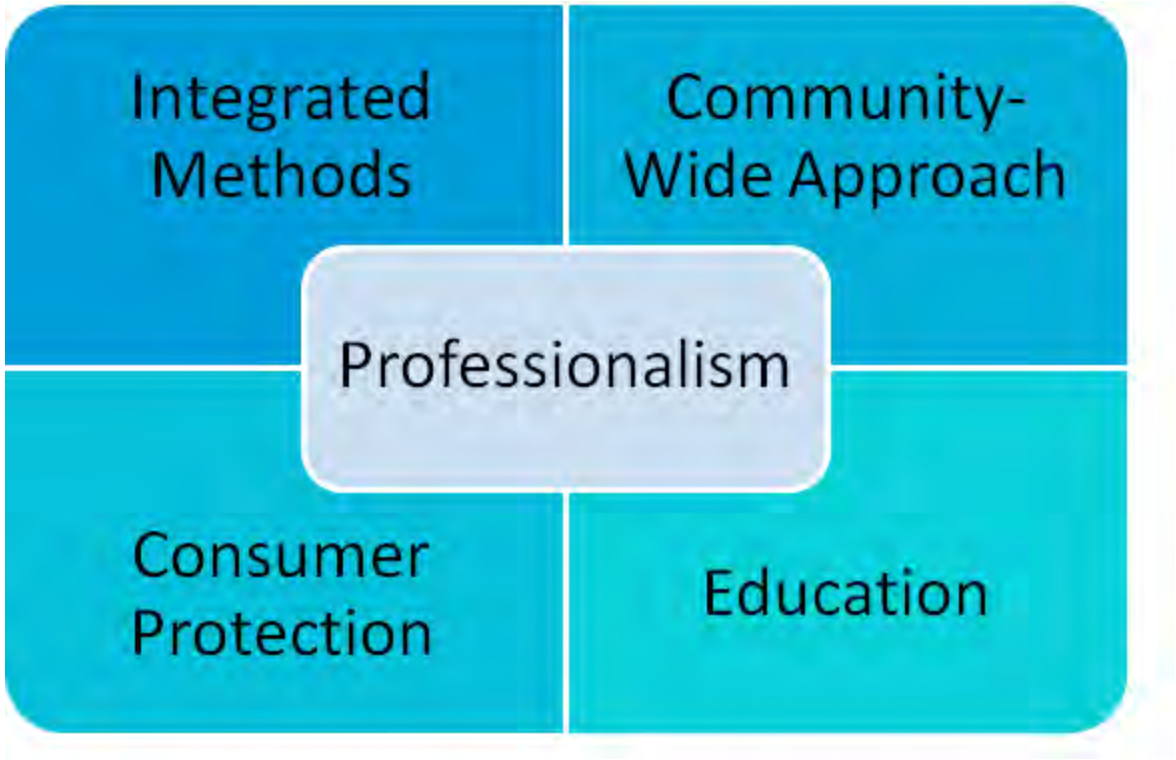
Tools

Poulins, 2013

Tools

Orkin, 2013

BMP's



http://www.bedbugbmps.org/

Overall Treatment Theme

- Positive Identification
- Use IPM techniques
- Choose the right control method/product
- Monitoring and repeat treatments
- Effectiveness
- Educate

Integrated Methods

Describes best practices for multiple methods of control

- Non-chemical: steam, vacuum, heat, freezing
- Traditional Chemical Options
- Monitoring Devices: Active vs Passive Monitors

Community Wide Approach

- Discourage disposal of homeowners belongings
- Recommendations for inspections and treatment of surrounding areas and adjacent rooms
- Recommendations for training and educating hotel and other facility staff about bed bug identification

Consumer Protection

Before beginning service:

- Identify active infestation
- Communicate fees
- Communicate details of service
- Communicate realistic expectations

Provide bed bug specific information with agreements

Canine detection teams require third party certification

Education

- Training requirements for all employees
- Additional requirements for technicians or salespeople involved in bed bug work
- Education of clients
- Client preparation, a ‘how to’ for best control results

Professionalism

Encourage professionalism through:

- Business practice recommendations
- Service Agreement guidelines
- Recordkeeping practices
- Training requirements
- Inspection practices
- IPM approaches

Why they are a control challenge?

1. Often hard to detect in small numbers.

   (small, generally nocturnal, cryptic, & fairly mobile)

2. No reliable attractant available (currently).

3. Readily detect (***&*** avoid) <u>many</u> chemicals.

4. Adults can live > 1 yr. without feeding.

   [Nymphs fed <u>≥</u> once can live > 3 mo. w/o feeding]

5. Insecticide resistance newly documented.

6. Very easily re-introduced and/or spread.

7. Products available are mostly direct contact, little to no residual, no control of eggs.

Challenges to Effective Control

- Hoarding Issues
- Laundry
- Lack of client co-operation due to cost, mistrust of technician, lack of education
- Room not properly prepared for treatment
- Client embarrassed does not tell anyone with an active infestation or re-introduction

Unique Location Challenges

What to do in locations that high numbers of people that may come in contact with bed bugs?

- Schools
- Daycares
- Hospitals
- Libraries
- Apartments
- Retail Environments
- Law Enforcement
- Fire/Paramedic

Future

- History has shown what to expect from bed bugs in the future — and the forecast is….. very concerning!!!
- Currently many locations are still in the increase phase and until it plateau’s more and more locations will become infested.
- Bed bug management will be handicapped until the chemical industry invents a safe, residually potent product with a permissive label. This will not be easy given the priorities and challenges facing the industry and the PMRA/EPA.

Questions?