

# What's New in the Bed Bug World? – Research Update

Dr. Susan C. Jones  
Professor of Entomology  
[jones.1800@osu.edu](mailto:jones.1800@osu.edu)



**THE OHIO STATE UNIVERSITY**

COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES

# Bed bugs are developing resistance to newer insecticides...

Journal of Medical Entomology Advance Access published January 28, 2016

Journal of Medical Entomology, 2016, 1–5  
doi: 10.1093/jme/tjv253  
Short Communication

OXFORD

Short Communication

## High Levels of Resistance in the Common Bed Bug, *Cimex lectularius* (Hemiptera: Cimicidae), to Neonicotinoid Insecticides

Alvaro Romero<sup>1,2</sup> and Troy D. Anderson<sup>3</sup>

<sup>1</sup>Department of Entomology, Plant Pathology and Weed Science, New Mexico State University, Las Cruces, NM 88003 (aromero2@nmsu.edu), <sup>2</sup>Corresponding author, e-mail: aromero2@nmsu.edu, and <sup>3</sup>Department of Entomology and Fralin Life Science Institute, Virginia Tech, Blacksburg, VA 24061 (anderst@vt.edu)

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Article

## Insecticide Resistance in Eggs and First Instars of the Bed Bug, *Cimex lectularius* (Hemiptera: Cimicidae)

Brittany E. Campbell<sup>1,\*</sup> and Dini M. Miller<sup>2</sup>

Journal of Economic Entomology, 110(3), 2017, 1195–1202  
doi: 10.1093/jee/tox070  
Advance Access Publication Date: 10 April 2017  
Research article

OXFORD

Household and Structural Insects

## Detection of Reduced Susceptibility to Chlorfenapyr- and Bifenthrin-Containing Products in Field Populations of the Bed Bug (Hemiptera: Cimicidae)

Aaron R. Ashbrook, Michael E. Scharf, Gary W. Bennett, and Ameya D. Gondhalekar<sup>1</sup>

Department of Entomology, Purdue University, West Lafayette, IN 47907 (aashbroo@purdue.edu; mscharf@purdue.edu; gbennett@purdue.edu; ameyag@purdue.edu), and <sup>1</sup>Corresponding author, e-mail: ameyag@purdue.edu

Subject Editor: Michael Rust

Received 27 October 2016; Editorial decision 30 January 2017

### Abstract

Insecticide resistance is a major impediment for effective control of *Cimex lectularius* L. Previous resistance detection studies with bed bugs have focused on certain pyrethroid, neonicotinoid, organochlorine, organophosphate, and carbamate insecticides. Within the pyrethroid class, resistance studies have mostly been limited to deltamethrin, lambda-cyhalothrin, and alpha- and beta-cyfluthrin. The goal of this study was to develop diagnostic concentration bioassays for assessing bed bug susceptibility levels to chlorfenapyr- and bifenthrin-containing products. First, glass vial and filter paper bioassay methods were compared for their utility in susceptibility monitoring. Statistical comparison of toxicity data between bioassays indicated that the vial assay was less confounded by assay substrate effects, required less insecticide, and was faster, especially for chlorfenapyr. Next, using vial diagnostic concentrations (LC<sub>50</sub>) for each insecticide, 10 laboratory-adapted field strains and the Harlan lab-susceptible strain

Department of Entomology and Nematology, University of Florida, 1881 Natural Area Drive, Gainesville, FL 32611, USA  
Urban Pest Management Laboratory, Department of Entomology, Virginia Tech, Drillfield Drive, Blacksburg, VA 24061, USA; E-Mail: dinim@vt.edu

Address to whom correspondence should be addressed; E-Mail: bedelong@ufl.edu; +1-352-273-3901.

Section Editor: Brian T. Forschler

Received: 30 October 2014 / Accepted: 9 January 2015 / Published: 15 January 2015

**Abstract:** Two strains of the common bed bug, *Cimex lectularius* L., eggs and first instars collected from pyrethroid-resistant adults were evaluated for insecticide resistance and compared to a susceptible strain. Dose-response bioassays were conducted using two insecticide formulations (Temprid: imidacloprid/β-cyfluthrin, and Transport: acetamiprid/bifenthrin). The lethal concentration (LC<sub>50</sub>) for the two resistant egg strains exposed to imidacloprid/β-cyfluthrin ranged from 3 to 5-fold higher than susceptible strain eggs. Resistant strain eggs dipped into formulations of acetamiprid/bifenthrin had LC<sub>50</sub> values which were significantly greater (39 to 1,080-fold) than susceptible strain eggs. Similar to eggs, resistant strain first instars exposed to residual applications of imidacloprid/β-cyfluthrin had LC<sub>50</sub> values ranging from 121 to 493-fold greater than susceptible strain first instars. When resistant strain first instars were treated with acetamiprid/bifenthrin, they had LC<sub>50</sub> values that were 99 to >1,900-fold greater than susceptible strain first instars. To determine differences between egg and first instar resistance, stage resistance ratios (SRR) were compared between the two stages. There was little difference between the egg and first instar stages, indicated by small SRR values ranging from 1.1 to 10.0. This study suggests that insecticide resistance is expressed early during bed bug development.

# Bed Bug-Killing Fungus – Promising Biopesticide



A bed bug killed by *Beauveria bassiana*. Photo: Penn State



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(wileyonlinelibrary.com) DOI 10.1002/ps.4576

## Susceptibility of insecticide-resistant bed bugs (*Cimex lectularius*) to infection by fungal biopesticide

Alexis M Barbarin,<sup>a</sup> Giovani S Bellicanta,<sup>b</sup> Jason A Osborne,<sup>c</sup> Coby Schal<sup>a</sup> and Nina E Jenkins<sup>b\*</sup>

### Abstract

**BACKGROUND:** Bed bugs are a public health concern, and their incidence is increasing worldwide. Bed bug infestations are notoriously difficult to eradicate, further exacerbated by widespread resistance to pyrethroid and neonicotinoid insecticides. This study evaluated the efficacy of the newly developed fungal biopesticide Aprehend™, containing *Beauveria bassiana*, against insecticide-resistant bed bugs.

**RESULTS:** Overall mortality for the Harold Harlan (insecticide-susceptible) strain was high (98–100%) following exposure to Aprehend™ or Suspend SC (deltamethrin). The mean survival times (MSTs) for Harold Harlan bed bugs were 5.1 days for Aprehend™ and 4.8 and 3.0 days for the low and high concentrations of Suspend SC respectively. All three strains of pyrethroid-resistant bed bugs were susceptible to infection by *B. bassiana*, resulting in MSTs of <6 days (median = 4 days) and >94% overall mortality. Conversely, mortality of the three insecticide-resistant strains after exposure to Suspend SC was only 16–40%.

**CONCLUSION:** These results demonstrate that Aprehend™ is equally effective against insecticide-susceptible and insecticide-resistant bed bugs and could provide pest control operators with a promising new tool for control of bed bugs and insecticide resistance management.

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**Keywords:** *Beauveria bassiana*; Aprehend™; Suspend SC; entomopathogenic fungi; insecticide resistance

World J Microbiol Biotechnol (2016) 32:177

DOI 10.1007/s11274-016-2131-3



REVIEW

## The production and uses of *Beauveria bassiana* as a microbial insecticide

Gabriel Moura Mascarin<sup>1</sup> · Stefan T. Jaronksi<sup>2</sup>

Received: 14 July 2016 / Accepted: 20 August 2016 / Published online: 15 September 2016  
© Springer Science+Business Media Dordrecht 2016

**Abstract** Among invertebrate fungal pathogens, *Beauveria bassiana* has assumed a key role in management of numerous arthropod agricultural, veterinary and forestry pests. *Beauveria* is typically deployed in one or more inundative applications of large numbers of aerial conidia in dry or liquid formulations, in a chemical paradigm. Mass production is mainly practiced by solid-state fermentation to yield hydrophobic aerial conidia, which remain the principal active ingredient of mycoinsecticides. More robust and cost-effective fermentation and formulation downstream platforms are imperative for its overall commercialization by industry. Hence, where economics allow, submerged liquid fermentation provides alternative method to produce effective and stable propagules that can be easily formulated as dry stable preparations. Formulation also continues to be a bottleneck in the development of stable and effective commercial *Beauveria*-mycoinsecticides in many countries, although good commercial formulations do exist. Future research on improving fermentation and formulation technologies coupled with the selection of multi-stress tolerant and virulent strains is needed to catalyze the widespread acceptance and usefulness of this fungus as a cost-effective mycoinsecticide. The role of *Beauveria* as one tool among many in integrated pest management, rather than a stand-alone management approach, needs to be better developed across the range of crop systems. Here, we provide an overview of mass-production and formulation strategies, updated list of registered commercial products, major biocontrol programs and ecological aspects affecting the use of *Beauveria* as a mycoinsecticide.

**Keywords** Mycoinsecticides · Fermentation · Pests · Formulation · Blastospores · Conidia · White muscardine · Biocontrol

# Aprehend™ fungal biopesticide

- <http://www.aprehend.com/>
- Spray-on formula based on an insect-infecting fungus found in nature
- Fungus quickly spreads from infected bed bugs to uninfected bed bug





# Aprehend™ application

<http://www.aprehend.com/>

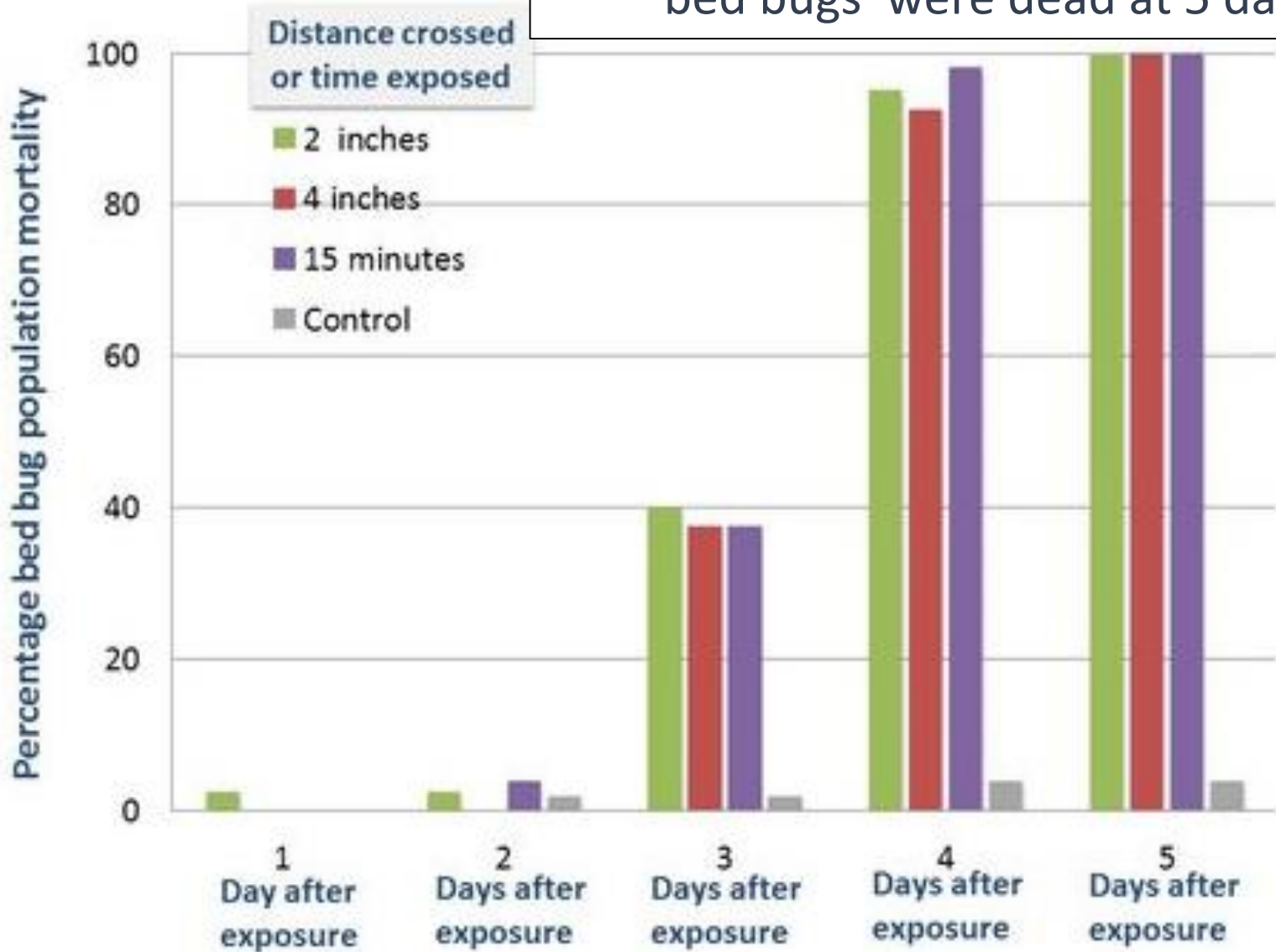
- Minimal resident preparation
- Sprayed strategically in areas with high bed bug traffic
- Residual activity for up to 3 months
- Can be used preventatively (quarterly applications)



# Aprehend™ -

<http://www.aprehend.com/efficacy>

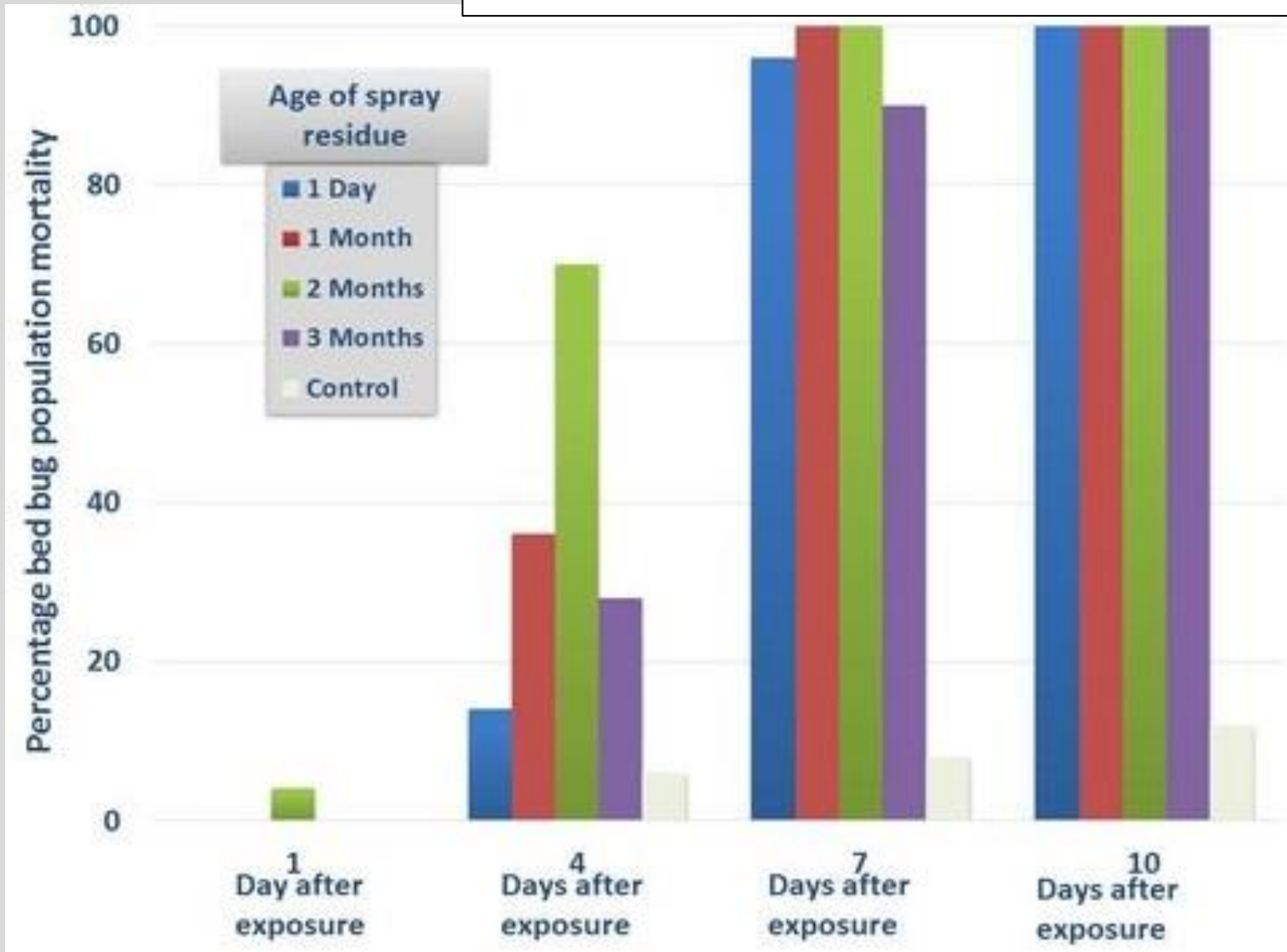
Brief contact (2 in. or 15 mins) with biopesticide-treated surface led to high levels of bed bug death within 4 days; all bed bugs were dead at 5 days.



# Aprehend™

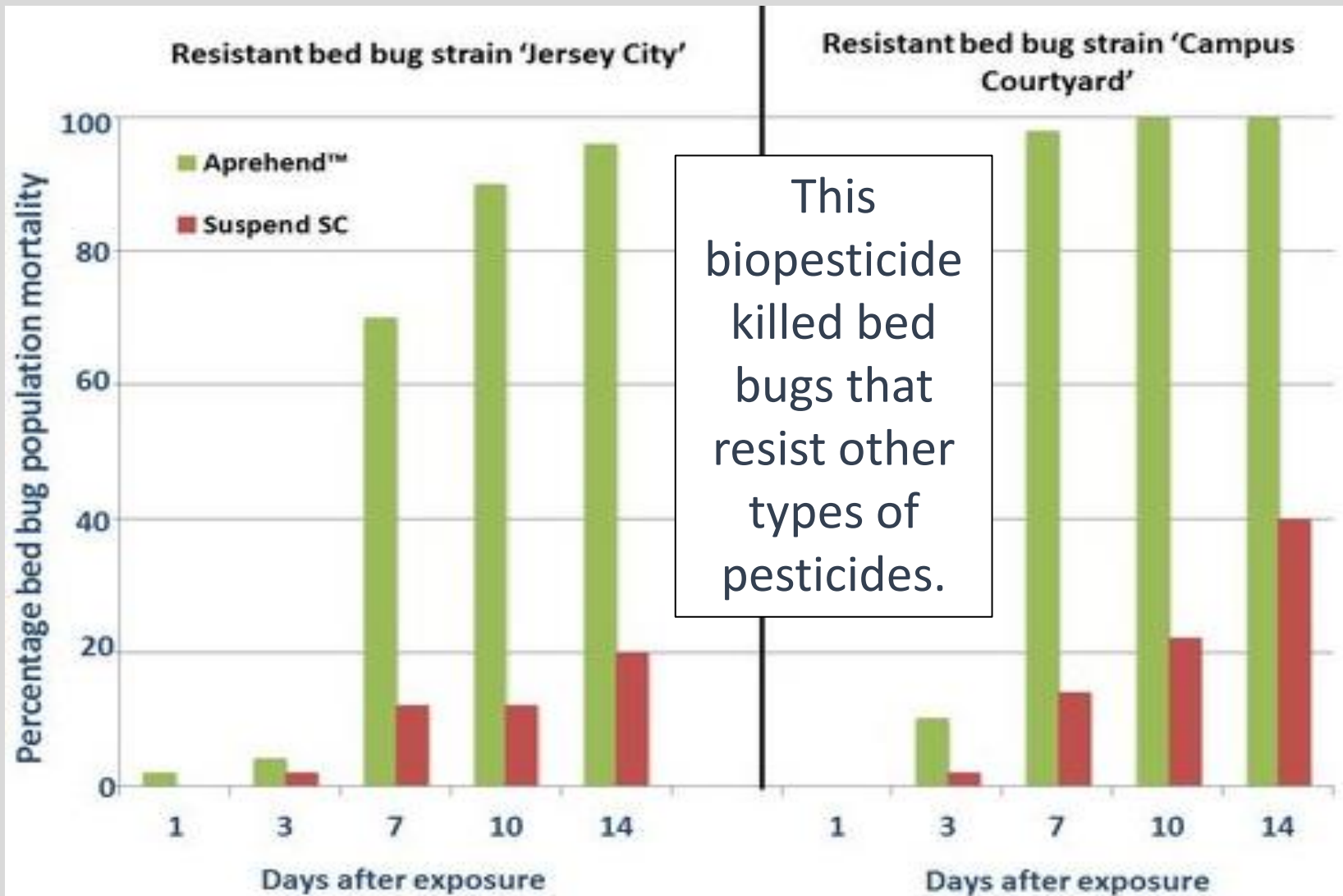
<http://www.aprehend.com/>

Biopesticide residue was effective at killing bed bugs up to 3 months after application; all bed bugs died within 7 to 10 days after exposure to treated surfaces.



# Aprehend™ – effectiveness against resistant bed bug strains

<http://www.aprehend.com/efficacy/>





# Delta Five

## Automated Insect Monitoring

- <https://deltafive.com/>
- “Smart” monitoring system
- Autonomously detects and captures pests, including bed bugs
- Automated dispensing of bed bug lure
- Sends notification (to email, mobile device, etc.) when pests are caught
- Image (low-resolution) of pest sent with notification
- Computerized management of multiple devices



## Behavioral Responses of Nymph and Adult *Cimex lectularius* (Hemiptera: Cimicidae) to Colored Harborages

Corraine A. McNeill,<sup>1,2</sup> Roberto M. Pereira,<sup>3</sup> Philip G. Koehler,<sup>3</sup> Seth A. McNeill,<sup>1</sup> and Rebecca W. Baldwin<sup>3</sup>

<sup>1</sup>Department of Science and Mathematics, Union College, 3800 S. 48th St., Lincoln, NE 68506-0050 (comcneil@ucollege.edu; semcneil@ucollege.edu), <sup>2</sup>Corresponding author, e-mail: comcneil@ucollege.edu, and <sup>3</sup>Department of Entomology and Nematology, University of Florida, Steinmetz Hall, Natural Area Drive, Gainesville, FL 32611-0620 (rpereira@ufl.edu; pqk@ufl.edu;

- Bed bugs were repelled from harborages that were yellow or green.
- Bed bug adults and 5<sup>th</sup> stage nymphs (final immature stage before molting to adult) showed strong preference for harborages that were red or black.
- First stage through fourth stage nymphs showed no color preference.
- Adult females laid more eggs on harborages that were red, black, or blue.
- Color may impact the effectiveness of bed bug monitors and traps.

# OSU's Ohio Statewide Bed Bug Surveys (2011 and 2016)

Survey regarding bed bug-related issues emailed or mailed to pest management companies and individuals licensed (category 10A) to treat for bed bugs in Ohio

– 2011 survey

- Response Rate =  $225/632 = 35.6\%$

– 2016 survey

- Response Rate =  $329/1041 = 31.6\%$

# 2009-10



## Headline news

### NEW REPORT RANKS TOP U.S. CITIES FOR BED BUG INFESTATIONS

8/26/2010

A new report compiled from Terminix data shows 15 cities stand above

The 2010 most bedbug-infested cities

1. New York
2. Philadelphia
3. Detroit
4. Cincinnati
5. Chicago
6. Denver
7. Columbus, Ohio
8. Dayton, Ohio
9. Washington, D.C.
10. Los Angeles
11. Boston
12. Indianapolis
13. Louisville, Ky.
14. Cleveland
15. Minneapolis, Minn.

## Headline news

### Orkin's Bed Bug Treatments in Commercial Properties on the Rise

8/20/2010

“...the five hot spots for bed bug activity, according to Orkin treatment data:”

Cincinnati

Columbus

Chicago

Denver

Detroit

“Nationally, Orkin saw bed bug treatments **double** from 2008 to 2009, a trend it expects will continue this year.”

# Cleveland Tops Terminix's Newest 'Top 20 Bed Bug Cities' List

(1 Jan 2017-30 June 2017)

August 25, 2017

1. Cleveland, Ohio
2. Cincinnati, Ohio
3. Detroit, Mich.
4. Las Vegas, Nev.
5. Denver, Colo.
6. Houston, Texas
7. Phoenix, Ariz.
8. Indianapolis, Ind.
9. Oklahoma City, Okla.
10. Philadelphia, Pa.

# 2016-17



## Orkin Releases New Top 50 Bed Bug Cities List

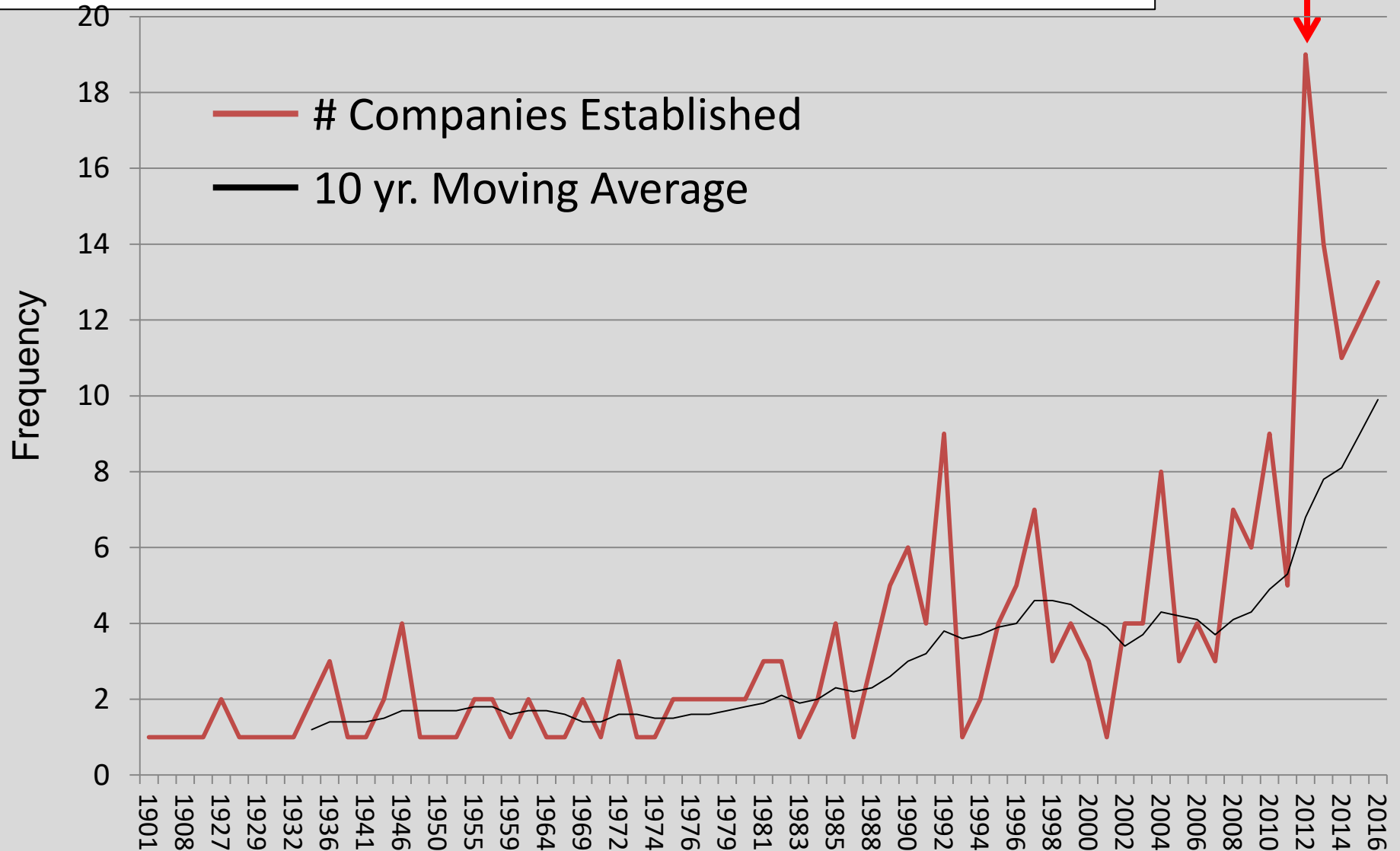
(1 Dec 2015-30 Nov 2016)

1. Baltimore (+9)
2. Washington, D.C. (+1)
3. Chicago (-2)
4. New York
5. Columbus, Ohio
6. Los Angeles (-4)
7. Detroit
8. Cincinnati
9. Philadelphia (-3)
10. San Francisco-Oakland-San Jose (+4)
11. Richmond-Petersburg, Va. (-2)
12. Raleigh-Durham, N.C. (-1)
13. Cleveland-Akron-Canton, Ohio (-1)
14. Indianapolis (+1)
15. Dallas-Ft. Worth (-2)



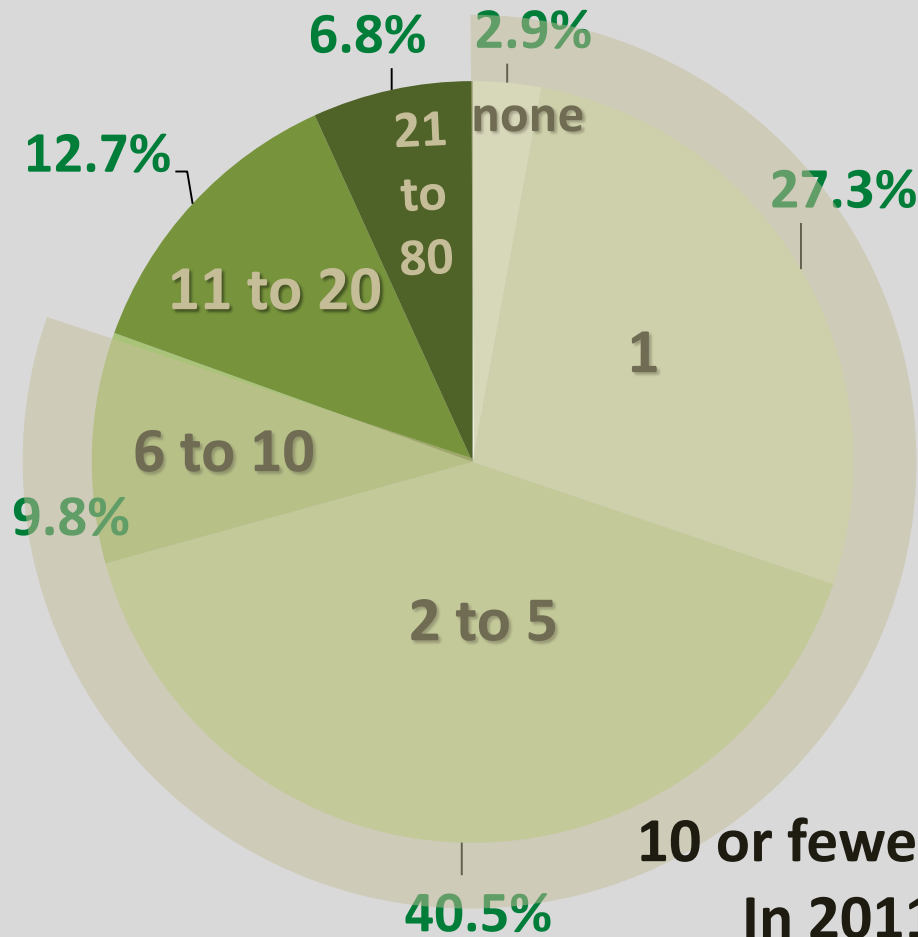
Overall trend is toward more companies that do bed bug work being established each year, with a huge increase in recent years.

Large spike in 2012 and 2013

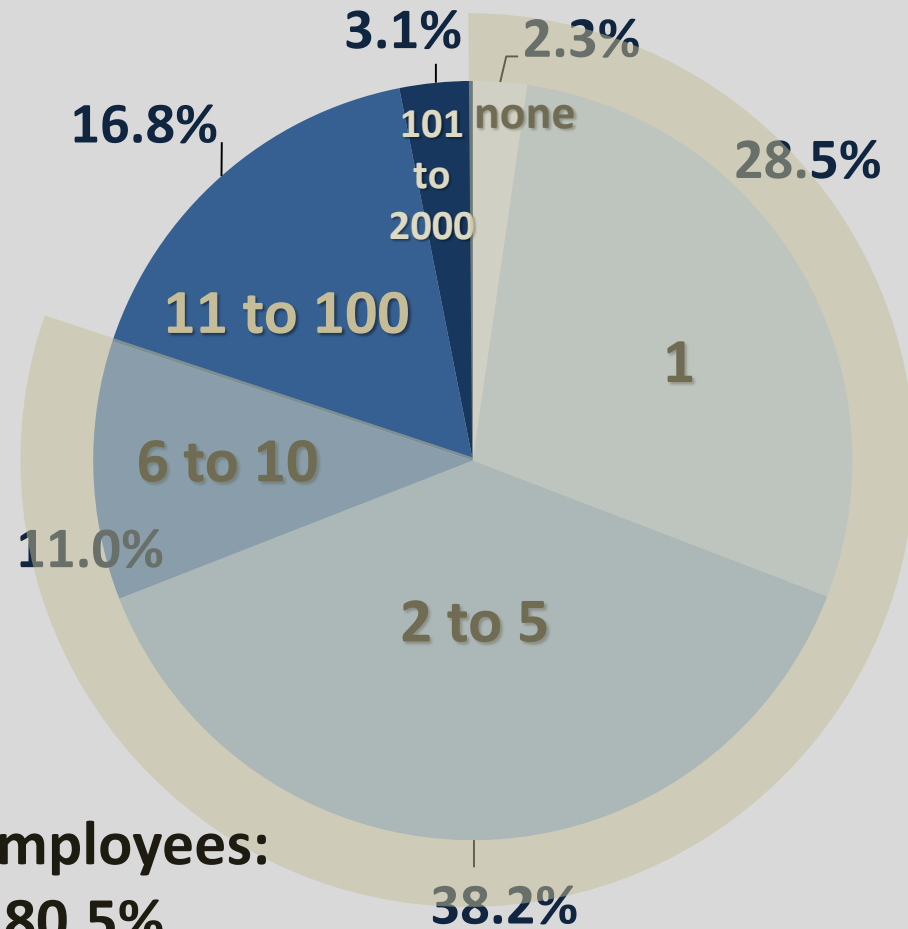


# OSU Survey: Co. Size (# employees)

2011



2016

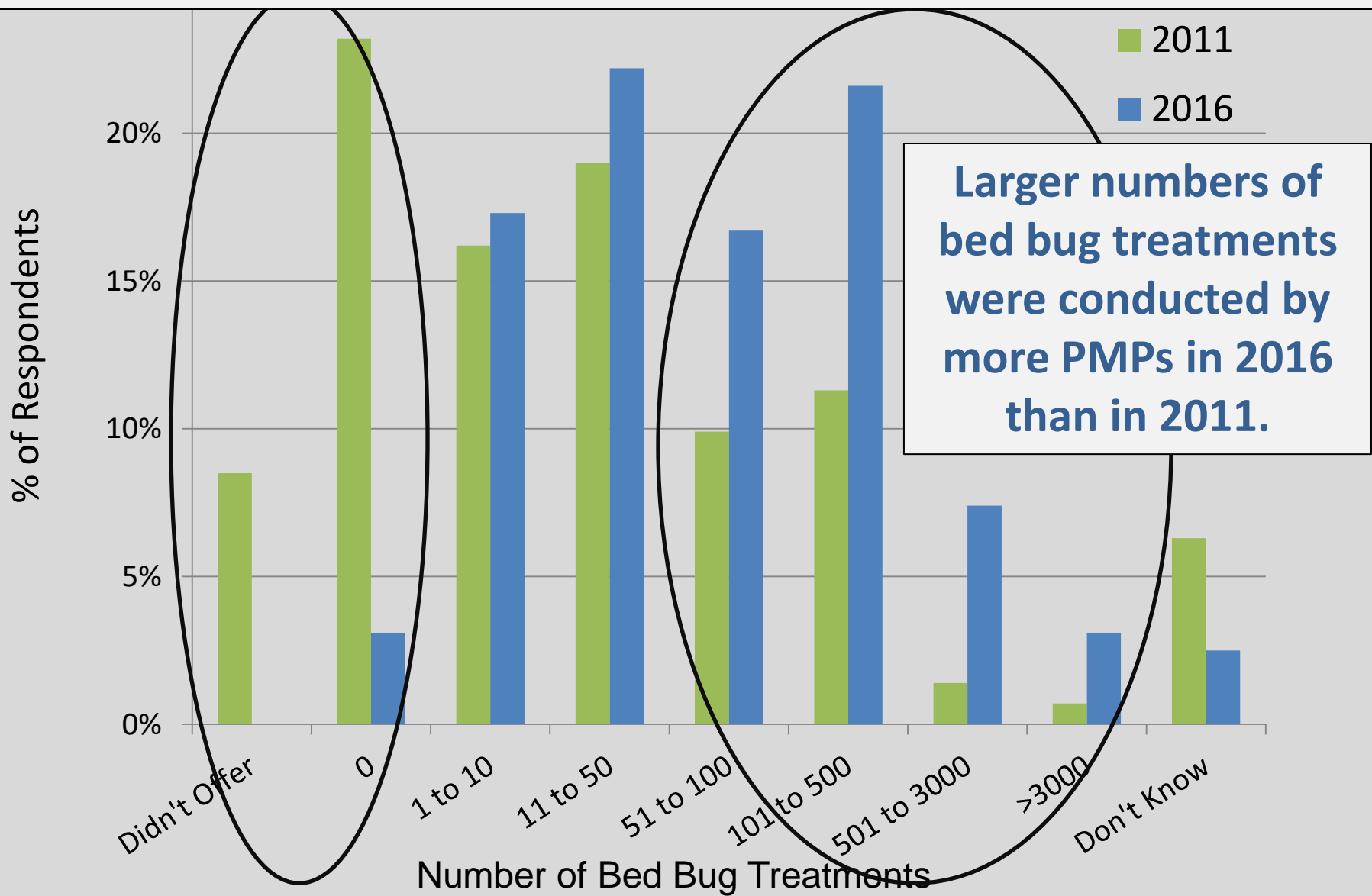


10 or fewer employees:

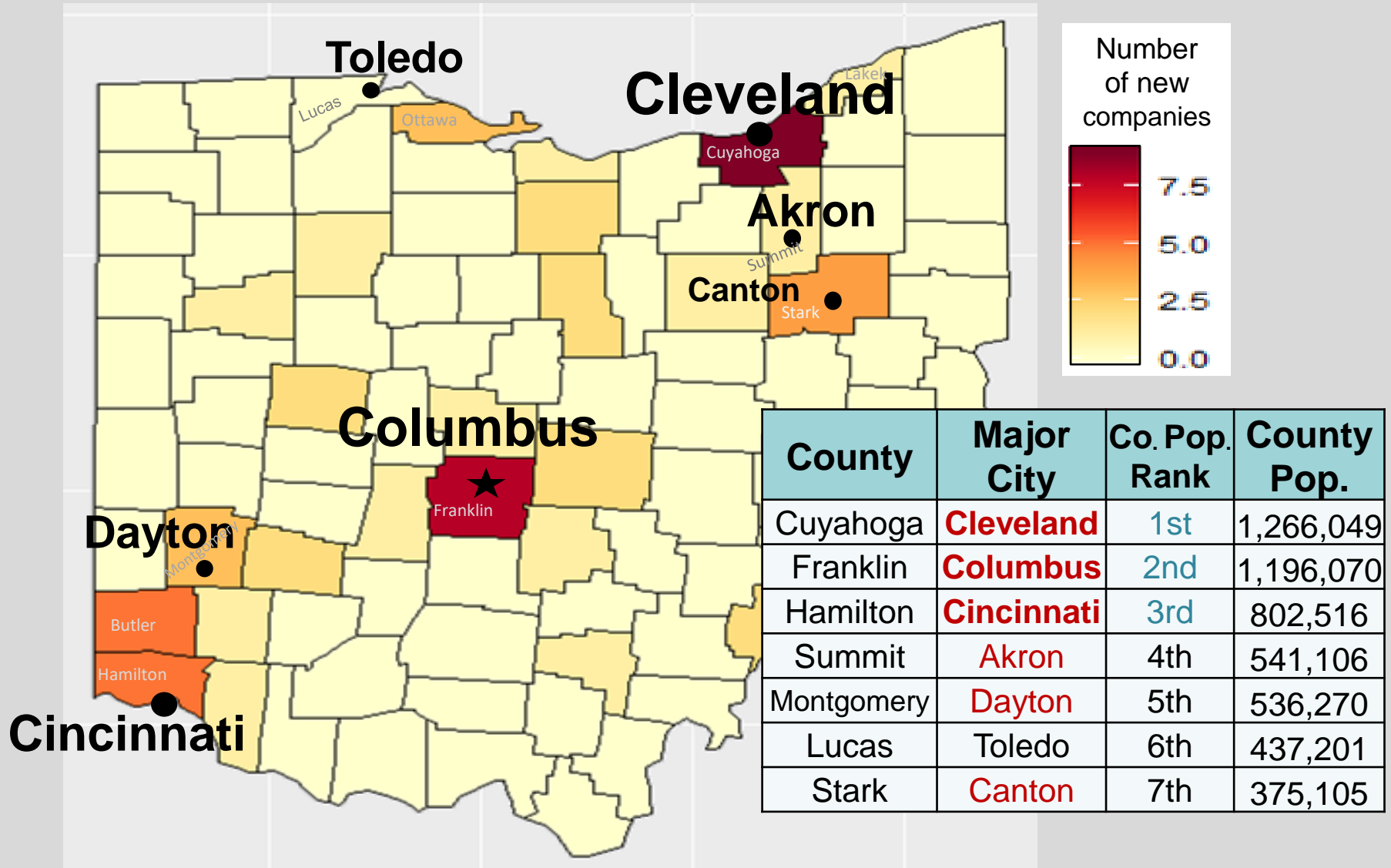
In 2011—80.5%

In 2016—80.0%

**In 2011, about 30% of responding PMPs didn't offer bed bug treatments or conducted none, but 5 years later in 2016, about 97% of respondents were performing bed bug treatments.**

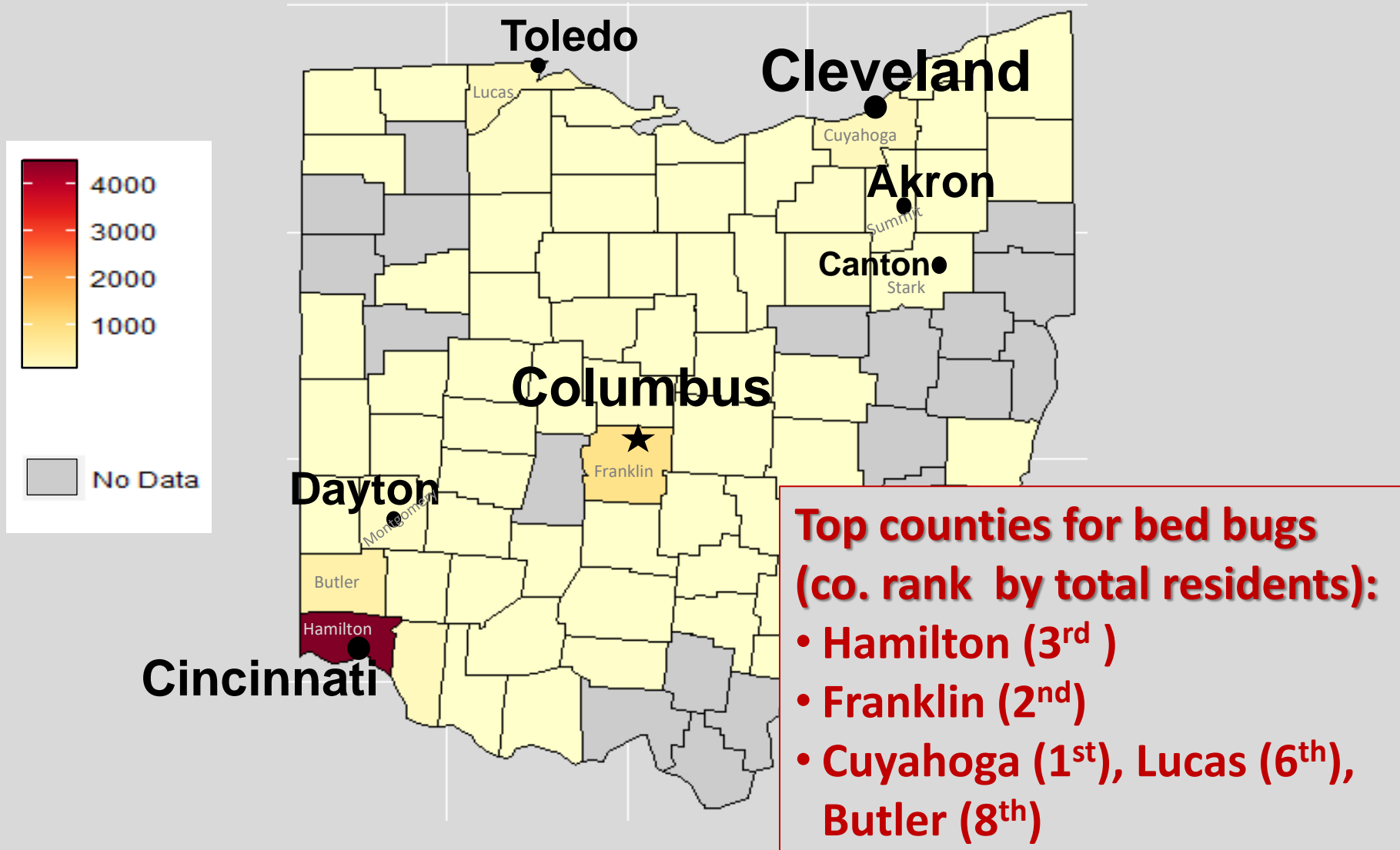


New companies primarily in and near Ohio's most heavily populated metro areas with the most bed bug treatments.



# OSU Survey: Number of Bed Bug Treatments

## 2005

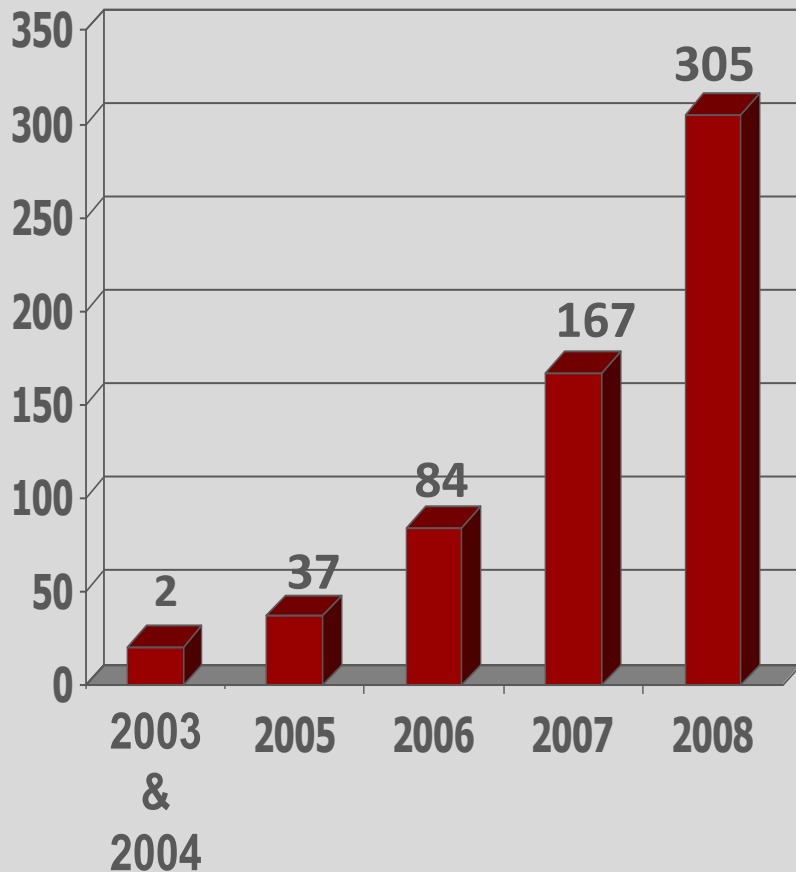




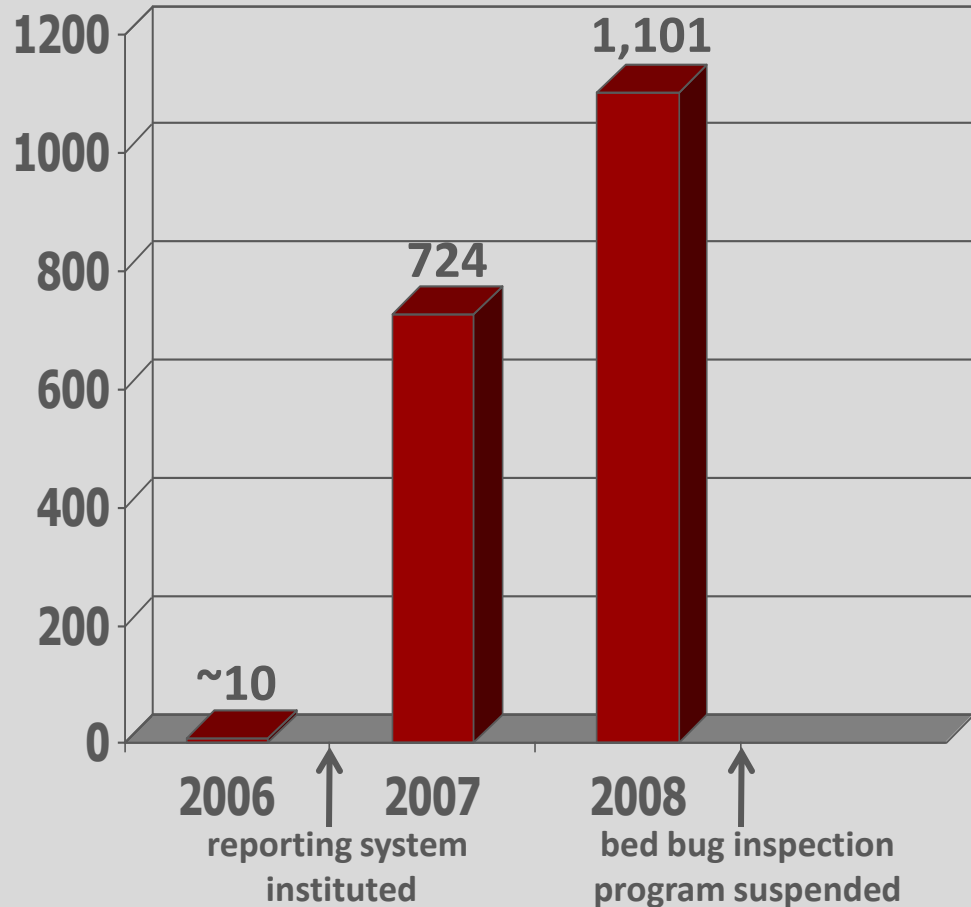
# *Bed Bugs Make Their Way to Ohio*

## **SW Ohio Bed Bug Complaints\***

Hamilton Co. Public Health Dept.<sup>1,2</sup>



Cincinnati Health Dept.<sup>3</sup>

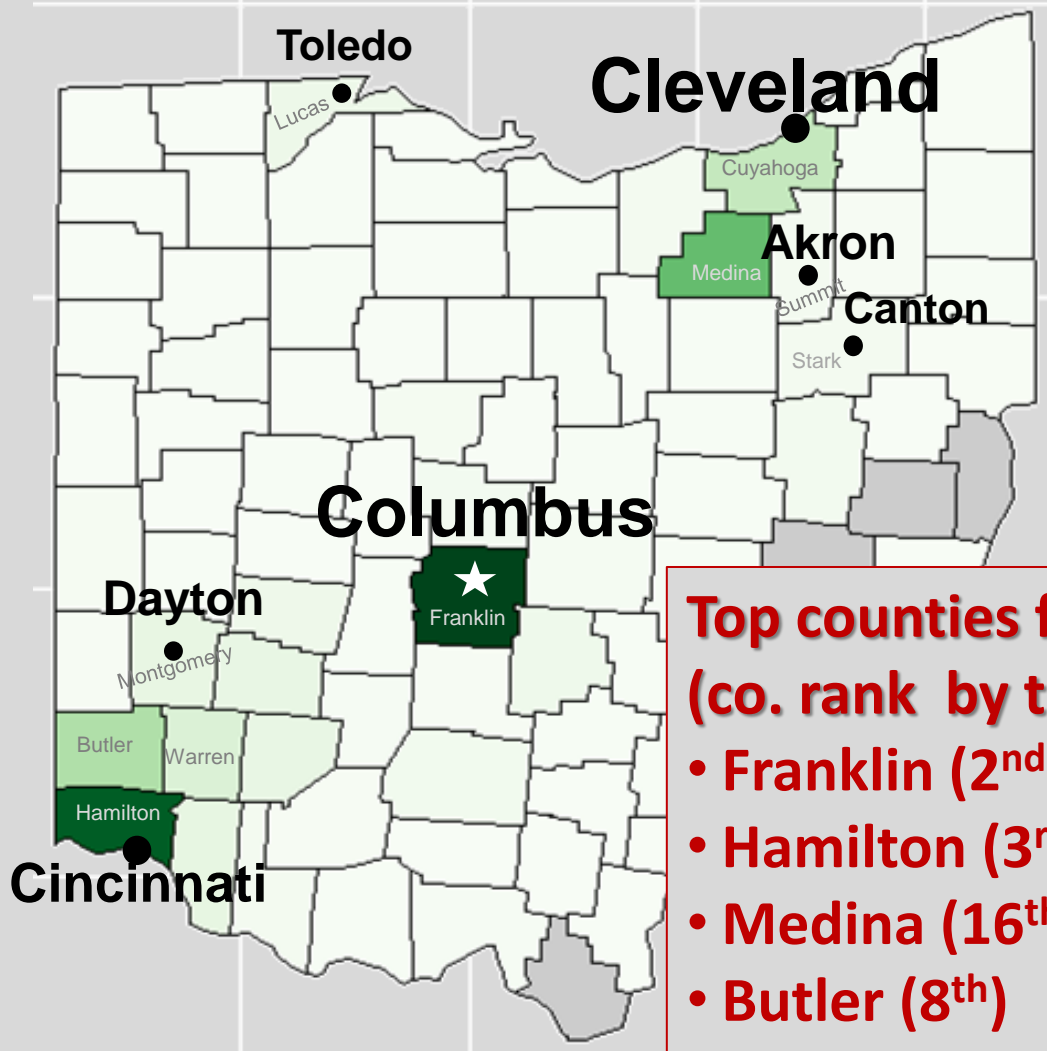
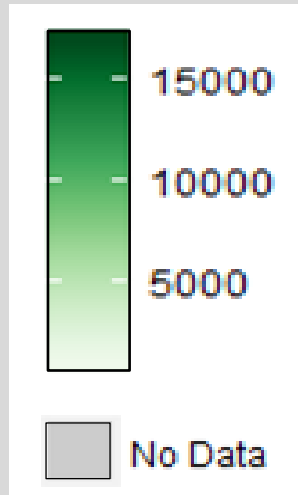


\* Represent a small fraction of overall bed bug infestations in area.

<sup>1</sup>Verified to be bed bugs. <sup>2</sup>Data courtesy of Greg Kesterman. <sup>3</sup>Data courtesy of Camille Jones.

# OSU Survey: Number of Bed Bug Treatments 2011

4-5X higher  
than 2005  
scale

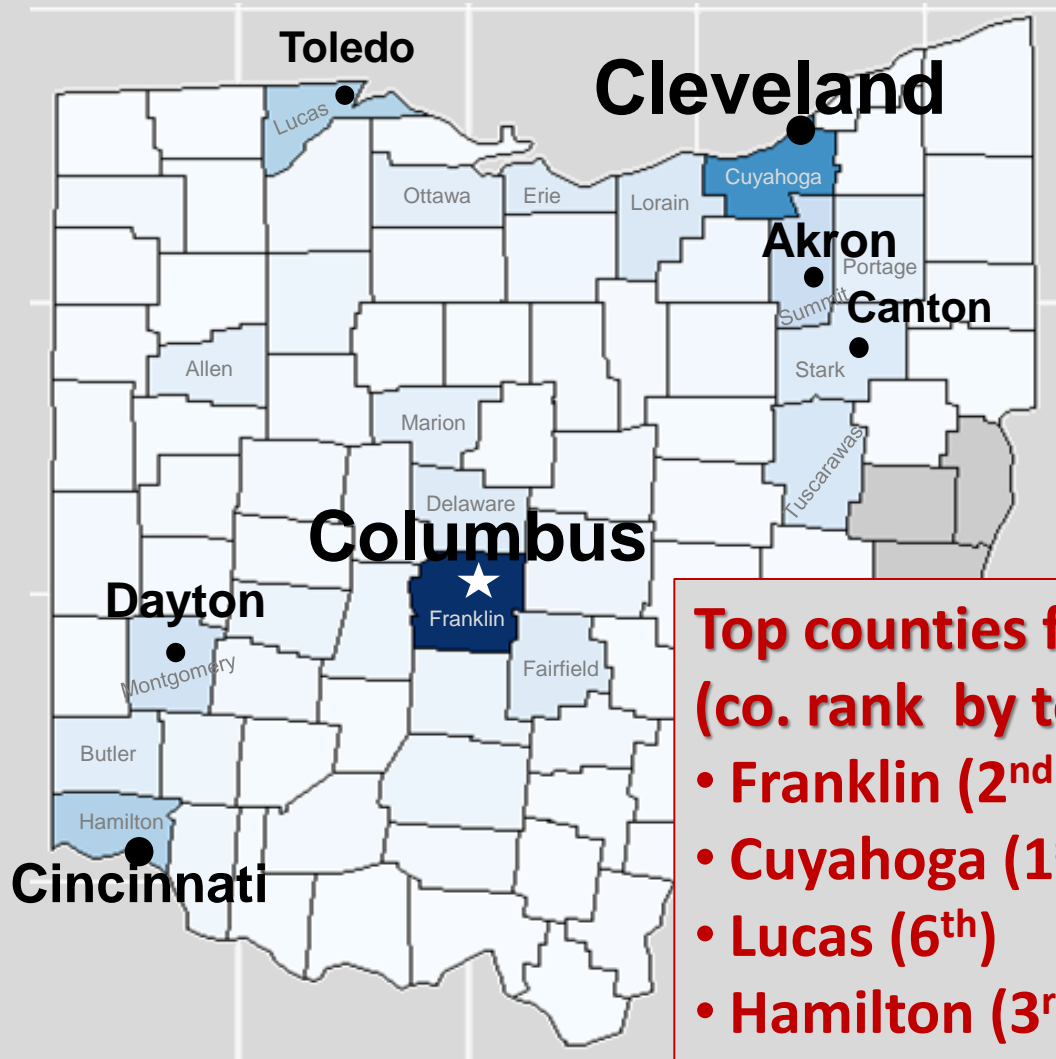
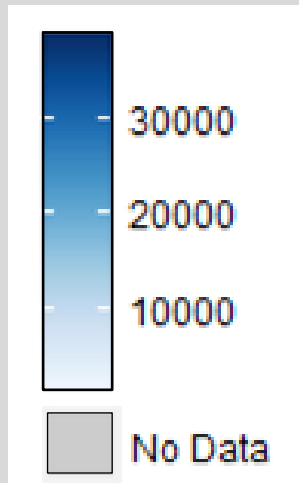


**Top counties for bed bugs  
(co. rank by total residents):**

- Franklin (2<sup>nd</sup>)
- Hamilton (3<sup>rd</sup>)
- Medina (16<sup>th</sup>)
- Butler (8<sup>th</sup>)
- Cuyahoga (1<sup>st</sup>)

# OSU Survey: Number of Bed Bug Treatments 2016

8-10X higher  
than 2005  
scale

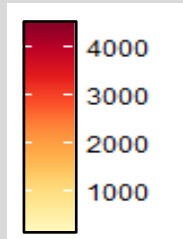


**Top counties for bed bugs  
(co. rank by total residents):**

- Franklin (2<sup>nd</sup>)
- Cuyahoga (1<sup>st</sup>)
- Lucas (6<sup>th</sup>)
- Hamilton (3<sup>rd</sup>)
- Summit (4<sup>th</sup>)

# Number of Bed Bug Treatments

2005

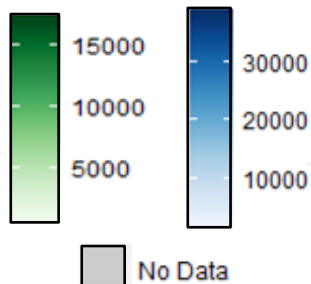


4-5X higher  
than 2005 scale

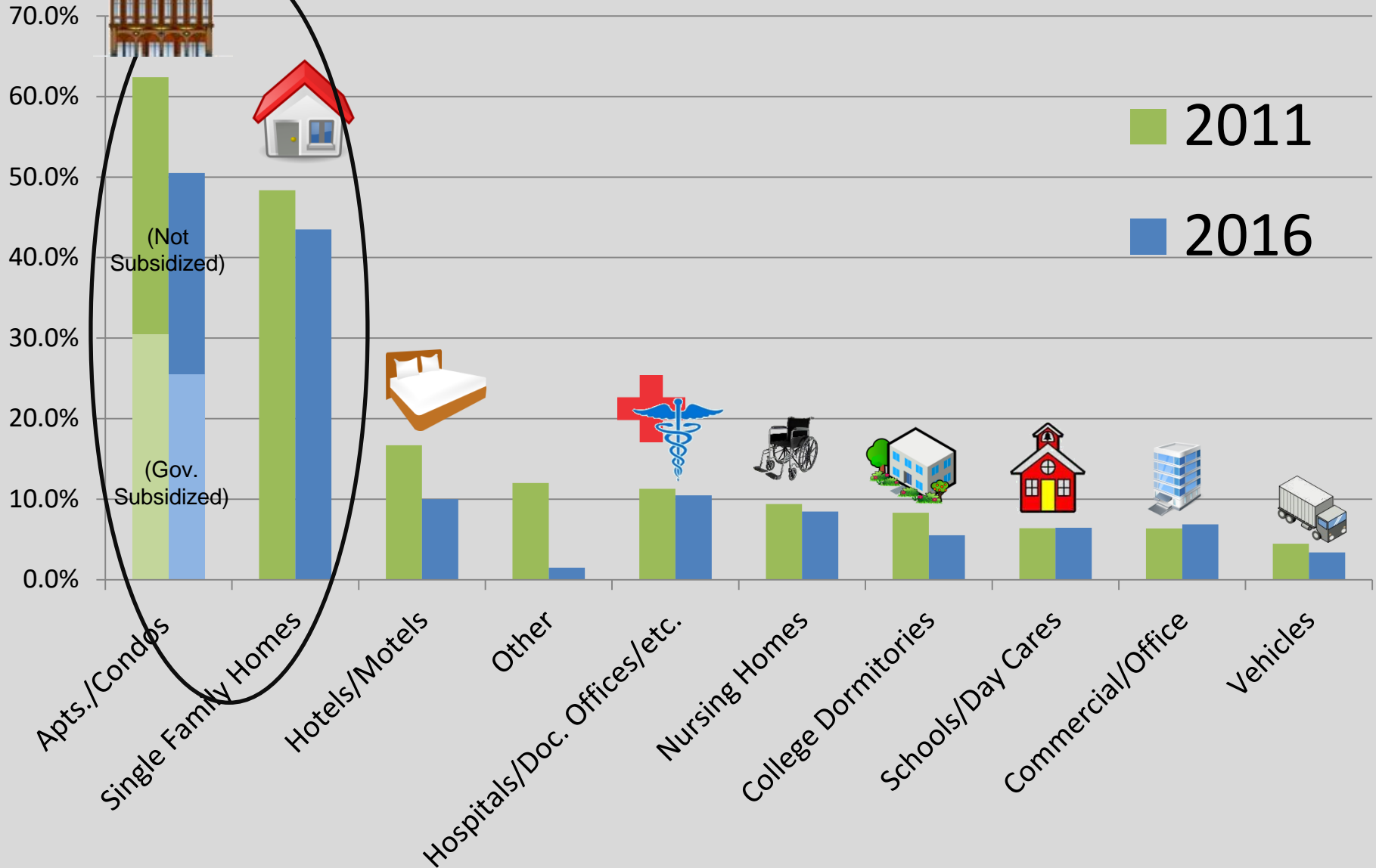
8-10X higher  
than 2005 scale

2011

2016

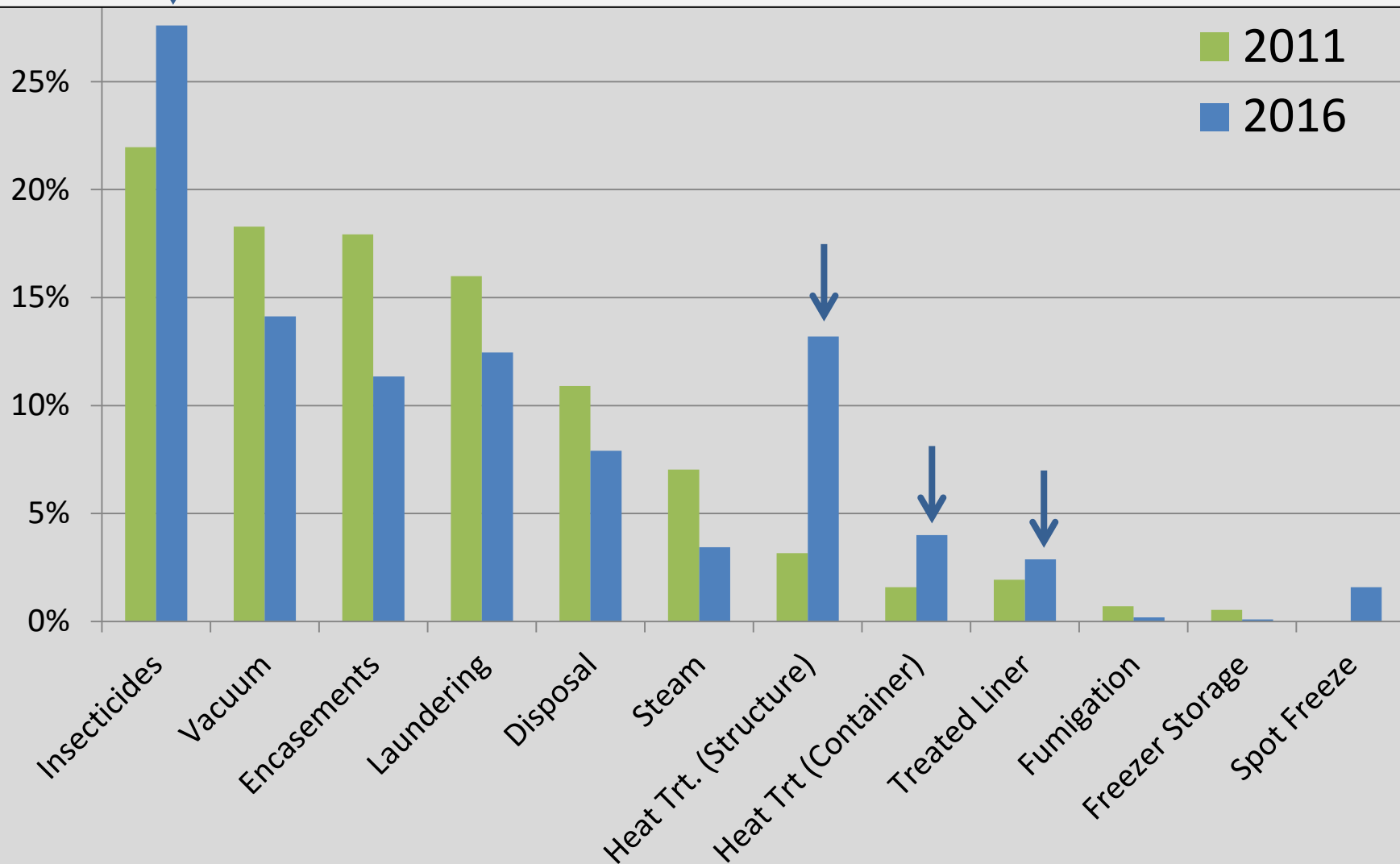


# Residences made up the largest share of bed bug work, especially multi-unit residences.





Since 2011, a larger percentage of OH PMPs are using insecticides, heat treatments (especially structure-based), and treated mattress liners.



# Top 5 Treatment Methods (nonexclusive):

2011

1. Insecticides\*
2. Vacuuming†
3. Encasements
4. Laundering
5. Disposal

2016

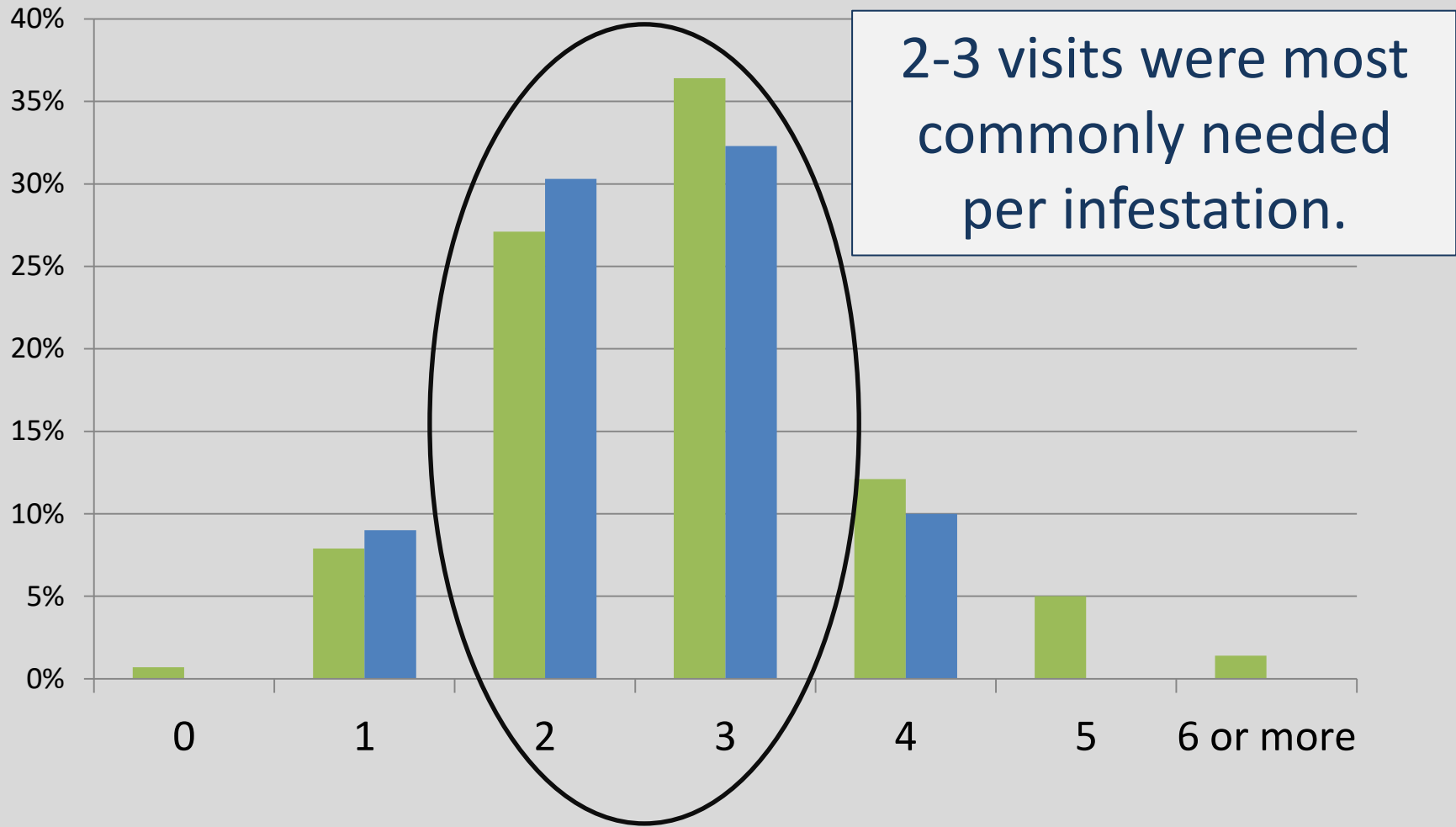
1. Insecticides\*
2. Vacuuming†
3. Heat treatment
4. Laundering
5. Encasements



\*'Insecticide Spray and Dust' listed as one category on 2011 survey but as two separate categories on 2016 survey

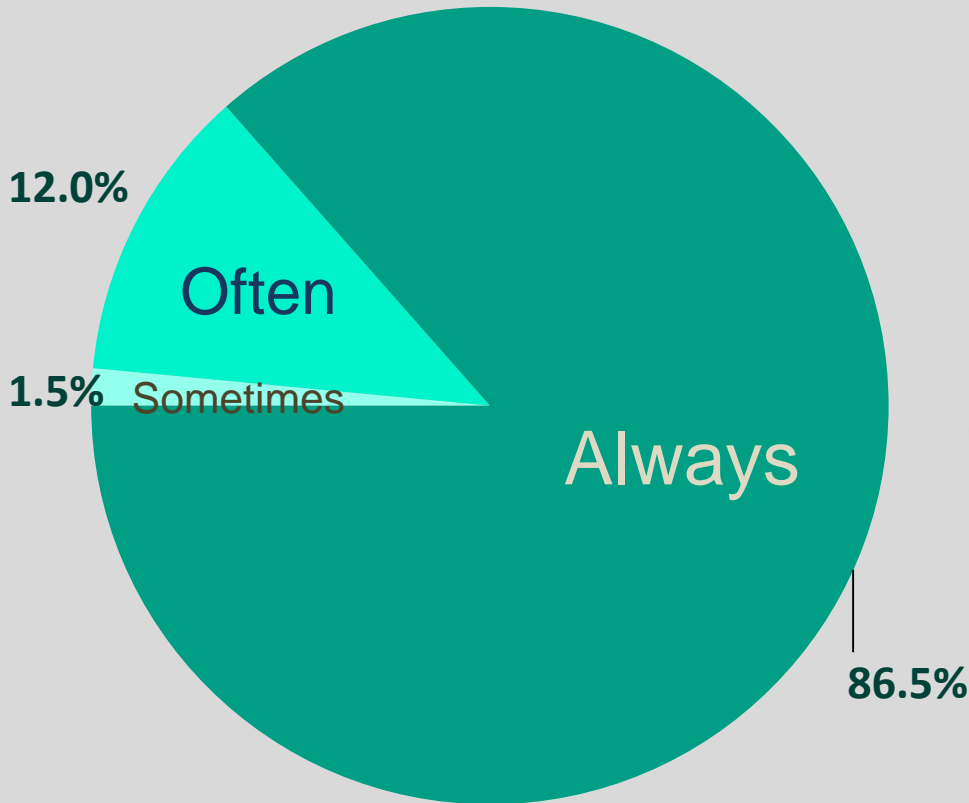
†Vacuuming 'by customer' and 'by other than customer' listed as two separate categories on both surveys

# OSU Survey: Visits Needed / Infestation

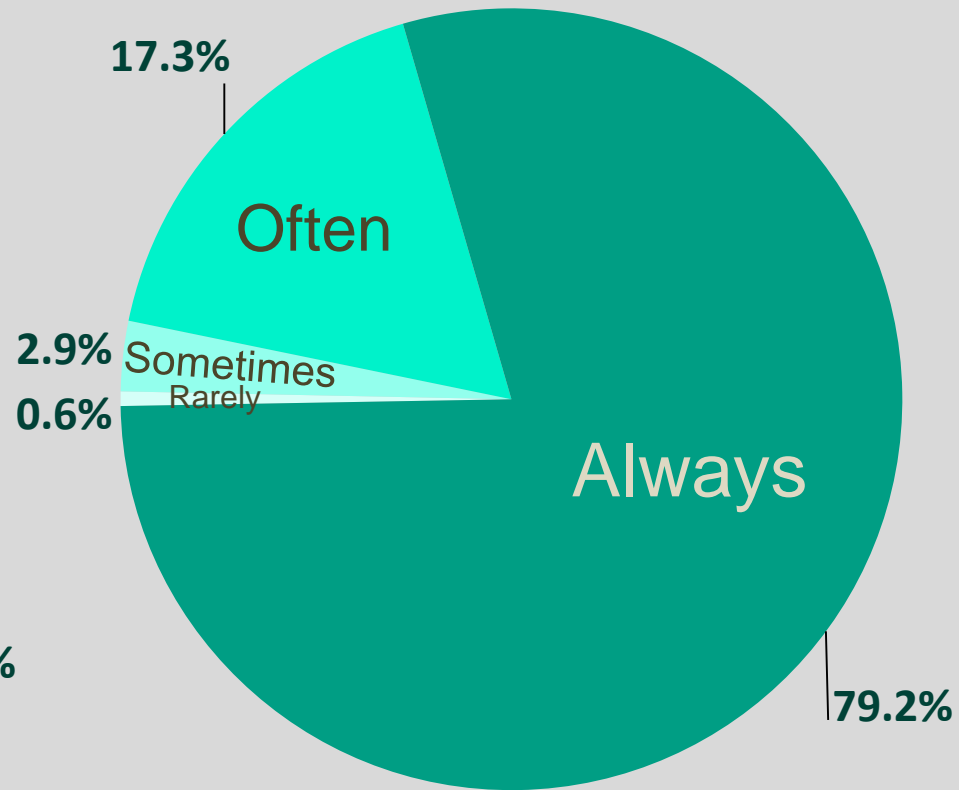


# Slight decrease in PMPs who “always” used visual detection

2011



2016



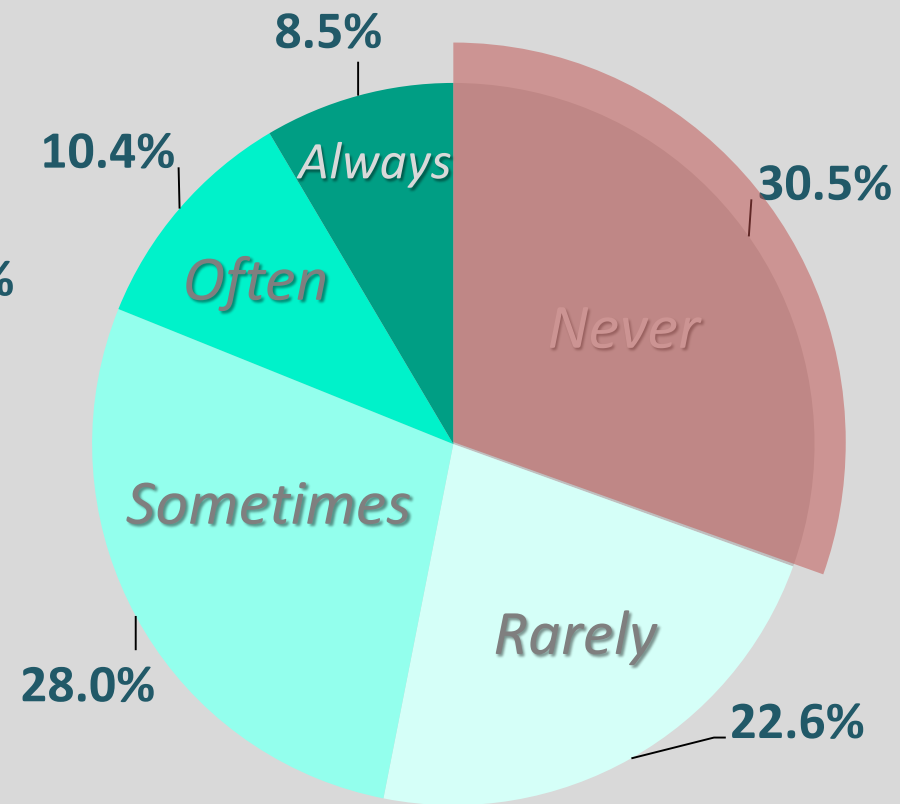
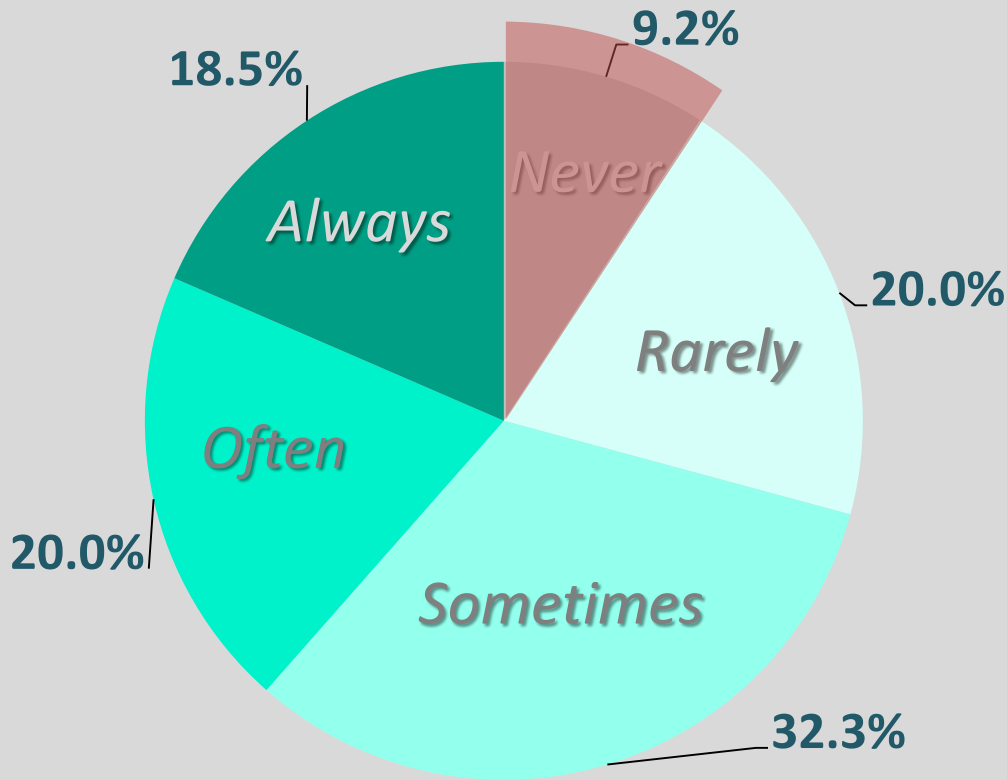


# Decreased use of sticky traps for bed bugs (sticky traps are not very effective in capturing bed bugs)



2011

2016



# Sticky Trap Ineffectiveness

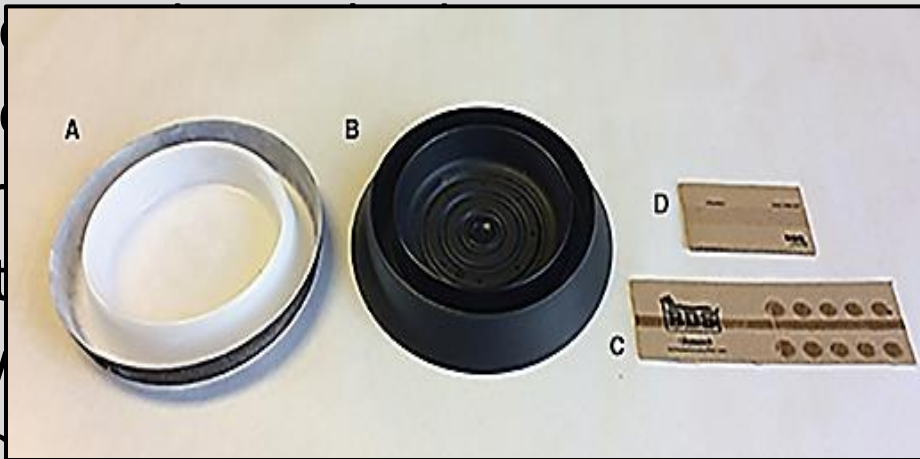
## Household and Structural Insects

### Bed Bug (Hemiptera: Cimicidae) Detection in Low-Income, High-Rise Apartments Using Four or Fewer Passive Monitors

K. M. Vail<sup>1</sup> and J. G. Chandler

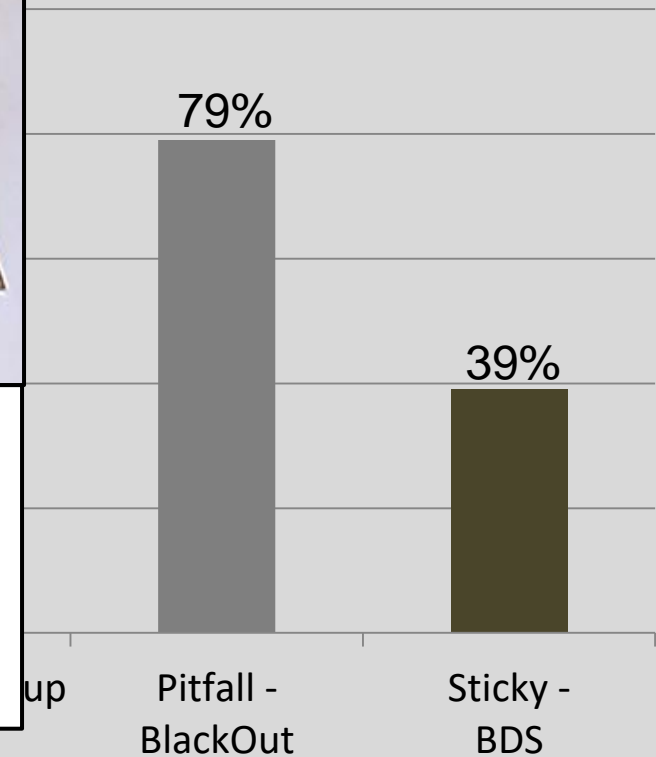
Entomology and Plant Pathology, 370 Plant Biotechnology Building, 2505 E J Chapman Drive, University of Tennessee, Knoxville, TN 37996-4560 (kvail@utk.edu; jchand11@utk.edu), and <sup>1</sup>Corresponding author, e-mail: kvail@utk.edu

“Failure to detect bed bugs in apartments using BDS [sticky traps] was significantly lower than pitfall traps. Climbu BG traps compared



(A) ClimbUp Insect Interceptor BG, (B) BlackOut BedBug Detector, and the sticky passive monitor, Bedbug Detection System (BDS), positioned in preparation for (C) inspection and (D) installation.

## Apartments Detected



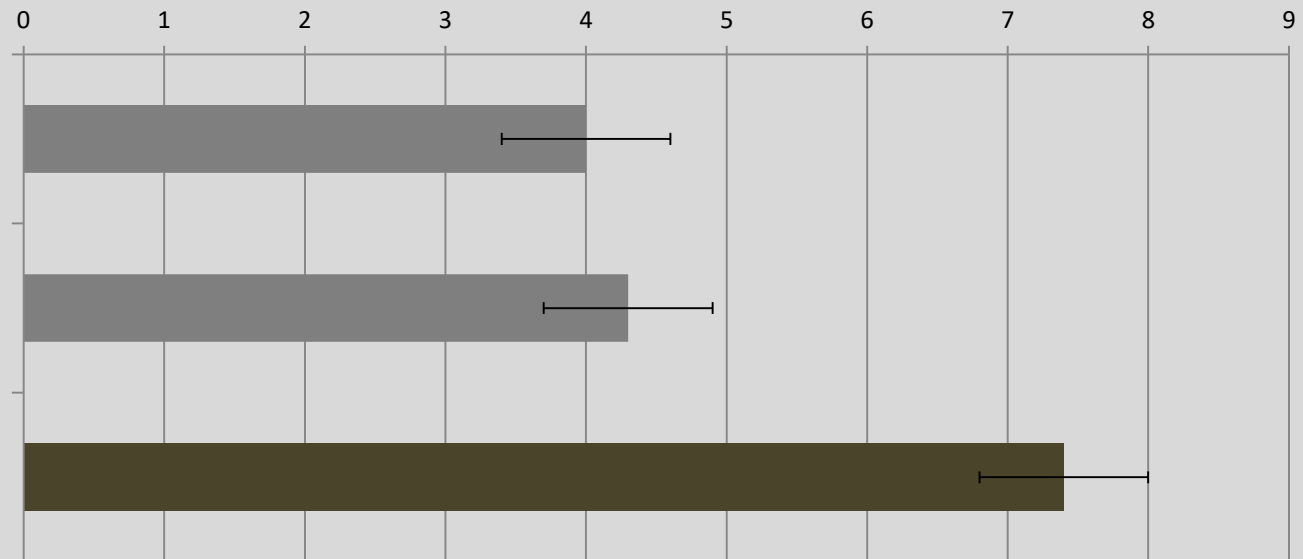
# Sticky Trap Ineffectiveness

## Bed Bug (Hemiptera: Cimicidae) Detection in Low-Income, High-Rise Apartments Using Four or Fewer Passive Monitors

K. M. Vail<sup>1</sup> and J. G. Chandler

Entomology and Plant Pathology, 370 Plant Biotechnology Building, 2505 E J Chapman Drive, University of Tennessee, Knoxville, TN 37996-4560 (kvail@utk.edu; jchand11@utk.edu), and <sup>1</sup>Corresponding author, e-mail: kvail@utk.edu

### Weeks to Detection



“The BDS [sticky monitor] required significantly longer time ( $7.4 \pm 0.6$  wk) to detect the bed bugs than either the Black ClimbUp ( $4.0 \pm 0.6$  wk) or the BlackOut ( $4.3 \pm 0.6$  wk) [pitfall monitors]...”



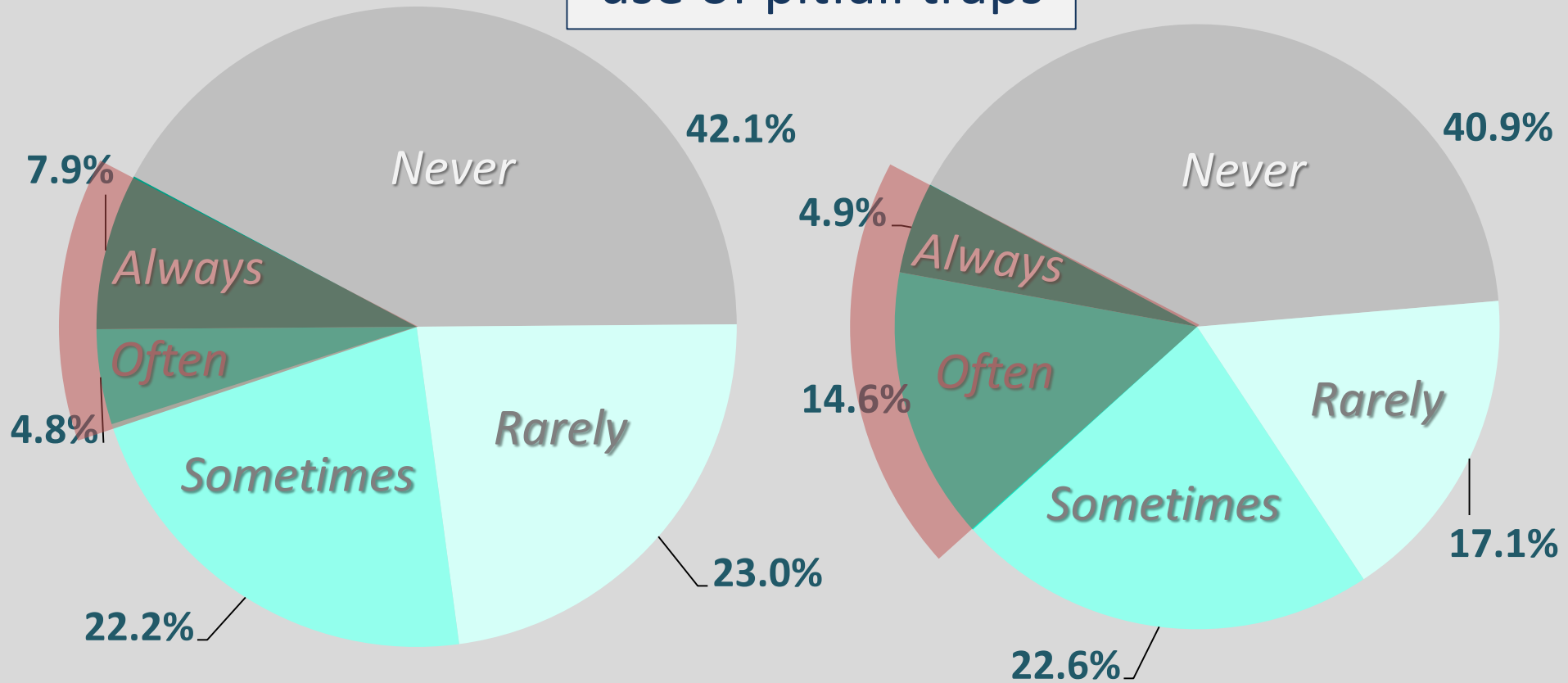
# OSU Survey: Percentage of PMPs Using Pitfall Traps (Passive Monitors)



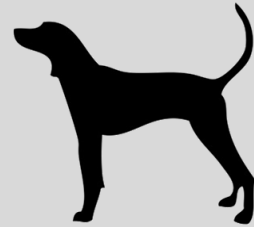
2011

Some increase in use of pitfall traps

2016

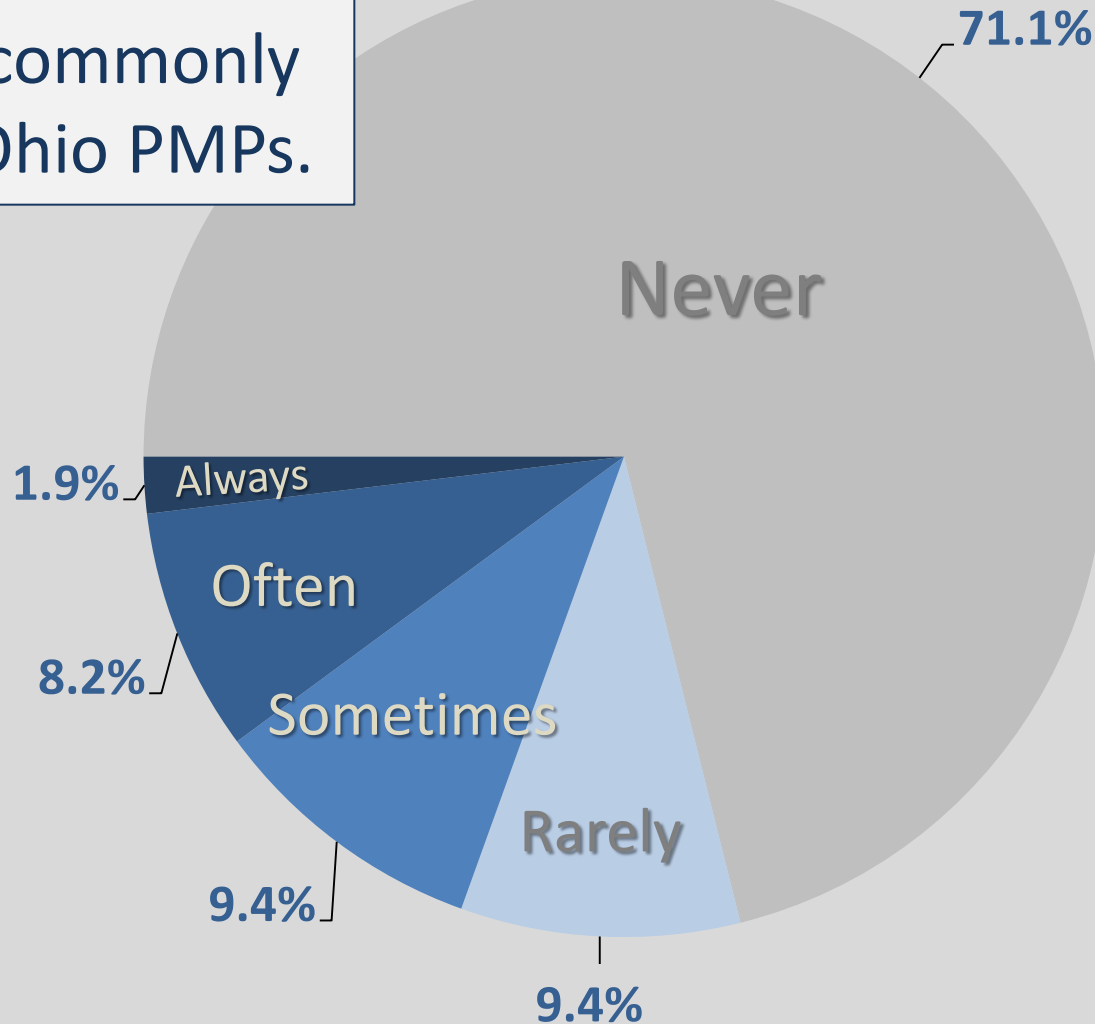


# OSU Survey: Percentage of Respondents Using Canine Detection (Active Monitoring)

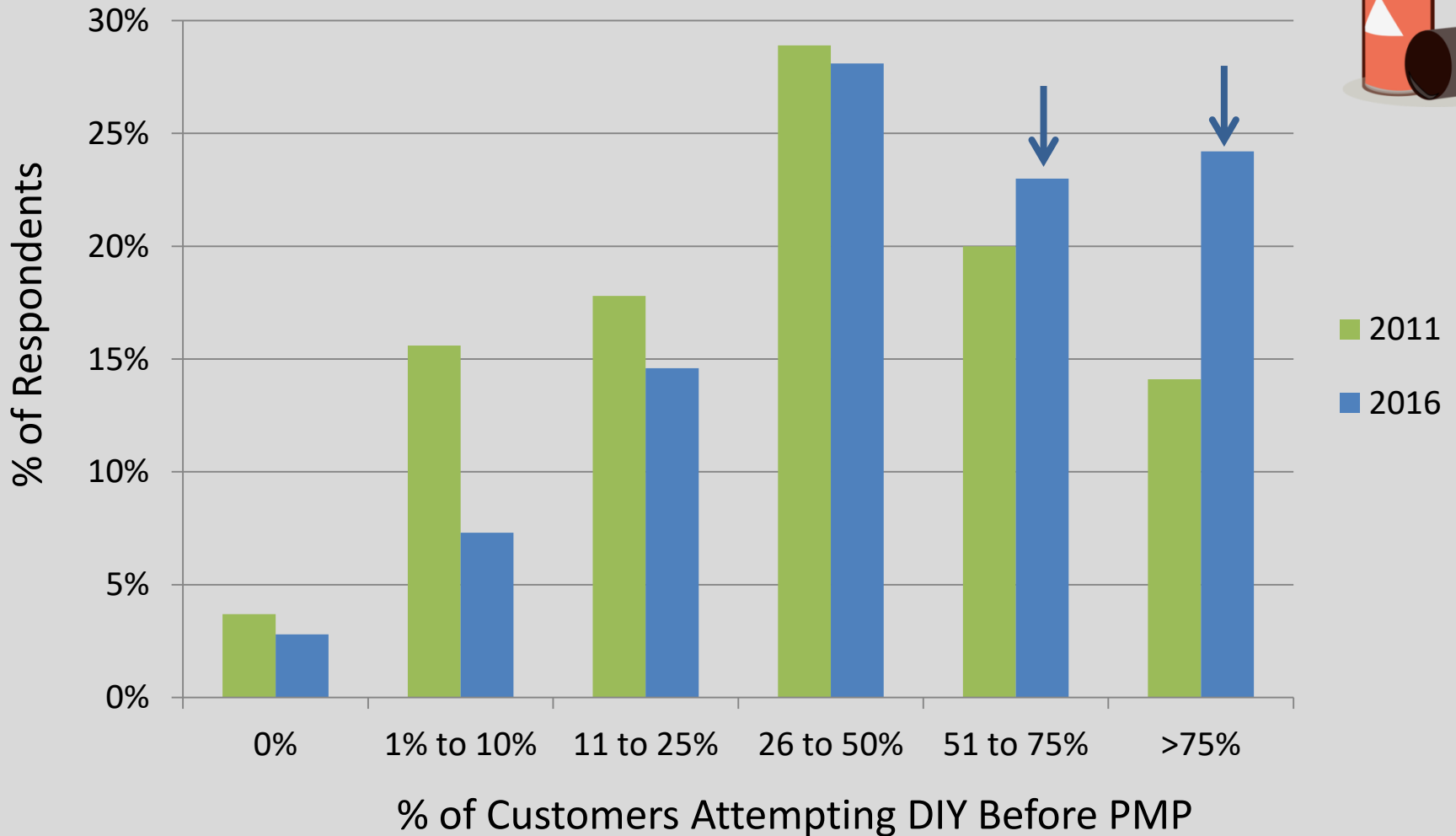


Canine detection was not commonly used by Ohio PMPs.

2016 survey only



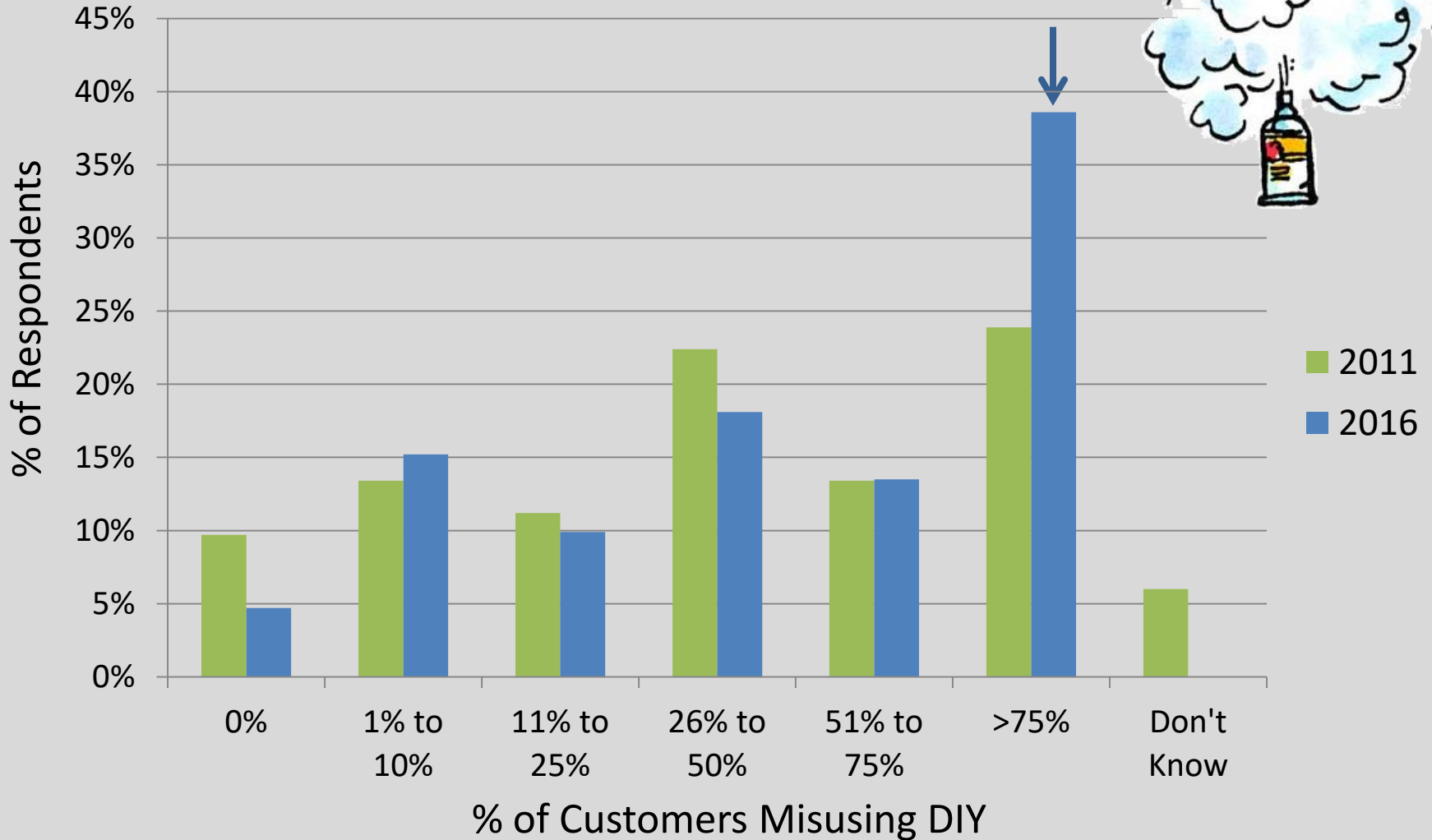
# Increasing # of customers initially attempting DIY before calling for professional services.



# Increasing number of customers misusing DIY products



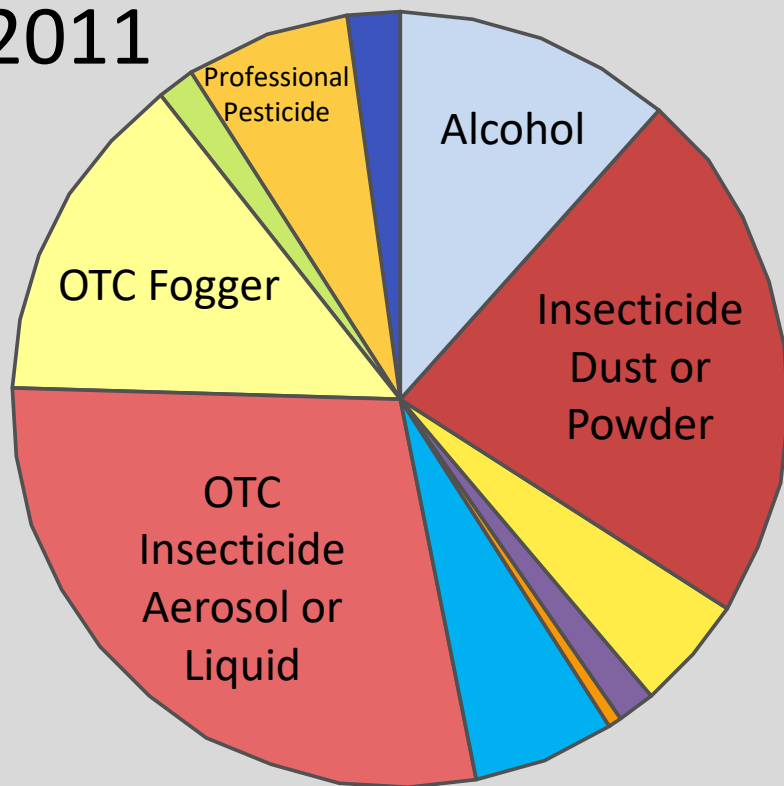
ucts



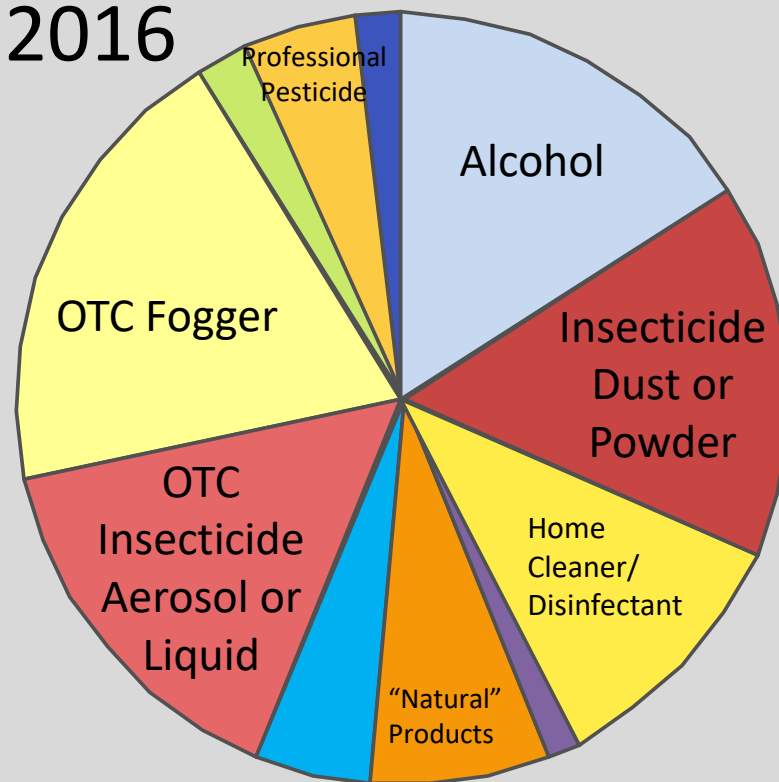
OTC foggers, alcohol, home cleaners, and “natural” products all increased as share of misused products.

- Alcohol
- Dust/powder pesticide
- Home Cleaner/disinfectant
- Illegal/unregistered pesticide
- Natural product spray or liquid
- Outdoor/Garden pesticide
- Over-the-counter aerosol or liquid
- Over-the-counter fogger
- Petroleum product
- Professional pesticide liquid or spray
- Other

2011



2016





**DON'T use bug bombs  
for bed bugs!**



*Bug bombs can worsen a bed bug problem!*



- **“Bug Bombs” work very poorly against crawling insects**
- **Few bugs will be killed!**
- **“Bug Bombs” can cause bed bugs (and cockroaches) to scatter!!!**





# Over-the-Counter Foggers (“Bug Bombs”)

“Kills on contact”  
“Effective long-term control”



“Kills on contact”  
“Kills flying, crawling,  
and biting insects”



“Kills on contact”  
“Kills bugs you see, kills  
bugs you don't see!”



HOUSEHOLD AND STRUCTURAL INSECTS

## Ineffectiveness of Over-the-Counter Total-Release Foggers Against the Bed Bug (*Heteroptera: Cimicidae*)

SUSAN C. JONES<sup>1</sup> AND JOSHUA L. BRYANT

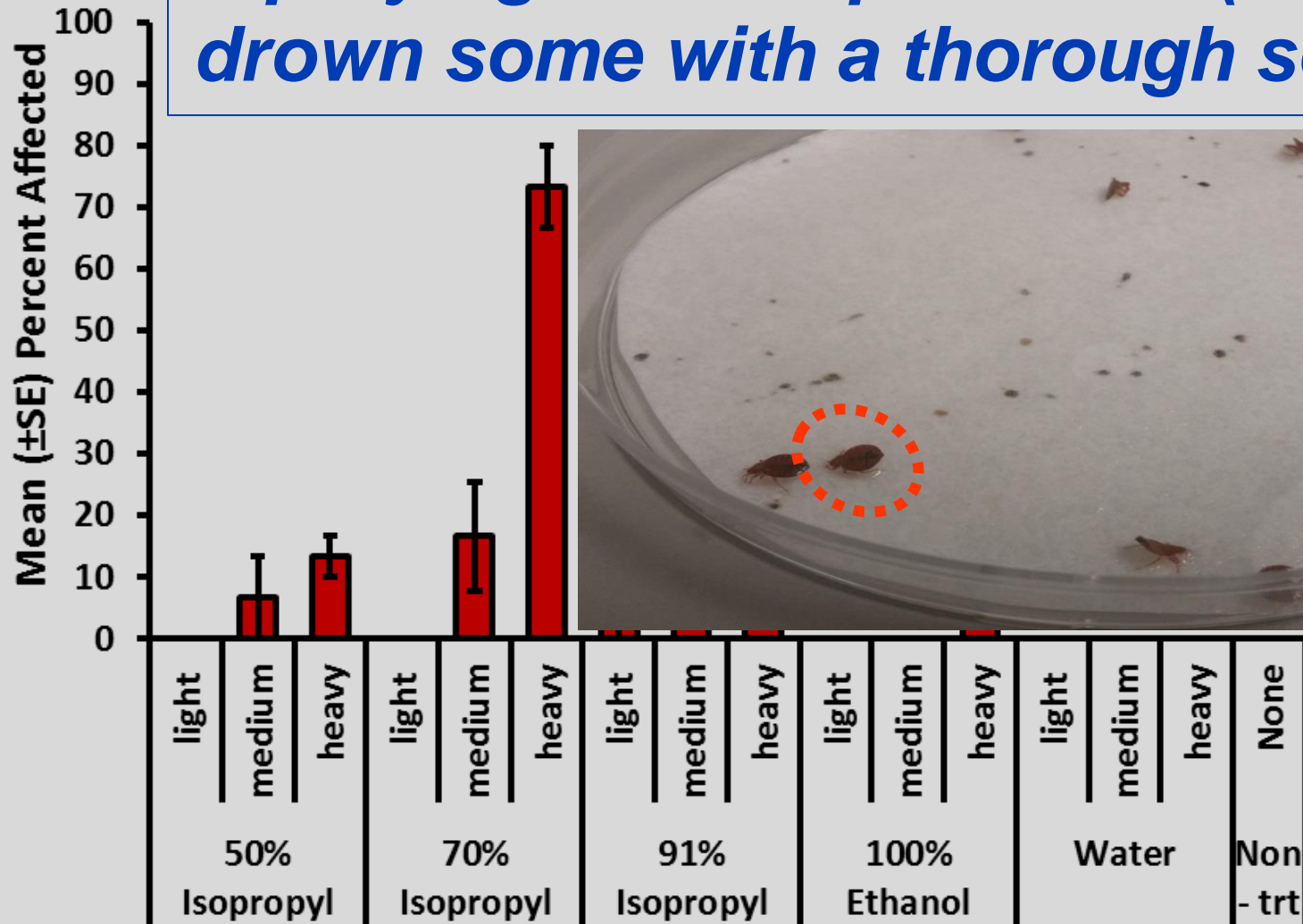
Department of Entomology, The Ohio State University, 2501 Carmack Road, Columbus, OH 43210-1065

J. Econ. Entomol. 105(3): 957-963 (2012); DOI: <http://dx.doi.org/10.1603/EC12037>

**ABSTRACT** Field-collected bed bugs (*Cimex lectularius* L.) showed little, if any, adverse effects after 2-h direct exposure to the aerosolized pyrethroid(s) from three over-the-counter total-release foggers ('bug bombs' or 'foggers'); Hotshot Bedbug and Flea Fogger, Spectracide Bug Stop Indoor Fogger, and Eliminator Indoor Fogger. One field-collected population, EPM, was an exception in that there was significant mortality at 5–7 d when bugs out in the open had been exposed to the Spectracide Fogger; mortality was low when these bugs had access to an optional harborage, a situation observed for all field-collected populations when exposed to the three foggers. Even the Harlan strain, the long-term laboratory population that is susceptible to pyrethroids and that served as an internal control in these experiments, was unaffected if the bugs were covered by a thin cloth layer that provided harborage. In residences and other settings, the majority of bed bugs hide in protected sites where they will not be directly contacted by the insecticide mist from foggers. This study provides scientific data supporting the position that total-release foggers should not be recommended for control of bed bugs, because 1) many field-collected bed bugs are resistant to pyrethroids; they are not affected by brief exposure to low concentrations of pyrethrins and/or pyrethroids added by foggers; and 2) there is minimal, if any, insecticide penetration into typical bed bug harborage sites. This study provides strong evidence that Hotshot Bedbug and Flea Fogger, Spectracide Bug Stop Indoor Fogger, and Eliminator Indoor Fogger were ineffective as bed bug control.



*You will not kill many bed bugs by spraying alcohol products. (You may drown some with a thorough soaking).*



**DON'T use ultrasonic repellent devices against bed bugs or other insects.**



# Efficacy of Commercially Available Ultrasonic Pest Repellent Devices to Affect Behavior of Bed Bugs (*Hemiptera: Cimicidae*)

K. M. YTURRALDE<sup>1</sup> AND R. W. HOFSTETTER

School of Forestry, Northern Arizona University, 200 East  
AZ 86011

J. Econ. Entomol. 166: 166-171 (2013)  
**ABSTRACT** Little is known about the behavior of bed bugs, *Cimex lectularius* L. (Hemiptera: Cimicidae), although many studies have shown that they are attracted to sound. The purpose of this study was to determine the efficacy of commercially available ultrasonic repellent devices to affect the behavior of bed bugs with or without sound during choice trials. Hosts were placed in a choice chamber with or without sound and control devices. The results showed that bed bugs did not attract bed bugs to the test (sound) devices. Bed bugs were also more likely to exit the middle compartment during treatment trials with ultrasonic devices. Our results confirm that sound are not a promising tool for repelling bed bugs.

**KEY WORDS** bed bug



cockroach feces

bed bugs nearby

cockroach shed skin

*Cimex lectularius*

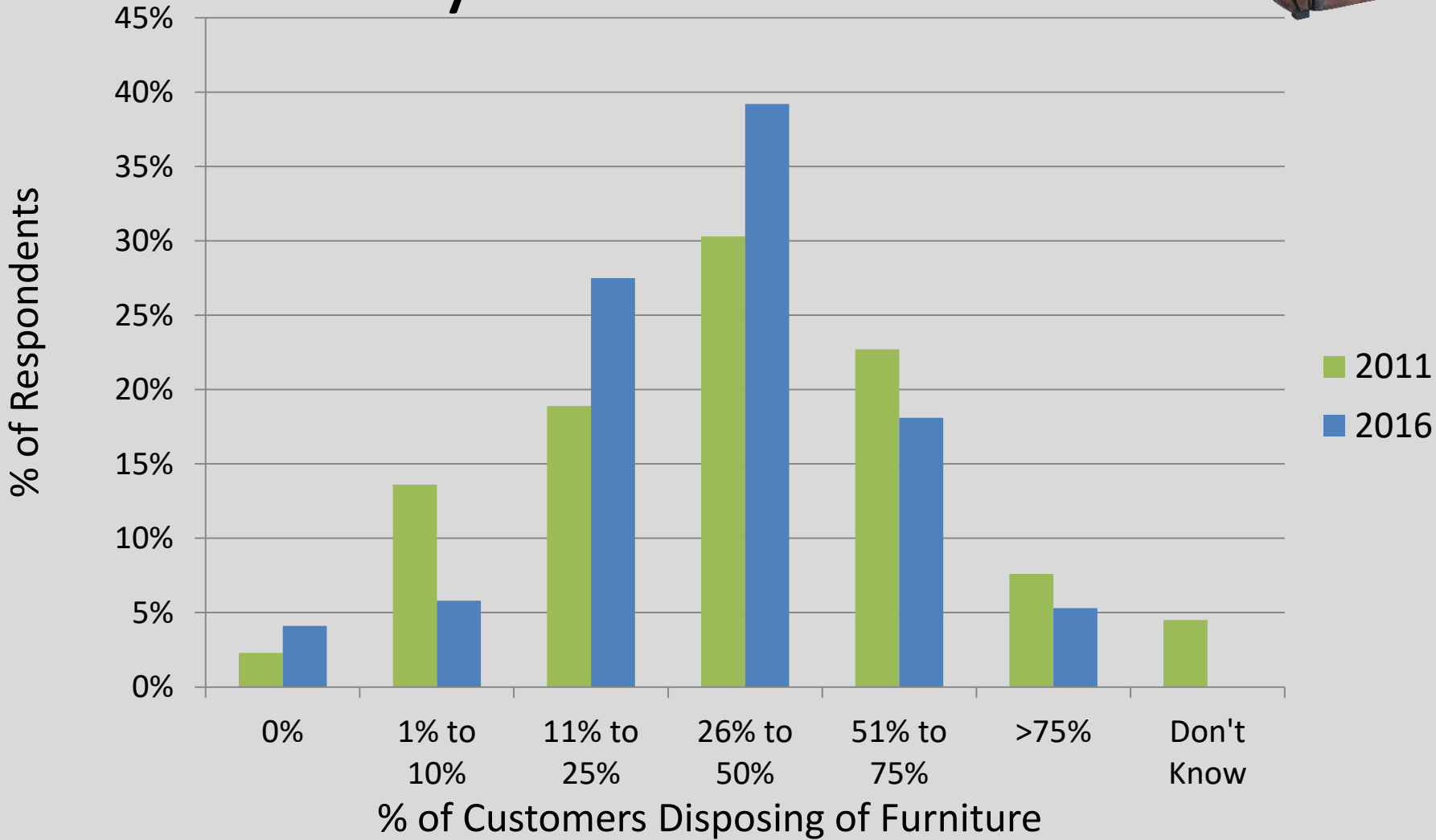


# ***Reasons why residents should not dispose of furniture, mattresses, etc.:***



- Bed bugs will fall off the furniture as it is being moved, hence spreading the problem.
- Infested furniture usually can be treated.
- Bed bugs can quickly infest replacement furniture.
- Items placed in dumpsters often are picked up and reused, thereby spreading bed bugs to other households.

# Many customers are disposing of bed bug-infested furniture.



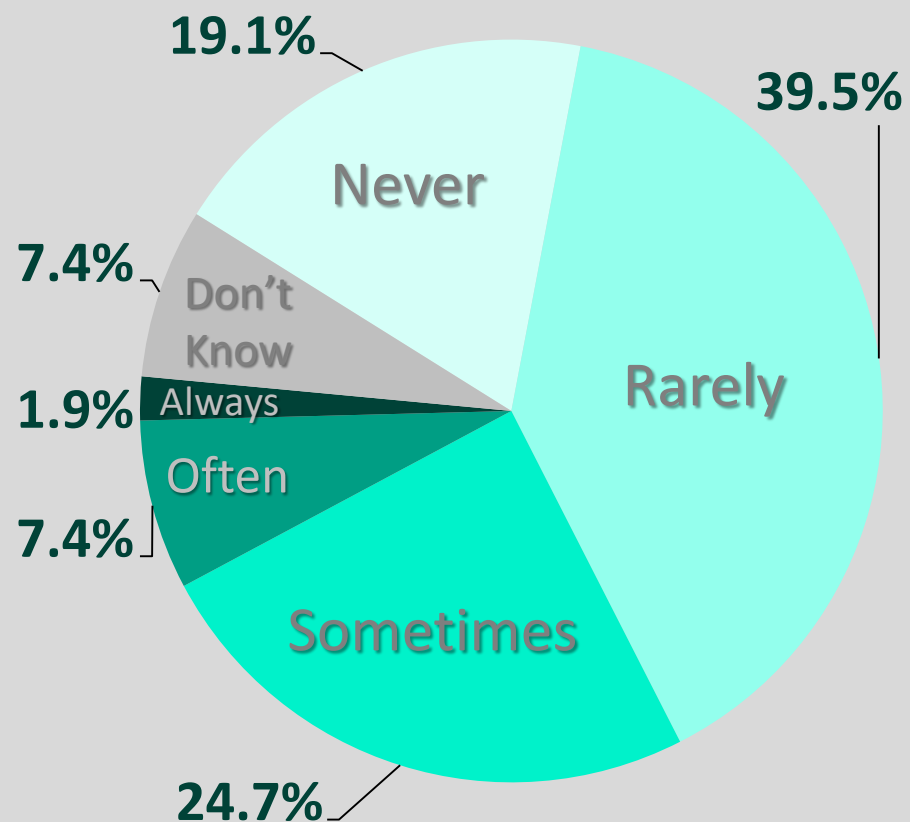
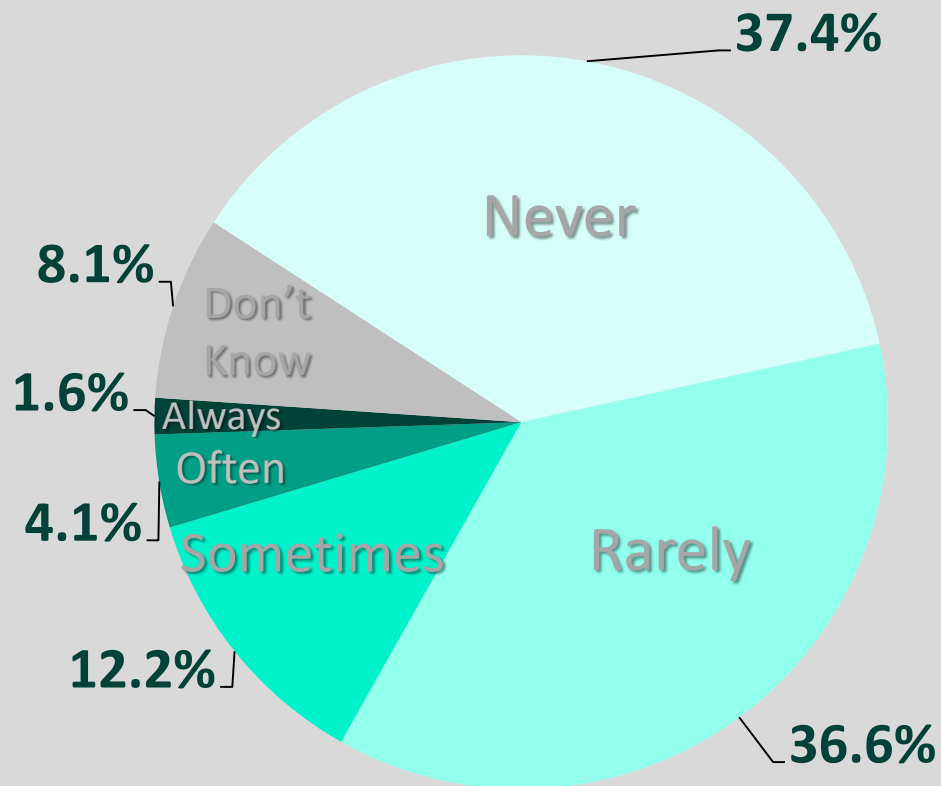
OSU

Some improvement on customers' wrapping items—still needs work.



2011

2016



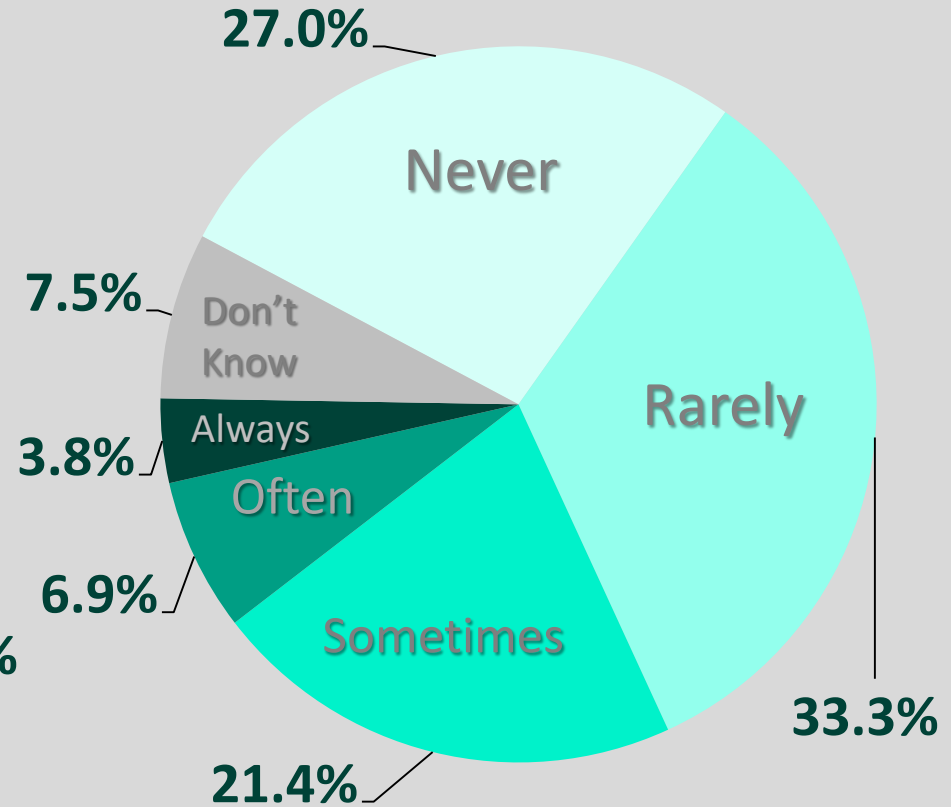
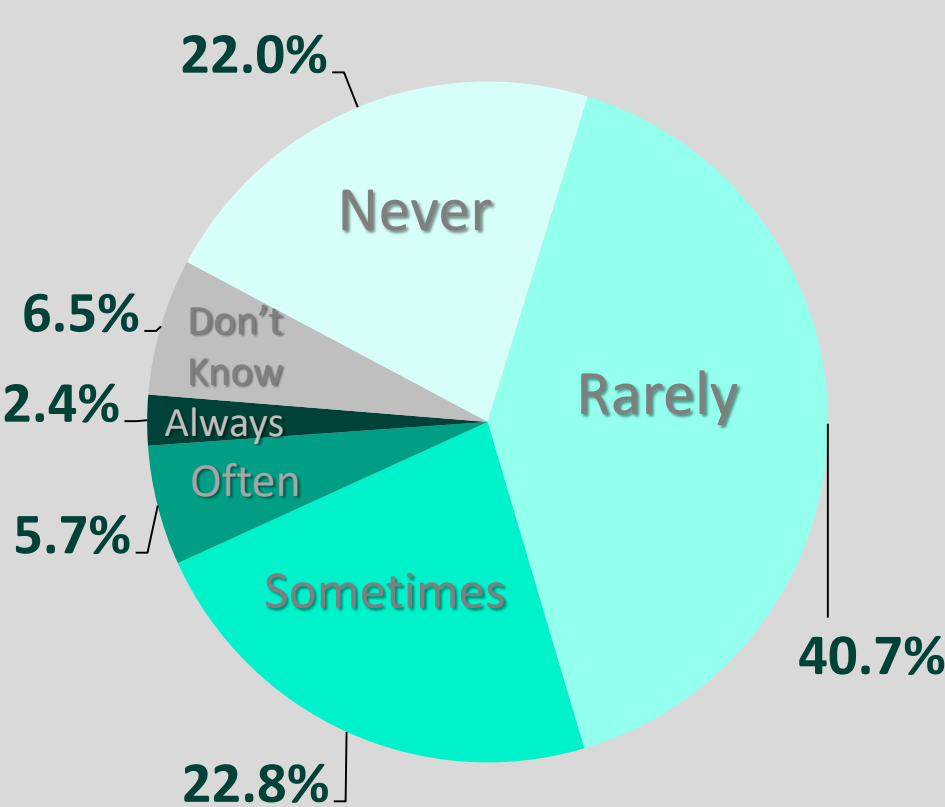


Not much change in customers' damaging/defacing items—needs more work.



2011

2016



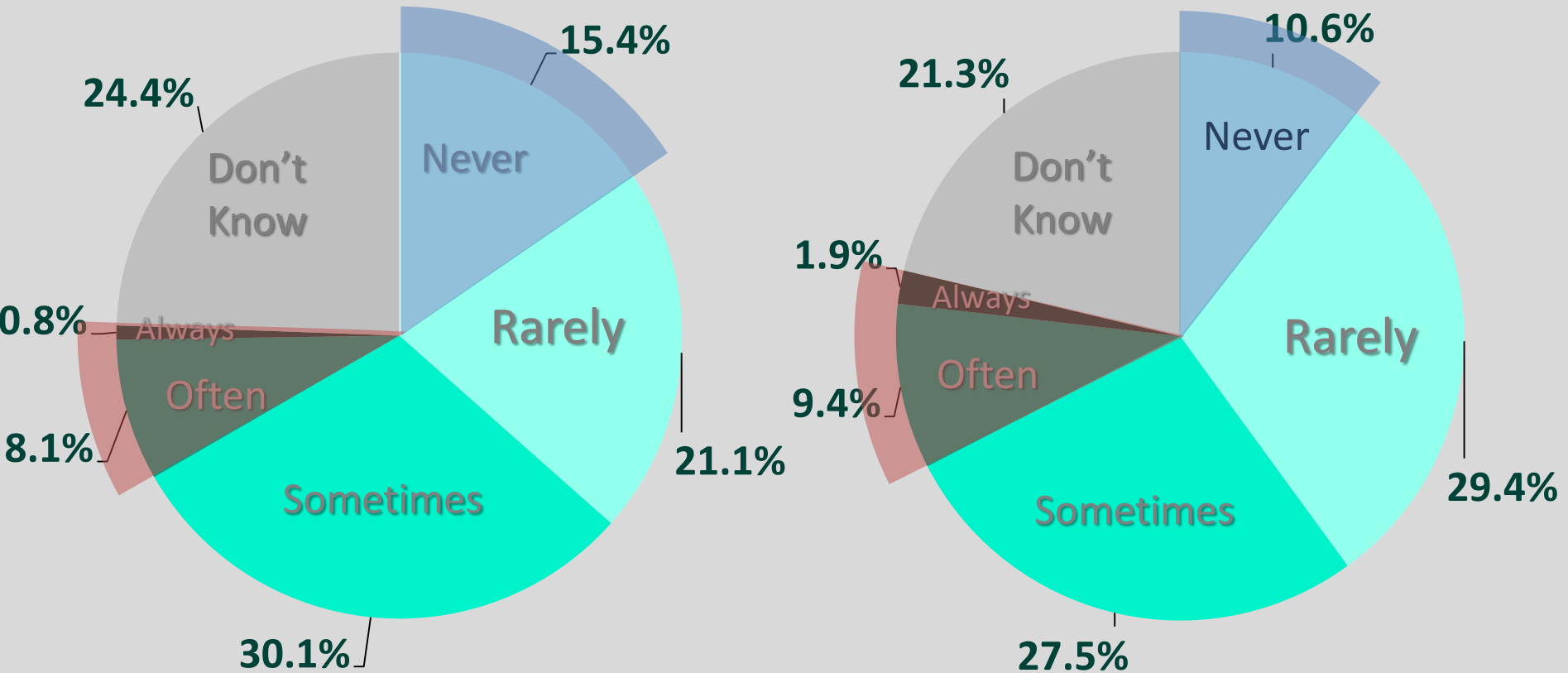
# OSU Survey: Frequency of Customers Giving Away/Selling Infested Items



☹️ If accurate, this is a very negative development!

2011

2016



# OSU Bed Bug Website

<http://u.osu.edu/bedbugs>

**THE OHIO STATE UNIVERSITY**  
COLLEGE OF FOOD, AGRICULTURAL,  
AND ENVIRONMENTAL SCIENCES

HOME GALLERIES **RESEARCH**

**RESEARCH**

- Bed Bug Control
- Insecticide Resistance
- Bed Bug Detection
- Bed Bug Dispersal
- Bed Bug Physiology, Biology, and Behavior
- Human Health Considerations
- Bed Bug Population Dynamics: Establishment, Growth, Diversity, etc.
- Laboratory Rearing of Bed Bugs
- Surveys
- Bed Bug History

**BUGS**

- General Information
- Bed Bug Bites
- Bed Bugs as Potential Disease Vectors
- Asthma
- Anemia
- Mental Health Effects

**Bed Bug Control**

2017

**Aak, A., E. Rollgheten, B. A. Rukke, and T. Blrkemoe. 2017.** bed bugs: a potential control solution? *Journal of Pest Science*

"The common bed bug (*Cimex lectularius*, Hemiptera; Cimicidae) infestations has greatly increased over the past 20 years. A eradication programs are expensive and laborious. We investigated the use of CO<sub>2</sub> as a bed bug activity stimulant. An initial experiment tested varying doses, available hiding places and the presence or absence of CO<sub>2</sub> with Syloid 244FP with or without CO<sub>2</sub> gas. Syloid was supplied at a concentration of 1.0 g/m<sup>2</sup> in the field experiment. The number of bed bugs decreased mortality in the laboratory. Bed bug activation by CO<sub>2</sub> was crucial for the eradication in the student dormitories. In fact, bed bugs were freed of bed bugs, whereas bed bugs were not freed of bed bug desiccant dust and CO<sub>2</sub> were freed of bed bugs, whereas bed bugs were not freed of bed bug desiccant dust treatment. The different results in the laboratory and field experiments suggest that the application of desiccant dust in combination with release of CO<sub>2</sub> is a promising bed bug control."

**Agnew, J. L., and A. Romero. 2017.** Behavioral responses of bed bugs (*Cimex lectularius*) to CO<sub>2</sub> and heat. *Insects*. 8: 83. doi: 10.3390/insects8030083

"Bed bugs have reemerged recently as a serious and growing pest problem in the world. These insects have become the most challenging pest to control."

# Acknowledgments

- Ohio Pest Management Association (OPMA)
- Sarah Casey
- Olimpia Ferguson

# Acknowledgements (Surveys)



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- Extension IPM Program

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- OSU Statistical Consulting Service
  - Steven Naber
  - Jeni Squiric
  - Michael Matthews
  - Chengong Han

# Acknowledgements

## Participating Companies (Surveys):

- 1 Call Pest Contracting
- 4 Corners Pest Solutions
- 4Sure Pest Control
- \*A & A Pest Control Service
- A-ABEL Exterminating Co.
- Abell Pest Control
- ABES Pest Control, Inc.
- Absolute Extermination and Inspection, LLC
- Accel Pest Control OH, LLC
- \*Ace Exterminating Co.
- Acme Exterminating, Inc.
- Action Exterminating
- Action Now, Inc.
- Action Pest Control, Inc. & American Exterminating Co.
- Advanced Pest Control
- Aero Pest Control, LLC
- Affordable Exterminating
- \*Aid Pest Control, LLC
- Algo Termite and Pest Control
- All Ohio Pest Control Co.
- All Pest Exterminating, Inc.
- AllPest Pest Control and Solutions
- All State Termite & Pest
- All-Pro Wildlife Control
- Alright Pest Solutions LLC
- Alron Pest Control
- Ampulex Environmental Solutions, LLC
- Andy's Alliance Pest Control
- Antrim Pest Control
- \*Apollo Pest Control
- \*Arab Termite and Pest Control
- Arnold-Wilmar Pest Solutions
- Arrest-A-Pest of Northern Ohio
- Avalon Pest Control
- Ayers Pest Mgt., LLC
- Bay Pest Control
- BCG, LLC
- Beastmaster Pest Services
- Bed Bug Burners, LLC
- Bob Seljan
- Boggs Pest Control, Inc.
- \*Bona Fide Commercial Services
- Brookside Lawn Service, Inc.
- Bryan Hartley
- Buckeye Bug Blasters, LLC
- \*Buckeye Exterminating, Inc.
- Budget Pest Control
- Buentello Pest Control
- Bug Off Pest Control
- Bug Zappers

\*Participated in both 2011 and 2016 surveys.  
Many participants elected to remain anonymous.

# Acknowledgements

## Participating Companies (Surveys):

- \*Capital City Exterminating Co.
- Cavalry Pest Control
- CCI Wireless
- Central Exterminating Co., Inc.
- Central Ohio Exterminating
- Certified Extermination Solution
- Christensen's Urban Insect Solutions, Inc.
- Classic Care
- \*Cleveland Chemical Pest Control, Inc.
- Clippinger Pest Control
- \*Columbus Pest Control, Inc.
- Complete Termite & Pest Control
- Contact Pest Control, LLC
- Couch's Termite & Pest Control
- Crankerup Pest Control
- Critter Control of Cincinnati
- Critter Control of Lexington
- Cuyahoga Metro. Housing Authority
- D/J Bug Away, LLC
- Dan's Pest Patrol
- David Hersh
- Dayton's Bed Bug Dog, LLC
- Dependable Pest Control
- Dick's All Be Gone Pest Control Ltd.
- Discreet Bed Bug Removal
- \*Discreet Pest Control
- Eco-Care Pest Control
- Economy Pest Control
- Ecopro Pest Solutions
- Elite Pest Management, LLC
- \*Epcon Lane
- Extermital Termite & Pest Control, Inc.
- Faith Enterprise Environmental Services
- First Choice Pest Control
- First Choice Pest Management Co.
- Flag City Pest Control, Inc.
- Frame's Pest Control, Inc.
- Friend's Termite & Pest Control
- Frobase Horticultural Services
- Gary Benson Pest Control
- Gary L. Bauer
- Geauga Metro. Housing Authority
- Gotcha! Pest Control Specialists, Inc.
- Grass Master, Inc.
- Great Lakes Pest Management Services

\*Participated in both 2011 and 2016 surveys.  
Many participants elected to remain anonymous.



# Acknowledgements

## Participating Companies (Surveys):

- Hartley's Termite & Pest Control, LLC
- Hawx Pest Control
- Hixco Integrated Pest Management
- Holmes Pest Control, Inc.
- Homewood Pest Control, LLC
- \*Hooper Termite & Pest Control
- House Physicians of Ohio
- Imperial Pest Control, LLC
- Innovative Pest Management, Inc.
- InspectOhio
- \*Integrity Pest Solutions, LLC
- JB Vegetation & Insect Control, LLC
- John Henry's Pest Control
- Joy Exterminating Co., LLC
- Keith's Perfect Fit, LLC
- Kline Pest Control Co., Inc.
- L&S Termite and Pest Control, Inc.
- Ladybug Services, LLC
- Lakewood Exterminating
- Lawnco, Inc.
- Licking Metro. Housing Authority
- Liechty & Sons Exterminating
- LongPro Pest Control
- Lucky Lee's Pest Control
- Lu-Crest Pest Control
- Lutes Flying Service, Inc.
- Mauger Exterminating Co.
- \*Meredith Pest Control
- Merlin's Pest Control
- Miami University
- Miami Valley Pest Control Service
- \*Michael's Pest Control
- Midwest Termite & Pest Control
- Moore Pest Management Co.
- Mulholland Pest Control, Inc.
- \*Ohio Exterminating Co., Inc.
- Ohio Valley Pest Control
- \*Orkin, LLC (mult. branches)
- Paragon Pest Elimination
- Patrick's Pest Control
- Pawnee Pest Management
- PCS Lawncare
- Pepzee Realty
- \*Permakil Pest Control, Inc.
- Pesco Pest Control, LLC
- Pest Pro Pest Solutions, Inc.
- \*Pest-All Exterminating
- Phelps Termite & Pest Control
- Pike Professional Pest Control
- \*Precision Pest Management
- Premier Pest Control, LLC

\*Participated in both 2011 and 2016 surveys.  
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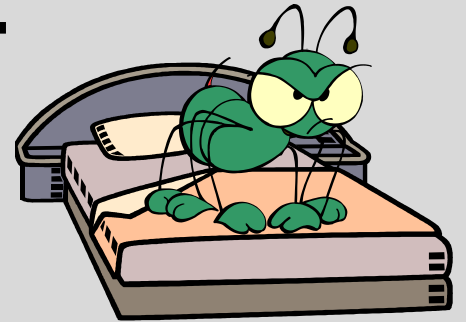
- Prevent Pest Control
- \*Pro Kill, Inc.
- Prokill Exterminating
- Redwine Pest Control
- Reliance Home Inspections
- Responsible Services
- Rid-X Pest Control, Inc.
- \*Rose Pest Solutions
- RxProtect
- S.A.B. Landscaping, Inc.
- Scherzinger Termite & Pest Control Management, LLC
- Scioto County Career Tech
- Seckman Pest Control
- Sideline Property
- \*Skyhigh Termite & Pest Control, LLC
- Snowball Pest Control
- \*Speed Exterminating Co., Inc.
- SPS Pest Control, Inc.
- State Termite & Pest Solutions
- Stewart Pest Control Co.
- Stauffs Corp. DBA: Aid Pest Control
- Sure Thing Pest Control
- T&M Pest Control, Inc.
- Terminator Services
- Terminix (multiple branches)
- Termitco
- \*Terry the Bug Man
- The Bug Guy Tom
- The X-Terminator
- TNT Exterminating Co.
- Tom's Pest Control
- Tony Shultz
- Torco
- TriCity Termite
- Truly Nolen, Inc. (multiple branches)
- Ultra Pest Control
- Universal Pest Control
- Valley Termite & Pest Control, LLC
- Vandagriff Pest Control
- Varmant Guard
- Vaughn Pest Control, LLC
- Vegetation Solutions
- Vollman Pest Control
- Wells Thur-O Pest Control, Inc.
- William A Barns Trust
- Wright's Termite Pest Co.
- Yards Done Right
- Ziehler Lawn and Tree Care, LLC

\*Participated in both 2011 and 2016 surveys.  
Many participants elected to remain anonymous.

# Thank You!



Sleep tight,  
and don't let the ...  
... well, you know the rest



Questions?

