Why cockroaches? 1. Pathogens

Pathogens isolated from cockroaches:
- bubonic plague (Pasteurella pestis)
- dysentery (Shigella alkiakensis)
- diarrhea (Shigella paradysenteriae)
- urinary tract infection (P. aeruginosa)
- abscesses (Staphylococcus aureus)
- food poisonings (Clostridium perfringens, Escherichia coli, Streptococcus faecalis, P. aeruginosa)
- gastroenteritis (Salmonella schottmuelleri, S. breedeney, S. oranienburg)
- typhoid fever (Salmonella typhi)
- leprosy (Mycobacterium leprae)
- anthrax (Bacillus anthracis)
- black leg (Glostridium chauvoei)
- tetanus (Glostridium tetani)
- tuberculosis (Mycobacterium spp.)


Why cockroaches? 2. Allergens

37% of Inner-City Children with Asthma are Sensitized to Cockroach Allergens!

**Why cockroaches? 2. Allergens**

More cockroaches = More allergen

![Graph showing cockroach concentration vs. allergen concentration](Wang et al. 2008. J Community Health 33: 31–39)

**Why cockroaches? Recap**

- Carry and vector pathogenic microbes, including antibiotic resistant microbes;
- Produce potent allergens that trigger asthma, especially in sensitized inner-city children;
- Contaminate foods, damage electrical circuits.
- Therefore, Need Pest Control Interventions;
- Large amounts of insecticides are used (and often mis-used) to control cockroaches.
- Solution: Integrated Pest Management – IPM

**Pest Control Options: Integrated Pest Management**

Achieving long-term, environmentally sound pest suppression through the use of a wide variety of technological and management practices, while reducing the hazards of pests and pesticide exposure

- Pest elimination
- Biological, genetic control
- Physical/mechanical control
- Cultural/sanitation practices
- Prevention: Limiting Resources

But... many obstacles: eg, expense, education, DIY products...

**Challenges with implementing IPM**

- Perceived as more expensive?
- More labor intensive?
- Requires better sanitation to eliminate food sources that compete with baits
- Requires more training and education, cooperation
- Insecticide Resistance to sprays and baits
  - Contracts that call for monthly/quarterly sprays!
  - Competing DIY products? TRFs and sprays!

**Total Release Foggers (TRFs)**

- "bug bombs" or "bombs", foggers, and total release aerosols
- pyrethroids & synergists (microsomal inhibitors; eg PBO)
- Inert ingredients include aerosol propellants — often flammable

![Total Release Foggers](TRFs.png)

**Total Release Foggers**

- 466 TRF-related events; NYC: 4 – 8 explosions/yr
- "TRFs pose a risk for acute, usually temporary health effects among users and bystanders."
- "TRFs can reduce pest populations and often are used by consumers as a low cost alternative to professional pest control services."

![TRFs vs. Baits](Efficacy.png)

**Why TRFs fail?**

- Insecticide resistance

MUD, EPA
Total Release Foggers: Study design

- 5 apartment complexes
- 6 apartments per complex
- 1 TRF type per complex
- 1 bait treatment per complex (positive "gold standard" control)

3–6 months before TRFs: Collected cockroaches → lab

3–7 days before TRFs: allergens, traps (population size), pesticide residues

4–6 hrs later: ventilation, clean-up, pesticide residues

Over time: 3 months
Total Release Foggers: Efficacy - apartments

- Mean trap catch (roaches)
- Time after treatment (weeks)
- Raid Fumigator
- Raid Deep Reach
- Hot Shot 2
- Hot Shot 3
- Combat
- Maxforce
- Bait
- kitchen

Total Release Foggers: Efficacy - apartments

- Mean trap catch (roaches)
- Time after treatment (weeks)
- Raid Fumigator
- Raid Concentrated Fogger
- Hot Shot Fogger 2
- Hot Shot Fogger 3

Total Release Foggers: Efficacy - Sentinel cockroaches

- Lab strain LD50 = 45 ng
  - to kill 50% roaches = 45 ng

- Apartment LD50 = 10,000 ng
  - 10,000 ng
  - 10,000 ÷ 45 = > 200X
  - High resistance, few options

- Low resistance, many options

- No change in allergens
- Pesticide residues: Extensive, long lasting

- Apply a pyrethroid insecticide (cypermethrin) to lab (susceptible) roaches and to apartment-collected roaches

Total Release Foggers: Resistance?

- Lab: exposed
- Lab: concealed

- Initial
- Intermediate
- Final (Failure to control)

Comparative efficacy of total release foggers and baits in relation to insecticide resistance

<table>
<thead>
<tr>
<th>Total Release Foggers</th>
<th>Gel Baits</th>
</tr>
</thead>
<tbody>
<tr>
<td>No efficacy:</td>
<td>Highly efficacious</td>
</tr>
<tr>
<td>On sentinels:</td>
<td>Population reduction</td>
</tr>
<tr>
<td>On apartment roaches:</td>
<td>Long-term efficacy</td>
</tr>
<tr>
<td>High resistance, few options</td>
<td>Low resistance, many options</td>
</tr>
<tr>
<td>No change in allergens</td>
<td>Allergen reduction</td>
</tr>
<tr>
<td>Cost: $7 – 14 (but zero efficacy!)</td>
<td>$7 – 14 (for 6 months to 1 year)</td>
</tr>
<tr>
<td>Labor: Very high (preparation, pets, vacating the home for 4-6 hours, cleanup)</td>
<td>Low: 30 – 45 min</td>
</tr>
<tr>
<td>Pesticide residues: Extensive, long lasting</td>
<td>Minimal, mainly due to translocation by roaches</td>
</tr>
</tbody>
</table>
Pest Control Options

**Formulation**
- Baits, Granular
- Dusts
- Residual Sprays
- TRFs

**Active Ingredients**
- Fipronil
- Hydramethylnon
- Indoxacarb
- Chlothianidin, etc.

**Attractants**
- Food odors
- Glucose
- Fructose

**Feeding stimulants**
- Chemical
- Physical

**Why do baits work so well? Target all life stages**

- Baits >>> Residual >>>>> TRFs
- Difficult in clutter
- Long lasting residual
- Broad spectrum
- Extensive coverage: >AI
- Resistance!
- Easy to use
- Long lasting residual
- Specific target sites
- Point sources: <AI
- More AI; <Resistance
- Secondary kill
- Add-ons: attractants

**IPM and allergen abatement in homes**

- Cockroach-infested apartments in Raleigh, NC
- Trap 50–1000 roaches (highly infested)

- Cockroach control: Baits
  - no change in untreated control homes
  - >97% reduction in treated homes
  - elimination in some

- Professional cleaning

- Education

- Monitor roaches
- Monitor
- Allergen sampling

- Baits highly efficacious: Cockroaches

- Thousands of cockroaches; Allergens that trigger asthma
- Food contamination; Large amounts of DIY insecticides
Baits are highly efficacious: Allergens

Allergen reduction
- no change in untreated control homes
- >96% Blag 1 reduction in treated homes
- several homes below clinical thresholds

IPM in homes: Outcomes due to?

Outcomes due to...
1. Pest control (Baits)?
   • whole-home, follow-ups, traps
2. Professional cleaning?
   • new vacuum (with HEPA filter)
3. Resident education?

Challenges with Baits & IPM Drivers

- More expensive? No!
- More labor? Not given the long-term activity
- Slow acting? Actually, a good thing (secondary kill)
- Alternative foods, sanitation? Probably an issue
- Competing products? TRFs and sprays!
- Misapplication, low application?
- Resistance emerging to insecticides in baits

Allergens in cockroach feces

Bla g 1 = a potent aero-allergen
1 female = ~1500 Units Bla g 1/ day

Morbidity (illness) threshold per gram dust = 8 Units

Baits are highly efficacious - not rocket science!

- Baits can eliminate large infestations
- Reduce allergens that trigger asthma

Resistance

- Physiological – Insecticide
  Selection for:
  - Metabolic breakdown, excretion, sequestration
  - Target site insensitivity
  - Reduced penetration

- Behavioral – Insecticide or inert ingredients
  Selection for:
  - Movement away from treated surface
  - Non-consumption of insecticide or inert ingredients
Example of resistance to AI: PR712

San Juan, Puerto Rico

B. germanica not controlled by baits:
- Indoxacarb
- Fipronil
- Hydramethylnon

Resistance to commercial bait AI’s

<table>
<thead>
<tr>
<th>Strain</th>
<th>Insecticide</th>
<th>RR50</th>
<th>RR90</th>
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<tr>
<td>Orlando Normal</td>
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Topical application

Resistance to commercial bait AI’s

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<td>PR-712 Hydramethylnon selected</td>
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</tr>
</tbody>
</table>

Topical application

Summary - Insecticide resistance

- Poor performance of commercial baits in some field locations
- High levels of resistance found to indoxacarb, fipronil and recently even to hydramethylnon
- Resistance increases with selection pressure
- High mortality in primary-kill lab assays
- Baits are not “immune” to resistance!

Emergence of glucose-averse behavior

Extremely strong selection pressure for the evolution of insecticide resistance:
- Physiological: hundreds of insects
- Behavioral: rare, poorly understood

Tasty sugars (glucose, fructose)

Insecticide

Extremely strong selection pressure for the evolution of insecticide resistance:
- Physiological: hundreds of insects
- Behavioral: rare, poorly understood
**Emergence of glucose-averse behavior**

Glucose Aversion in the German Cockroach, Blattella germanica

- Reject a bait ingredient — glucose
- No resistance to the insecticide
- Genetically-based: maintained in the lab for >20 yrs
- Highly adaptive under toxic bait pressure
- Omnivore: Significant fitness costs when baits are not present

**Glucose-aversion and fitness**

Under strong selection with glucose-containing toxic baits, glucose-aversion is highly adaptive.

**“Arms Race” between us and cockroaches**

- Monitor efficacy of various baits:
- Rapid taste test (Coke challenge)
- Use multiple bait formulations
- Rotate among bait products
- Eradicate infestations!
Tips for Successful Cockroach Control

– Avoid resistance
– Use a variety of baits (active ingredients, formulations)
– Incorporate IGR’s & boric acid products
– Integrate new chemistries (chlorfenapyr, indoxacarb, acetamiprid)
– Rotate through different baits every 3 – 4 months
– Good sanitation is critical
– Follow up with inspections & monitoring
– If the problem persists don’t keep doing the same thing: It Isn’t Working!