Overview of Pesticide Resistance

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Working with our community to ensure a safe and healthy environment.
Why We Are Concerned
Culex tarsalis

- Western encephalitis mosquito
- Feed on birds and mammals
- Vector of several encephalitic viruses
- Night feeder
- Can disperse up to 17 miles from breeding sites
Culex quinquefasciatus
Culex quinquefasciatus

- Southern house mosquito
- Polluted water; residential and commercial sources
- Feeds on birds and humans
- Night feeder
- Flies less than a mile
- Vector of dog heartworm and several encephalitic viruses
Flooded School Play Field
MARICOPA COUNTY VECTOR CONTROL

MOSQUITO SURVEILLANCE TRAP

BUCKET DOES NOT HOLD WATER

MARICOPA COUNTY

ARIZONA

WEST NILE VIRUS PROGRAM

602-506-0700

MCES
Vector Control
Do not Touch
(602) 506-0700
Spray a population
Survivor with “something special”
Offspring of the survivor
Spray again – more survivors
Spray again – more survivors
Spray again – more survivors
At what point do you have a resistant population?
Insecticide Resistance is a genetic change in response to selection by toxicants that may impair control in the field. (Sawicki, 1987)
Definition #2

- Insecticide Resistance Action Committee (IRAC)
  - Is a **heritable change** in the sensitivity of a pest population that is reflected in the repeated failure of a product to achieve the expected level of control when used according to the label recommendation for that pest species.
How to Develop Insecticide Resistance in Vectors

- Single class of insecticide
- Long–residual action
- Slow–release formulation
- Apply to all life states, all generations
- Treat all habitat where pest occurs
Mechanisms of Resistance

- Behavioral
- Reduced Penetration
- Metabolic
- Altered Target Site

So which mechanism gets selected?
Behavioral Resistance

- Example: some *Anopheles* mosquitoes developed a preference for resting outside that prevented them from coming in contact with pesticide sprayed on interior walls.
The number of biochemical receptors for the chemicals may be reduced in the pest, or the receptor may be altered, reducing the pest's sensitivity to the compound.
Metabolic Changes

- Frequently a pest becomes resistant to a pesticide because it develops physiological changes that protect it from the chemical.
- In some cases, a pest may gain an increased number of copies of a gene, allowing it to produce more of a protective enzyme that breaks down the pesticide into less toxic chemicals.
  - Such enzymes include esterases, glutathione transferases, and mixed microsomal oxidases
Other mechanisms include:

- Increased rates of excretion of toxic molecules
- Their sequestration and storage inside of the insect body away from vulnerable tissues and organs
- Decreased toxin penetration through the insect body wall
Cross Resistance

- Occurs when the genetic mutation that made the pest resistant to one pesticide also makes it resistant to other pesticides, especially ones with similar mechanisms of action.
Multiple Resistance

- Is the phenomenon in which a pest is resistant to more than one class of pesticides. This can happen if one pesticide is used until pests display a resistance and then another is used until they are resistant to that one, and so on.
Strategies for Detecting Resistance

- WHO Larval Test
- WHO Adult Test
- Bottle Bioassay – adults
- Topical Applications – adults
  - Wind Tunnel, Microliter syringes etc.
- Biochemical Assays – both
- Molecular Tools – both
- Field Tests – both
Results of 2010 Study

- Caged field trials using *Culex quinquefasciatus* and *Cx. tarsalis* were conducted to evaluate efficacy of a permethrin based product. Overall mortality in the field trials was less than 40% on *Cx. tarsalis* at .0035 lb/acre and less than 50% at .007 lb/acre. Mortality at the high label rate was higher for *Cx. quinquefasciatus*, overall 76%.
Results of 2010 Study

- Subsequent testing of mosquitoes in the lab for resistance using a variety of methods demonstrated resistance in the population to permethrin, resmethrin, sumethrin and malathion with both altered target site and metabolic resistance as the underlying mechanisms.
Phenotypic expression of resistance mechanisms for *Cx. quinquefasciatus* from Maricopa Co AZ 2010 using bottle bioassays
Resistance Management Issues

- What is it?
- When will it arrive?
- Once it’s here is that it for using for the chemical?
- How do I know I have it?
- What do I do?
- What roles do outside forces play in selection for resistance?
- Where do I go for help?
Surveillance for Resistance

Detection

Action

Evaluation
What do I do if I find it?

ASK MORE QUESTIONS

- What class is the insecticide?
- Are other members of this class also less effective?
- What mechanism is the likely cause?
- What do I know of the spray history of my population?
- What level of control can I live with?
What Are My Alternatives?

- Change dose of chemical.
- Change chemicals within same class.
- Change chemical to a different class.
- Use a rotation or mosaic of chemical treatments.
- Reduce number of treatments by accepting higher action thresholds.
- Target a different life stage better.

Decisions should be based on surveillance data.
Mosquitocides Available for MADs in the US

- **Adulticides:**
  - **Organophosphates**
    - Naled
    - Malathion
    - Chlorpyrifos
  - **Pyrethroids**
    - Permethrin
    - Pyrethrum
    - d-phenothrin (Sumethrin)
    - Resmethrin
    - Etofenprox
- **Larvacides:**
  - **Biologicals**
    - *Bacillus thuringiensis israelensis* (B.t.i.)
    - *Bacillus sphaericus*
  - **Insect Growth Regulators**
    - Methoprene
  - **Oils**
  - **Monomolecular films**
  - **Organophosphate**
    - Temephos
  - **Nicotinic acetylcholine receptor**
    - Spinosad
Special uses not commonly employed by MADs

- **Barrier Treatments**
  - Pyrethroids
    - Permethrin
    - Deltamethrin
    - Beta-cyfluthrin
    - Bifenthrin
    - Lambda-cyhalothrin
    - Tau-fluvalinate

- **Misting Systems**
  - Pyrethrins
  - Pyrethroids
    - Permethrin
  - Oils
  - Rosemary/Cinnamon/lemongrass
New Products

- **Targeting Larvae**
  - Natralur™ – Spinosad = mix of spinosyn A & D
    - Nicotinic acetylcholine receptor (nAChR) allosteric modulators

- **Targeting Adults**
  - Zenivex™ – Etofenprox = pyrethroid ether
    - Sodium channel modulator with no ester linkage
On the Horizon?

- Lethal Ovitraps with pyriproxyfen = pyridine
  - Juvenile hormone analog
- Lethal Ovitraps with Bifenthrin = pyrethroid
  - Sodium channel modulator