Center for
VECTOR BIOLOGY
RUTGERS

# Life after insecticide resistance is detected: a conversation

Dina Fonseca, PhD

Director, Center for Vector Biology

Professor, Entomology, Ecology & Evolution, Microbiology

# Insecticide Resistance (IR) can impact control

- In the larval stages, IR is initially associated with a reduction in the duration of treatment efficacy – Caribbean and Brazilian *Ae. aegypti (*Temephos = OP)
  - Susceptible – 8 weeks control
  - 5-fold resistance – 3 weeks control
  - 15-fold resistance - < 50% control after 1 week
- Caribbean – no evidence of reduction in either larval or adult *Ae. aegypti* densities was reported in nine localities after three rounds of ULV thermal fogging with deltamethrin (Marcombe et al 2009, 2011).
- Florida - failed ULV applications of pyrethroids to control Zika virus transmission – last resort use of an organophosphate (malathion)

Marcombe et al. 2009. Reduced efficacy of pyrethroid space sprays for dengue control in an area of Martinique with pyrethroid resistance. Am J Trop Med Hyg 80: 745-751.

Marcombe et al. 2011. Pyrethroid resistance reduces the efficacy of space sprays for dengue control on the island of Martinique (Caribbean). PLoS Negl Trop Dis 5: e1202

Rawlins SC.1998. Spatial distribution of insecticide resistance in Caribbean populations of *Aedes aegypti* and its significance. Rev Panam Salud Publica 4: 243-251.

Parker etal. 2020. Baseline Susceptibility Status of Florida Populations of *Aedes aegypti* (Diptera: Culicidae) *and Aedes albopictus*. J Med Entomol. 57(5):1550-1559

# Work from my lab

Sebastien Marcombe

- Marcombe et al 2014 – IR in *Aedes albopictus* eastern USA
  - Bioassays on field-collected specimens from NJ, PA, FL (11 insecticides)
  - characterized a susceptible strain of *Ae. albopictus* (strain ATM-NJ95).
  - Used biochemical and molecular assays to identify putative IR mechanisms
- Johnson & Fonseca 2016 – IR in residential and wetland *Culex pipiens*
  - first observations of the OP resistance alleles Ester$^{B1}$ (up to 23%) and Ester$^{2}$ (14%) and the classical knockdown resistance(kdr) mutation L1014F in New Jersey *Cx. pipiens* (5.1% heterogygotes, 1.4% homozygotes, indicating positive selection)
  - Detected double mutants at Ester and kdr

Brian Johnson

Marcombe S, Farajollahi A, Healy SP, Clark GG, Fonseca DM. 2014. Insecticide resistance status of United States populations of Aedes albopictus and mechanisms involved. PLoS One. 9(7):e101992.
Johnson BJ, Fonseca DM. 2016. Insecticide resistance alleles in wetland and residential populations of the West Nile virus vector Culex pipiens in New Jersey. Pest Manag Sci. 72(3):481-8.

**Rutgers Center for Vector Biology** (formerly known as "Mosquito Research and Control Program")

Research on vectors and pathogens - ecology, evolution, surveillance and control

Close association with NJ's 21 county mosquito control programs & residents

Regular multi-institutional collaboration with other professional organizations (DEP, DOH, Homeland Security, USDA, CDC)

State-of-the-art molecular laboratory; field and colony work (ACL2 insectaries; BSL2)

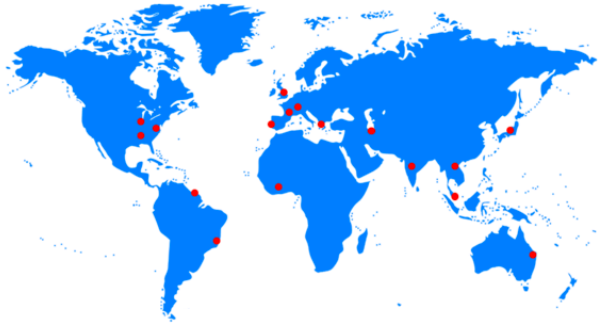
Federally and state funded projects

John B. Smith(1858-1912)

Thomas Headlee (1877-1946)

NJMCA
New Jersey Mosquito Control Association, Inc.
Est. 1913

# The Worldwide Insecticide resistance Network (WIN)




WORLDWIDE INSECTICIDE RESISTANCE NETWORK
WIN

The Worldwide Insecticide resistance Network

IRD Institut de Recherche pour le Développement FRANCE
cnrs
World Health Organization
TDR For research on diseases of poverty

# Pesticide Use and Resistance Monitoring in the NE US

(1) determine the current extent of pesticide use and resistance monitoring within the region;

(2) determine roadblocks preventing the expansion of regional pesticide resistance monitoring programs;

(3) assess how NEVBD can assist the public health community and expand pesticide resistance monitoring activities.

NEVBD

NORTHEAST REGIONAL CENTER FOR EXCELLENCE IN VECTOR-BORNE DISEASES

**2019 Pesticide Use and Resistance Monitoring in the Northeastern United States**

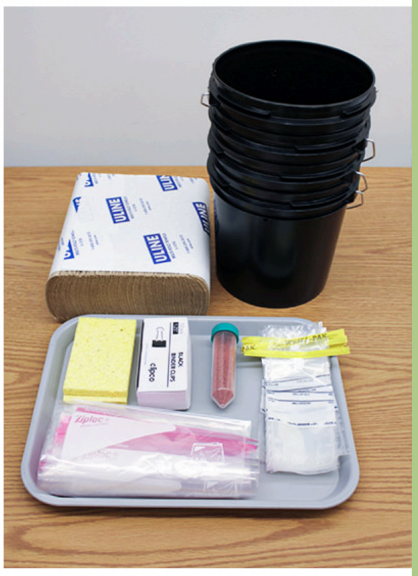
By: Joseph D. Poggi, James Burtis, PhD, Emily Mader, MPH MPP, Laura C. Harrington, PhD

# NEVBD PESTICIDE RESISTANCE MONITORING PROGRAM

The Northeast Regional Center for Excellence in Vector-Borne Diseases has established a pesticide resistance monitoring network covering the Northeastern region to support public health and mosquito control agencies in detecting pesticide resistance in mosquito populations.

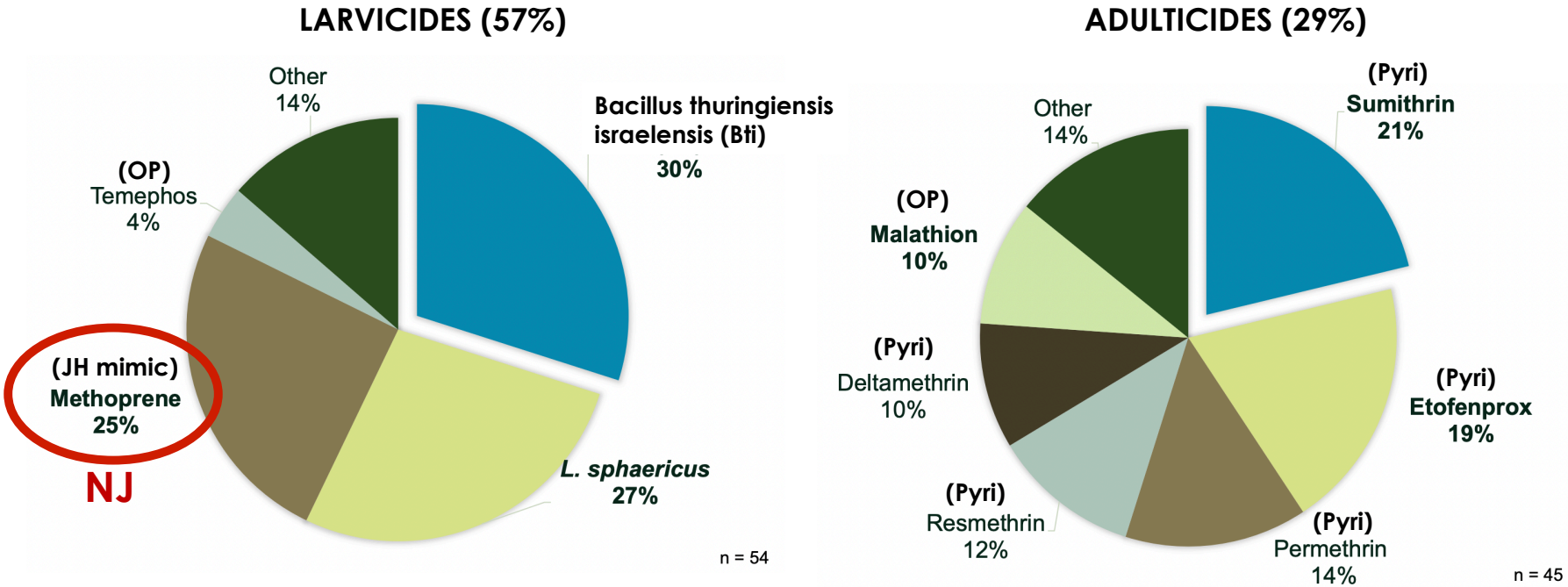
This program offers two primary services to our network: specimen submissions to Cornell for testing and specimen collection kits. Please scroll below to learn more about these services.

If you're interested in receiving periodic updates about the Pesticide Resistance Program please **sign up for mailing list here**.



## Specimen Submission to Cornell University for Testing:

# Primary insecticides used in the NE US (ME – VA)

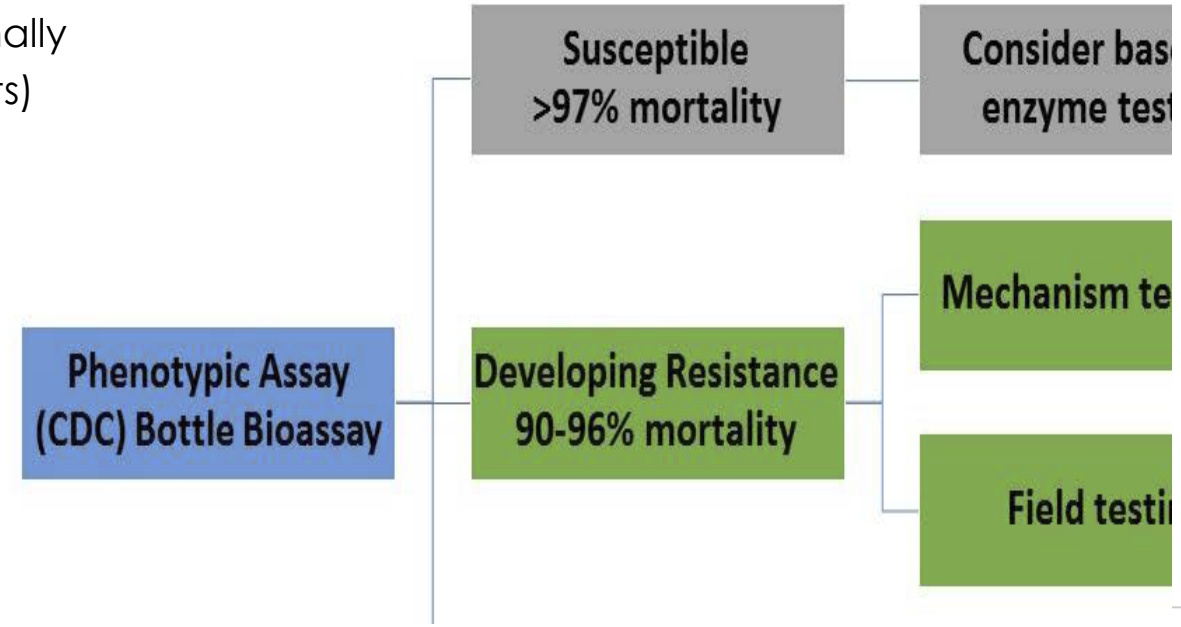



Burtis JC, Poggi JD, McMillan JR et al. 2021. NEVBD Pesticide Resistance Monitoring Network: Establishing a Centralized Network to Increase Regional Capacity for Pesticide Resistance Detection and Monitoring. J Med Entomol. 58(2):787-797

# Insecticide resistance was detected in your mosquitoes!! **Now what?**

https://www.cdc.gov/zika/pdfs/guidelines-for-aedes-surveillance-and-insecticide-resistance-testing.pdf

- Test for IR in an operationally relevant setting (field tests)
- Quantify
  - intensity
  - spatial extent
  - temporal extent



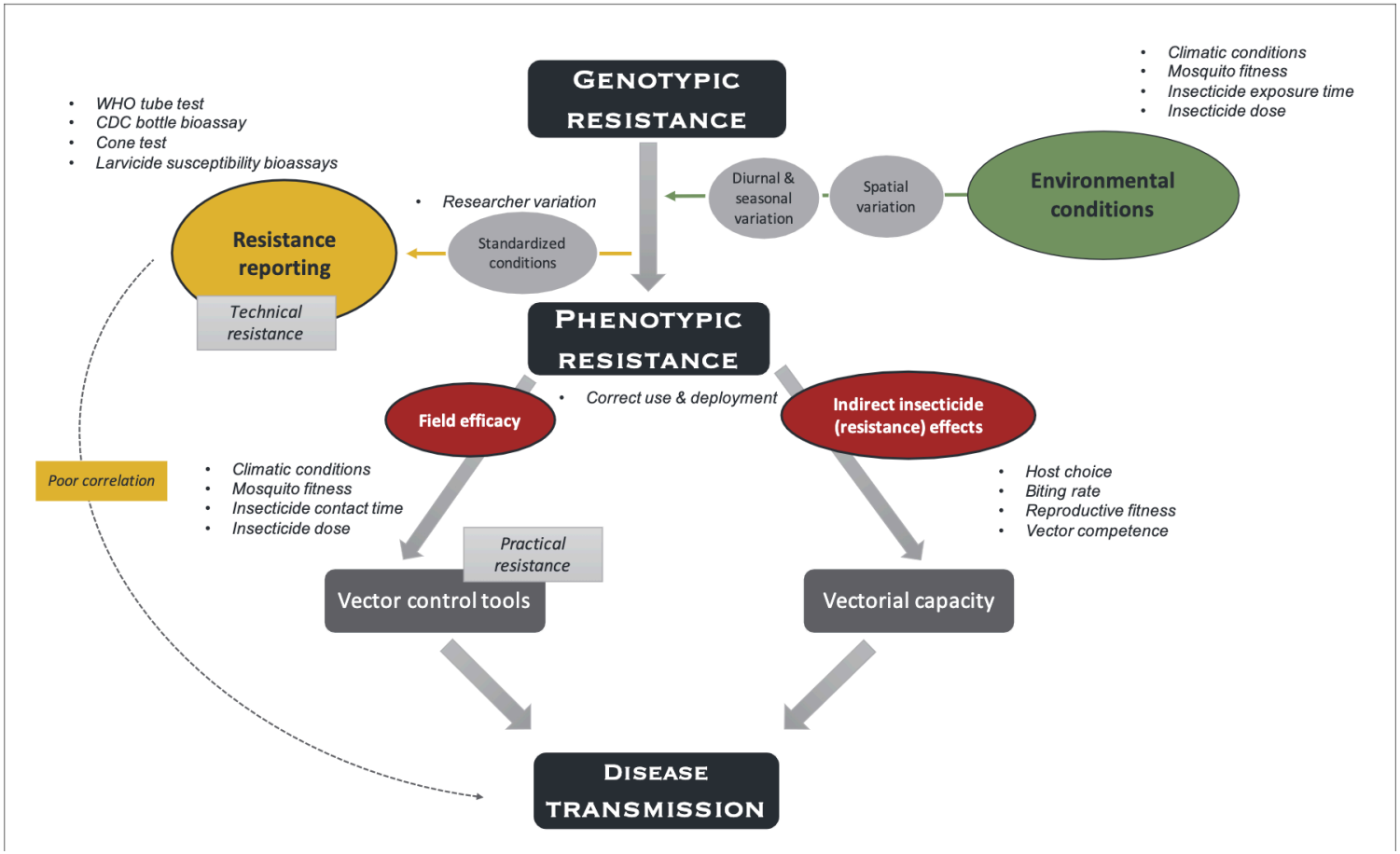

Hernandez JR, Longnecker M, Fredregill CL, Debboun M, Pietrantonio PV. 2021. Kdr genotyping of the Nav channel of *Aedes aegypti* (L.) mosquito populations in Harris County (Houston), Texas, USA, after Permanone 31-66 field tests and its influence on probability of survival. PLoS Negl Trop Dis.:e0009833.

# "REACTIVE ALTERNATION" – changing insecticides after control failure – is NOT IRM.

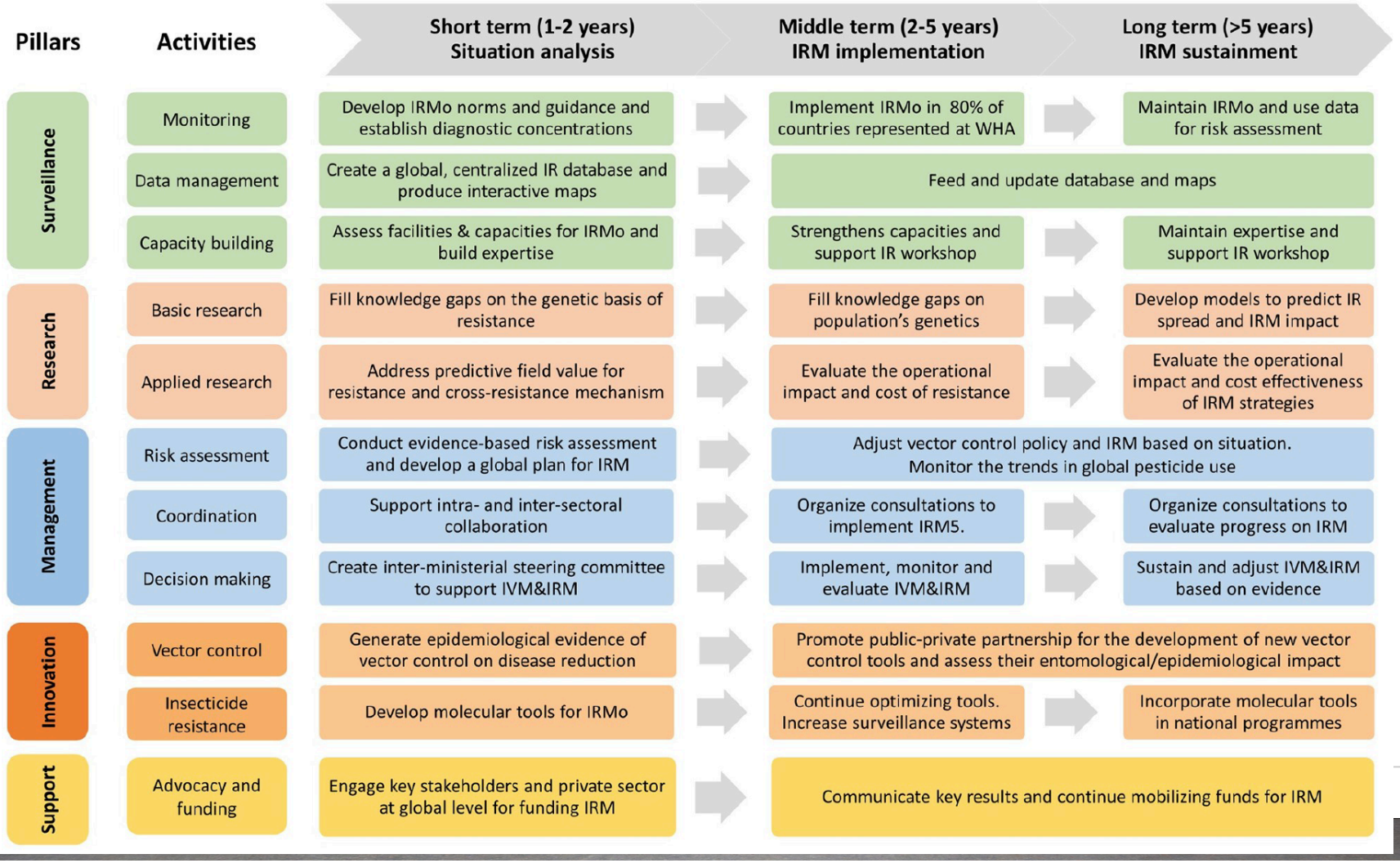
- High levels of resistance are hard to reverse
  - Loss of genetic variation
    - Homozygous resistant populations (e.g., Florida and California *Ae. aegyptii,* Cornel et al 2016, Parker-Crockett et al 2021))
  - Multiple resistance mechanisms (e.g., up-regulated esterases and *kdr* mutations, Johnson & Fonseca 2016)
  - Presence of additional selection from agriculture and household insecticide use
- Effect of IR on vector competence

Cornel *et al.* Surveillance, 2016. insecticide resistance and control of an invasive *Aedes aegypti* (Diptera: Culicidae) population in California F1000Research 5:194.

Parker-Crockett et al. 2021. Influence of Pyrethroid Resistance on Vector Competency for Zika Virus by Aedes aegypti (Diptera: Culicidae). J Med Entomol. 58(4):1908-1916




Namias A, Jobe NB, Paaijmans KP, Huijben S. 2021 The need for practical insecticide-resistance guidelines to effectively inform mosquito-borne disease control programs. Elife :e65655




Dusfour I, Vontas J, David J-P, Weetman, D, Fonseca DM, Corbel V, et al. 2019 Management of insecticide resistance in the major Aedes vectors of arboviruses: Advances and challenges. PLoS Negl Trop Dis 13(10): e0007615.

# Insecticide Resistance Management Strategies

- ROTATION - temporal alternation of insecticides with different modes of action
  - rotation frequency must provide insufficient time for IR.
    - depends on (1) residual efficacy of treatments and (2) generation time
- MOSAIC - spatial alternation of insecticides with different modes of action
  - best for strong fliers with ranges larger than mosaic
- MIXTURES - concurrent use of insecticides with different modes of action
  - no cross resistance between insecticides
  - same residual efficacy to maintain the ratio between active ingredients
  - resistance functionally recessive (i.e., only double-homozygous resistant can survive the mixture)

# What I would like

- A quantitative measure of IR impact on local control
- A better understanding of IR dynamics in "my" mosquito populations
  - Type and levels of IR
  - Spatial and temporal trends in IR
  - Drivers of IR
  - Measures of fitness costs of resistance
- Alternative tools for mosquito control
  - new actives
  - non-insecticidal approaches
    - that work in an emergency

# Contact information

Center for
VECTOR BIOLOGY
RUTGERS

Dina M. Fonseca, PhD
Professor, Entomology
Director CVB
Rutgers University
180 Jones Ave.
New Brunswick, NJ 08901
Email: dina.fonseca@rutgers.edu
http://fonseca-lab.com
http://vectorbio.rutgers.edu


*Aedes albopictus,*
Asian tiger mosquito, working

Thank you