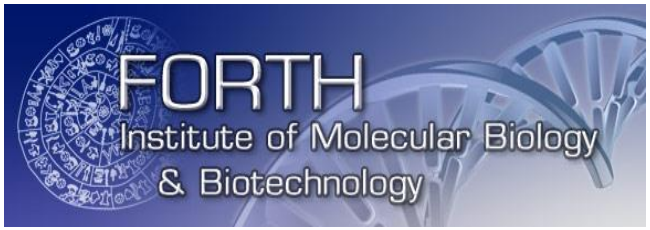
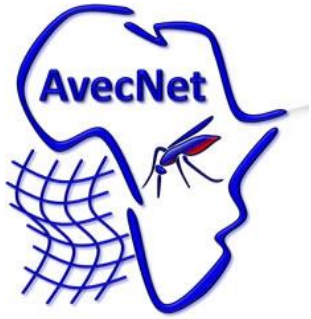
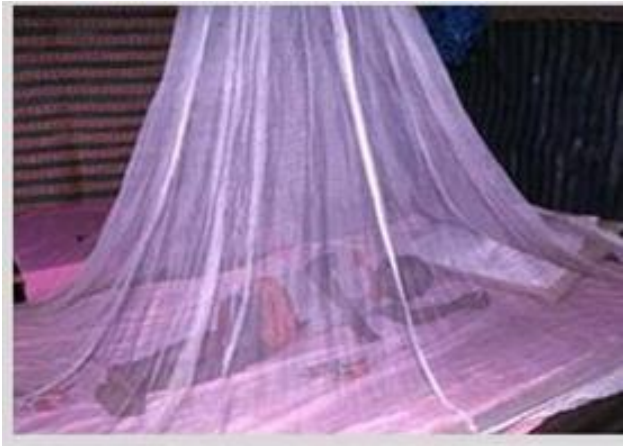
The problem of insecticide resistance in mosquitoes, and the role of modern technologies & novel vector control tools for its management

John Vontas



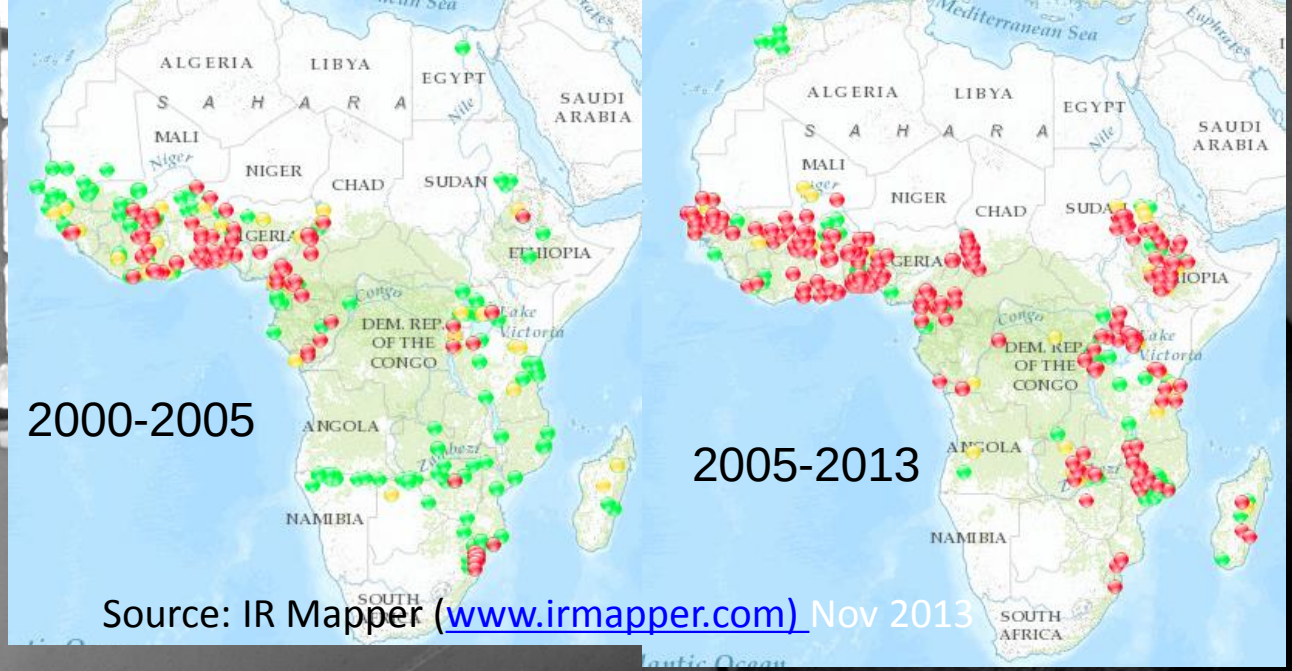


Insecticides: main tool to control insects and the diseases they transmit



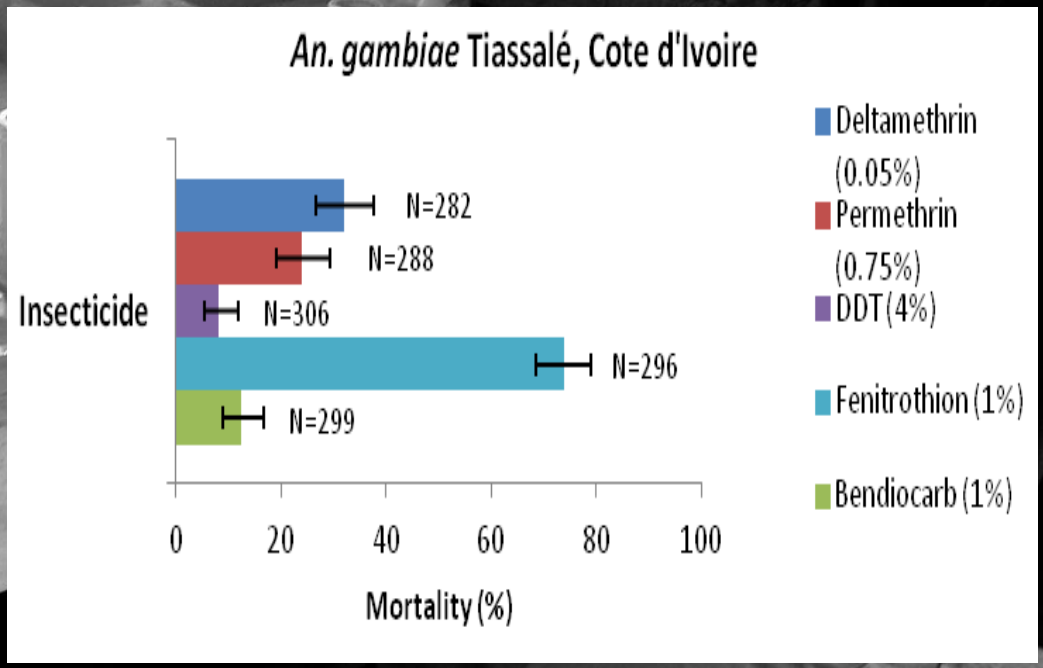
Pyrethroid resistance first detected in African malaria vectors in 1993

Slide: courtesy of Hilary Ranson



Source: IR Mapper (www.irmapper.com) Nov 2013

- **Strength of resistance >100-1000 x not uncommon**
- **In Burkina Faso resistance increased 10 x in single year**



C. Edi et al (2012) Emerging Infectious Diseases 18, 9

Why are those mosquitoes so resistant?

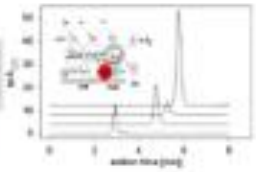
(relative contribution of resistance genes and mutations, alone or in combination?)

Selection pressures? (MC activities? agriculture?)

We don’t know ...

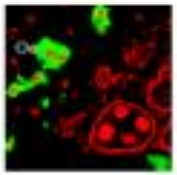
Genomics, may help to improve our understanding ..

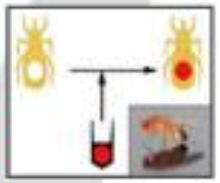
Identify & validate resistance loci



Phenotype resistance

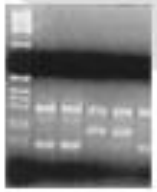
Immunolocalization & – *in vivo* analysis



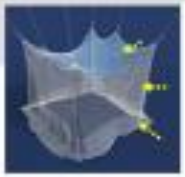


Disease and Pest Control

Diagnostics - informed decisions (IRM)



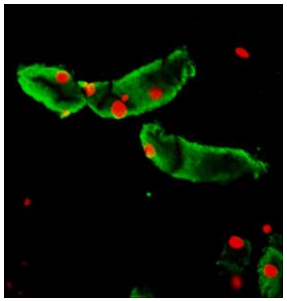
Novel products - Synergists



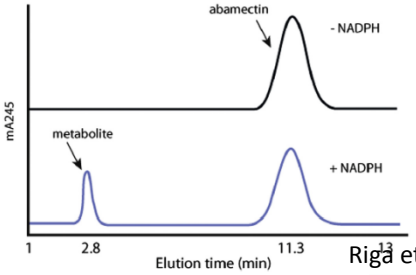
Analysis of insecticide resistance mechanisms

Βιοδοκιμές

Ανοσοϊστοχημεία

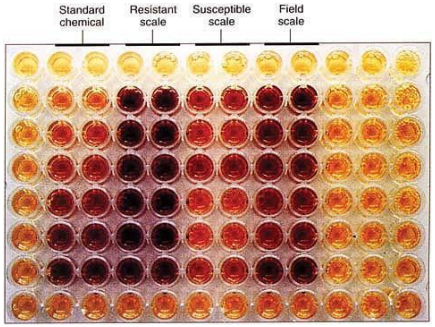


Έκφραση και χαρακτηρισμός ανασυνδιασμένων πρωτεϊνών

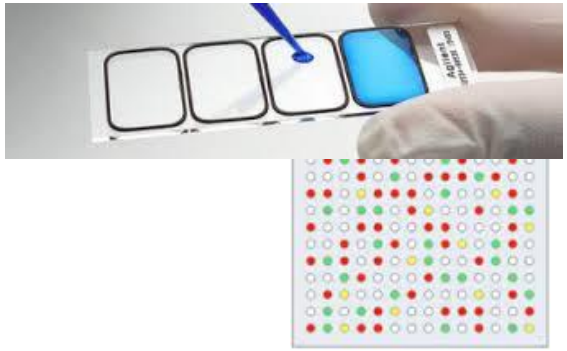


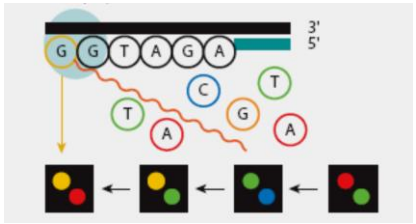
Rigá et al.,

Βιοχημικές αναλύσεις



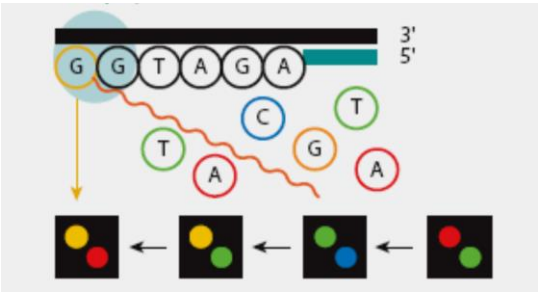
Αναλύσεις μεταγραφώματος



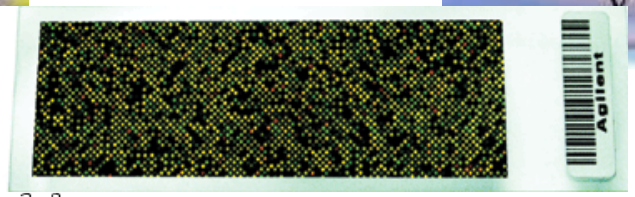


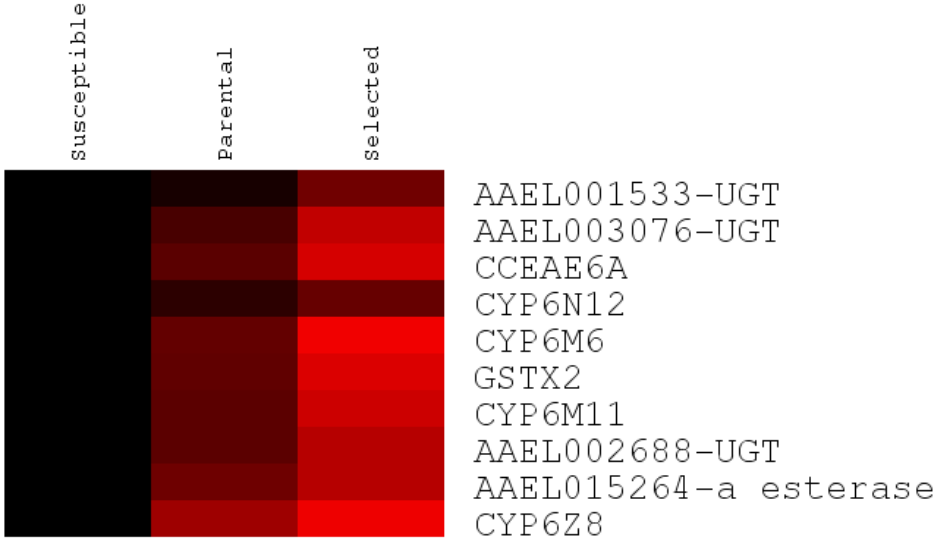
NGS – 454

Molecular analysis of insecticide resistance of Aedes albopictus



NGS – 454



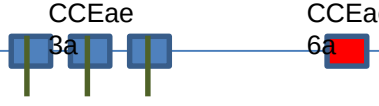


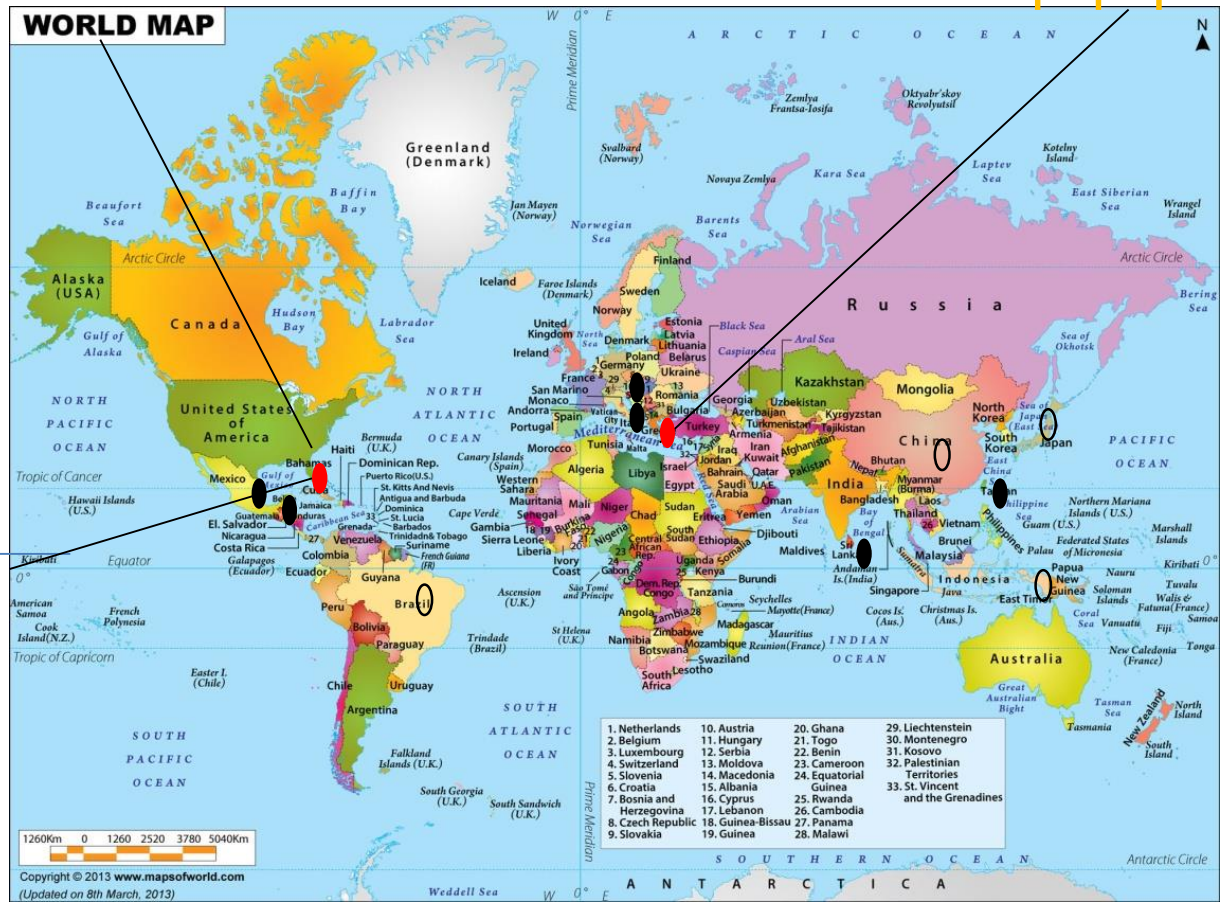
Gene	Parental	Selected
AAEL001533-UGT	4.435	53.81
AAEL003076-UGT	6.11	55.505
CCEAE6A	0	22.995
CYP6N12	0.155	21.195
CYP9J17	1.03	17.56
CYP6Z7	0.005	16.4

Molecular & functional characterization of resistance in *Ae. albopictus*
Grigoraki et al (2015a) PLoSNTD; Grigoraki et al (2015b) IBMB - submitted

Geographical distribution and origin of amplified esterase loci associated with temephos resistance

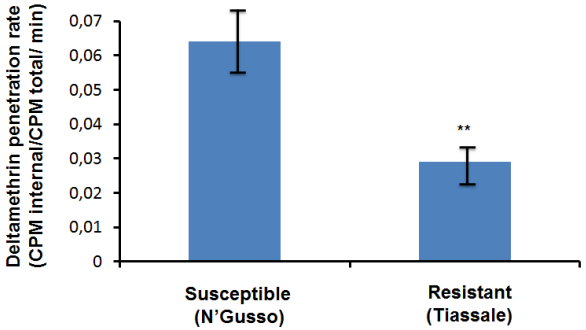
- Amplification found
- No Amplification found
- To be tested

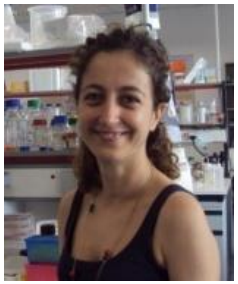


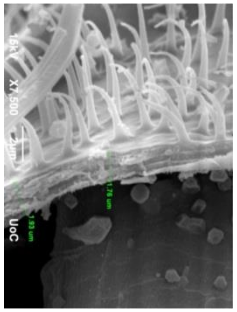


Ανάλυση πολύ υψηλών επιπέδων ανθεκτικότητας *Anopheles gambiae* από τη Δ. Αφρική στα πυρεθροειδή εντομοκτόνα

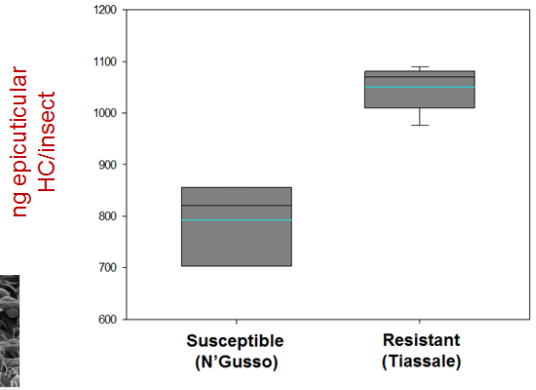
Substantially reduced insecticide uptake in resistance insects

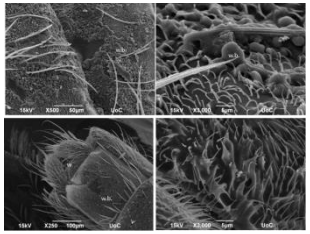




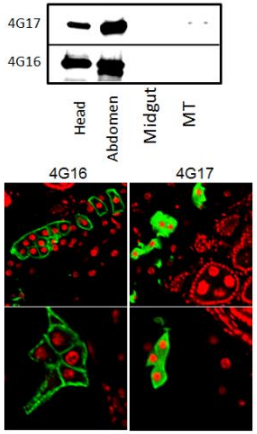


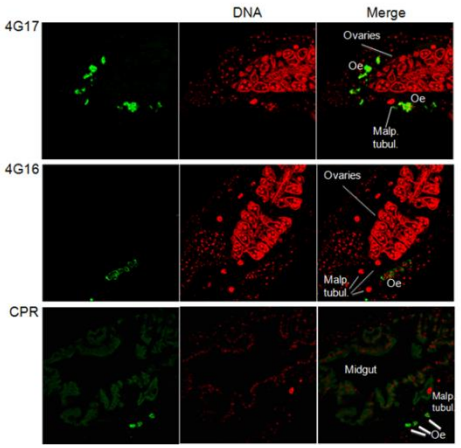
elevated epicuticular HCs





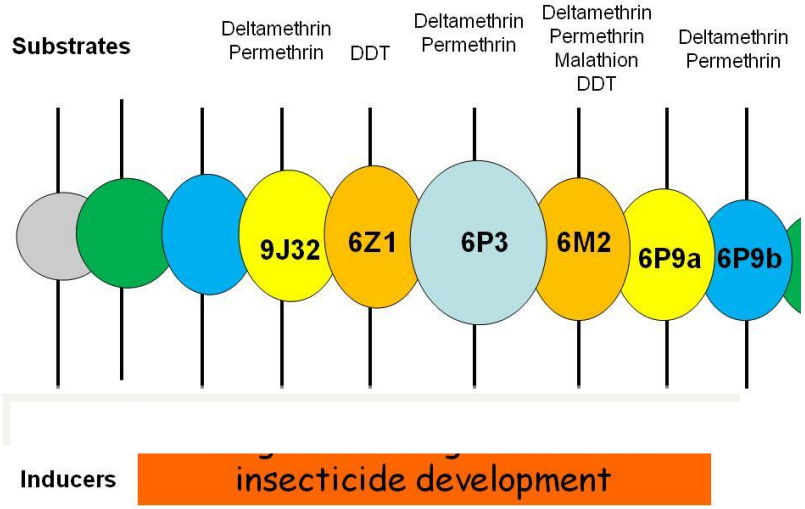
CYP4G16/17 are over-expressed on the oenocytes of R mosquitoes and have decarbonylases activity (HC)





✓Tools for early screen of novel insecticides

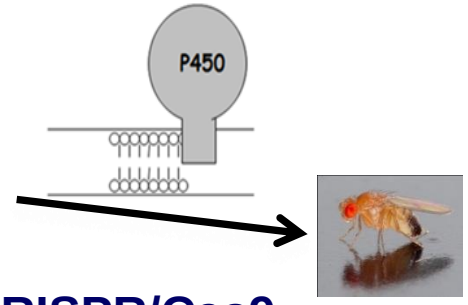
In vitro



Commercial Quantities

CYP6P3, 6P9a, 9J32
Cypex, Scotland

In vivo



CRISPR/Cas9

New paradigms in vector control

Spatial Repellents

Durable lining

Pyriproxifen to breeding sites

Combination nets

ATSB

"antimosquito cattles"

Environmental management

Fish – larvae control

Algae dsRNA

Laser Kill

GM mosquito

wolbachia

SIT

Ventilators

Ivermectins (human)

Novel traps- attract and kill

Plastic screens

Using adult mosquitoes to transfer insecticides to *Aedes aegypti* larval habitats

Gregor J. Devine[a,1], Elvira Zamora Perea[b], Gerry F. Killeen[c,d], Jeffrey D. Stancil[e,2], Suzanne J. Clark[a], and Amy C. Morrison[f]

[a]Department of Plant and Invertebrate Ecology, Rothamsted Research, Harpenden AL5 2JQ, United Kingdom; [b]Laboratorio de Salud Publica, Iquitos, Peru; [c]Ifakara Health Institute, Dar es Salaam, United Republic of Tanzania; [d]Vector Group, Liverpool School of Tropical Medicine, Liverpool L3 5QA, United Kingdom; [e]Naval Medical Research Center Detachment, United States Navy, Lima, Peru; and [f] Department of Entomology, University of California, Davis, CA 95616

Edited by Barry J. Beaty, Colorado State University, Fort Collins, CO, and approved April 14, 2009 (received for review February 7, 2009)

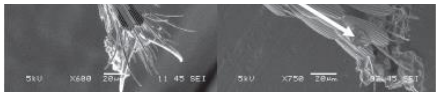
Vector control is a key means of combating mosquito-borne diseases and the only tool available for tackling the transmission of dengue, a disease for which no vaccine, prophylaxis, or therapeutant currently exists. The most effective mosquito control methods

contamination of
sentinel site
containing juvenile

Cell

A *Wolbachia* Symbiont in *Aedes aegypti* Limits Infection with Dengue, Chikungunya, and *Plasmodium*

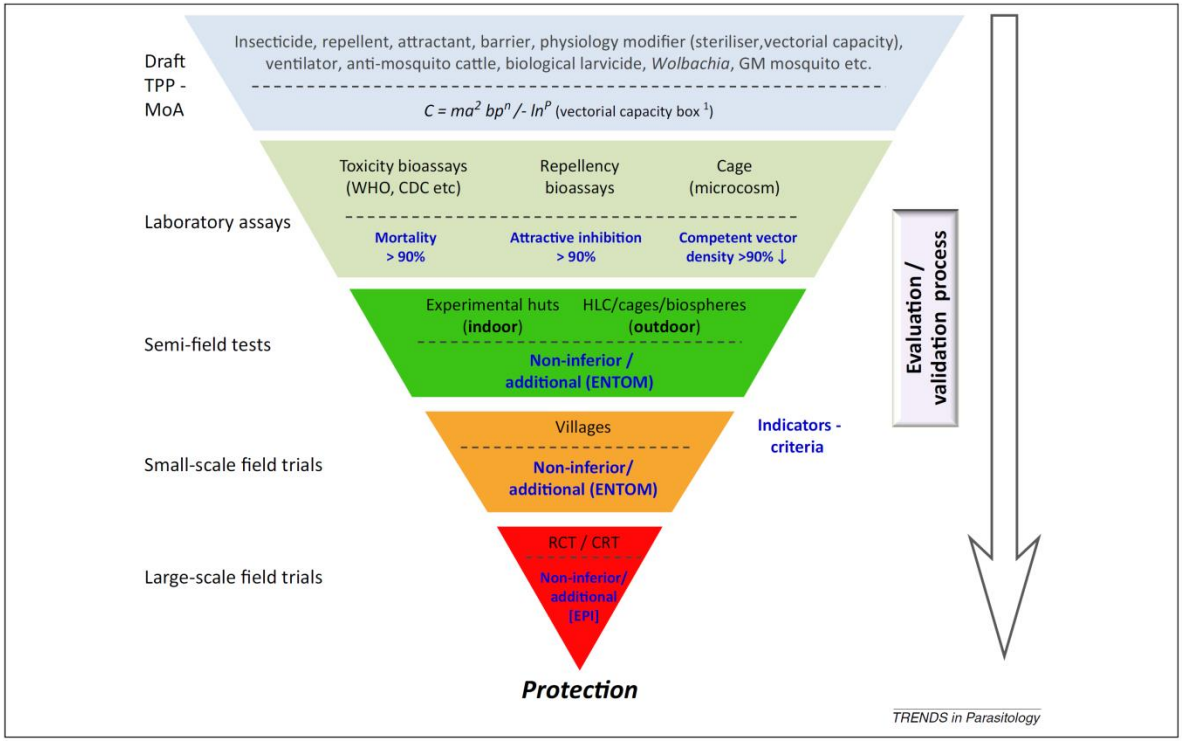
Luciano A. Moreira,[1,2] Iñaki Iturbe-Ormaetxe,[1] Jason A. Jeffery,[3] Guangjin Lu,[3] Alyssa T. Pyke,[4] Lauren M. Hedges,[1] Bruno C. Rocha,[2] Sonja Hall-Mendelin,[5] Andrew Day,[5] Markus Riegler,[1,6] Leon E. Hugo,[3] Karyn N. Johnson,[1] Brian H. Kay,[3] Elizabeth A. McGraw,[1] Andrew F. van den Hurk,[4,5] Peter A. Ryan,[3] and Scott L. O'Neill[1,*]



Framework for rapid assessment and adoption of new vector control tools

John Vontas[1,2*], Sarah Moore[3,4,5*], Immo Kleinschmidt[6], Hilary Ranson[7], Steve Lindsay[8], Christian Lengeler[4], Nicholas Hamon[1], Tom McLean[1], and Janet Hemingway[1,7]

Trends in Parasitology, 30, 2014

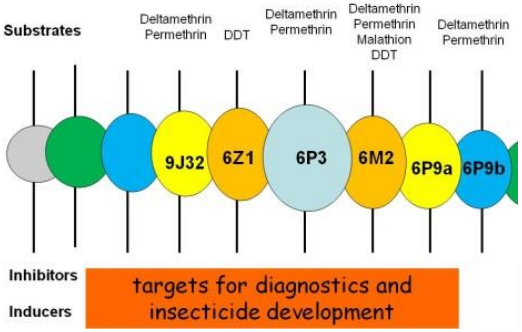


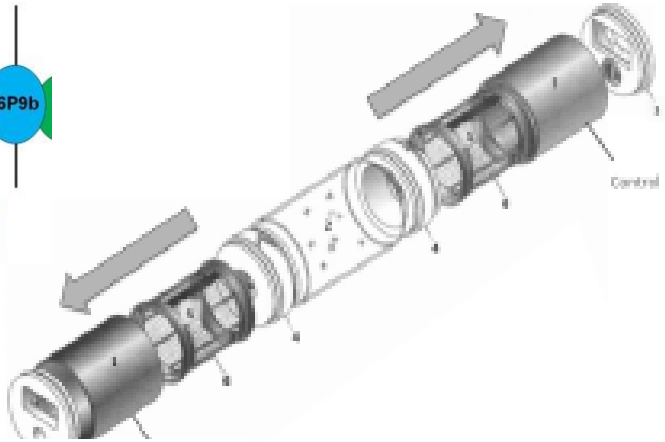
BILL & MELINDA GATES foundation

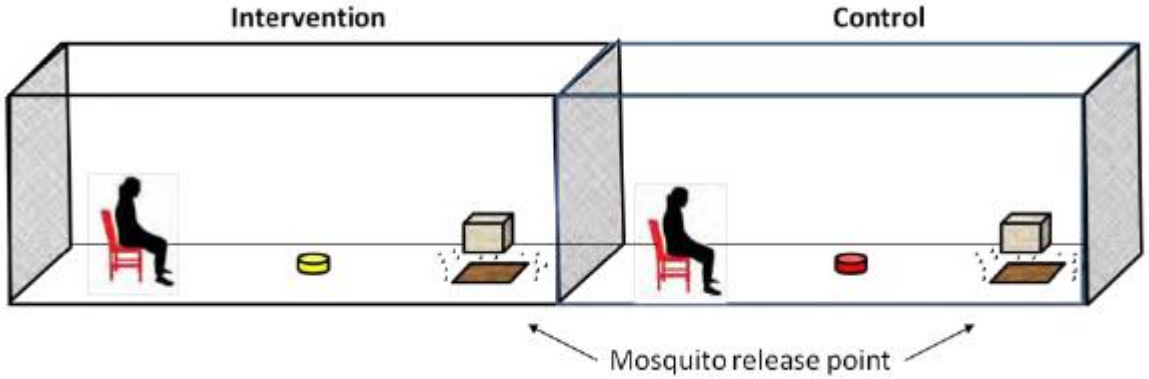
IVCC COMBATING INSECT BORNE DISEASE The Innovative Vector Control Consortium

ROLL BACK MALARIA PARTNERSHIP

VCWG-WHO


Substrates
Deltamethrin Permethrin
DDT
Deltamethrin Permethrin
Deltamethrin Permethrin Malathion DDT
Deltamethrin Permethrin
9J32
6Z1
6P3
6M2
6P9a
6P9b
Inhibitors
Inducers
targets for diagnostics and insecticide development

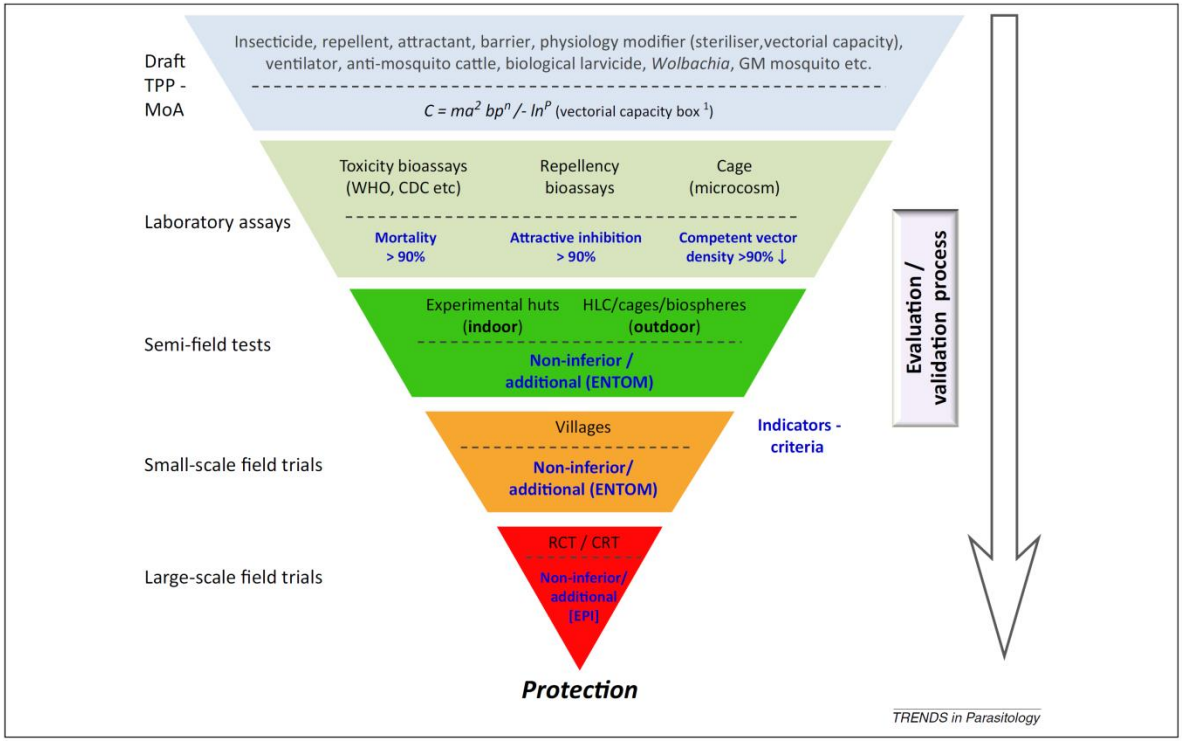

Control


Intervention
Control
Mosquito release point

Framework for rapid assessment and adoption of new vector control tools

John Vontas[1,2*], Sarah Moore[3,4,5*], Immo Kleinschmidt[6], Hilary Ranson[7], Steve Lindsay[8], Christian Lengeler[4], Nicholas Hamon[1], Tom McLean[1], and Janet Hemingway[1,7]

Trends in Parasitology, 30, 2014



BILL & MELINDA GATES foundation

IVCC COMBATING INSECT BORNE DISEASE The Innovative Vector Control Consortium

ROLL BACK MALARIA PARTNERSHIP

VCWG-WHO

BILL & MELINDA GATES foundation

IVCC

BMGF/IVCC
Insecticide Resistance Convening
London
Monday 7th – Wednesday 9th December 2015

THE LANCET

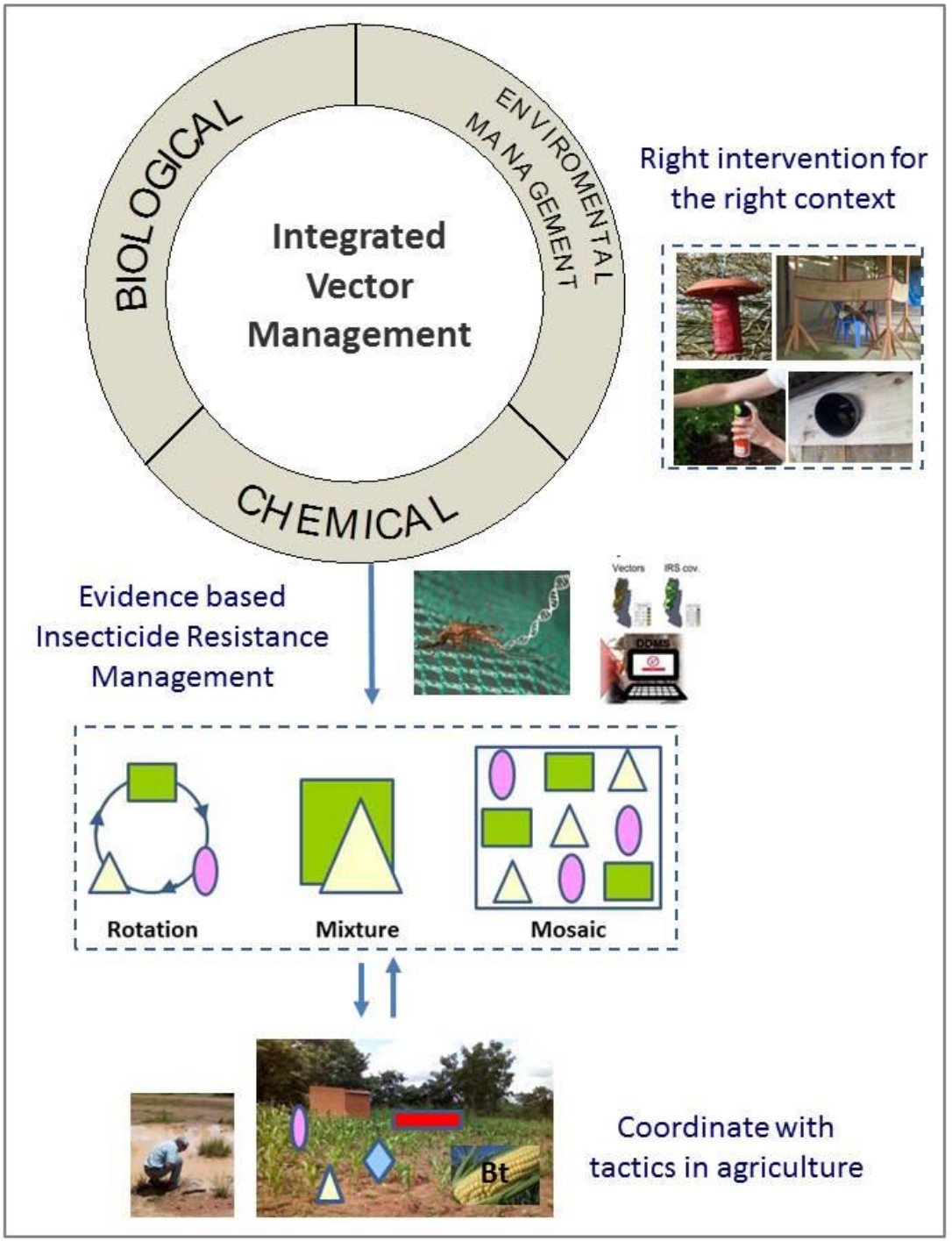
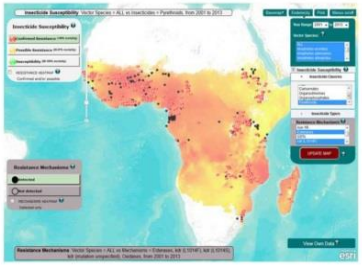


Figure 5. Introduction and management of novel VCTs in the context of IRM and IVM strategies

Implementation of VCTs in IVM and IRM frame

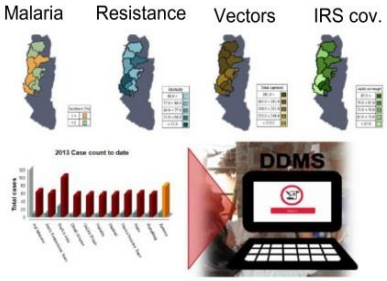
… means to systematically gather and organize IR and other entomological data, such as the DDMS and the IR Mapper, as well as the use of communication technologies, for exemplifying good practices can facilitate IRM…

IR Mapper



interactive website for reporting/visualising insecticide resistance in disease vectors.

DDMS: Disease Data Management System

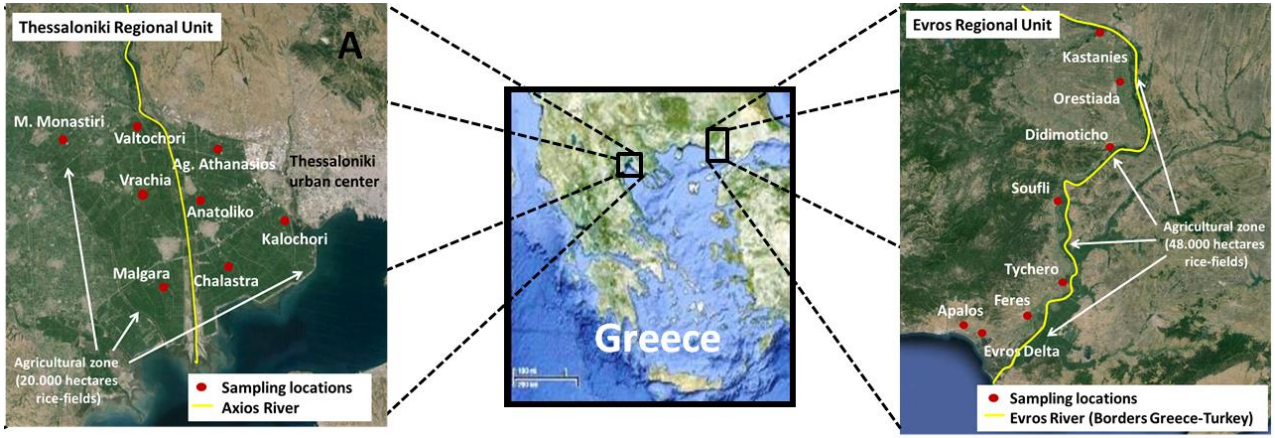


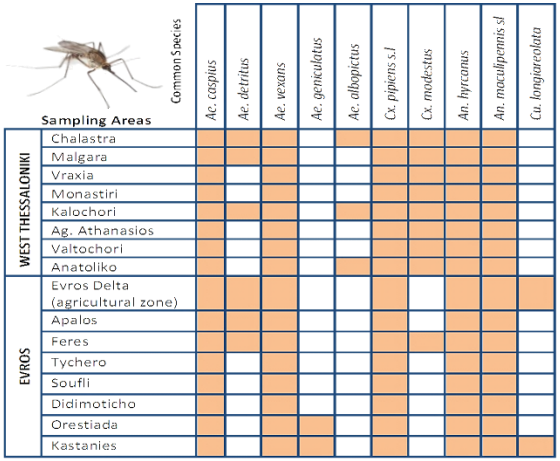
Bringing data together, to make informed decisions

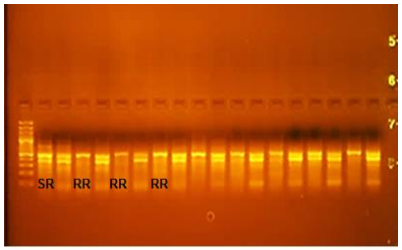
Serious GAMING

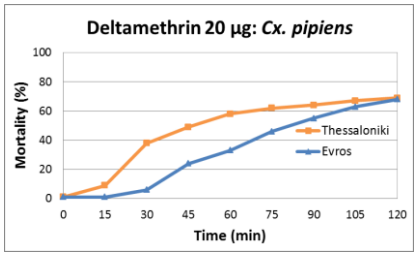
for effectively communicating disease vector control management guidelines to vector control programmes

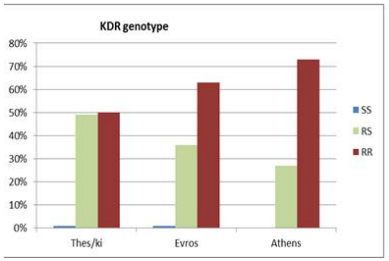
Παρακολούθηση της συχνότητας και διασποράς της ανθεκτικότητας σε πληθυσμούς *Culex pipiens* στην Ελλάδα





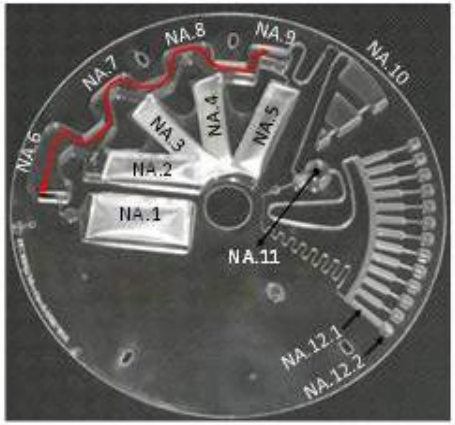


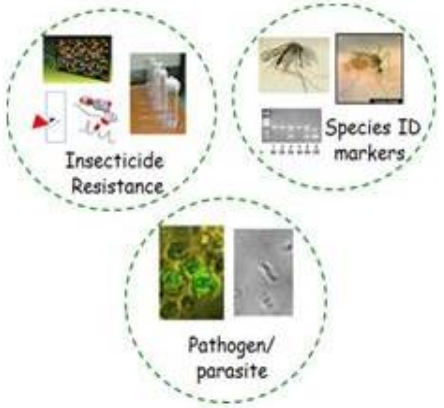


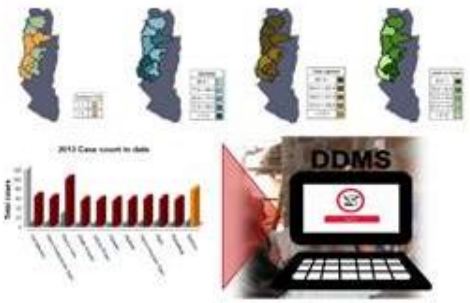


Μ. ΦΩΤΑΚΗΣ, **Α. ΧΑΣΚΟΠΟΥΛΟΥ**, Λ. ΓΡΗΓΟΡΑΚΗ, Α. ΤΣΙΑΜΑΝΤΑΣ, Σ. ΚΟΥΝΑΔΗ ΚΑΙ Ι. ΒΟΝΤΑΣ Ανάλυση της πληθυσμιακής δομής και ανθεκτικότητας στα εντομοκτόνα σε πληθυσμούς κουνουπιών του γένους Culex, Anopheles και Aedes από διάφορες περιοχές της Ελλάδας (in preparation)

DMC-MALVEC
HORIZON 2020







IMBB, AUA,LSTM,HSG, JU
STPHI,OCEAC,MoHZ,CSRS

«**Automated diagnostic platform, data management and communication tool, for improving the impact of malaria vector control interventions**»
LabDisk: sample-to-answer for monitoring the species ID, the infection status of mosquitoes and the insecticide resistance profile of malaria vector populations.

Acknowledgments

Linda Grigoraki
Vassileia Balabanidou
Vassilis Douris
Maria Riga
Evangelia Morou
Max Fotakis
Natassa Kambouraki
Amalia Anthousi

LSTM
Gareth Lycett
Mark Paine
Hilary Ranson

CNRS
Mylene Weill
Pierrick Labbe

NCSR Demokritos
Luc Swevers

INIBI-LP, Argentina
Patricia Juarez

University of Nevada
Gary Bloqmuist

AvecNet

INFRAVEC

COOPERATION

BILL & MELINDA GATES foundation
IVCC
COMBATING INSECT BORNE DISEASE
The Innovative Vector Control Consortium

ΕΣΠΑ 2007-2013
πρόγραμμα για την ανάπτυξη

BAYER