European Research Council

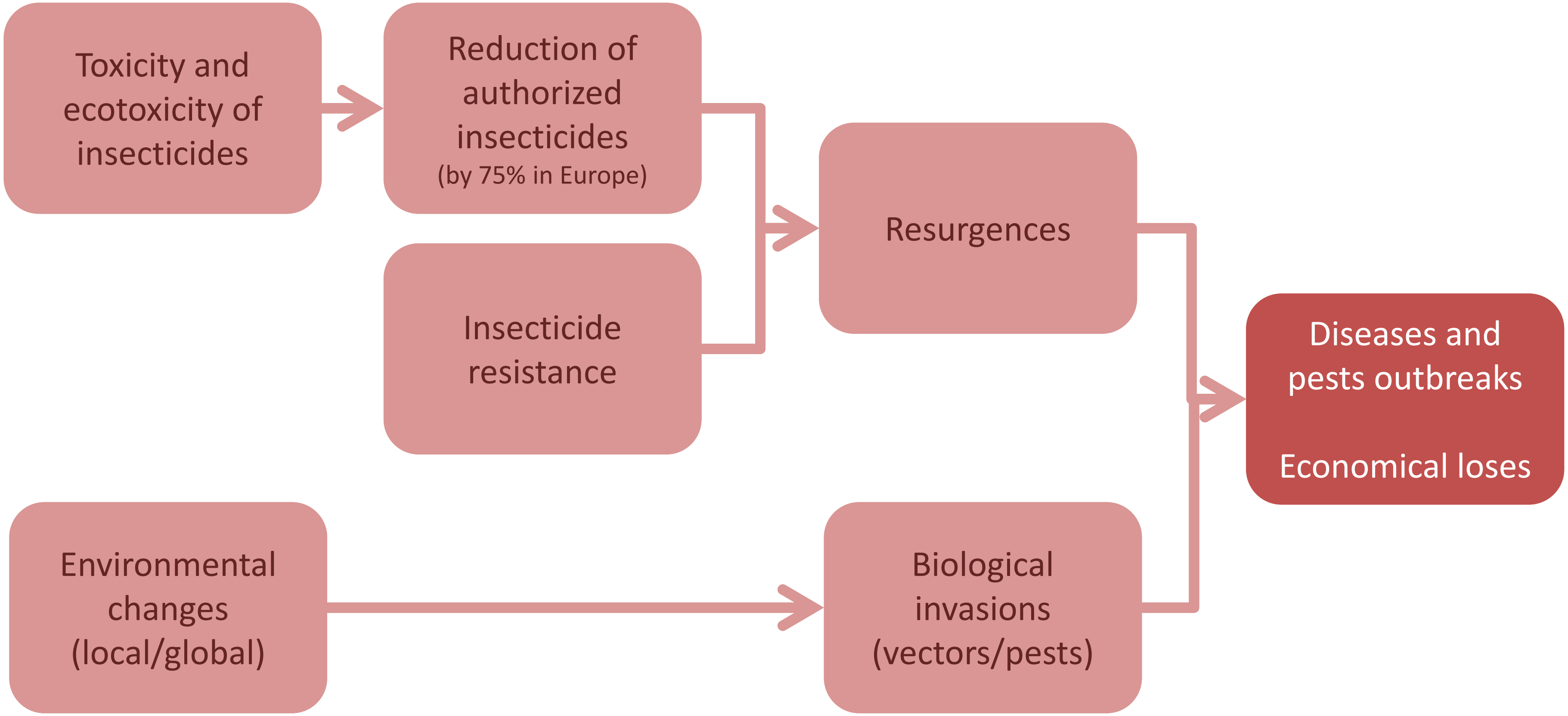
"BOOSTED SIT" AS AN ADDITIONAL TOOL IN AW-IPM PROGRAMMES

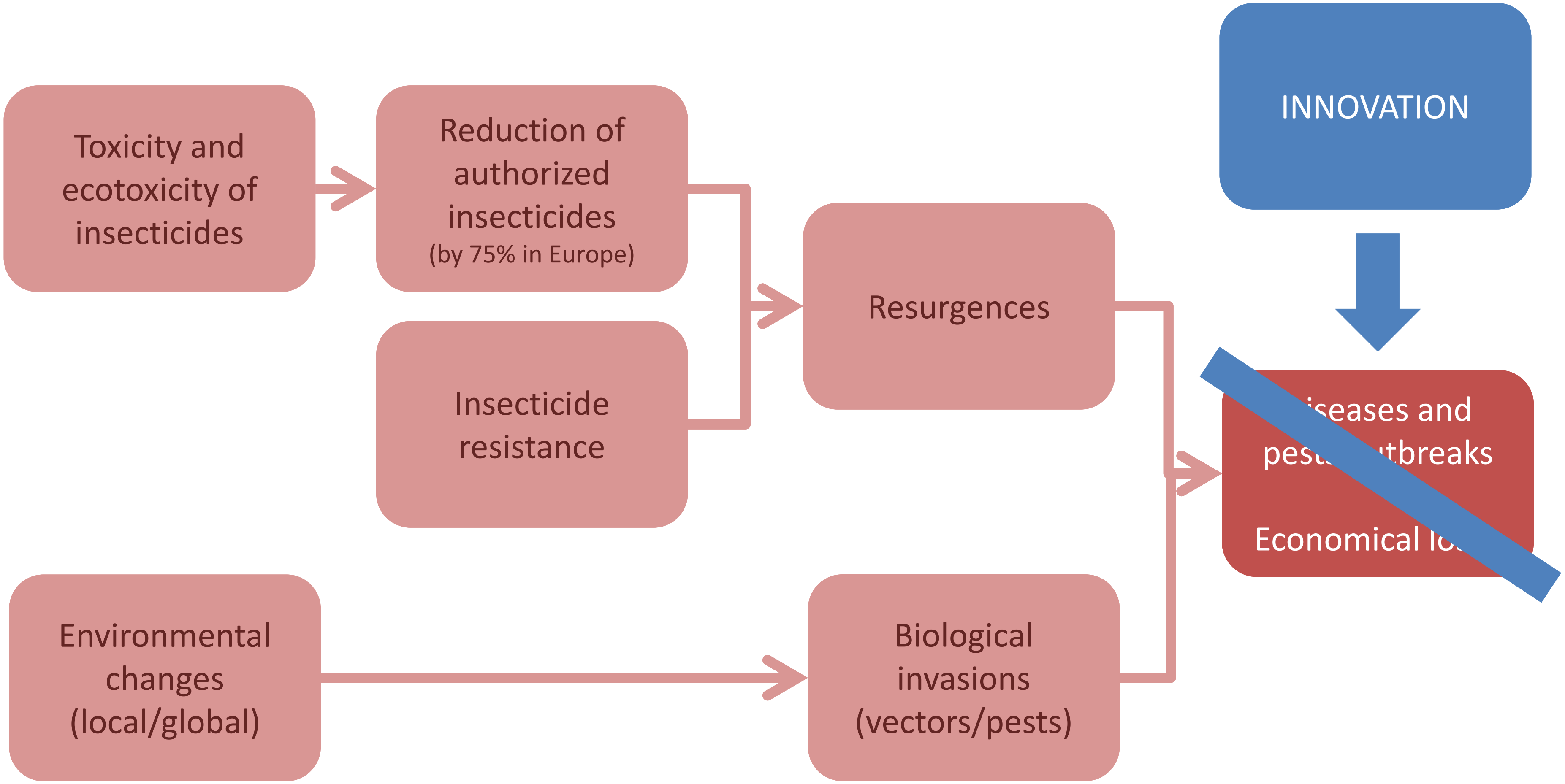
Jérémy Bouyer

Third FAO–IAEA International Conference on Area-wide Management of Insect Pests, 22-26 May in Vienna

ERC Consolidator Grant
LS9 Panel Applied Life Sciences and Non-Medical Biotechnology

THE CHALLENGE


Toxicity and ecotoxicity of insecticides
Reduction of authorized insecticides
(by 75% in Europe)
Insecticide resistance
Resurgences
Diseases and pests outbreaks
Economical loses
Environmental changes (local/global)
Biological invasions (vectors/pests)



INNOVATION
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Resurgences
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pest
tbreaks
Economical lo
Environmental changes (local/global)
Biological invasions (vectors/pests)

The range of insecticides available for vector control

… worse in Europe!

Vector Control Intervention type	Number of WHO recommended insecticide families	Insecticide families	Number of molecules recommended in each family
Indoor Residual Spraying	4	Pyrethroids ~~Carbamates~~ ~~Organophosphates~~ DDT	6 2 3 1
Long-lasting insecticide treated nets	1 (+*1*)	Pyrethroids (*Piperonyl butoxide*)	3
Space Sprays	2 (+*1*)	Pyrethroids ~~Organophosphates~~ (*Piperonyl butoxide*)	4 1
Larvicides	5	Bacterial larvicide Benzoylureas Juvenile Hormone mimics ~~Organophosphates~~ ~~Spinosyns~~	1 2 1 4 1

Resistance to pyrethroids and DDT is now widespread in many mosquito populations

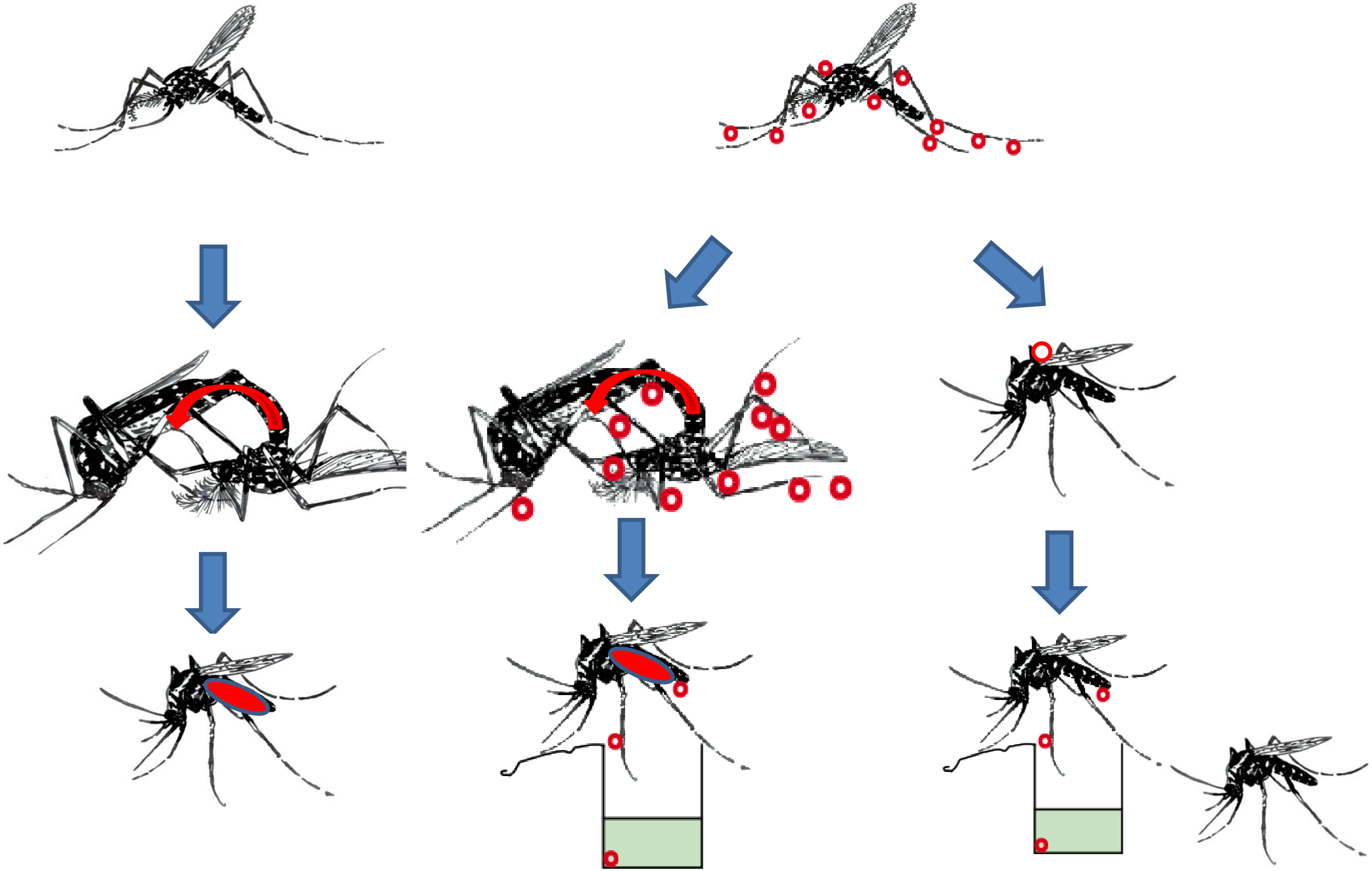
Bayer CropScience

Source: Justin McBeath ISNTD Bites – March 19th 2015

THE PRINCIPLE

SIT

Boosted SIT

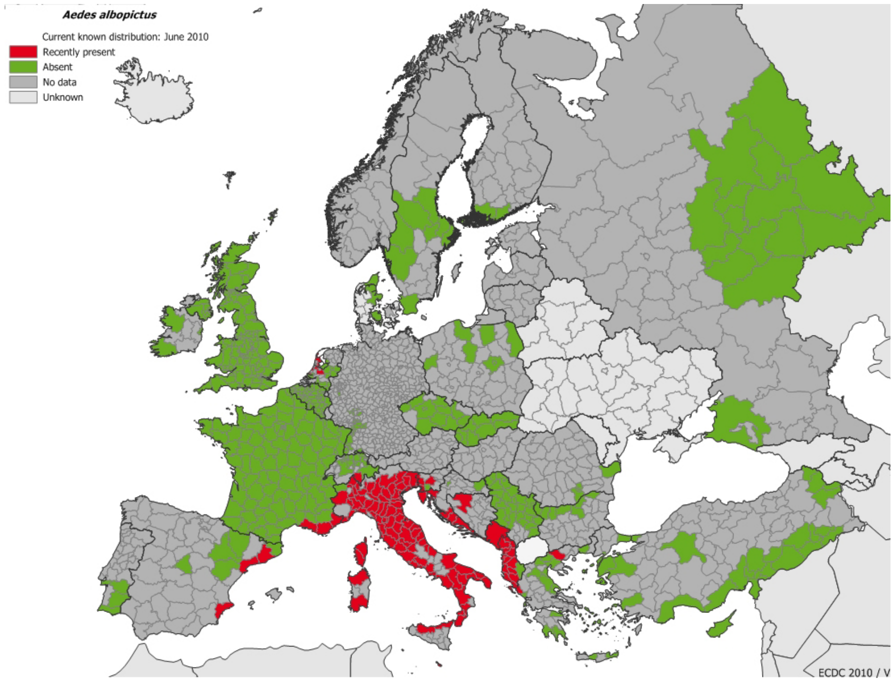


Bouyer & Lefrançois Trends Parasitol 2014

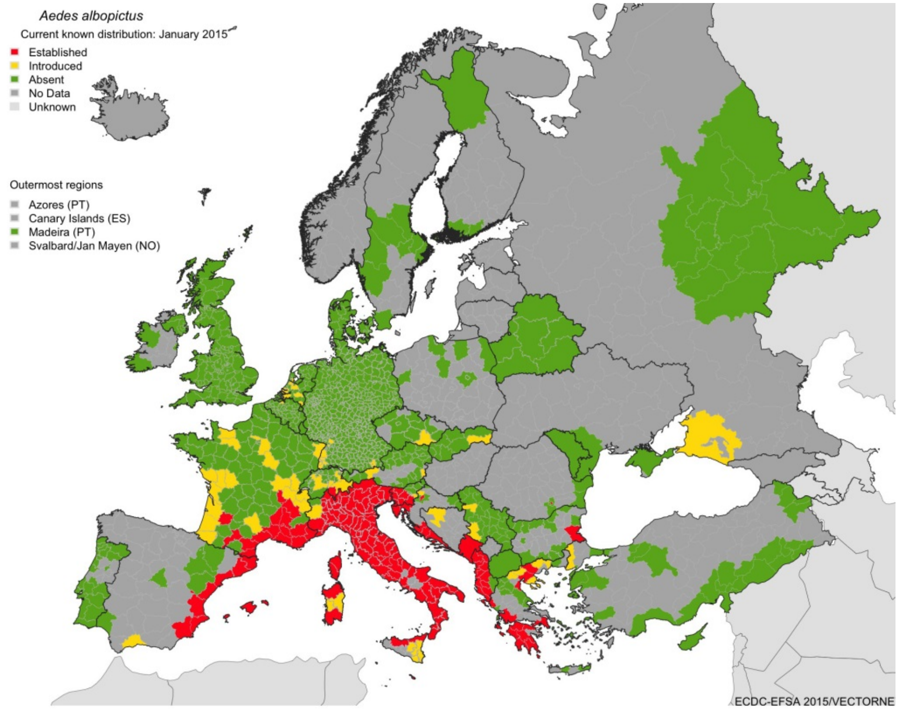
INSECT MODELS

PUBLIC HEALTH

Mosquitoes
Aedes albopictus


Aedes albopictus
Current known distribution: June 2010
Recently present
Absent
No data
Unknown
ECDC 2010 / V

2010


Aedes albopictus
Current known distribution: January 2015
Established
Introduced
Absent
No Data
Unknown
Outermost regions
Azores (PT)
Canary Islands (ES)
Madeira (PT)
Svalbard/Jan Mayen (NO)
ECDC-EFSA 2015/VECTORNE

2015

AGRICULTURE

Fruit flies

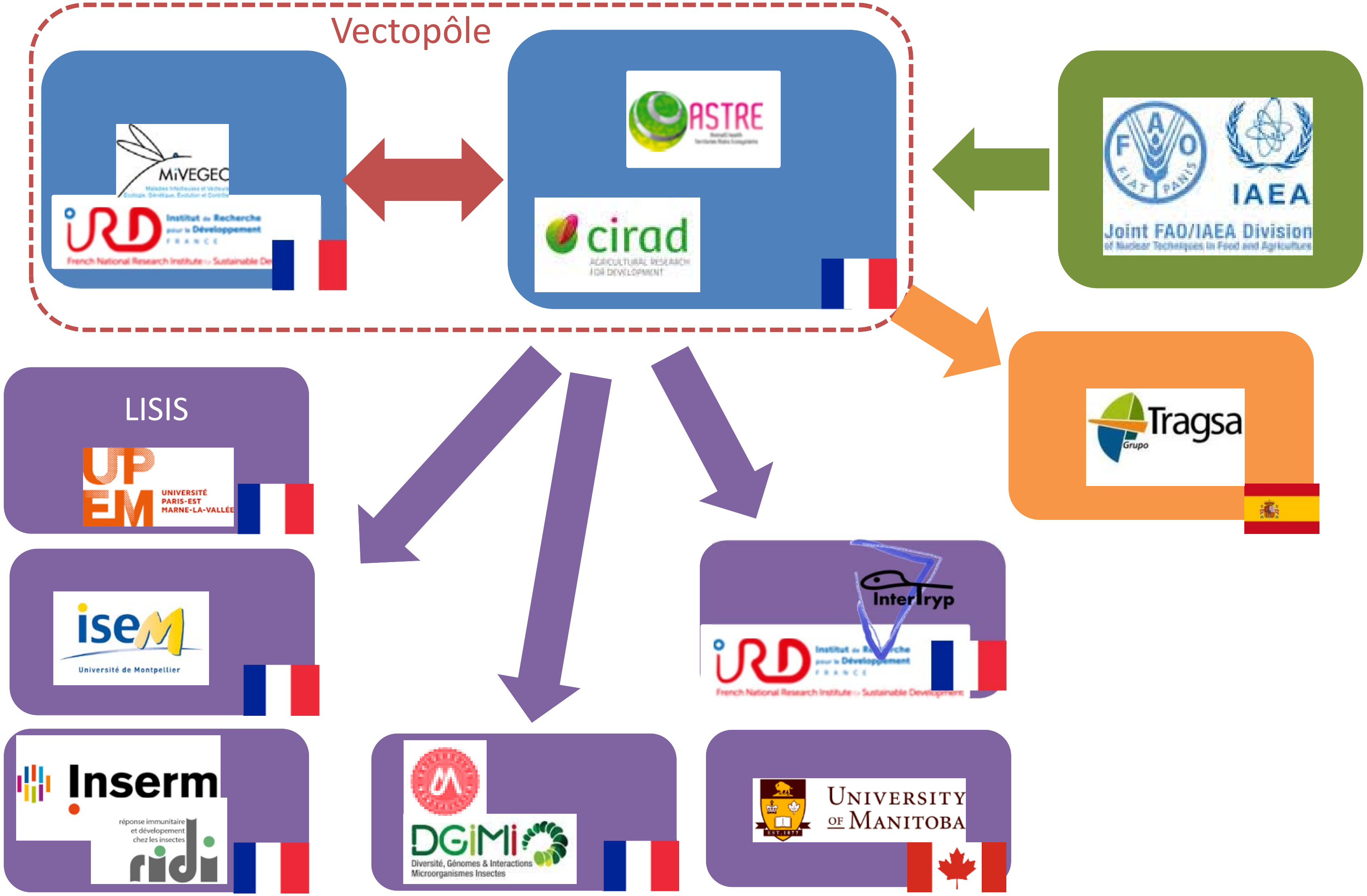
Ceratitis capitata

PUBLIC & ANIMAL HEALTH

Tsetse flies

Glossina palpalis gambiensis

THE TEAM


Vectopôle
MiVEGEC
IRD Institut de Recherche pour le Développement
French National Research Institute for Sustainable Development
ASTRE
cirad
AGRICULTURAL RESEARCH FOR DEVELOPMENT
IAEA
Joint FAO/IAEA Division
of Nuclear Techniques in Food and Agriculture
Tragsa
Grupo
LISIS
UPEM UNIVERSITÉ PARIS-EST MARNE-LA-VALLÉE
isem
Université de Montpellier
Inserm
réponse immunitaire et développement chez les insectes
ridi
DGIMI
Diversité, Génomes & Interactions Microorganismes Insectes
InterTryp
University of Manitoba

WHAT IS NEEDED TO RUN BOOSTED SIT? WHAT WILL WE ADDRESS?

Transfer of biocides during mating and impact on female fertility (PP & Bti & Densovirus)

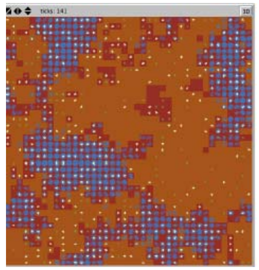
Impact of boosted SIT in semi-field and field trials with the best biocide (*Ae. albopictus* & *C. capitata*)

Semi-field trials → *Experimental field trials*

Relative impacts of SIT and boosted-SIT on population dynamics and resilience

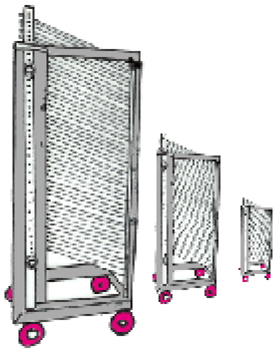
$$\kappa = \frac{1 - \Phi^l(1 - \zeta\psi^T(1 - \eta\Phi^u))}{\zeta\Phi^l\psi^T}$$

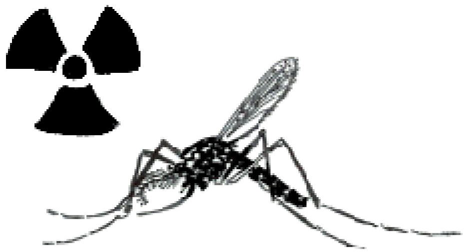
Deterministic models



Individual-based models

Mass rearing and irradiation procedures





FAO-IAEA IPCL

Sex separation method (female elimination) and quality control

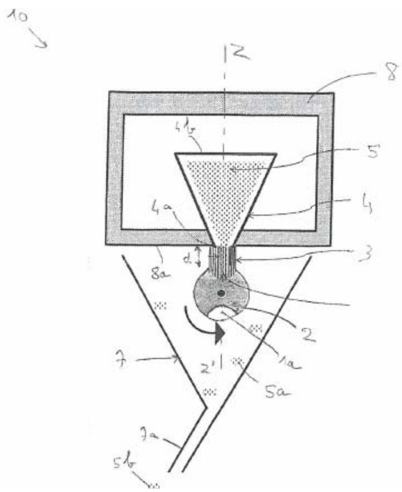
Sexing of mosquitoes and handling procedures

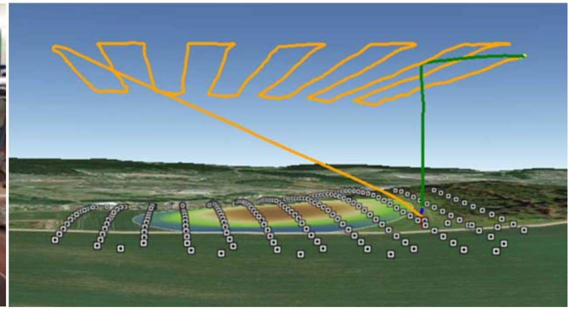
Quality control of produced strains

2 strategies:

- *Development of non-transgenic GSS*
- *RNAi sexing*

Development of an automatic release machine





Regulatory issues
and social acceptability of boosted SIT

Risk assessment → *Regulatory issues* → *Social acceptability*

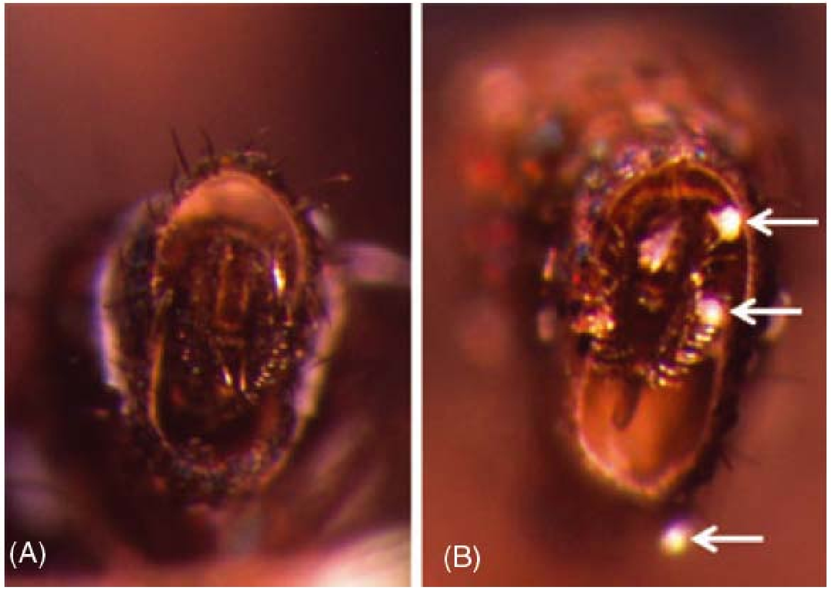
↓

Review of regulatory issues, technical constraints and social acceptability of genetic control in Europe

PRELIMINARY RESULTS

Transmission of pyriproxifen

Transfer qualitatively confirmed
(Gaugler et al., 2012)

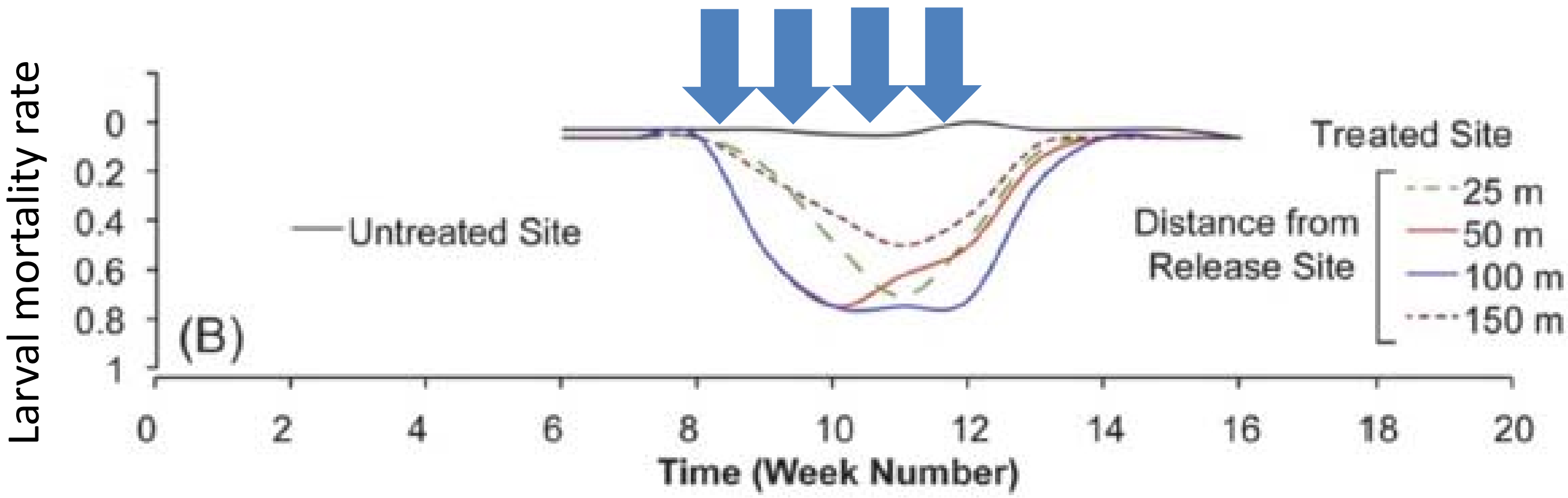


Medical and Veterinary Entomology
Medical and Veterinary Entomology (2012) 26, 37–45 doi: 10.1111/j.1365-2915.2011.00970.x

An autodissemination station for the transfer of an insect growth regulator to mosquito oviposition sites

R. GAUGLER, D. SUMAN and Y. WANG
Center for Vector Biology, Rutgers University, New Brunswick, NJ, U.S.A.

Strong increase of immature mortality around release sites of coated males
(Mains et al., 2015)



PLOS | NEGLECTED TROPICAL DISEASES

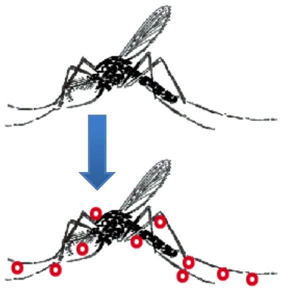
RESEARCH ARTICLE

Male Mosquitoes as Vehicles for Insecticide

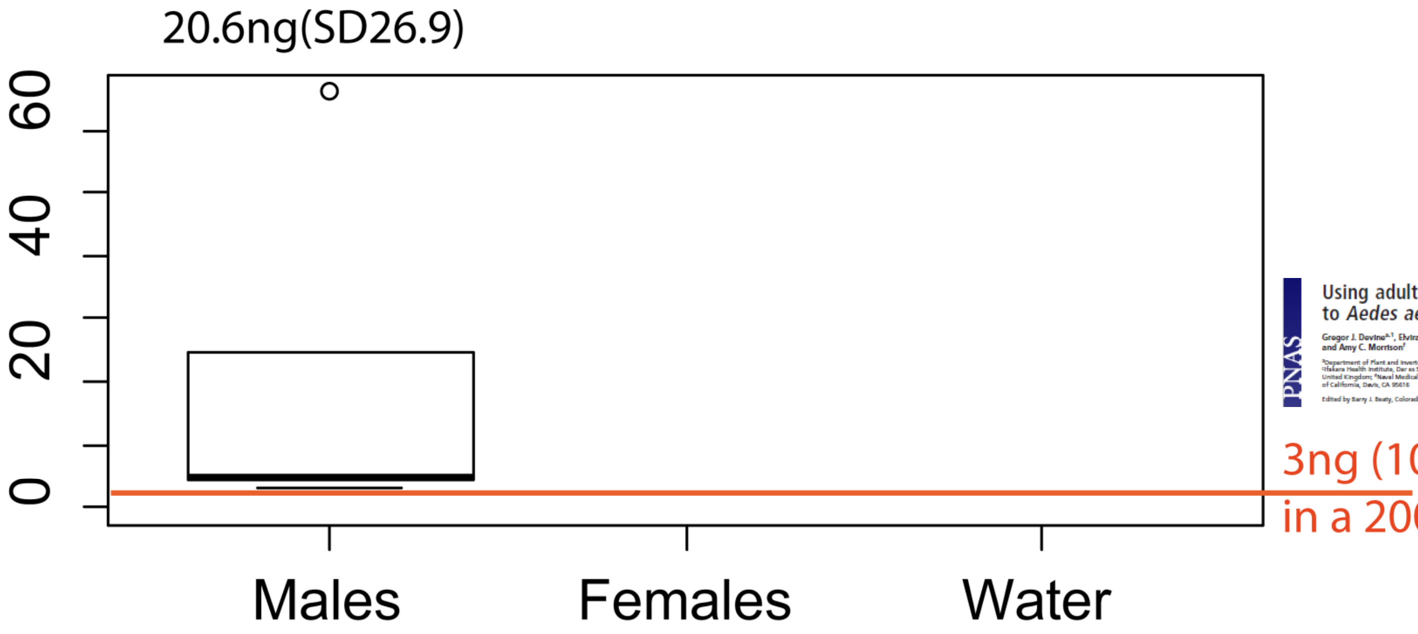
James W. Mains, Corey L. Brelsfoard, Stephen L. Dobson*

MosquitoMate, Inc., Lexington, Kentucky, United States of America

Transfer of PP during mating (dry powder)



Contamination technique



PNAS

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

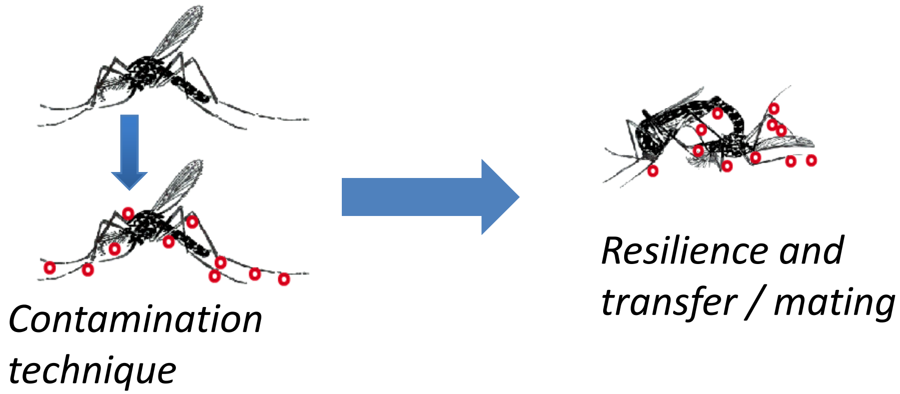
Gregor J. Devine[a,1], Elvira Zamora Perea[b], Gerry F. Killeen[c,d], Jeffrey D. Stancil[e,2], Suzanne J. Clark[a], and Amy C. Morrison[f]

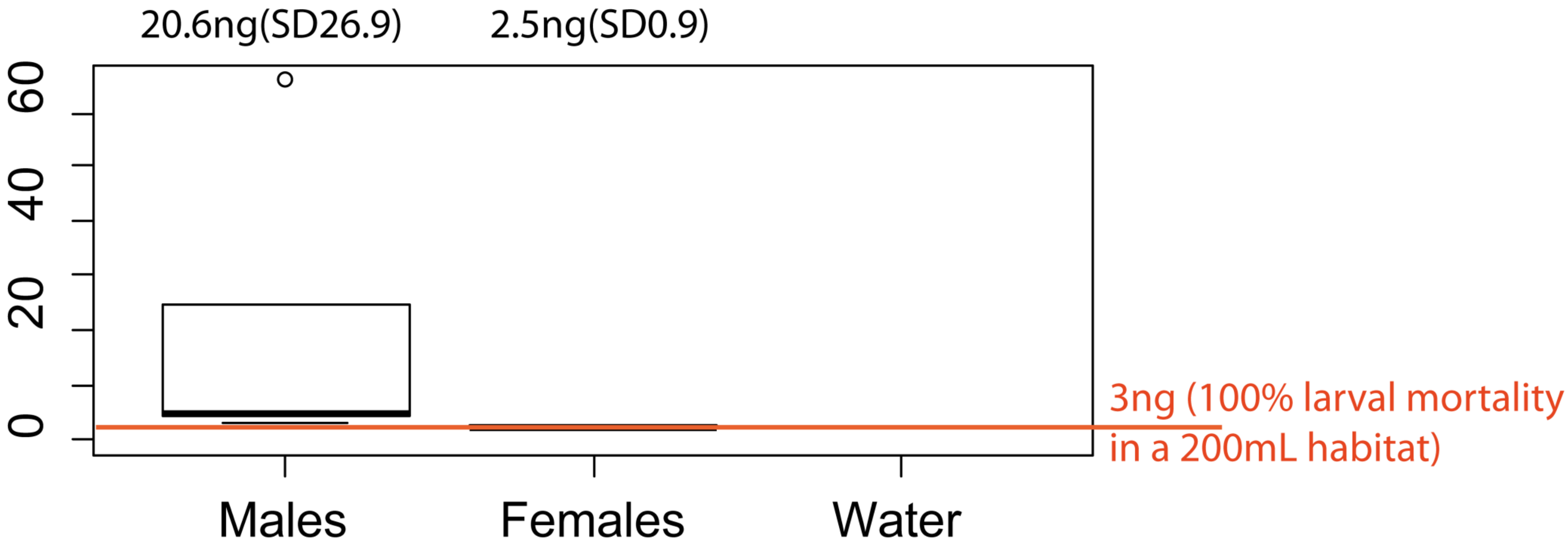
[a]Department of Plant and Invertebrate Ecology, Rothamsted Research, Harpenden AL5 2JQ, United Kingdom; [b]Laboratorio de Salud Publica, Iquitos, Peru; [c]Ifakara Health Institute, Dar es Salaam, United Republic of Tanzania; [d]Vector Group, Liverpool School of Tropical Medicine, Liverpool L3 5QA, United 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)

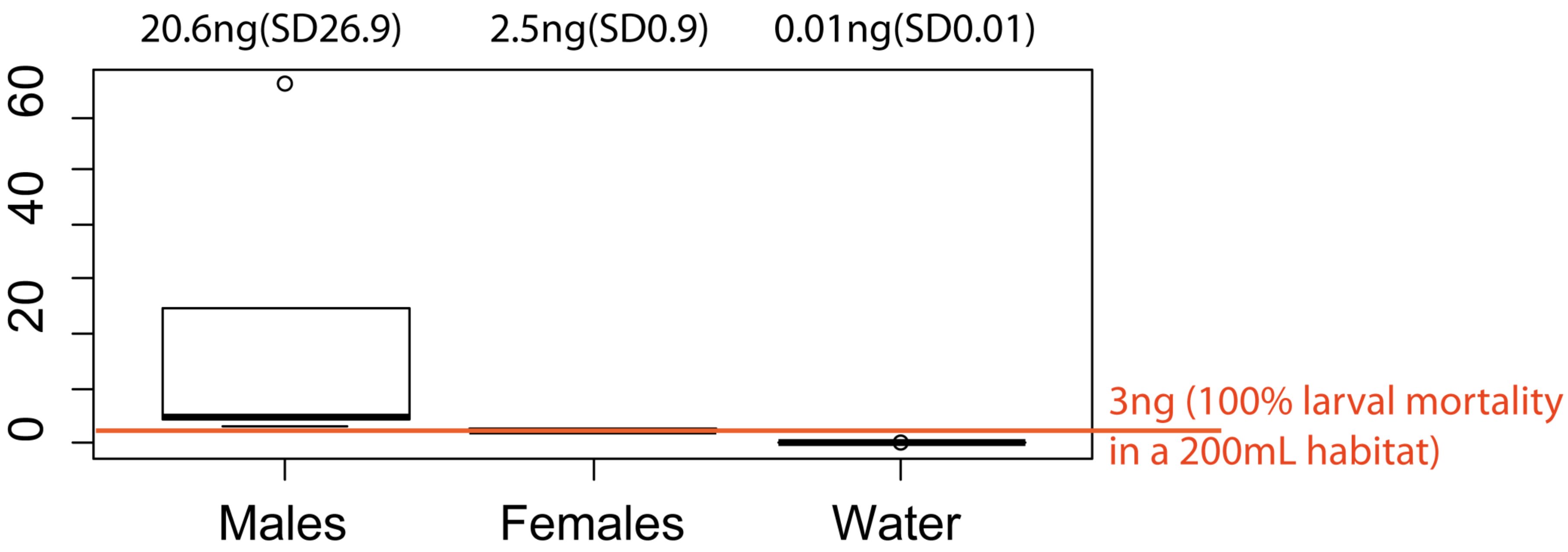
3ng (100% larval mortality in a 200mL habitat)

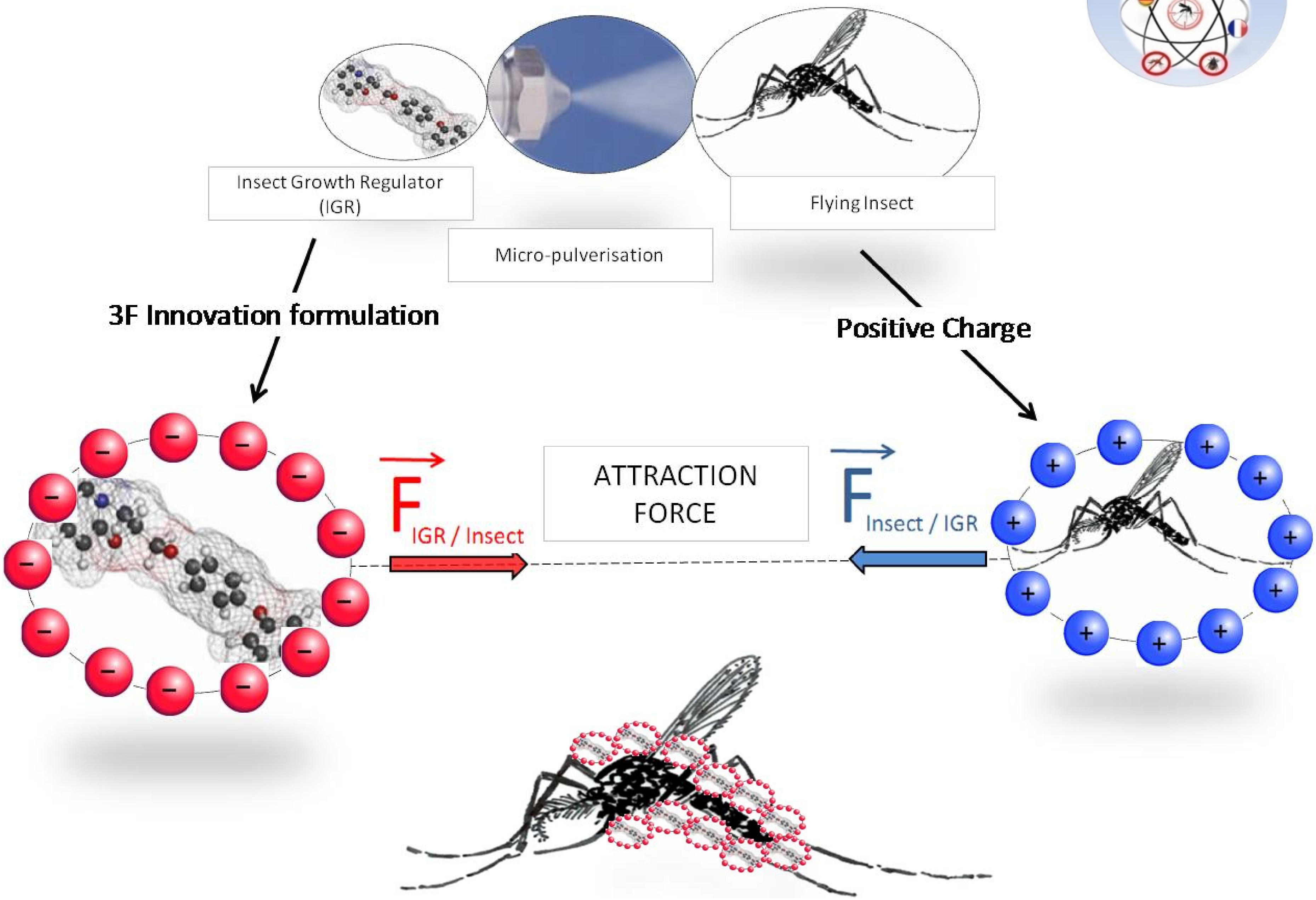
Transfer of PP during mating (dry powder)



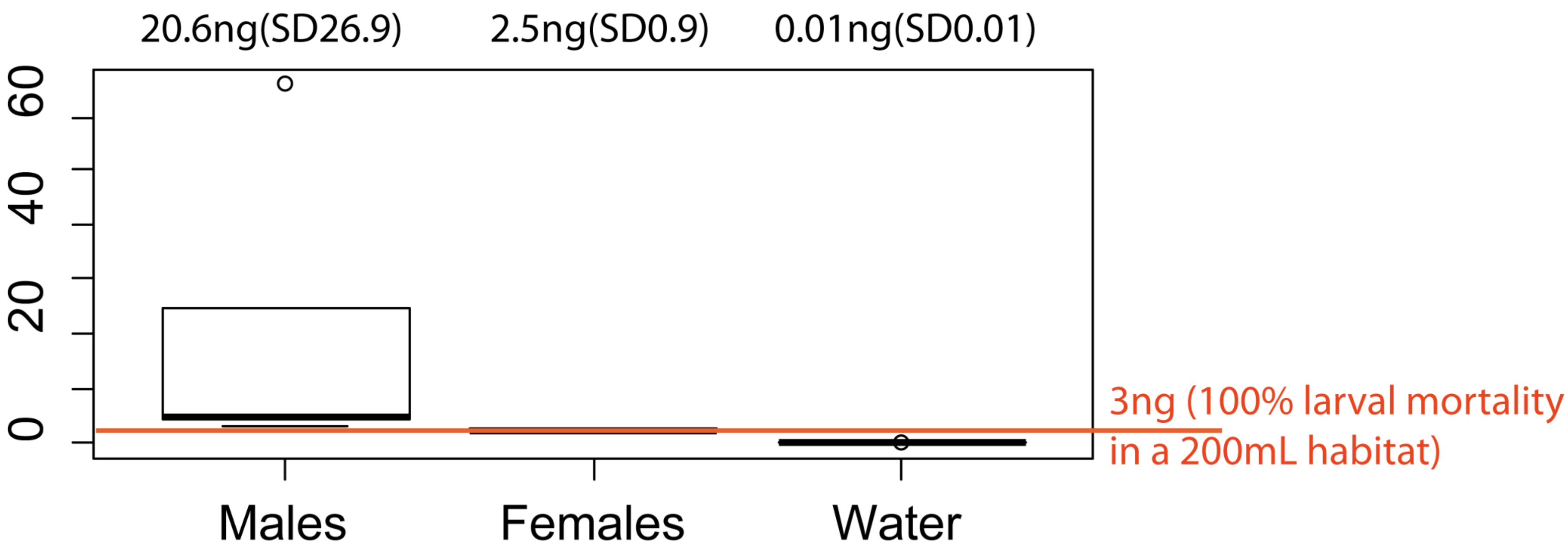


Transfer of PP during mating (dry powder)

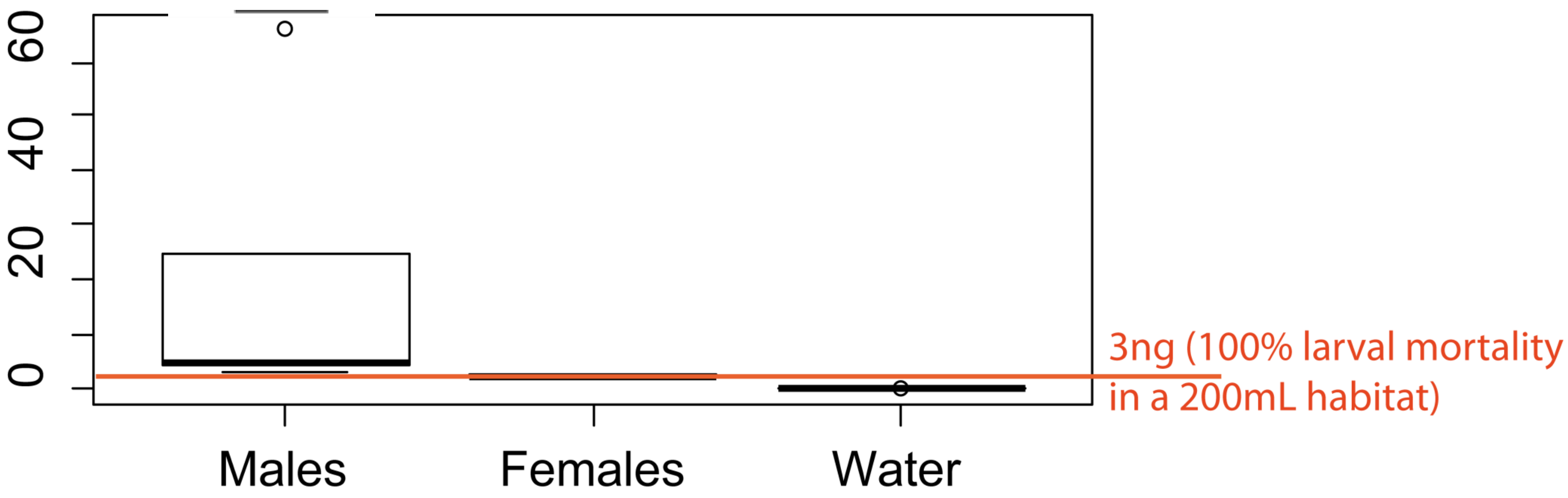



Insect Growth Regulator (IGR)
Micro-pulverisation
Flying Insect
3F Innovation formulation
Positive Charge
F IGR / Insect
ATTRACTION FORCE
F Insect / IGR

Transfer of PP during mating (dry powder)



Transfer of PP during mating (3FInnovation formulation)

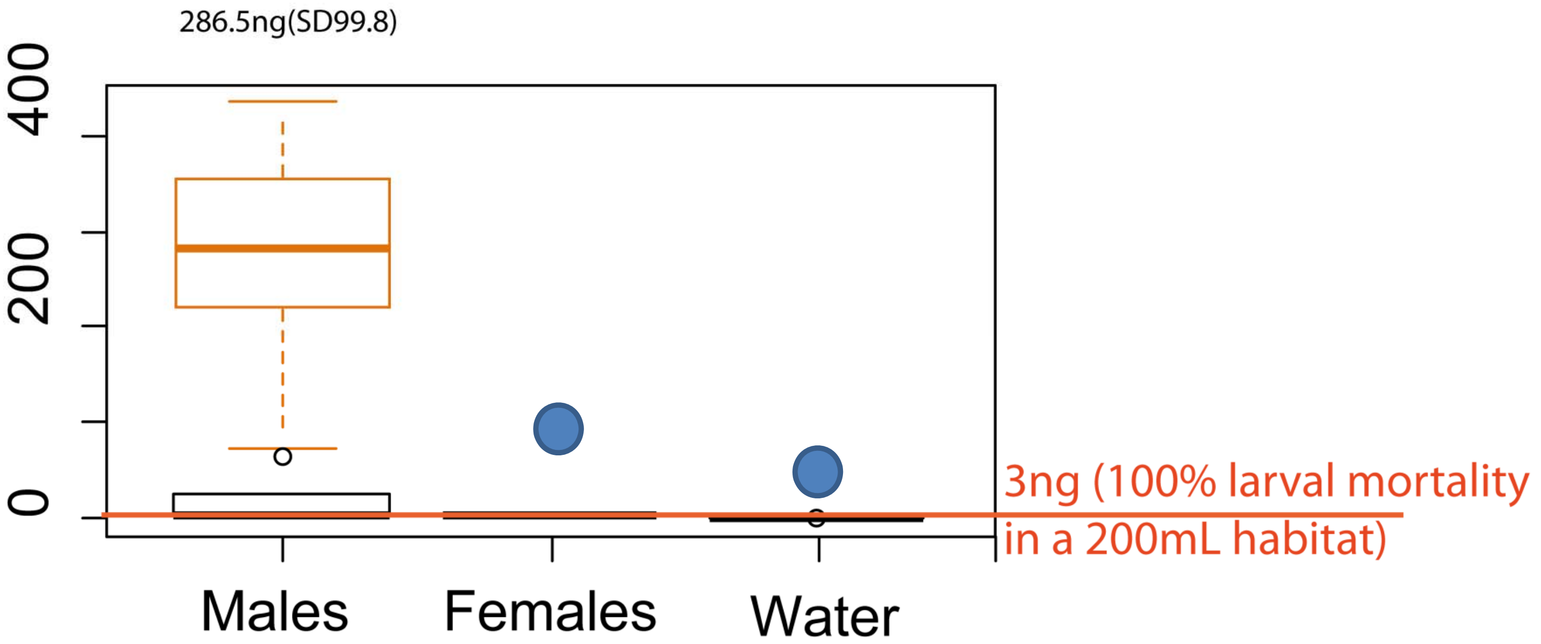


Transfer of PP during mating (3FInnovation formulation)

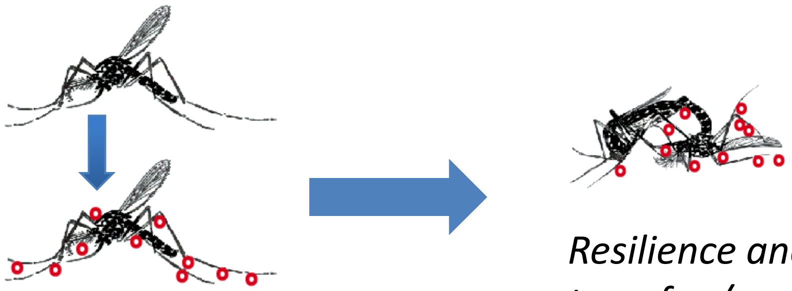
Resilience and transfer / mating

+

Transfer breeding sites & impact on fecundity

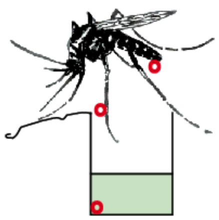


Transfer of PP during mating (3FInnovation formulation)

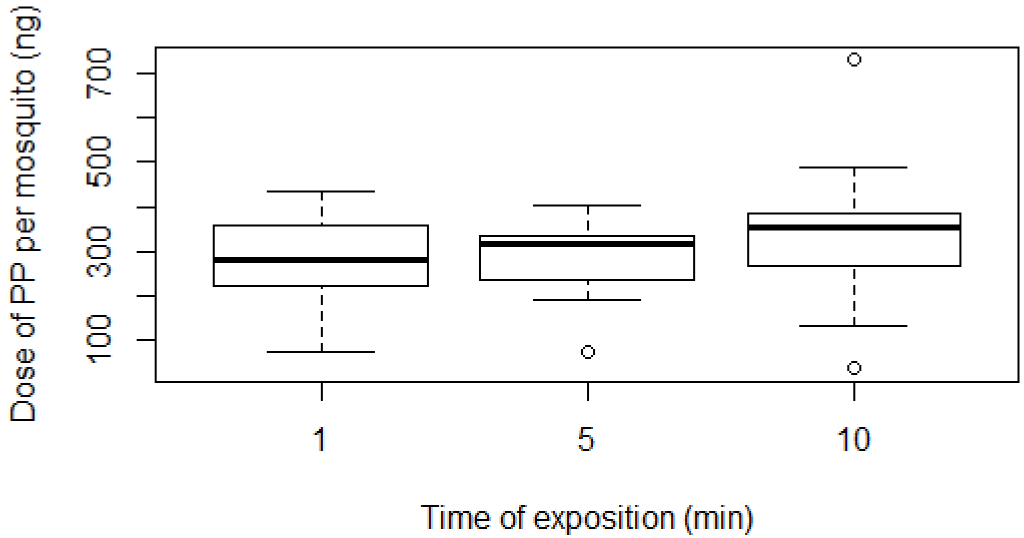


Resilience and transfer / mating

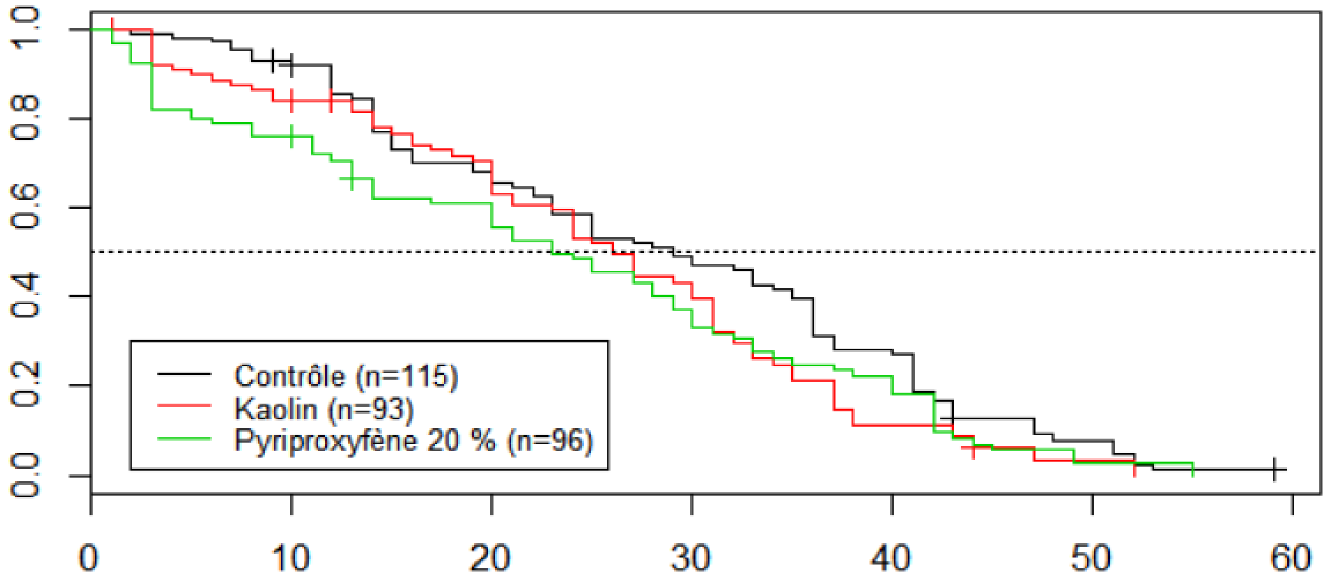
+



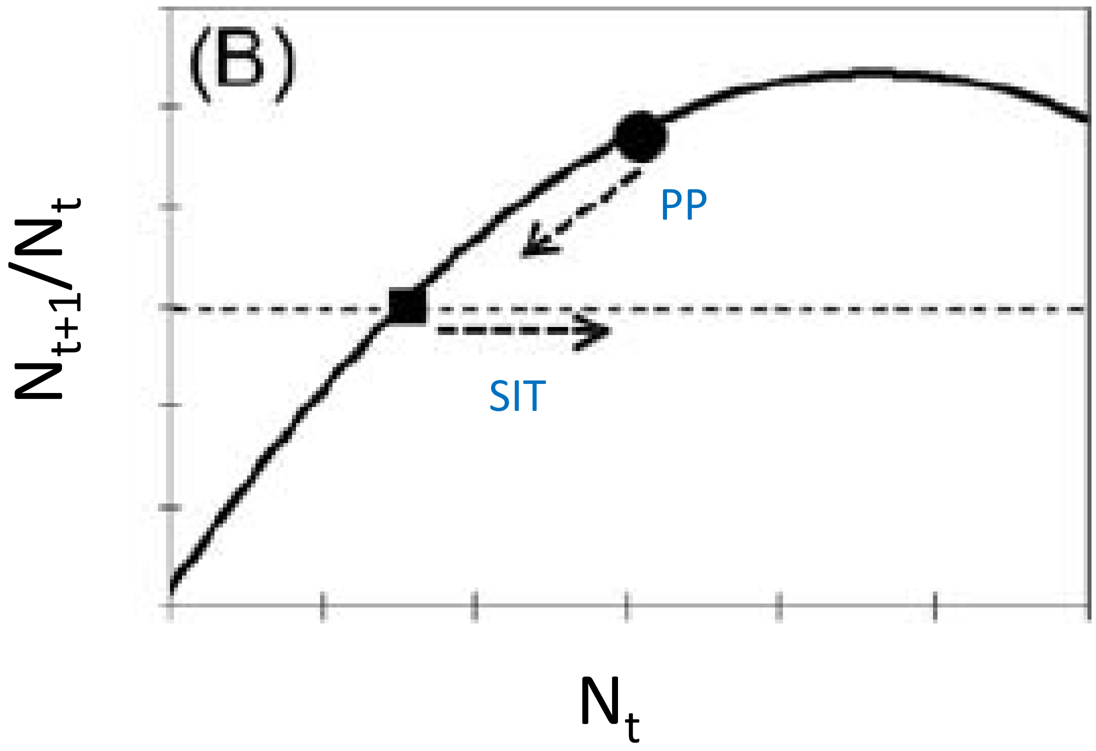
Transfer breeding sites & impact on fecundity



No impact on male survival



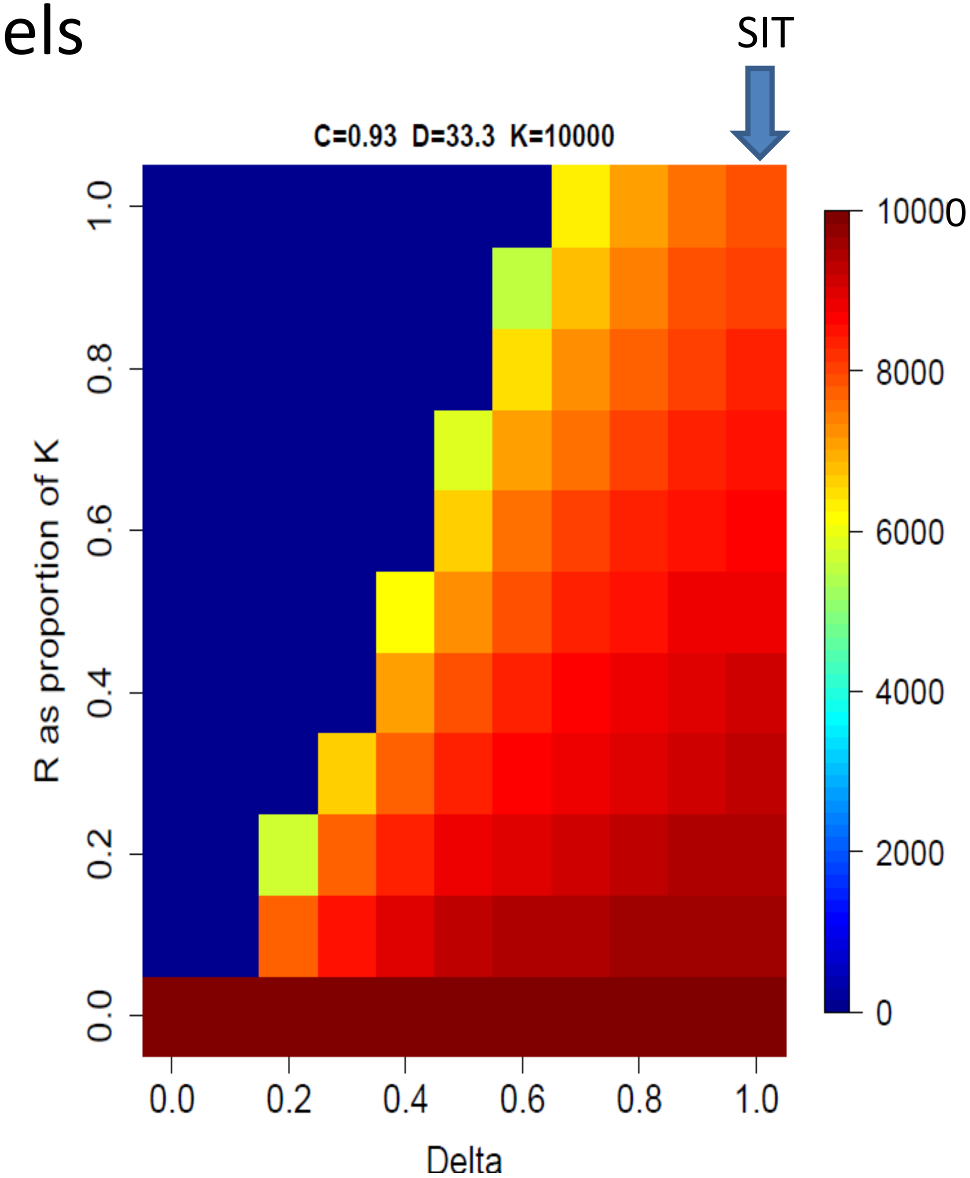
Boosted SIT with pyriproxifen, a synergistic combined tactic to eradicate insects



(B) Synergistically combining a density-independent tactic to reduce population density with one that increases an Allee threshold. (Suckling et al. J Eco Entomol 2012)

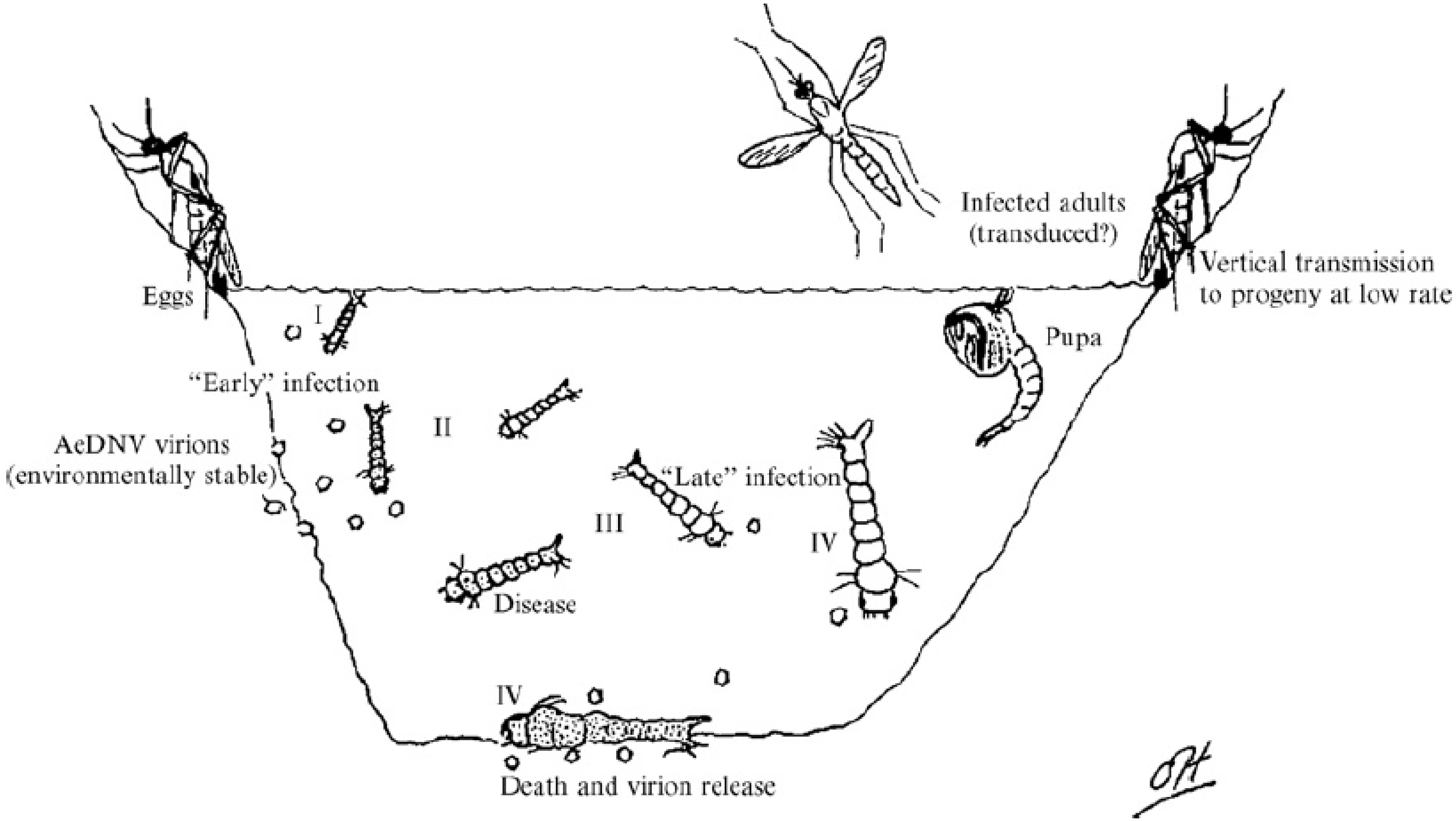
Preliminary models

Density of sexually active females after 2 years of releasing R males (shown as a proportion of the carrying capacity K)

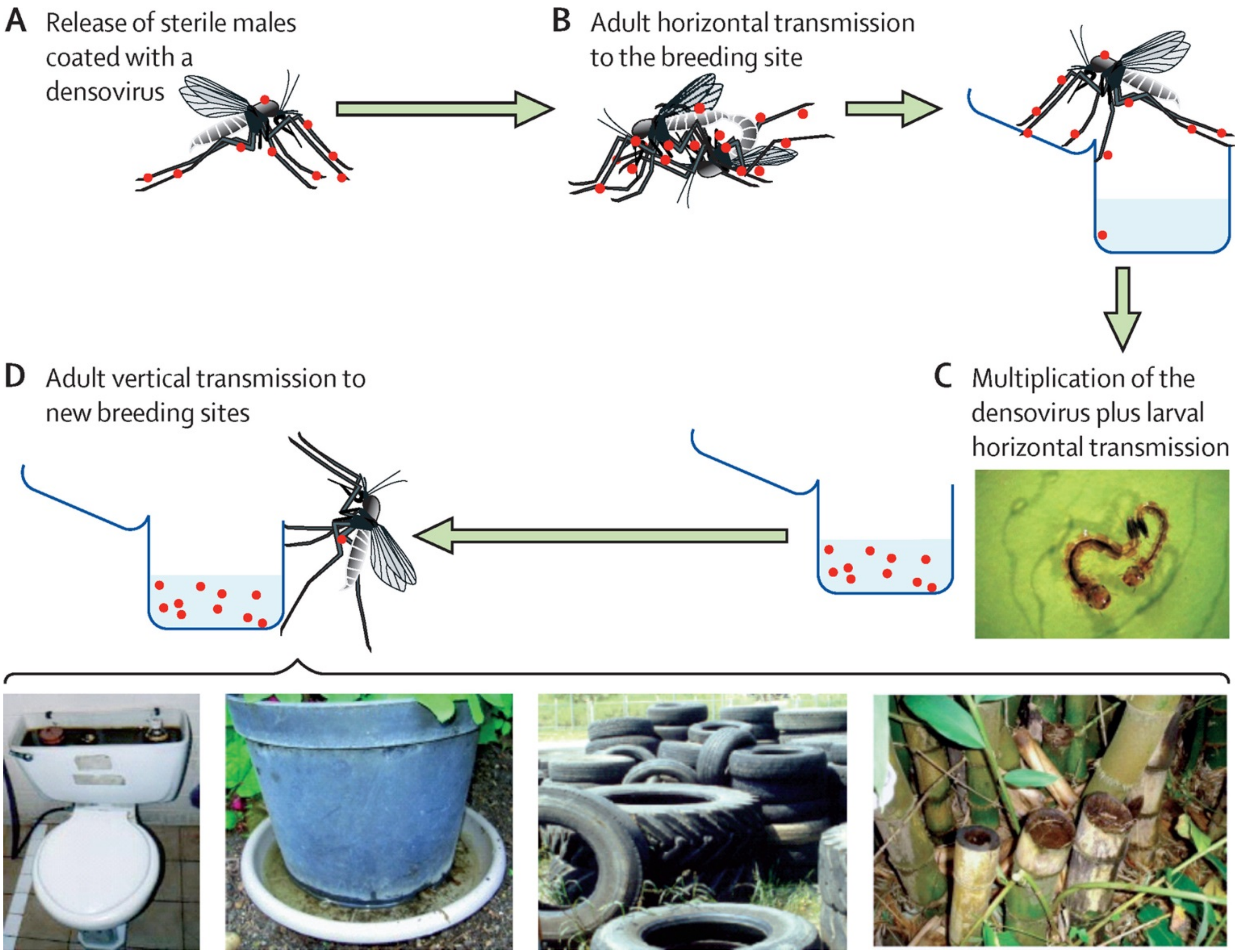


Proportion of larvae surviving in the contaminated site

What about associating SIT to DENSOVIRUSES?

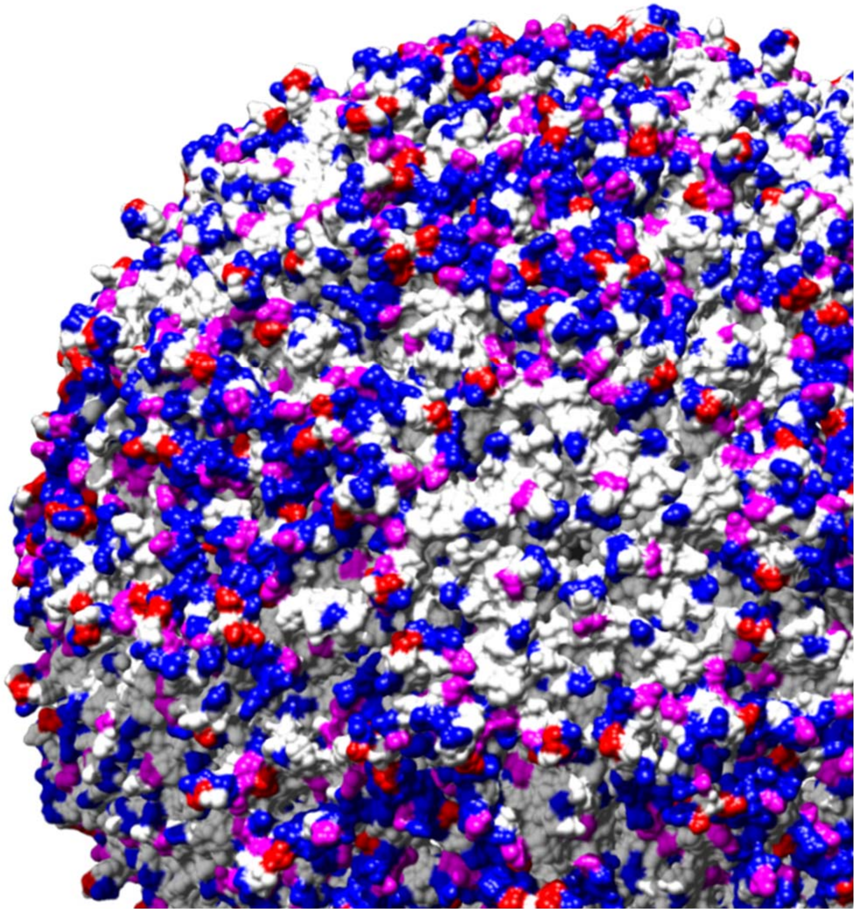


Drawn by Steve Higgs

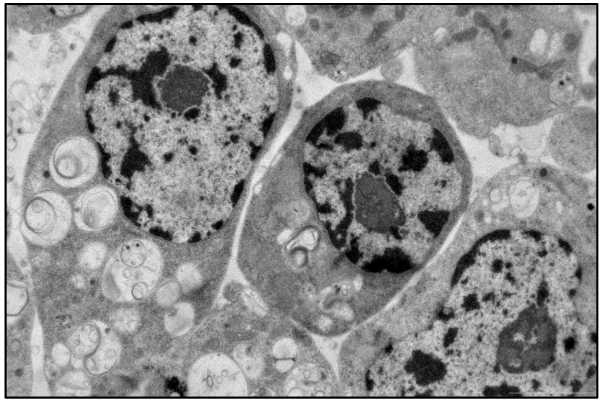


The Lancet Global Health 2016 4, DOI: (10.1016/S2214-109X(16)00082-6)

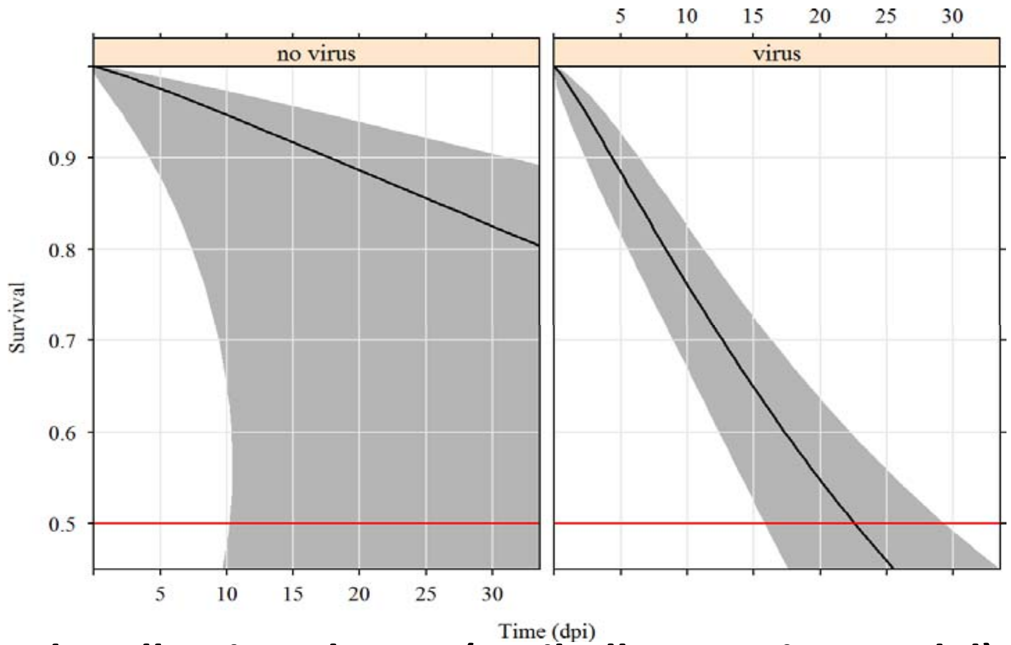
Availability of infectious clones



AalDV2 (*Aedes albopictus* Densovirus strain 2)



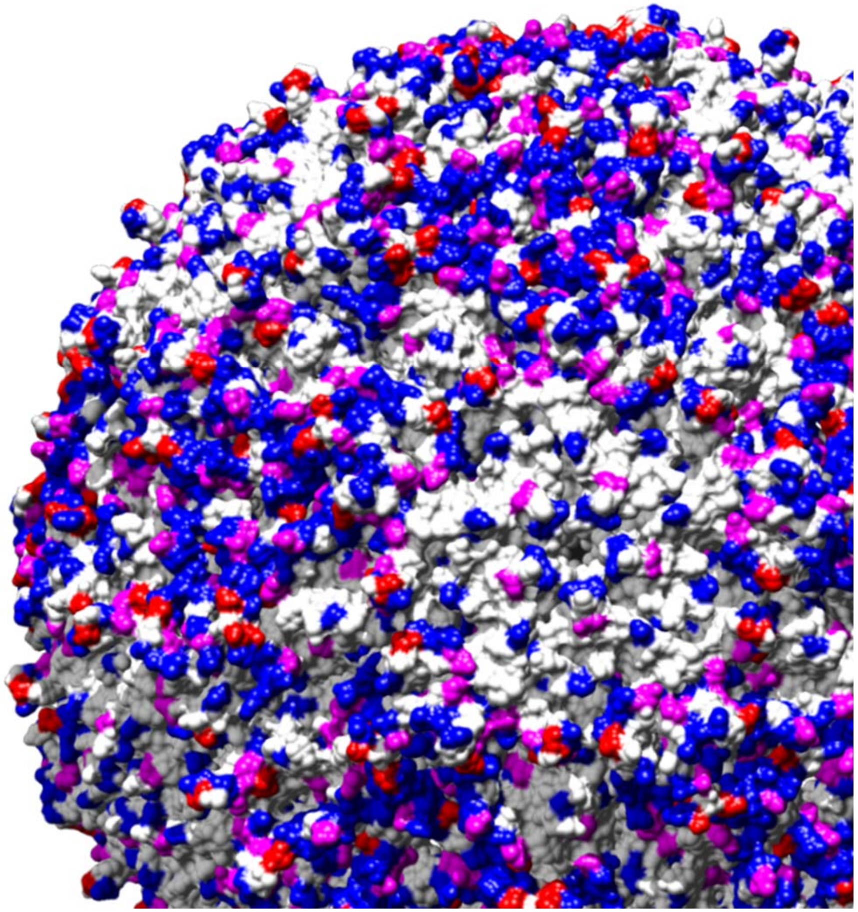
+40% mortality
(10e7 -10e8 viral genomes /larva)



Probability of survival of *Aedes albopictus* larvae (Weibull regression model)

Availability of infectious clones

High specificity



High specificity

TABLE II
PATHOGENESIS OF AeDNV TO INVERTEBRATE SPECIES[a]

Animal species	Number of individuals	Developmental stage	Route of infection	Pathological effect
Insects				
Ae. aegypti	1140	Instar I–IV larvae	PO	+
Ae. albopictus	550	Instar I larvae	PO	+
Ae. togoi	450	Instar I larvae	PO	+
Ae. vexans	419	Instar I, II larvae	PO	+
Ae. geniculatus	233	Instar I larvae	PO	+
Ae. caspius dorsalis	905	Instar I, II larvae	PO	+
Ae. cantans	440	Instar II larvae	PO	+
Ae. caspius caspius	90	Instar II larvae	PO	+
C. pipiens pipiens	915	Instar I, II larvae	PO	+
C. p. molestus	641	Instar I larvae	PO	+
C. annulata	315	Instar I, II larvae	PO	+
An. maculipennis	548	Instar I, II larvae	PO	−
Chironomus sp.	142	Larvae	PO	−
M. domestica	335	Instar III, IV larvae	PO, IL	−
P. regina	210	Instar III, IV larave	PO, IL	−
A. mellifera	200	Adult	PO	−
G. mellonella	450	Instar III, IV larvae	PO, IL	−
B. mori	115	Instar III, IV larvae	PO, IL	−
A. crataegi	184	Instar III, IV larvae	PO, IL	−
M. neustria	270	Instar III, IV larvae	PO, IL	−
P. dispar	225	Instar III, IV larvae	PO, IL	−
Crustaceans				
Daphnia sp.		Adults and youth	PO	−
Cyclops sp.		Adults and youth	PO	−
Worms				
Lumbricus sp.	50	Adults	SC	−

Carlson et al. 2006 Advances in virus research

EXPECTED BREAKTHROUGH

Fundamental expected breakthrough

Quantification of vertical and horizontal transfers of biopestcides in mosquitoes in natural populations

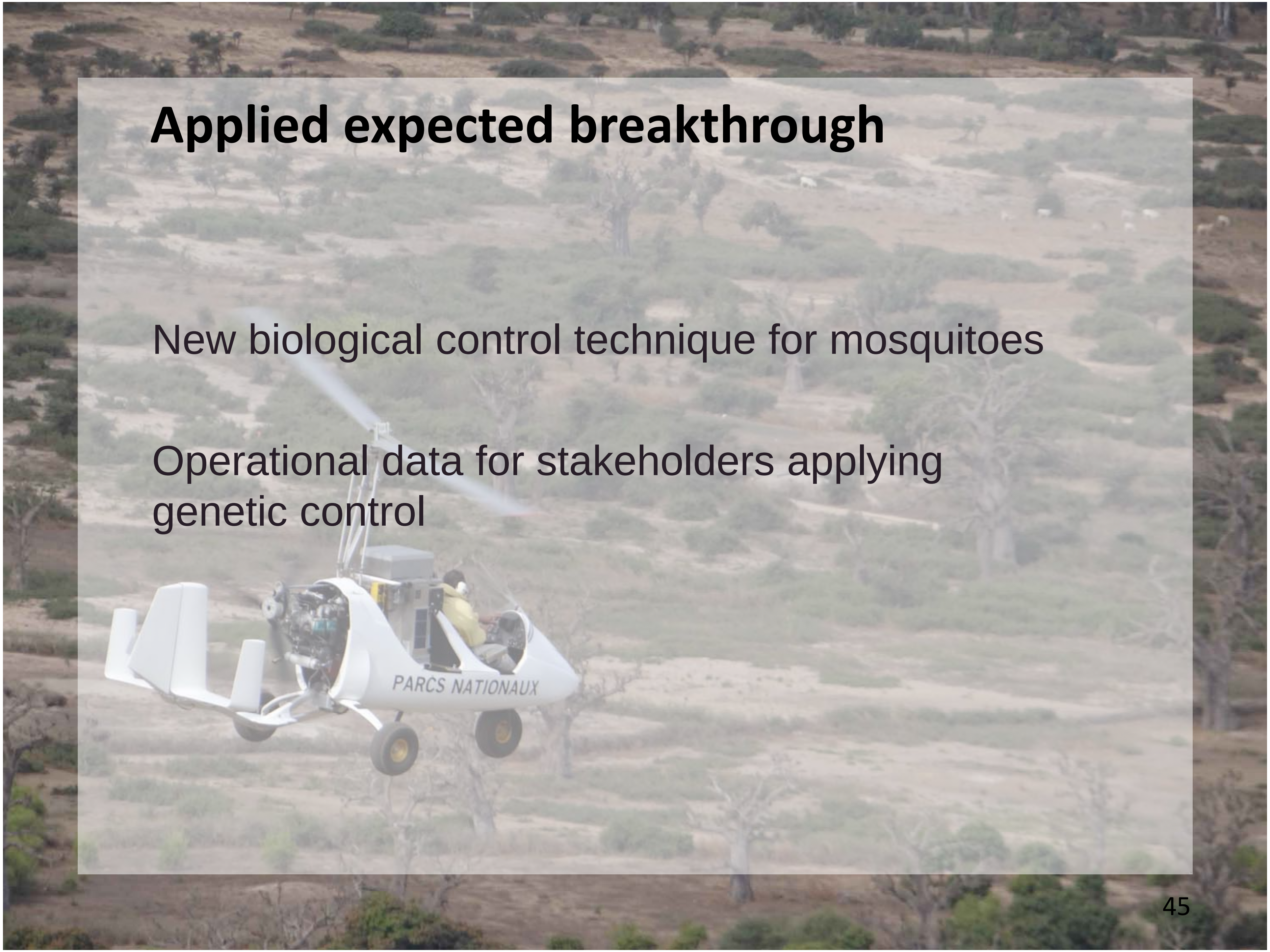
Quantification of the impacts of SIT ±biocides on population dynamics & evolutionary response of target populations

→ generic conclusions on the sustainability of boosted SIT versus chemical control

Applied expected breakthrough

New biological control technique for mosquitoes

Operational data for stakeholders applying genetic control



Thanks!

REVOLINC

European Commission

The EU Framework Programme for Research and Innovation

HORIZON 2020

erc European Research Council