Prevention of arboviral diseases

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Arbivoral diseases affecting humans

Mosquito borne:

- Yellow fever
- Dengue 1,2,3 & 4
- Chikungunya
- *Ziika*
- Japanese encephalitis
- West Nile
- Usutu
- Mayaro

Tick borne:

- Tick-borne encephalitis
- Crime-Congo haemorrhagic fever

Sandfly borne:

- Toscana
- Oropouche

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Important global threats

	Regions at risk	Endemic region	Pathways for introduction*
Japanese encephalitis virus	Americas	Asia	Infected livestock
Rift Valley fever virus	Americas, southern Europe	Africa, Asia	Infected livestock
Venezuelan equine encephalitis virus	Europe, Asia, Africa	Americas	Infected livestock
Chikungunya virus	Europe, Americas, Australia	Africa, Asia	Infected people
Mayaro virus	Africa, Asia, Europe	South America	Infected people
Zika virus	Europe, Americas	Africa, Asia	Infected people
Crimean-Congo haemorrhagic fever	North Africa, east Asia, central and western Europe	Africa, Asia, Europe	Infected livestock
Dengue virus	Southern Europe	Southern hemisphere	Infected people
West Nile virus	Central Europe, Turkey	Africa, Asia, Europe, Australia	Migratory or dispersing birds
Sindbis virus	Northern Europe	Africa, Asia, Australia	Migratory or dispersing birds

(Kilpatrick & Randolph, The Lancet, 2012)

Just 2 years ago....


LIVE ET
ON THE SCENE
GMA
HEALTH
ALERT
AT THE ZIKA VIRUS EPICENTER
MORE CASES DETECTED IN U.S.
GMA
@GMA


THE
USUAL SUSPECTS

1. Could we have seen this coming?
2. What are our current and future risks?
3. What can we do about it?

1. **Could we have seen this coming?**
2. What are our current and future risks?
3. What can we do about it?

1. **Could we have seen this coming?**

    - Historical context
    - Spread of the mosquito & the disease

Yellow Fever commission, Cuba, 1900

Carlos Finlay, 1881: mosquito hypothesis

Reed Carroll Agramonte Lazear

Yellow Fever commission, Cuba, 1900

Unhygienic,
NOT mosquito-proof

Hygienic,
Mosquito-proof

Concern about diseases spread by *Aedes aegypti*

- Introduction of *Aedes aegypti* and yellow fever into North America (1700s)
- Abandonment of construction Panama canal (1880s)
- Epidemics of yellow fever in South America (1920-1950s)

Solution: eradication of *Aedes aegypti* with insecticides

Eradication of *Aedes aegypti* …?

Fred L. Soper
(1893 – 1977)

Concern about diseases spread by *Aedes aegypti*

- Epidemics of **yellow fever** in South America (1920-1950s)

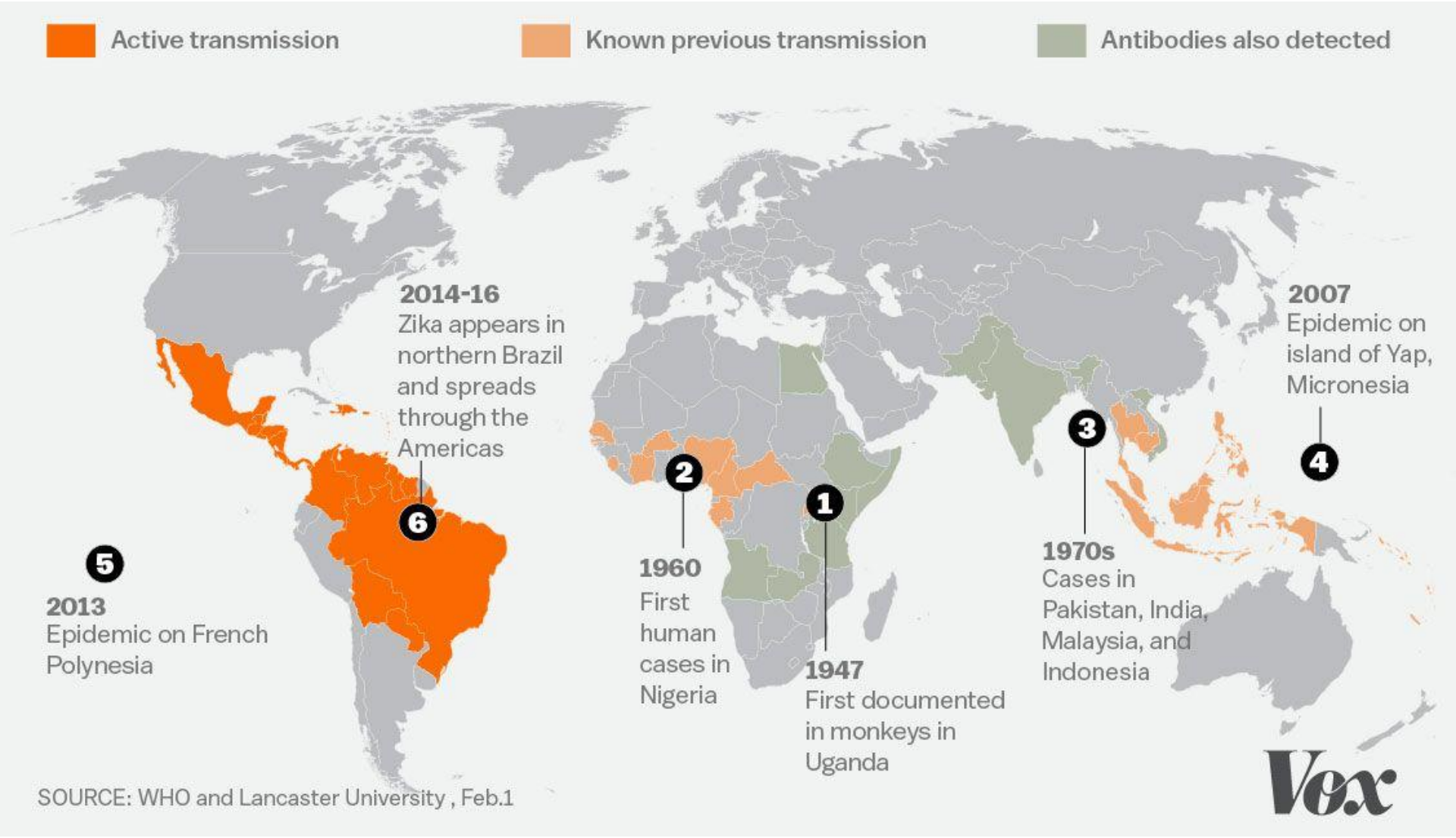
…… *Aedes aegypti* eradication campaign (1950-1960)

- Spread of **dengue** across the world (1970s-2000)
- **Chikungunya** outbreak Reunion / India / Italy (2006-2007)
- **Chikungunya** outbreak Carribean (2014)
- **Zika** outbreak South America (2016-2017)

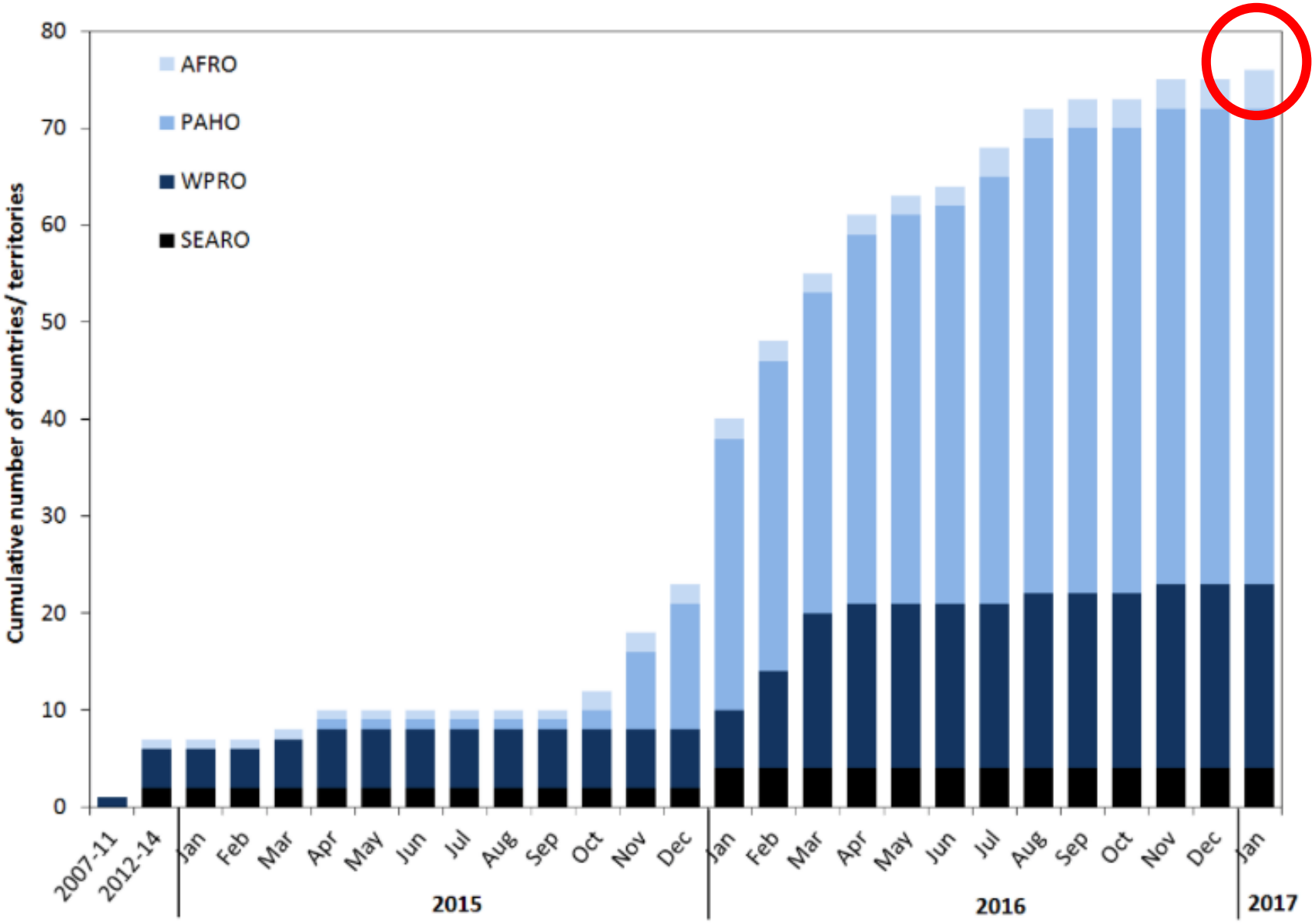
1947

ZIIKA FOREST.
PROPERTY
OF
GANDA VIRUS RESEARCH
INSTITUTE (UVRI)
P.O.BOX 49 ENTEBBE

How the Zika virus spread: in space…



… and time


AFRO
PAHO
WPRO
SEARO
Cumulative number of countries/ territories
0
10
20
30
40
50
60
70
80
2007-11
2012-14
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2015
Jan
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May
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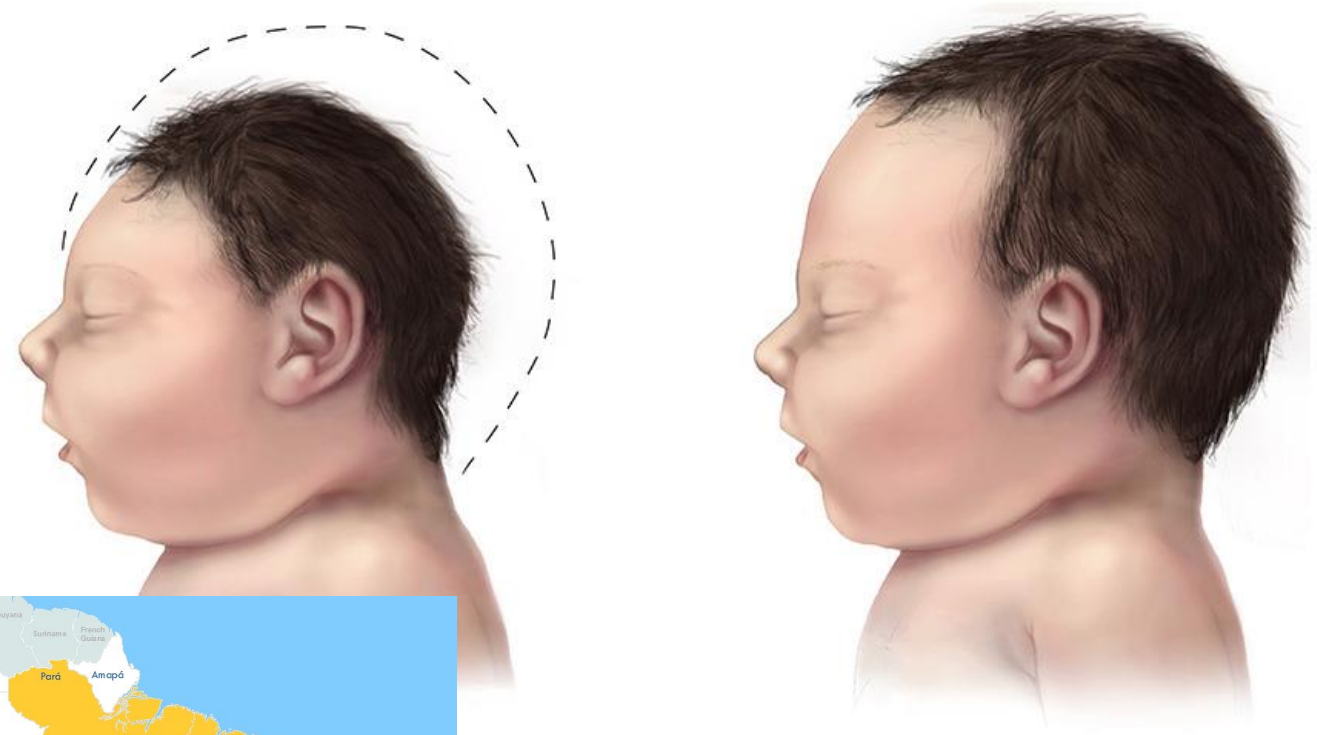
2016
Jan
2017

2015



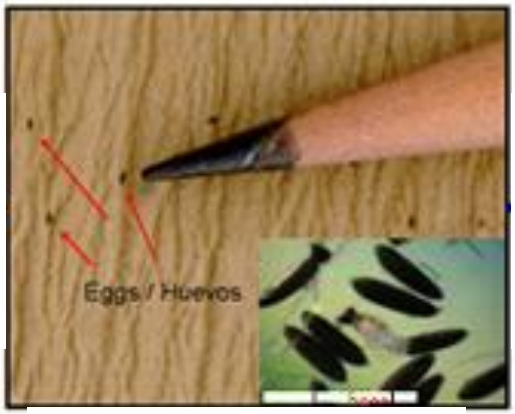
Up to January 2018:
223,734 confirmed cases;
>3720 recorded Zika babies;

1. Could we have seen this coming?
2. **What are our current and future risks?**
3. What can we do about it?

2. What are our current and future risks?

- Mosquito life cycle
- Disease transmission cycle
- Risk assessment

Life cycle of *Aedes aegypti* L.



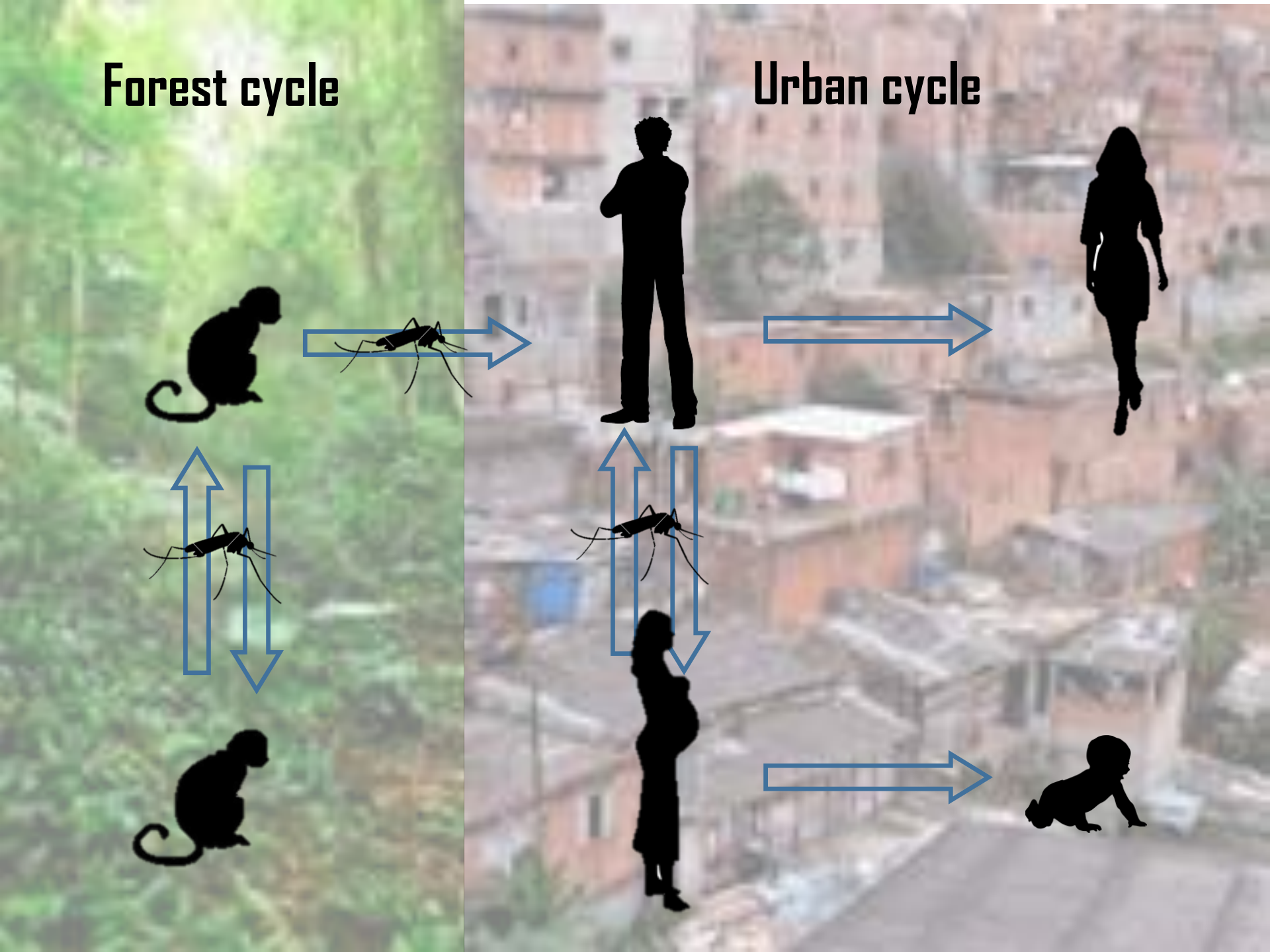
Eggs

Larvae (1-4)

Pupae

Adults

Source: cdc.gov


Forest cycle
Urban cycle

Growing threat: urban centres and *Aedes aegypti* distribution

By 2050, > 66%of world population in urban centres

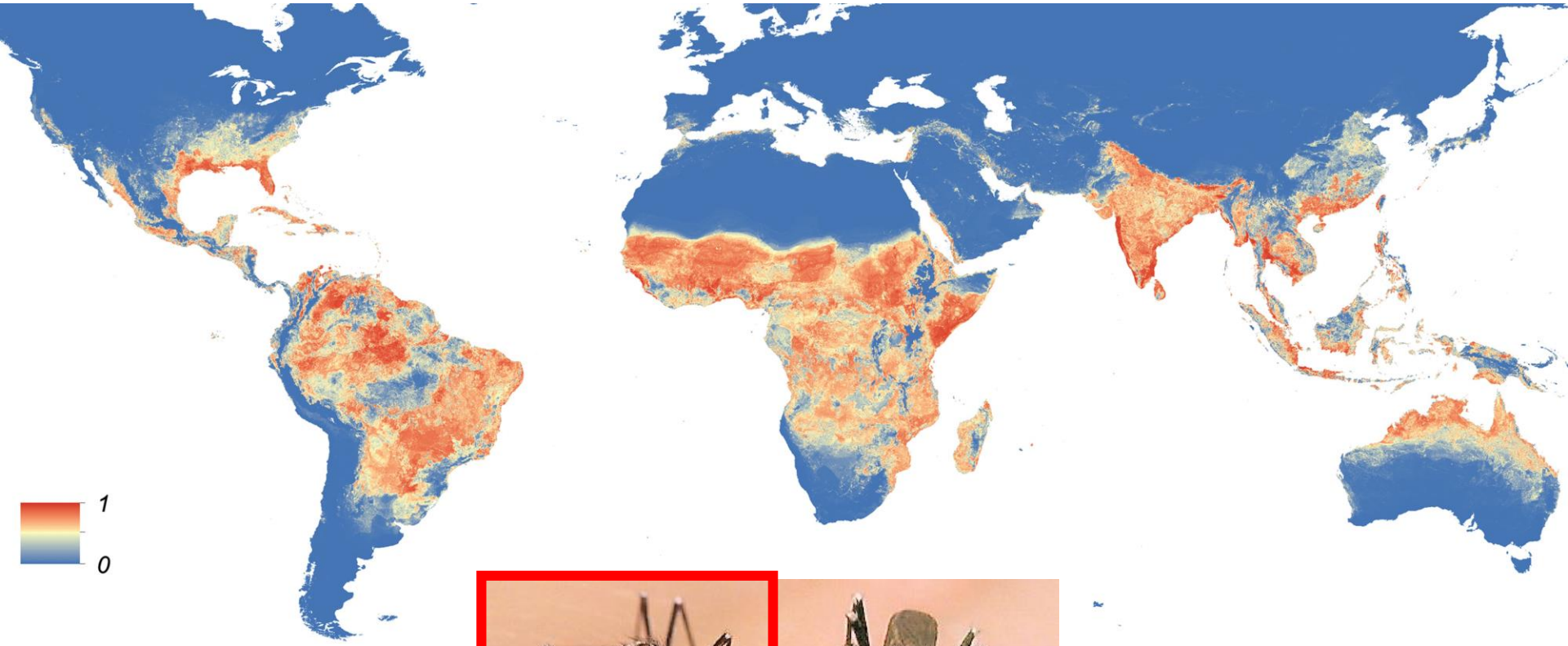
Lindsay et al., *Bull WHO* 2017

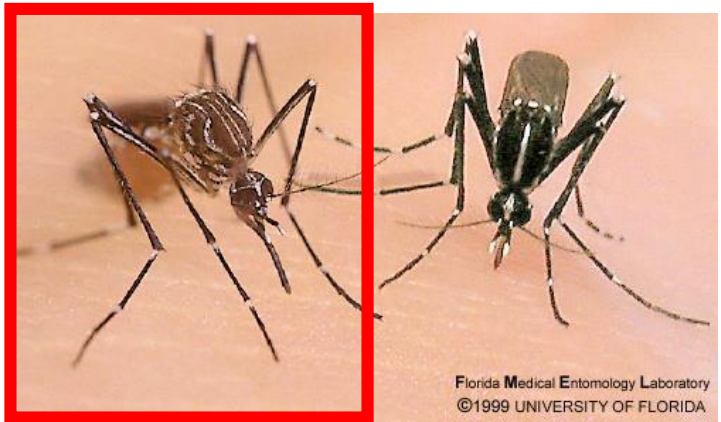






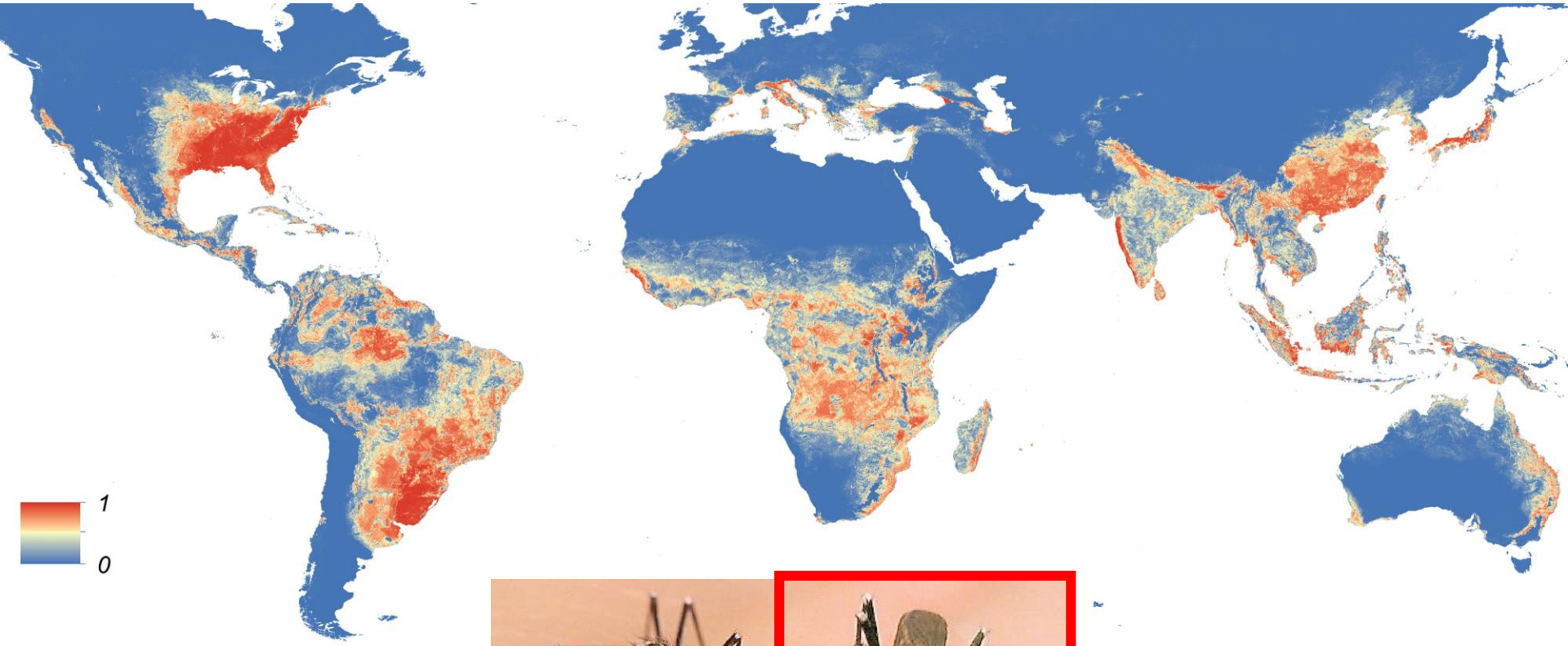
Predicted distribution of *Ae. aegypti*

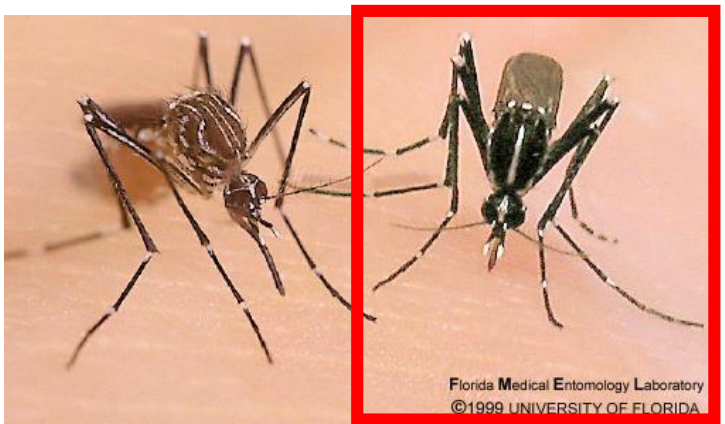




Kraemer et al., 2015

Predicted distribution of *Ae. albopictus*





Kraemer et al., 2015

Risk assessment

Introduction routes

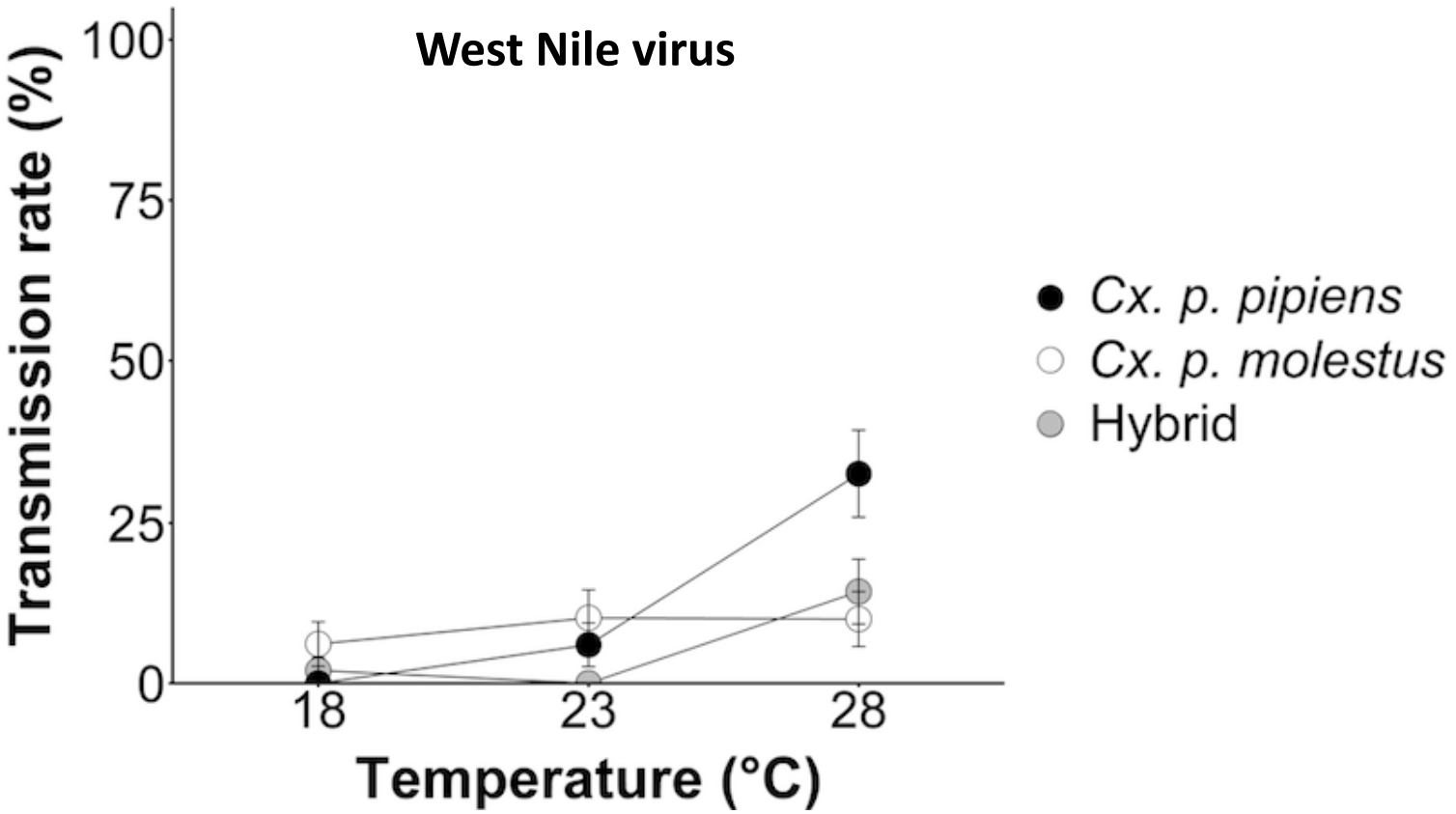
Susceptibility of mosquitoes

Models

$$R_0 = \frac{ma^2bcp^n}{r(-\ln p)}$$

Risk assessment: susceptibility of mosquitoes: ‘milking mosquitoes’

Risk assessment: susceptibility of mosquitoes: ‘milking mosquitoes’



Vogels et al., 2016

1. Could we have seen this coming?
2. What are our current and future risks?
3. **What can we do about it?**

3. What can we do about it?

- Mosquito control: current efforts
- New technologies & innovations

Insecticides against adults and larvae

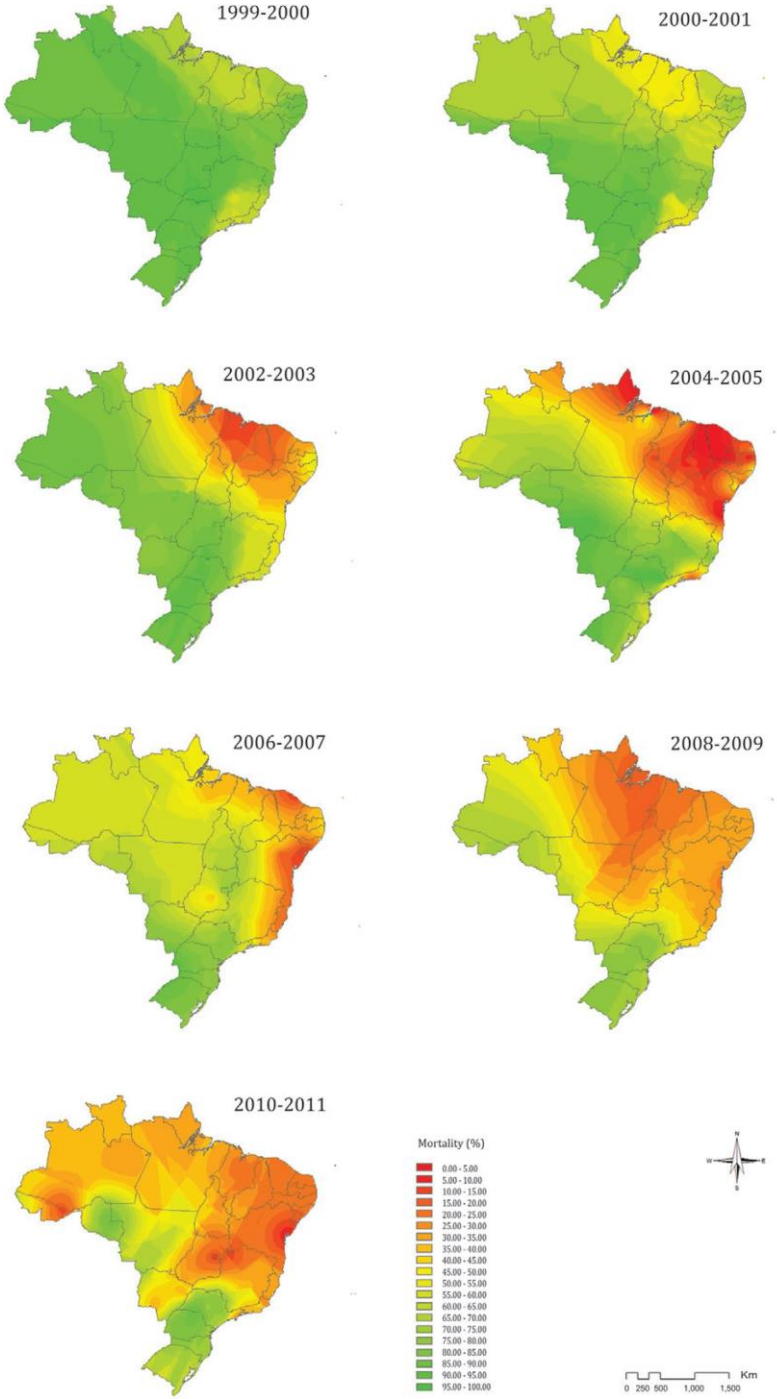
Fogging against mosquitoes outdoors, Brazil 2016

Insecticides against adults and larvae

Fogging against mosquitoes in a church, Brazil 2016

Insecticides against adults and larvae

Fogging against mosquitoes in houses, Brazil 2016



Spread of resistance to temephos in *Aedes aegypti*, Brazil, 1999-2011

Chediak et al, 2016

Community engagement in removal of breeding sites

Suriname, February 2016

Alternative tools: RIDL (GMO)

RIDL = Release of Insects carrying a Dominant Lethal gene, aimed to kill females by genetic strategy

Example: release of sterile mosquitoes in Piracicaba, Brazil (2017) to eradicate the mosquito population

Newsweek | International Business Times

Activists in Florida block release of GM mosquitoes which could suppress Zika outbreak

18 Aug. 2016

TIME

INFECTIOUS DISEASE

Genetically Modified Mosquitoes Divide Florida Residents

9 Nov. 2016

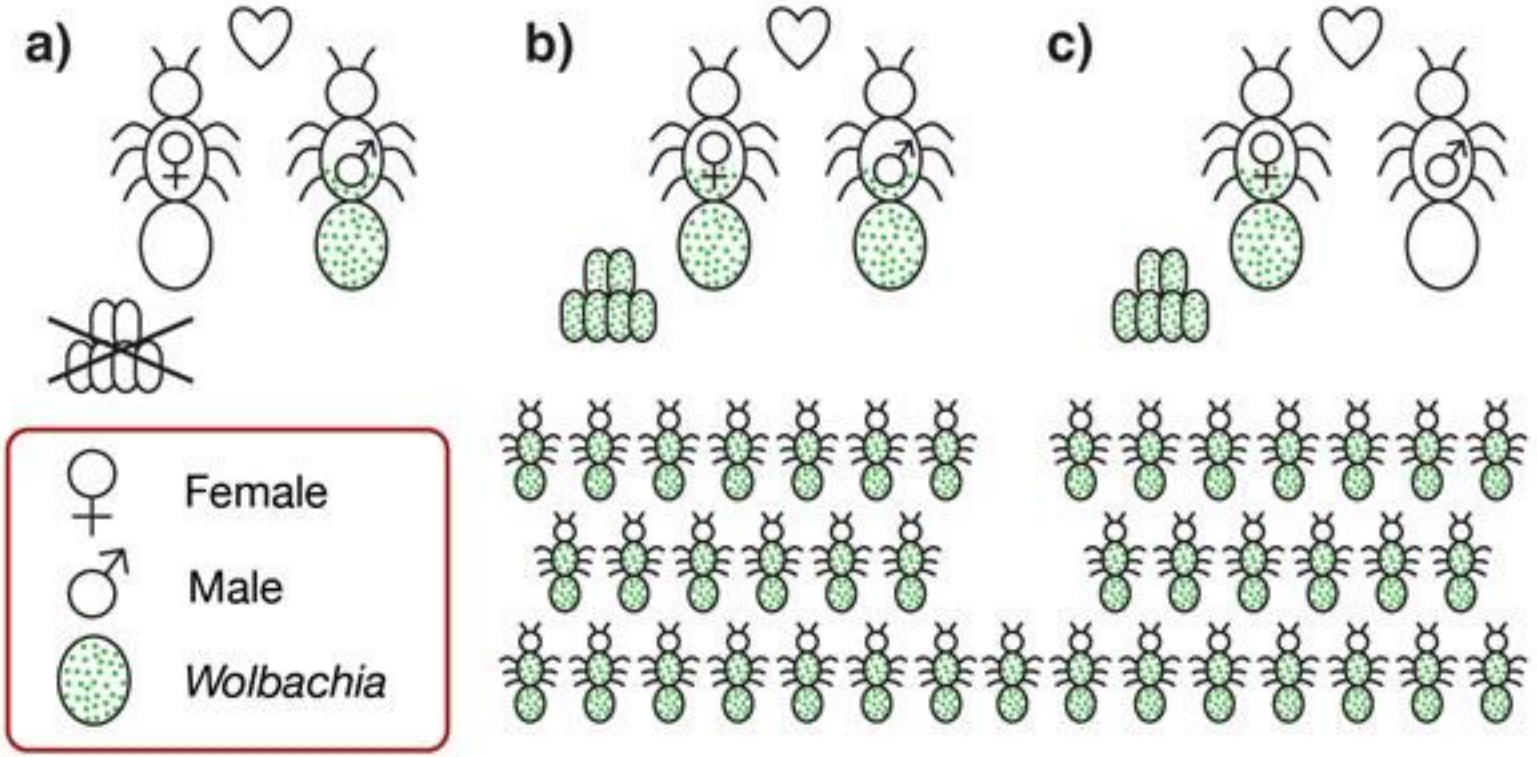
Alternative tools: *Wolbachia*

Release of *Wolbachia* carrying mosquitoes to

a) reduce population size
b) replace population with *Wolbachia*-transfected mosquitoes

Source: World Mosquito Program, 2018

How *Wolbachia* spreads in the wild mosquito population



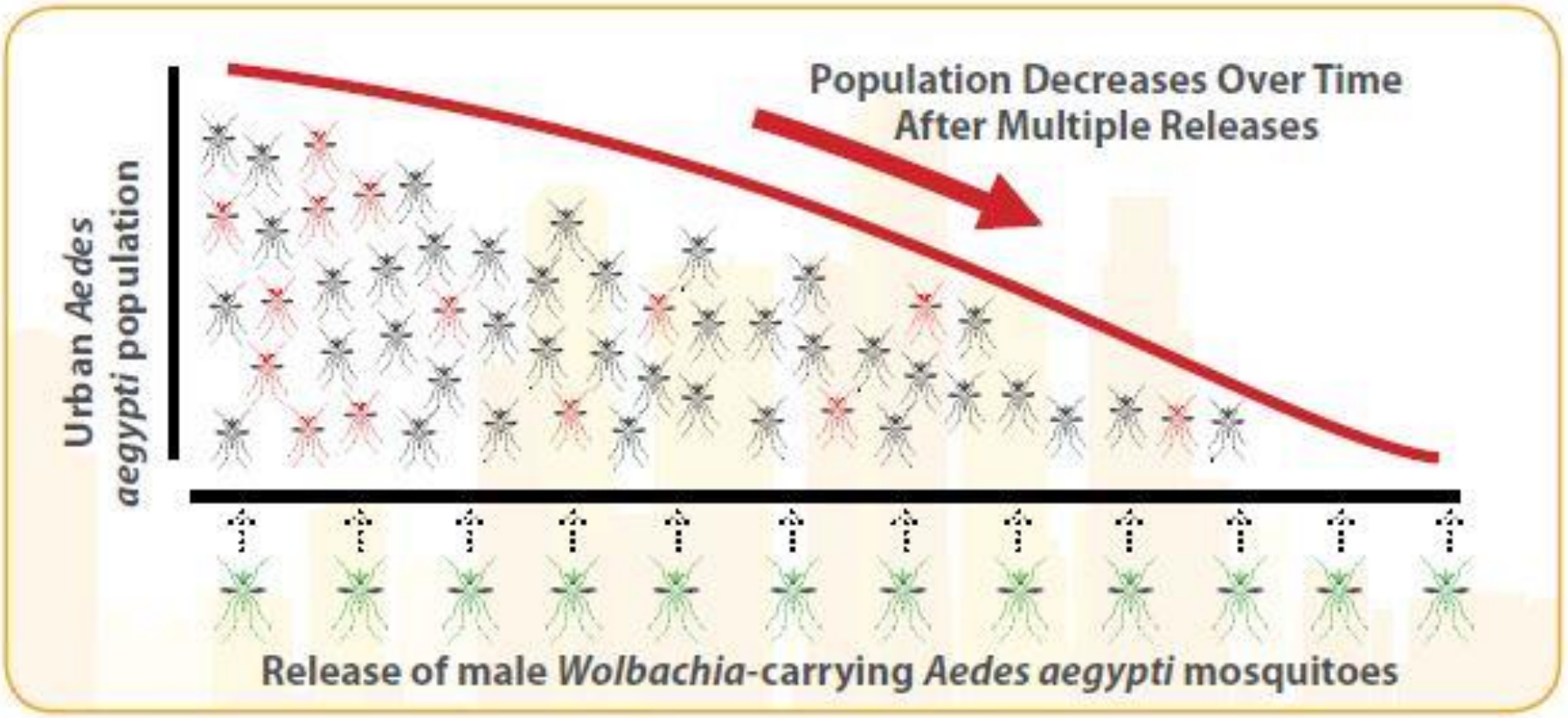
The diagram above explains **Cytoplasmic Incompatibility** and how by releasing a limited number of mosquitoes with *Wolbachia* to breed with wild type mosquitoes, over a small number of generations, will result in all the mosquitoes having *Wolbachia*.

a) When male mosquitoes with *Wolbachia* mate with female wild mosquitoes that don't have *Wolbachia* those females will have eggs but they won't hatch.

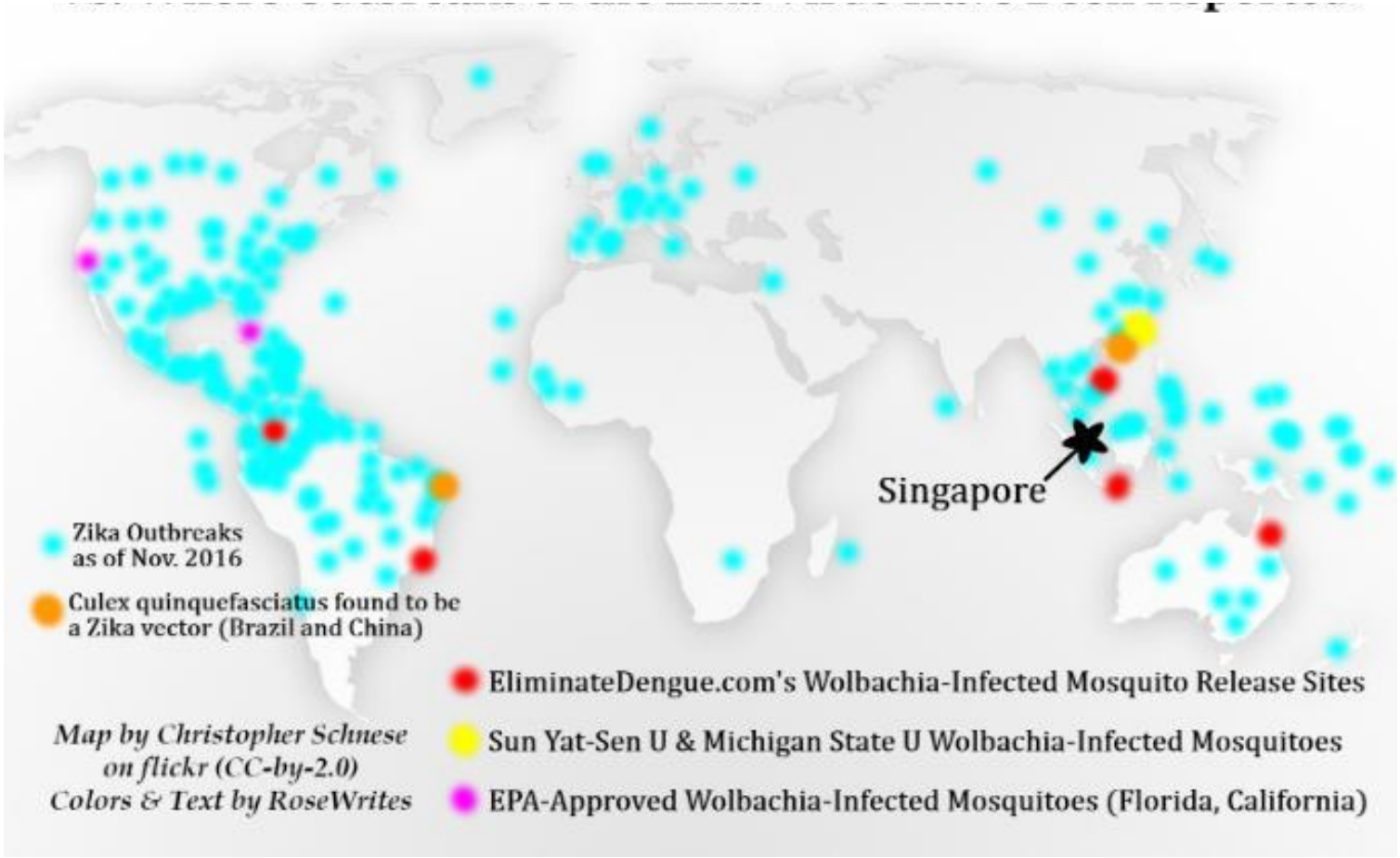
b) When male mosquitoes with *Wolbachia* mate with females that are already carrying *Wolbachia* the mating will be normal and the offspring will all have *Wolbachia* .

c) When female mosquitoes with *Wolbachia* mate with males without *Wolbachia* all her offspring will have *Wolbachia*.

Alternative tools: *Wolbachia*

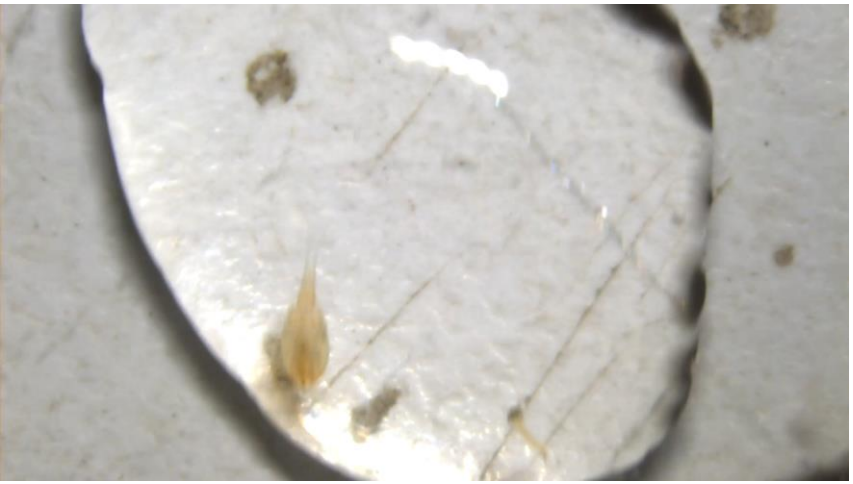


Sites for release of *Wolbachia*-transfected mosquitoes



Source: World Mosquito Program, 2018

Alternative tools: biological control



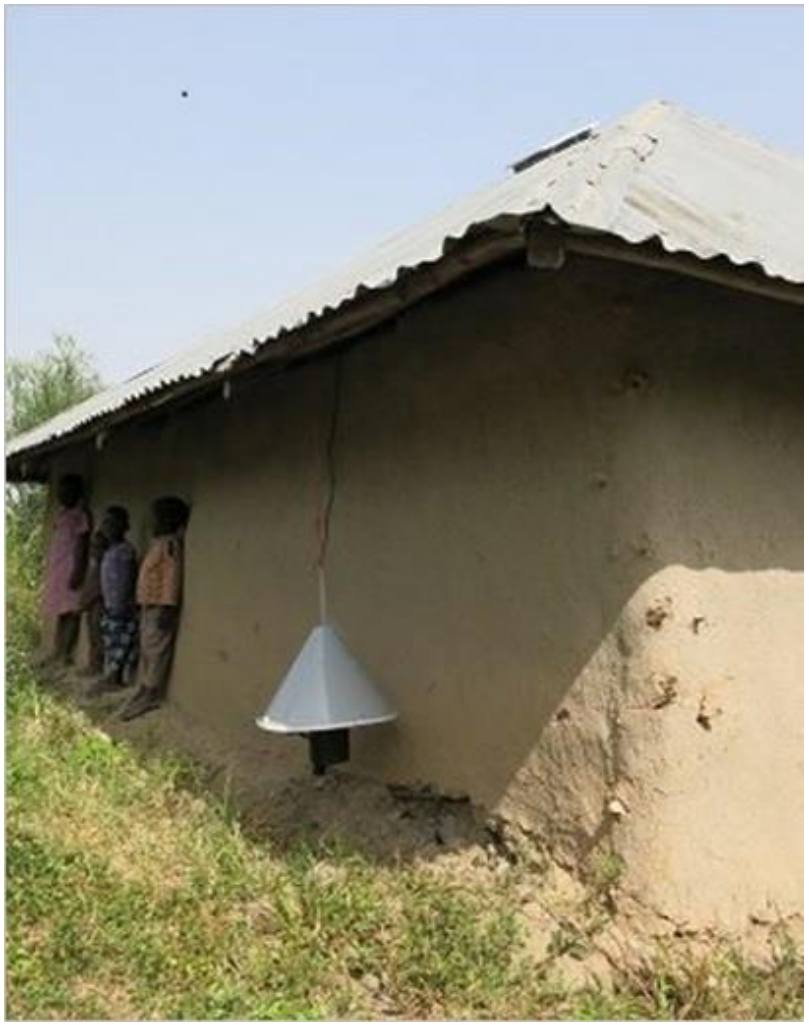
Release or application of *natural enemies* to reduce population size:

- Fungi
- Fish
- Bacteria
- Copepods
- and more…

Movie credits: Wim van Egmond (up); Joeri Groot (bottom)

Alternative tools: removal trapping

- attracting mosquitoes to odour-baited traps -



Homan et al., *Lancet* 2016

1. **Could we have seen this coming?**
   Not at this scale

2. **What are our current and future risks?**
   Risks are perceived ”high”

3. **What can we do about it?**
   Integrated vector management & vaccination

CONCLUSION

- Arboviral diseases occur worldwide
- *Aedes aegypti* most common vector of multiple arboviruses
- Poverty and rapid urbanization enhance the public health threat caused by *Aedes aegypti*
- Arboviral diseases are prone to invading ”new” continents
- Insecticidal control of arbovirus vectors not effective
- Vector control most effective way of preventing outbreaks; novel methods of vector control are being developed that show great promise in effectiveness


THANK YOU