Artropodi e clima
Che ruolo hanno i cambiamenti climatici sulle popolazioni di artropodi ?
Dipartimento di Scienze mediche veterinarie-Università di Bologna- Ozzano Emilia
10 Maggio 2019

# Il ruolo della densità dei vettori nel rischio epidemiologico


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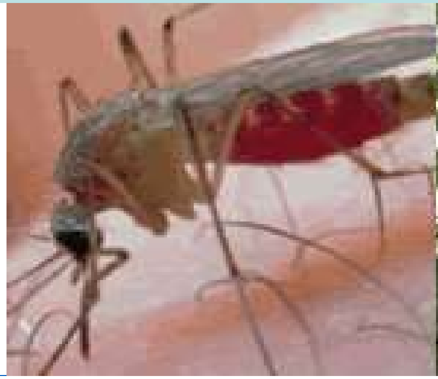
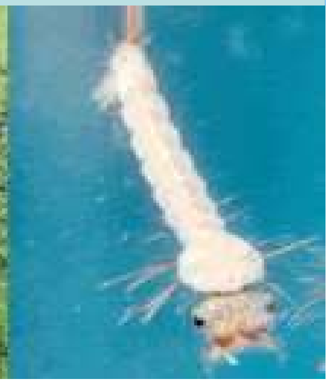
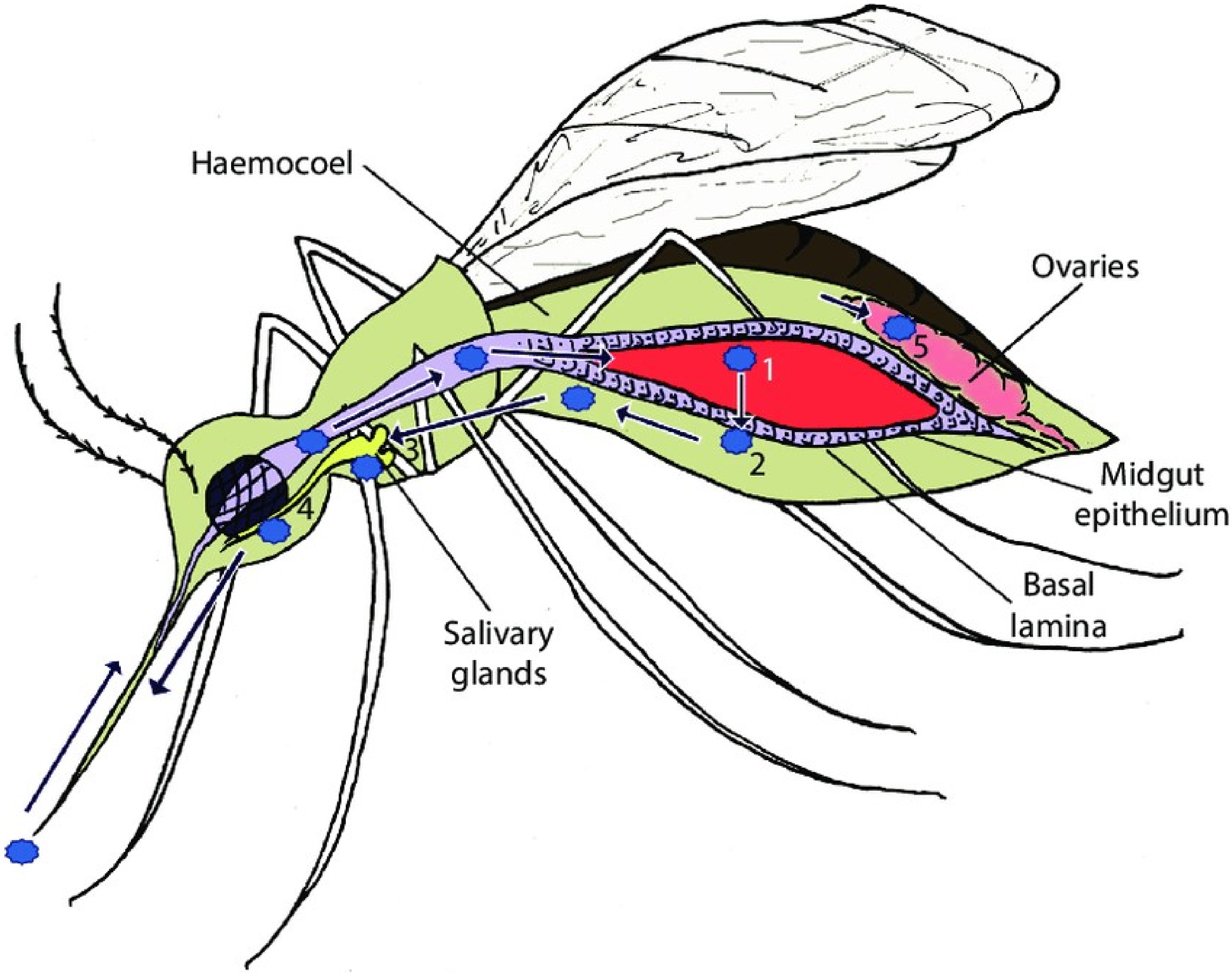
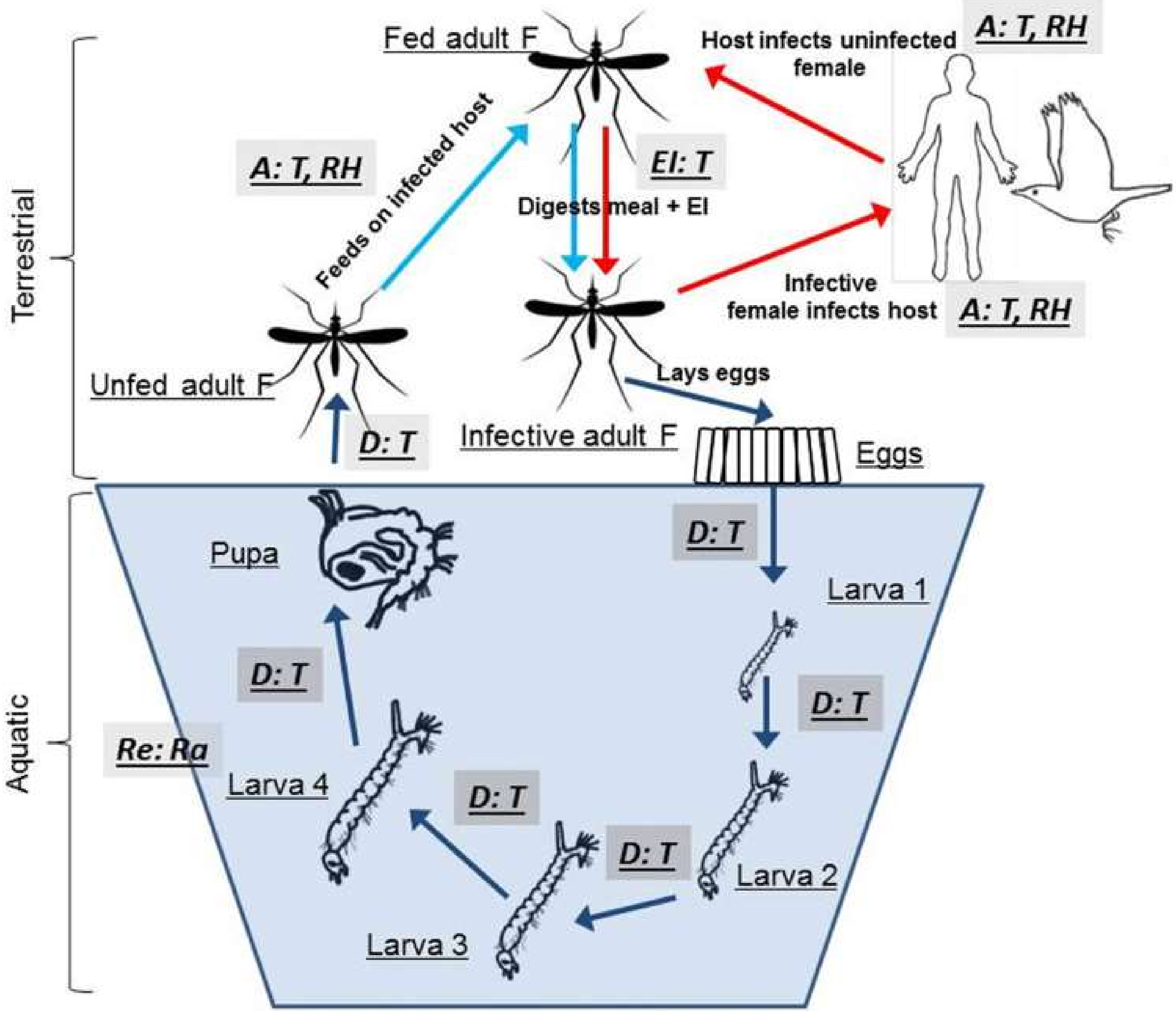
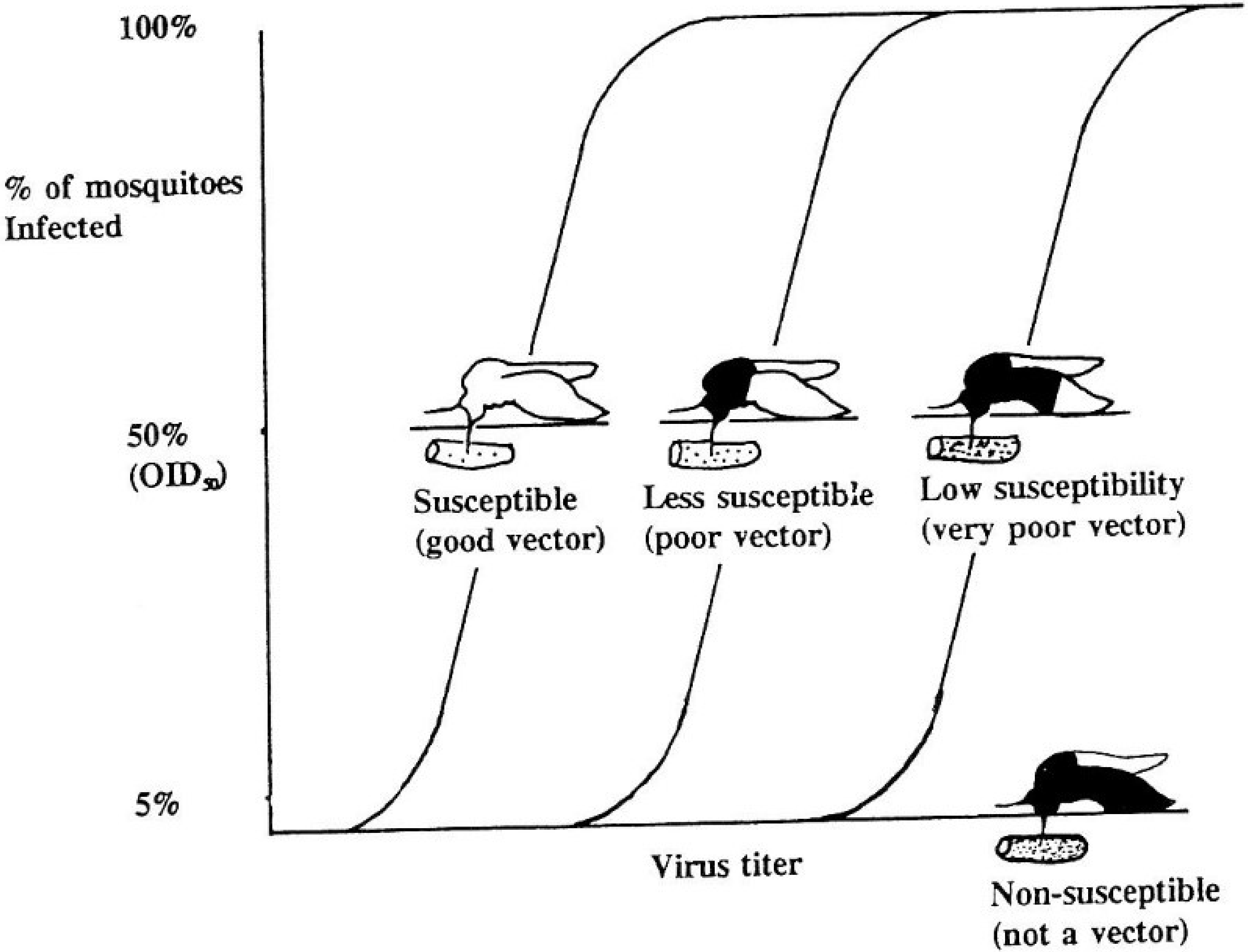
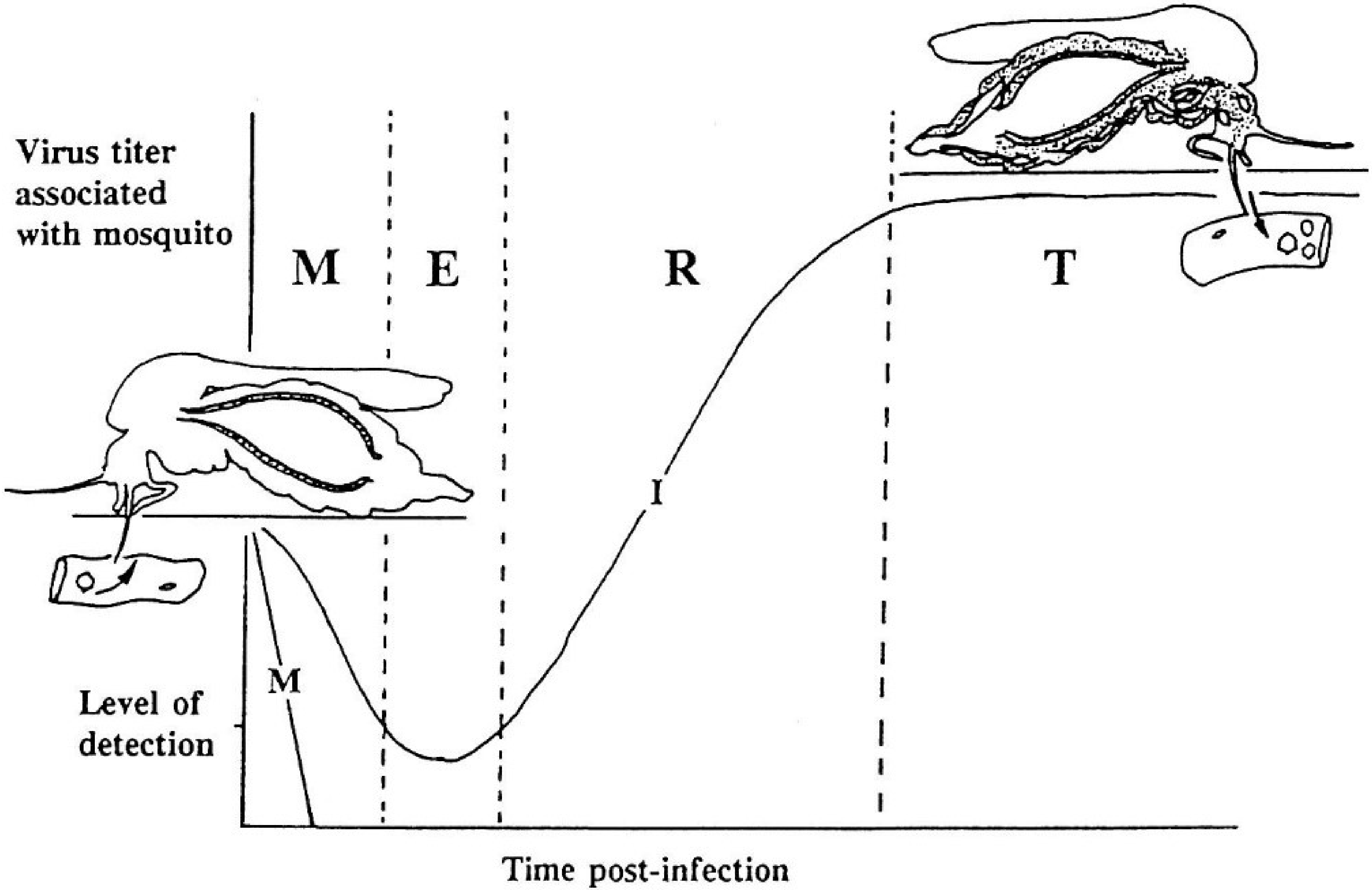



Haemocoel
Ovaries
1
5
3
2
4
Midgut
epithelium
Basal
lamina
Salivary
glands


Terrestrial
Aquatic
Fed adult F
Host infects uninfected female
A: T, RH
A: T, RH
Feeds on infected host
EI: T
Digests meal + EI
Infective female infects host
A: T, RH
Unfed adult F
Lays eggs
D: T
Infective adult F
Eggs
D: T
Pupa
Larva 1
D: T
D: T
Re: Ra
Larva 4
D: T
D: T
Larva 2
Larva 3


100%
% of mosquitoes Infected
50% (OID50)
5%
Susceptible (good vector)
Less susceptible (poor vector)
Low susceptibility (very poor vector)
Virus titer
Non-susceptible (not a vector)


Virus titer
associated
with mosquito
M
E
R
T
I
M
Level of
detection
Time post-infection

# METHODS & TOOLS AEDES

- House Index
- Container Index
- Breteau Index
- Number of pupae/premise (PG)
- Number of pupae/Ha (PHa)
- Ovitrap data
- Gravid trap
- Sticky trap
- BG-trap
- Human Landing Collection (HLC)

Table 6.1: Examples of how diverse environmental changes affect the occurrence of various infectious diseases in humans (Refernce 5)

| Environmental changes | Example diseases | Pathway of effect |
|---|---|---|
| Dams, canals, irrigation | Schistosomiasis | ▲ Snail host habitat, human contact |
| | Malaria | ▲ Breeding sites for mosquitoes |
| | Helminthiasies | ▲ Larval contact due to moist soil |
| | River blindness | ▼ Blackfly breeding, ▼ disease |
| Agricultural intensification | Malaria | Crop insecticides and ▲ vector resistance |
| | Venezuelan haemorraghic fever | ▲ rodent abundance, contact |
| Urbanization, urban crowding | Cholera | ▼ sanitation, hygiene; ▲ water contamination |
| | Dengue | Water-collecting trash, ▲ *Aedes aegypti* mosquito breeding sites |
| | Cutaneous leishmaniasis | ▲ proximity, sandfly vectors |
| Deforestation and new habitation | Malaria | ▲ Breeding sites and vectors, immigration of susceptible people |
| | Oropouche | ▲ contact, breeding of vectors |
| | Visceral leishmaniasis | ▲ contact with sandfly vectors |
| Reforestation | Lyme disease | ▲ tick hosts, outdoor exposure |
| Ocean warming | Red tide | ▲ Toxic algal blooms |
| Elevated precipitation | Rift valley fever | ▲ Pools for mosquito breeding |
| | Hantavirus pulmonary syndrome | ▲ Rodent food, habitat, abundance |

Da WHO-WMO-UNEP Climate Change and Human Health

# Climate change impacts

- Life-cycles of vectors
- Environment and ecology of vectors
- Life-cycles of reservoirs
- Life-cycles of pathogen
- Human behaviour
- Geographical distribution of vectors (latitude & altitude)
- Seasonality (risk periods)
- Establishment of new vector species

**DENV-CHIKV-ZIKAV-YFV //**
***Aedes albopictus***

**WEST NILE //** ***Culex pipiens***

# *Aedes albopictus*

- **exotic species**
- **first detection in Europe:** 1978, Albania
- **larval habitat**: artificial containers, three holes
- **ethology**: female actives daily, very aggressive
- **hosts**: opportunistic
- **overwintering**: diapausing eggs

# COMPETENZA VETTORIALE *AEDES ALBOPICTUS (1)*

## FLAVIVIRIDAE

| | infezione | trasmissione | |
|---|---|---|---|
| Dengue | +++ | +++ | Mitchell et al., 1987 |
| | +++ | +++ | in Mitchell, 1991 |
| Den-1 | +++ | +++ | Vega-Rua et al., 2013 |
| Den-1/Den-2 | ++ | + | Brustolin et al., 2018 |
| JEV 3,5 | +++ | +++ | de Wispelaere, 2017 |
| St. Louis E. | + | + | Savage et al., 1994 |
| Usutu | + | + | Puggioli et al., 2017 |
| | - | - | Cook et al., 2018 |
| West Nile | +(?) | +(?) | in Shroyer, 1986 |
| | +++ | +++ | Turell et al., 2001 |
| | +++ | +++ | Sardelis et al., 2002 |
| Zika | +++ | +++ | Wong et al., 2013 |
| | ++ | + | Chouin-C. et al., 2016 |
| | ++ | + | Jupille et al., 2016 |
| | ++ | + | Di Luca et al., 2016 |
| | ++ | + | Heitmann et al., 2017 |
| Yellow fever | ++ | ++ | in Mitchell, 1991 |
| | ++ | + | Amraoui et al., 2016 |
| | +++ | + | Couto-Lima et al.,2017 |

+++alta; ++moderata; +bassa; -assente; (?)non determinata

# COMPETENZA VETTORIALE *AEDES ALBOPICTUS* (2)

## TOGAVIRIDAE

| | infezione | trasmissione | |
|---|---|---|---|
| Eastern Equine E. | +++ | ++ | Turell et al., 1994 |
| Western Equine E. | +++ | +++ | in Mitchell, 1991 |
| Venez. Equine E. | +++ | ++ | Turell e B.,1992 |
| Ross River | ++ | ++ | Mitchell et al., 1987 |
| Mayaro | ++ | ++ | in Mitchell, 1991 |
| <u>Chikungunya</u> | +++ | ++ | Mangiafico, 1971 |
| | ++ | ++ | Tesh et al., 1976 |
| | +++ | ++ | Turell et al., 1992 |
| 226A/A226V | +++ | +++ | Vazeille et al., 2007 |
| A226V | +++ | ++ | Bellini et al., 2012 |
| A226V | +++ | ++ | Vega-Rua et al.,2013 |
| A226V | +++ | +++ | Severini et al., 2018 |
| Sindbis | +(?) | +(?) | in Mitchell, 1994 |
| | ++ | ++ | Dohm et al., 1995 |

+++alta; ++moderata; +bassa; -assente; (?)non determinata

# COMPETENZA VETTORIALE *AEDES ALBOPICTUS (3)*

## BUNYAVIRIDAE

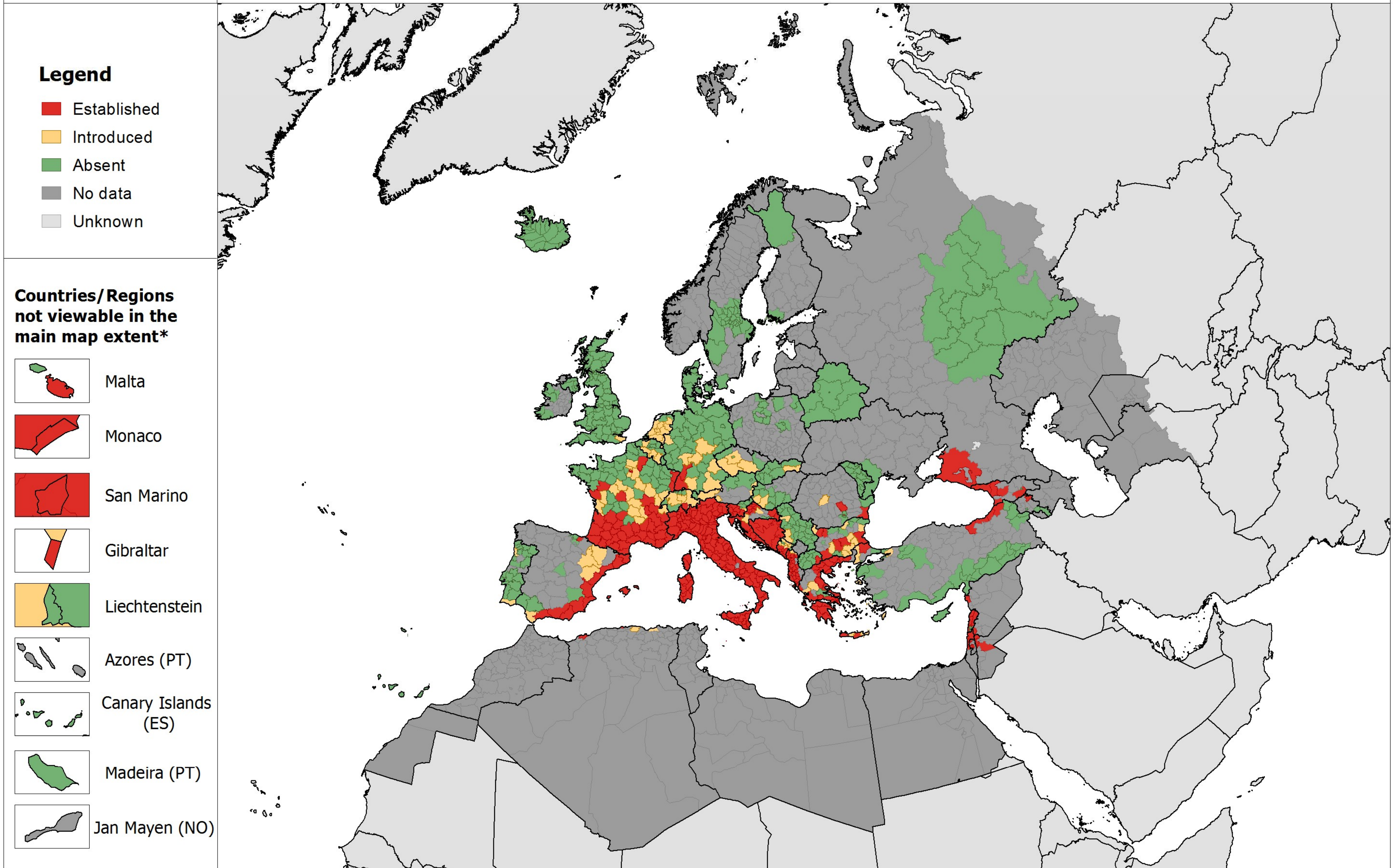
| | infezione | trasmissione | |
|---|---|---|---|
| LaCrosse | +++ | ++ | in Mitchell, 1991 |
| Jamest. Canyon | +++ | + | in Mitchell, 1991 |
| Keystone | +++ | - | in Mitchell, 1991 |
| Oropouche | + | - | in Mitchell, 1991 |
| Potosi | + | + | in Mitchell, 1991 |
| Rift Valley Fever | ++ | + | in Mitchell, 1991 |
| Tahyna | + | (?) | Portolani et al., 2001 |
| Trivittatus | + | - | in Mitchell, 1991 |

## REOVIRIDAE

| | | | |
|---|---|---|---|
| Orungo | +(?) | +(?) | in Shroyer, 1986 |

+++alta; ++moderata; +bassa; -assente; (?)non determinata

## *Aedes albopictus*, January 2019



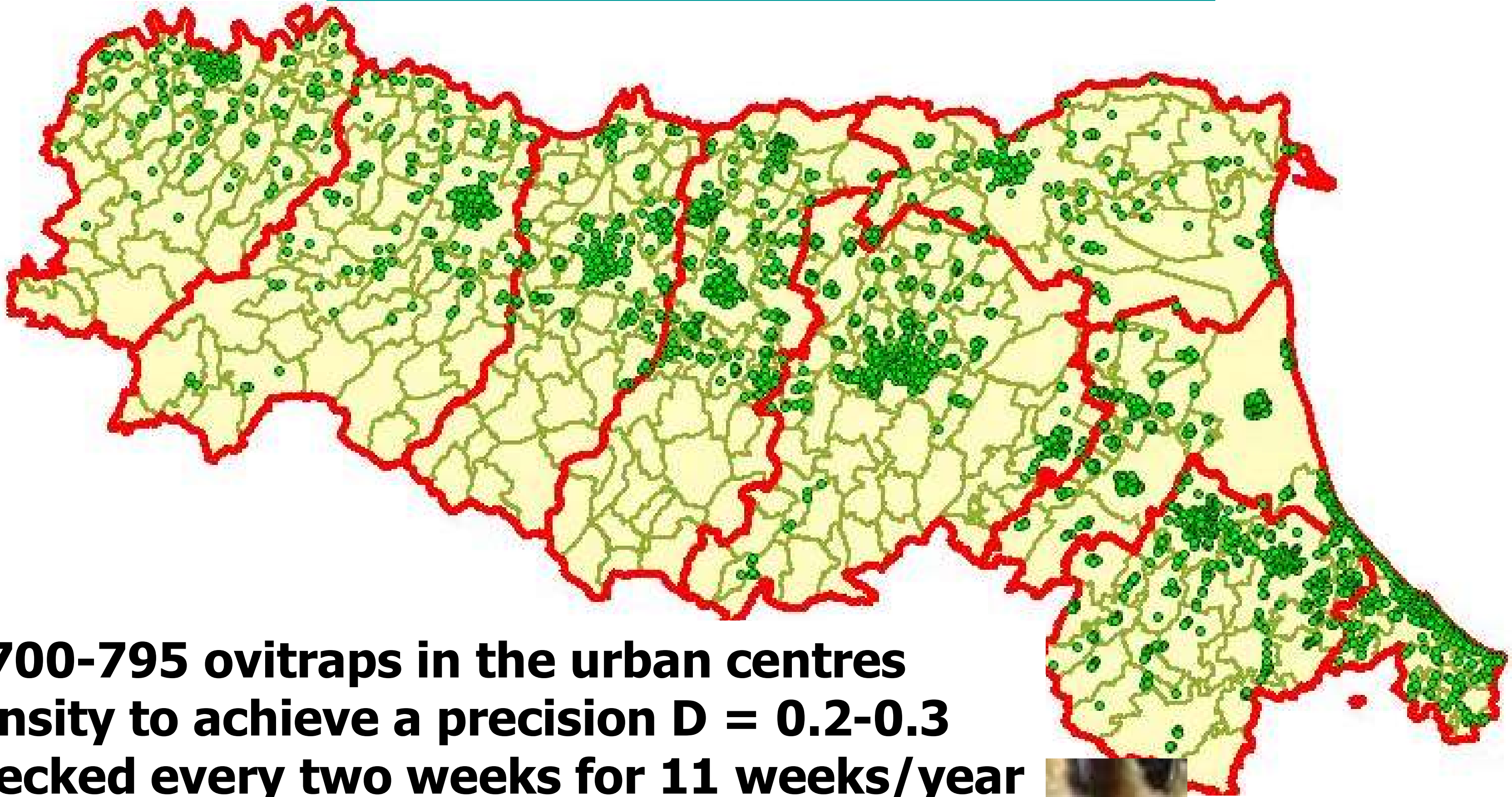

ECDC and EFSA, map produced on 16 Jan 2019. Data presented in this map are collected by the VectorNet project. Maps are validated by external experts prior to publication. Please note that the depicted data do not reflect the official views of the countries. * Countries/Regions are displayed at different scales to facilitate their visualisation. Administrative boundaries © EuroGeographics, UNFAO, TurkStat.

# Eventi di trasmissione autoctona DENV e CHIKV in Europa

| | |
|---|---|
| 2007 | Italy, Emilia-Romagna region. CHIKV E1-A226V ≈ 330 cases |
| 2010 | Croatia, Pelješac peninsula. DENV-1 <20 suspected cases by serology |
| 2010 | France, Alpes-Maritimes. DENV-1 2 cases |
| 2010 | France, Var department. CHIKV E1-A226 2 cases |
| 2012 | Portugal, Madeira island. DENV-1 ≈ 2100 cases |
| 2013 | France, Bouches du Rhône. DENV-2 1 case |
| 2014 | France, Hérault department. CHIKV E1-A226V 11 cases |
| 2014 | France, Var department. DENV-1 1 case |
| 2014 | France, Var department. DENV-2 1 case |
| 2014 | France, Bouches du Rhône. DENV-2 2 cases |
| 2015 | France, Gard department. DENV-1 6 cases |
| 2017 | France, Var department. CHIKV E1-A226V 17 cases |
| 2017 | Italy, Lazio/Calabria regions. CHIKV 489 cases |
| 2018 | France, Alpes Maritimes. DENV-2 5 cases |
| 2018 | France, Hérault. DENV-1 1 cases |
| 2018 | Spain, Cadiz(?). DENV 5 cases |

**da ECDC modificato**

# Quantitative monitoring of *Aedes albopictus*
# Emilia-Romagna (4.4 ML inhabitants)
# http://www.zanzaratigreonline.it/



- -2,700-795 ovitraps in the urban centres
- -density to achieve a precision D = 0.2-0.3
- -checked every two weeks for 11 weeks/year

# Person product moment correlations (R)

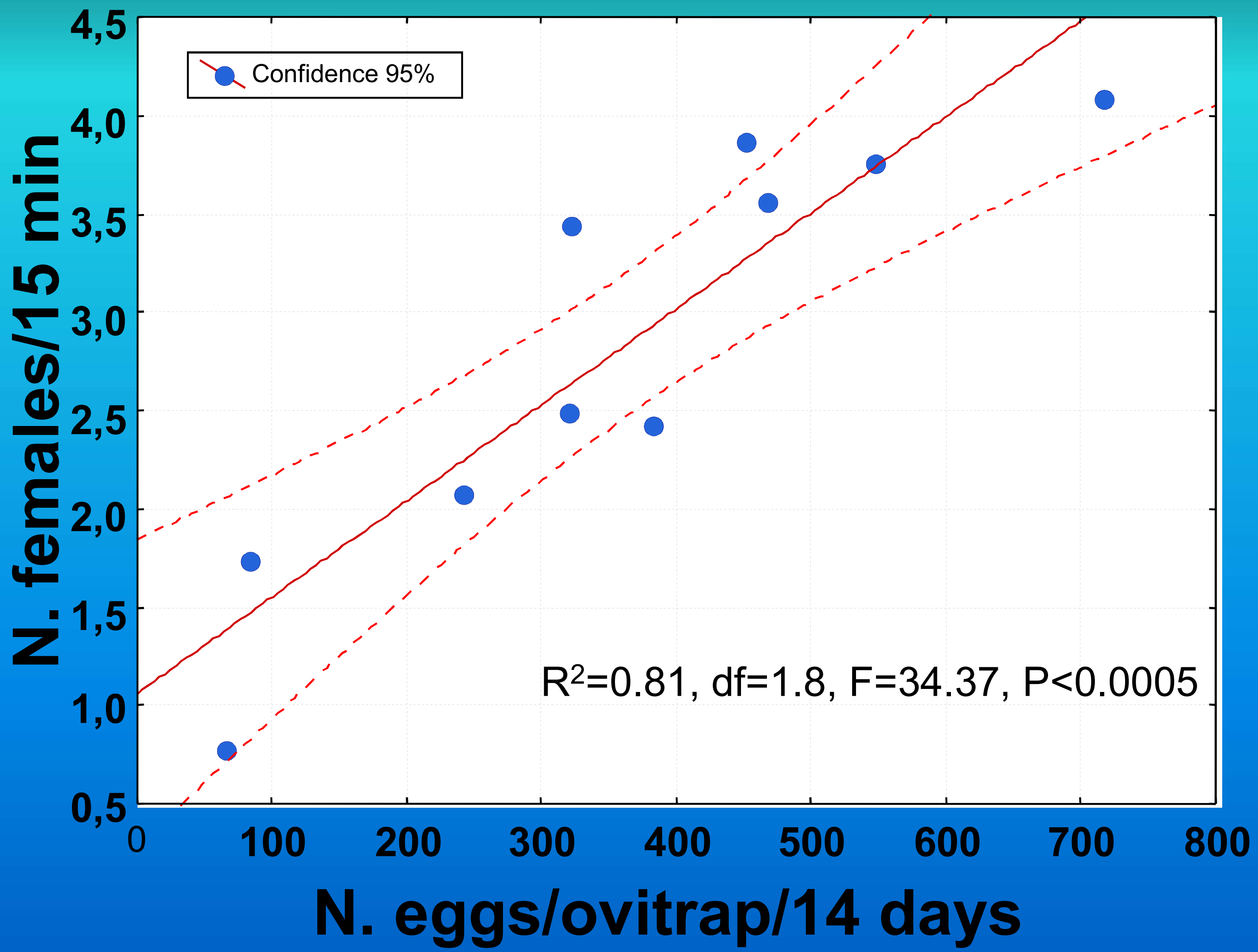
| Sampling method | Mean number of eggs/week/ovitrap | | |
|---|---|---|---|
| | Previous week | Sampling week | Following week |
| PDS – Pupae per hectare | 0.1703 | 0.3396 | 0.8622** |
| NBC – (No. bites received the day before the adult sampling) | 0.6279 | 0.7243* | 0.6318 |
| HLC – (No. biting females caught in 15 min) | 0.7092* | 0.8604** | 0.7013* |

*Rate between bites/human/day and mean egg density*.

We defined *B* the rate between the number of bites per human per day (*ma*) calculated by means PDS, NBC and HLC and the average egg density per week (*E*) calculated from the data provided by the ovitraps

$$B = ma / E$$

# Correlation between HLC and N. eggs



# Epidemiological equation for VBD

N bites/human/day

Vectorial competence

Length extrinsic cycle

$$R_0 = \frac{ma^2 * V * P^n}{-\log_e P}$$

Daily survival

Log daily survival

CENTRO agricoltura ambiente "Giorgio Nicoli"

# Parameters in the $R_0$ equation

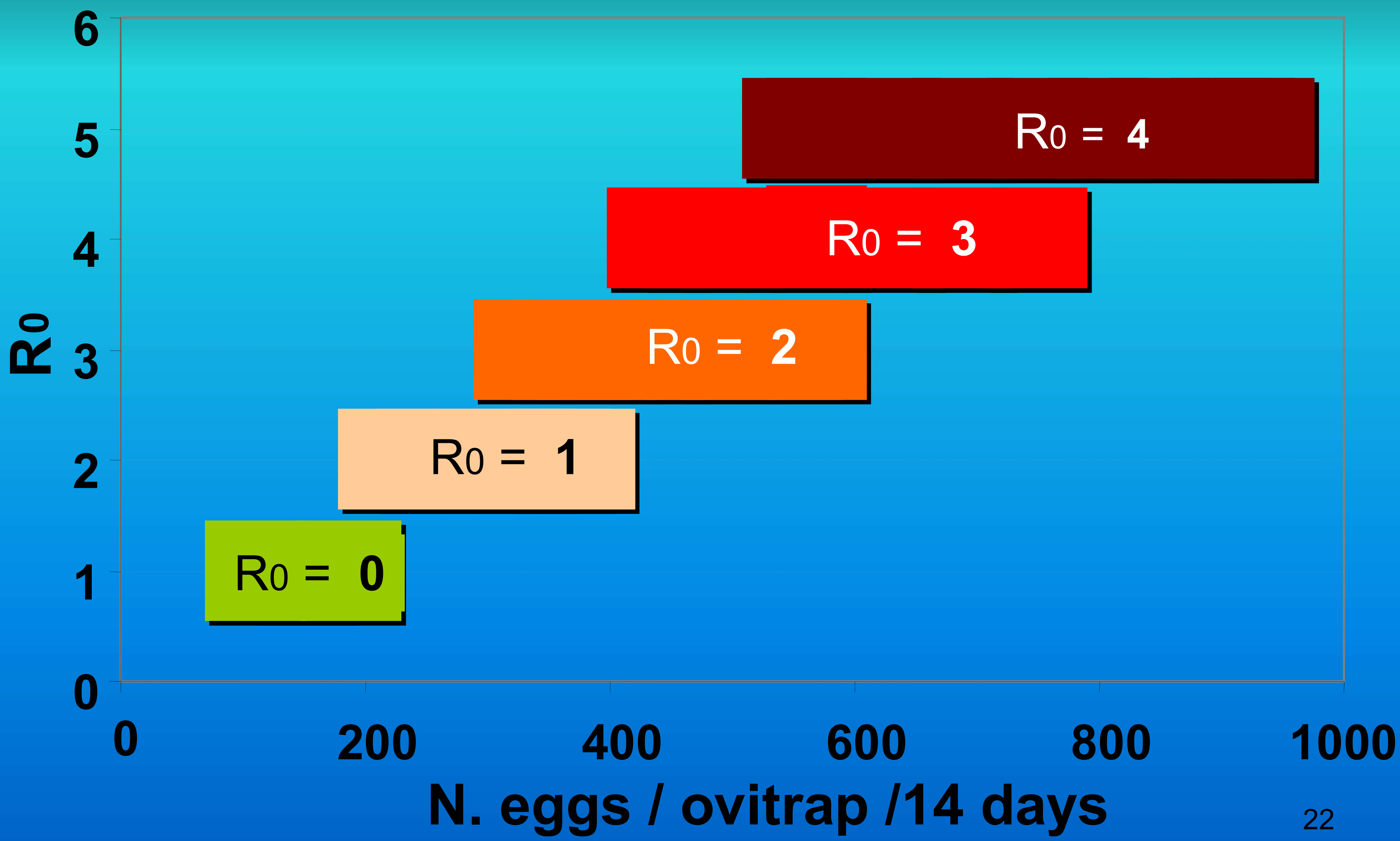
| Parameter | Label | Value | Reference |
|---|---|---|---|
| Multifeeding/gonotrophic cycle | *mF* | 1.20 | Hawley 1988 |
| Host Feeding Pattern | *AI* | 0.86-0.96 | Valerio et al. 2010 |
| Gonotrophic cycle | *GC* | 4 - 11 days | Calculated in function of temperature by means the model of Focks et al. 1993. |
| Vector competence | *Sm* | Chik.: 24 – 80% | Vazeille et al. 2007<br>Talbalaghi et al. 2010<br>Mitchell 1991 |
| Viremia | *V* | 6 days | Peters and Dalrymple 1990<br>Boelle et al. 2008 |
| Females daily survival rate | *p* | 0.90 | Hawley 1988<br>Willis and Nasci 1994<br>Almeida et al. 2005 |
| Extrinsic incubation period | *i* | EIP=0.71GC | Dubrulle et al. 2009<br>Hawley 1988 |
| Population susceptibility to Dengue and CHIKV | *Sv* | 1 | Moro et al. 2010 |
| Vectorial capacity correction factor | $X_V$ | 0.101 | Calculated |
| Bites per Egg Rate | *B* | PDS: 0.033 ± 0.015<br>HLC: 0.042 ± 0.021<br>NBC: 0.027 ± 0.028 | Calculated |

# R0 value estimated in the CHIK epidemic 2007 Italy

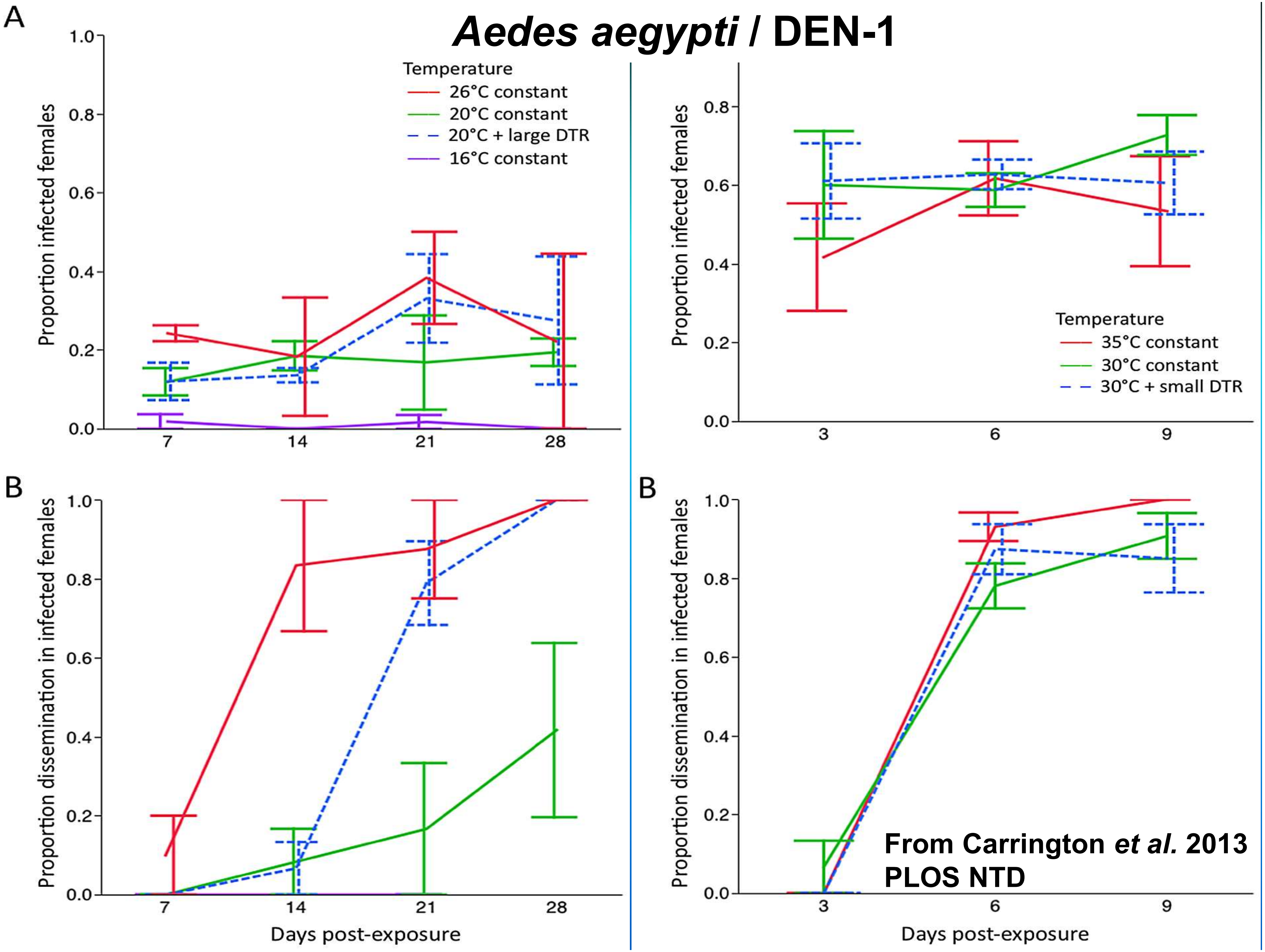
| Method | $R_0$ | |
|---|---|---|
| | mean | 95% CI |
| intrinsic growth rate | 3.62 | (3.11, 4.21) |
| fitting data | 3.93 | (3.17, 4.79) |

From Rizzo et al. 2008

# Relation between egg densities and R0



# *Aedes aegypti* / DEN-1



# WEST NILE VIRUS // *CULEX*

- Family Flaviviridae, genus Flavivirus
- The most widespread arbovirus in the world
- Epidemiology & vectors differ between regions

# Sorveglianza entomologica WNV

***Culex pipiens &***
***Culex modestus***

RT-PCR

**POOLS**
- monospecie
- monodata
- monostazione

**Periodicità bisettimanale**

# CASI WNND PER PAESE EU

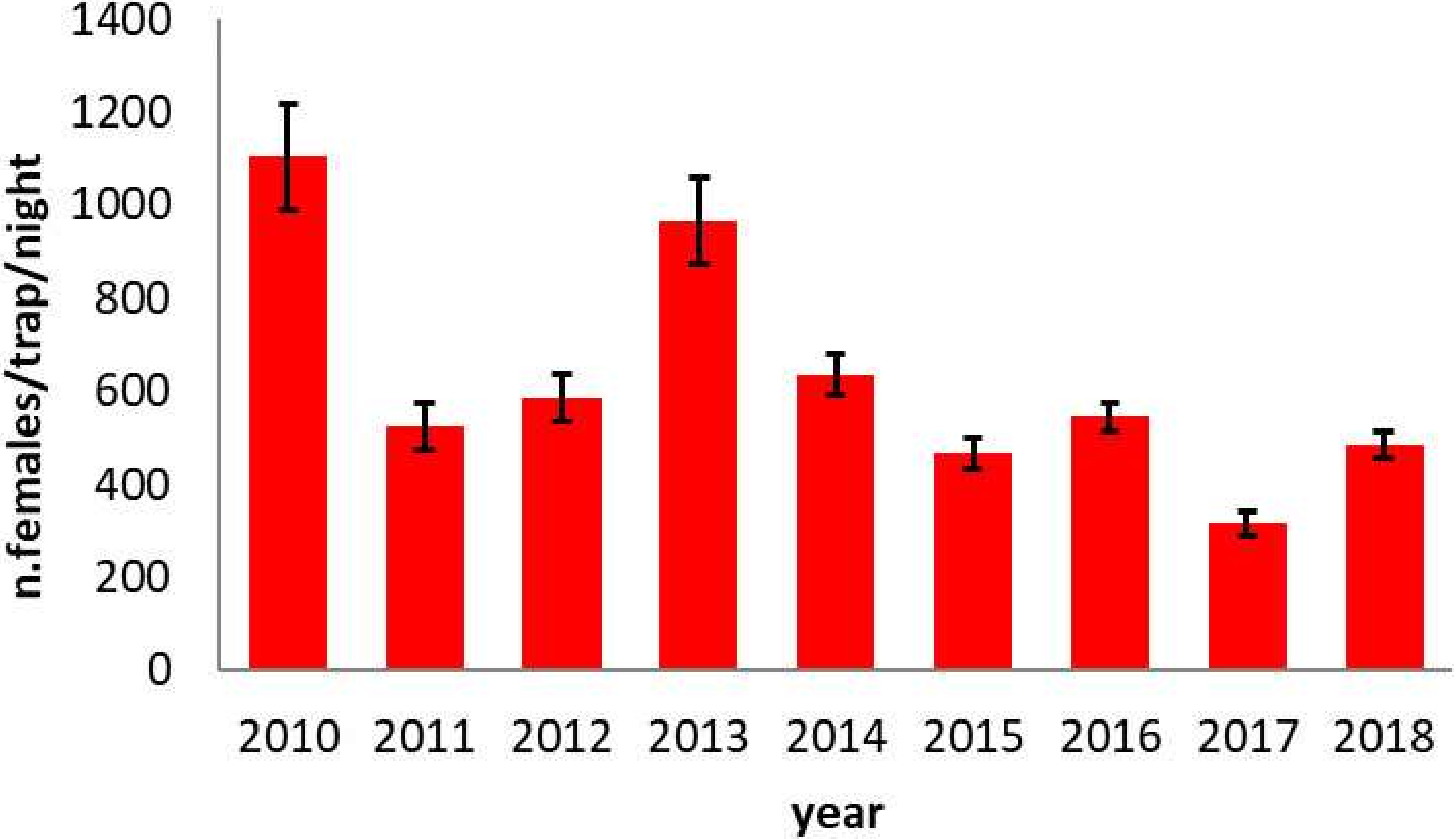
| | 1996 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Romania** | 393 | 2 | 57 | 11 | 14 | 24 | 23 | 32 | 93 | 66 | 277 | ?? |
| **Grecia** | 0 | 0 | 262 | 100 | 161 | 86 | 15 | 0 | 0 | 48 | 309 | ?? |
| **Serbia** | 0 | 0 | 0 | 0 | 69 | 302 | 76 | 28 | 41 | 49 | 415 | ?? |
| **Italia** | 0 | 16 | 3 | 14 | 50 | 69 | 24 | 61 | 76 | 57 | 577 | ?? |

# Sintesi dei casi WNND in Emilia-Romagna

| | | N. casi umani WNND | N. donatori positivi | N. casi equini WNND |
|---|---|---|---|---|
| EMILIA-ROMAGNA | 2008 | ? | ? | 21 |
| | 2009 | 9 | ? | 46 |
| | 2010 | 0 | 4* | 0 |
| | 2011 | 0 | 0 | 0 |
| | 2012 | 0 | 0 | 0 |
| | 2013 | 20 | 12 | 7 |
| | 2014 | 7 | 2 | 2 |
| | 2015 | 17 | 6 | 3 |
| | 2016 | 21 | 9 | 4 |
| | 2017 | 15 | 3 | 0 |
| | 2018 | 97 | 22 | 13 |

*** Non confermati**

# Medie catture *Culex pipiens* Emilia- Romagna (64 trappole $CO_2$)



# *Grazie per l'attenzione*