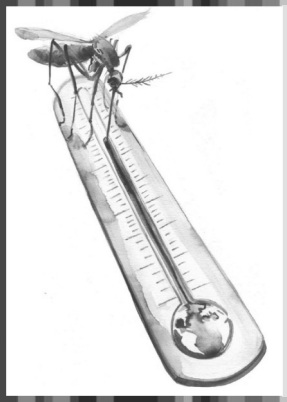


climate change and arboviruses

NECTM9

Ralph Huits MD PhD

SACRO CUORE DON CALABRIA IRCCS

1922 - 2022 SACRO CUORE

1

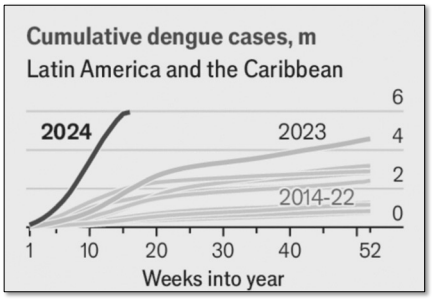
Conflict of Interest

- Salary support through GeoSentinel, cooperative agreement U01CK000632-01-00 between the Centers for Disease Control and Prevention and the International Society of Travel Medicine.
- Valneva sponsored speaker's bureau

2

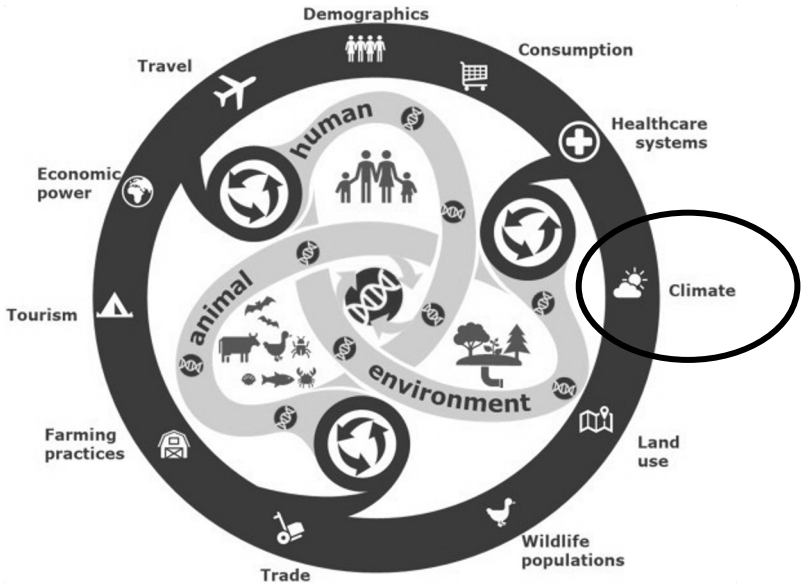
Outline

- Climate change
- Effects on arbovirus transmission
  - the Mosquitome
  - Mechanistic views
  - Pattern matching
- Climate science and epidemiology



3

Drivers of arbovirus expansion



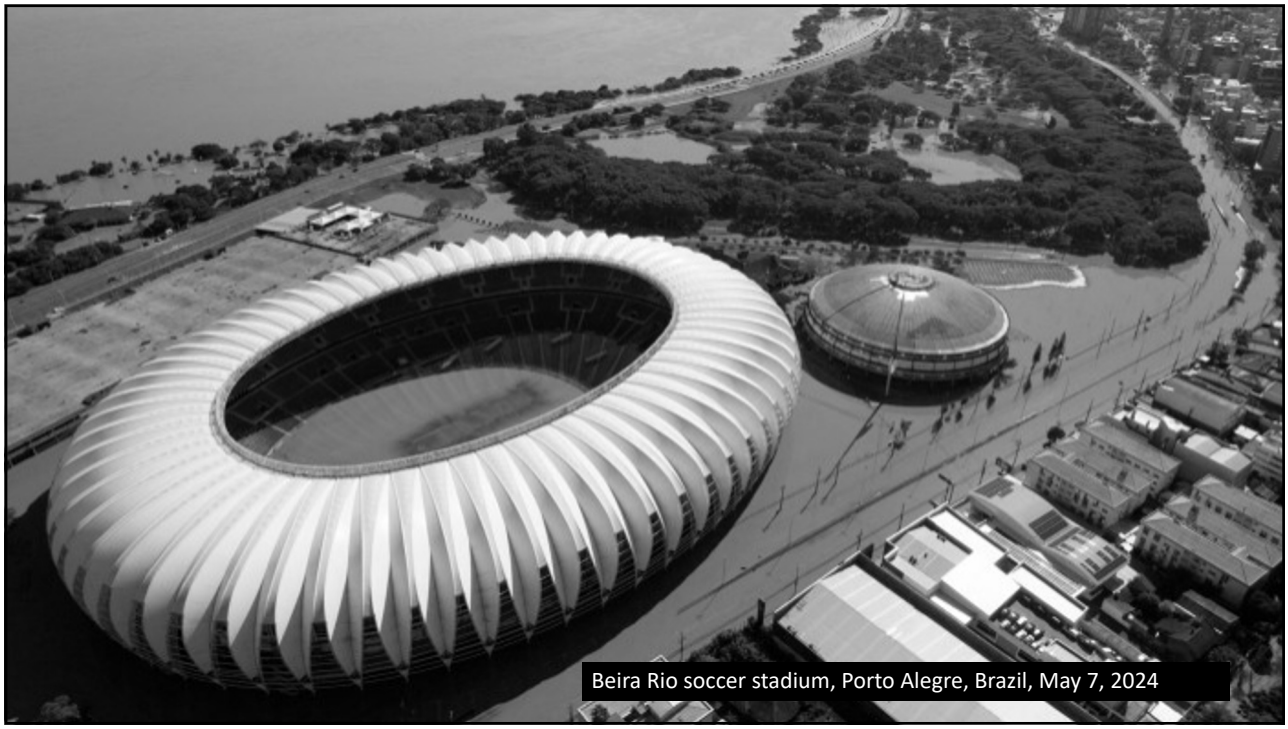
Sikkema, Encyclopedia of Virology, 2021

4

5

Lalo de Almeida, ‘Draught in the Amazone’, contestant 2024 WORLD PRESS PHOTO

6



Beira Rio soccer stadium, Porto Alegre, Brazil, May 7, 2024

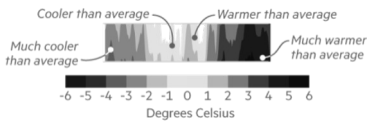
7

Karachi, Pakistan August 27, 2020

8

9

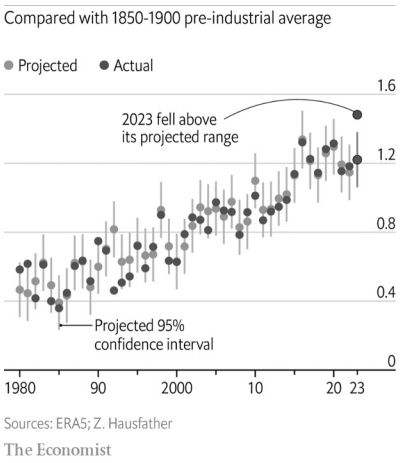
More extremes at the extremes



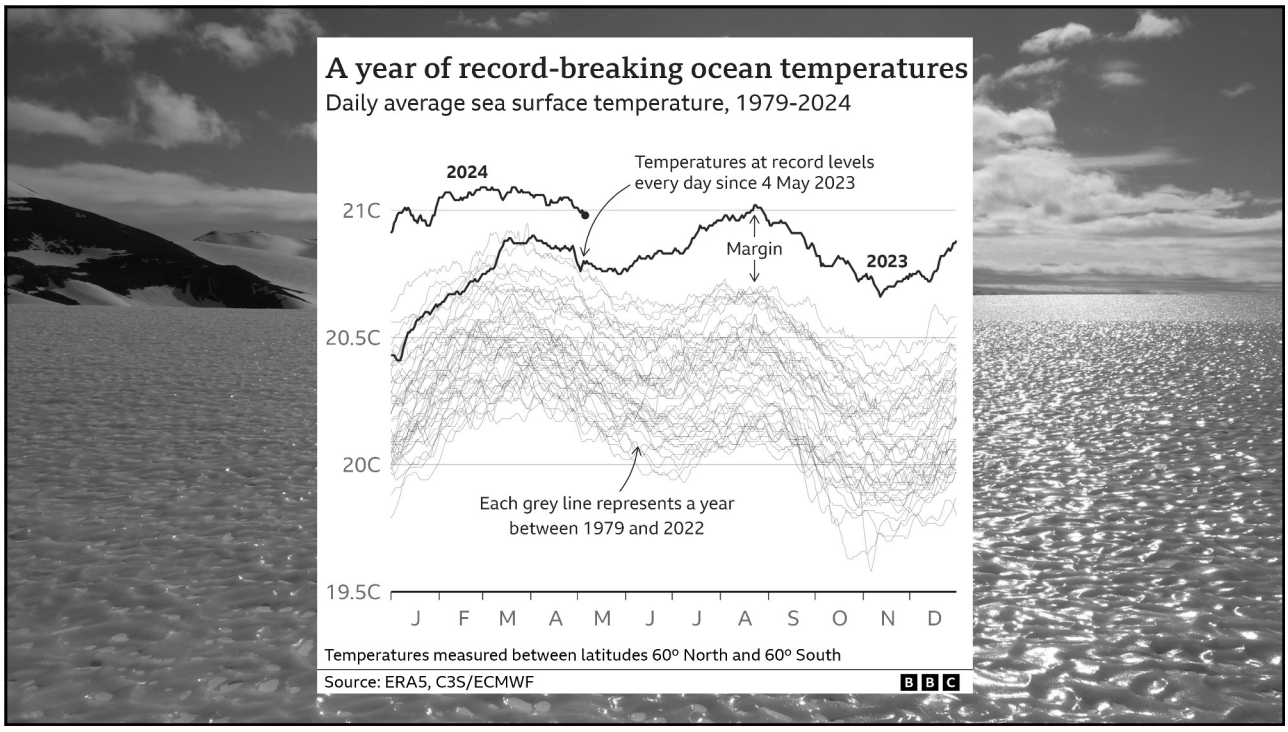
10

Temperatures in Europe increase more than twice global average

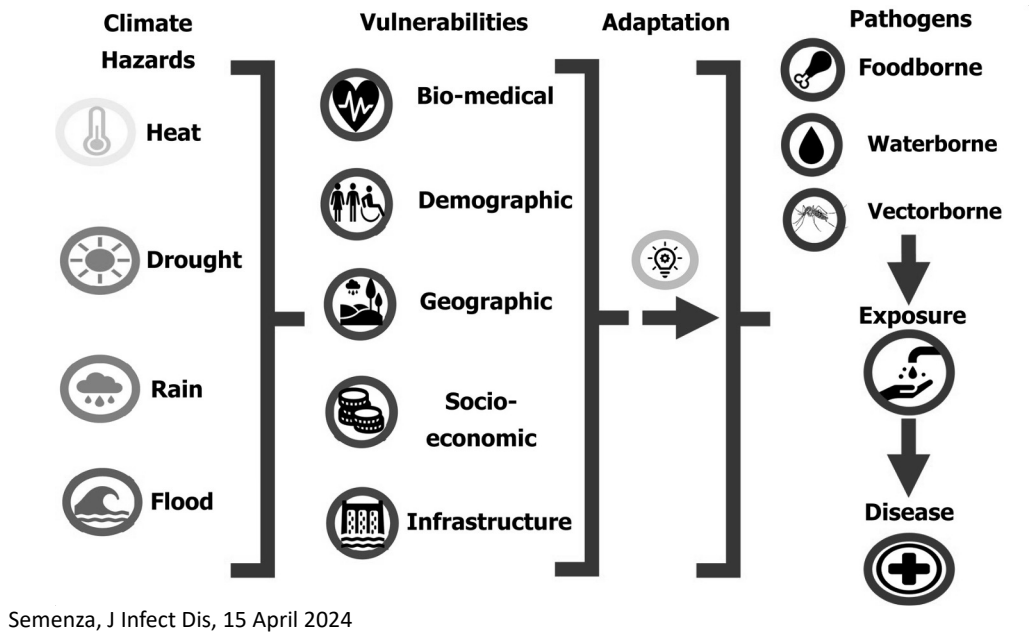
Carlo Buontempo



11



12



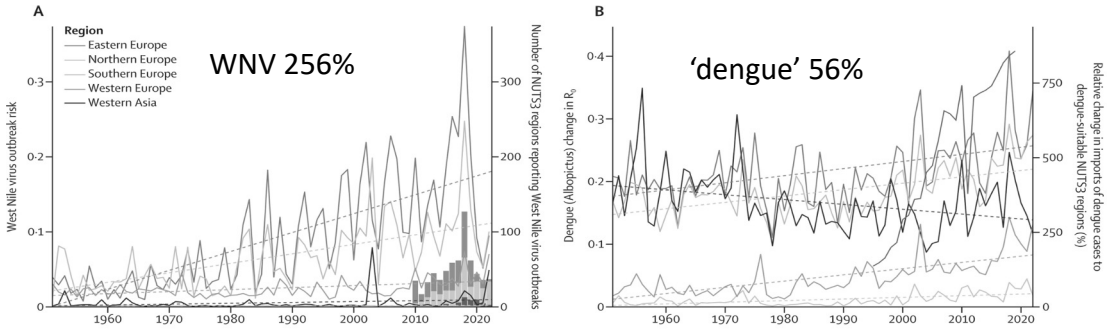
Semenza, J Infect Dis, 15 April 2024

13

LANCET COUNTDOWN: HEALTH AND CLIMATE CHANGE IN EUROPE

Climate suitability for climate-sensitive pathogens and disease vectors - indicator 1.3

The Lancet Public Health, May 12, 2024



Relative outbreak risk 2013–22 vs. 1951–60:

14

"The stark **reality** is that **longer hot seasons** will enlarge the **seasonal window** for the spread of **mosquito-borne** diseases and favour increasingly **frequent outbreaks** that are increasingly **complex to deal with**."

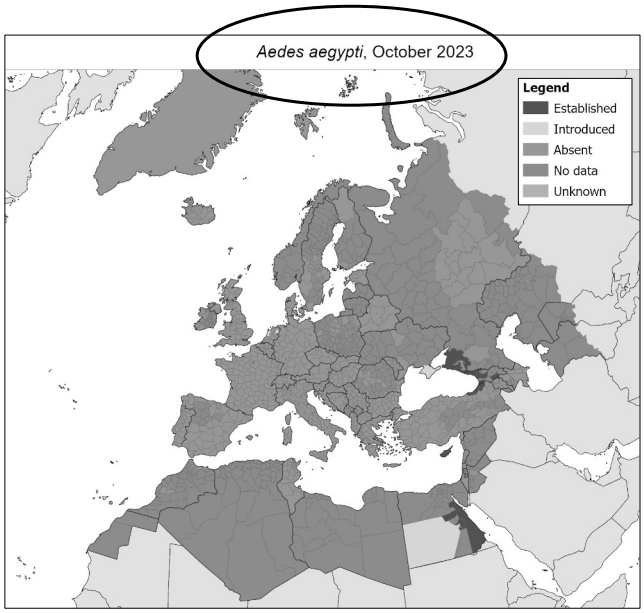
The Guardian

-Rachel Lowe-

Thu 25 Apr 2024

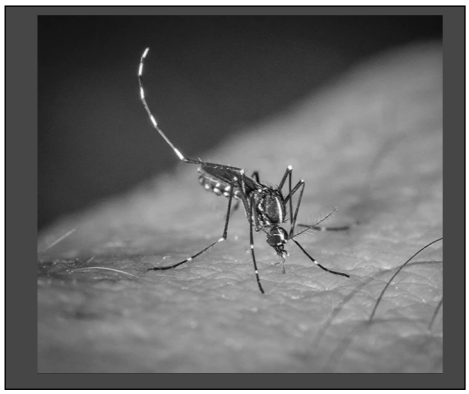
15

Aedes aegypti in Europe

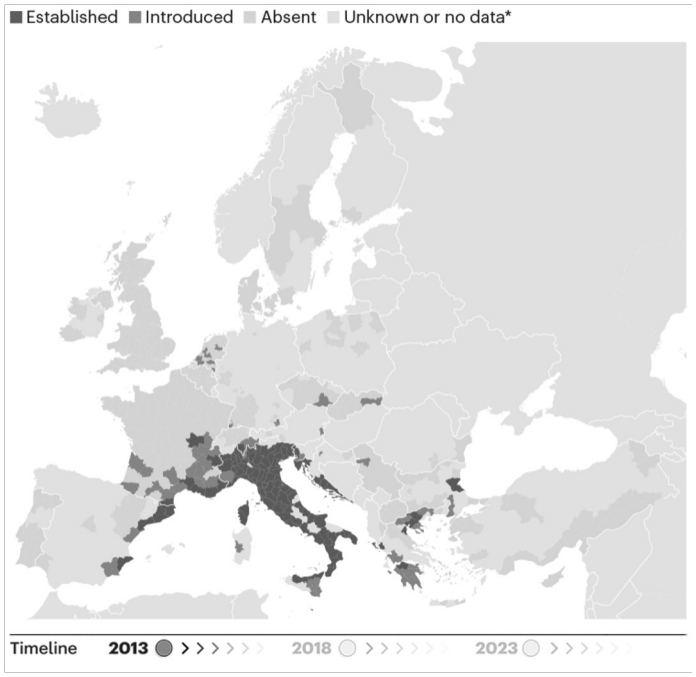


16

Aedes albopictus in Europe



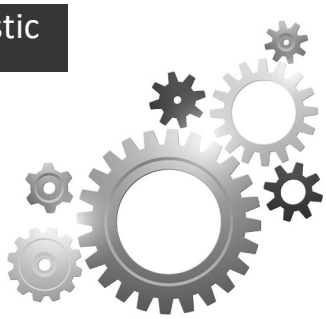
Ainsworth Nature 2023



17

Evidence for effects of climate change on vectors/ arboviruses?

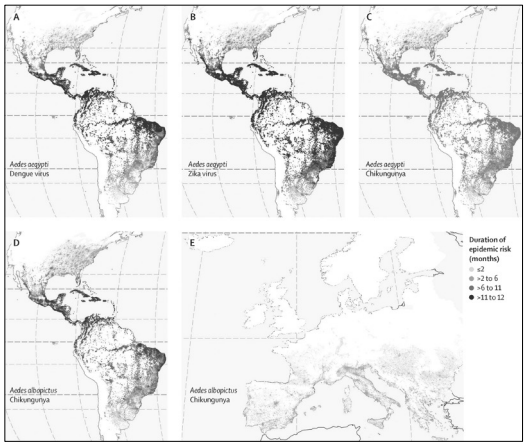
Mechanistic



$$\left(ma^2 \times p^n / -\ln p\right) \times bc \times 1/r$$

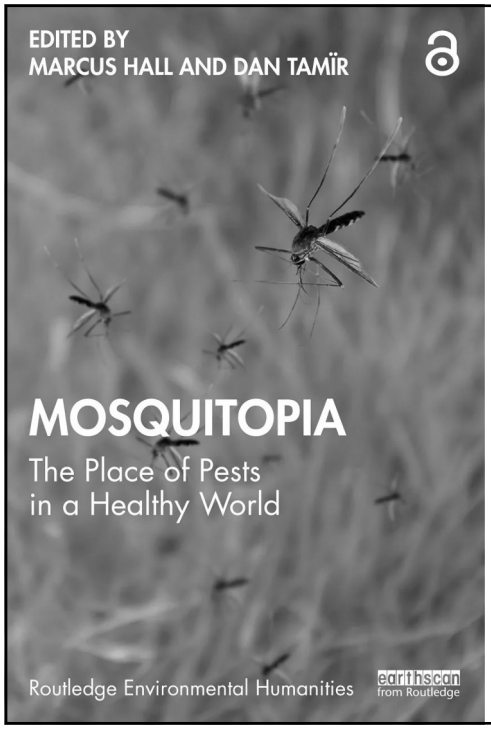
Bellone, Front. Microbiol. 2020

'Pattern matching'



Zardini, The Lancet Planetary Health 2024

18



A WORLD WITHOUT MOSQUITOES

Save 'em or Swat 'em?

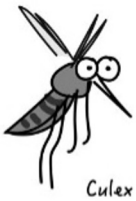
Nature 2010 (466), p.432

"<2% of insectivore gut content is mosquitoes"
Janet McAllister

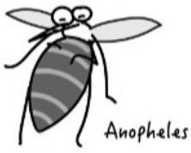
"I would eat raw onions and celery for the rest of my life if I could do away with the little bastards"

"Don't let our inability to destroy these little bastards take anything away from the dream of mass mosquito murder"
Joe Conlon

19



There are more than 3,500 different mosquito species
here are just a few

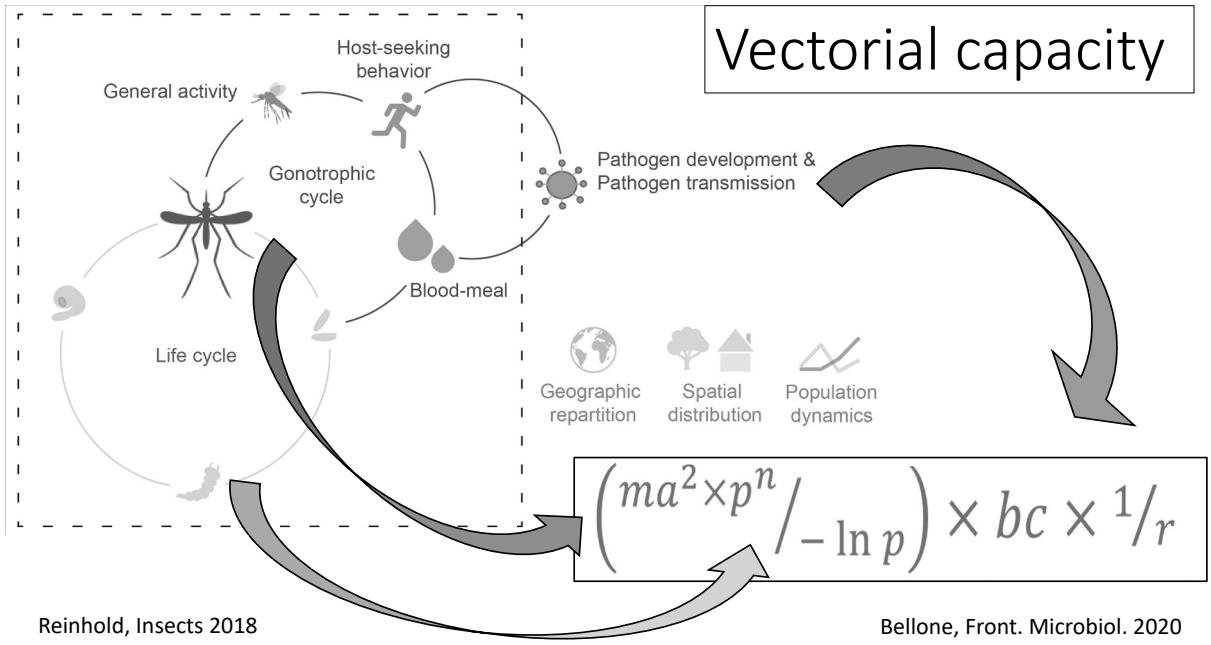


"Mosquitome"

the group of mosquito species
that have successfully
adapted to humans
and human-made environments.

www.worldmosquitoprogram.org

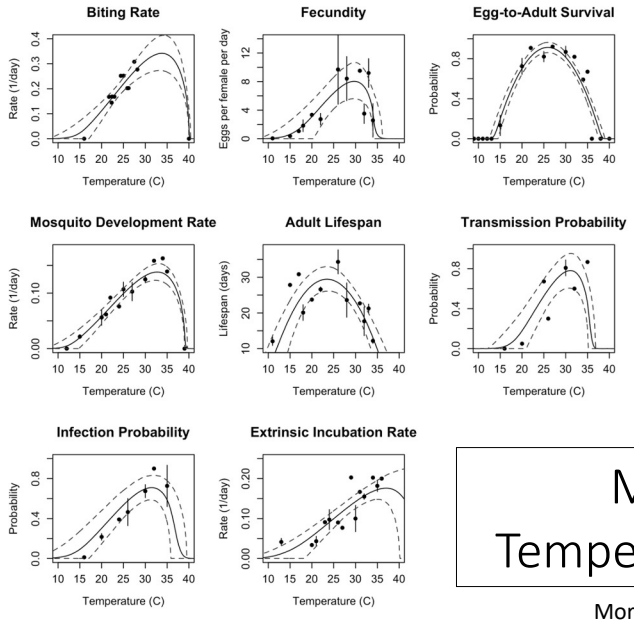
20



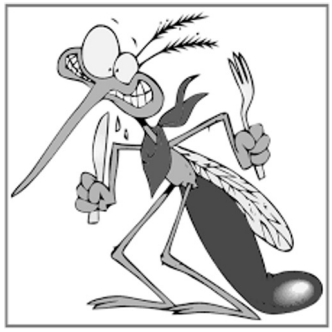
Reinhold, Insects 2018

Bellone, Front. Microbiol. 2020

21



Mechanistic

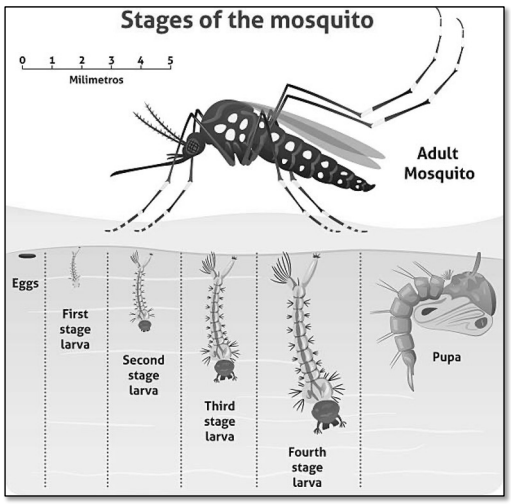


Mosquito life: Temperature Dependent

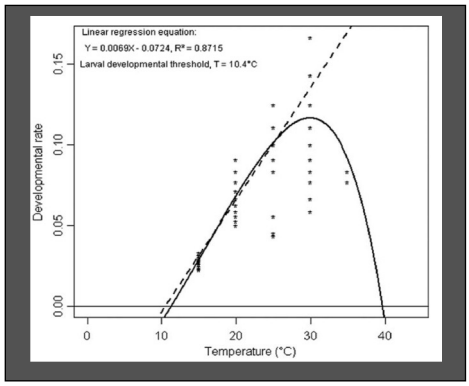
Mordecai PLOS Neglected Tropical Diseases 2022

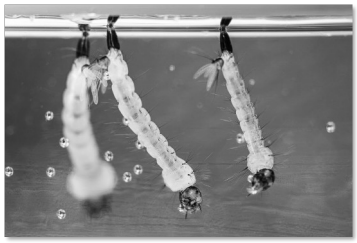
22

vector abundance



2 days	7-14 days *	2 days





Delatte, J Med Entomol 2009

23

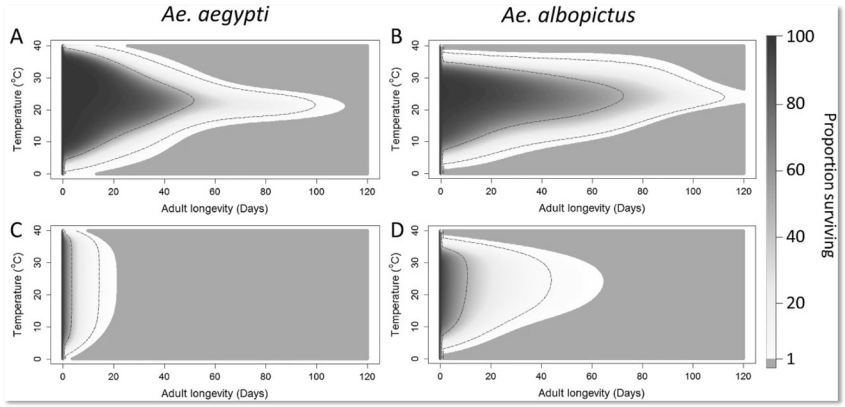
Vector lifespan

Ae. aegypti

Ae. albopictus

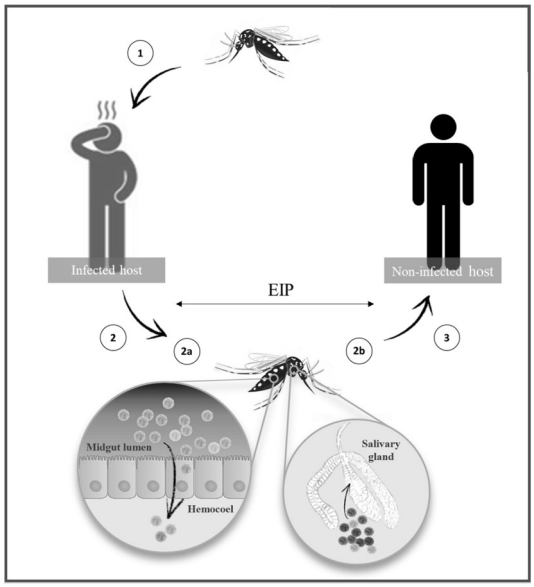
Laboratory

Field settings



Brady, *Parasites Vectors* 2013

24



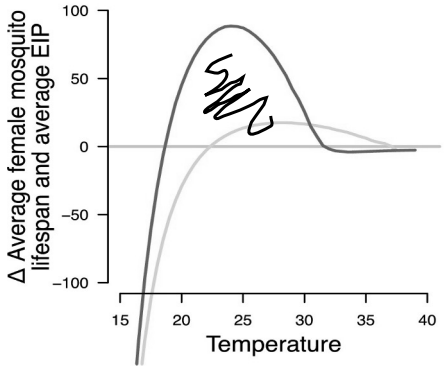
Bellone, Front. Microbiol. 2020

Extrinsic incubation period

viremic bloodmeal

mosquito becomes infectious

25



Ae. aegypti

Ae. albopictus

Lifespan > EIP

'Virus-vector combination'

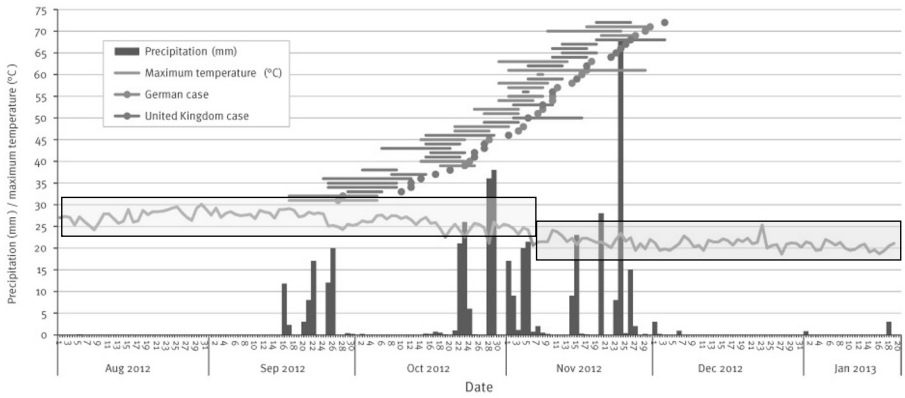
26

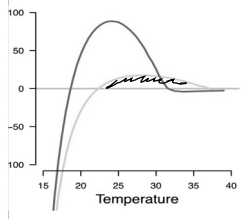
Lifespan > EIP

Dengue in Madeira, 2012

3 October- 25 November: 2,000 cases

Ae. Aegypti emerges in Madeira 2007
- Almeida, EuroSurveillance 2007



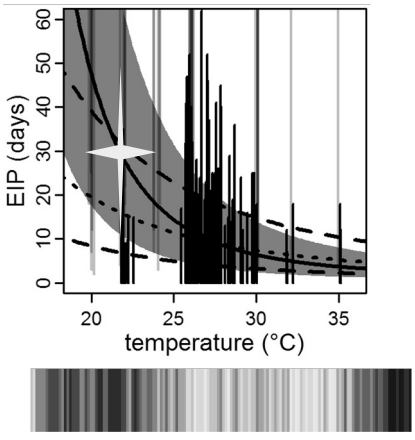


Frank, EuroSurveillance 2013

27

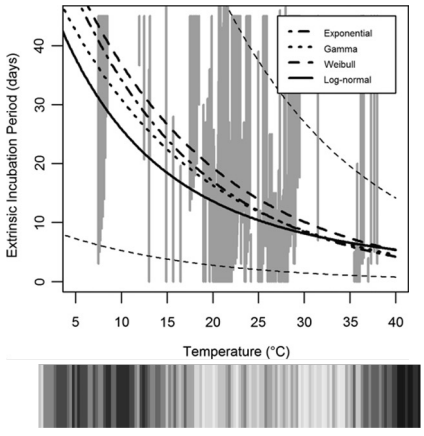
EIP – temperature dependent

Dengue virus



Chan PLoS ONE. 2012

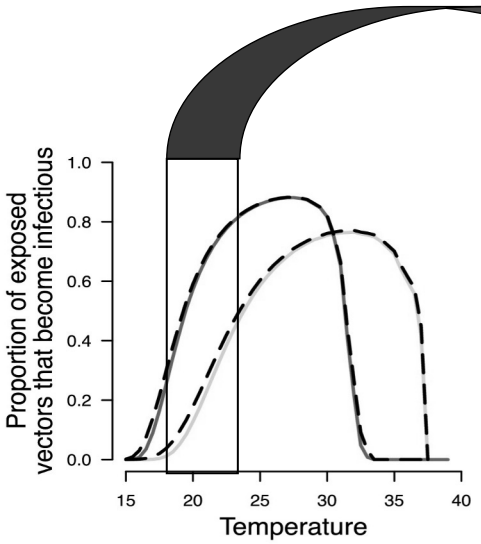
Yellow fever virus

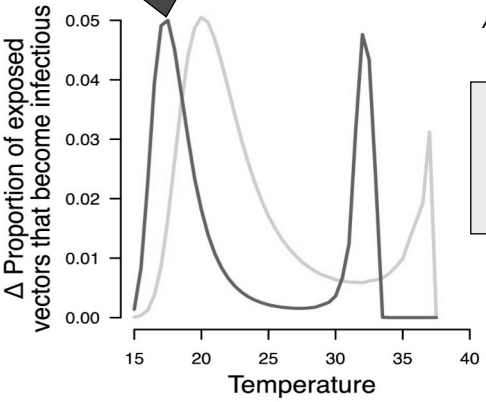


Johansson. Am J Trop Med Hyg. 2010

28

EIP variability





Ae. albopictus

Ae. aegypti

Kamiya Epidemics 2020

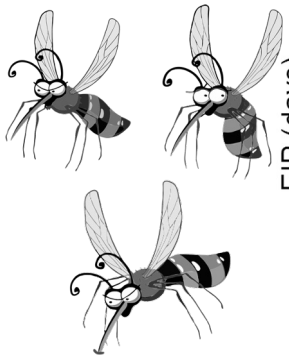
29

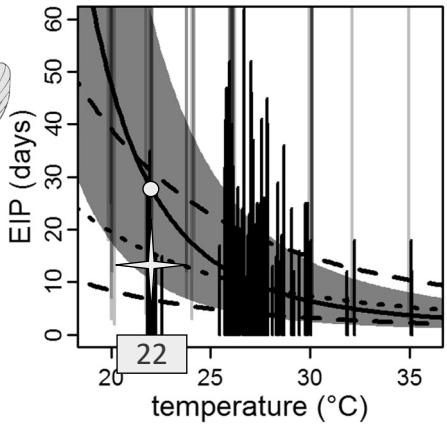
Role of EIP variability in temperate climates

‘virus-vector’ combinations

faster EIP completion

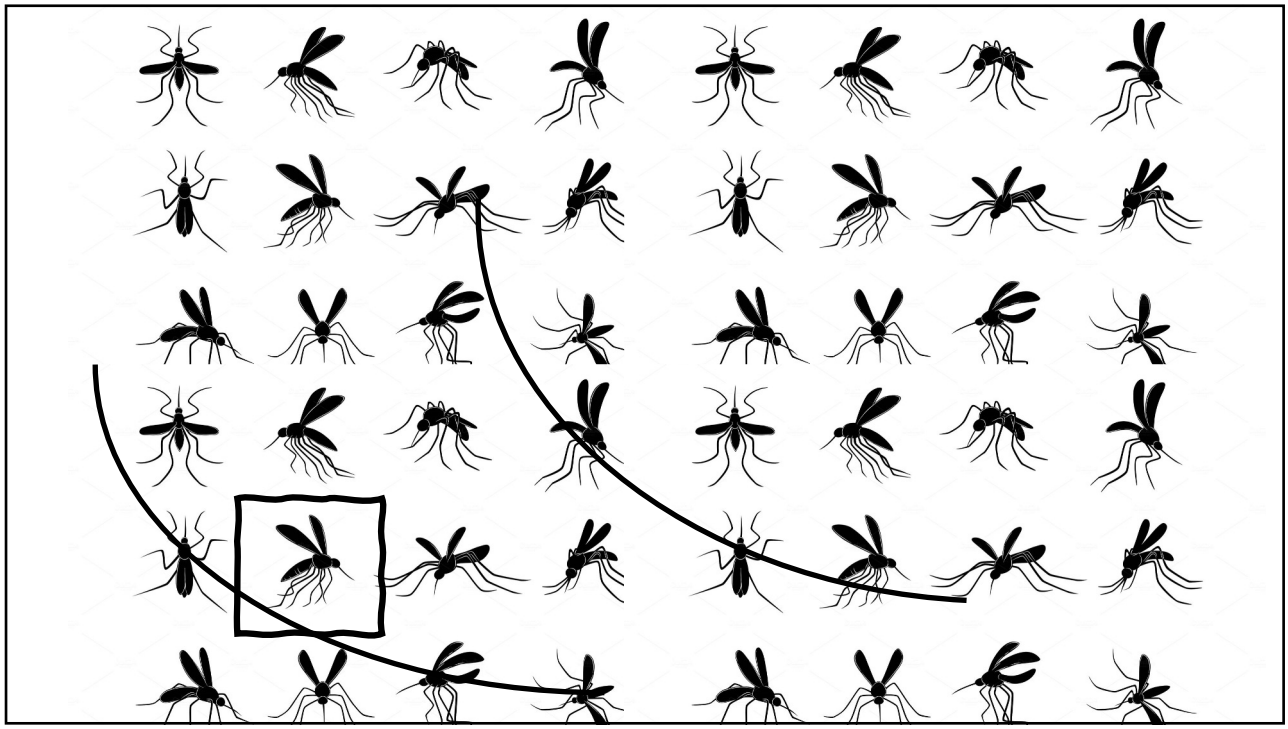
Evolutionary advantage





Kamiya Epidemics 2020

30

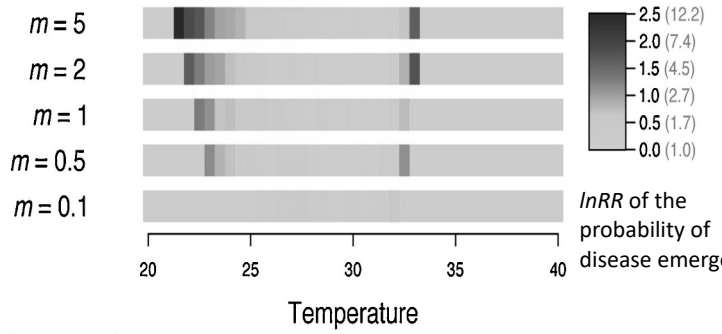


31

Impact of EIP variability

Increasing mosquito-to-human Ratios (m)

Aedes albopictus



lnRR of the probability of disease emergence

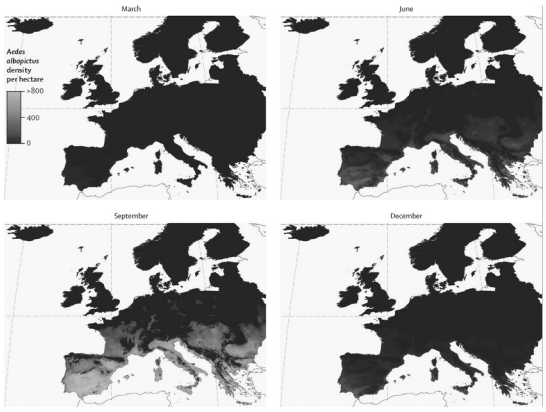
Dengue Risk USA - July -

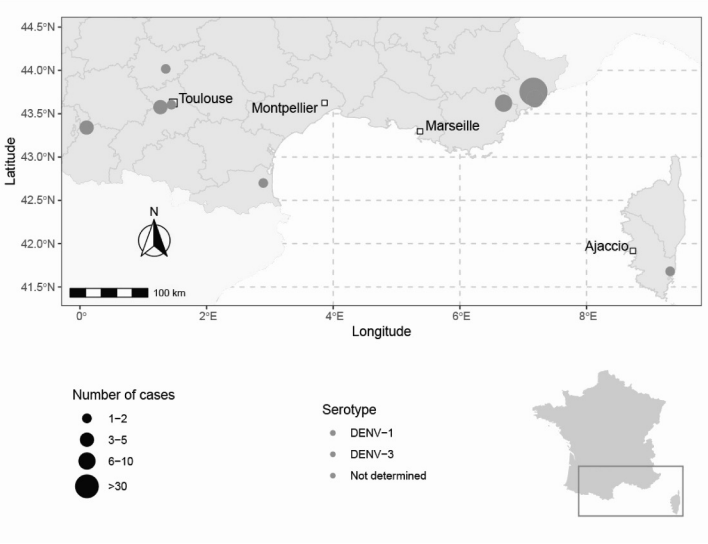
Kamiya Epidemics 2020

32

Small-scale outbreaks …

Dengue in France, 12 June- 20 September, 2022





Zardini, The Lancet Planetary Health 2024

Cochet, Eurosurveillance 2022

33

What about chikungunya?


pathogens

MDPI

Article

Identifying Knowledge Gaps through the Systematic Review of Temperature-Driven Variability in the Competence of *Aedes aegypti* and *Ae. albopictus* for Chikungunya Virus

2023

Rebecca C. Christofferson [1,*], Erik A. Turner [1] and Víctor Hugo Peña-García [2]


Contents lists available at ScienceDirect

Current Research in Parasitology & Vector-Borne Diseases

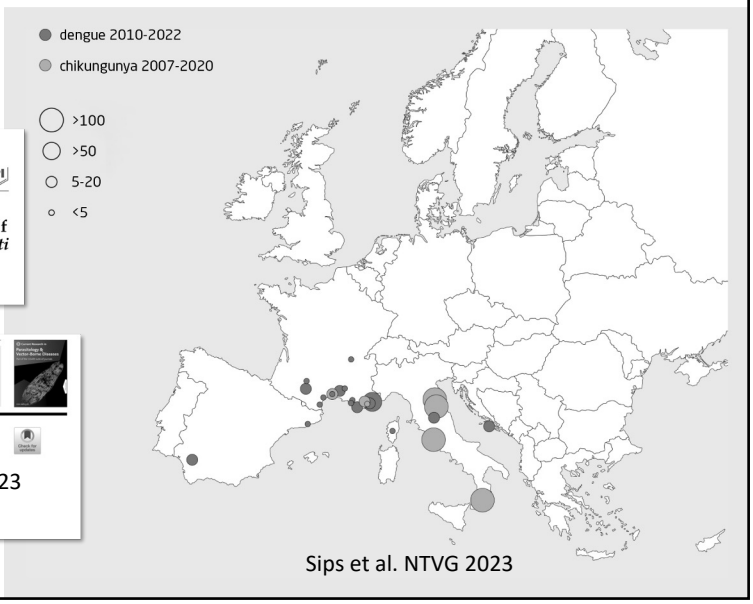
journal homepage: www.sciencedirect.com/journal/current-research-in-parasitology-and-vector-borne-diseases

ELSEVIER

Temperature and transmission of chikungunya, dengue, and Zika viruses: A systematic review of experimental studies on *Aedes aegypti* and *Aedes albopictus*

2023

Méryl Delrieu [a,*], Jean-Philippe Martinet [a], Olivia O'Connor [a], Elvina Viennet [d], Christophe Menkes [e], Valérie Burtet-Sarramegna [b], Francesca D. Frentiu [c,*], Myrielle Dupont-Rouzeyrol [a,*]

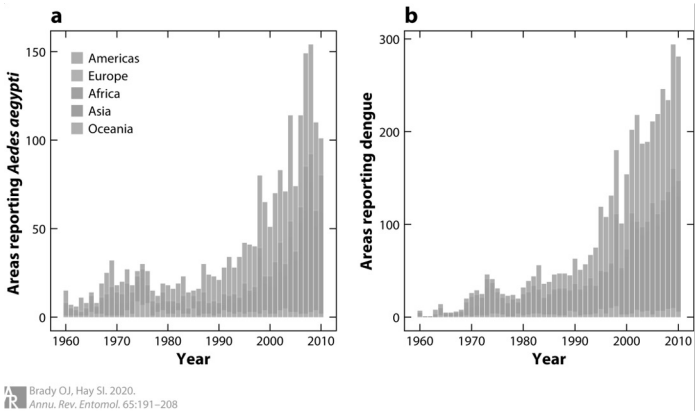


Sips et al. NTVG 2023

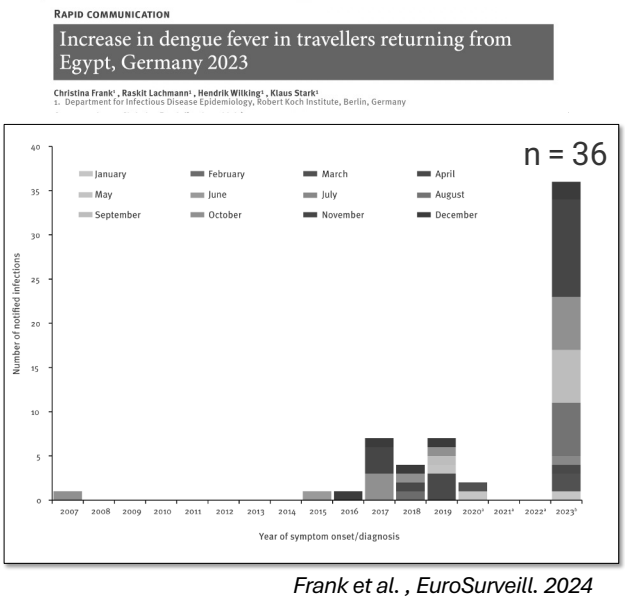
34

What patterns to look for?

'Pattern matching'



35



Frank et al. , EuroSurveill. 2024

Re-emergence of *Ae. Aegypti* in Egypt, confirmed 2017

Abozeid, Lancet Inf Dis 2018

May 17, 2024

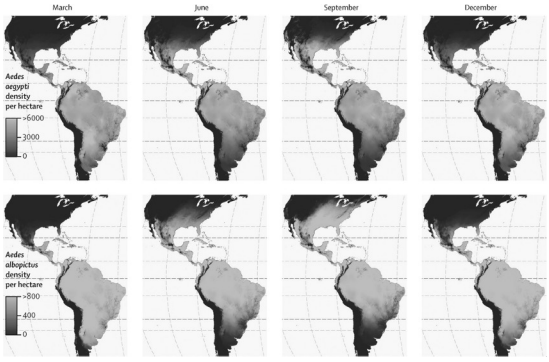
ProMED-mail post 8716533
GeoSentinel Network alert

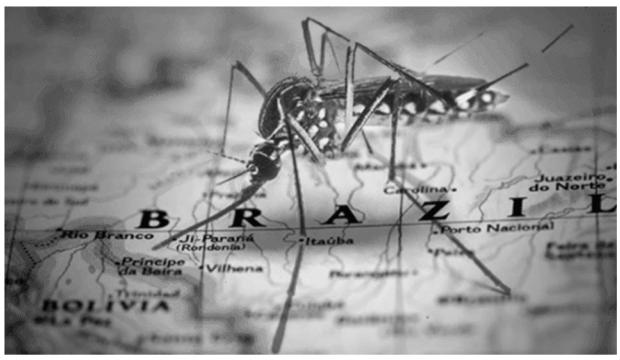
3 travelers Sharm El Sheikh to Milan:

RT-PCR DENV-2 positive

36

Vector presence -seasonality





Zardini, The Lancet Planetary Health 2024

37

Weather forecast 2050

Bastin et al. PLoS ONE 2019

38

Use of meteorological databases

eg ERA-5 database

Hourly estimates of:
- Sea Surface Temperature (SST)
- Total Precipitation (TP)A-5

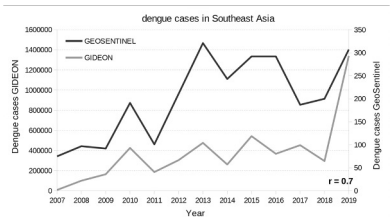
spatial resolution:
0.25° x 0.25° (~27.5 km²)

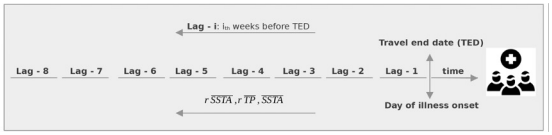
PROGRAMME OF THE EUROPEAN UNION

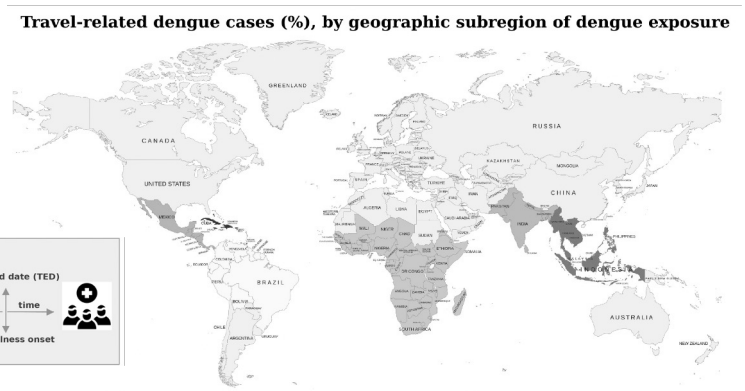
opernicus Europe's eyes on Earth

39

Coupling meteorological parameters to … sentinel reporting of travel-related dengue



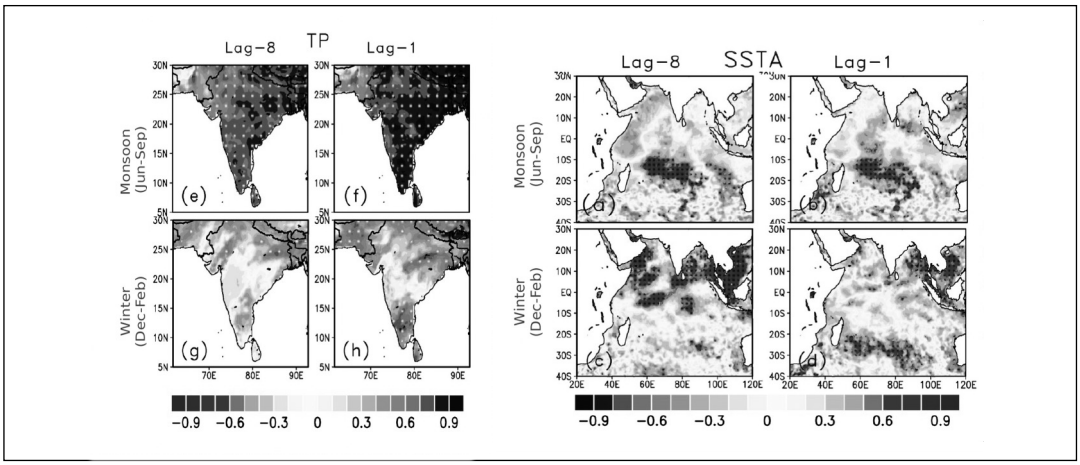




CSIDlab — HEIDELBERG INSTITUTE OF GLOBAL HEALTH — IWR — GeoSentinel

40

(e.g.) total precipitation and sea surface temperature



Dafka et al., abstract presented at EGU24-General Assembly
(manuscript in preparation)

—CSIDlab— HEIDELBERG INSTITUTE OF GLOBAL HEALTH IHR GeoSentinel

41

Potential SST drivers of the travel-related dengue cases per subregion and season

- summer: North Pacific and tropical Atlantic warm SSTA|winter: NAO-
- summer: Atlantic (warm) - Pacific (cool) SST Gradient
- monsoon, post-monsoon: Southern Pacific SSTs |boreal summer, pre-monsoon: Northern and Southern tropical Atlantic SSTs, Atlantic Niño pattern
- spring: SASD- | summer: IOD+
- pre-monsoon, monsoon, post-monsoon: IOD+ | pre-monsoon, winter: Southern Indian warm SSTA
- summer: IOD- |winter: warm equatorial tropical Indian SSTs and South China Sea SST gradient

Dafka et al., abstract presented at EGU24-General Assembly
(manuscript in preparation)

—CSIDlab— HEIDELBERG INSTITUTE OF GLOBAL HEALTH IHR GeoSentinel

42

… combining climate science with epidemiology
may be a promising strategy
to identify and combat disease outbreaks
in addition to timely interventions
such as vector control and vaccination campaigns

Dafka et al., abstract presented at EGU24-General Assembly
(manuscript in preparation)

—CSIDlab— HEIDELBERG INSTITUTE OF GLOBAL HEALTH IWR GeoSentinel

43

Conclusions

Climate change:

- Not driving arboviruses at a global scale
- Leading to expansion of vector habitats
- Affecting spread of arboviruses
- Empirical evidence scarce
- Knowledge base
  - ‘mechanistic’ approaches
  - ‘pattern matching’
- Promising developments by combining climate science with epidemiology

You don’t need a weatherman
To know which way the wind blows

Subterranean Homesick Blues, Bob Dylan, 1965

44

45