EFFECTS OF CLIMATE ON THE EMERGENCE AND THE SPREAD OF VECTOR BORNE INFECTIOUS DISEASES

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VECTOR BORNE INFECTIOUS DISEASES

- An infectious disease is an illness resulting from the presence of pathogens in an organism which is transmissible
- In vector-borne diseases the pathogens responsible of the disease are transmitted from an infected individual to another individual by a competent vector (e.g., arthropods, foxes, bats, . . .)
- An emerging disease is a disease whose incidence is increasing

Disease	Vector
malaria	mosquito
dengue fever	mosquito
yellow fever	mosquito
chikungunya	mosquito
lyme	tick
rabies	fox, raccoon, bat, . . .
Hendra virus	horse
. . .	. . .

Necessary conditions for the emergence of *new* vector borne diseases

I Importation of new species (e.g., as an effect of the globalization)

II Proliferation of new species (e.g., due to the arising of *new* opportune habitat)

Emerging infectious diseases in Italy

Has Italy already experienced the emergence of *"new"* infectious diseases?

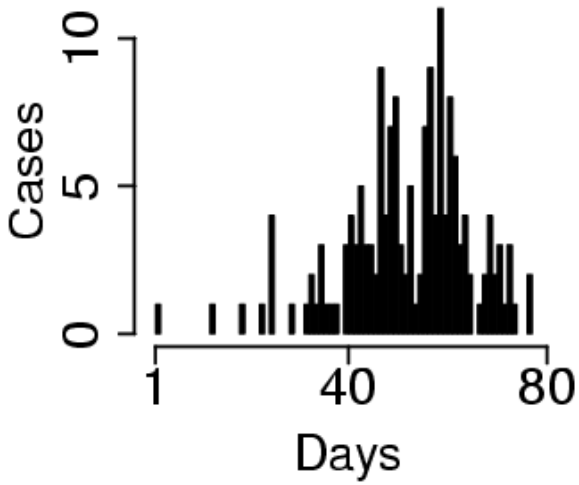
Yes! Chikungunya epidemic on summer 2007

About chikungunya

- Caused by chikungunya virus (CHIKV)
- Vector-borne disease (A.Albopictus as competent vector)
- Symptoms: high fever, arthralgic disease

About the Italian outbreak

- Index case on June 23, 2007 (man arriving from India)
- Epidemic in Castiglione di Cervia and Castiglione di Ravenna (Emilia Romagna, 4,000 inhabitants)
- Large outbreak: $\approx$ 10% of the population were infected



Castiglione 2007, Chikungunya epidemic

Modeling the epidemiology of chikungunya

A mathematical model is a representation of the essential aspects of a system

Ingredients for modeling an epidemiological process: pathogen and population

Modeling chikungunya:

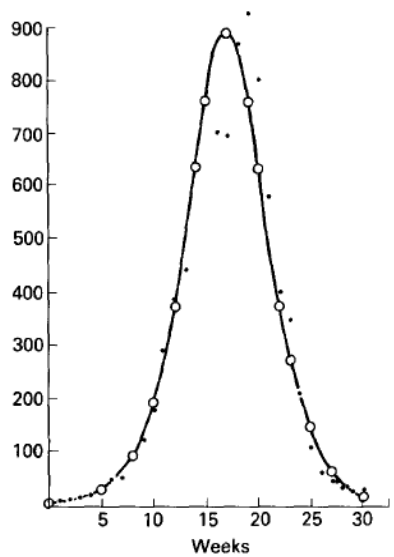
- Host population (humans): "constant" over time
- Vector population (A. Albopictus): dynamical
- Pathogen transmission process: Vector $\longrightarrow$ Human $\longrightarrow$ Vector $\longrightarrow \ldots$

Why to model the 2007 CHIKV outbreak?

1. Estimating the transmissibility potential of the disease (in a temperate climate area)
2. Assessing the effectiveness of the enacted control strategies

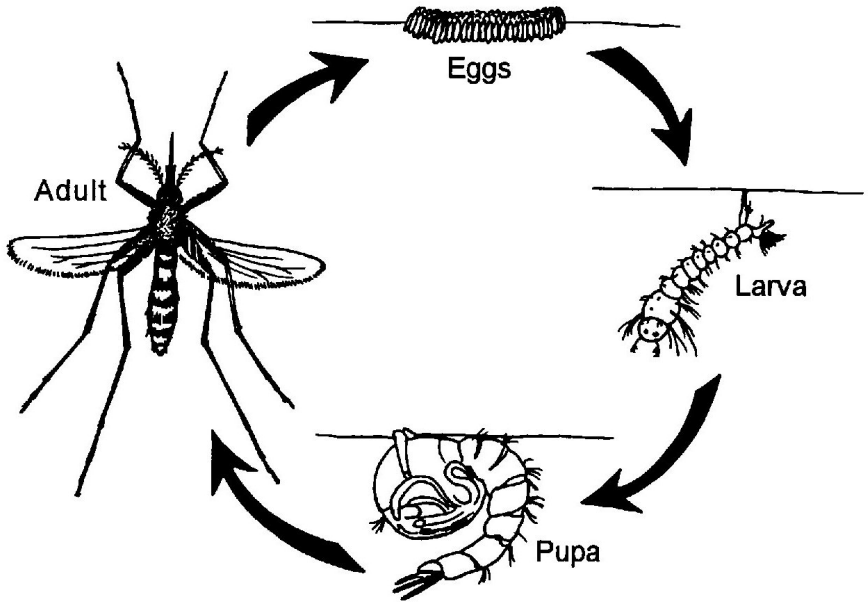
SIR model: Kermack and McKendrick, 1927

$$\begin{cases} \dot{S} &= -\beta \frac{I}{N} S \\ \dot{I} &= \beta \frac{I}{N} S - \gamma I \\ \dot{R} &= \gamma I \end{cases}$$

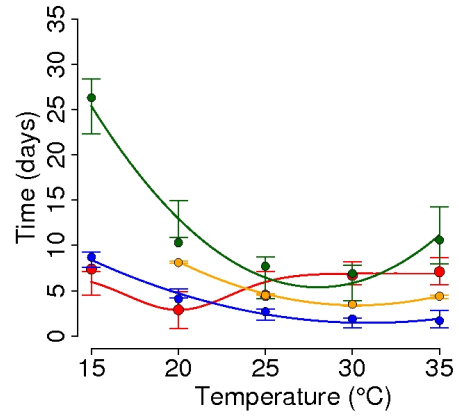


Bombay 1915-16, plague epidemic

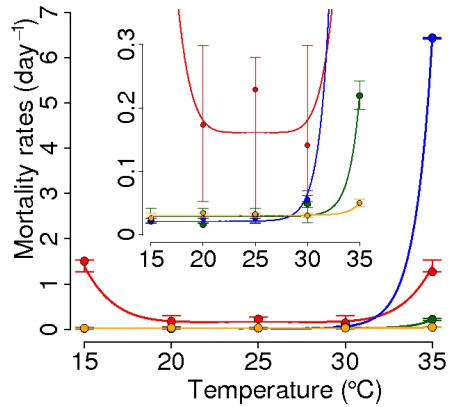
Modeling A.albopictus dynamics: the role of temperature



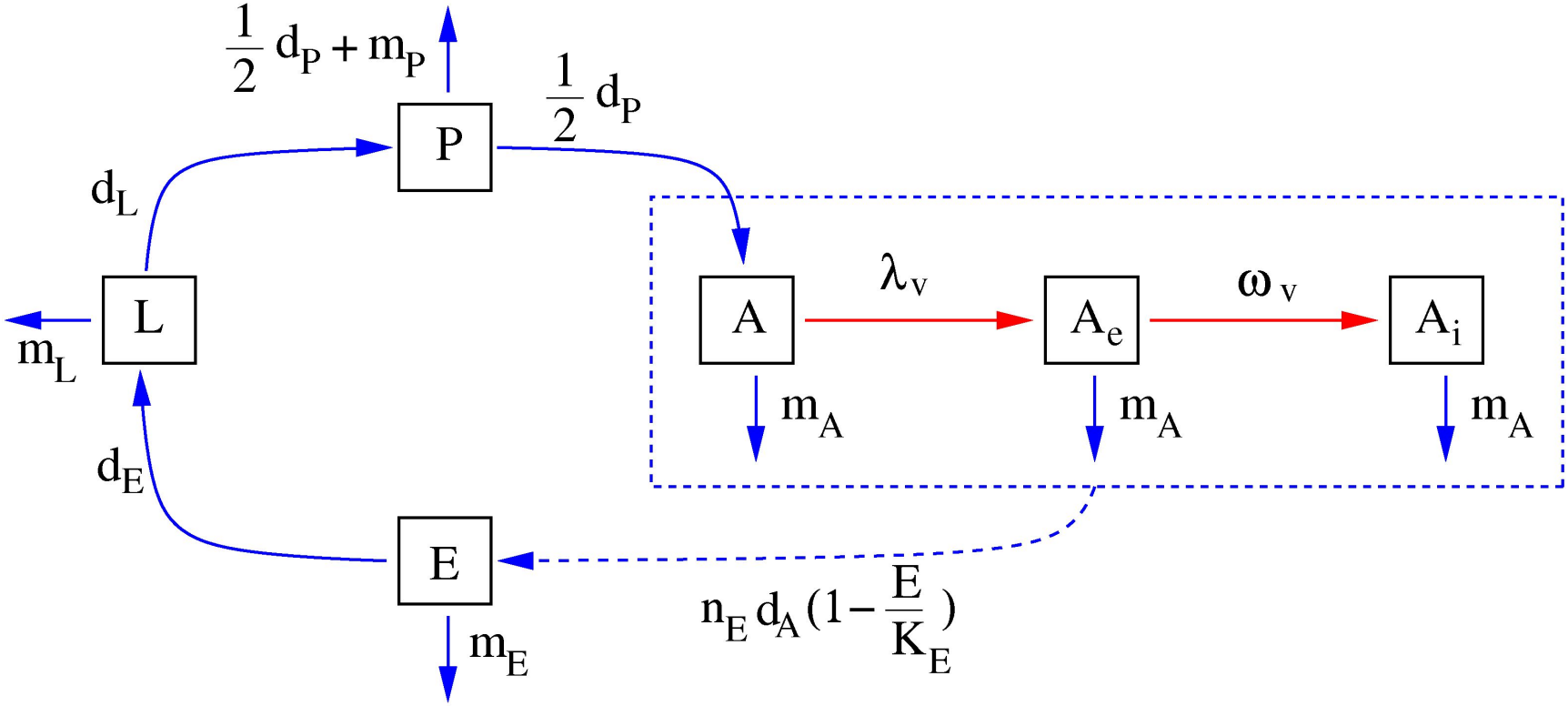
Model parameters depend on temperature of air and water

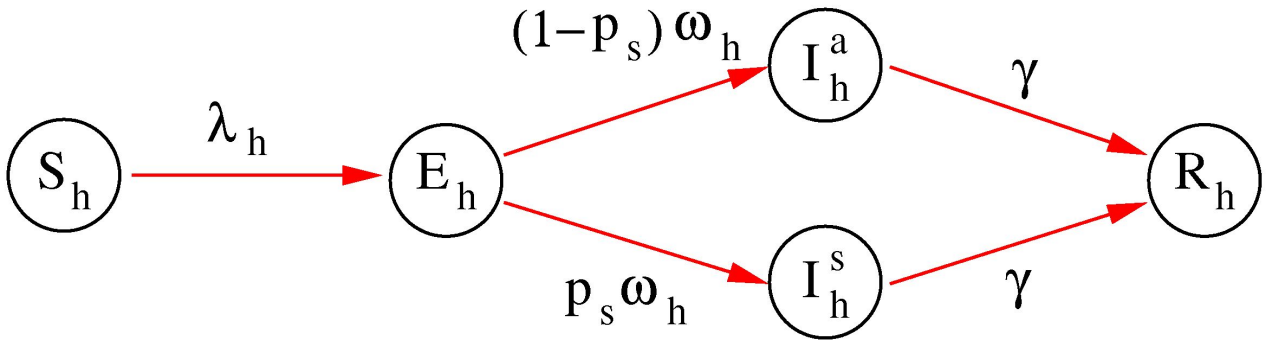


$$\begin{cases} \dot{E} &= n_E d_A A(1-\frac{E}{K_E}) - m_E E - d_E E \\ \dot{L} &= d_E E - m_L L - d_L L \\ \dot{P} &= d_L L - m_P P - d_P P \\ \dot{A} &= \frac{1}{2} d_P P - m_A A \end{cases}$$



Modeling CHIKV transmission





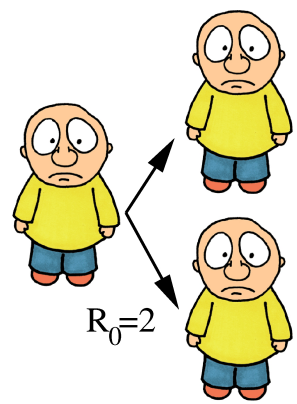
THE BASIC REPRODUCTIVE NUMBER R_0

Definition

- R_0 of host–vector infectious diseases is the number of secondary infections that arise when a single infective host is introduced into a fully susceptible host population through pathogen transmission by the vector
- R_0^{VH} is the average number of hosts directly infected by the introduction of a single infective vector into a fully susceptible host population
- R_0^{HV} is the average number of vectors directly infected by the introduction of a single infective host into a fully susceptible vector population

Computation

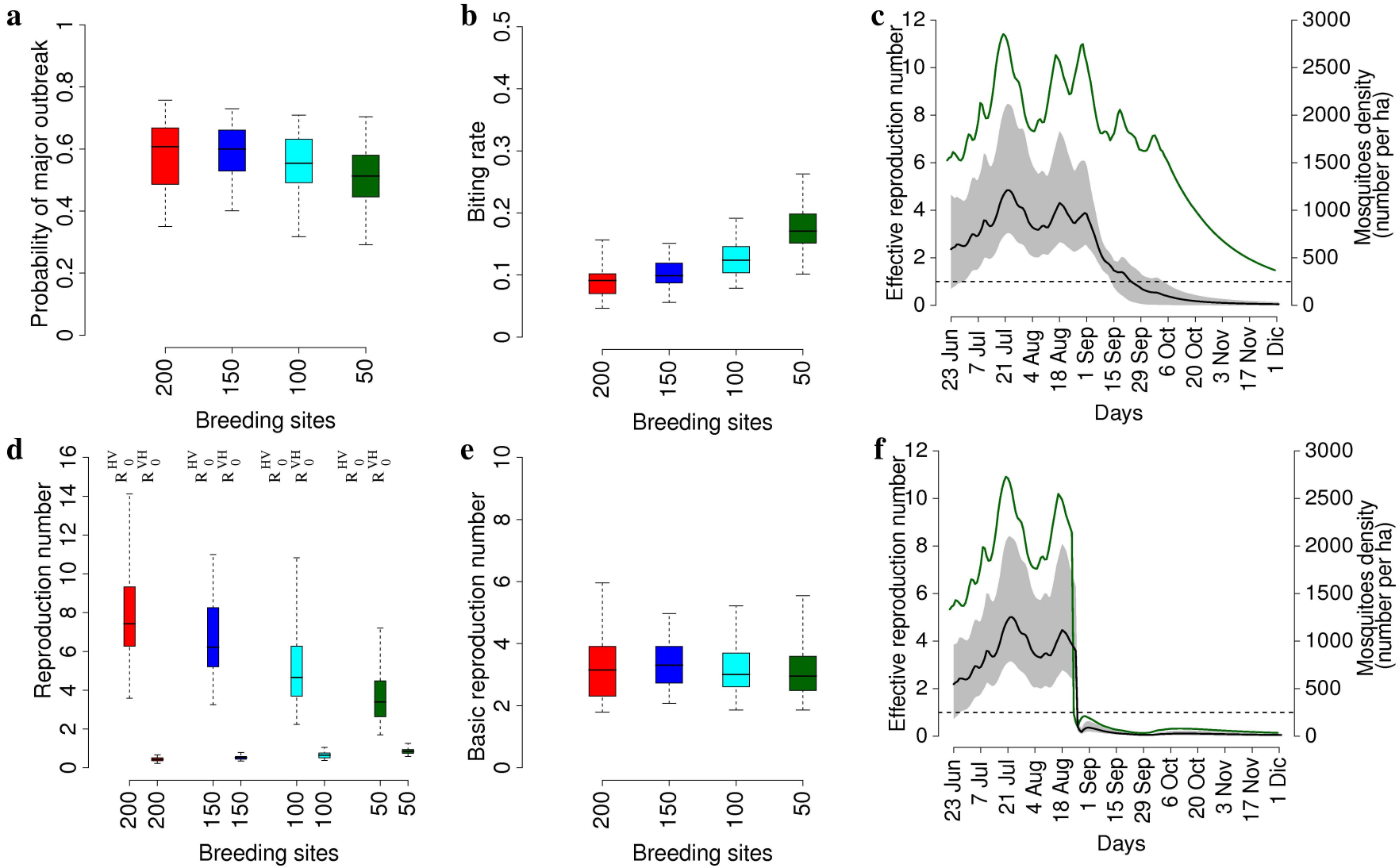
- $R_0 = R_0^{VH} R_0^{HV}$



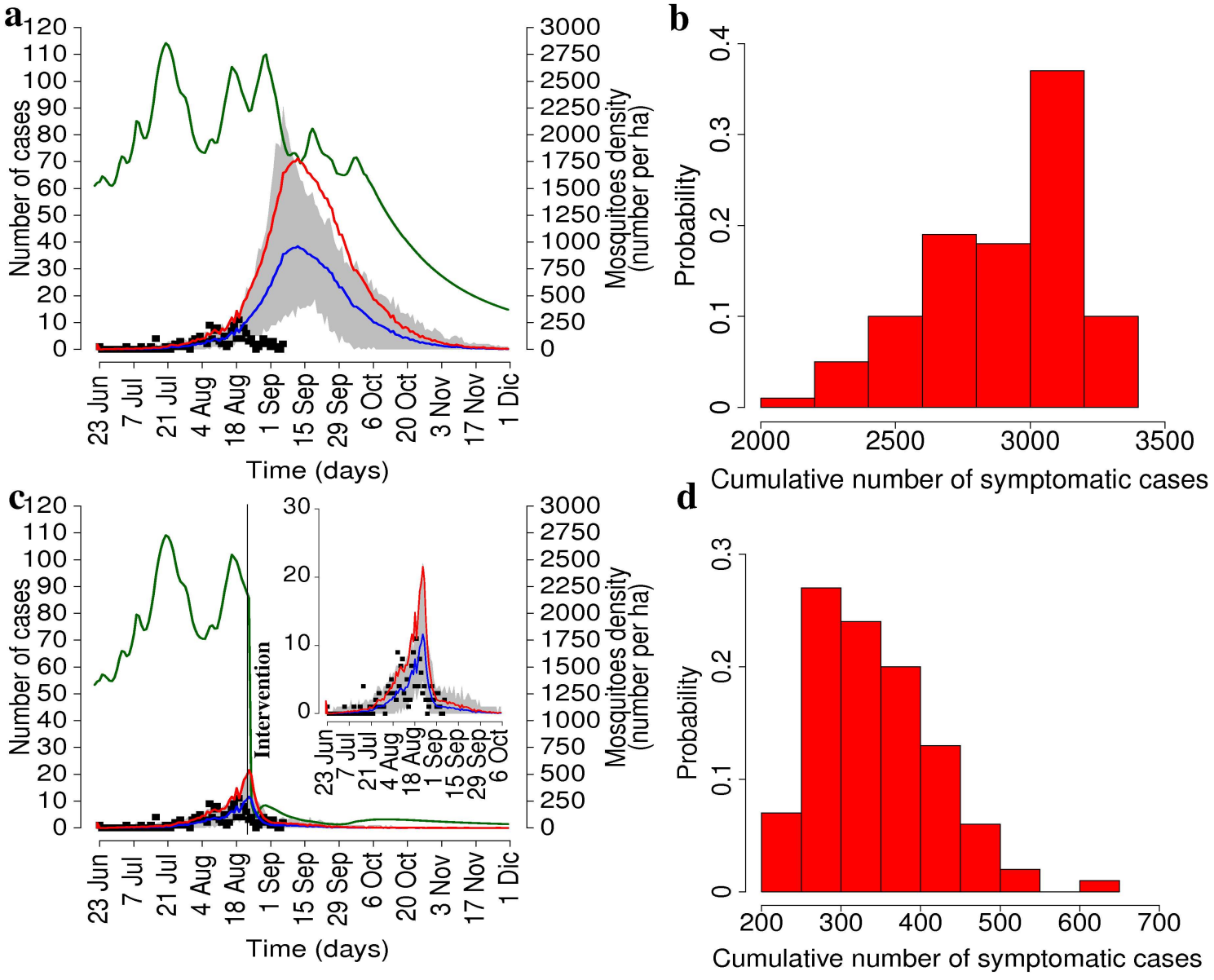
Implication

- $R_0 > 1$ chance of observing a “large” outbreak
- The larger R_0 the more difficult to control the epidemic is

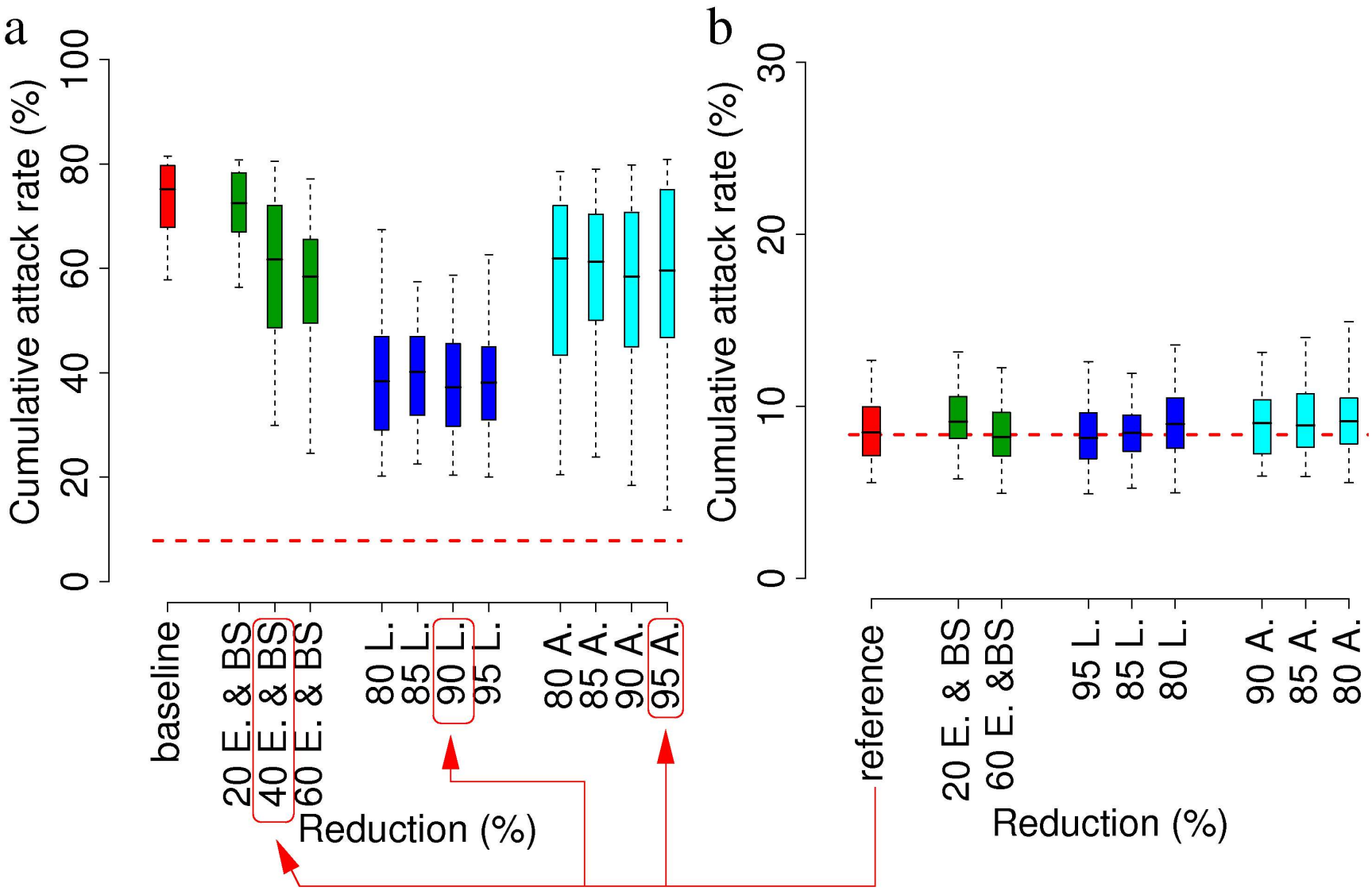
Breeding sites, biting rate and reproductive numbers



EPIDEMIC DYNAMICS AND FINAL EPIDEMIC SIZE

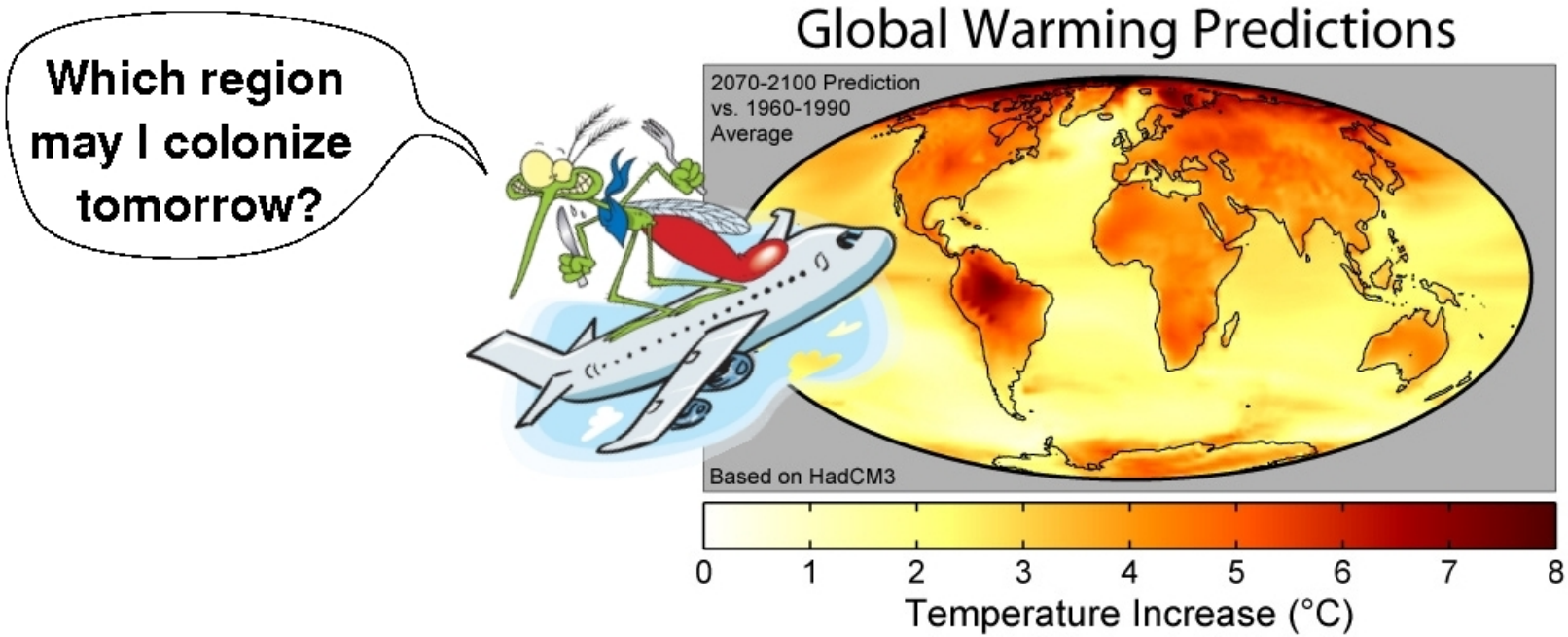


EFFICACY OF DIFFERENT DISINFESTATIONS



Summary and conclusion

- Emerging vector borne infectious diseases represent a real threat, as proved by the Italian chikungunya outbreak
- CHIKV can be highly transmissible also in temperate climate countries
- Chikungunya can be controlled by massive disinfestations
- Globalization and climate changes contribute to the emergence of *new* infectious diseases



Thanks for your attention

Acknowledgments

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