GC-INVAMOFECT project

Global Change and INVAsive MOsquitoes as inFECTious disease risks in Europe

Patrick MAVINGUI
(CNRS, University of Lyon)

Principal vector-borne diseases

Typhus	Lice
Rickettsiosis	Ticks
Pest	Fleas
Onchocercociasis	Black fly
Loiasis	Chrysops
Sleeping sickness	Glossina
Chagas disease	Triatomines
Leishmaniosis	Phlebotomines
Bancroft's filariasis	Mosquitoes
Malaria	Mosquitoes
Dengue	Mosquitoes
Chikungunya	Mosquitoes
Rift Valley Fever	Mosquitoes
West Nile	Mosquitoes
Tick borne encephalities	Ticks (*Ixodes*)
Tick borne hemor. fever	Ticks (*Hyalomma*)

Different species of mosquitos can carry different diseases

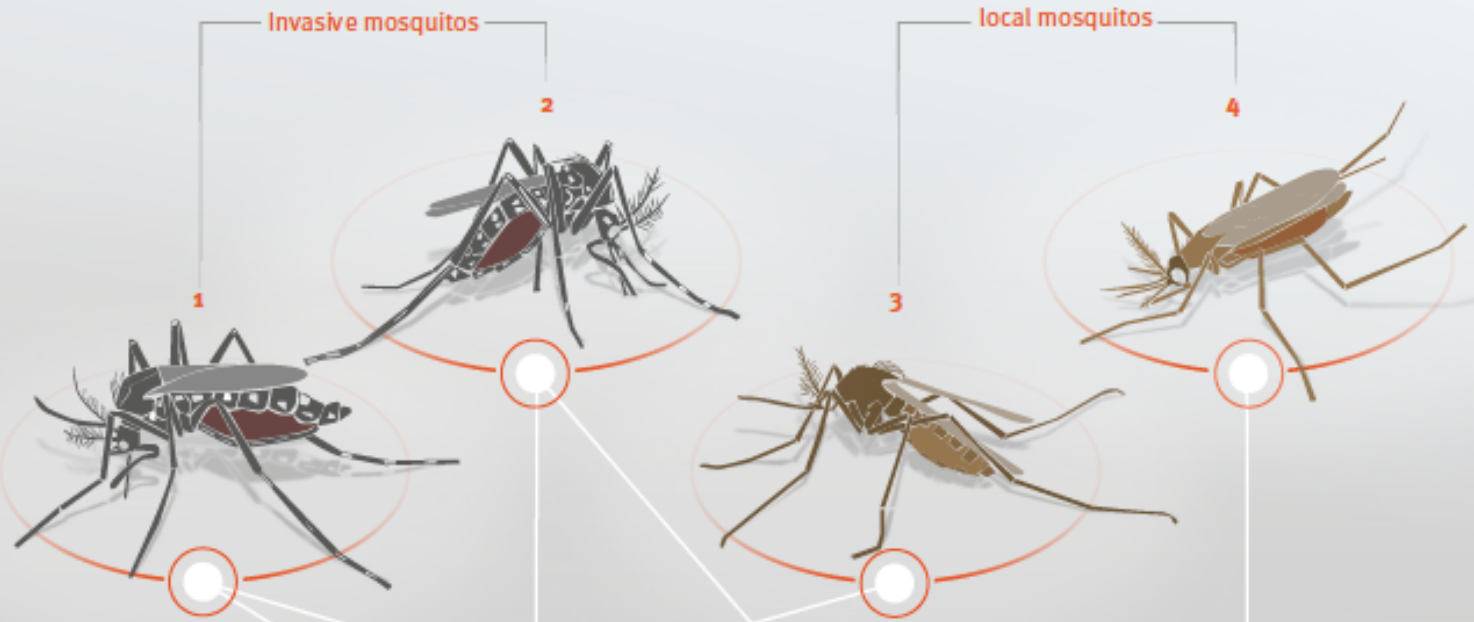
Invasive mosquitoes are determined by their ability to colonise new territories. A considerable increase in the spread of invasive mosquitoes has been observed in Europe since the late 1990s.

1. After dispearence in the 20th century ***Aedes aegypti*** has recently established in Madeira. It is also present around the Black Sea coast, Russia and Georgia.

2. ***Aedes albopictus*** is considered to be the most invasive mosquito species in the world.

3. ***Culex pipiens*** is the most widespread mosquito in Europe

4. The ***Anopheles*** mosquito can be found from south-eastern Sweden to Portugal.



West Nile Fever
Cases can be severe, most often among the elderly. An estimated 1 out of 140 to 320 persons infected can get severly sick.

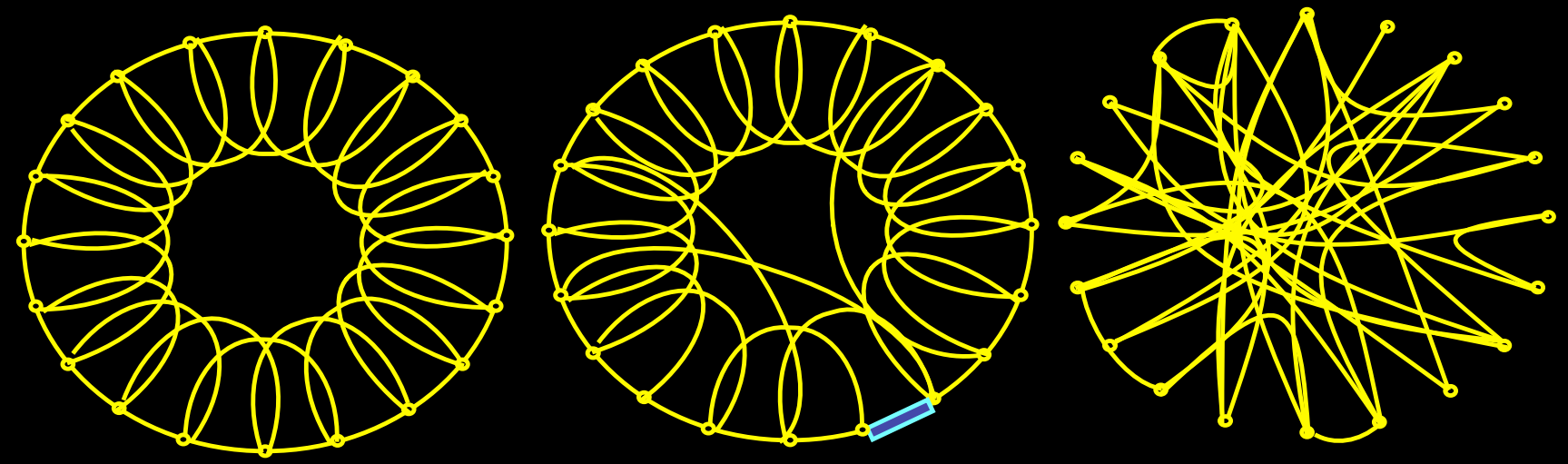
Dengue:
Most infected people have fever lasting 10 days. More then 390 million cases are estimated worldwide.

Chikungunya
Infected people suffer from fever and strong arthralgia, which can last for months. No vaccination is available.

Malaria
Worldwide, approx. 600 000 deaths people die every year. Early diagnosis and prompt treatment can prevent illness and death. Prophylaxis is available.

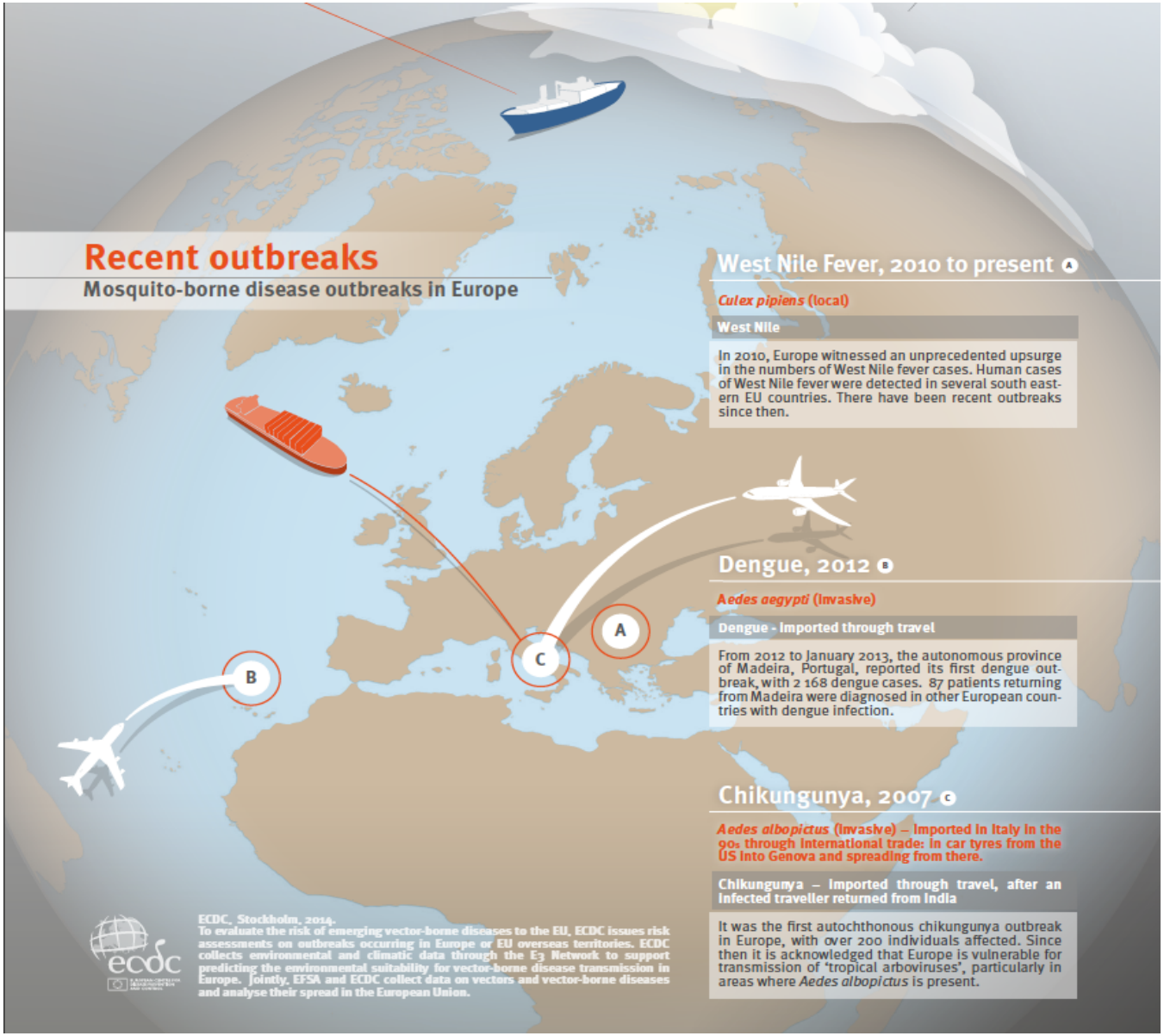
HUMAN TRAVELS

Regular | Small-world | Random



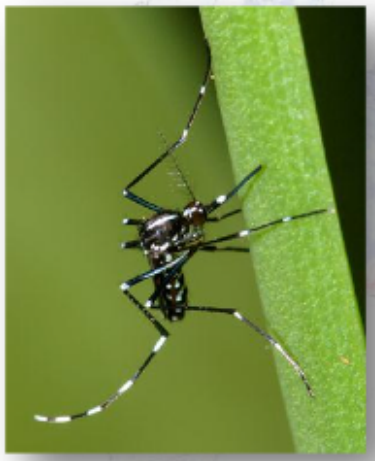
Increasing randomness


biodiversa


Recent outbreaks
Mosquito-borne disease outbreaks in Europe
West Nile Fever, 2010 to present A
Culex pipiens (local)
West Nile
In 2010, Europe witnessed an unprecedented upsurge in the numbers of West Nile fever cases. Human cases of West Nile fever were detected in several south eastern EU countries. There have been recent outbreaks since then.
Dengue, 2012 B
Aedes aegypti (invasive)
Dengue - Imported through travel
From 2012 to January 2013, the autonomous province of Madeira, Portugal, reported its first dengue outbreak, with 2 168 dengue cases. 87 patients returning from Madeira were diagnosed in other European countries with dengue infection.
Chikungunya, 2007 C
Aedes albopictus (invasive) – Imported in Italy in the 90s through international trade: in car tyres from the US into Genova and spreading from there.
Chikungunya – Imported through travel, after an infected traveller returned from India
It was the first autochthonous chikungunya outbreak in Europe, with over 200 individuals affected. Since then it is acknowledged that Europe is vulnerable for transmission of 'tropical arboviruses', particularly in areas where Aedes albopictus is present.
A
B
C
ecdc
ECDC, Stockholm, 2014.
To evaluate the risk of emerging vector-borne diseases to the EU, ECDC issues risk assessments on outbreaks occurring in Europe or EU overseas territories. ECDC collects environmental and climatic data through the E3 Network to support predicting the environmental suitability for vector-borne disease transmission in Europe. Jointly, EFSA and ECDC collect data on vectors and vector-borne diseases and analyse their spread in the European Union.

- ≈ 3,500 mosquito species
- ≈ 90 indigenous species in Europe
  * ≈ 39 in Austria
  *≈ 50 in Germany
  * ≈ 65 in France

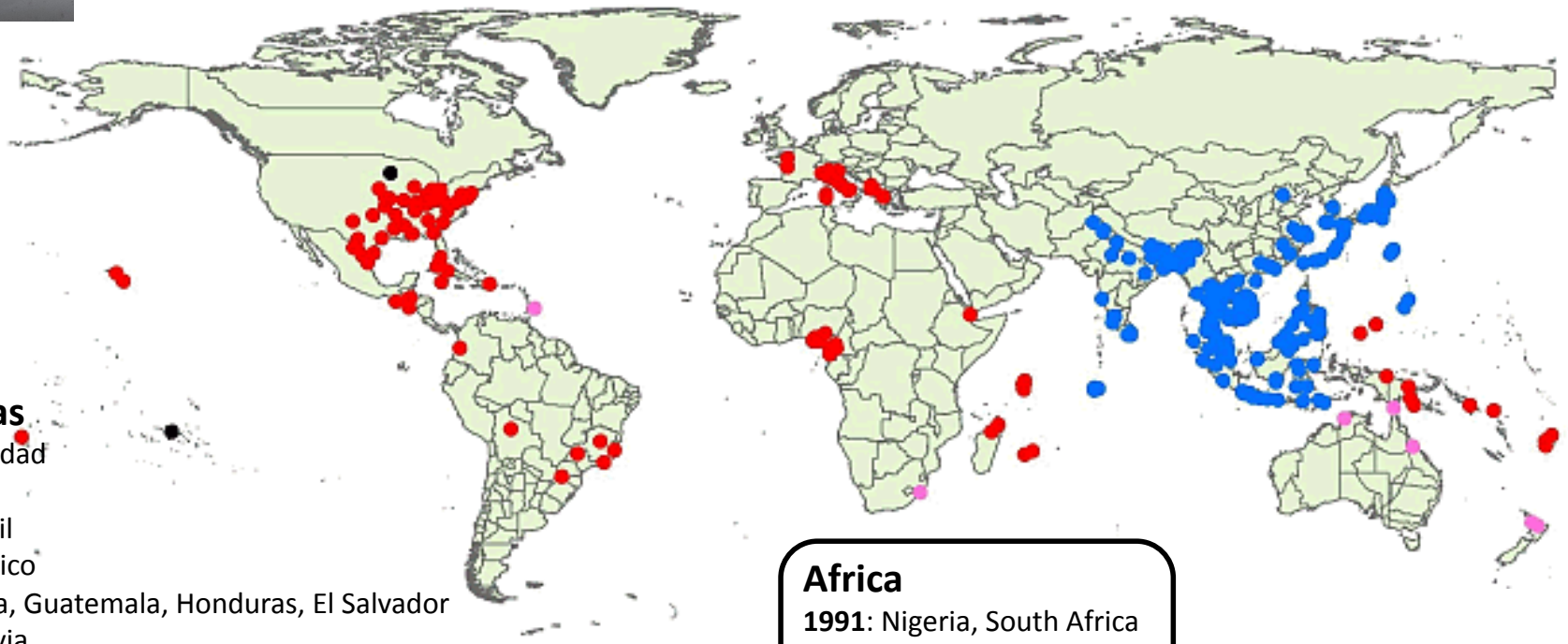
Invasive mosquitoes



Ae. aegypti
Ae. albopictus ←
Ae. atropalpus
Ae. japonicus ←
Ae. koreicus

Tiger mosquito: an invasive species

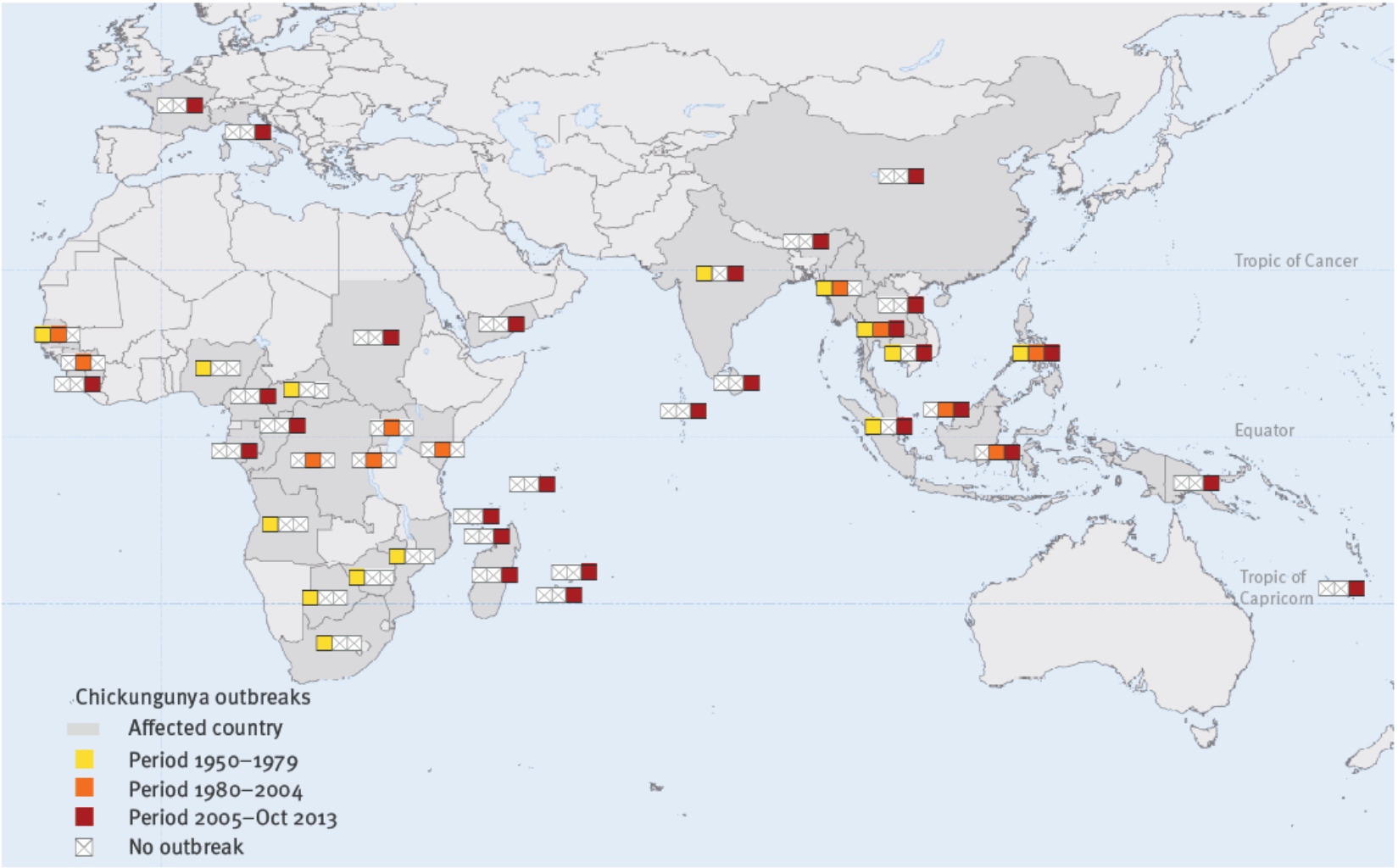
Europe
1979: Albania
1990: Italy
1999: France
2001: Serbia, Montenegro
2003: Switzerland, Greece, Israel
2004: Belgium, Spain
2005: Netherlands, Slovenia, Croatia, Bosnia, Herzegovia
2007: Austria, Germany



Americas
1983: Trinidad
1985: USA
1986: Brazil
1988: Mexico
1995: Cuba, Guatemala, Honduras, El Salvador
1997: Bolivia
1998: Argentina, Colombia, Paraguay
2002: Panama
2003: Nicaragua

Africa
1991: Nigeria, South Africa
2000: Cameroon
2001: Guinea
2006: Gabon

Historical overview of the chikungunya outbreaks prior to the emergence of the chikungunya virus in the Caribbean in December 2013



Bortel et al. 2014. Euro Surveill

Aedes albopictus

Current known distribution: January 2014

- Established
- Introduced
- Absent
- No Data
- Unknown

Outermost regions

- Azores (PT)
- Canary Islands (ES)
- Madeira (PT)
- Svalbard/Jan Mayen (NO)

ECDC 2014/VBORNET

Global change drivers

- ✓Temperature changes
- ✓Rainfall
- ✓Urbanization
- ✓Land use and deforestation
- ✓Irrigation and water storage
- ✓Chemical pollution
- ✓Increase trade, travel

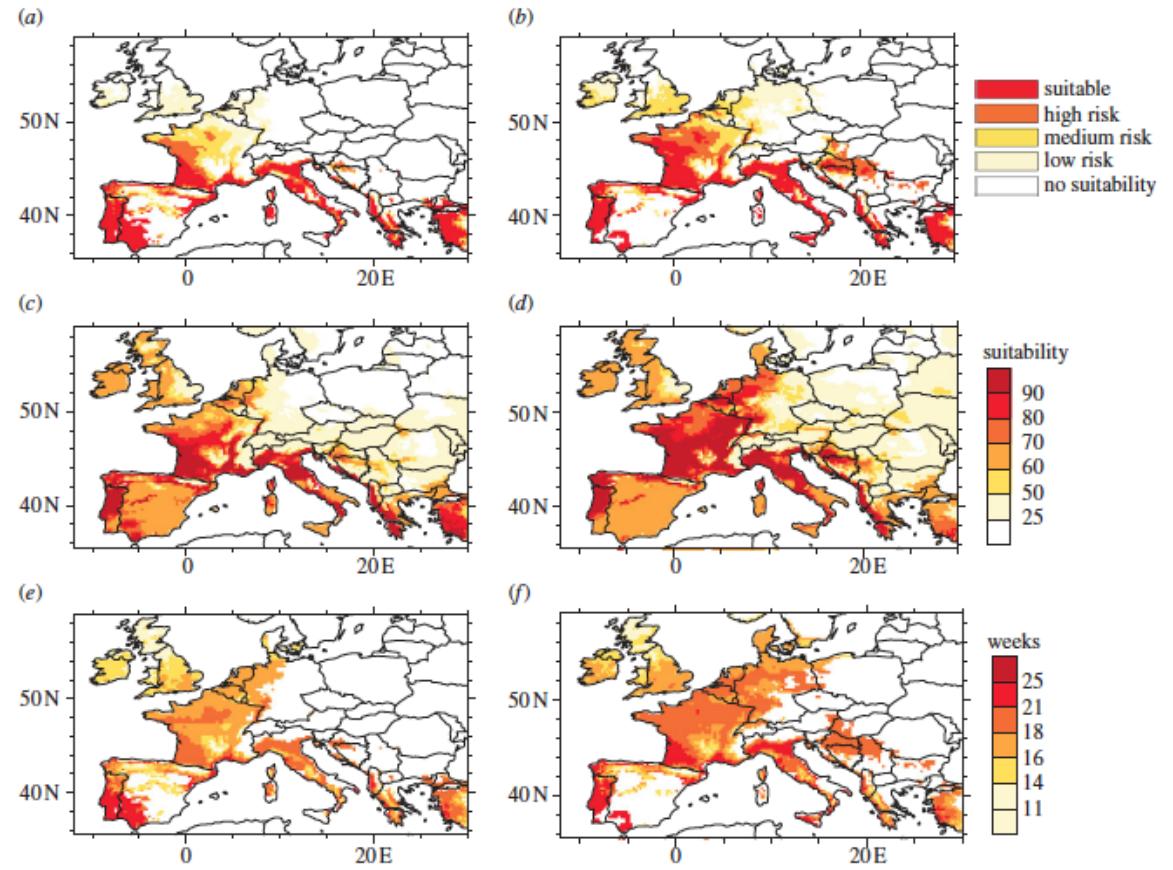


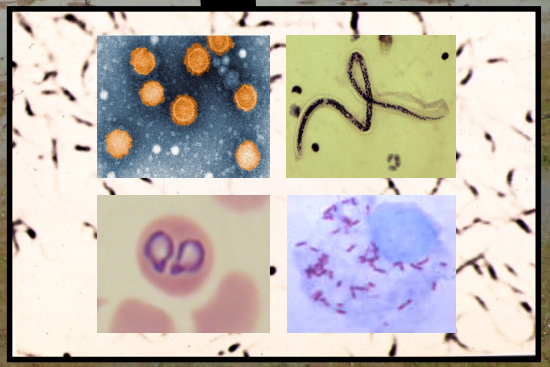
Figure 3. Observed climate suitability of *A. albopictus* based on different models (rows) and for two different time periods (columns). (*a*,*b*) The climate suitability is calculated based on model 1 for (*a*) 1960–1989 and (*b*) 1990–2009. (*c*,*d*) The climate suitability is based on model 2. This is carried out for (*c*) 1960–1989 and (*d*) 1990–2009. (*e*,*f*) Weeks of adult mosquito activity for (*e*) 1960–1989 and (*f*) 1990–2009 based on model 3. See §2 for further details.

- No vaccine against a large majority of mosquito-borne diseases
- Major strategy to limit transmission based on vector control

No vector
No transmission

Host

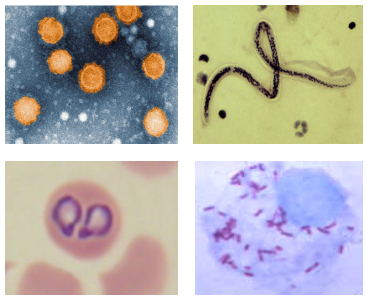
Environment



Pathogens

Vectorial pathosystem = V + P + R + H + E + M

Pathogens



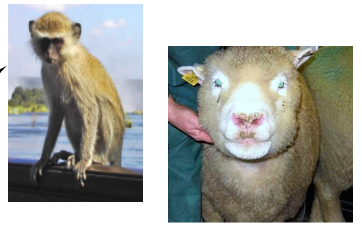
Parasitism

Vectors

Parasitism

Epizooty

Reservoirs/victims



Zoonoses

Antagonism

Cooperation

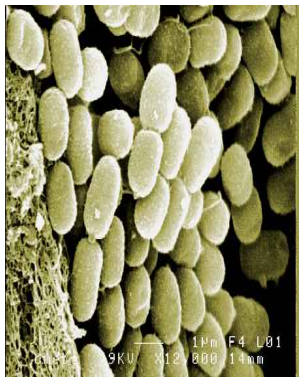
Symbiosis

Holobiont

pleiotropy

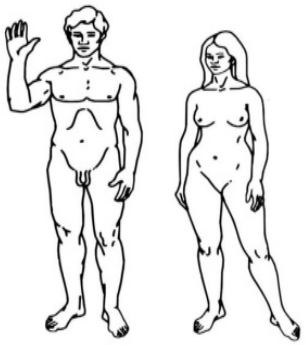
Pathogenicity

Epidemy



Symbionts

Environment



Host victims

What do health and environmental decision makers and stakeholders expect from entomologists, microbiologists, ecologists …

- **Assess the risk**
  - Contribute to the definition of risk levels when setting up the preparedness plans;
  - Describe the level of risk at present;
  - Anticipate/predict the dynamics of the vector
    « when will an area move from level 0b to level 1? »;
  - Describe the ability of the vector for autochthonous transmission of the disease.

- **Guide prevention and control measures**
  - Which vector control methods and when? Efficacy and toxicity
  - Assess the results

- **Participate in the communication to professionnals and the public**

GC-INVAMOFECT scientific objective

Demonstrate and characterize the biological invasion and adaptation of mosquitoes and associated infectious risks under global changes (anthropization, lande use, climate)

Scientific questions to answer

(i) *What are the current niche occupations of the two mosquito invasive species in Europe under climate change and anthropogenic pressure?*
(ii) *What are the potential functions and the diversity of the microbiota (symbionts and pathogens) associated with invasive wild mosquitoes in Europe?*
(iii) *Do microbes facilitate or constrain adaptation to a changing environment (temperature, anthropogenic activities)?*
(iv) *How pathogens-symbionts interactions evolve in European invasive mosquitoes?*
(v) *Can we establish correlations between mosquito spreading, microbiota content, ecological and high-level human activities to guide coherent policy vector control and biodiversity conservation in articulation with human and animal health?*

Mosquito models

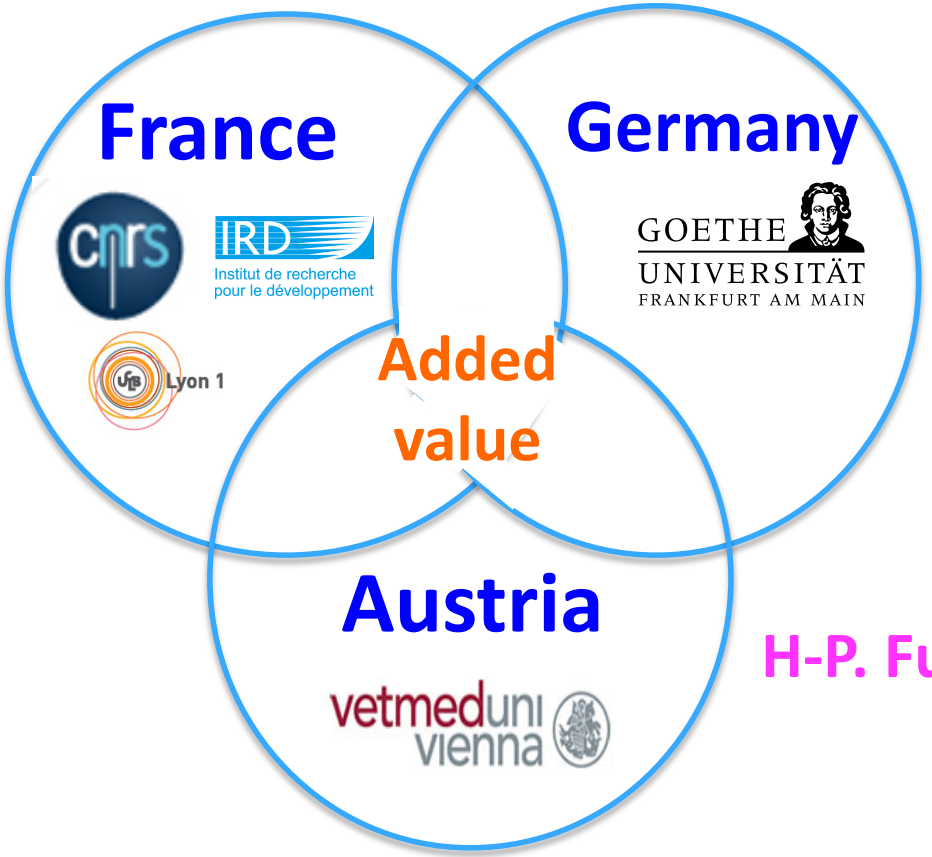
Aedes albopictus and *Aedes* (*Ochlerotatus*) *japonicus*

Consortium

Agence Nationale de la Recherche ANR

P. Mavingui

D. Fontenille



DFG

S. Klimpel

H-P. Fuehrer

Vborn Net

EID MÉDITERRANÉE
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Démoustication

Entente Interdépartementale pour la démoustication
AIN-ISERE-RHONE-SAONE
EID

FWF

anses
agence nationale de sécurité sanitaire alimentation, environnement, travail

Sequence Databases

WP0. Coordination and management of the project

Coordinator : CNRS (Patrick Mavingui)

WP1. Ecology and prevalence of invasive mosquitoes

Leaders: IRD (D. Fontenille), IEED (S. Klimpel)

Partners : CNRS, IEED, IRD, UVM

WP2. Mosquito metagenomics

Leaders: CNRS (C. Valiente Moro)

Partners : CNRS, IEED, IRD, UVM

WP3. Mosquito-borne pathogen community

Leaders: UVM (HP. Fuehrer), CNRS (D. Lavillette)

Partners : CNRS, IEED, IRD, UVM

WP4. Microbial interference on adaptive life traits and vector competence

Leaders: IRD (F. Simard), CNRS (P. Mavingui)

Partners : CNRS, IEED, IRD, UVM

WP5

Modelling

Leaders:
IEED (S. Klimpel)
IRD (D. Ayala)

Partners:
IEED, IRD, UVM

WP1 – MOSQUITO ECOLOGY & PREVALENCE

Leaders: Didier F & Sven K **Partners involved: all**

Sampling and describing spatiotemporal distribution of targeted mosquitoes (*Ae. albopictus*, *Oc. japonicus*) under environmental parameters (climate, land use, anthropogenic activities)

Task 1
Mosquito sampling & occurrence data

- New sampling
- Historical collection

Task 2
Ecological site characterization

- Record data

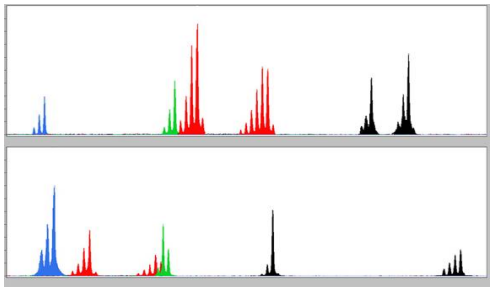
Comparative analysis and provide samples to other WPs

WP2 – MOSQUITO MICROBIAL METAGENOMICS

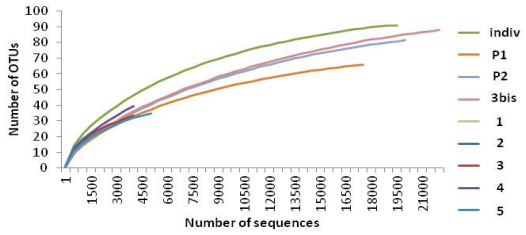
Leader: Claire VM **Partners involved: all**

To use NGS technologies to provide taxonomic and functional diversity data, gathered from studies of the relationship between mosquito, its associated microbiota and environmental conditions.

Task 1
Genotyping of mosquitoes



Task 2
Microbial metataxogenomics



Task 3
Microbial metatranscriptomics

Comparative analysis

WP3 – MOSQUITO-BORNE PATHOGEN COMMUNITY

Leaders: Hans-Peter F & Dmitri L Partners involved: all

Task 1
Pathobiome identification

NGS sequencing Tech
(virome, bacteriome,)

Task 2
Specific screening & prevalence of known pathogens

NGS sequencing Tech
Generic primers
(Alpha, Flavi, Paramyxo …)

Comparative analysis

WP4 – MICROBIAL INERFERENCE ON ADAPTIVE LIFE HISTORY TRAITS & VECTOR COMPETENCE

LeaderS: Fred S F & Patrick M **Partners involved: all**

To perform experimental approach for deciphering the impact of bacterials symbionts on mosquito adpative life history traits and competence

Task 1
Microbiota & phenotypic plasticity

Mosquito bacteria symbiosis & temperature

Mosquito bacteria symbiosis & pollution (ammonia)

Task 2
Microbiota & vector competence

Experimental infection

Comparative analysis

WP5 – MODELLING, INTEGRATION, PREDICTION, DECISION-MAKING, TOOLS

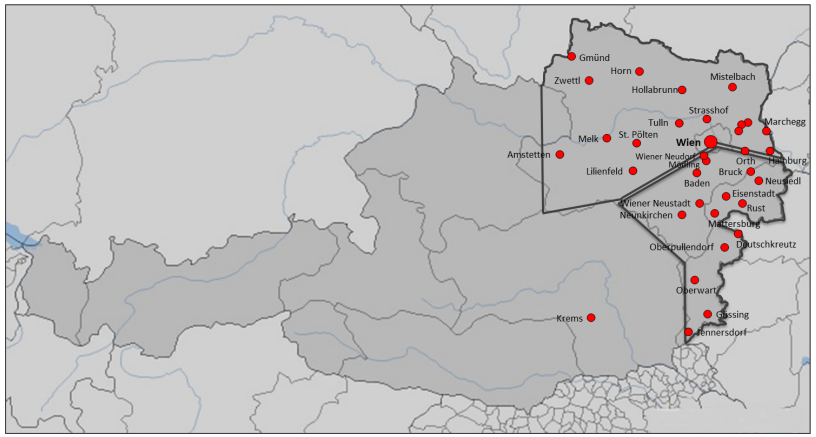
LeaderS: Sven K & D Ayala **Partners involved: 2, 3, 4**

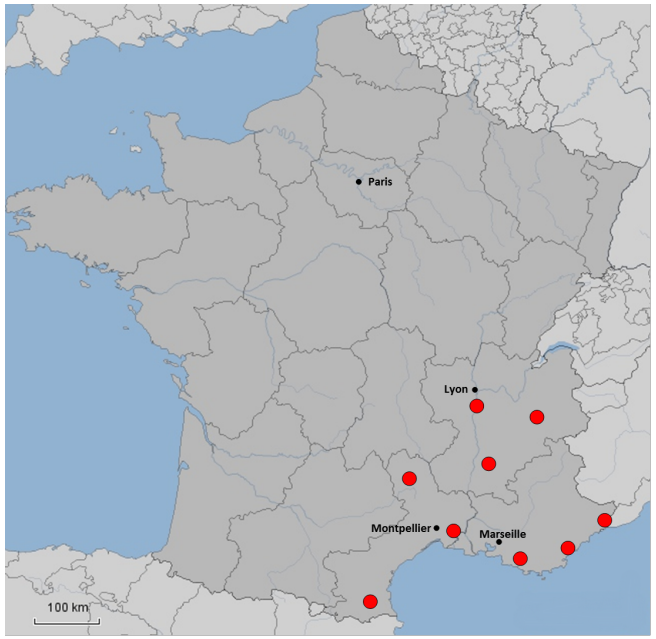
Task 1
Ecological niche modelling

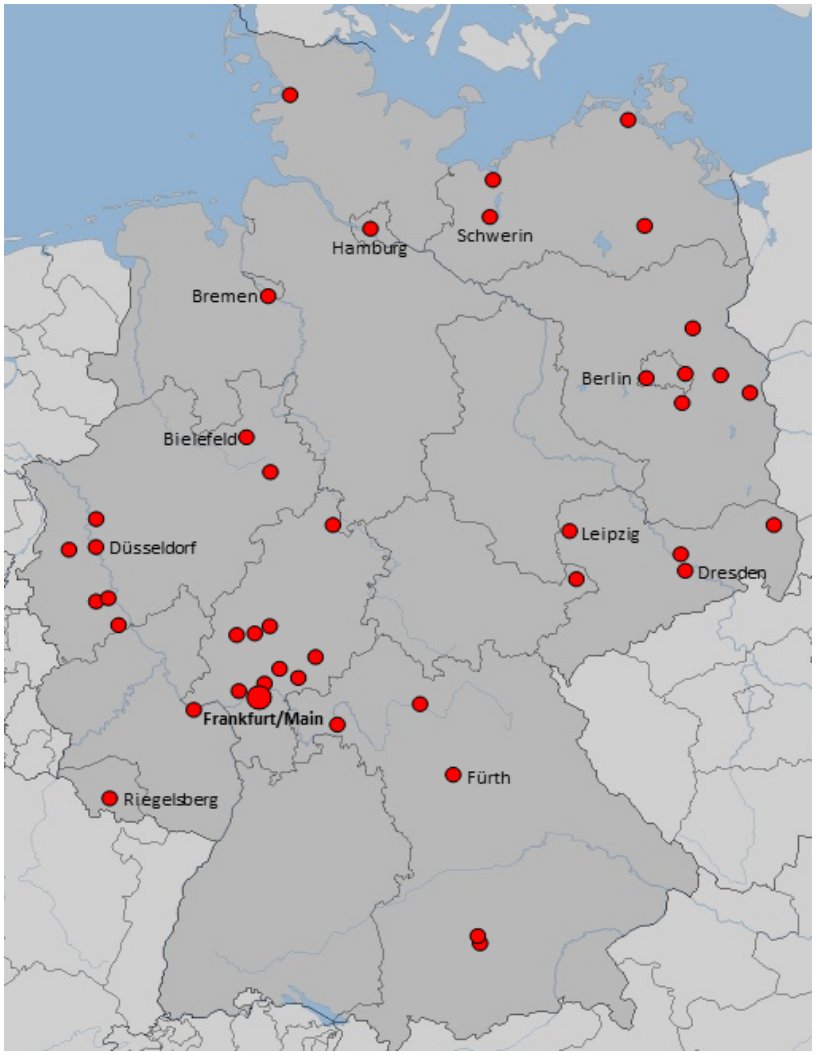
Task 2
Microbiota diversity & local adaptation

Comparative analysis

WP1 – Task 1 Sampling, monitoring maps







Adult trapping by BG-sentinel

- **27 permanent + 13 non-permanent sampling sites (sampled every second week for 24h)**
- **Until mid. Sep. 2014 – 8,246 female mosquitoes**
- **21 species out of 5 genera**
- **Most abundant mosquito genera were *Aedes/ Ochlerotatus* (4996 individuals), followed by *Culex* (1784 individuals), *Coquillettidia* (1278 individuals), *Anopheles* (187 individuals) and *Culiseta* (1 individual).**

- **Invasive species examined in 2014: *Anopheles hyrcanus***

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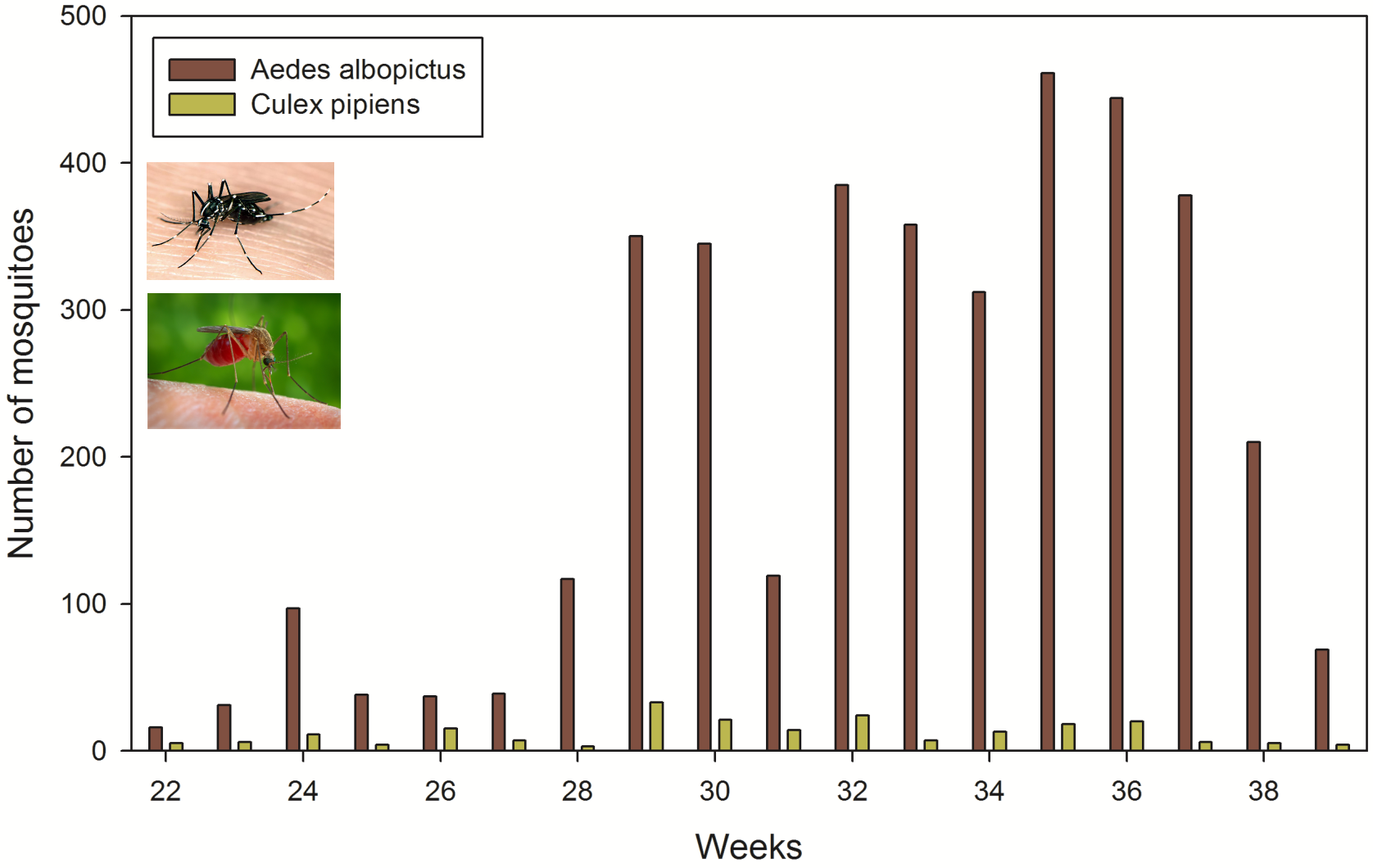
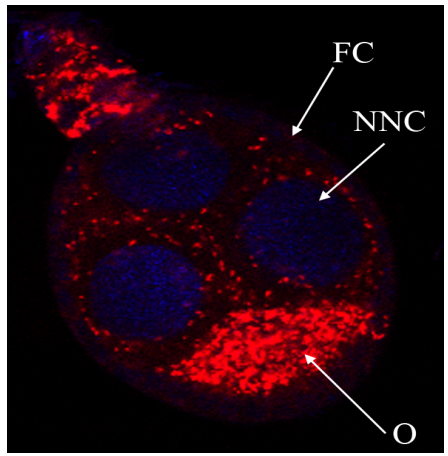

Aedes albopictus
Culex pipiens
Number of mosquitoes
0
100
200
300
400
500
22
24
26
28
30
32
34
36
38
Weeks



Dissecting mosquitoes in BSL2 - © G. Minard

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- **Presse**
- **Ö1-Ö3 Radio**
- **Radio Wien**
- **Biorama**
- **NÖN**
- **Universum**

Tigermoskitos und japanische Buschmücken

In einem länderübergreifenden Forschungsprojekt sind Wiener Forscher auf Insektenjagd. Sie erforschen, welche Stechmückenarten in Österreich heimisch sind und ob sie Krankheitserreger in sich haben. VON ALICE GRANCY

Malaria gilt als Tropenkrankheit. Bis in die 1950er-Jahre gab es Malaria – wenn auch in einer sanfteren, in der Regel nicht tödlichen Form – auch in Österreich. Seither gilt die Krankheit als ausgerottet. Mit der Globalisierung und dem Klimawandel siedeln sich neue Insektenarten aus fernen Ländern an.

In einem vom Österreichischen Wissenschaftsfonds FWF geförderten, länderübergreifenden Projekt untersuchen Wissenschaftler des Instituts für Parasitologie der Vetmed-Uni Wien nun, welche Stechmücken es aktuell in Österreich gibt. Zugleich prüfen sie, ob neue Krankheitserreger zu finden sind, und wenn ja, welche.

„An sich ist die Anophelesmücke auch in Österreich heimisch. Die häufigsten Arten, die Malaria übertragen, jedoch nicht", sagt Projektleiter Hans-Peter Führer.

Im Fokus der Wiener Forscher stehen zwei asiatische Mückenarten: der asiatische Tigermoskito und die japanische Buschmücke. Der Tigermoskito überträgt etwa das gefährliche Dengue-Fieber.

Beide Mückenarten wurden in den letzten Jahren bereits in Österreich nachgewiesen. „Darum ist es notwendig zu prüfen, ob sie sich schon angesiedelt haben." Die Insekten gelangen auf unterschiedlichen Wegen nach Europa: Manche Mücken legen ihre Eier etwa in Autoreifen ab. Oft kommen sie aber auch auf Schiffen nach Europa.

IN KÜRZE

Länderübergreifende Forschung. In einem internationalen Programm des Wissenschaftsfonds FWF untersuchen Wiener Forscher gemeinsam mit Kollegen aus Deutschland und Frankreich, wie sich Stechmücken in Europa ausbreiten.

Fallen für Insekten. Vor Kurzem gingen die Forscher in die Feldphase: Sie sammeln nun zwei Jahre lang an 30 Standorten in Niederösterreich, Burgenland und Wien Stechmücken. „Dazu gibt es spezielle Fallen", so Führer. Sind die Stechmücken gefangen, wird ihre Art bestimmt. Dann geht es weiter ins Labor. „Wir untersuchen mit molekularbiologischen Methoden, ob und welche Krankheitserreger sie in sich tragen", sagt der Parasitologe. In Österreich gibt es derzeit kaum von der Stechmücke auf den Menschen übertragbare Krankheiten. Das könnte sich ändern, wenn neue Erreger und Stechmücken ins Land kommen. Ziel der Forschungsarbeiten ist es, eine Grundlage für Handlungsempfehlungen für den künftigen Umgang mit den Insekten zu schaffen.

VBORNET

Entente Interdépartementale pour la démoustication

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Démoustication

anses
agence nationale de sécurité sanitaire alimentation, environnement, travail

Sequence Databases

Thank you for your attention

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