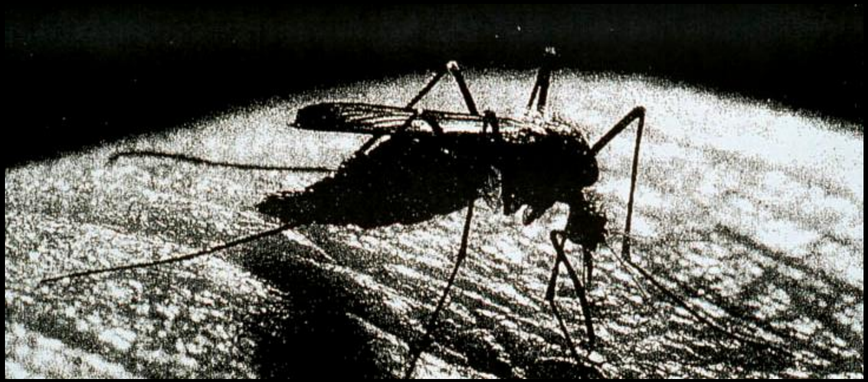
The impact of climate change on pests



CIEH Pest Control Conference: safeguarding public health

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NIHR Health Protection Research Unit in emerging and zoonotic infections, Liverpool, UK
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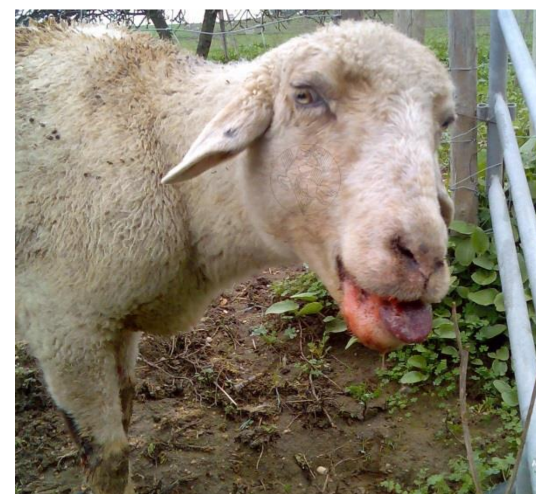
Impacts of vector-borne diseases (VBD)

2nd Plague pandemic 14th century

Malaria in Africa

Zika outbreak in Latin America 2015-2016

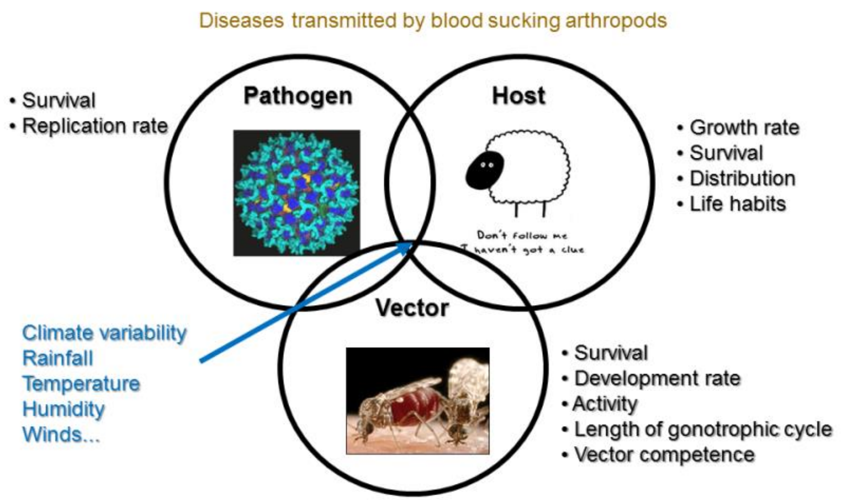
Bluetongue outbreak in Northern Europe Aug-Sep-Oct 2006



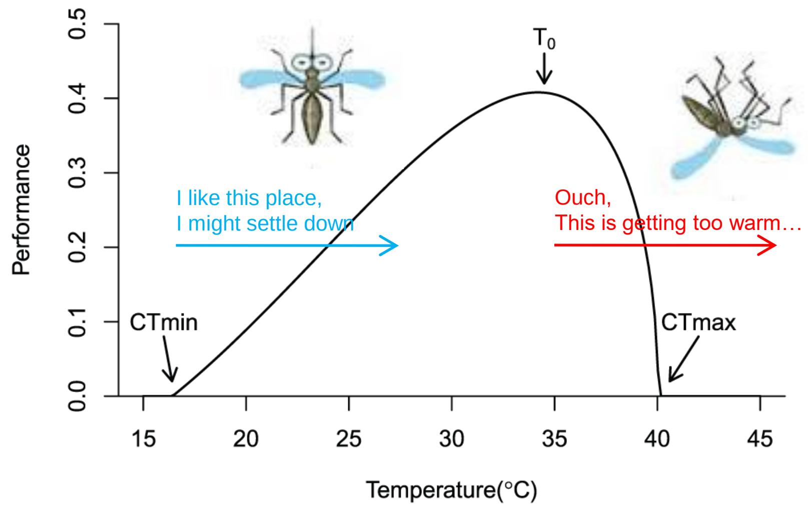
Yellow fever outbreak – Angola, DRC 2015-2016

Climate change impacts on VBDs

VBDs are climate sensitive



Vectorial capacity = f(Tº)



Lafferty KD and Mordecai EA 2016 - [F1000Research 2016, 5:2040]

Modelling the impact of climate variability on VBD burden, development of early warning systems (seasonal to climate change time scales).

Temperature effect on vector biting rates (**a(T)**)

[Scott et al., 2000, J Med Entomol 37(1):89–101]

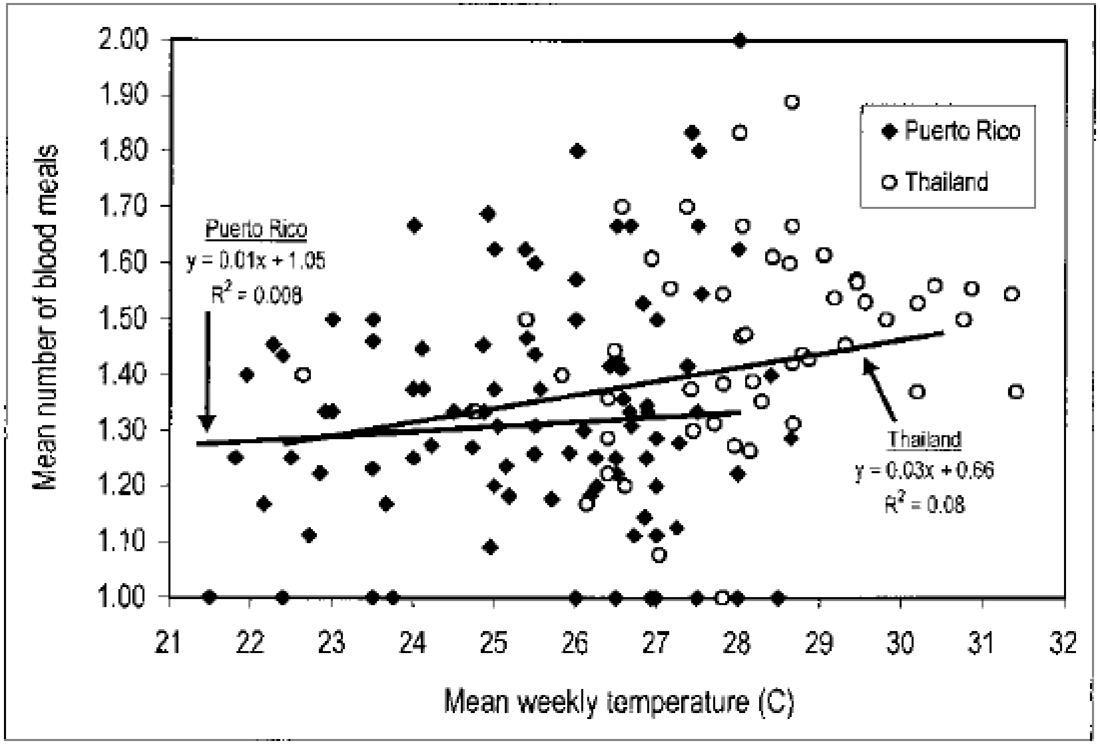


Fig. 5. Relationship between temperature and blood-feeding frequency of female *Ae. aegypti* collected weekly in Thailand (1990–1992) and Puerto Rico (1991–1993). Linear regression lines and equations for each site are included.

Biting rates:

Number of mosquito bites per day per host.
When temperature increases, biting rate increases.

Left:
Biting rates of Ae. aegypti, the yellow fever mosquito; it can transmit dengue, Zika & yellow fever viruses.

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Temperature effect on vector dvpt & mortality (μ(T))

Brady et al., 2013, Parasite and Vectors 6:351

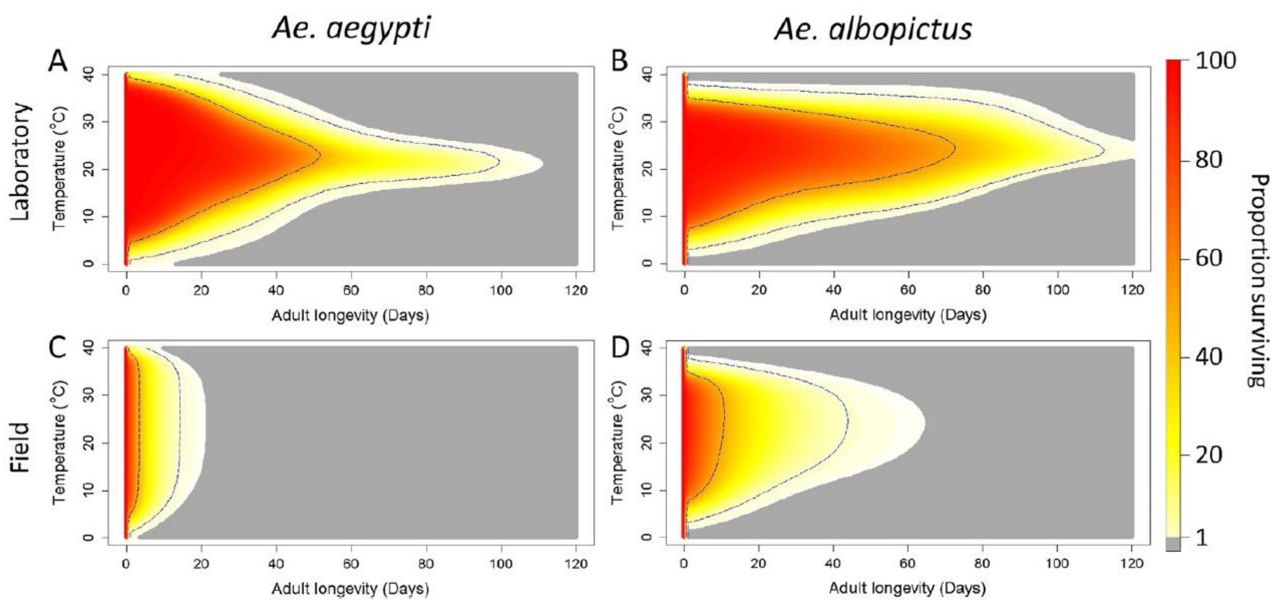


Figure 4 **The distribution of adult female *Aedes aegypti* and *Aedes albopictus* survival across a range of temperatures under laboratory conditions (A and B) and field conditions (C and D).** Colours from red to yellow show survival from 100% - 1% of the population remaining. Grey indicates <1% of the population remaining. Dotted blue lines show the limits for 50% and 95% of the original population remaining.

Ae. aegypti, the yellow fever mosquito

Ae. albopictus, the Asian tiger mosquito

Development rate and mortality:

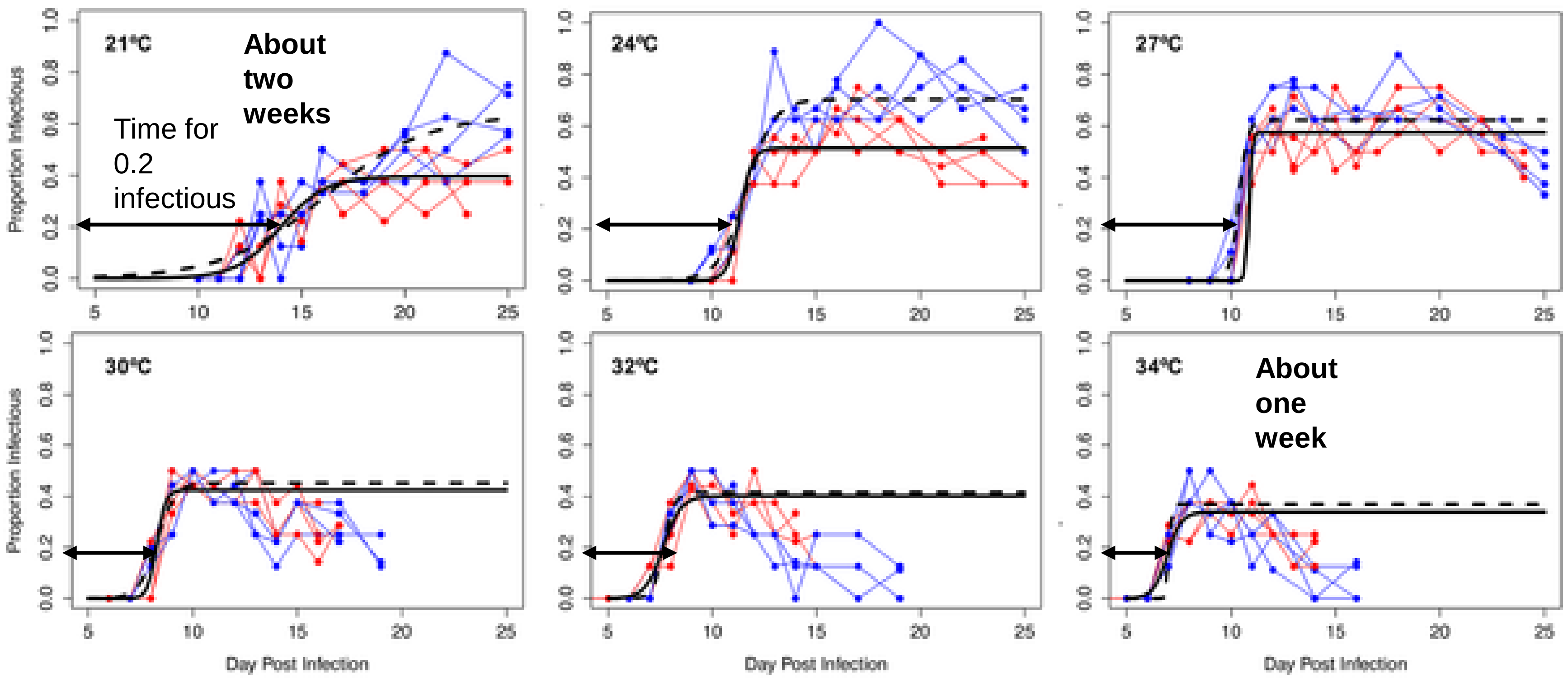
Mosquitoes develop faster at high temperature - if temperature exceeds about 35-37^{o}C mortality tends to increase. Eggs can overwinter &/or resist desiccation.

Water is needed for breeding sites.

Significant differences between the lab and the field!

Temperatures effect on Extrinsic Incubation Period (**EIP(T)**)

Shapiro et al., 2017, Plos Biology 15(10)



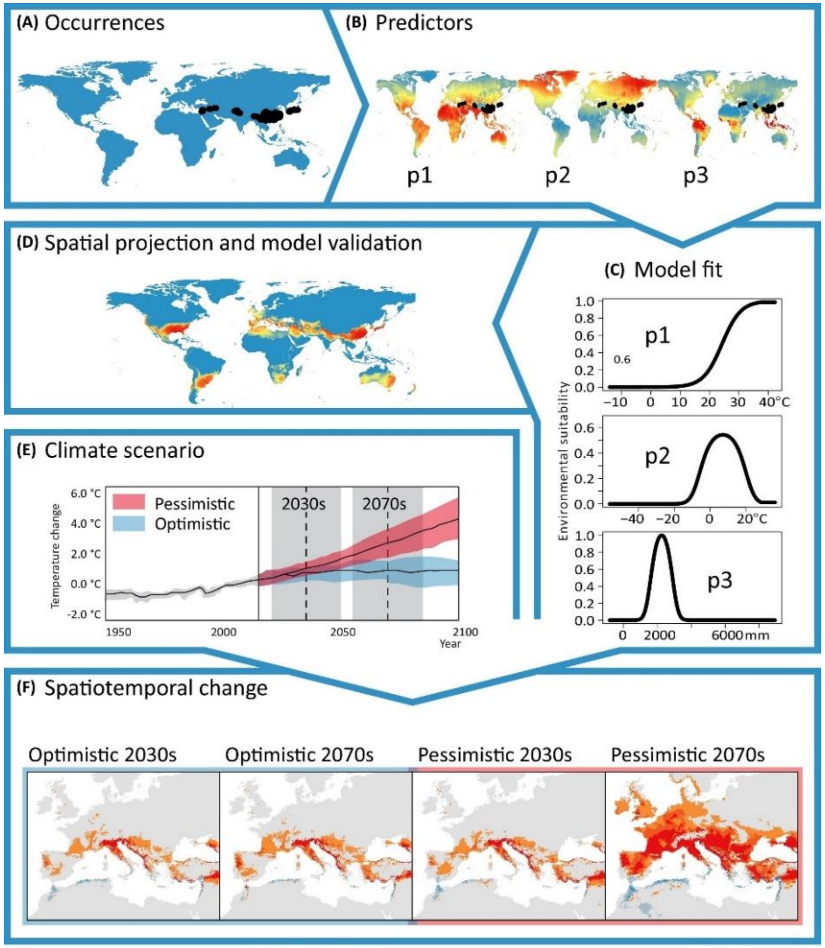
The Extrinsic Incubation Period (EIP) - example for *P. falciparum* and *An. gambiae*: time required for the pathogen to develop inside the mosquito vector before it becomes infectious (when the pathogen is detected in their salivary glands).

When temperature increases, the EIP decreases e.g. it shortens.

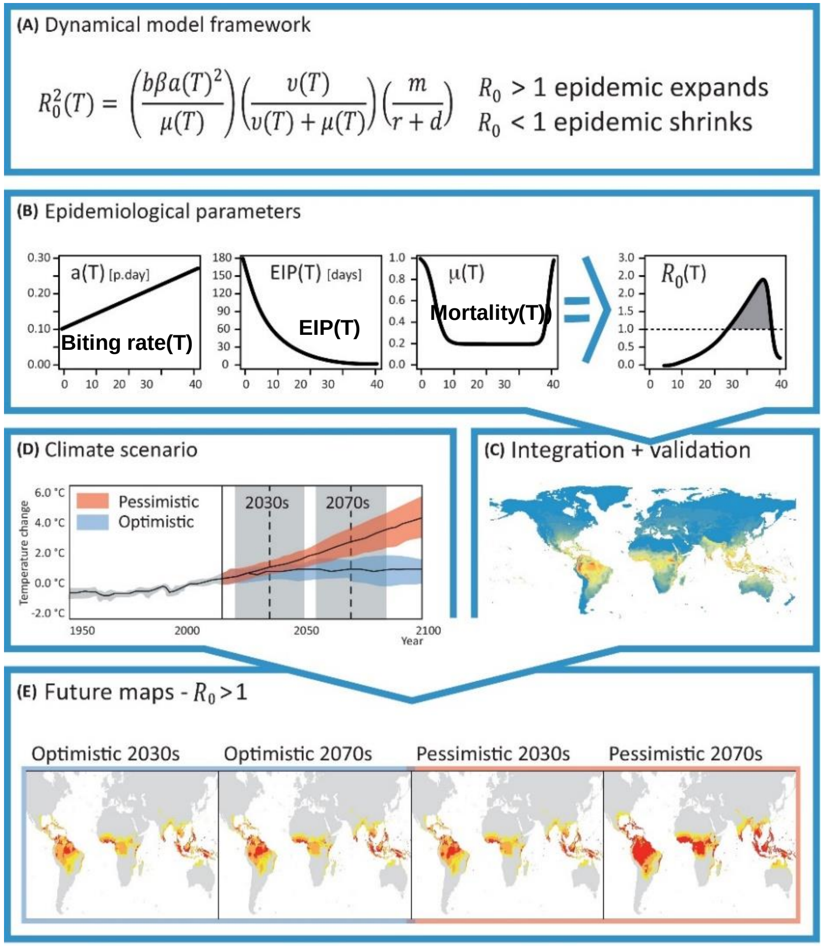
If the temperature is too low, mosquito dies before the pathogen can replicate in their body e.g. before becoming infectious (about 30days life span in the field).

Methods to model the impact of climate on VBDs

Statistical models



Mechanistic models



Stat models: Maxent, BRTs, Bayesian models, Mahalanobis distance…

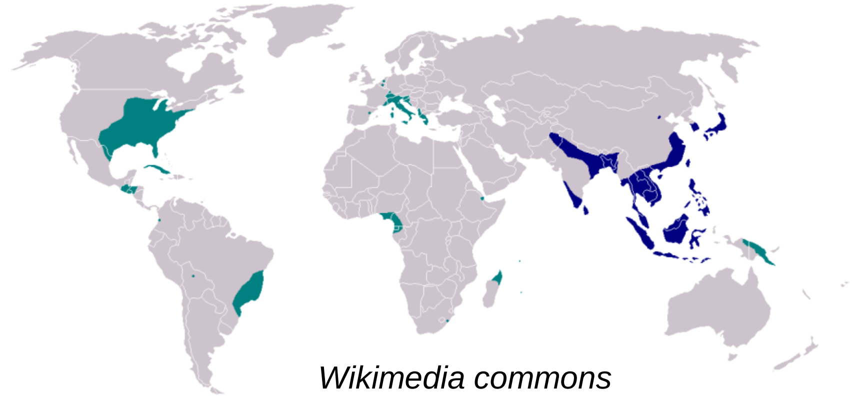
Mechanistic models: SEIR/SIR, R_0, Fuzzy logic, climate envelope…

Tjaden et al. (2018). Trends in Parasitology 34(3): 227-245. http://dx.doi.org/10.1016/j.pt.2017.11.006

Research example: the Asian tiger mosquito, *Ae. albopictus*

The Asian tiger mosquito: *Aedes albopictus*

Rapid spread worldwide



blue: original distribution, cyan: areas where introduced in the last 30 years.

Main introduction routes

Figure 2. Main Aedes albopictus *inroduction routes: (A) Used tyres. (B),(C) Lucky Bamboo (*Dracaena spp.*).*

Scholte & Schaffner, 2007

Rapid spread in Europe & France

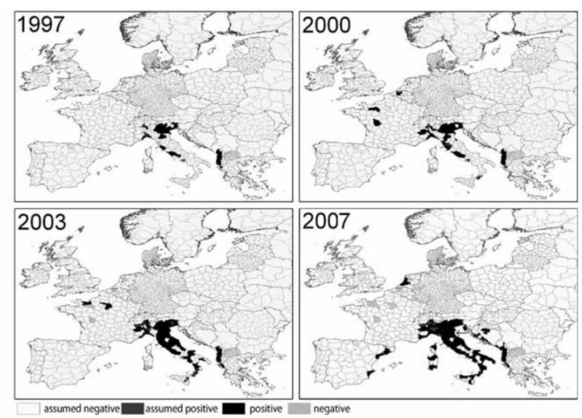
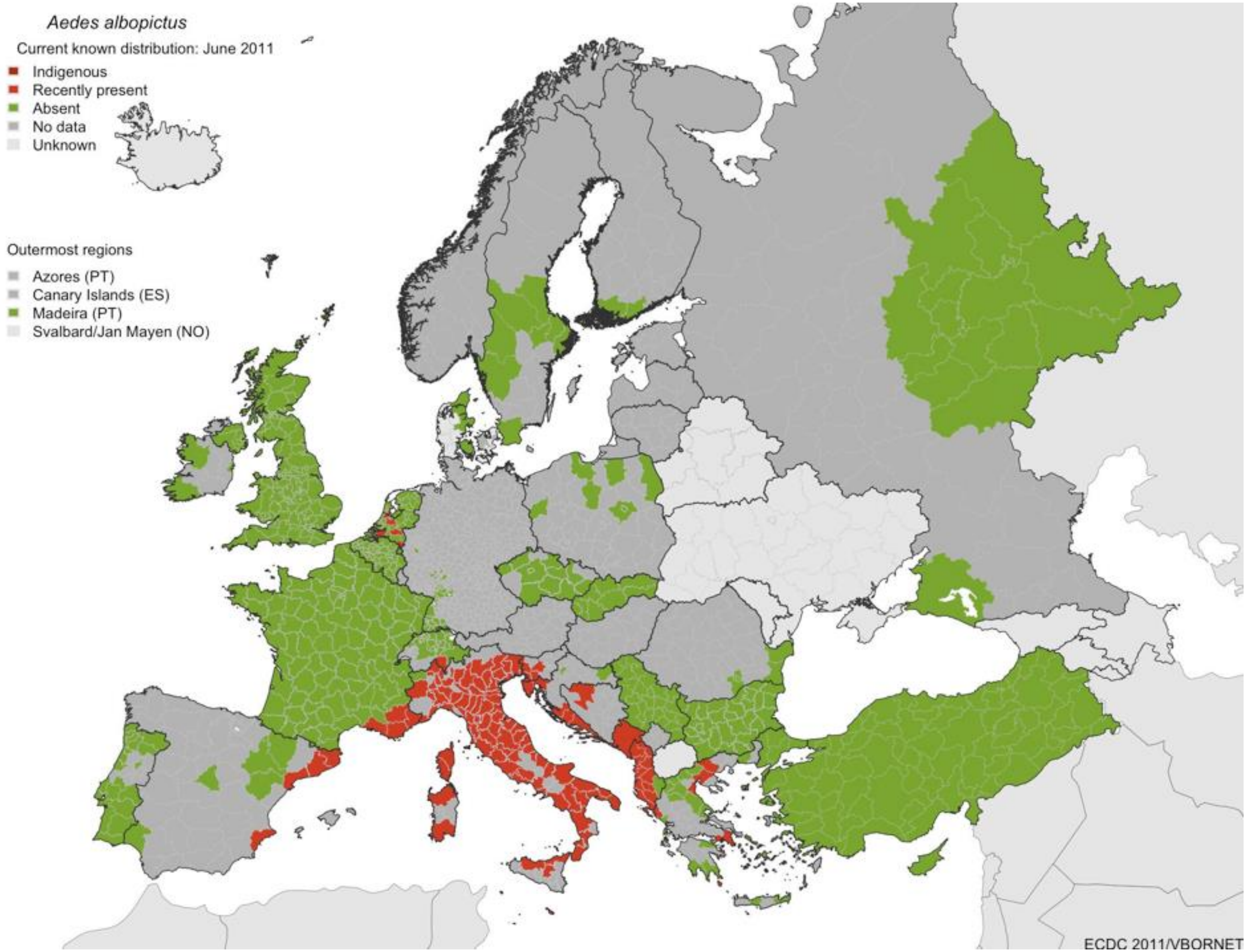


Figure 3. Presence of Aedes albopictus *in Europe per province for the years 1997-2007. Data to complete this figure were kindly made available by Roberto Romi (Italy), Roger Eritja and David Roiz (Spain), Eleonora Flacio (Switzerland), Charles Jeannin (France), Anna Klobučar (Croatia), Zoran Lukac (Bosnia and Herzegovina), Igor Pajovic and Dusan Petrić (Serbia and Montenegro), Bjoern Pluskota (Germany), Anna Samanidou-Voyadjoglou (Greece). The map was made by Patrizia Scarpulla. The 2007 outbreak of Chikungunya virus in Italy is indicated with an arrow in the 2007 box.*

Scholte & Schaffner, 2007

Aedes albopictus – distribution June 2011



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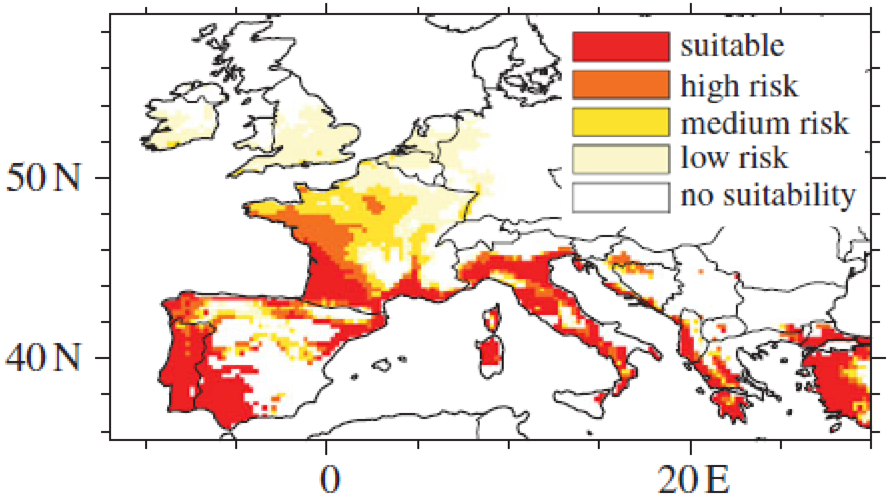
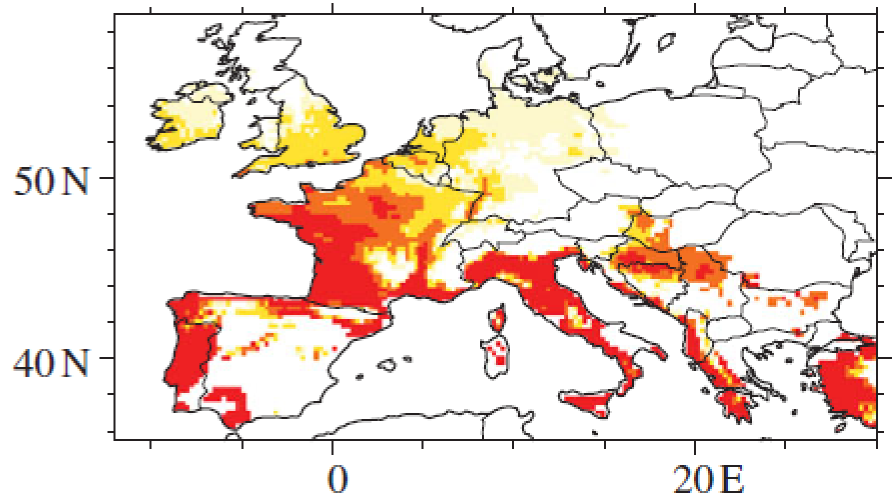
Regions suitable for *Ae. albopictus – U. Liv & PHE work*

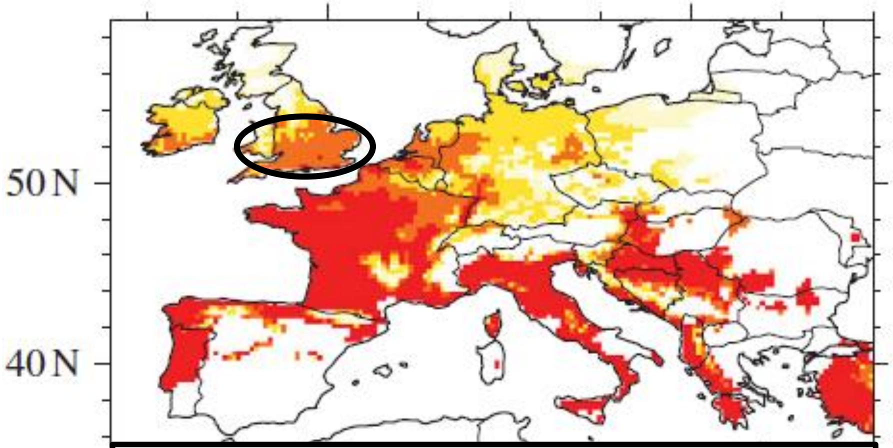
Climate obs (EOBS) 1960-1989



Climate obs (EOBS) 1990-2009



Climate Models (ENSEMBLES 11 RCMS) 2030-2050



Model based on an overwintering criterion (Tjanuary >0C, Rain_annual>500mm) and different thresholds in annual Temperature:

suitable	12C< T_annual
high risk	11C< T_annual < 12C
medium risk:	10C< T_annual < 11C
low risk:	9C< T_annual < 10C
no suitability:	T_annual < 9C

Future risk increase: Benelux, Balkans, western Germany, the southern UK

Future risk decrease: Spain and Mediterranean islands

Main findings:

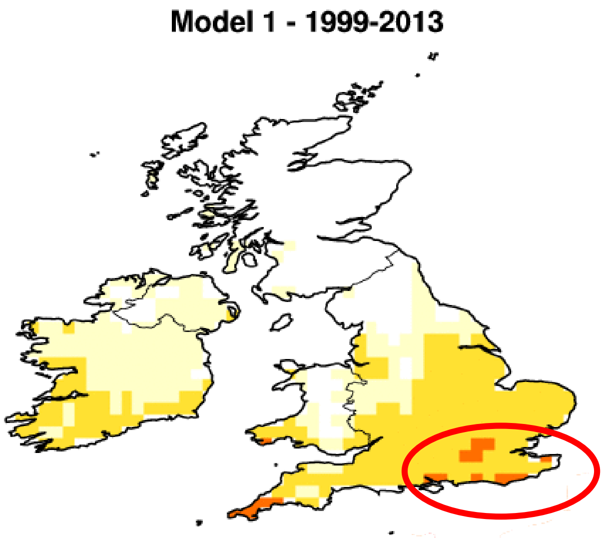
1) Climate already suitable over a large area for its establishment in 1960-1989

2) Climatic suitability increased over the past 20 years over central-northern Europe and the Balkans

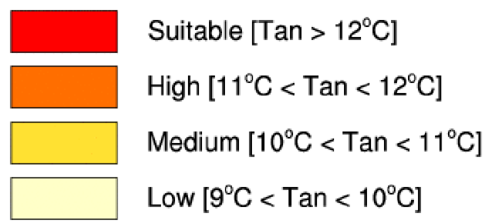
3) Similar trend for the future (risk increases in the North and decreases over southern Europe)

Caminade et al., 2012, JRSI

HPRU kick off meeting, Liverpool Nov 2014

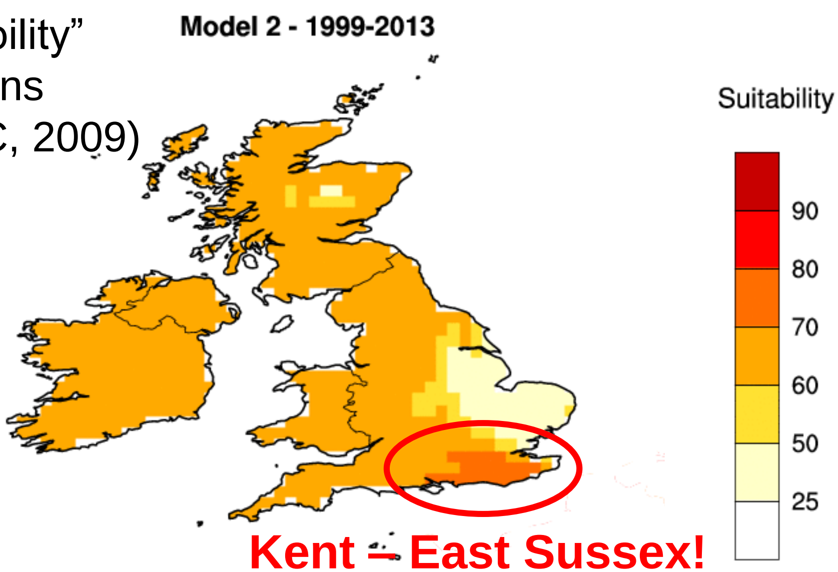


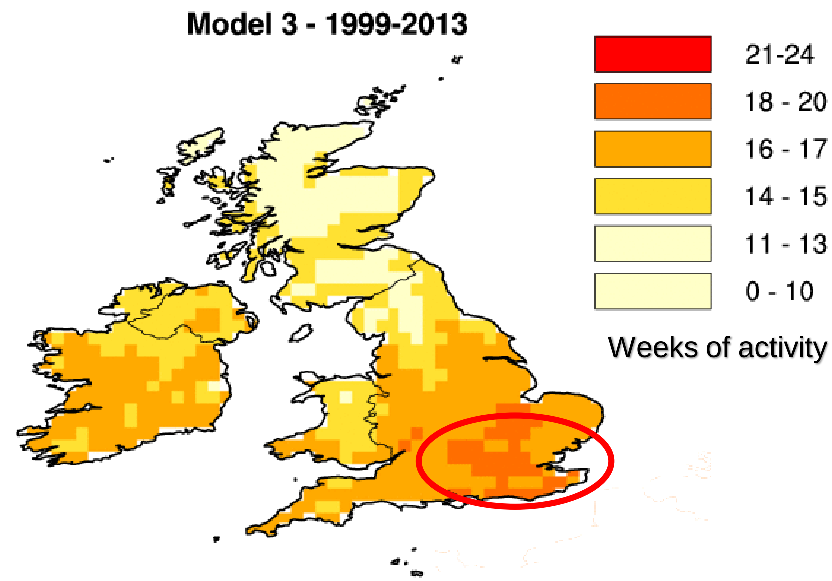
Model 1: Overwintering criterion + Annual Temperature and rainfall thresholds (Kobayashi et al., 2002)



Model 3
Overwintering, temperature and photoperiod (Medlock et al, 2006).

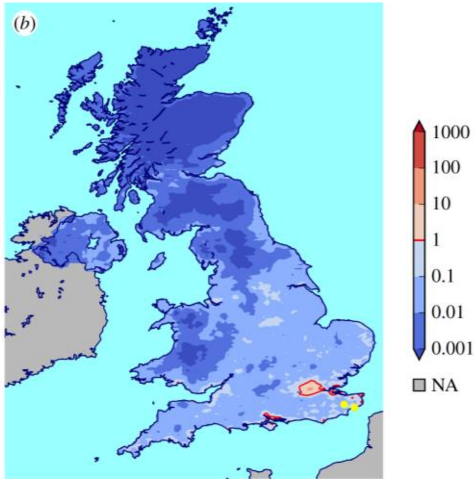
Model 2:
"Suitability" functions (ECDC, 2009)





Risk for the UK - 2019

Recent climatic suitability 2006-16

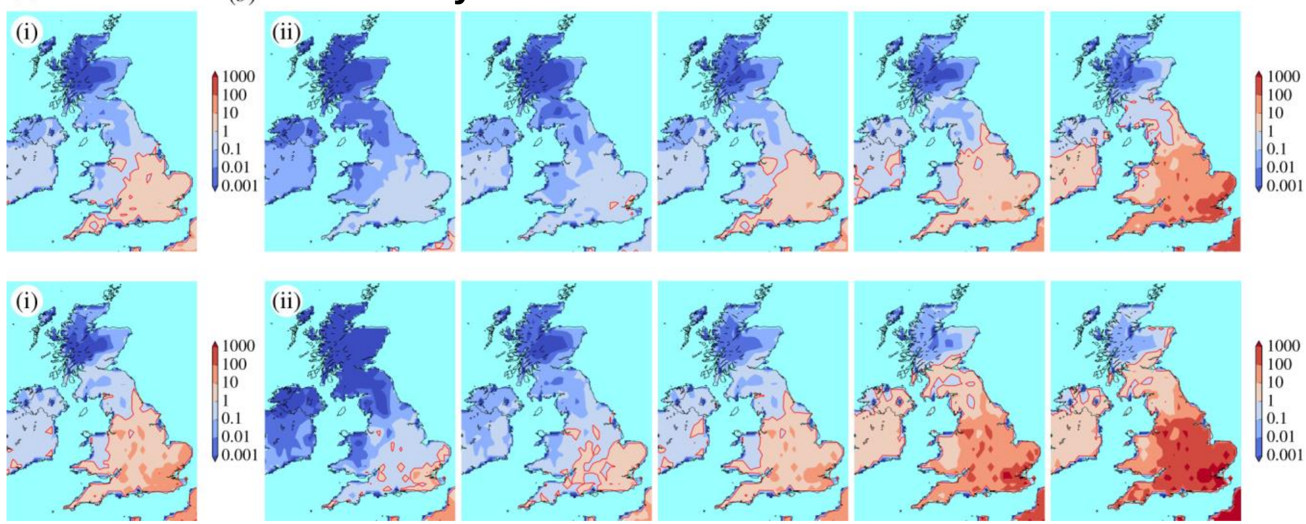


Recent context:
Thames estuary & Kent at risk
Future scenarios:
Climatic suitability to increase over southern UK

Future climatic suitability 2060-69

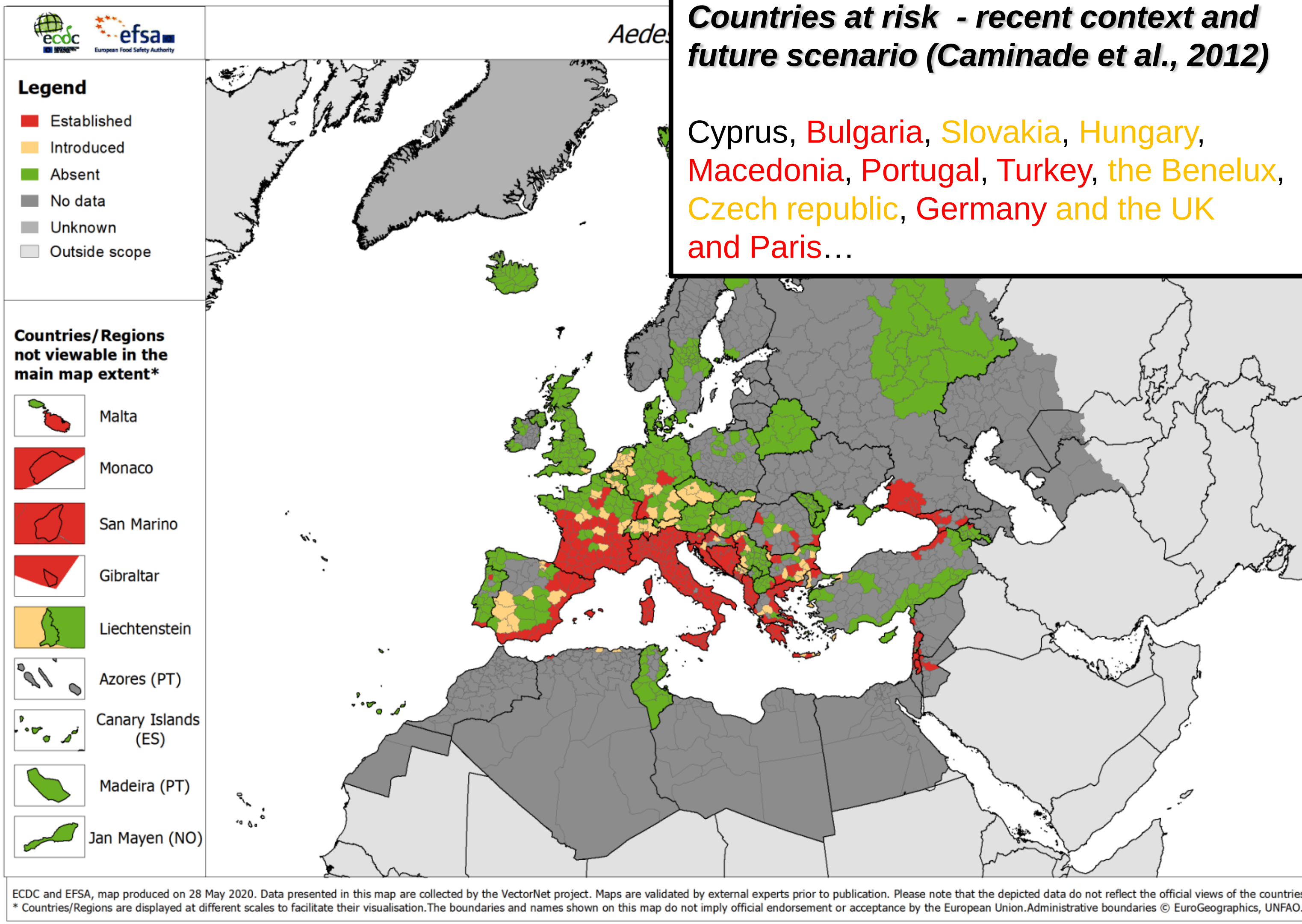
RCP4.5

RCP8.5



Colder -> warmer climate models

Aedes albopictus – distribution May 2020



Countries at risk - recent context and future scenario (Caminade et al., 2012)

Cyprus, Bulgaria, Slovakia, Hungary, Macedonia, Portugal, Turkey, the Benelux, Czech republic, Germany and the UK and Paris…

Recent news…

LSHTM – Public Health England Oct 2016

LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE

- For Students
- For Staff
- For Alumni
- For Press

STUDY | FACULTIES | RESEARCH | AB

Home → News and Events → News → 2016

Asian Tiger mosquito eggs found in Kent - expert comment

Wednesday, 19 October 2016

A small number of eggs of the *Aedes albopictus* (or Asian Tiger) mosquito, which is capable of transmitting diseases including dengue, chikungunya and Zika have been found in the UK for the first time.

In recent years, there have been a number of exotic mosquitoes that have become established in Europe and Public Health England (PHE) conducts surveillance for invasive mosquitoes in the UK. It was through this routine surveillance that PHE confirmed eggs from *Aedes albopictus* in one trap in Kent.

Not established yet in the UK.
To be continued…

ECDC – October 2019

RAPID RISK ASSESSMENT

Zika virus disease in Var department, France

16 October 2019

Summary

On 1 October 2019, a case of locally acquired Zika virus (ZIKV) disease in France (Hyères city, Var department) was laboratory confirmed. The case had symptoms compatible with ZIKV disease during the first half of August 2019. The case did not report any history of travel to countries with historical ZIKV transmission. No evidence of sexual transmission was retrieved during the investigation. No imported ZIKV disease cases were reported in the area in 2019. Further epidemiological investigations are ongoing to define the most probable mode of transmission. At this stage, vector-borne ZIKV transmission is the hypothesis that forms the basis for this ECDC risk assessment. If this hypothesis turned out to be correct, this event would mark the first case of autochtonous vectorborne transmission of ZIKV in Europe.

Vector control measures are being implemented near the residence of the case. To date, investigations have not managed to identify additional cases, but further cases may be detected through ongoing active case finding.

Ae. albopictus is widely established in southern Europe (see *Ae. albopictus*, current known distribution, August 2019) and a competent vector for ZIKV. However, it is considered a less competent vector than the tropical and subtropical vector *Ae. aegypti*. The occurrence of sporadic cases or clusters of locally acquired vector-borne ZIKV cases is possible, notably in the Mediterranean region of Europe when environmental conditions during summer and early autumn can support vector abundance and arbovirus replication at a level that is sufficient for autochthonous transmission of ZIKV. The report of a locally acquired ZIKV disease case in the southern part of France is thus not unexpected.

To date, and based on ECDC's epidemiological assessment, the probability of ongoing vector-borne local transmission in Hyères (and surrounding areas) is considered very low because current evidence does not indicate the existence of a more extensive cluster of ZIKV cases. As temperatures are progressively decreasing during autumn, the environmental conditions are currently not favourable for sustained transmission. The current risk posed to the population, including pregnant women and their unborn children, is very low. If autochthonous, vector-borne cases could be documented, for example by detecting additional locally acquired cases in the immediate vicinity of the case, the risk for pregnant women and unborn children would be low instead of very low. It is possible that the ongoing investigation will retrospectively identify locally acquired cases because *Ae. albopictus*

Other research examples

Xylella fastidiosa (Xf)

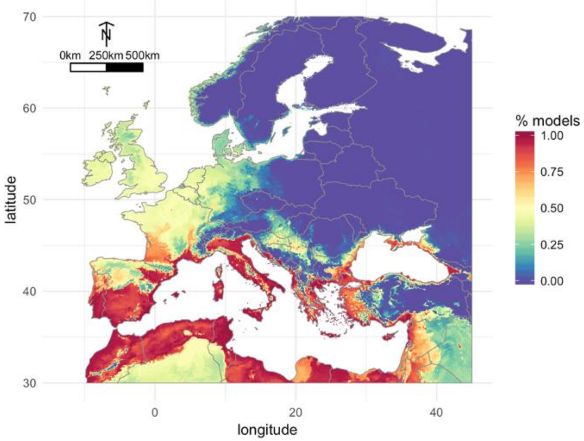
Article | Open Access | Published: 20 June 2019

Xylella fastidiosa: climate suitability of European continent

Martin Godefroid, Astrid Cruaud, Jean-Claude Streito, Jean-Yves Rasplus & Jean-Pierre Rossi

Scientific Reports **9**, Article number: 8844 (2019) | Cite this article

A *Xylella fastidiosa fastidiosa*



Food and Agriculture Organization of the United Nations

International Plant Protection Convention
Protecting the world's plant resources from pests

Facing the threat of *Xylella fastidiosa* together

The bacterium *Xylella fastidiosa* is a serious threat to agriculture, the environment and the economy. Its geographical distribution and its host range have greatly expanded in recent years.

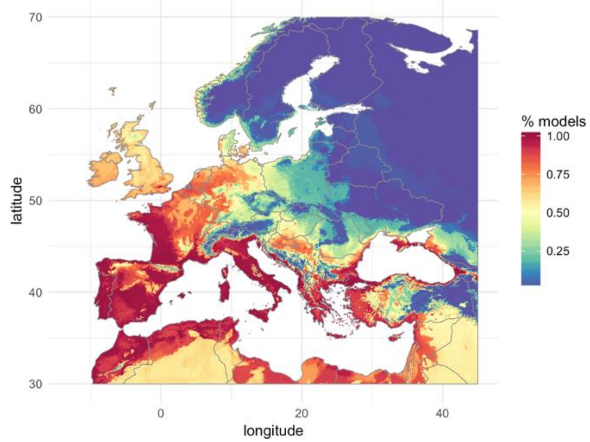
Coordinated efforts should be made globally to avoid further spread.

Figure 1 - Olive quick decline syndrome (Source: Franco Valentini, CIHEAM)

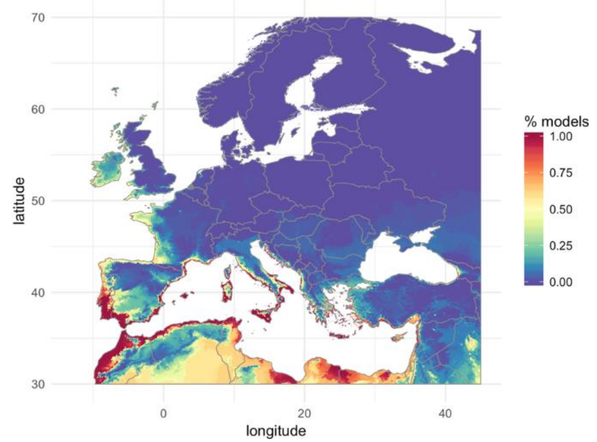
About the vectors

Any xylem sap feeding insect is a potential vector of *Xylella fastidiosa*. The sharpshooters *Homalodisca vitripennis* and *Acrogonia terminalis* are primary vectors in California and Brazil, respectively. The meadow spittlebug *Philaenus spumarius* is the only known vector in Italy and is widely distributed in Europe and in the Mediterranean region. However, with ongoing research, new vectors may be identified as the bacterium expands its geographical range.

B *Xylella fastidiosa multiplex*



C *Xylella fastidiosa pauca*



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Asian Hornet

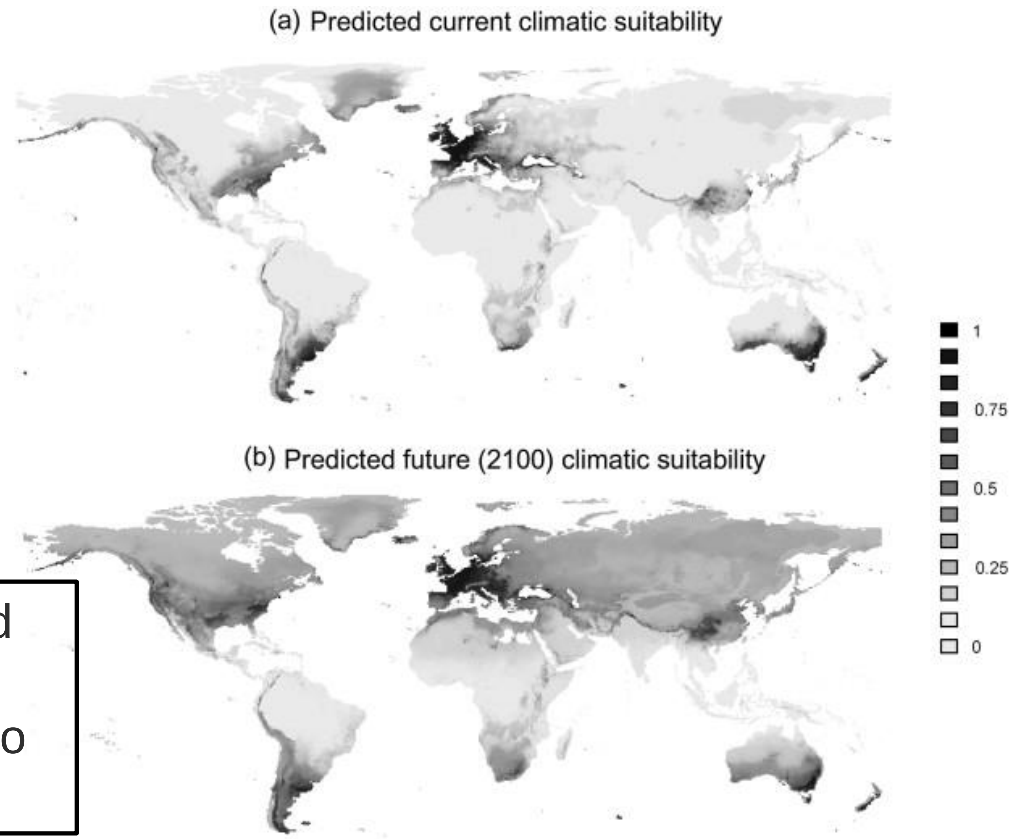
Chris Looney fills a tree cavity with carbon dioxide after vacuuming a nest of **Asian giant hornets** from inside it, on 24 October in Blaine, Washington.
Photograph: Elaine Thompson/AFP/Getty Images
Source: Guardian
https://www.theguardian.com/environment/2020/oct/31/us-murder-hornets-nest-asian-giant

This **bee-hawking hornet** already invaded range in Europe, in Spain and in Central and Eastern Europe – from Switzerland to Hungary up to Southern Sweden.

Biological Conservation
Volume 157, January 2013, Pages 4-10

Climate change increases the risk of invasion by the Yellow-legged hornet

Morgane Barbet-Massin [a, b], Quentin Rome [c], Franck Muller [c], Adrien Perrard [c], Claire Villemant [c], Frédéric Jiguet [a]



Conclusions

- Climate change, coupled with globalization, impacts insects vector borne diseases distribution (breeding sites – development and survival of vectors, pathogen development rate inside the vector e.g. EIP…)
- Increasing evidences that climate change already played a role in the background over the past 20 years: worrying vector trends have been observed in different temperate, arctic and highland regions. Sporadic outbreaks of vector-borne diseases have been observed in temperate climes (Southern Europe, southern USA, China…)
- Many factors to consider to anticipate the real future of infectious diseases (socio-economic, demography, land use changes, drug and insecticide resistance, technological break through, human behavior, interaction with animals…) -> One Health
- Need to use different disease modelling approaches and ensemble of climate models, emission & population scenarios to assess uncertainties, and these can be quite large!
- Model validation is critical but difficult - validation relies on the quality of health and climate data!
- Climate change is already affecting our health directly (climatic extremes: heat waves, floods, air pollution…) and will have significant indirect effects from macro to micro scale e.g. on freshwater and oceanic resources, agriculture, livelihoods, population migration… It only started e.g. aperitif time…