# Mosquito surveillance and management in the wetland of Doñana National Park, Spain

Martina Ferraguti,
J. Martínez de la Puente, S. Ruiz, R. Soriguer, J. Figuerola

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Akrotiri Environmental Education Centre
Κέντρο Περιβαλλοντικής Εκπαίδευσης Ακρωτηρίου

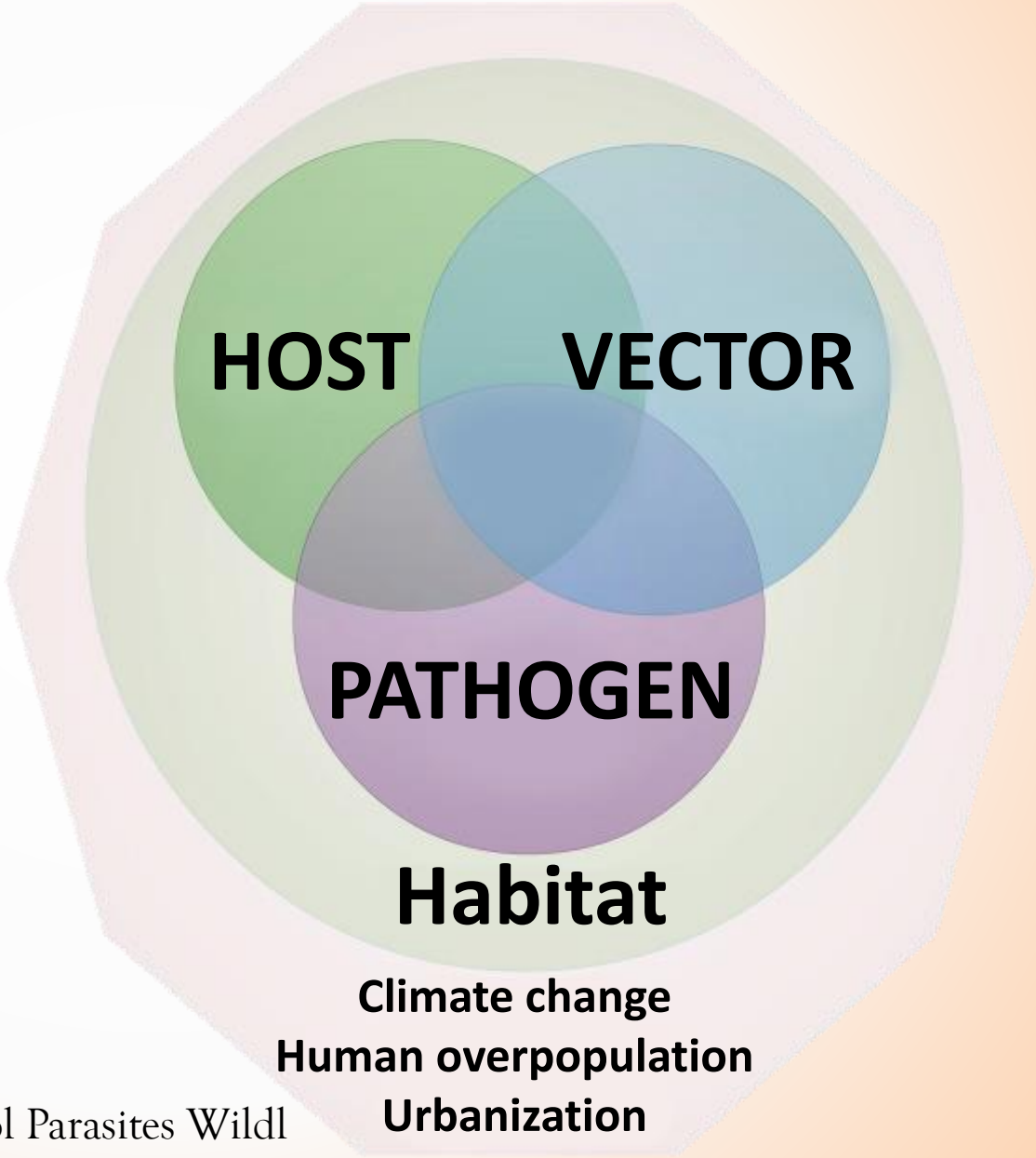
# Natural habitat

# Rural habitat

# Urban habitat

# HABITATS ARE RAPIDLY CHANGING...

"... across the planet and the consequences will have major and long-lasting effects on **vector** and **host communities**"




modified from Sehgal 2015, Int J Parasitol Parasites Wildl

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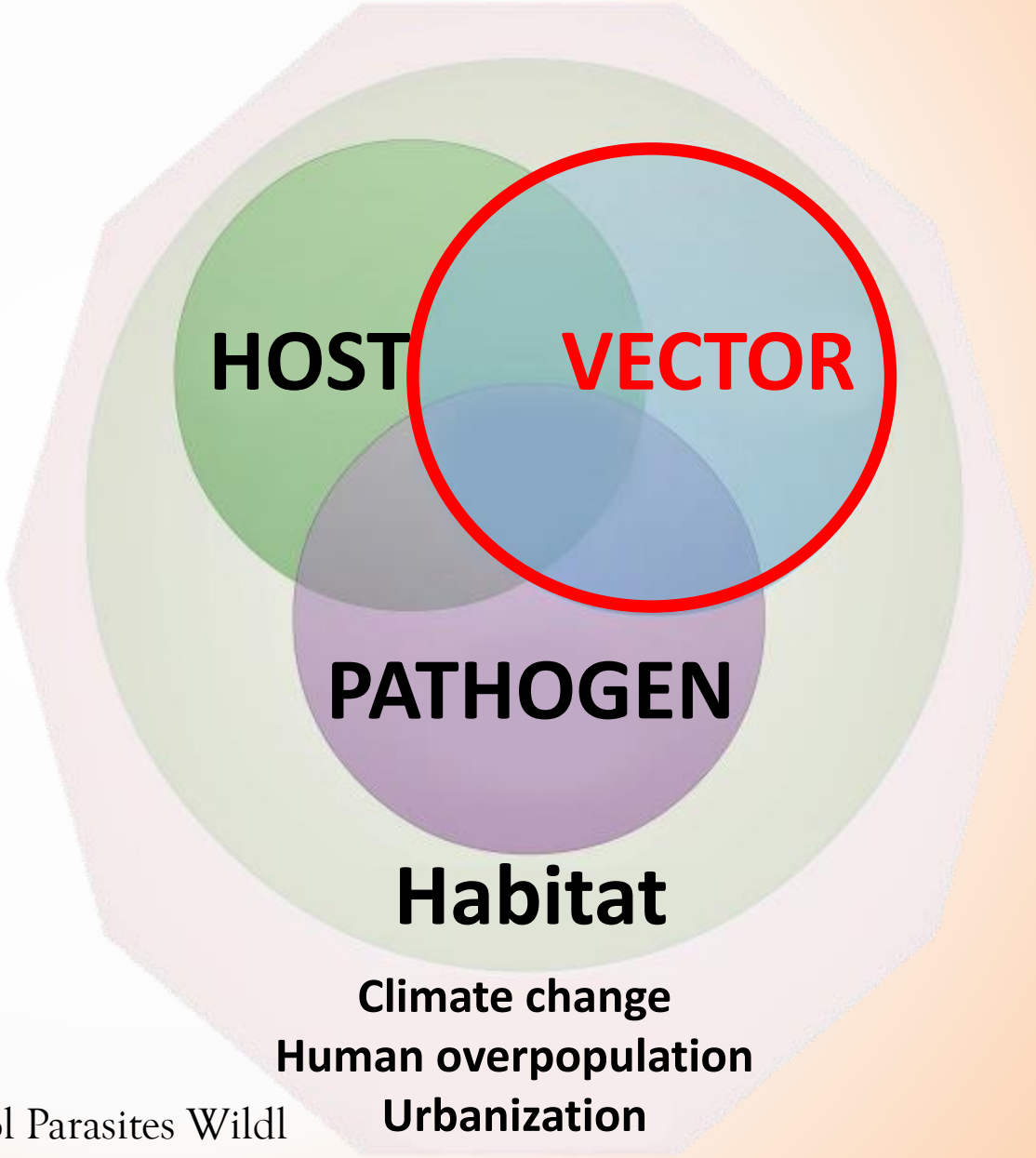


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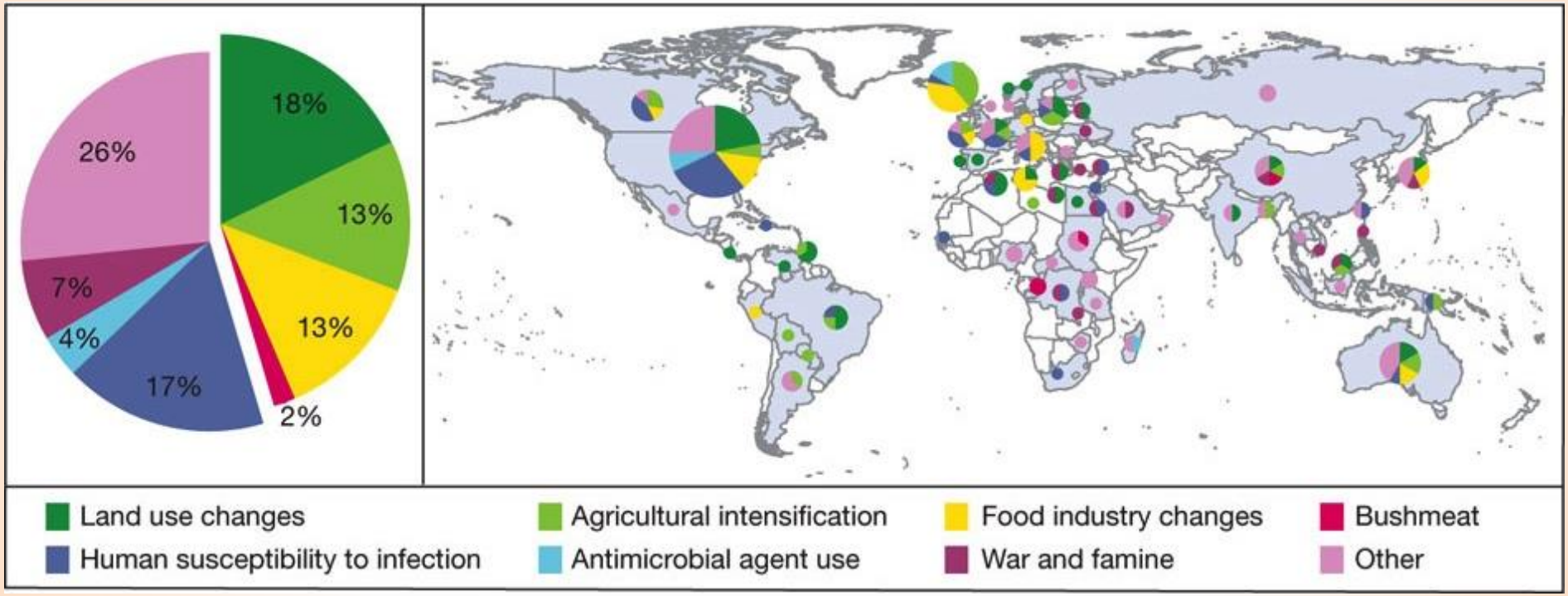
# NEW OPPORTUNITIES FOR BREEDING...

# ... AND THEY LIKE CITIES!

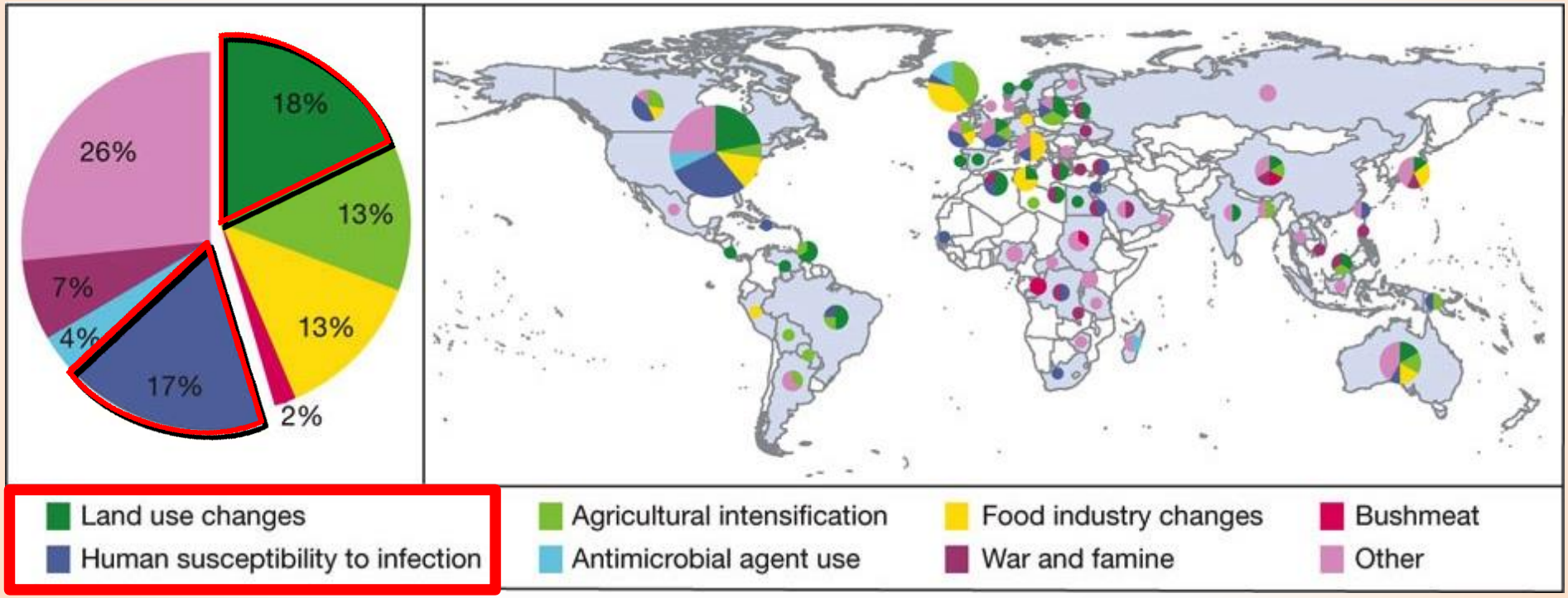
# The incidence of vector-borne diseases is increasing




Keesing *et al.* 2010, Nature

# THE INCIDENCE OF VECTOR-BORNE DISEASES IS INCREASING

having **human landscape transformation** an important effect on pathogen transmission.

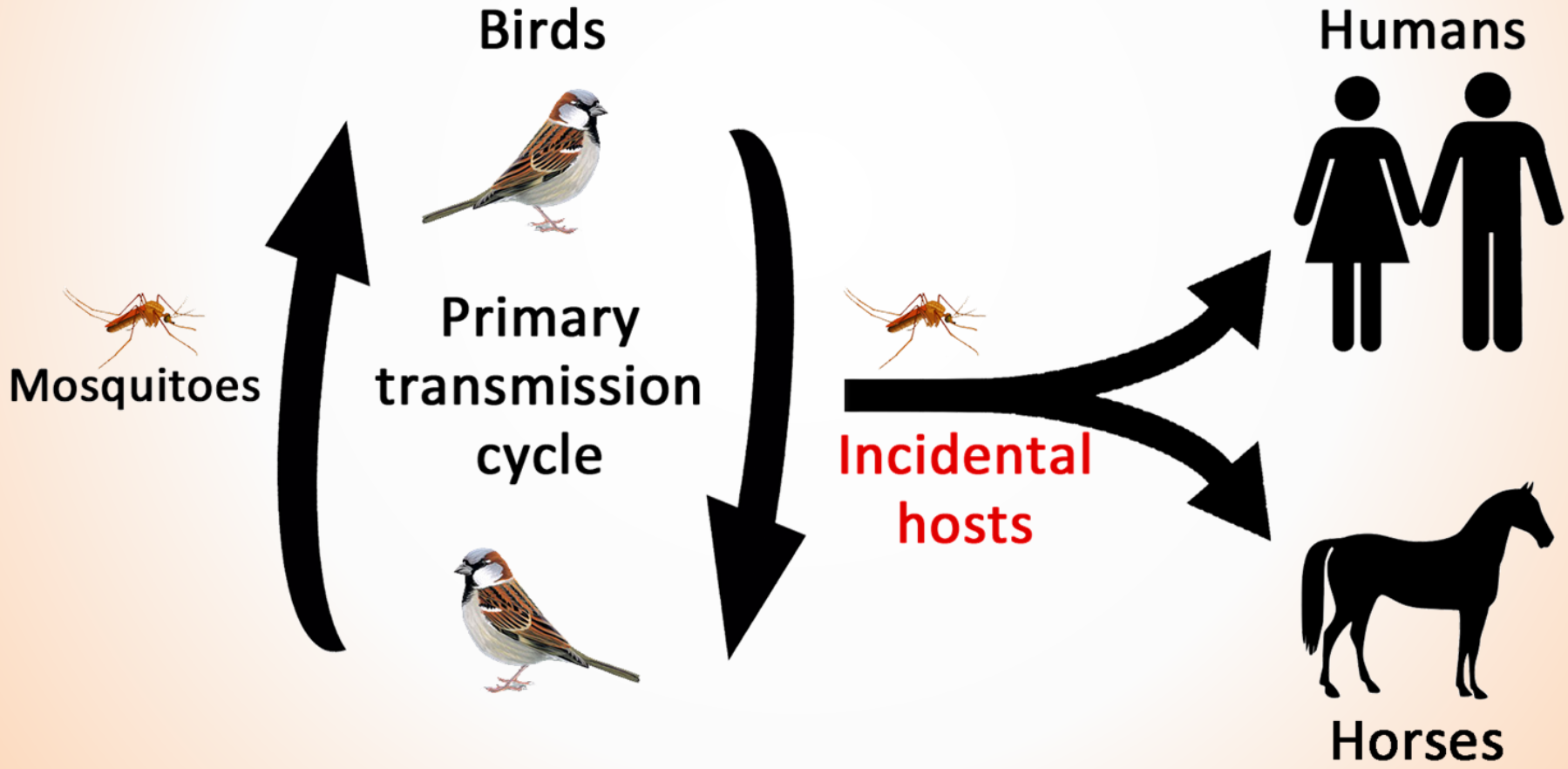



Keesing *et al.* 2010, Nature

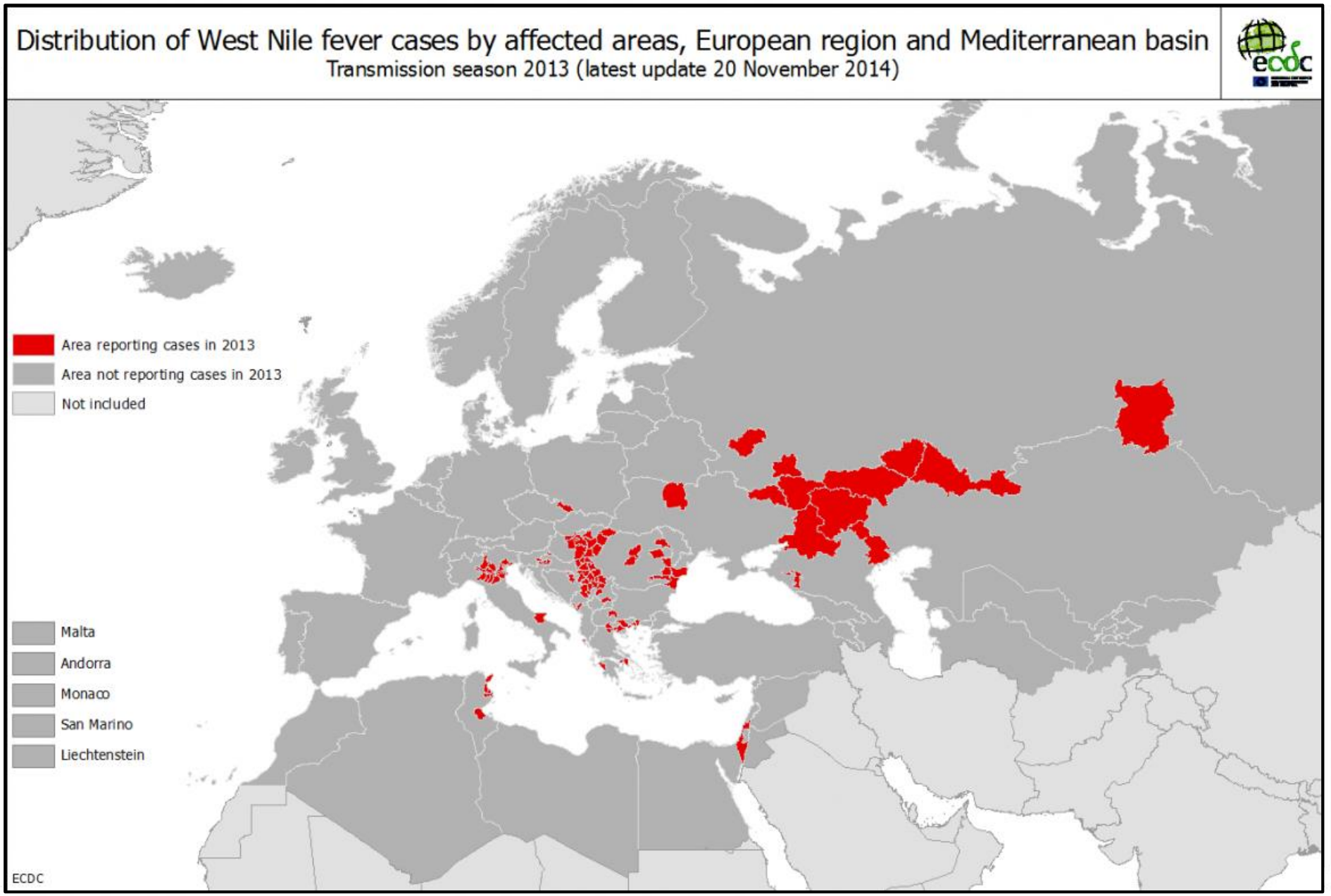
# West Nile virus (WNV)

Emerging zoonotic arbovirus (arthropod-borne virus) *Flavivirus* genus.

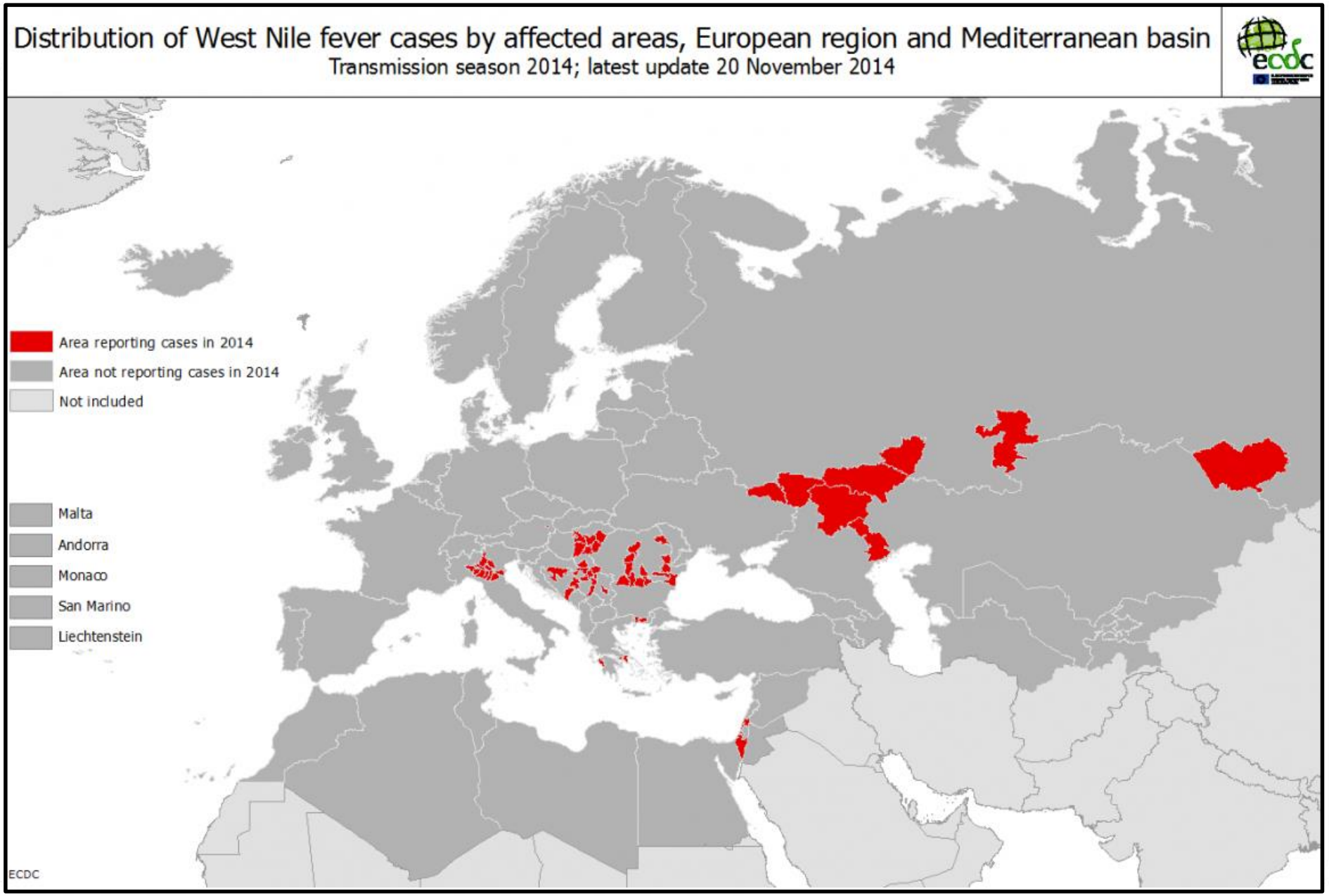
*Culex* mosquitoes are the most important vectors.



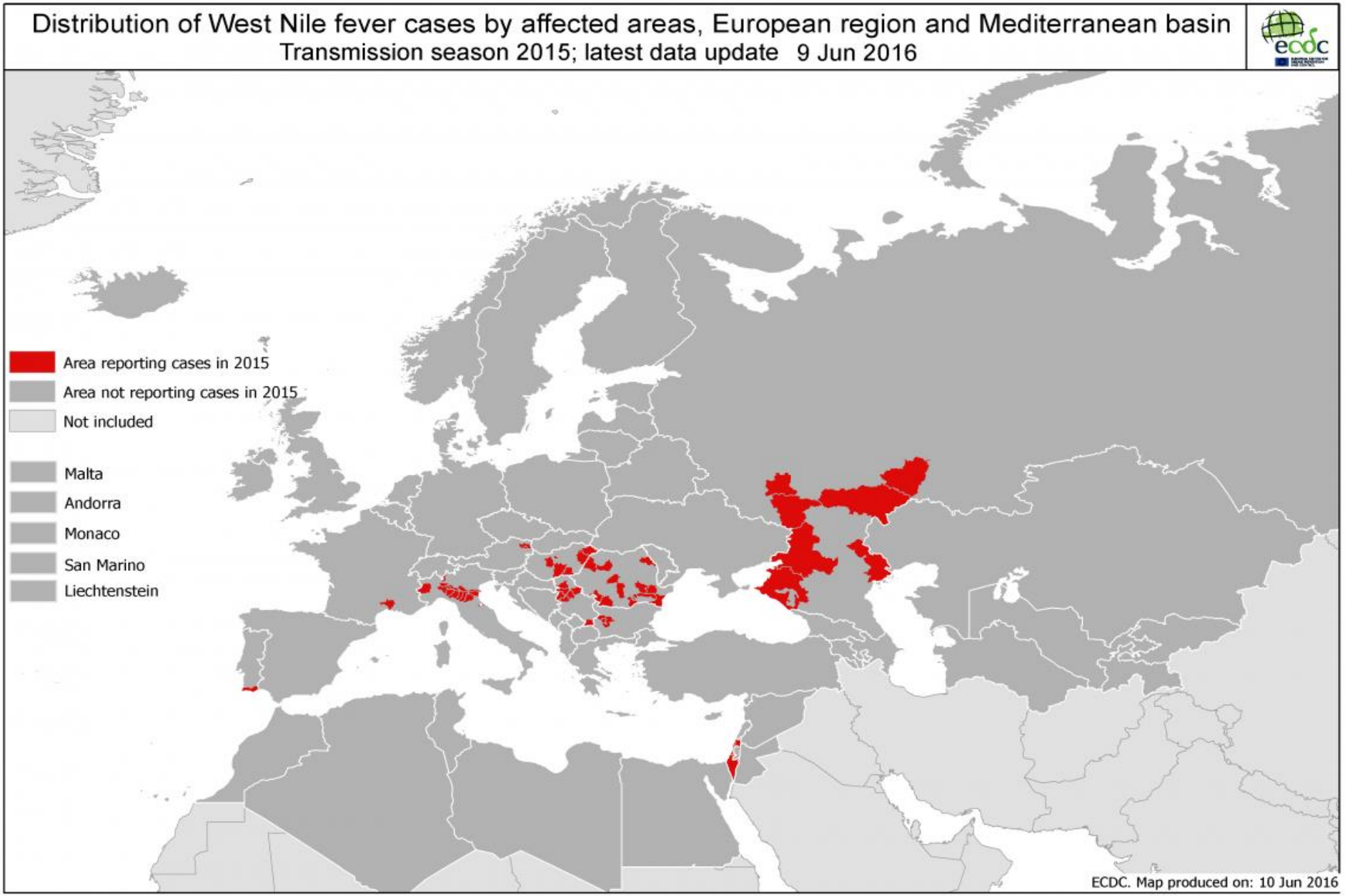
# West Nile fever transmission season 2013



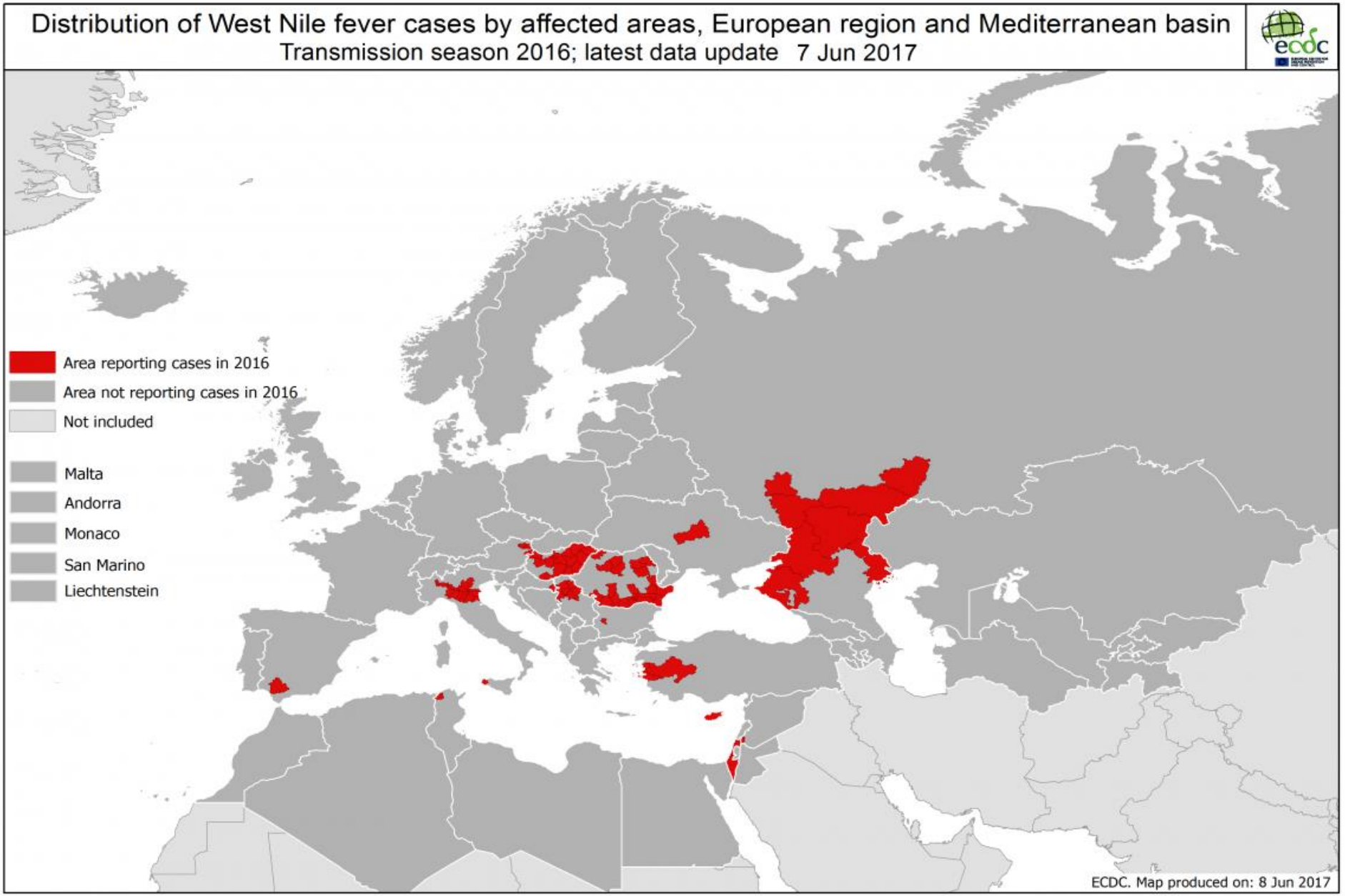
# West Nile fever transmission season 2014



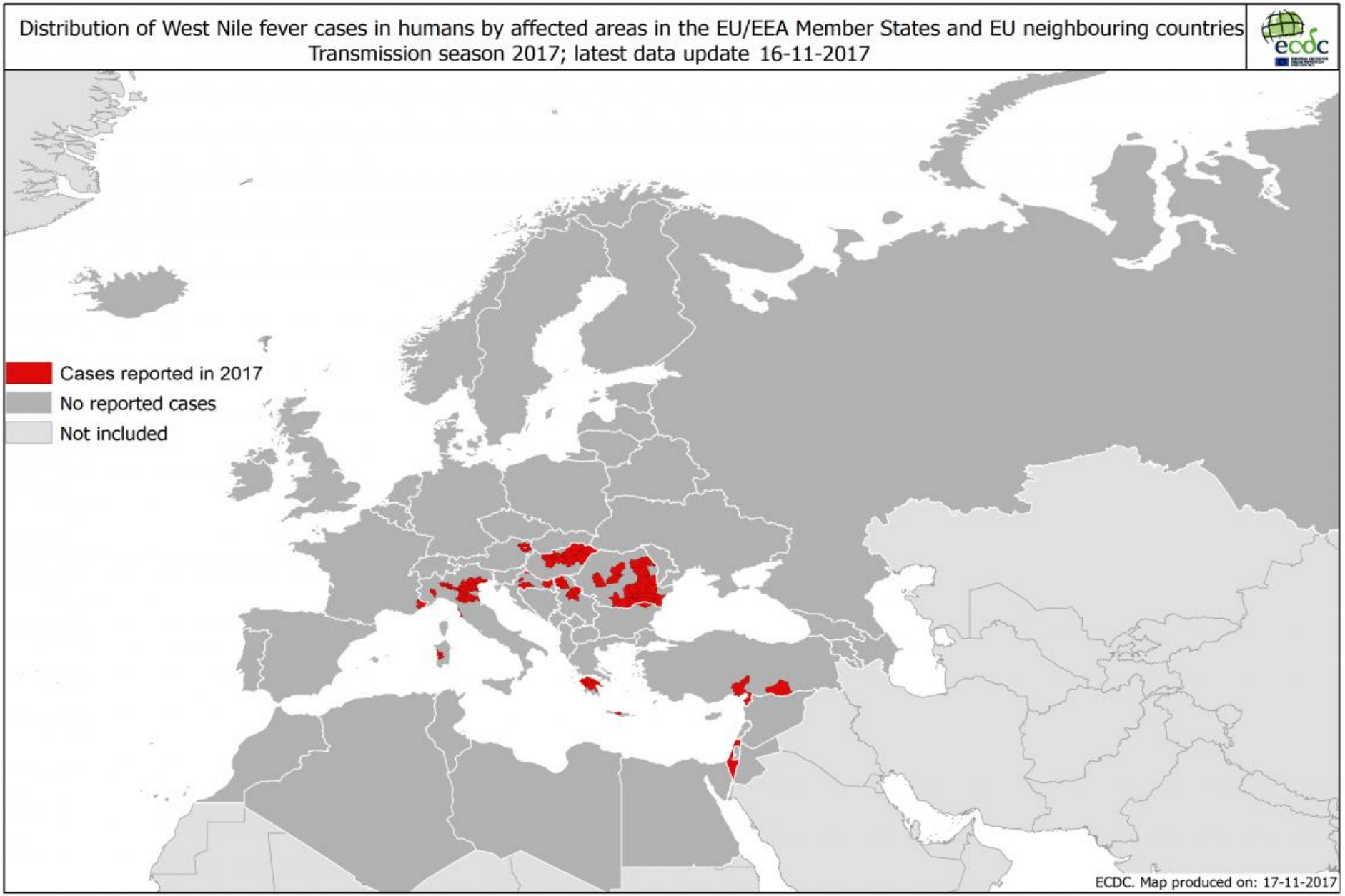
# West Nile fever transmission season 2015



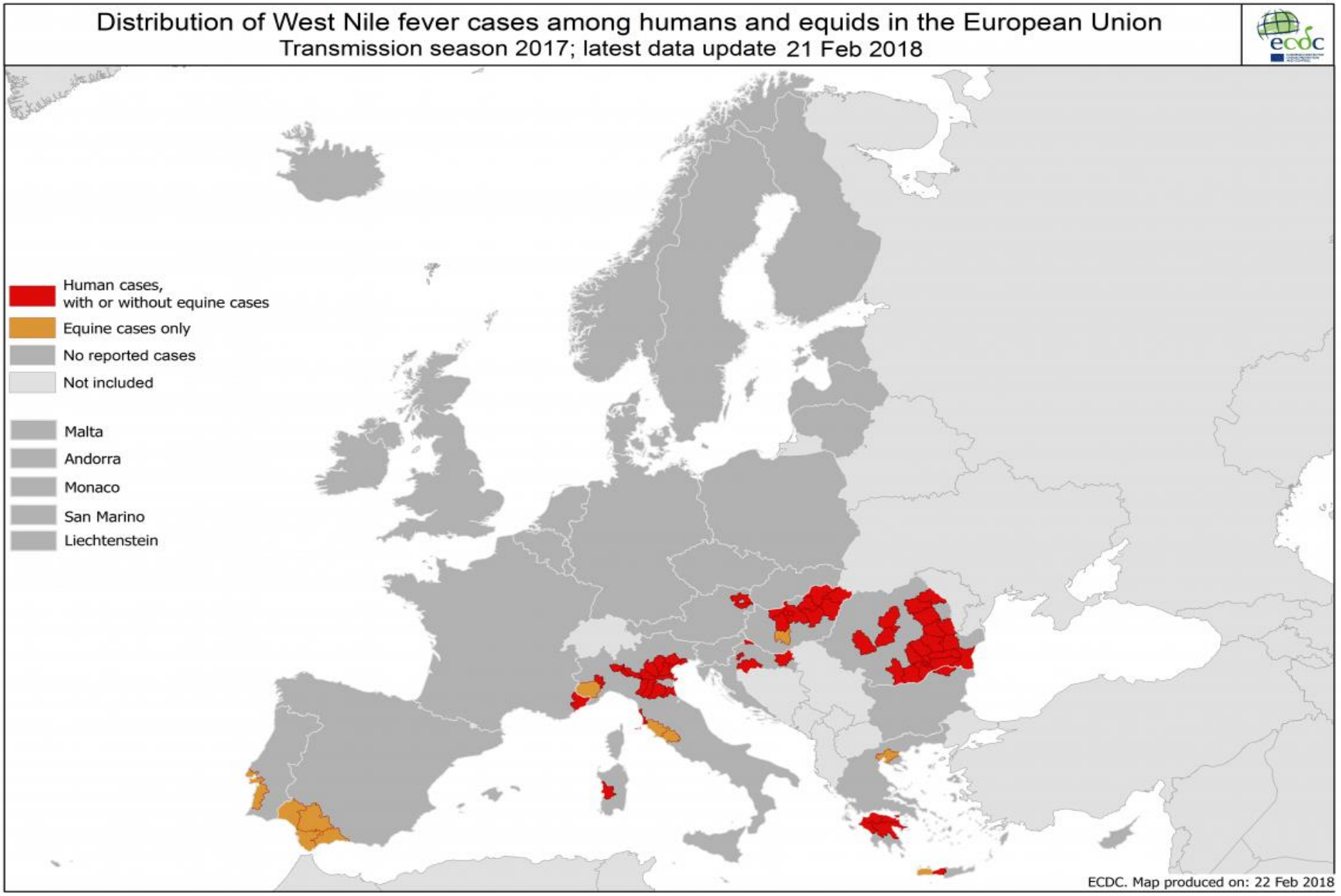
# West Nile fever transmission season 2016

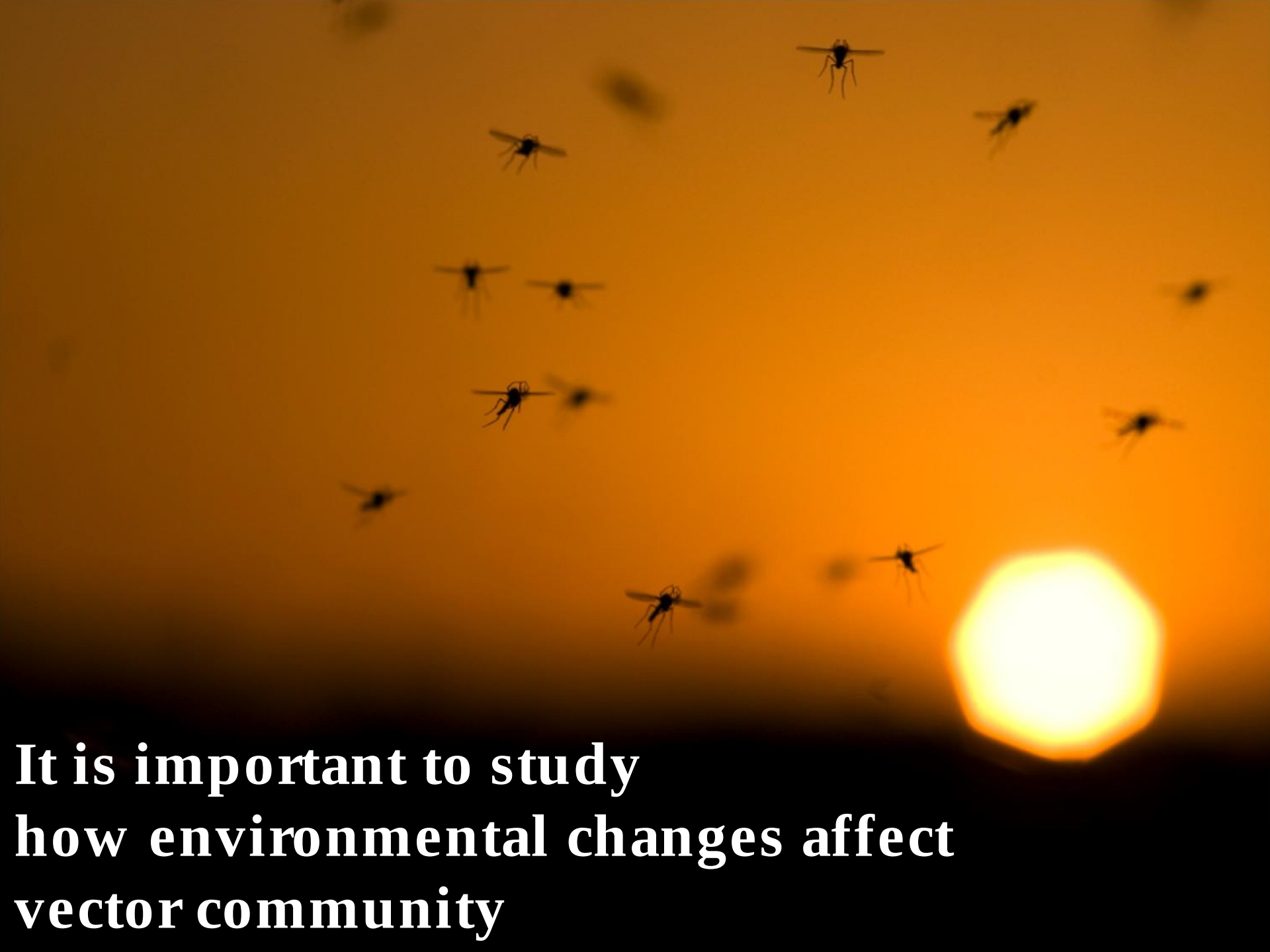


# West Nile fever transmission season 2017



# 2017: 204 human and 127 equine cases in the EU.





**It is important to study how environmental changes affect vector community**

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# Effects of landscape anthropization on mosquito community composition and abundance

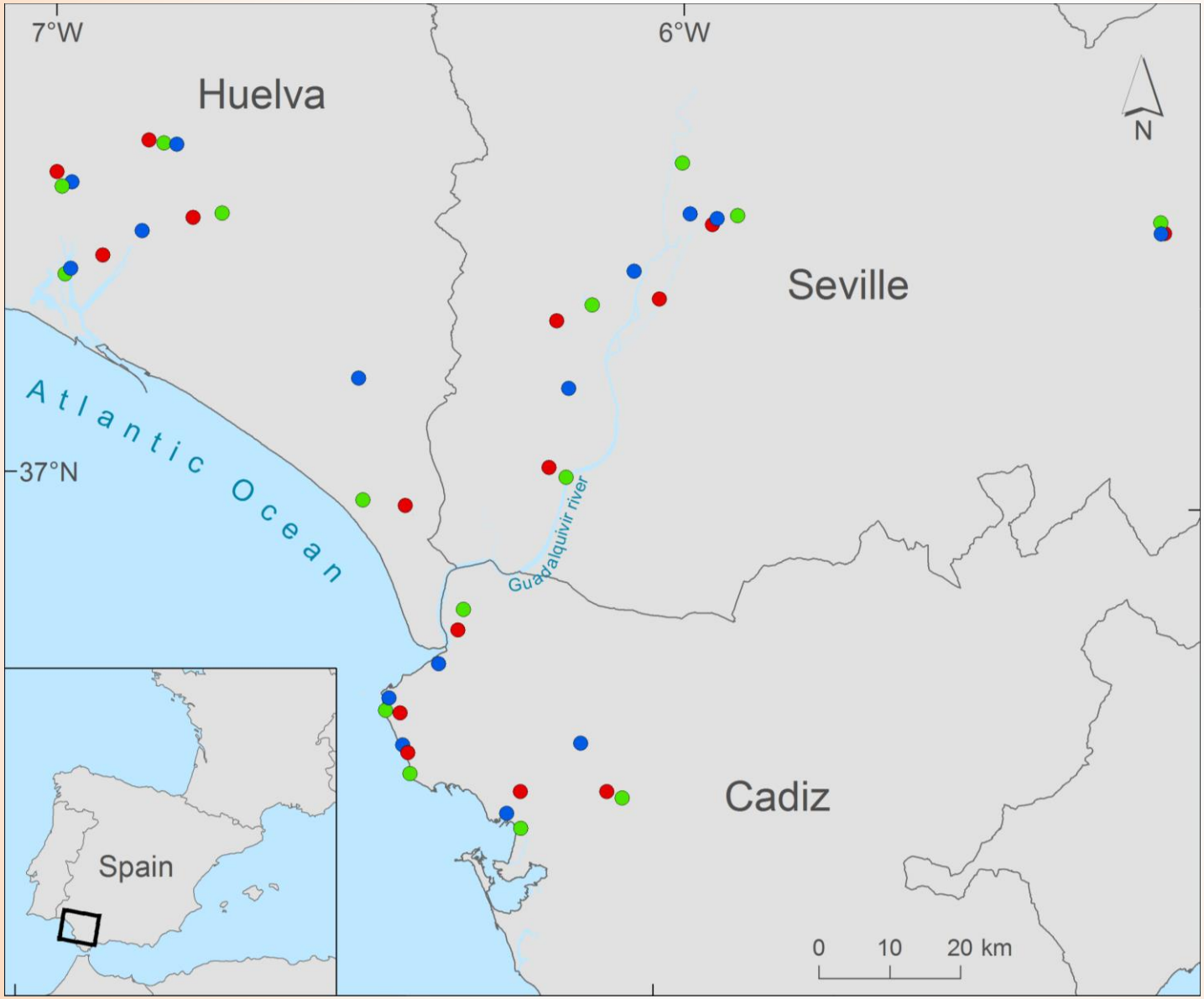
Received: 25 October 2015
Accepted: 09 June 2016
Published: 04 July 2016

Martina Ferraguti[1], Josué Martínez-de la Puente[1,2], David Roiz[1,†], Santiago Ruiz[2,3], Ramón Soriguer[1,2] & Jordi Figuerola[1,2]

OBJECTIVE: identify the impact of the environmental changes on the vector communities.

# General Material and Methods

# The study area: 45 localities in SW Spain

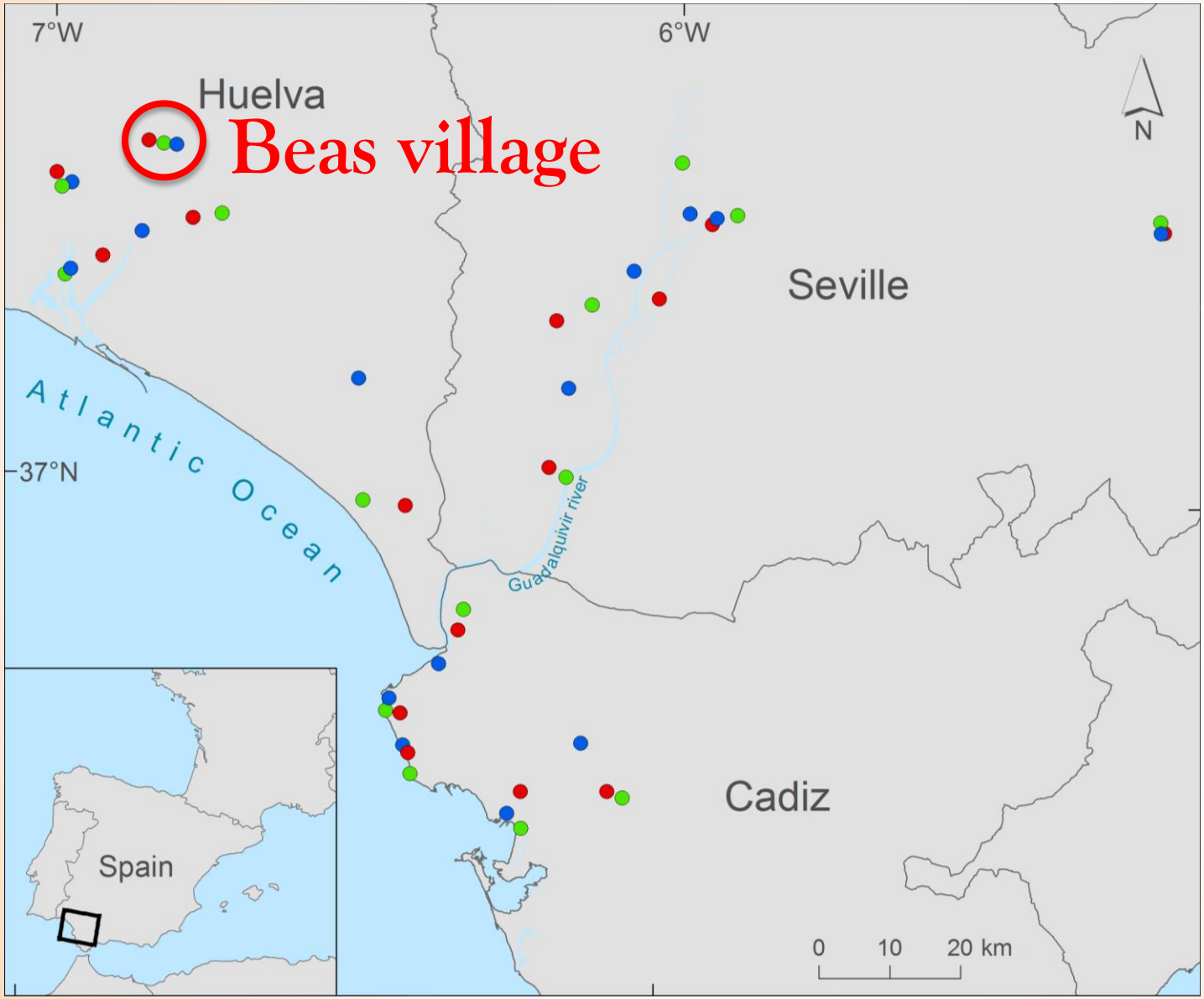



Natural

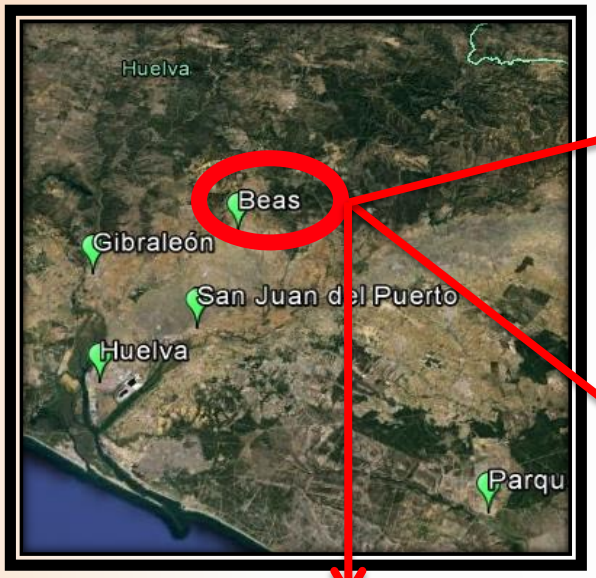
Rural

Urban

# THE STUDY AREA: 45 LOCALITIES IN SW SPAIN



# 3 TYPES OF HABITAT: 45 sampling sites




## Natural - meadow


## Urban - village


## Rural - horse farm

# Mosquito Sampling

340 829 females

13 species

5 genera

# MOST COMMON MOSQUITO SPECIES

*Culex theileri* - 282,891
*Ochlerotatus caspius* - 21,155
*Culex pipiens* - 19,268
*Culex perexiguus* - 5,939
*Anopheles atroparvus* - 5,387
*Culiseta annulata* - 2,514
*Ochlerotatus detritus* - 1,495
*Culex modestus* - 1,237
*Culiseta longiareolata* - 476

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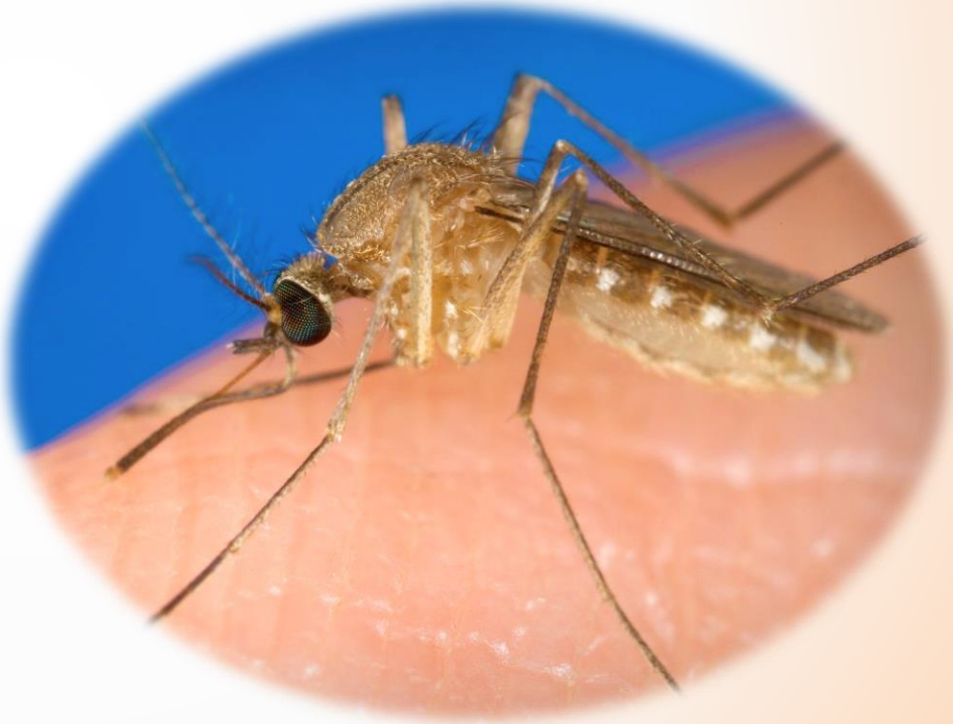

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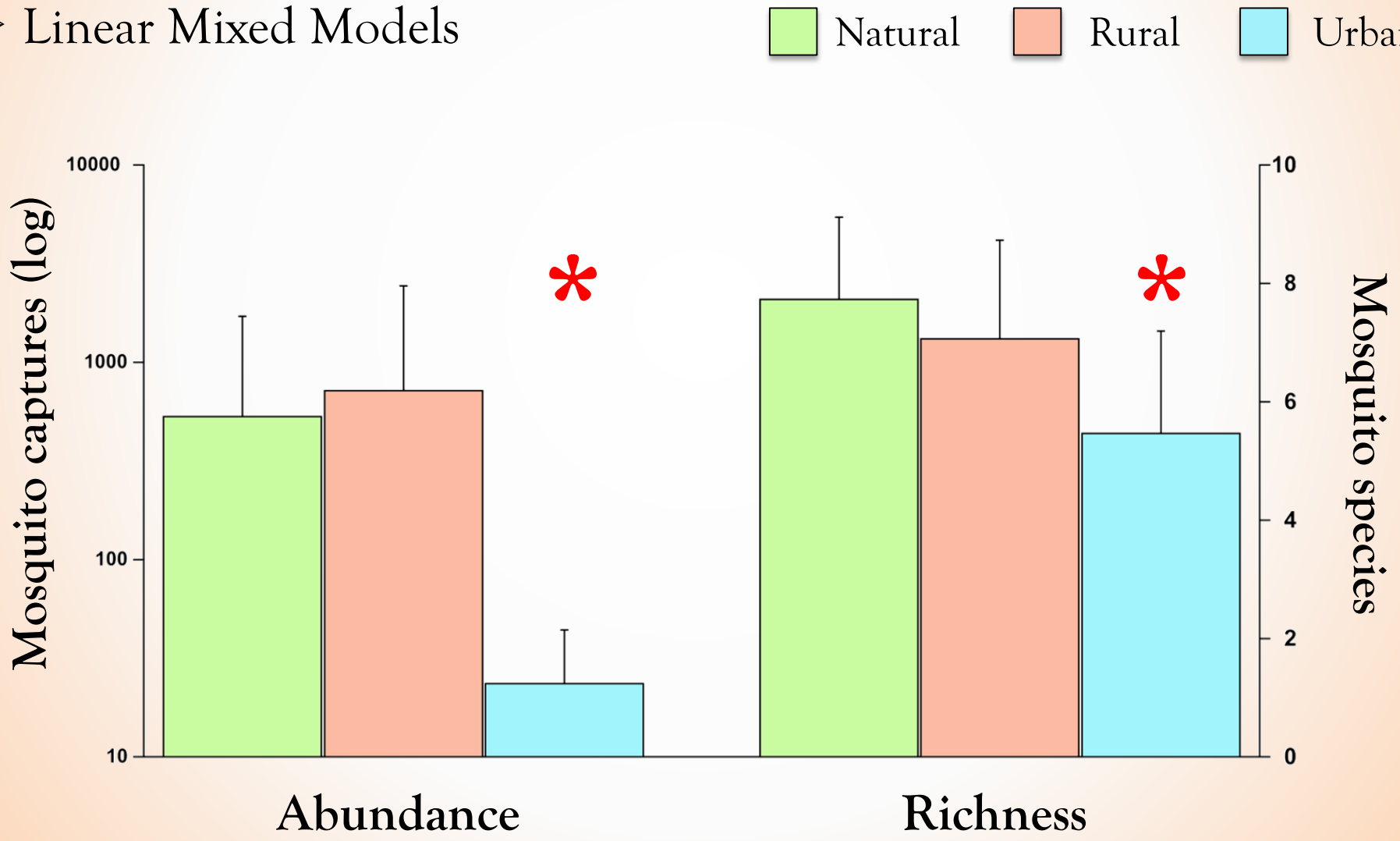
Mosquito **abundance** and **richness** were similar in natural and in rural areas but greater than in **urban** areas.

- Linear Mixed Models



# The captures of each of the commonest mosquito species were **lower in urban areas** than in natural ones

| Mosquito variable | Urban | Rural | Natural | $\chi^2$ | p |
|---|---|---|---|---|---|
| *An. atroparvus* | 0.23 (0.35)$^{a}$ | 0.97 (0.35)$^{b}$ | 0.91 (0.34)$^{b}$ | 8.02 | 0.018 |
| *Cx. modestus* | 0.16 (0.25)$^{a}$ | 0.39 (0.25)$^{ab}$ | 0.79 (0.24)$^{b}$ | 10.30 | 0.006 |
| *Cx. perexiguus* | 0.20 (0.35)$^{a}$ | 0.78 (0.35)$^{ab}$ | 1.05 (0.34)$^{b}$ | 7.97 | 0.019 |
| *Cx. pipiens* | 2.65 (0.25)$^{a}$ | 2.54 (0.25)$^{a}$ | 3.33 (0.25)$^{b}$ | 7.90 | 0.019 |
| *Cx. theileri* | 0.99 (0.64)$^{a}$ | 3.20 (0.64)$^{b}$ | 3.06 (0.62)$^{b}$ | 24.98 | <0.001 |
| *Oc. caspius* | 0.51 (0.38)$^{a}$ | 1.85 (0.38)$^{b}$ | 2.29 (0.38)$^{b}$ | 16.63 | <0.001 |

# *Cx. pipiens* was the most abundant species in urban areas!!

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# ➢ Random Forest

Human density

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Human density

Season NDVI

# ➢ RANDOM FOREST

Human density

Season NDVI

Hydrology

# ➢ Random Forest

Human density

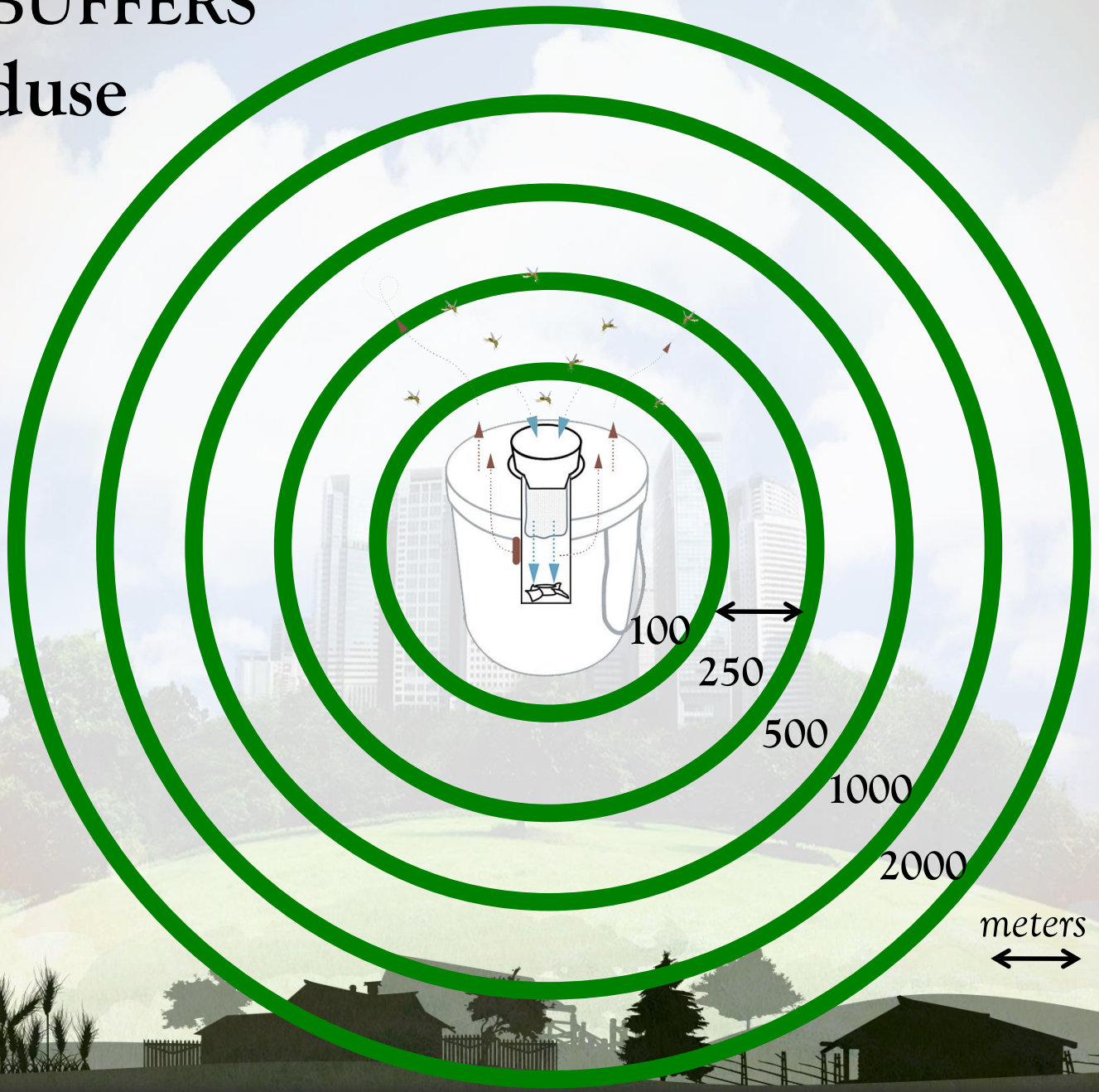
Season NDVI

Hydrology

Landuse

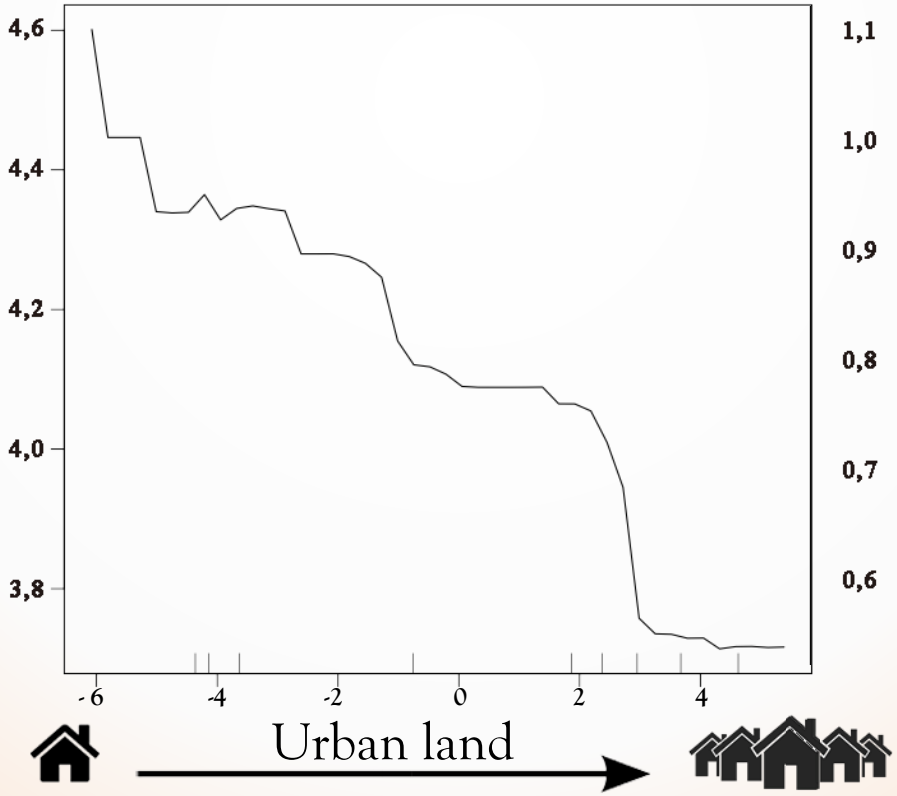
- X 5 BUFFERS

Landuse



| Mosquito variable | Buffer | % Var. explained | Most important variables in model |
|---|---|---|---|
| Abundance | 1000 | 45.35 | (+) Wetlands, (−) Urban land, (−) Human density |
| Richness | 250 | 32.06 | (−) Urban land, (−) Human density, (−) Marshland |
| *An. atroparvus* | 1000 | 41.25 | (+) Summer NDVI, (+) Wetlands, (−) Urban land |
| *Cx. modestus* | 100 | 19.07 | (+) Wetlands, (−) Marshland, (+) Summer NDVI, (−) Winter NDVI |
| *Cx. perexiguus* | 1000 | 26.59 | (+) Summer NDVI, (+) Autumn NDVI, (−) Urban land |
| *Cx. theileri* | 2000 | 45.55 | (−) Urban land, (+) Wetlands, (+) Summer NDVI |
| *Oc. caspius* | 500 | 45.76 | (−) Marshland, (−) Urban land |

Mosquito abundance



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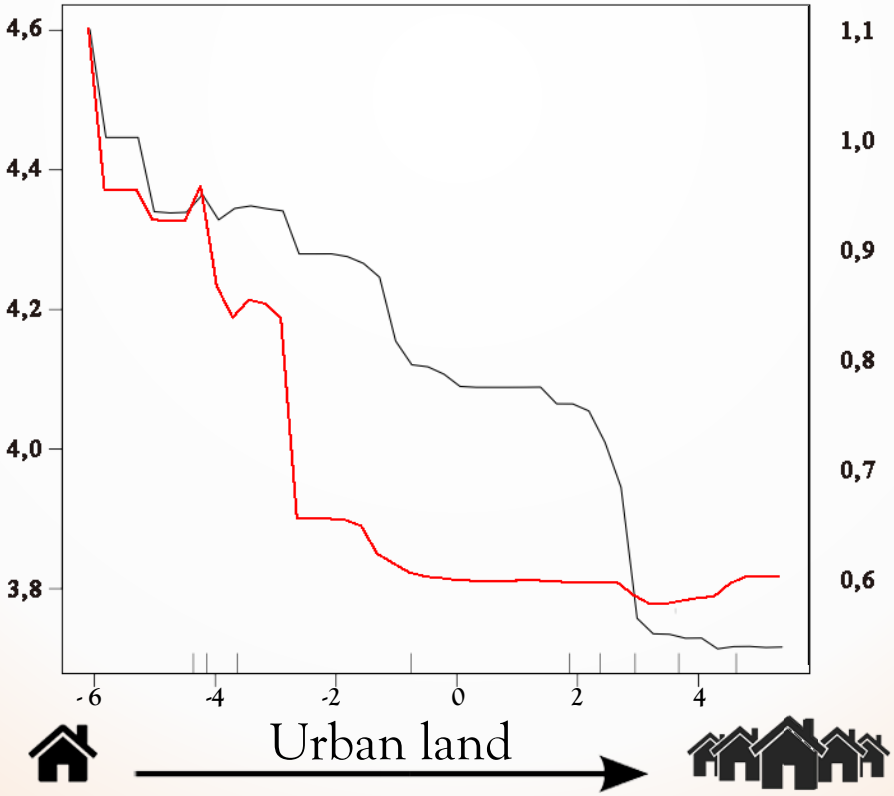


*Culex perexiguus*

SCIENTIFIC REPORTS

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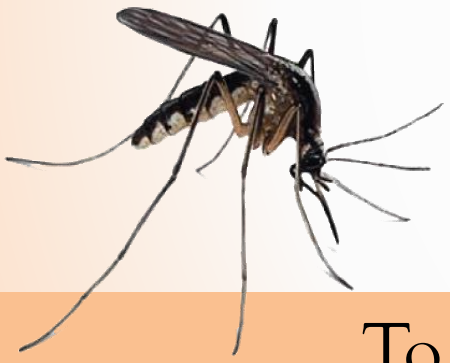
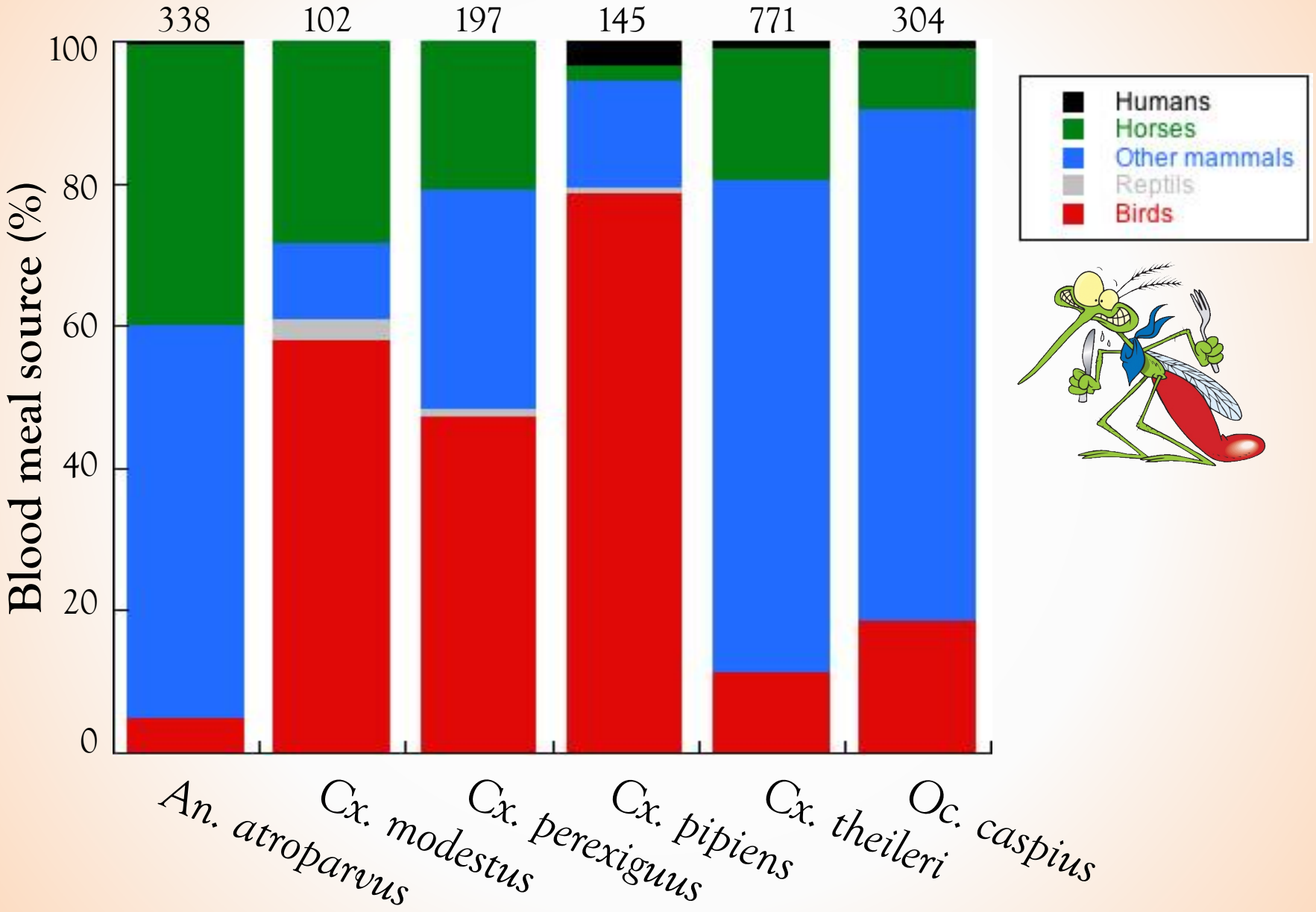
# Mosquito community influences West Nile virus seroprevalence in wild birds: implications for the risk of spillover into human populations

Josué Martínez-de la Puente[1,4], Martina Ferraguti[1], Santiago Ruiz[2,4], David Roiz[1,5], Francisco Llorente[3], Elisa Pérez-Ramírez[3], Miguel Ángel Jiménez-Clavero[3,4], Ramón Soriguer[1,4] & Jordi Figuerola[1,4]



To investigate the **impact of mosquito** populations on the transmission of **WNV** in house sparrows in an **urbanization** gradient.

# Mosquito Feeding Preferences




(data unpublished)

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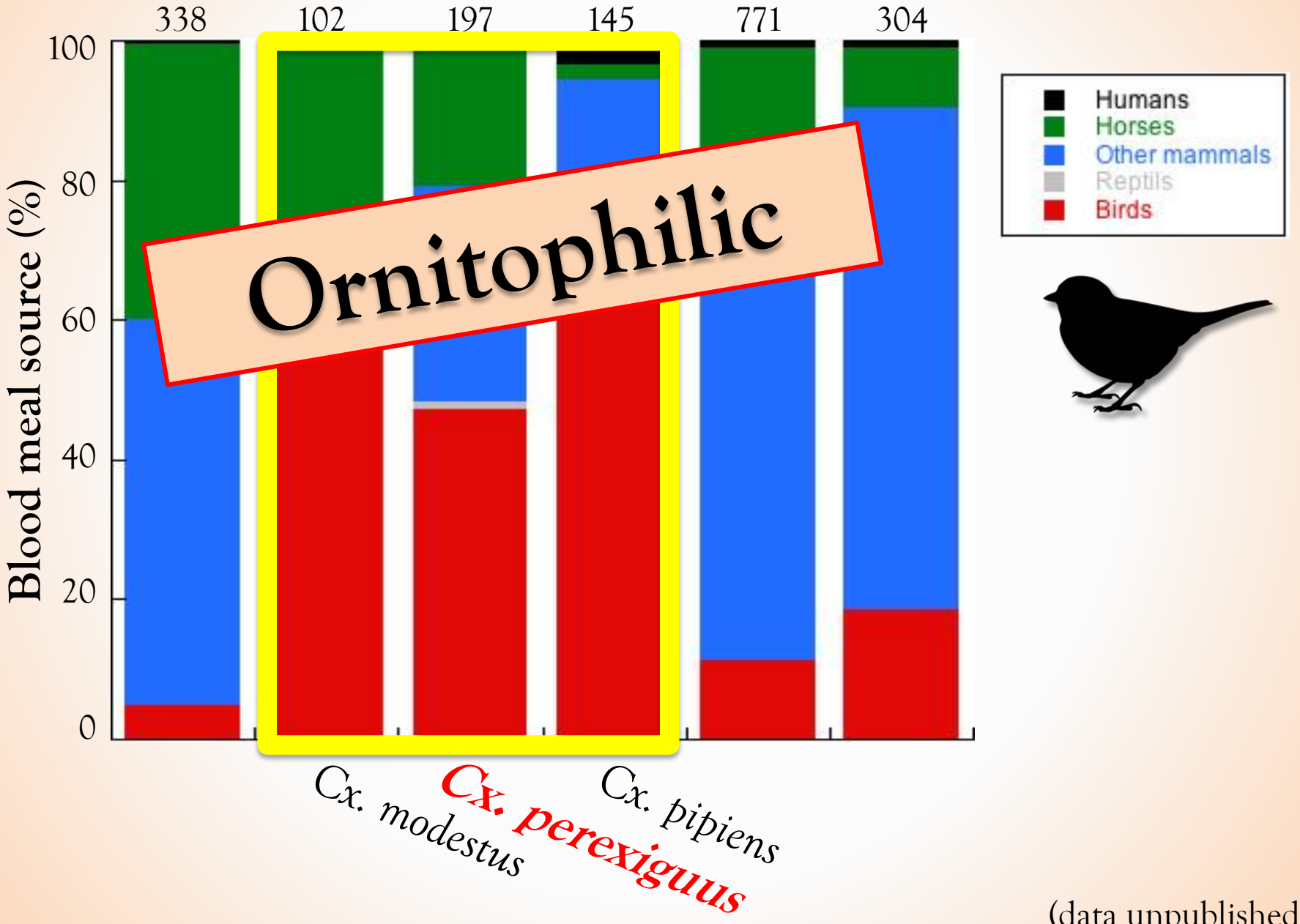


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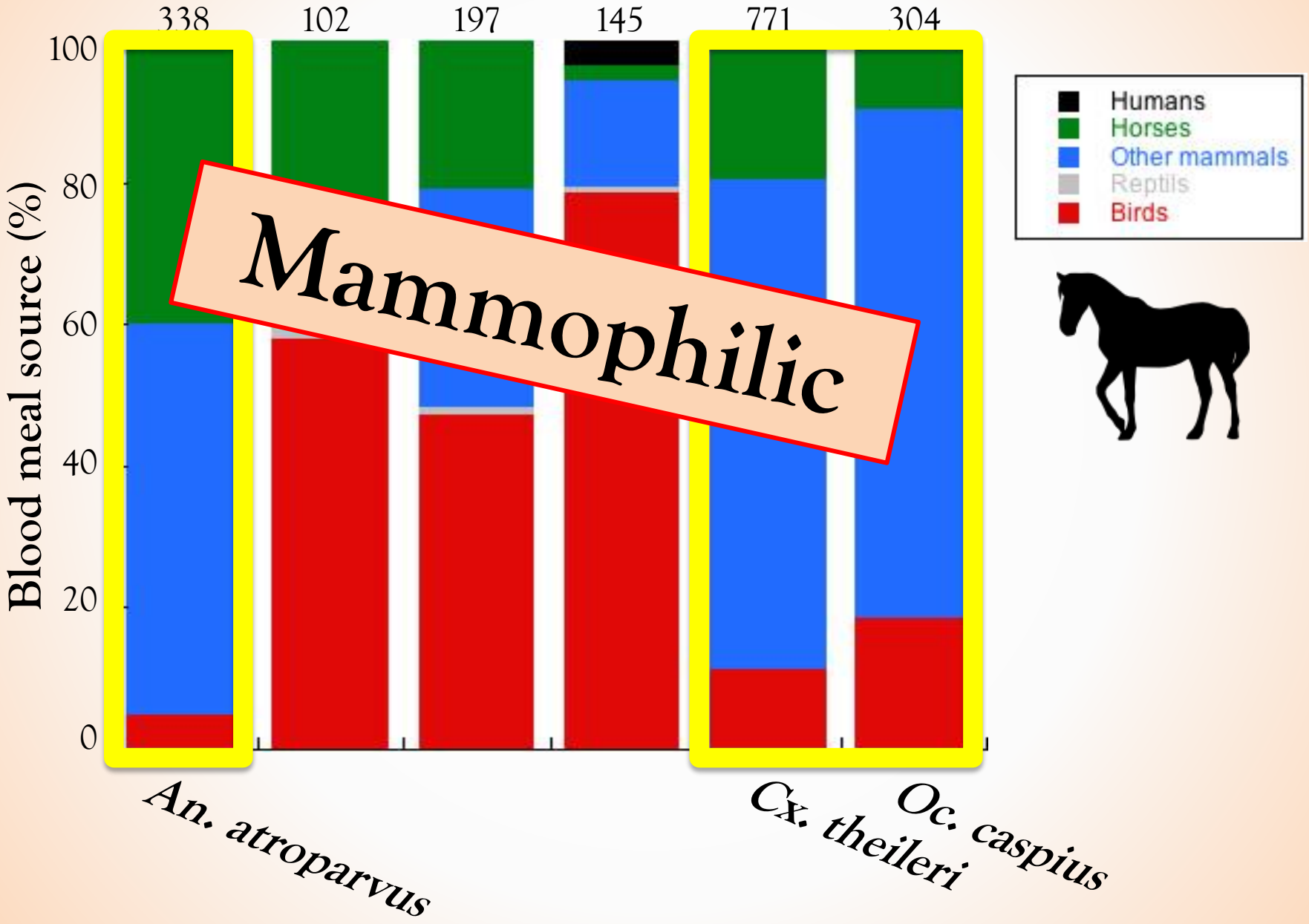

# Mosquito Vector Competence

Not all mosquito species are able to transmit all pathogens!

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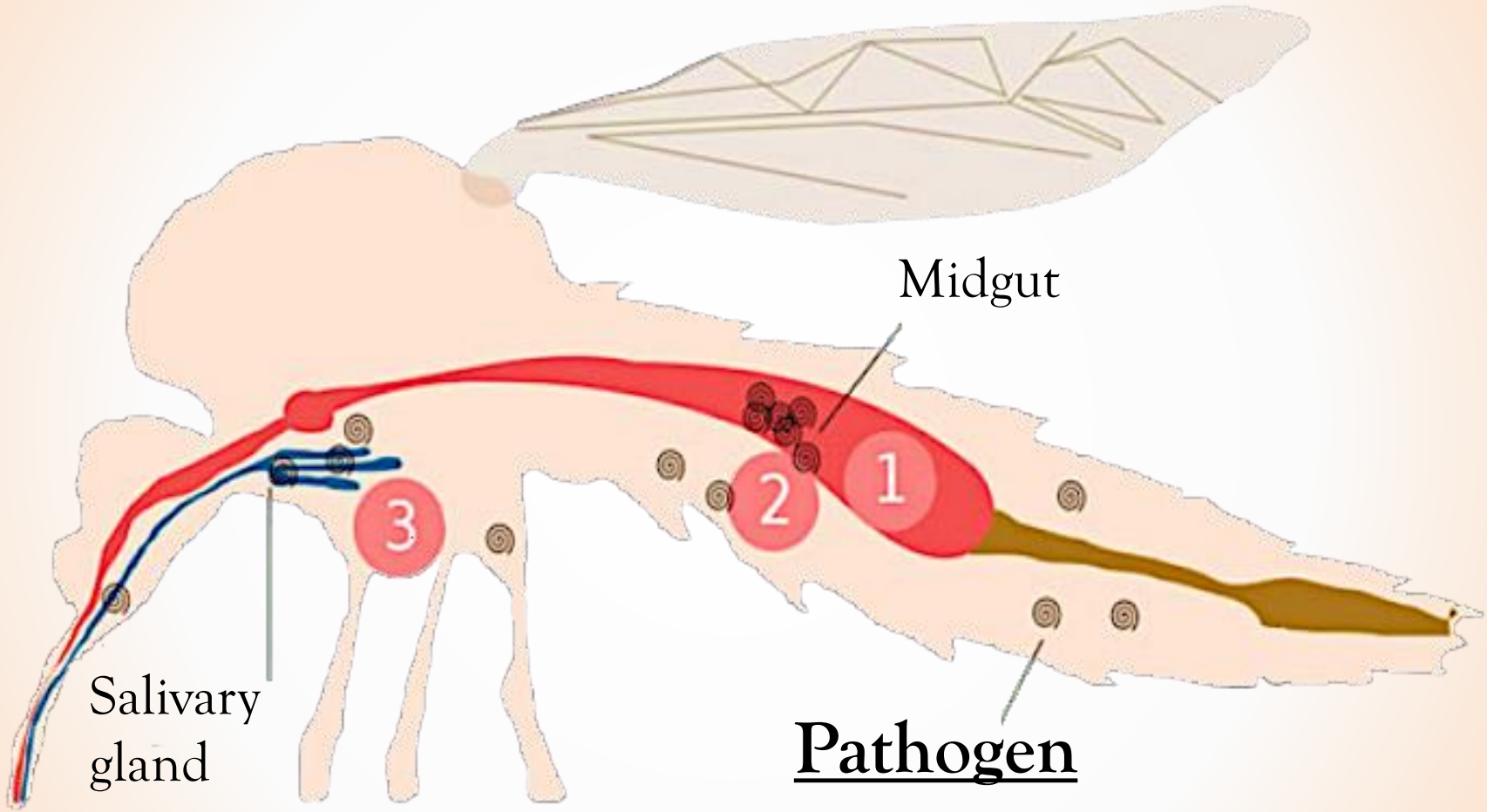



Not all mosquito species are able to transmit all pathogens!

OPEN ACCESS Freely available online

PLoS one

# Feeding Patterns of Potential West Nile Virus Vectors in South-West Spain

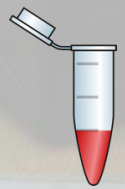
**Joaquín Muñoz[1], Santiago Ruiz[2], Ramón Soriguer[1], Miguel Alcaide[1,3], Duarte S. Viana[1], David Roiz[1], Ana Vázquez[4], Jordi Figuerola[1]***

**1** Estación Biológica de Doñana (CSIC), Seville, Spain, **2** Servicio de Control de Mosquitos, Diputación de Huelva, Huelva, Spain, **3** Department of Organismic and Evolutionary Biology, Harvard University, Cambridge, Massachusetts, United States of America, **4** CNM-Instituto de Salud Carlos III, Majadahonda, Spain

***Cx. perexiguus*** drives the transmission of **WNV** in Southern Spain

# Bird Sampling

# Bird Sampling



2588

blood samples

- ✓ 90 per site.
- ✓ Abundant and widespread species.
- ✓ Competent host.


The seroprevalences analyses were performed in the BSL-3 laboratory at CISA in accordance with all current biosafety guidelines.

# West Nile seroprevalence in Birds

| | WNV | | |
|---|---|---|---|
| | *est* | *z* | *p* |
| Habitat category | | | |
| Mosquito richness | 0.77 | 1.72 | 0.09 |
| *Cx. pipiens* | | | |
| *Cx. modestus* | -0.69 | 1.64 | 0.10 |
| *Cx. perexiguus* | **1.39** | **2.82** | **0.01** |
| *Cx. theileri* | -0.92 | 1.87 | 0.06 |
| *Oc. caspius* | **-0.94** | **2.02** | **0.04** |
| *An. atroparvus* | **-1.01** | **1.99** | **0.05** |
| $R^2$ | | **44%** | |

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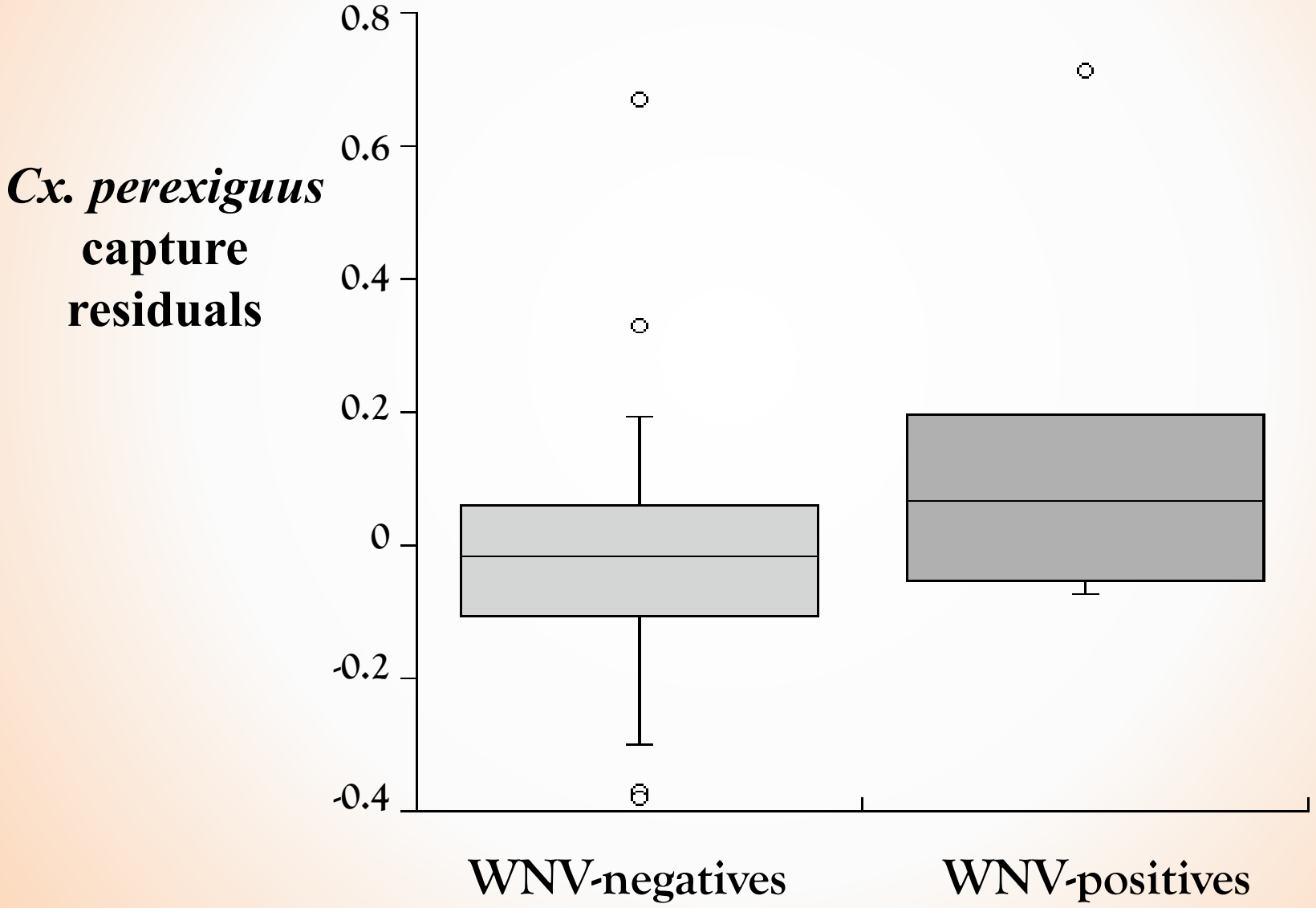
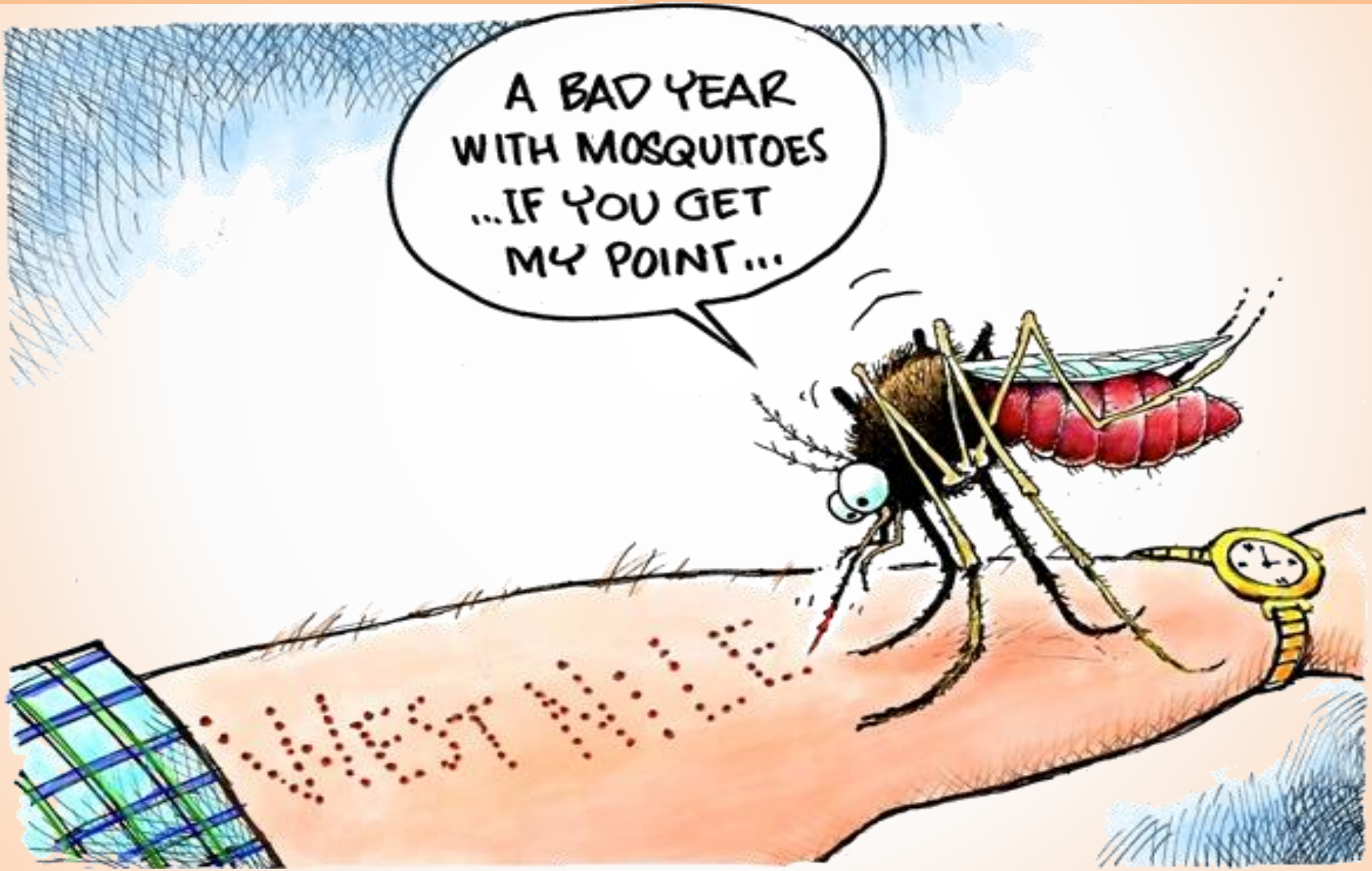
We confirm Muñoz's work prediction

# Number of *Cx. perexiguus* captured in areas with and without positive cases of WNV antibodies in house sparrows.



# Why are human cases uncommon in Southern Spain?



# All **positive** cases of WNV-specific antibodies by VNT in bird sera were found in **rural** and **natural habitats**

(*est*= -1.89, *z*=1.88; *p*=0.06)

Mean: 77 (0-1424) people

**WNV negative** cases in **birds**

>

Mean: 0 people

**WNV positive** cases in **birds**

..to sum up:

# Urbanization reduce mosquito abundance, potentially affecting pathogen transmission

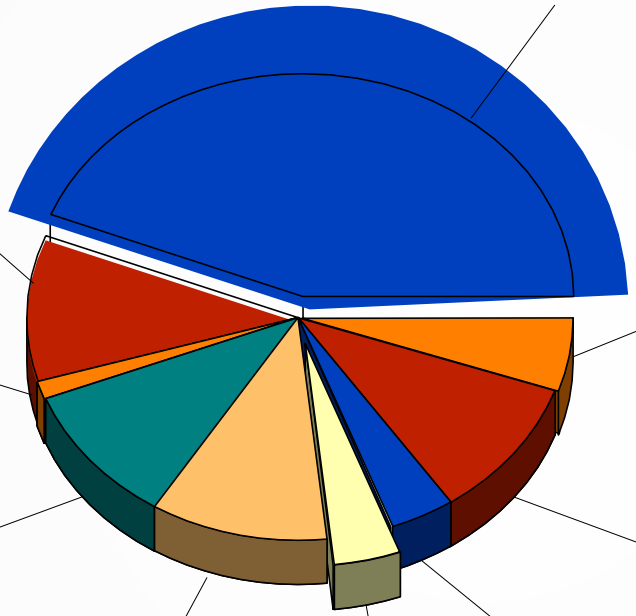
# Mosquito Control Service of Huelva

# Mosquito Surveillance

Santiago Ruiz

**Reduction** of **mosquito** pests to thresholds compatible with the sanitary, environmental and economic requirements.

# Field Work Organization



Larvicidal treatment **44.1%**

Adulticide treatment **5.2%**

Bridge construction **10.4%**

Rev. zones **3.9%**

Spindles **3.9%**

Others **10.5%**

Clearing **10.4%**

Advices **1.3%**

Drains **10.4%**

DIPUTACIÓN DE HUELVA

# CHEMICAL CONTROL

## The commercial insecticide treatments are:

- *Bacillus thuringiensis isra* **(Bti)** - Vectobac 12AS


DIPUTACIÓN DE HUELVA

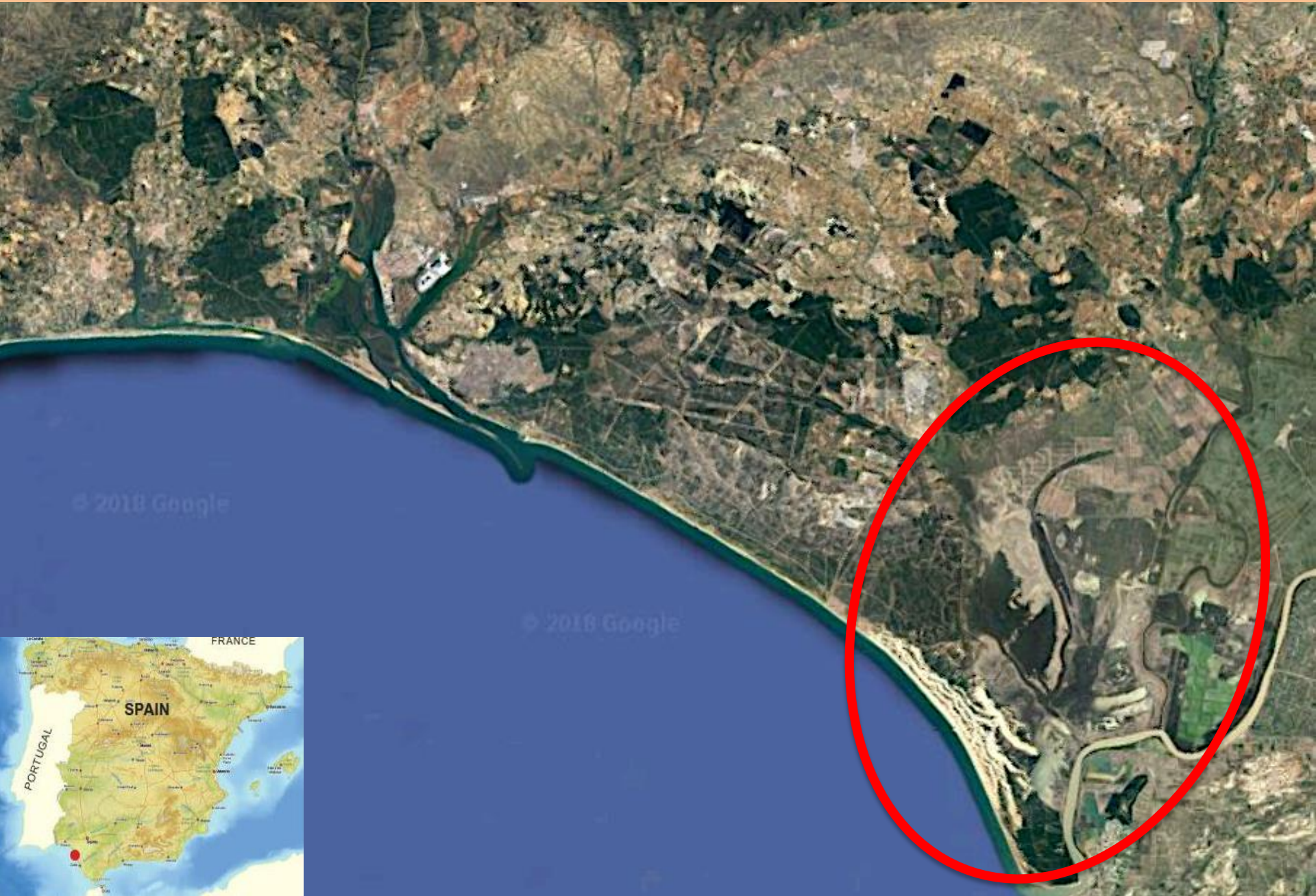
# Chemical Control

## The commercial insecticide treatments are:

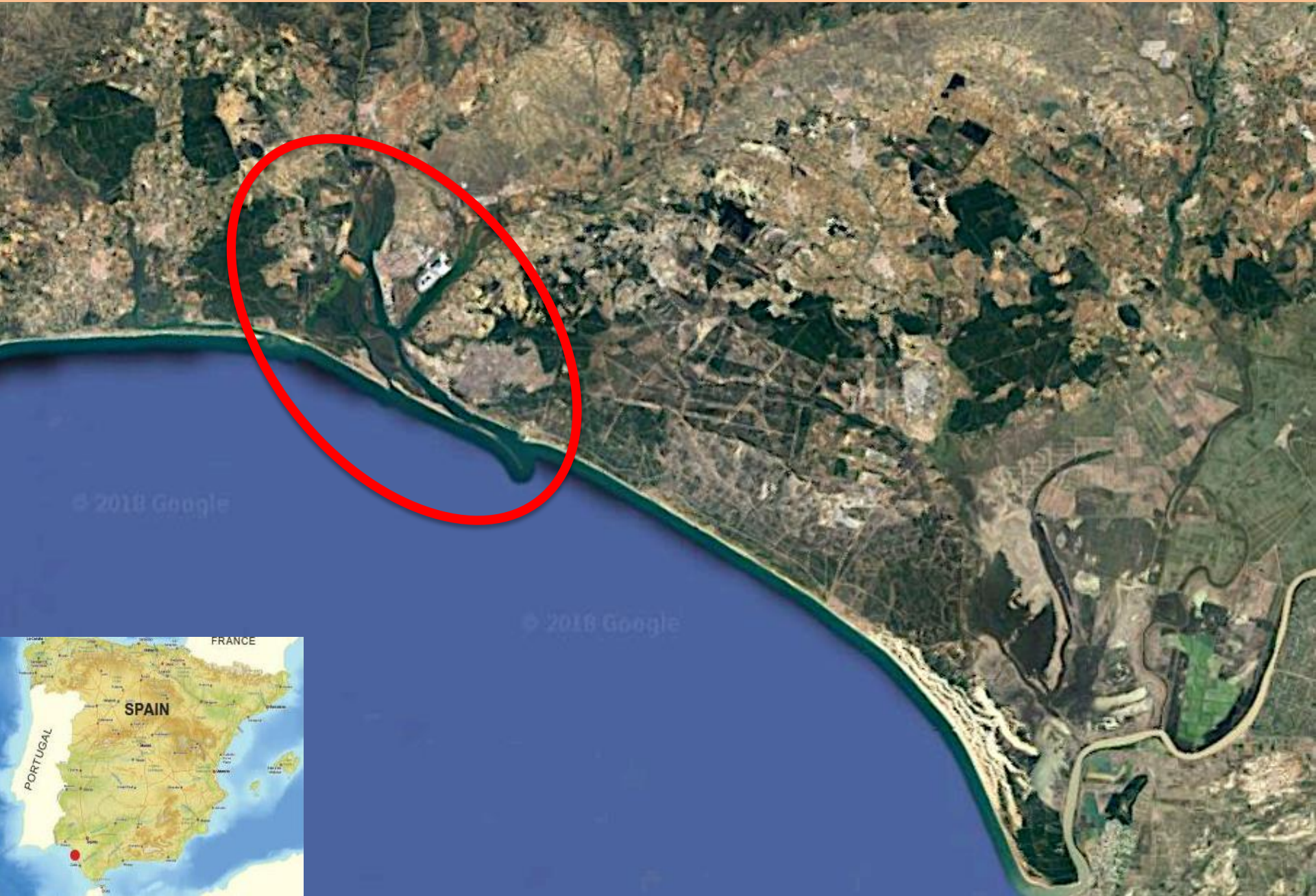
- *Bacillus thuringiensis isra* (**Bti**) - Vectobac 12AS
- Pyrethroid


DIPUTACIÓN DE HUELVA

# Doñana National Park



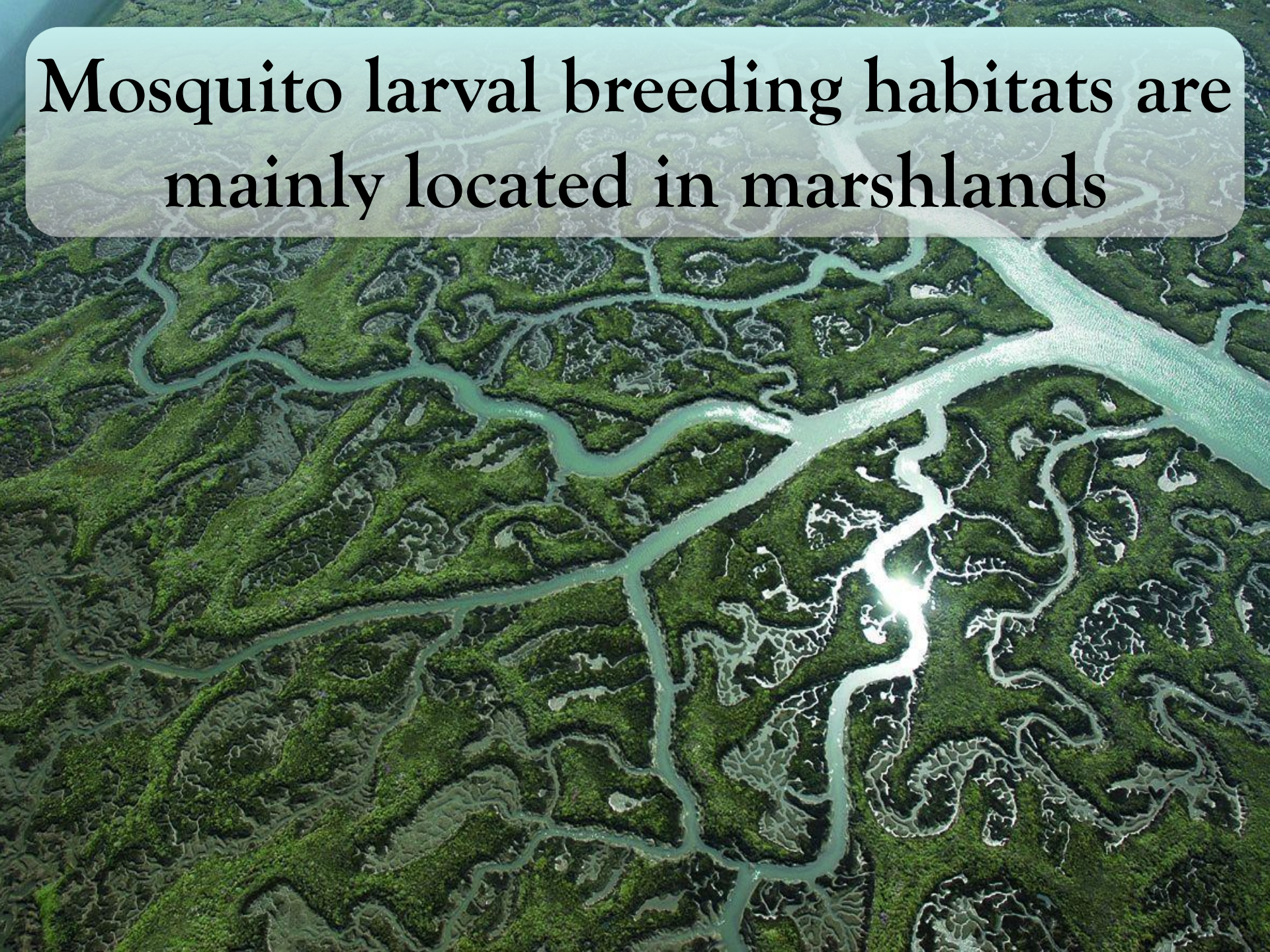
# The Odiel Marshes



# Hydrographic basins of Huelva province

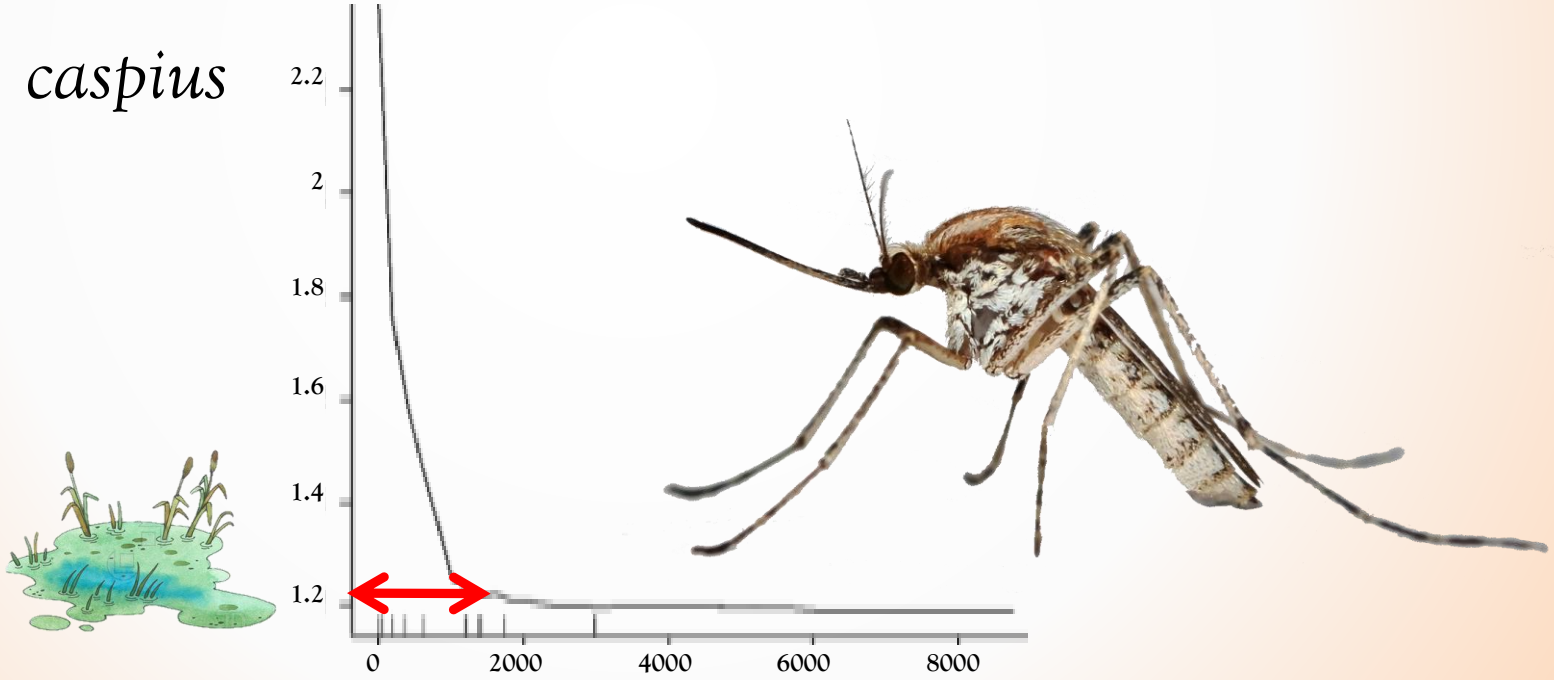

Río Guadiana
Río Múrtigas
Rivera Chanza
Rivera de Calaboza
Rivera de Malagón
Rivera Cobica
Rivera de la Viguera
Riv. de Meca
Rivera Grande
Río Oraque
Río Odiel
Río Tinto
Río Corumbel
Río Piedras
Marismas del Río Piedras
Flecha del Rompido
Marismas de Isla Cristina
Marismas del Odiel
Lagunas de Palos y Las Madres
Arroyo de la Rocina
Lagunas de Matalagrana
Humedales de Doñana
Río Guadalquivir
Río Guadiamar
Río Viar
Río Corbones
Rivera de Cala
Rivera de Huelva
Arroyo Salado
C.H. GUADALQUIVIR
Acuífero Almonte-Marisma

# Mosquito larval breeding habitats are mainly located in marshlands



| Mosquito variable | Buffer | % Var. explained | Most important variables in model |
|---|---|---|---|
| Abundance | 1000 | 45.35 | (+) Wetlands, (−) Urban land, (−) Human density |
| Richness | 250 | 32.06 | (−) Urban land, (−) Human density, (−) Marshland |
| *An. atroparvus* | 1000 | 41.25 | (+) Summer NDVI, (+) Wetlands, (−) Urban land |
| *Cx. modestus* | 100 | 19.07 | (+) Wetlands, (−) Marshland, (+) Summer NDVI, (−) Winter NDVI |
| *Cx. perexiguus* | 1000 | 26.59 | (+) Summer NDVI, (+) Autumn NDVI, (−) Urban land |
| *Cx. theileri* | 2000 | 45.55 | (−) Urban land, (+) Wetlands, (+) Summer NDVI |
| *Oc. caspius* | 500 | 45.76 | (−) Marshland, (−) Urban land |

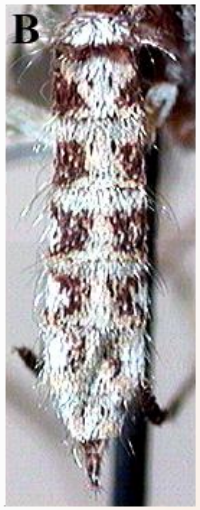
# *Oc. caspius*




Ferraguti et al. 2016. *Sci Rep*

# *Ochlerotatus caspius* (Pallas)

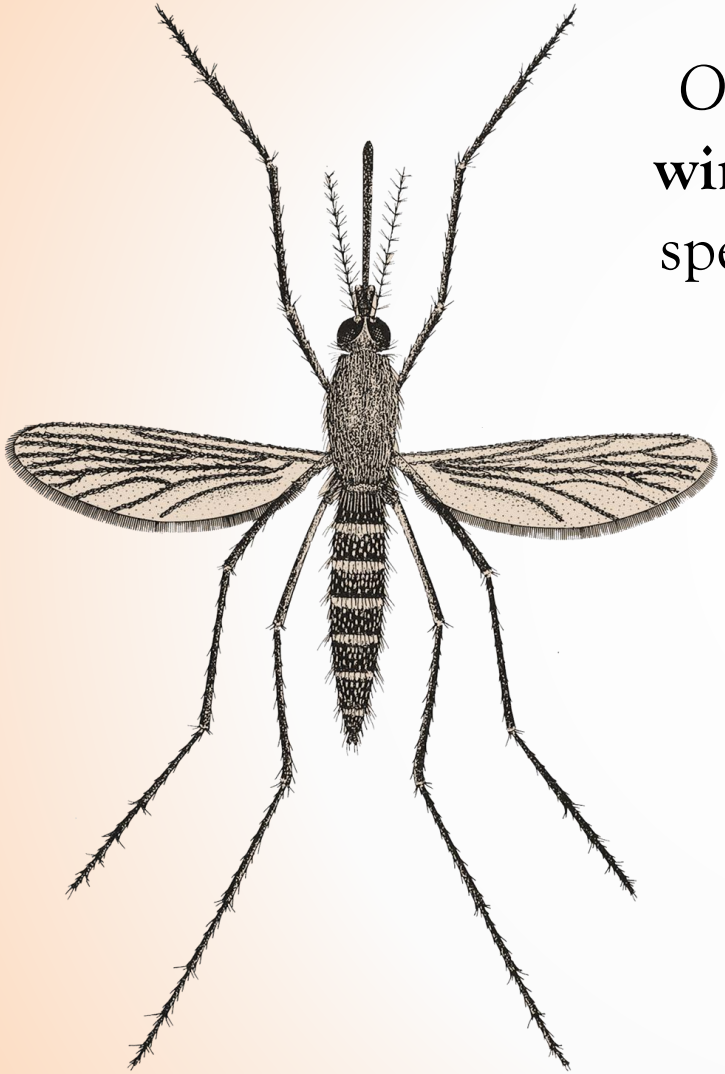
Oc. *caspius* occurs predominantly during **summer**. Females readily bite on **humans** and other mammals. The species can carry West Nile virus and other viruses.

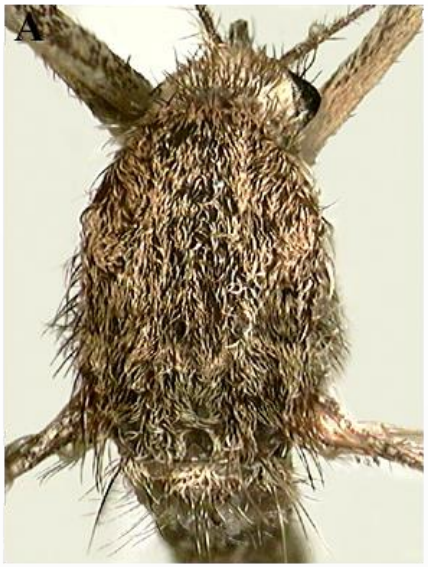


**Habitat**: coastal marshes, rock holes, areas of intermittent flooding.

# *Ochlerotatus detritus* (Haliday)



*Oc. detritus* appears in **spring, autumn** and **winter.** Females prefer bite on **humans.** The species can carry Japanese encephalitis virus and other Flavivirus.






**Habitat:** coastal marshes, rock holes, areas of intermittent flooding.

# *Culex pipiens* s.l. (complex)

*Cx. pipiens* is **the common house mosquito**. Widely distributed, can carry different diseases including West Nile virus, Rift Valley fever and Sindbis virus, among others.

**Habitat**: stagnant water, shaded or unshaded.

**Treatment** cycles are developed during **March-October**, when the warm temperatures accelerate the rhythms of larval development.

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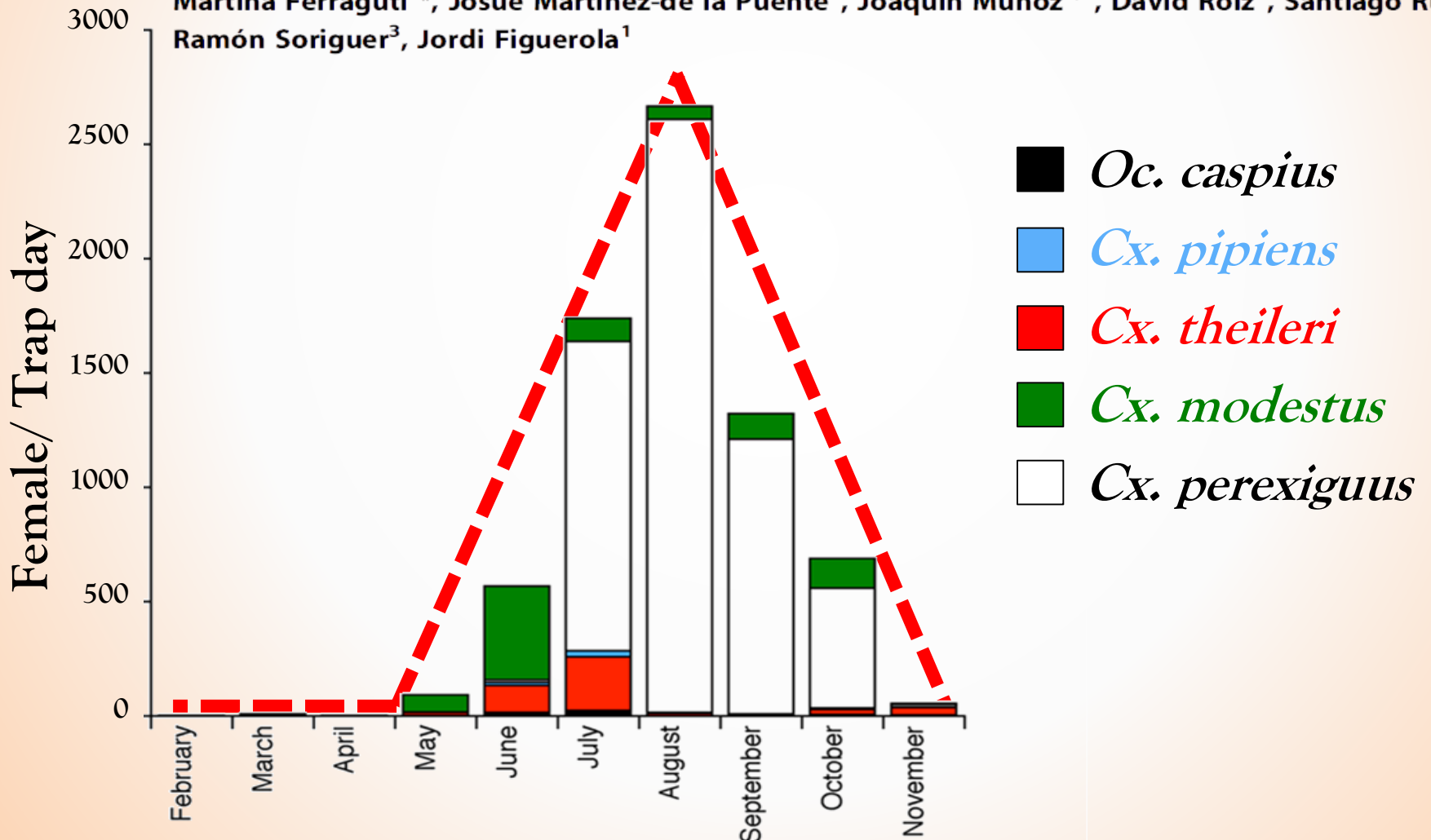
PLOS ONE

# Avian *Plasmodium* in *Culex* and *Ochlerotatus* Mosquitoes from Southern Spain: Effects of Season and Host-Feeding Source on Parasite Dynamics

Martina Ferraguti[1*], Josué Martínez-de la Puente[1], Joaquín Muñoz[1,4], David Roiz[1], Santiago Ruiz[2], Ramón Soriguer[3], Jordi Figuerola[1]



# Larval Control

# Larval Control

# Larval Control

# Larval Control

By **aerial** or land only **larval** treatments with **Bti** manual spray equipment

# Adult Control

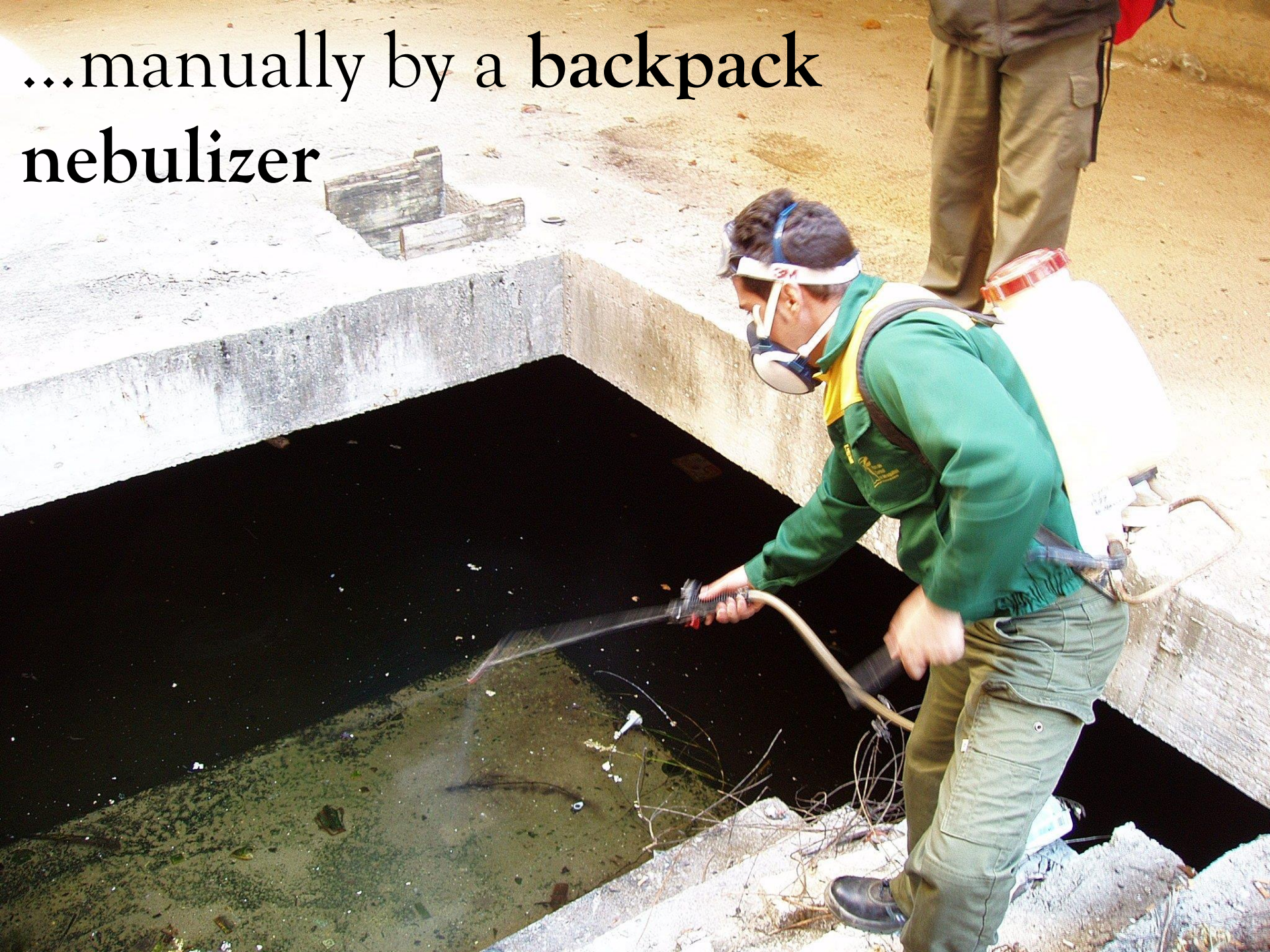
# Adult Control

# Adult Control


# In the lab, **mosquitoes** are **identified**

In **cities, adulticidal** treatments are carried out by nebulization, preferably with **pyrethroid** pesticides

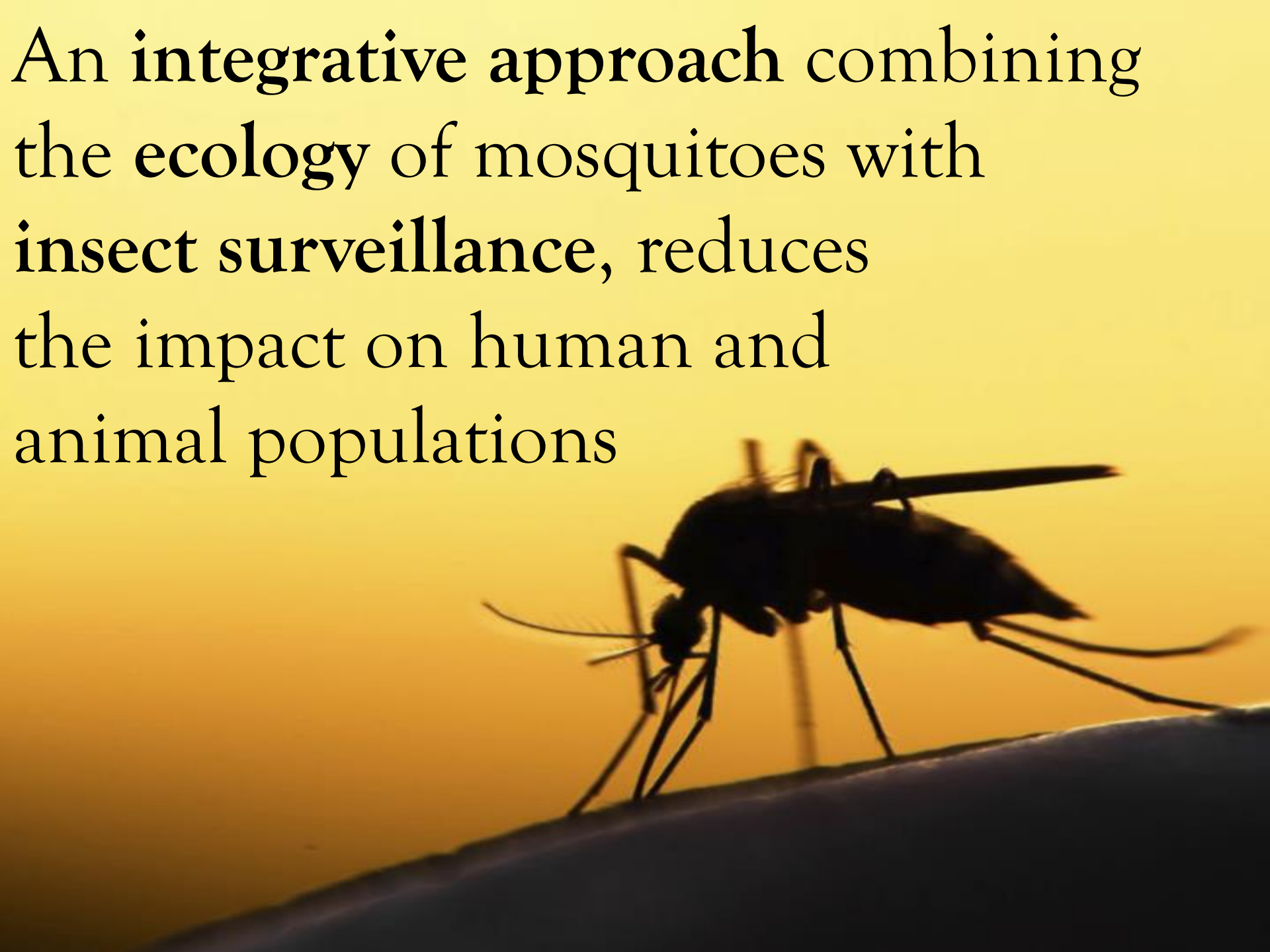
**Urban gardens** are sprayed by a pickup, or..

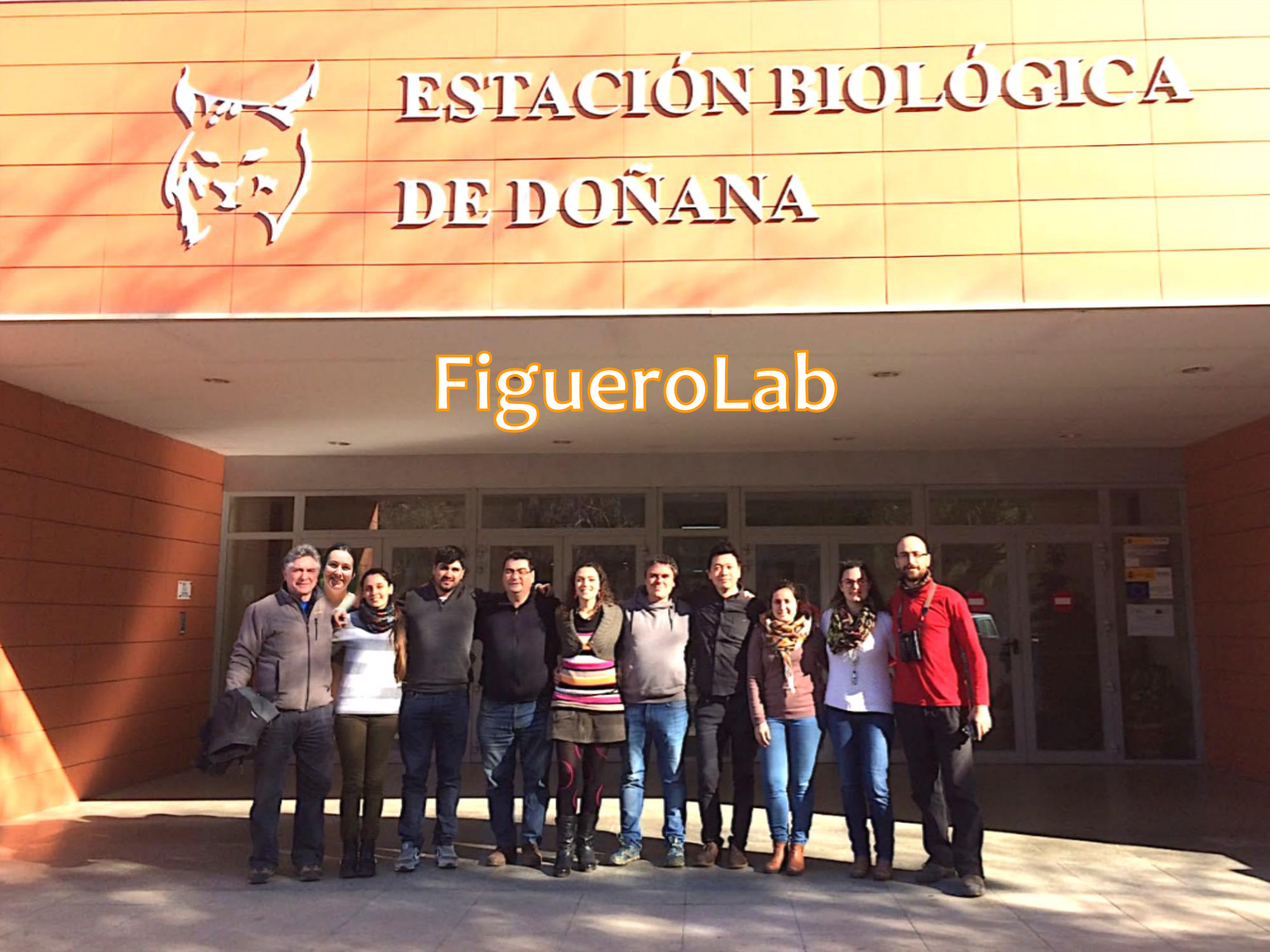

...manually by a **backpack**
**nebulizer**

# In natural systems

Regeneration of drainage networks with communication channels. Through the management of the environment, the flood pattern of the larval habitats is modified -> no longer functional for larval breeding.

An **integrative approach** combining the **ecology** of mosquitoes with **insect surveillance**, reduces the impact on human and animal populations

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Akrotiri Environmental Education Centre
Κέντρο Περιβαλλοντικής Εκπαίδευσης Ακρωτηρίου

# Mosquito surveillance and management in the wetland of Doñana National Park, Spain

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