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RÉPUBLIQUE FRANÇAISE

MINISTÈRE
DE L'AGRICULTURE
ET DE
L'ALIMENTATION

Modeling Japanese encephalitis: Characterization of JEV transmission dynamics & estimation of human exposure in Cambodia

WOAH Webinar on Vector-borne Zoonoses affecting equines - Japanese Encephalitis (JE) and West Nile fever (WNF)

Wednesday 29th March 2023

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alimentation, environnement, travail

Institut Pasteur du Cambodge

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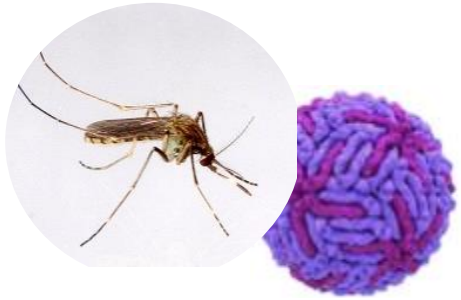
Dispositif en Partenariat dP

ONE HEALTH OI

Context & epidemiology



- Vectorborne zoonosis, flavivirus
- Main cause of viral encephalitis in Asia
- ¾ clinical cases: children → severe forms

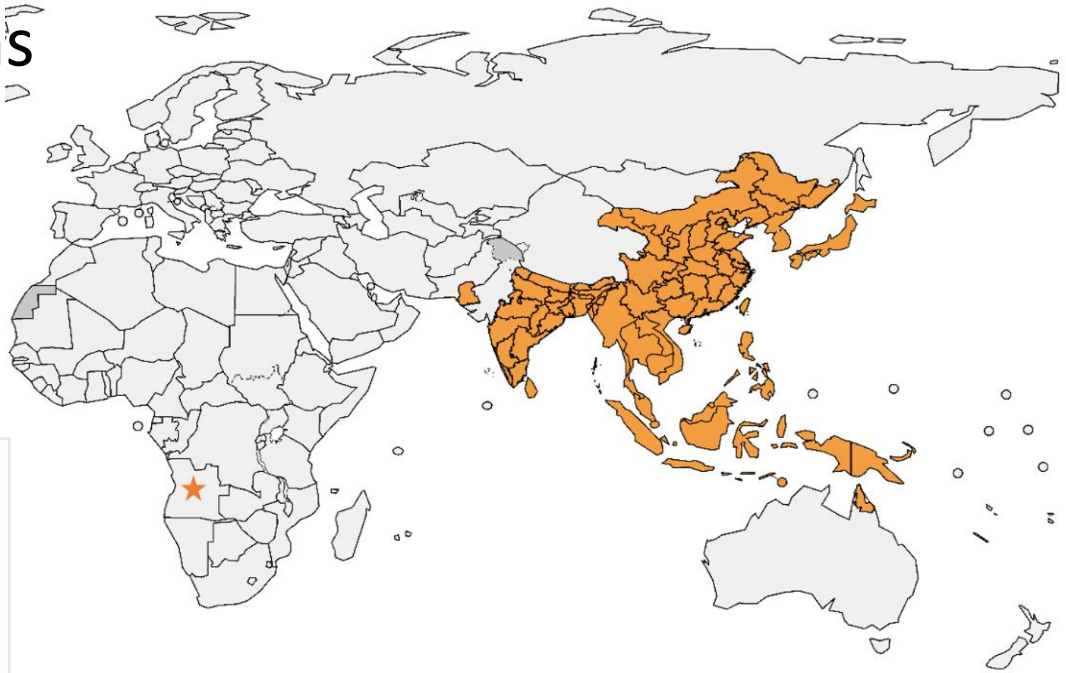
> 100 500 clinical cases/year

> 25 000 deaths/year

- Angola 2016 - Australia 2022

The NEW ENGLAND JOURNAL of MEDICINE

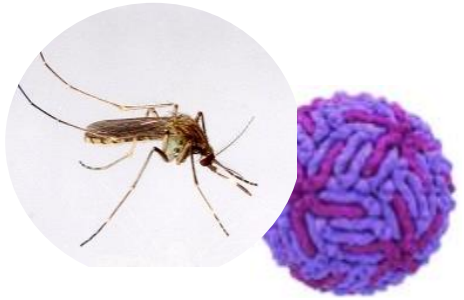
Autochthonous Japanese Encephalitis with Yellow Fever Coinfection in Africa



JE distribution in 2018 (Source: WHO, 2018)

Quan et al 2020, Campbell et al 2011, Impoinvil et al 2013, Le Flohic et al 2013, WHO 2018, Simon-Loriere et al 2017, Maeki et al 2019

Context & epidemiology



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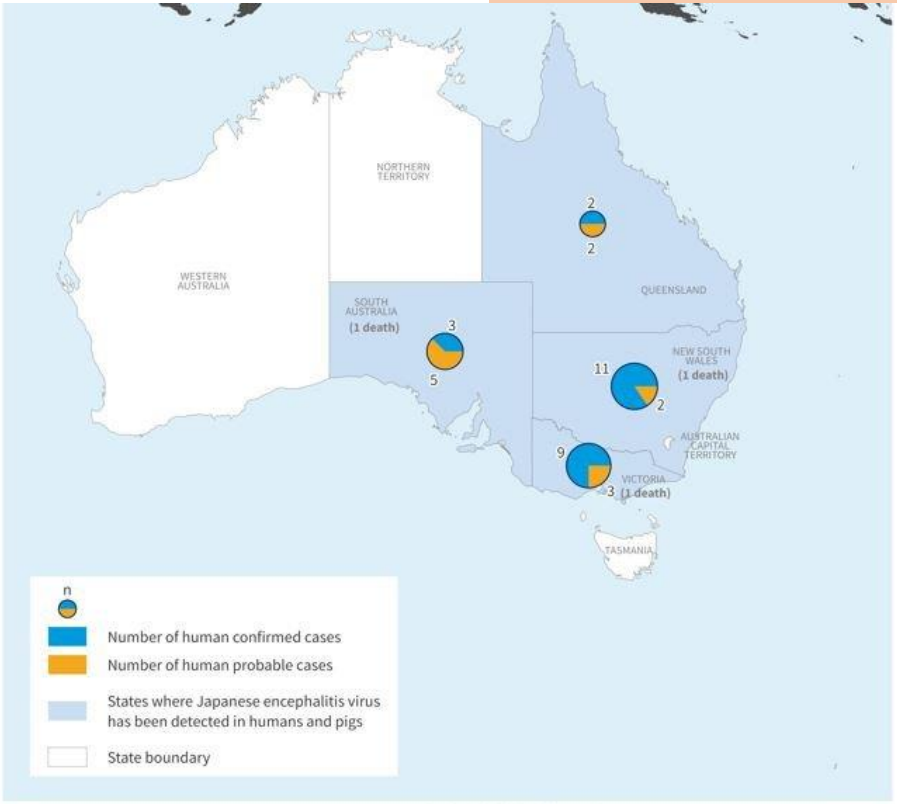
World Health Organization

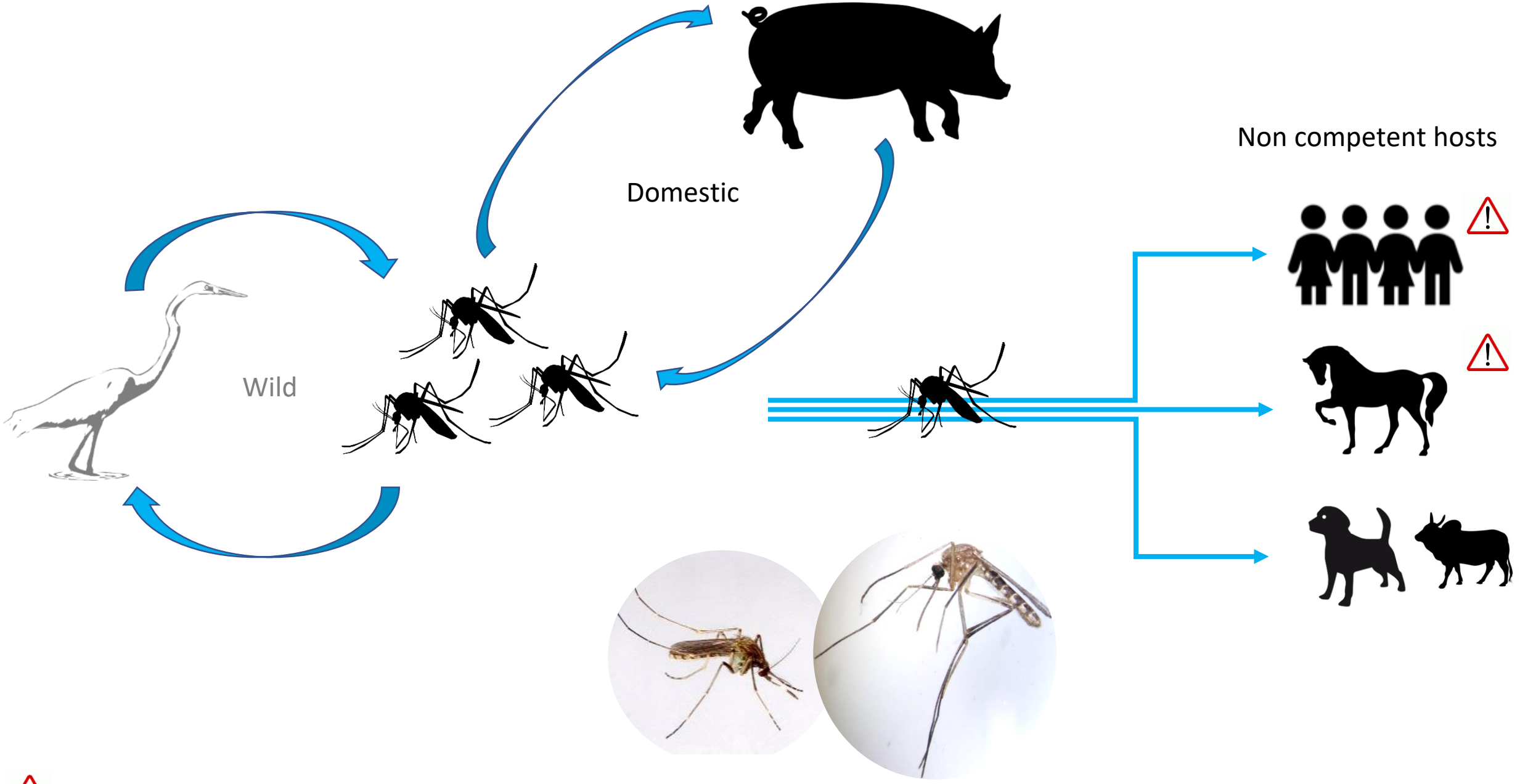
Disease Outbreak News

28 April 2022 | Japanese encephalitis - Australia



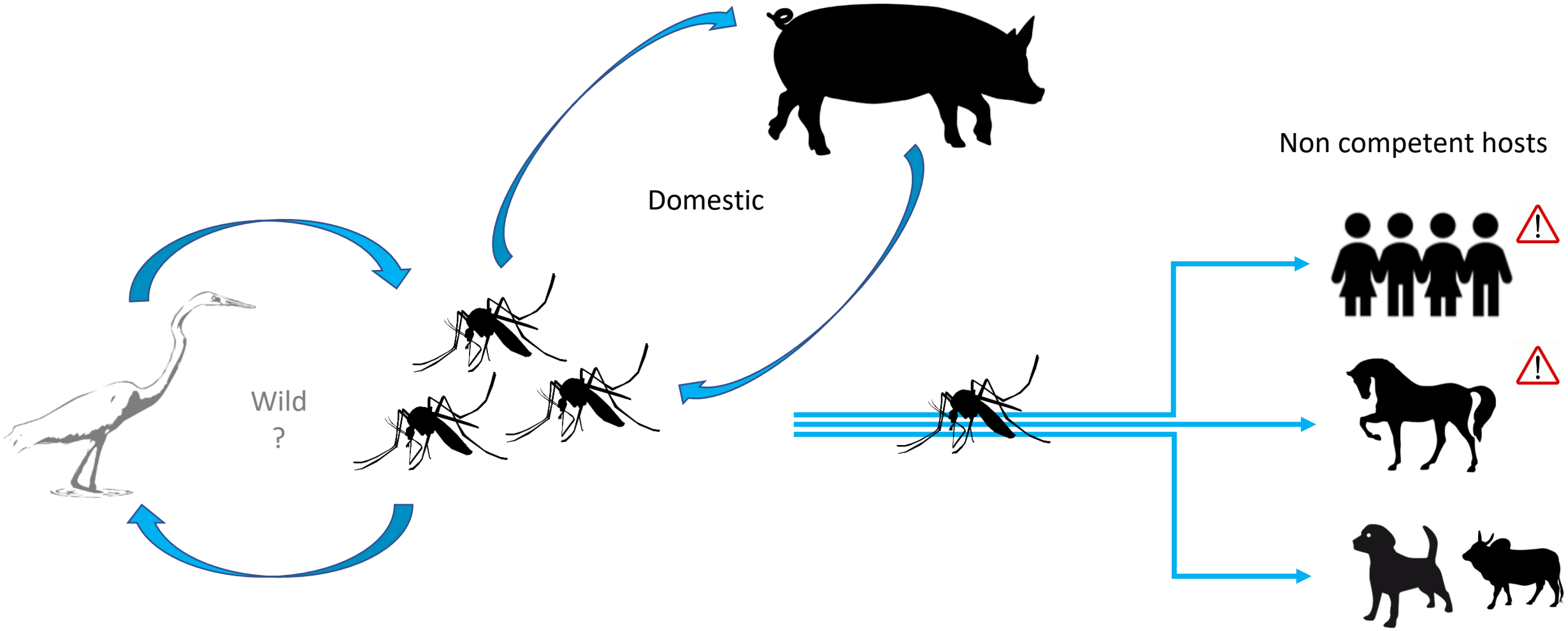
Distribution of confirmed (n=25) and probable (n=12) human cases and deaths (n=3) of Japanese encephalitis (JE) and states in which JE virus has been detected in pigs, Australia, 2022. Source: WHO

Quan et al 2020, Campbell et al 2011, Impoinvil et al 2013, Le Flohic et al 2013, WHO 2018, Simon-Loriere et al 2017, Maeki et



⚠ : risk of encephalitis

Buescher et al 1959



RESEARCH Open Access

Serological evidence of continued Japanese encephalitis virus transmission in Singapore nearly three decades after end of pig farming

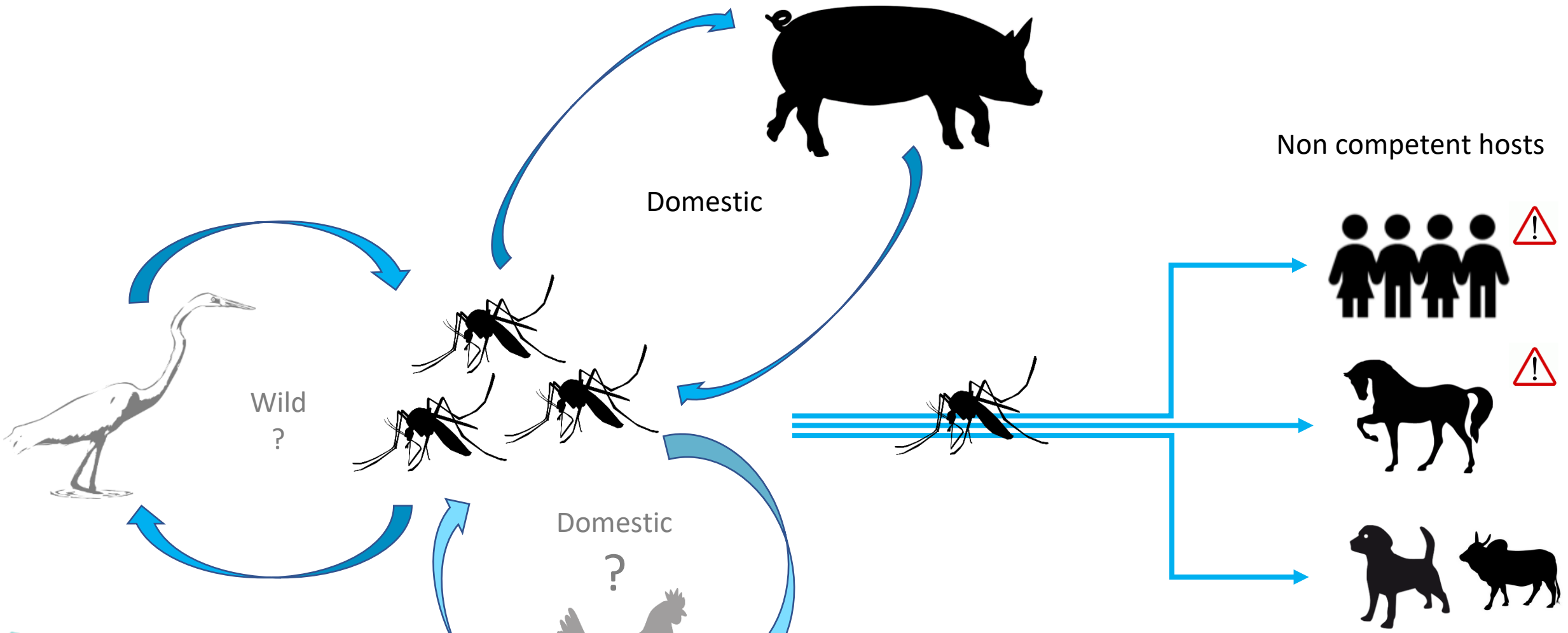
Grace Yap[1,2], Xiao Fang Lim[1], Sharon Chan[3], Choon Beng How[3], Mahathir Humaidi[1*], Gladys Yeo[1], Diyar Mailepessov[1], Marcella Kong[1], Yee Ling Lai[1], Chiharu Okumura[4] and Lee Ching Ng[1]

Review

viruses

How Central Is the Domestic Pig in the Epidemiological Cycle of Japanese Encephalitis Virus? A Review of Scientific Evidence and Implications for Disease Control

Héléna Ladreyt [1,2], Benoit Durand [1], Philippe Dussart [3] and Véronique Chevalier [2,4,5,*]

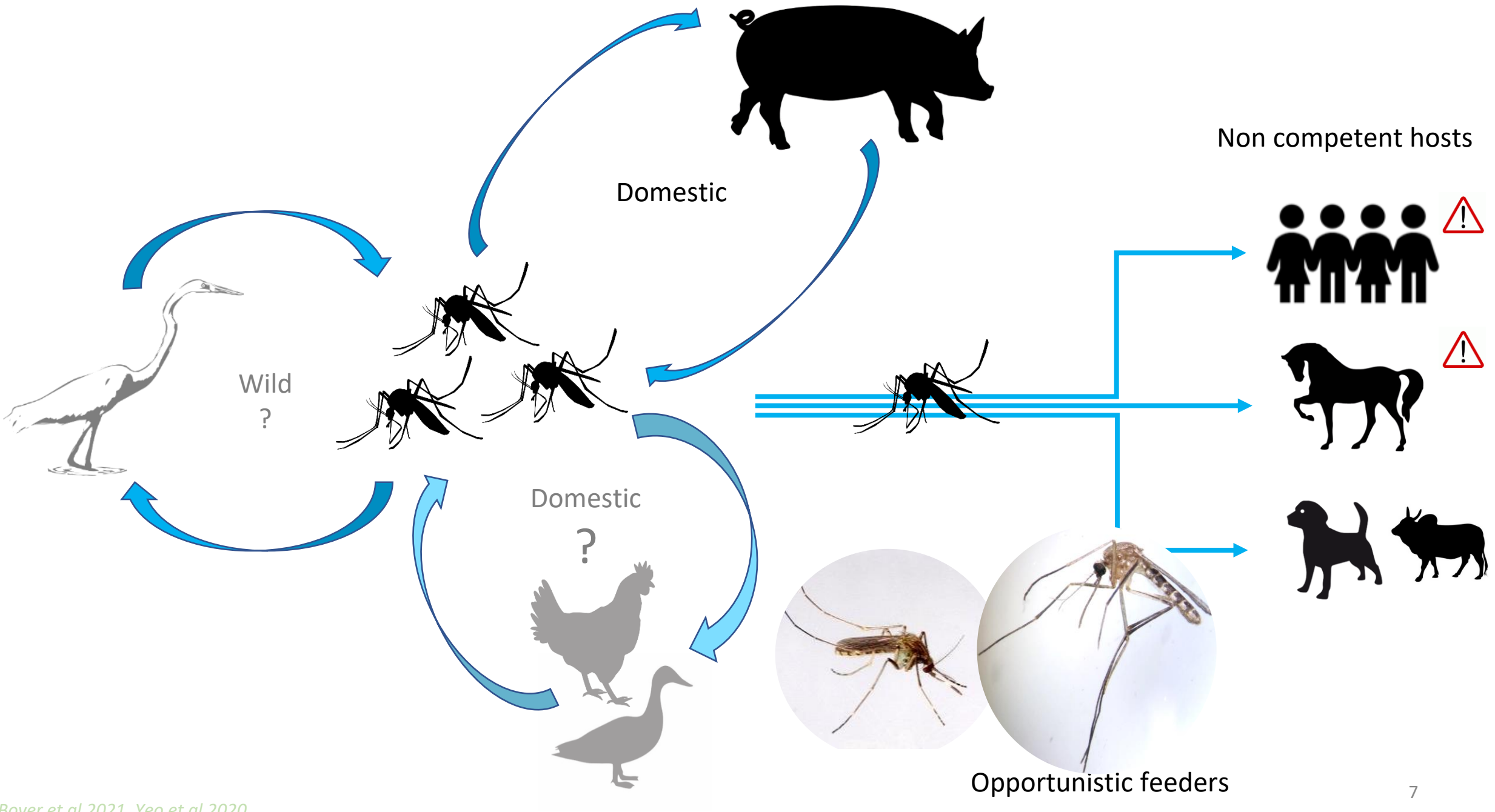


frontiers in Veterinary Science

Serological Evidence for Japanese Encephalitis and West Nile Virus Infections in Domestic Birds in Cambodia

Heidi Auerswald[1], Anne-Sophie Ruget[2,3], Helena Ladreyt[3,4,5], Saraden In[1], Sokthearom Mao[1], San Sorn[6], Sothyra Tum[7], Veasna Duong[1], Philippe Dussart[1], Julien Cappelle[2,3,4,8†] and Véronique Chevalier[2,3,4†]*

Cleton et al 2014, Auerswald et al 2020



Boyer et al 2021, Yeo et al 2020

JE in Cambodia

- **Endemic**

IPC, Horwood et al 2017, Chheng et al 2013, Boyer et al 2021, Chevalier et al 2021, Auerswald et al 2020, Cappelle et al 2016, Di Francesco et al 2018, Duong et al, 2017

JE in Cambodia

- **Endemic**

- Intense circulation in pigs
- But low density of wild birds and pigs & high density of poultry

→ characterize JEV epidemiological cycle

IPC, Horwood et al 2017, Chheng et al 2013, Boyer et al 2021, Chevalier et al 2021, Auerswald et al 2020, Cappelle et al 2016, Di Francesco et al 2018, Duong et al, 2017

JE in Cambodia



- **Endemic**

- Intense circulation in pigs
- But low density of wild birds and pigs & high density of poultry

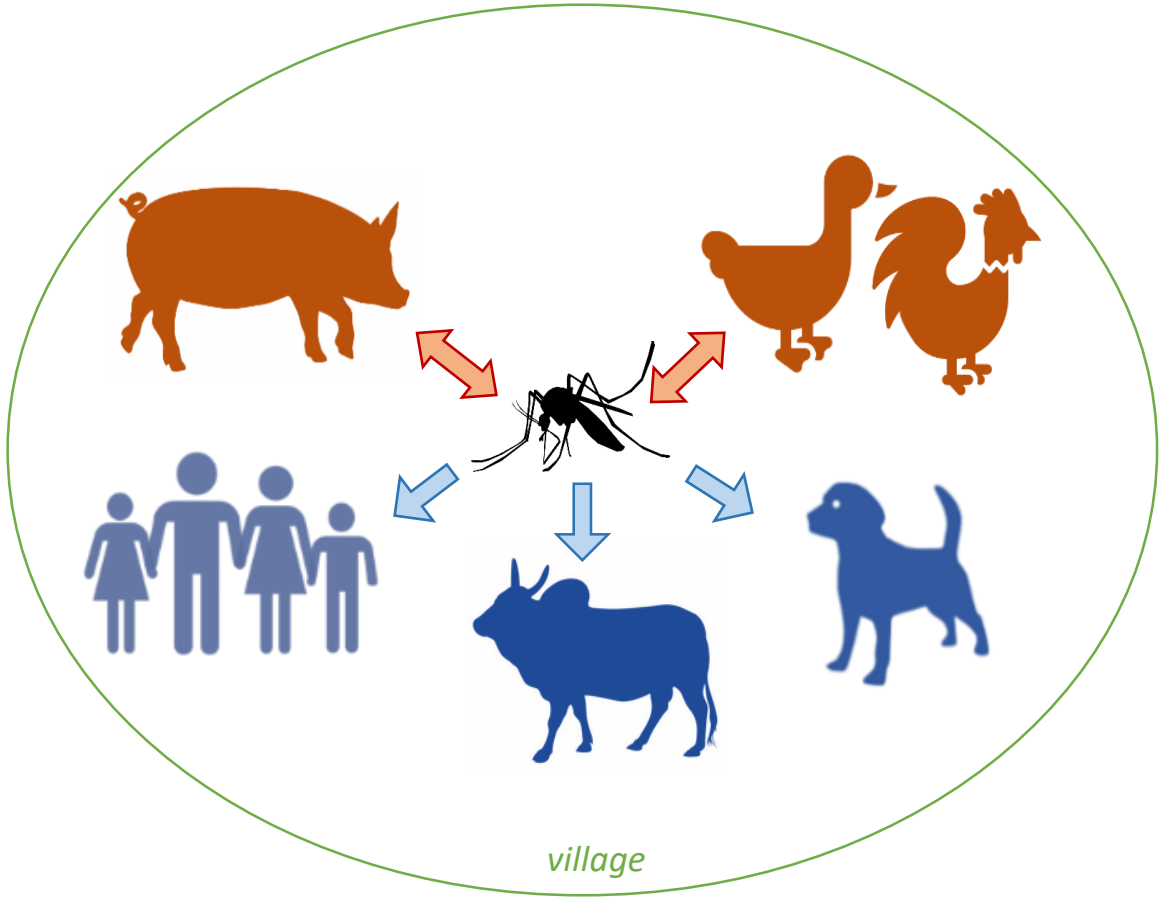
→ characterize JEV epidemiological cycle

- Human cases (JEV: > 45% of childhood encephalitis treated in hospial)
- But under-reporting/under-detection

→ provide an estimate of human exposure

IPC, Horwood et al 2017, Chheng et al 2013, Boyer et al 2021, Chevalier et al 2021, Auerswald et al 2020, Cappelle et al 2016, Di Francesco et al 2018, Duong et al, 2017

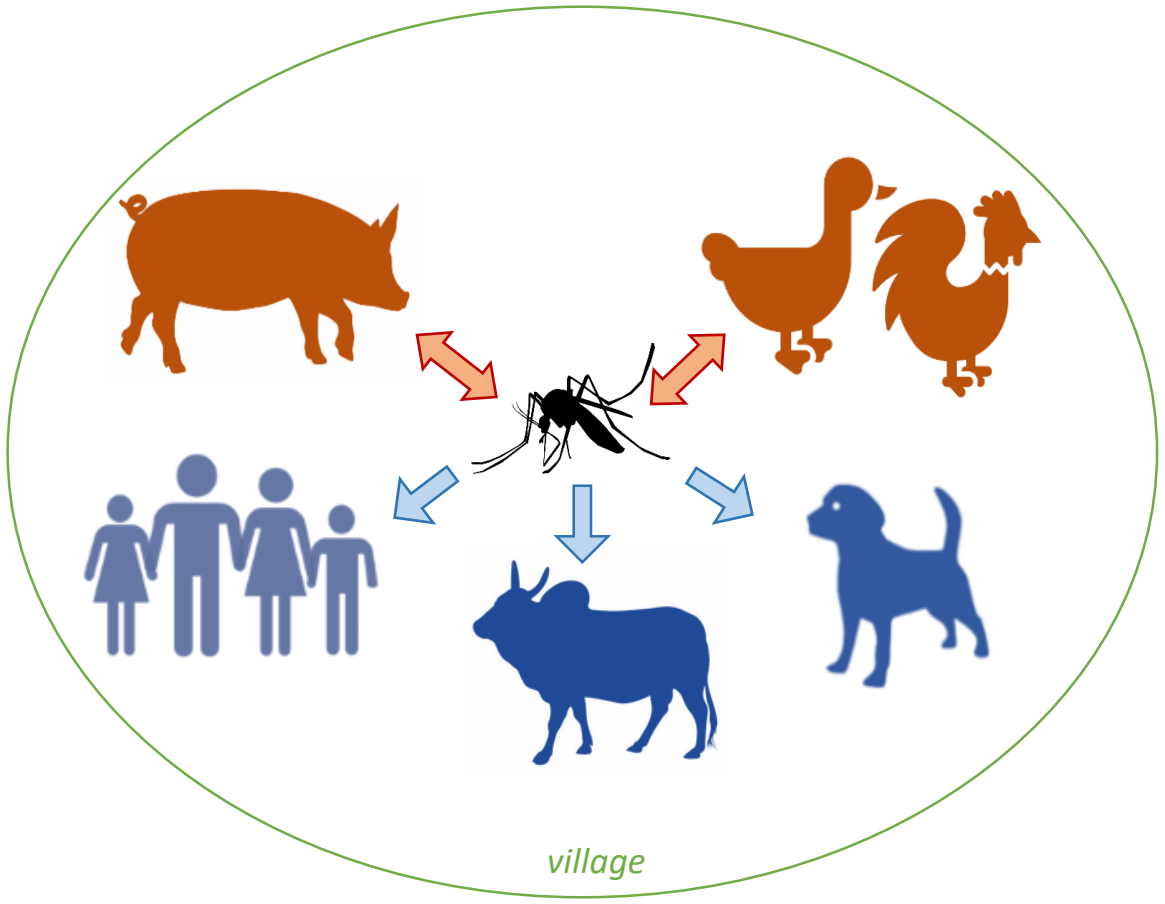
Epidemiological system

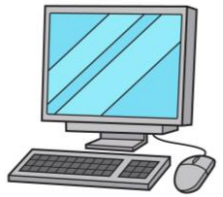


→ characterize JEV epidemiological cycle

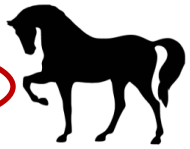
→ provide an estimate of human exposure

Epidemiological system





Other region → other system



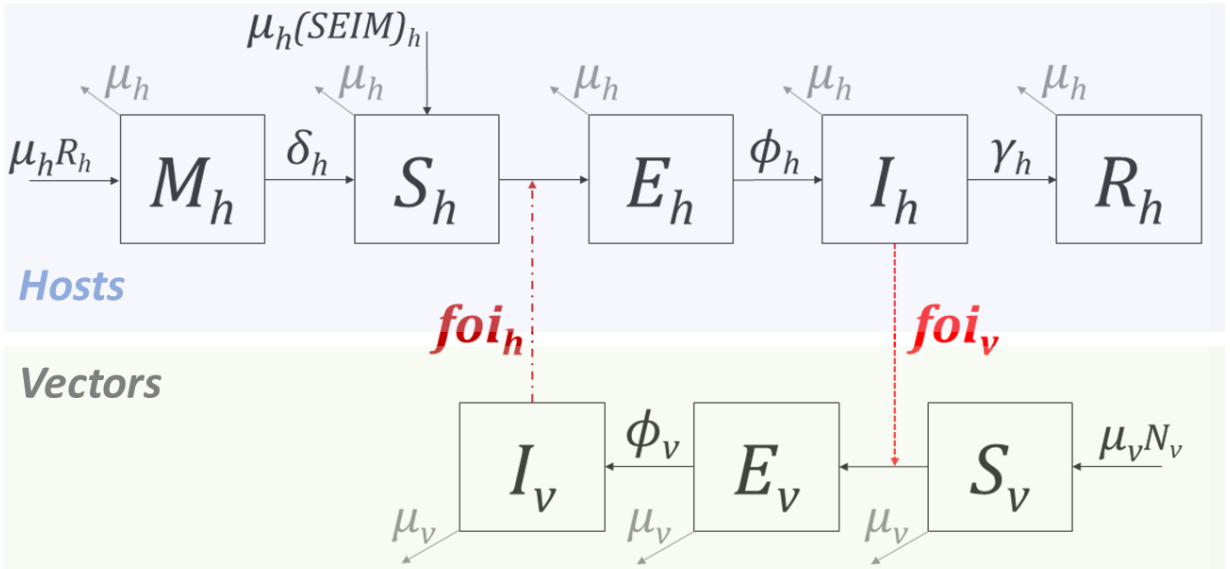
→ characterize JEV epidemiological cycle

→ provide an estimate of human exposure

Model structure & parameters

HEALTH STATES of hosts and vectors

M: protected my maternal immunity
S: sensitive, healthy
E: infected but non infectious (latent)
I: infected & infectious
R: immune



→ characterize JEV epidemiological cycle

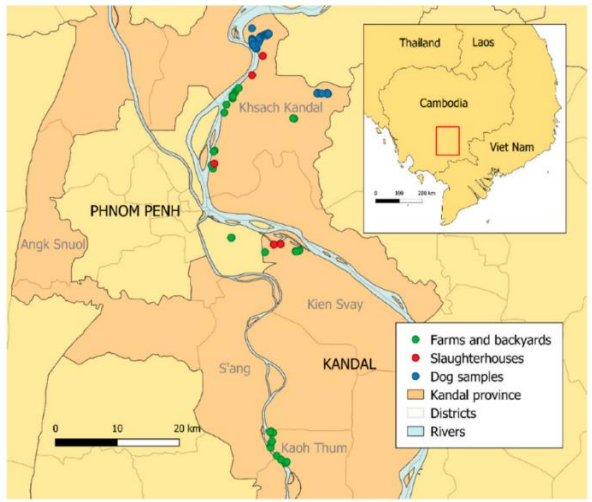
→ provide an estimate of human exposure

Ladreyt et al, 2022

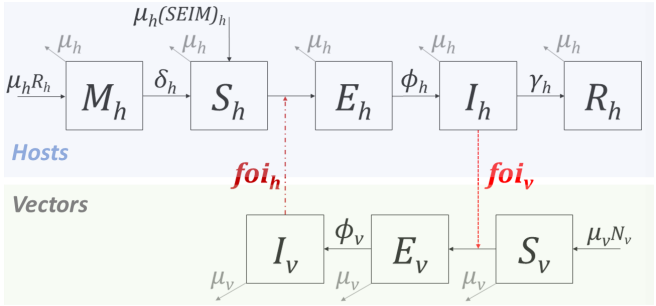
Model calibration: serological & demographic data

Possible because JE endemic in Cambodia

Observed seroprevalences/species



Average host population sizes in a village (all species)



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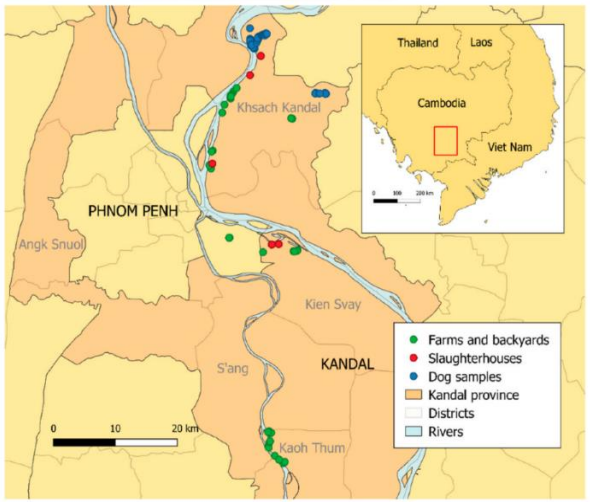

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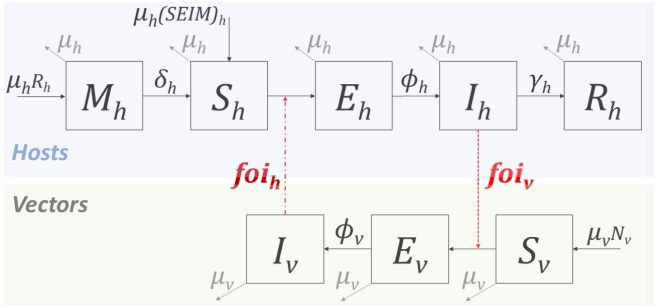
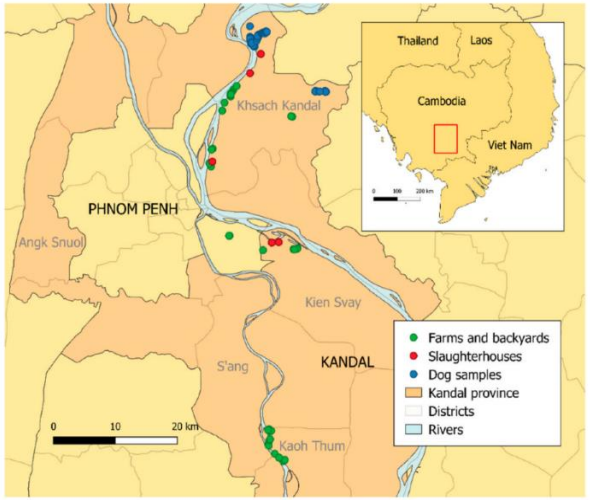


Predicted seroprevalences/species

Ladreyt et al, 2022

Model outputs

Observed seroprevalences/species



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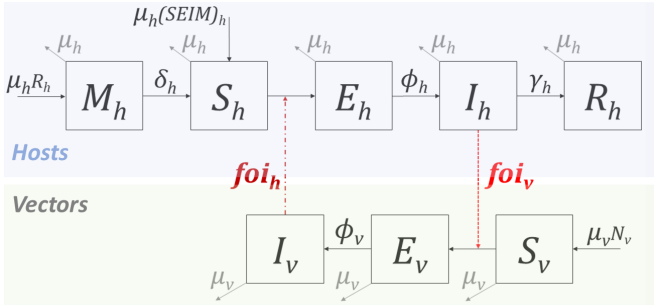


Model outputs:

R_0

→ characterize JEV epidemiological cycle

(Can JEV invade the population?)

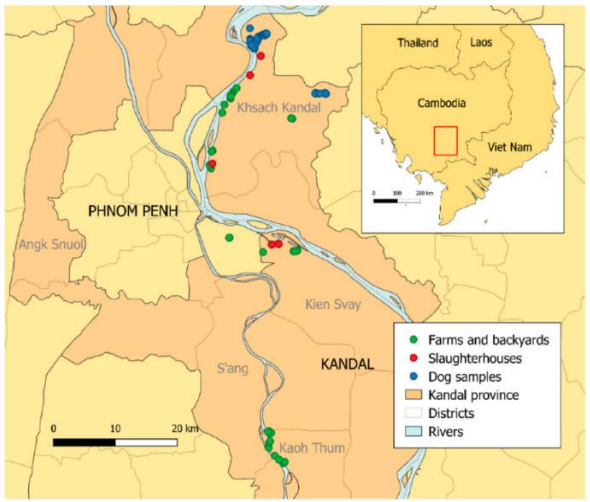
Probability of exposure, incidence rate

→ provide an estimate of human exposure

Ladreyt et al, 2022

Model outputs

Observed seroprevalences/species



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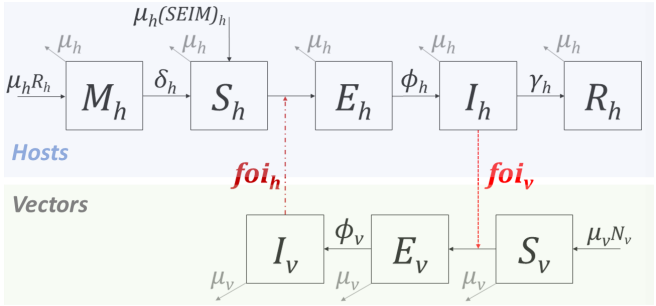

Other endemic regions → local data

Model outputs:

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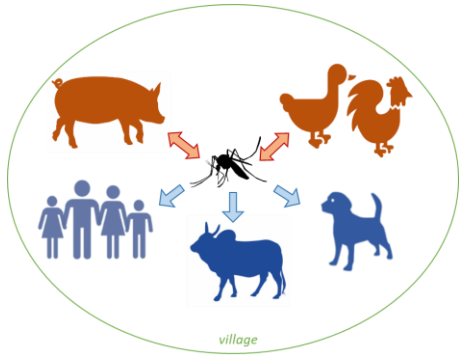
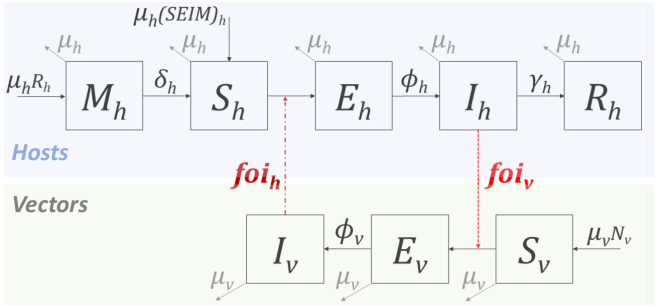
Ladreyt et al, 2022

Model outputs





Model outputs:

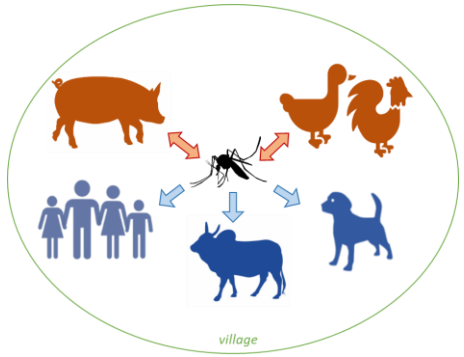
R_0 **1,3**

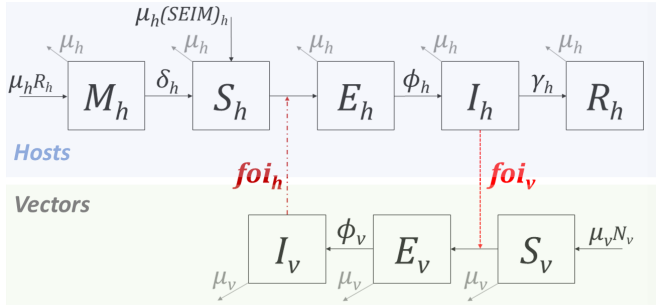
(Can JEV invade the population?)

Probability of exposure, incidence rate **~50 people infected/year/village**

Ladreyt et al, 2022

Model outputs





Model outputs:

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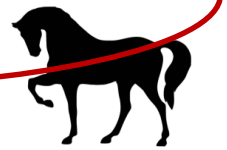
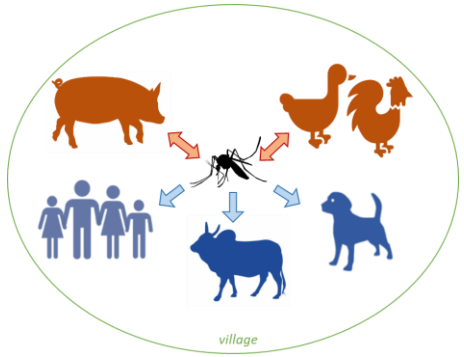
Probability of exposure, incidence rate **~50 people infected/year/village**

Exposure indicators could be estimated for any other host

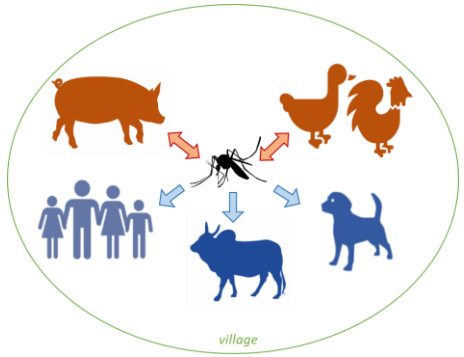


Model applications



- Model to characterize JEV circulation in Cambodian villages & estimate human exposure
- Model calibration with serological data

Model applications



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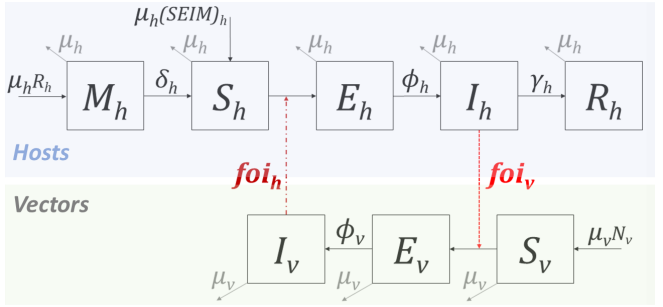
- Could be used in other regions ⟸ *Local model parameters*
  Local serological & demographic data



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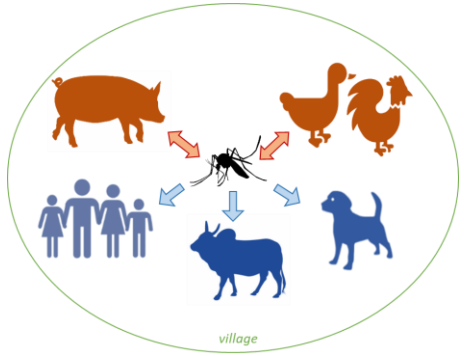

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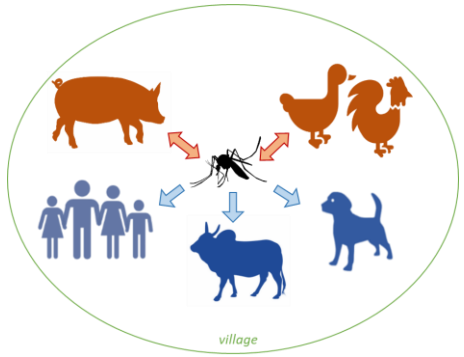
Model applications



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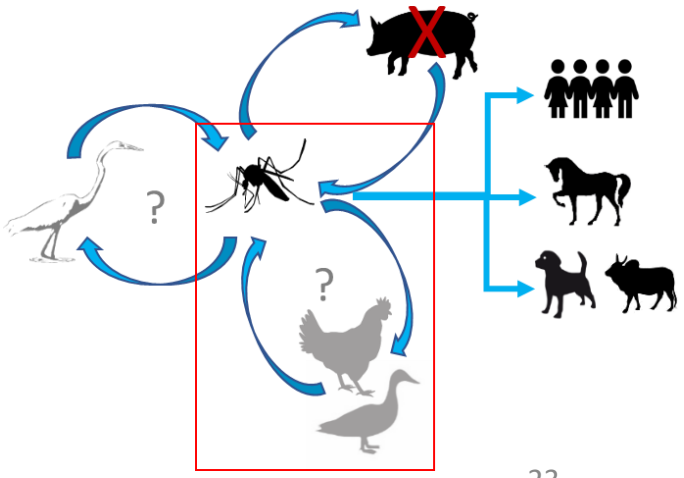
  → In Cambodia, JEV could circulate in a system with no pigs



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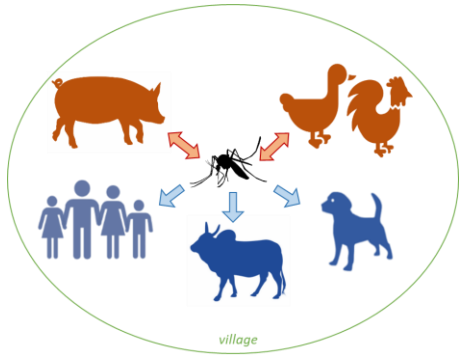

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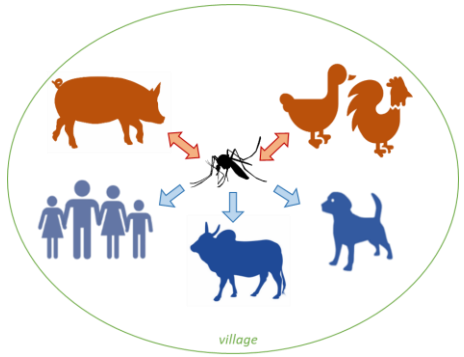
  → In Cambodia, JEV could circulate in a system with no pigs
  → Dilution effect?
  → Estimate risk of exposure (animal health)

Model applications



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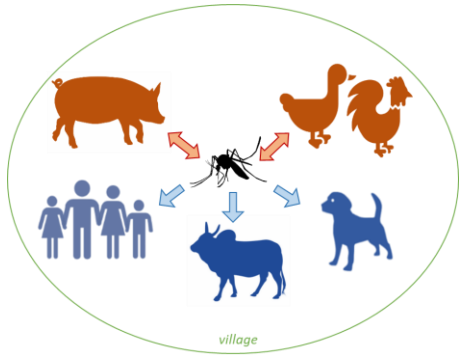
- Identify sentinel species

Model applications



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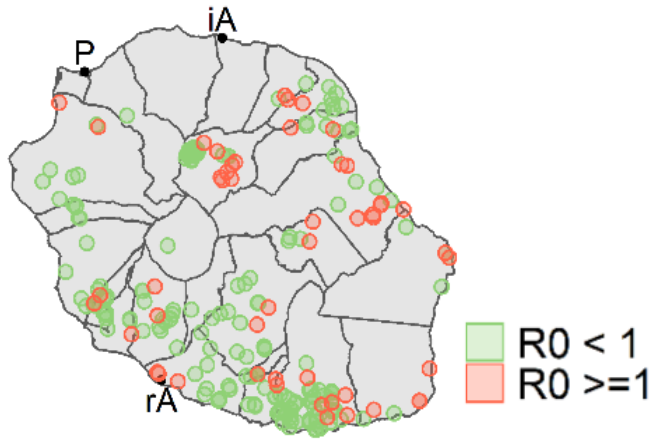
- Identify sentinel species

- Run the model in disease-free context → Local circulation if JEV introduced?
  → Need to set up surveillance?

⚠ *Assumptions, local data/parameters*



Reunion Island, Indian Ocean




Thank you for your attention

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PLOS NEGLECTED TROPICAL DISEASES

Ladreyt H, Chevalier V, Durand B (2022) Modelling Japanese encephalitis virus transmission dynamics and human exposure in a Cambodian rural multi-host system. PLoS Negl Trop Dis 16(7): e0010572. ***https://doi.org/10.1371/journal.pntd.0010572***

anses agence nationale de sécurité sanitaire alimentation, environnement, travail

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Dispositif en Partenariat dP ONE HEALTH OI

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