

Mosquito Biology and vulnerability to control



REDUCING DEATHS AND SUFFERING
FROM TROPICAL DISEASES





LAOL

Fire, pipes & chlorine – changed our urban world



- 1834 in Marseille
- 1866 in London
- 1982 in Hamburg



Great Plague of 1665-1666
68,596 recorded deaths (100,000?)

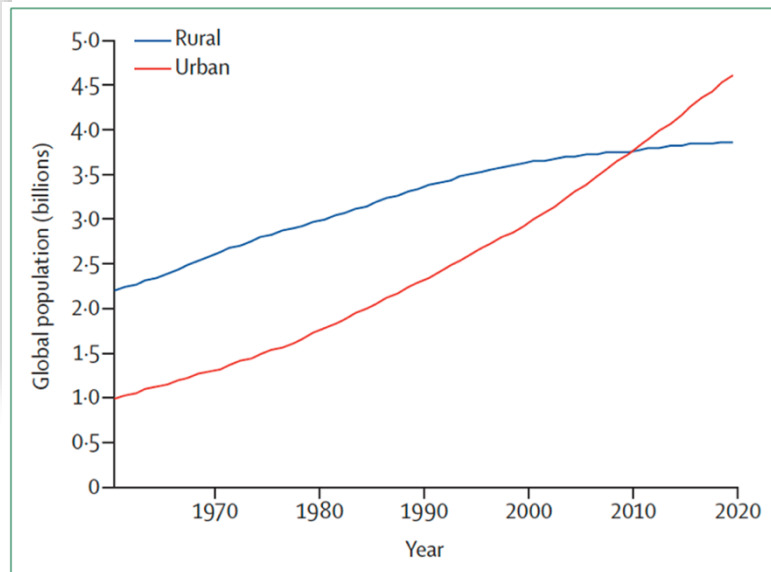
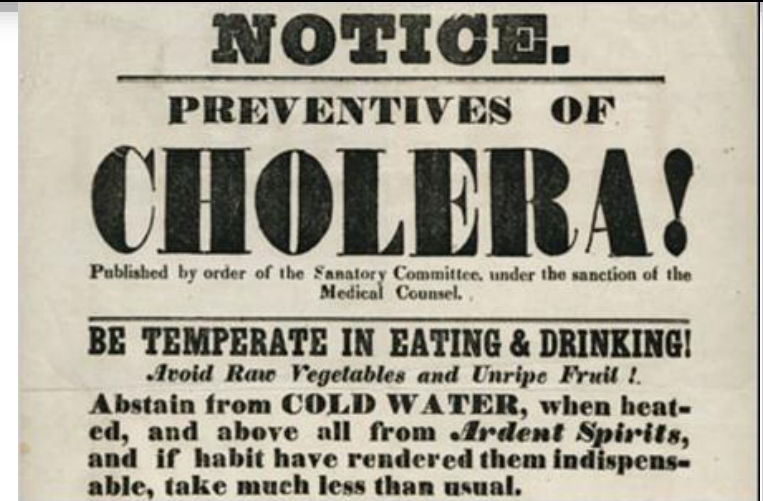


Figure 5. Proportion of the world's population in urban and rural areas, 1960-2020

This figure was created from World Bank data on basis of World Development Indicators

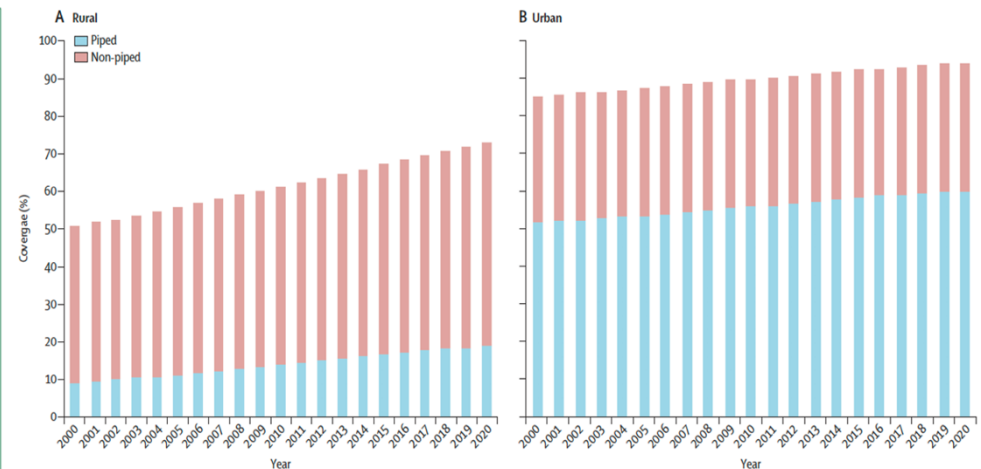


Figure 6. Coverage of house-hold drinking water by facility type across rural and urban areas for the least developed countries, 2000-2020. Facility types are piped and non-piped piped.

This figure was created from data from the WHO-UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene.

The 3 Key Types of Adult Mosquito

Anopheles

Bite at night

Bite during the day



Malaria

In some areas -
Lymphatic Filariasis

Culex



Mostly nuisance biting

In some areas -
Lymphatic Filariasis &
Arboviruses

Aedes

Bite at dusk



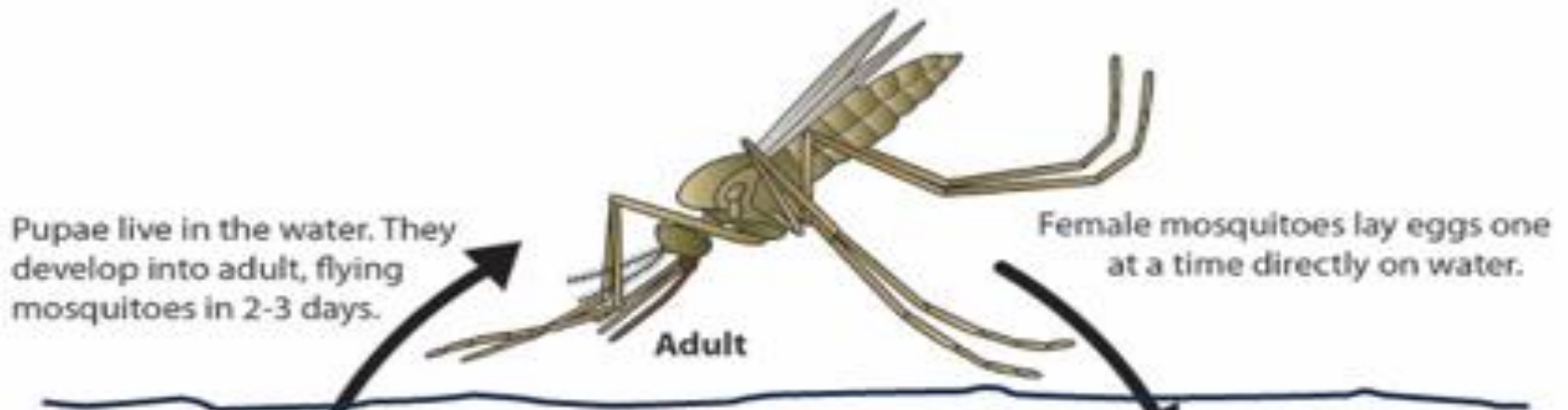
Dengue Fever, Zika,
Yellow Fever,
Chikungunya,
Arboviruses



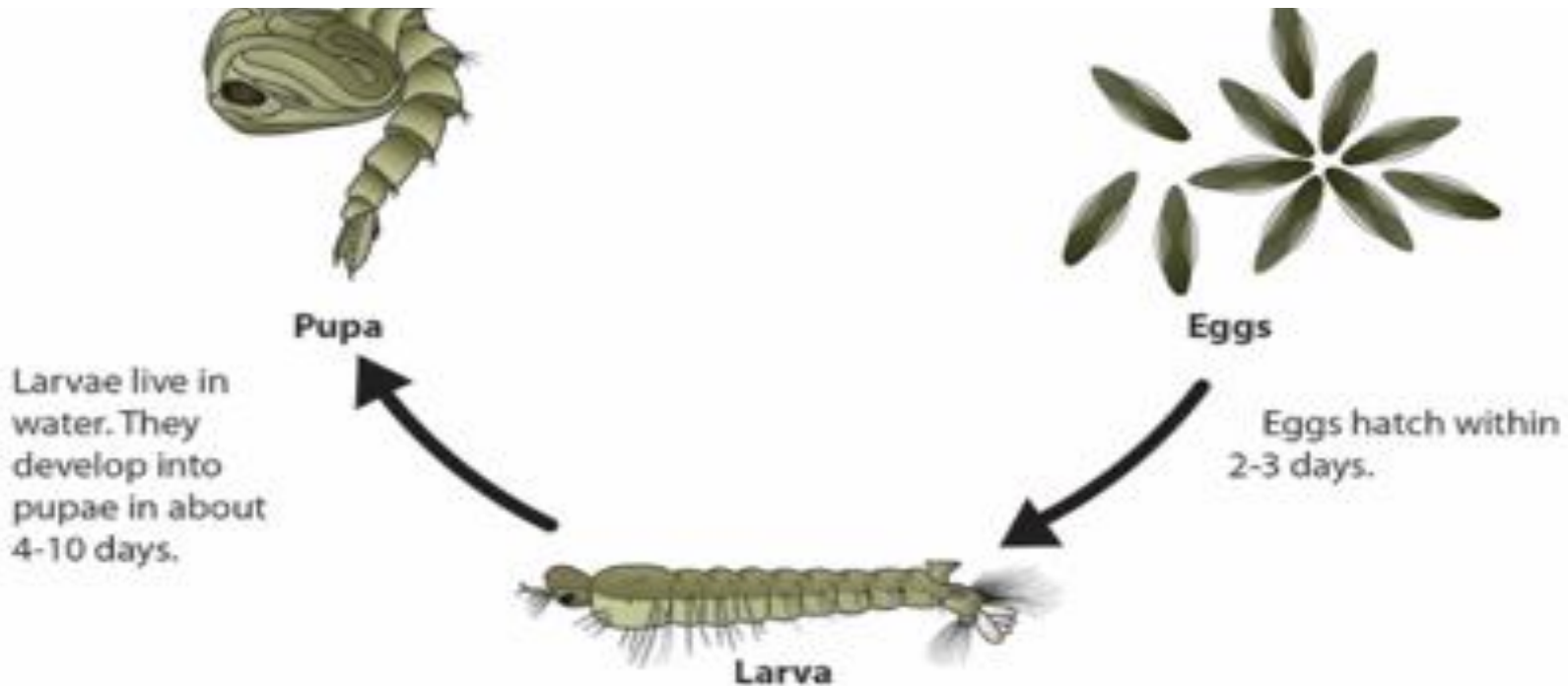
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112 mosquito genera >3500 different species worldwide, but relatively few species are vectors of human diseases



If water quality, temperature & nutrients are ideal, eggs develop well and produce large "ready to fly" adults.



Similarities: Mosquito species for VBDs

- Lay their eggs in water
- 3 of 4 mosquito life stages are aquatic – last 10-14 days (depending on temperature and nutrients)
- Emerge from water as flying adults, live for 2-4 wks
- May blood feed and transmit disease within 2-3 wks
- The viability of biological vector insect species, and the pathogens they transmit, are temperature and climate sensitive; most thrive optimally in tropical climates



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Key Differences: Mosquito spp. For VBDs

- What type / format of water they prefer to lay eggs on
- What time of day or night they prefer to take blood meals
- What sort of blood meals they prefer (bird, animal, human) or do they have no strong preference
- The feeding behaviour (are they persistent or skitty?)
- Their resting behaviour

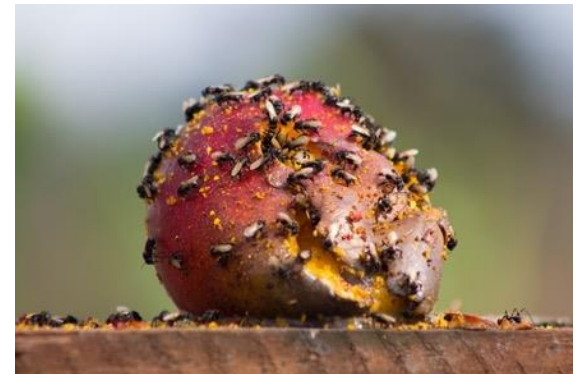
Changes in human behaviour, contexts and climate affect vectors and VBDs



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Where Killers breed and raise their young in Humanitarian Emergencies:



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Vulnerability to VBDs in Emergencies

People caught up in or displaced by conflict or natural crises have:

- Poor shelter = increased exposure to insect bites
- Poor water, poor container management, & flood / surface water = increased insect numbers and disease transmission
- Open defecation sites & poorly maintained latrines increase flies numbers and disease transmission
- Malnutrition compromises immune status



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Female Anopheles Biology



Wikimedia Commons / James Gathany (CDC)

Malaria

**Lymphatic
filariasis**



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Malaria - Vectors

- >400 species of *Anopheles*
- ~40 are malaria vectors of major importance
- The intensity of transmission depends on: factors related to the parasite, the vector, the human host, and the environment



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Anopheles Mosquito

Female *Anopheles* mosquito feeds on human or animal blood as they need this for egg development. Note “tail in the air” and long palps with white tips



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Anopheles: clean ground water breeders

- River/Stream Fringes
- Puddles, footprints
- Flood water
- Channels
- Sun exposed



Adult vectors are primarily nocturnal blood feeding spp. And very vulnerable to control when blood feeding, if houses have ITNs or IRS –(a few highly efficient species only)



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***Anopheles gambiae* breeding sites**

Look in:

**Unpolluted, sun exposed
temporary, small pools of water**

For example:

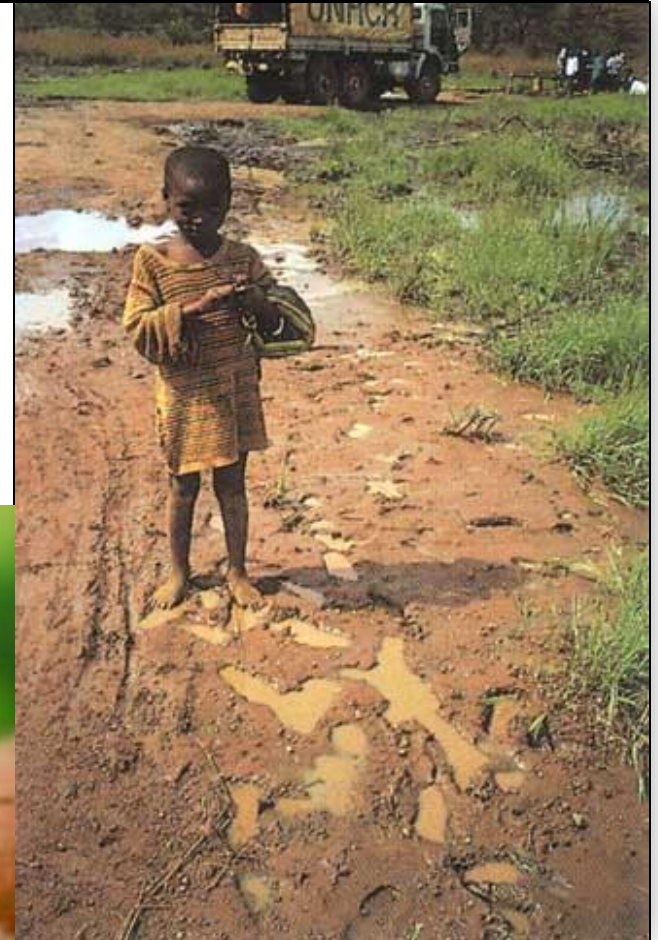
River / stream fringes

Puddles, footprints

Receding flood water

Channels

Road ruts

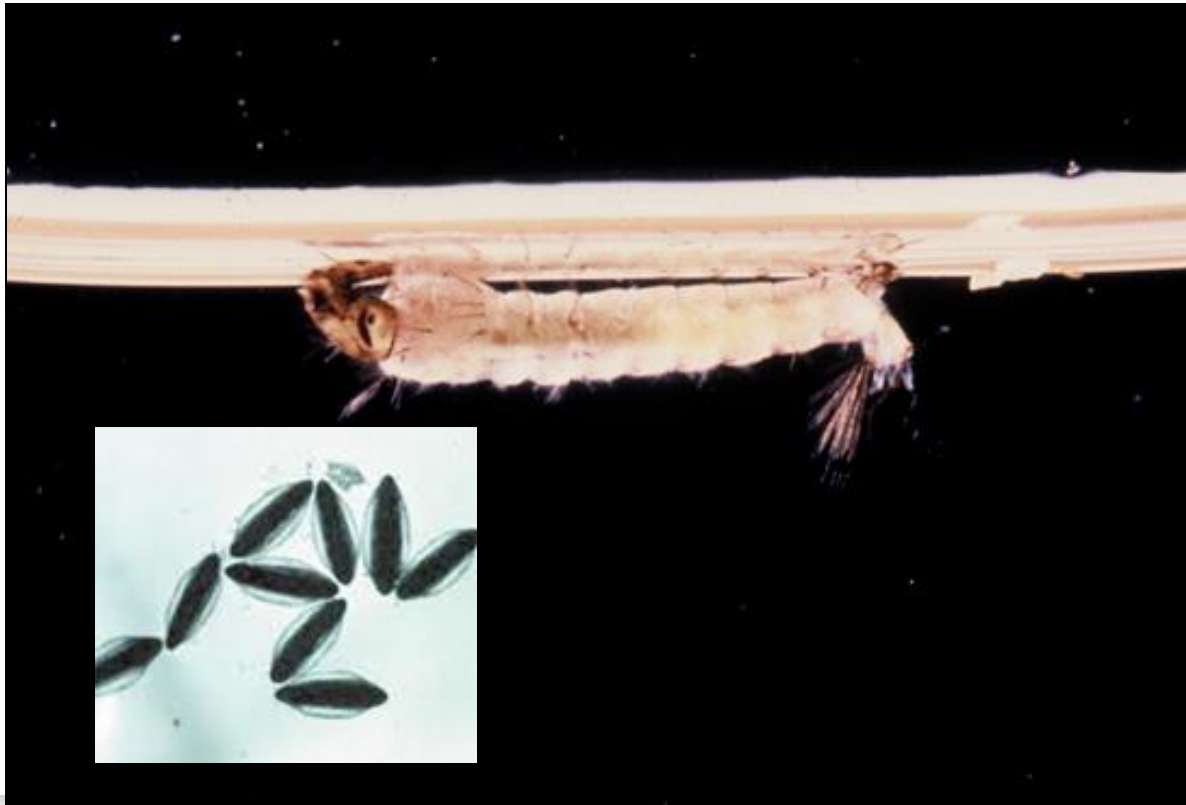


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Anopheles Mosquito Larva

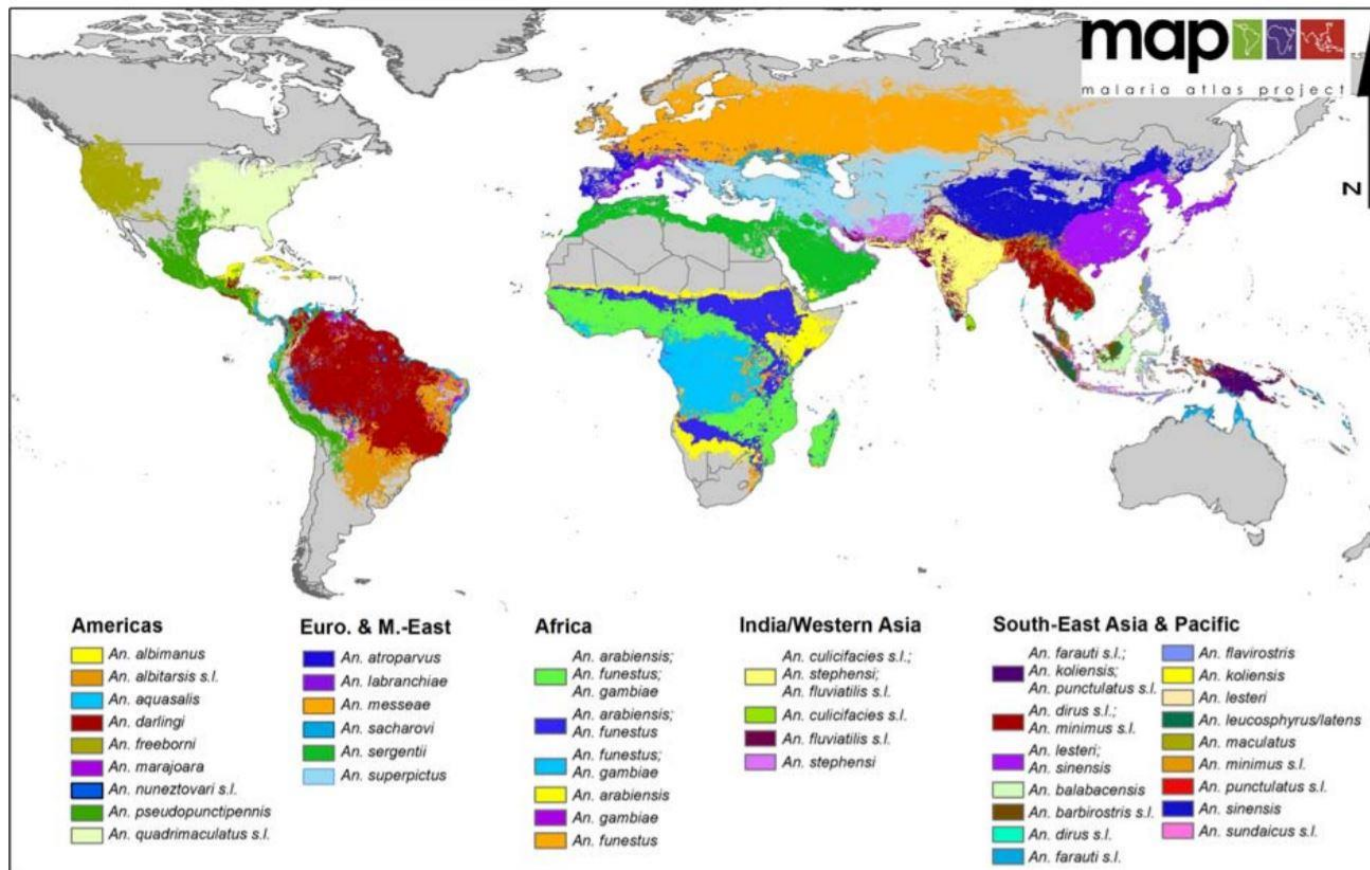
Note: Floating parallel to surface and breathing air, but not through a siphon, eggs with “floats”



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Anopheles Distribution



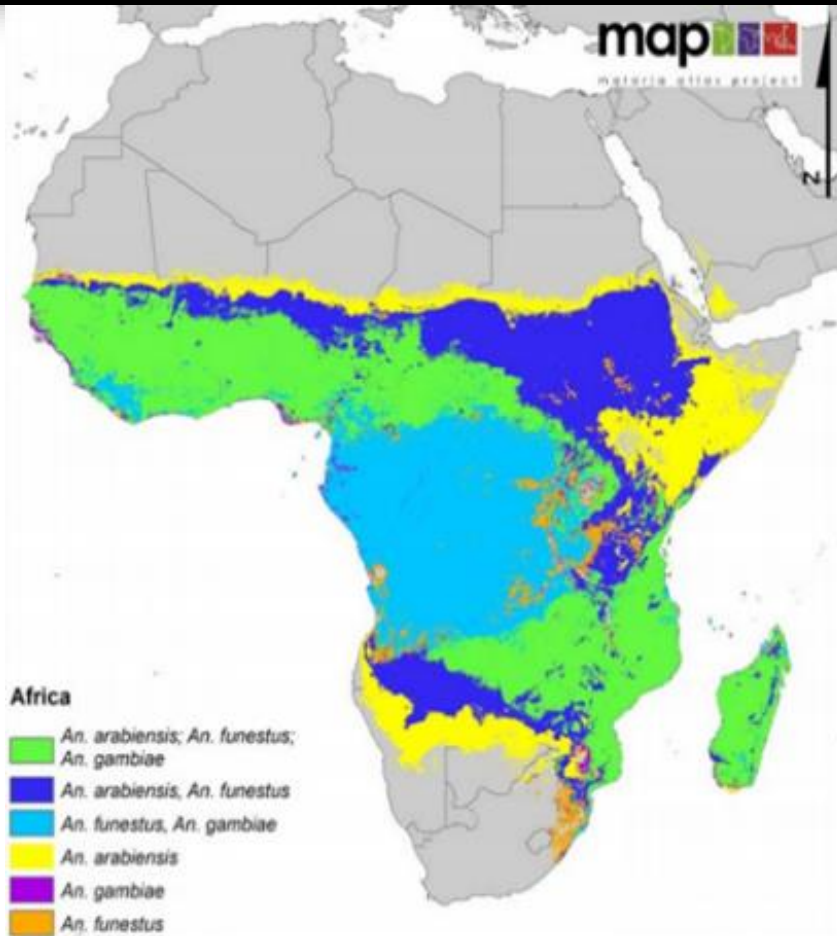
Sinka, M.E. et al. (2012). A global map of dominant malaria vectors. *Parasites & Vectors* 2012, 5:69



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Malaria Vector Distribution: Africa



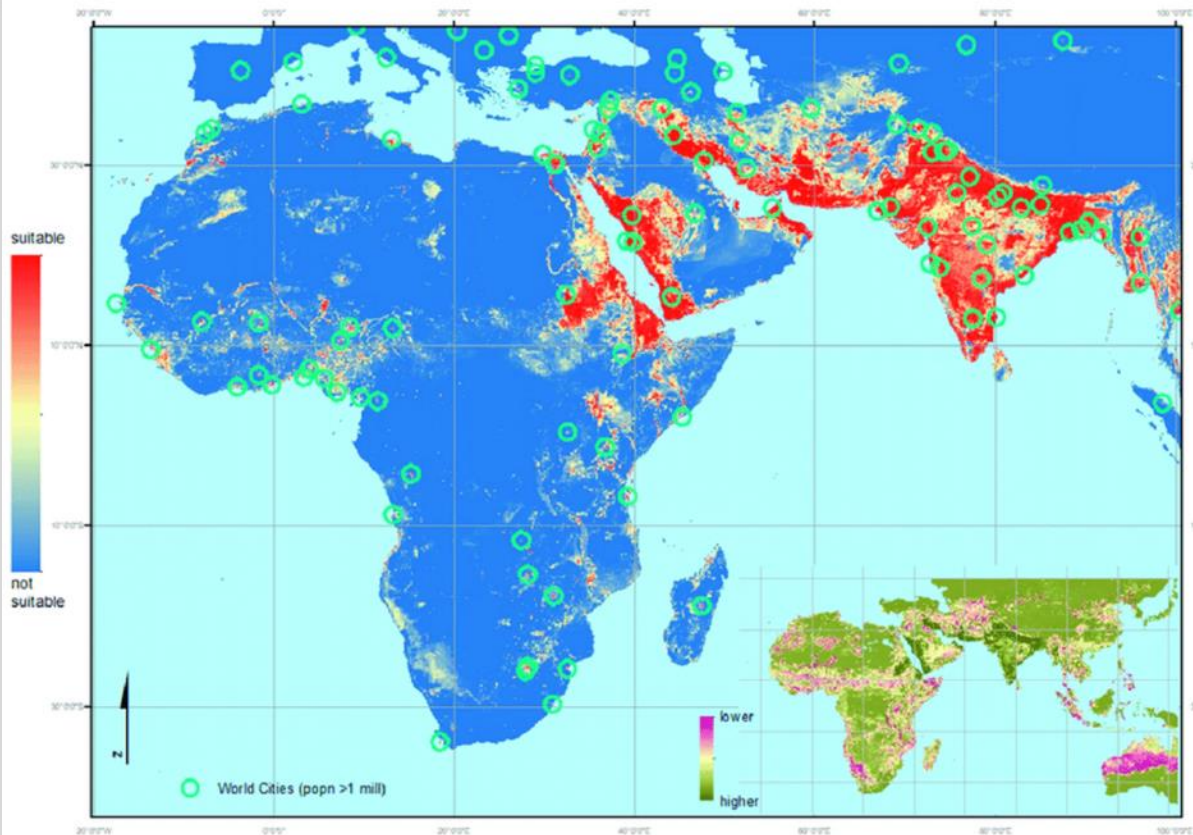
Sinka, M.E. et al. (2012). A global map of dominant malaria vectors. *Parasites & Vectors* 2012, 5:69



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Anopheles Stephensi – The unwelcome intruder



The most
invasive &
efficient malaria
vector yet.

Lays eggs in
open surface
pools, contained
water & waste
water

Sinka, M et al (2020). A new malaria vector in Africa: Predicting the expansion range of *Anopheles stephensi* and identifying the urban populations at risk. *Proceedings of the National Academy of Sciences of the United States of America*. 117. 10.1073/pnas.2003976117.

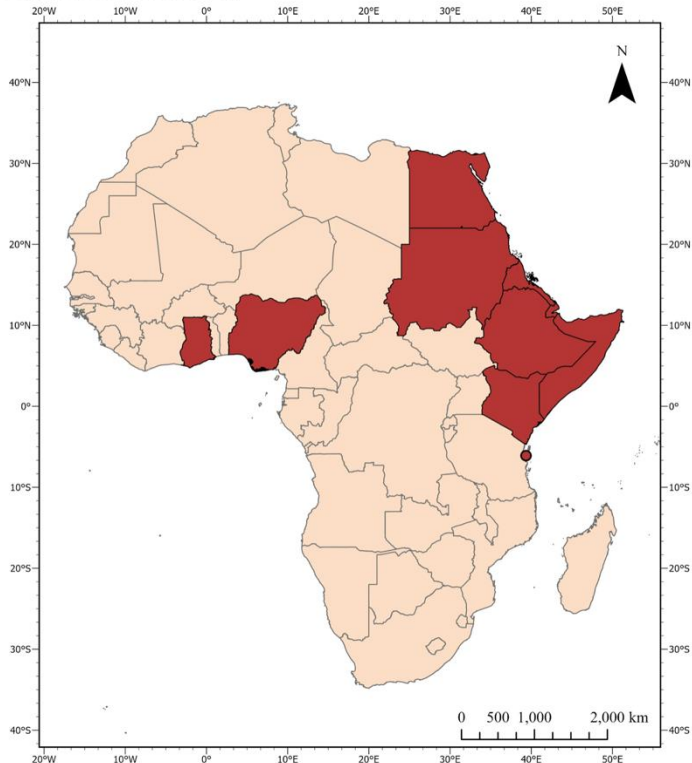


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An. Stepehensi – tragically similar to *Aedes albopictus*

From: Implications of Climate Change and *Anopheles stephensi* Liston in Africa: Knowledge Gaps and Lessons from History



A rural vector from SE Asia, turned into an urban invader in Africa, using a wide variety of clean and grey containerized water for egg development



Pecor, D.B., Potter, A.M. & Linton, Y.M. Implications of Climate Change and *Anopheles stephensi* Liston in Africa: Knowledge Gaps and Lessons from History. *Curr Trop Med Rep* 10, 320–330 (2023).
<https://doi.org/10.1007/s40475-023-00296-7>

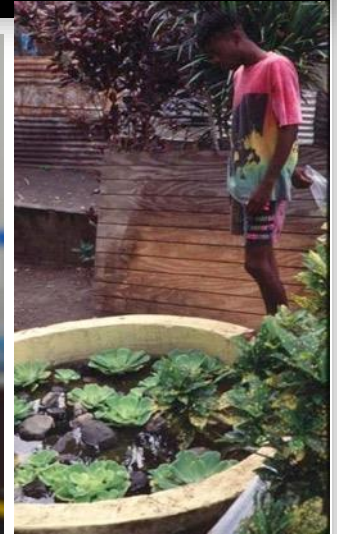
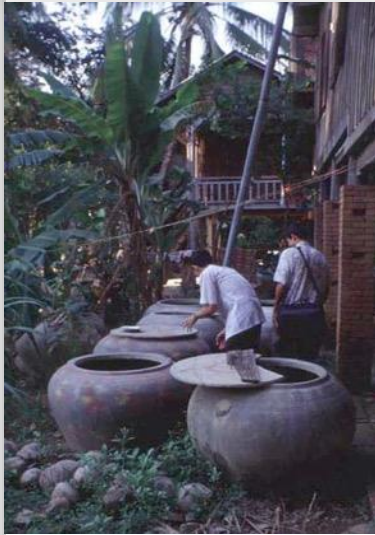


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Aedes spp & *An stephensi* will lay eggs in similar containers.

NB. *Aedes* eggs adhere to container walls



Aedes Mosquito Biology



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Aedes-Borne Diseases



Dengue

Zika

Chikungunya

Yellow Fever

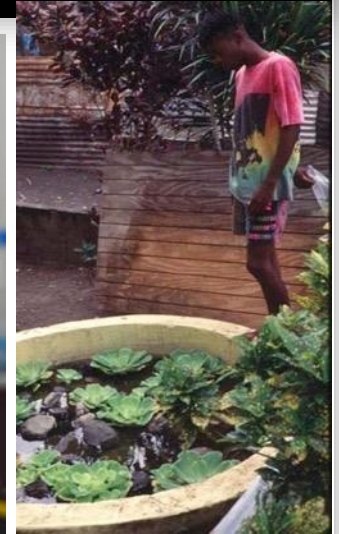
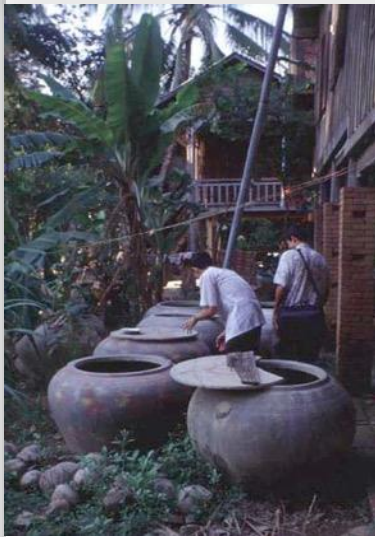


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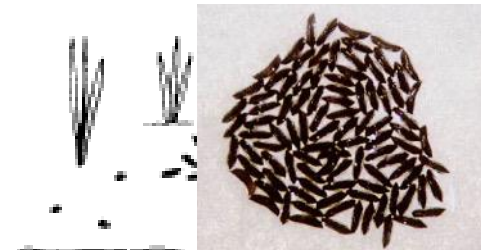
Aedes Mosquito Life Cycle

Adult stage:
survive ~2-4
weeks



Adult Aedes
(adults survive an
average of 30 days)

**Egg stage: 1-2 days (in
fresh and clean water)**



eggs in damp soil
subject to periodic flooding
(overwinter as eggs)

**Pupal stage: ~2
days**



(10 to 14 days)



larvae or wigglers

**Larval stage: 3
instars**

pupae or tumblers



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Mosquito Egg Morphology

***Aedes* ~150 eggs per batch, laid separately unlike most species.**

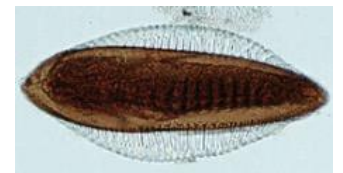
- Smooth, long, ovoid shaped, ~1 mm long.
- Eggs can survive for very long periods in a dry state, often for more than a year



Culex lay eggs one at a time on water surface, sticking them together to form a raft of ~200 eggs 0.7 mm long eggs.



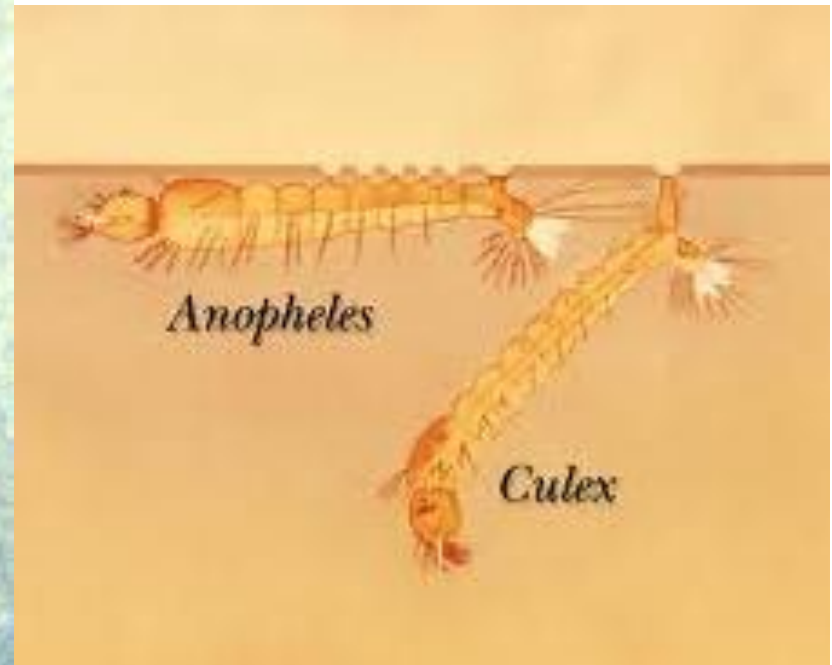
Anopheles adult females lay 50–200 eggs/oviposition. Eggs are laid singly and directly on water. They have floats on either side and are ~0.5 × 0.2 mm



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Mosquito Larvae



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Mosquito Adult Morphology

Aedes



Bite during the day

Culex



Bite at dusk, after dark
and dawn

Anopheles



Bite at night, mainly
indoorsbut not all
species, or all always!



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Resting and Feeding Behaviour of Aedes

- Both sexes feed on plant juices and sugary solutions
- Only female needs blood for eggs maturation
- Feeds on human, cattle and other domestic animals

Resting behaviour of *Aedes* differs greatly from *Anopheles* causing malaria

- Feeds indoor and outdoor (endophagic and exophagic)
- But **rests predominantly outdoors** (exophilic)
- **Preferable biting times are; before and at sunset and early morning times**
- Predominately/exclusively rests outdoor in dark and humid places



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Vectors: *Aedes aegypti*

- Lives around human habitation
- Flies < 200 meters generally
- Lays eggs and produces larvae preferentially in artificial containers
- Take blood meals from multiple hosts leading to higher transmission rates



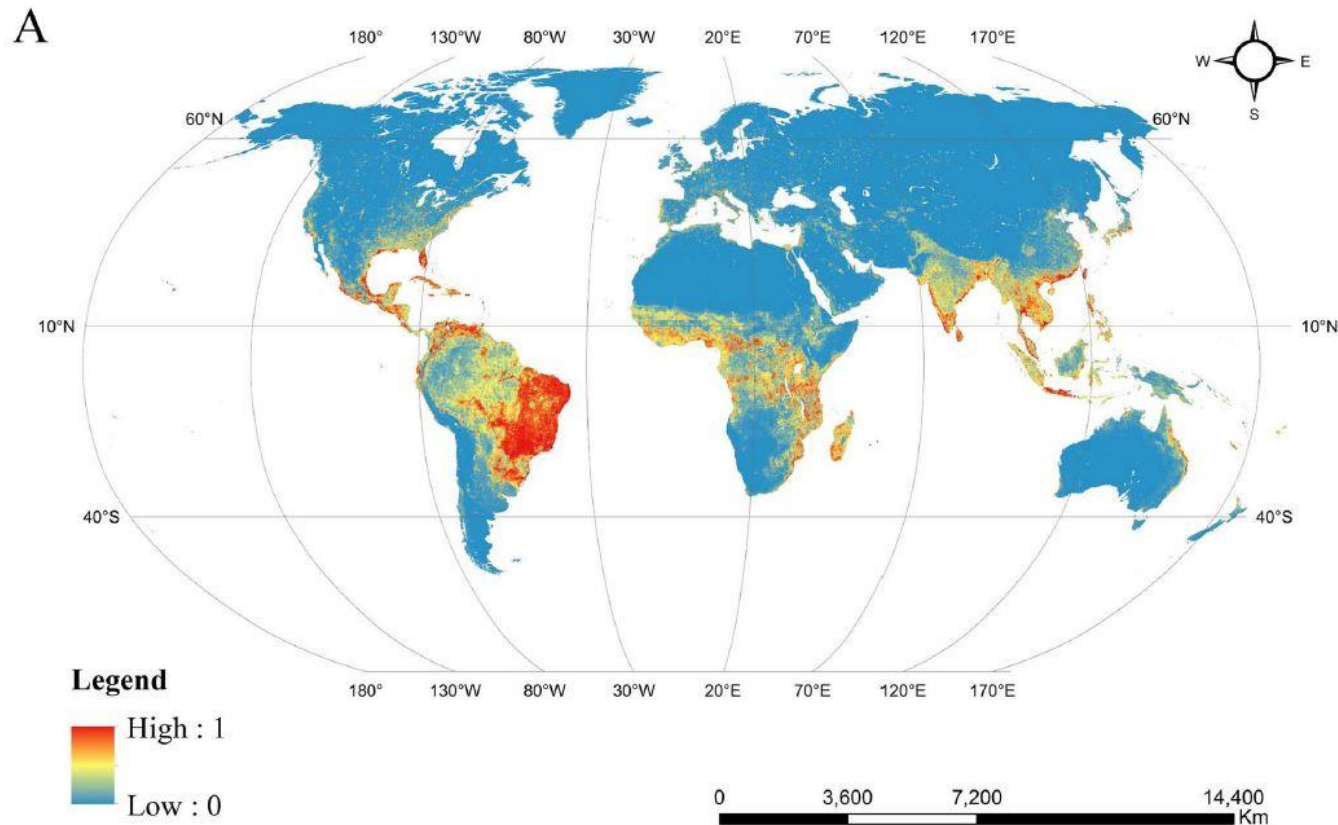
http://www.imsc.res.in/~indu/JM/2009/JanFeb/SNews/Aedes_aegypti_CDC-Gathany.jpg



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Global Map of the Distribution of *Aedes aegypti*



Ding, F. et al. (2018). Mapping the spatial distribution of *Aedes aegypti* and *Aedes albopictus*. *Acta Tropica*: 178,155–162.



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Vectors: *Aedes albopictus*

- Native to tropical/subtropical southeast Asia
- Has now invaded Africa and Europe
- Breeds in rural, camp and urban areas
- “Albopictus,” meaning “white-painted”



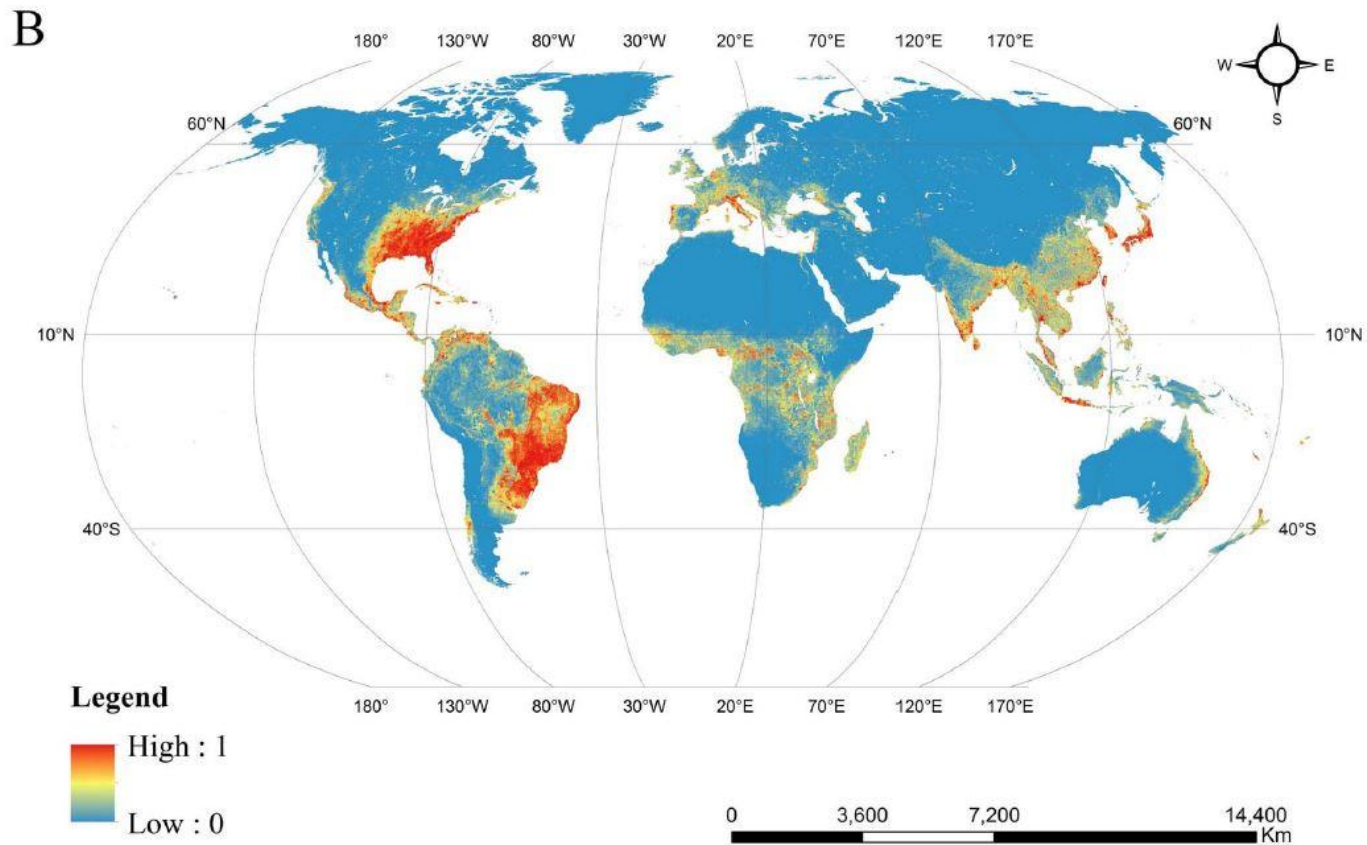
<https://ecdc.europa.eu/en/disease-vectors/facts/mosquito-factsheets/aedes-albopictus>
Skuse, F. A. A. (1894). "The banded mosquito of Bengal". *Indian Museum Notes*. 3 (5): 20.



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Aedes – Urban Settings: Maputo



Urban settings such will see the main burden of disease



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Urban Settings - Reasons

1. Communities with lots of waste containers
2. Communities that store domestic water supplies in drums / containers outside or inside homes
3. Poor urban areas, town and village communities, rather than affluent with high quality housing
4. All people, and all ages living in *Aedes* areas, are at risk, because of *Aedes* day-biting behaviour



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Flavivirus Transmission

Aedes mosquitoes usually bite during the day, peaking during early morning and late afternoon/evening



Wikimedia Commons / James Gathany/CDC



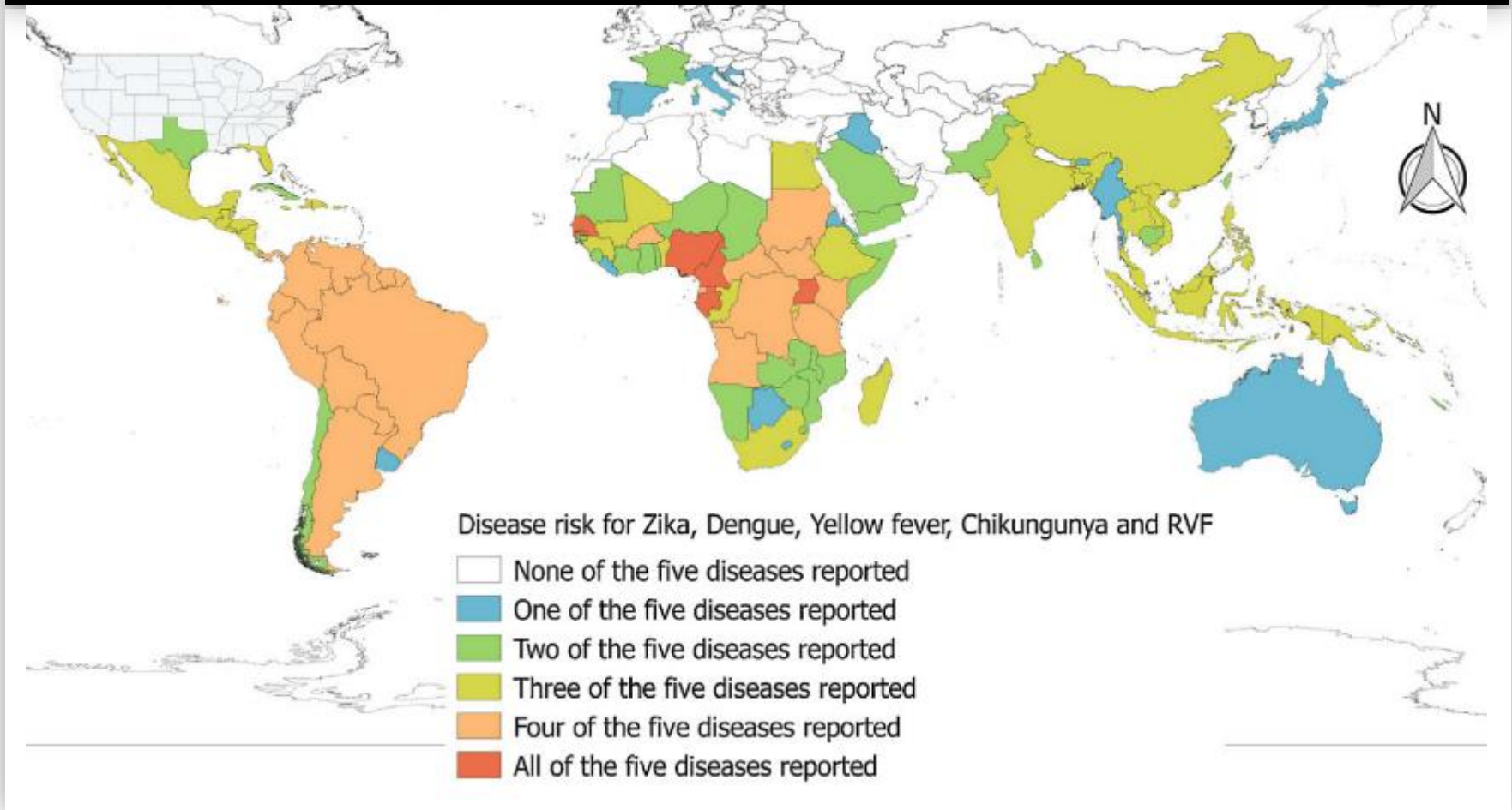
CDC Public Health Image Library



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Aedes-Borne Disease Map - 2018



Leta, S. et al. (2018). Global risk mapping for major diseases transmitted by *Aedes aegypti* and *Aedes albopictus*. *International Journal of Infectious Diseases*, 67: 25–35



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Aedes, Culex & Invasive Anopheles Cross Over Egg Laying Sites in Camp & also Urban Spaces



Abdel-Meguid, A.D. Effect of physicochemical factors of breeding sites on larval density and detoxification enzymes activities of *Culex pipiens* (L.) (Diptera: Culicidae) in qalyubia governorate, Egypt. Int J Trop Insect Sci 42, 235–244 (2022).



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Clean safe water – or mosquito breeding site?



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WASH management = invasive vector control



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Solutions to water supply or aedes breeding sites?



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Impact of vector control campaigns

Why is it important to control diseases transmitted by mosquitoes?

- Vector-borne diseases can't be control by treatment alone
- Few VBD vaccines available
- Some VBDs especially those transmitted by aedes have no curative treatment or vaccination available



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Overlapping factors needed for VBDs

1. Suitable arthropods
2. Suitable sites for egg laying/development
3. Basic climatic conditions for arthropod and pathogen
4. Unprotected humans
5. Pathogens

Most of the world have all of these factors, some have 1 to 4.

- Some mosquitoes prefer open rainwater pools, others containerized or wastewater



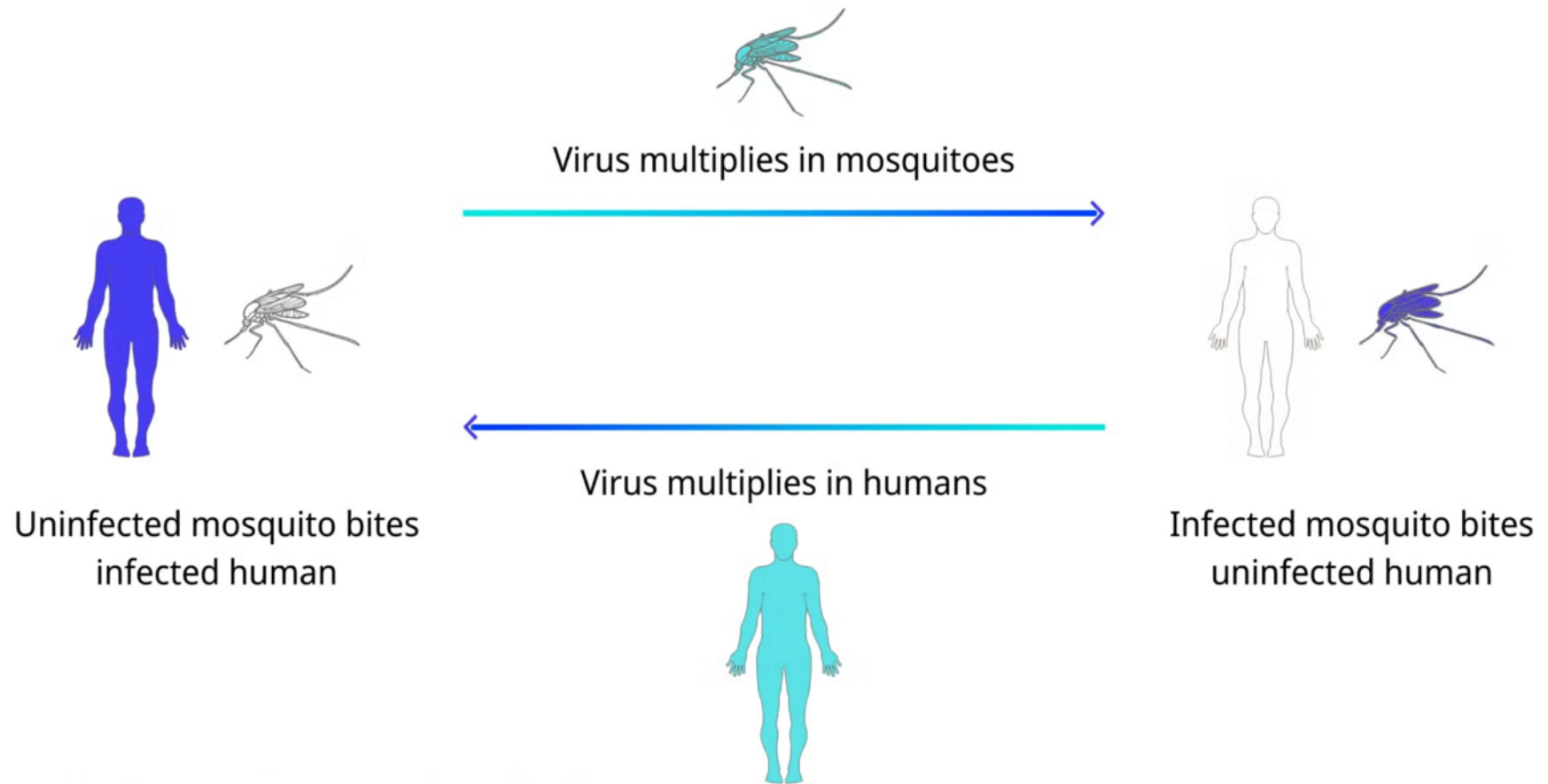
- Sandflies generally prefer domestic waste and cracks in walls, floors or tree bark



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Insects and humans can play the role of disease vector



Visualization: Rebecca Glassman & Jacqueline Houtman, Pandemic Tracking Collective

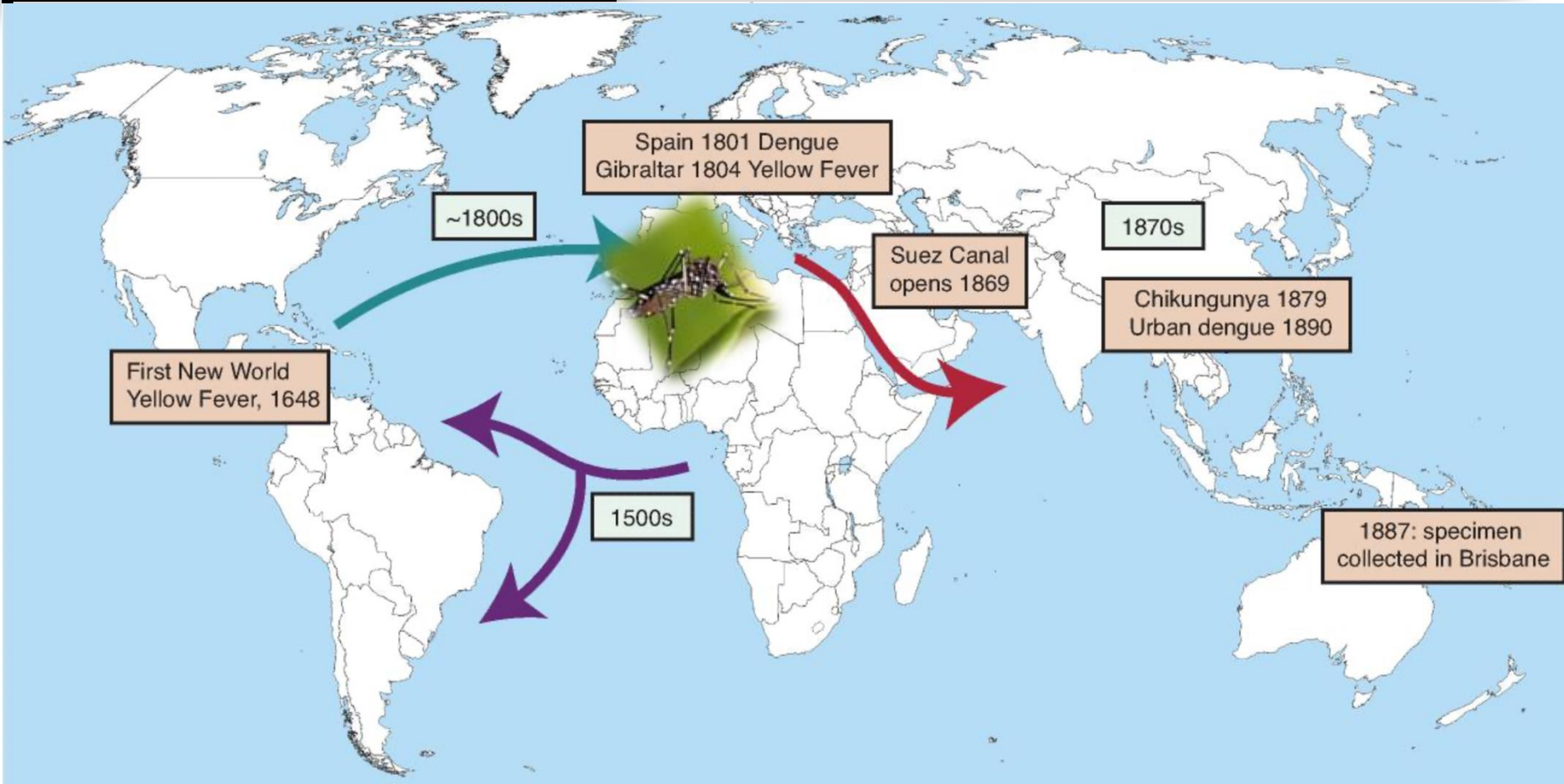


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A world on the move

Moving people, insects and pathogens



UN DESA January 2025

Eurosat



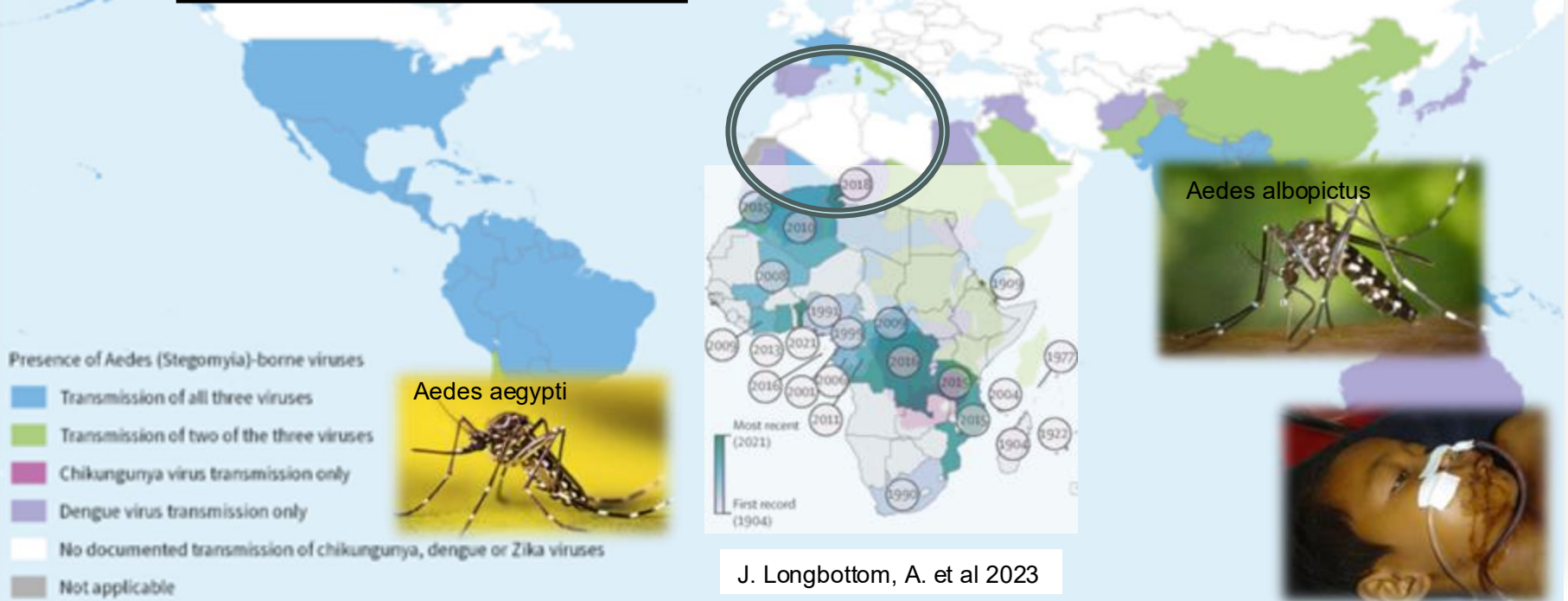
Summary of the history of *Ae. aegypti* over the last 600 years.

Powell, J.R. et al 2018



Countries, territories or areas with previous or current local mosquito-borne transmission of more than one *Aedes*-borne virus (dengue, chikungunya and Zika) as of 30 April 2024 (WHO)

Fast growing disease: 1960s a few dengue cases reported in around 9 Asian countries. Now 390 million infections annually worldwide, 96 million are symptomatic cases. Over 4 billion people in 136 countries are at risk of infection (WHO)



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Both types of *Aedes* mosquitoes vector viral disease pathogens to humans – both are tigers

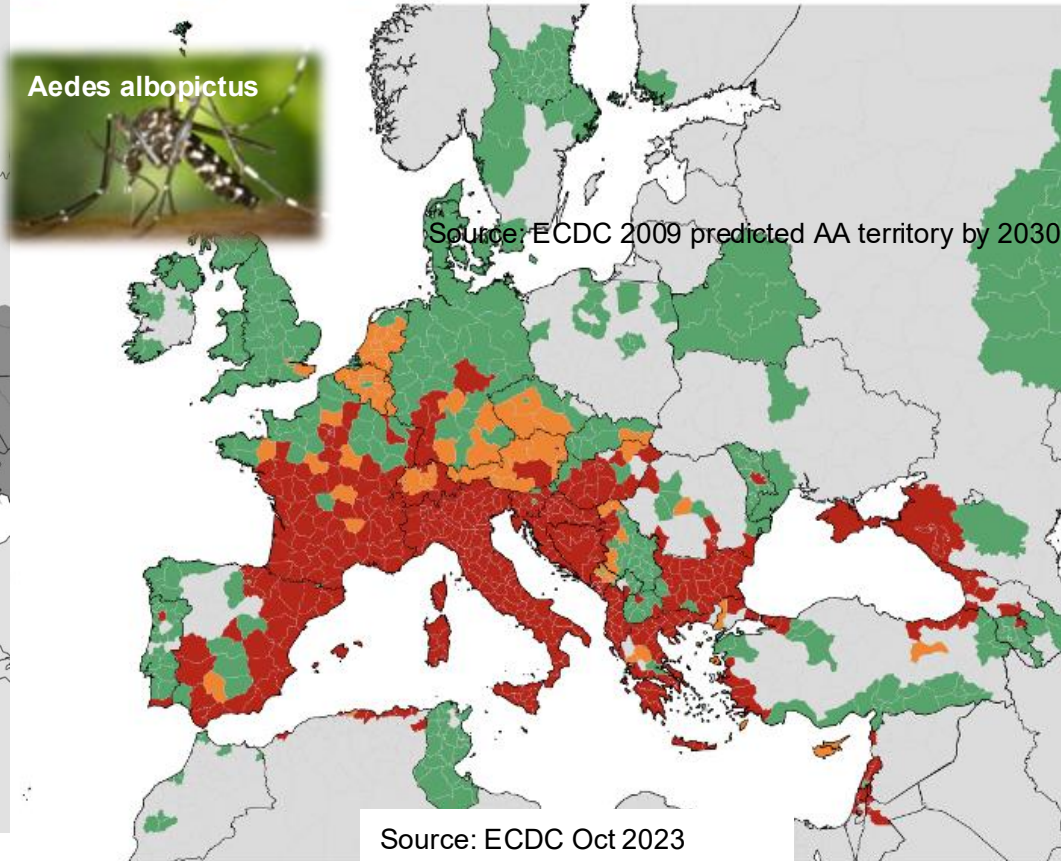
Aedes aegypti, May 2024



Scholte, Ernst-Jan & Schaffner, Francis. (2017)

Habitats of the invasive Asian tiger mosquito have expanded throughout Europe

■ Established ■ Introduced ■ Not present ■ No data



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Culex mosquitoes and West Nile Virus



West Nile virus detected in UK mosquitoes for first time

21 May 2025

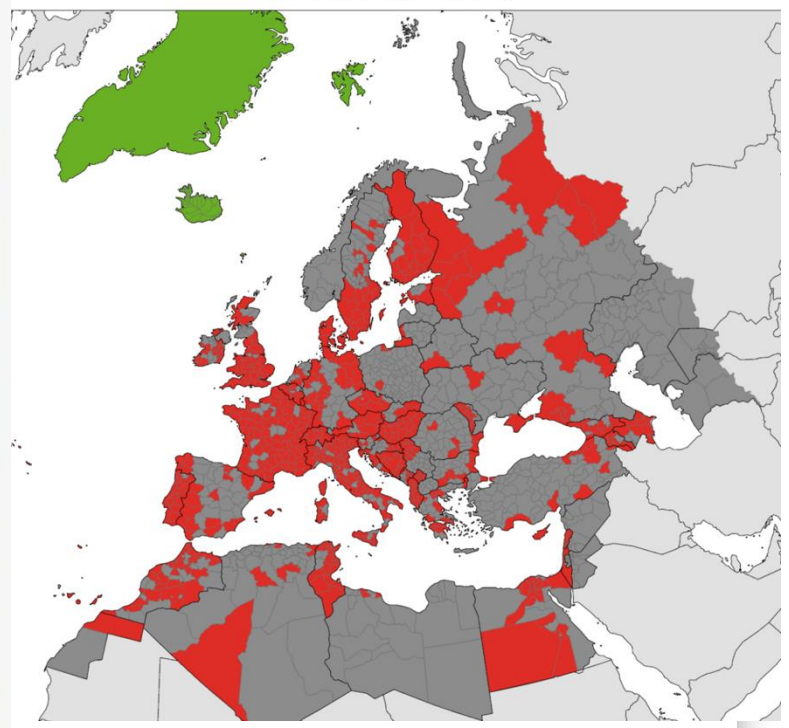


GETTY IMAGES

The fragments were found in two samples of *Aedes vexans* mosquitoes, the health security agency said

Sofia Ferreira Santos **Philippa Roxby**
BBC News Health reporter

Culex pipiens group, August 2023



Zia Farooq, Henrik Sjödin, Jan C. Semenza, et al. European projections of West Nile virus transmission under climate change scenarios, *One Health*, Vol. 16 doi.10.1016/j.onehlt.2023.100509



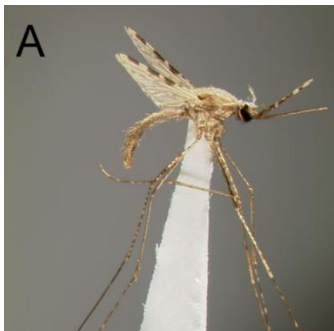
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Scale of Urban Malaria + Dengue Risk in Africa (2024)

Scale of Urban Malaria + Dengue Risk in Europe?

Urban development policy, climate mitigation, water conservation, wilding, & health are siloed, currently increasing VBDs



Share of urban and rural populations, 1950-2050 (% of total population) UNDP 2014



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Life Cycle of *Anopheles*

