Mosquito surveillance in dengue control

Asia PGI Training Workshop

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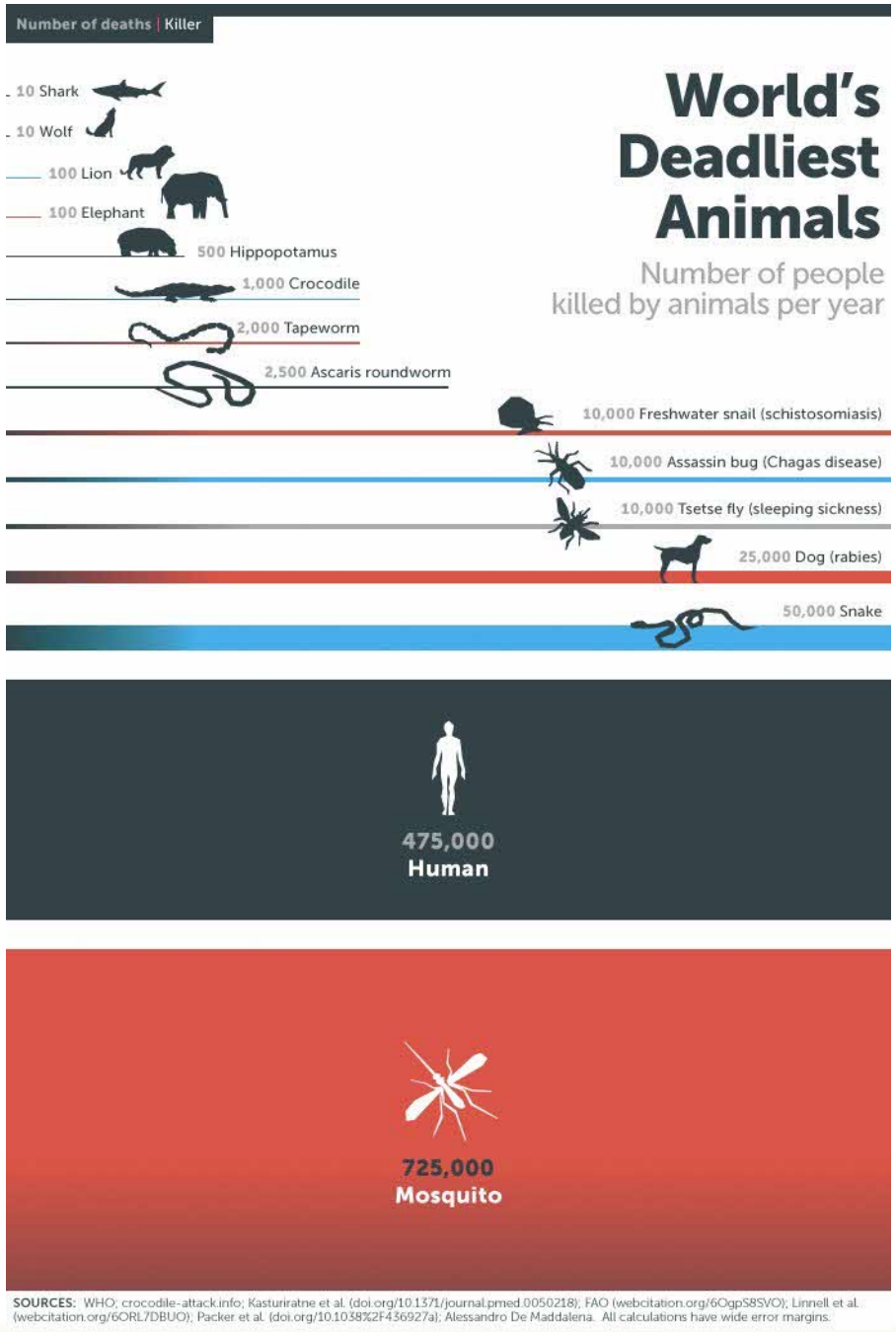
National Environment Agency
Safeguard · Nurture · Cherish



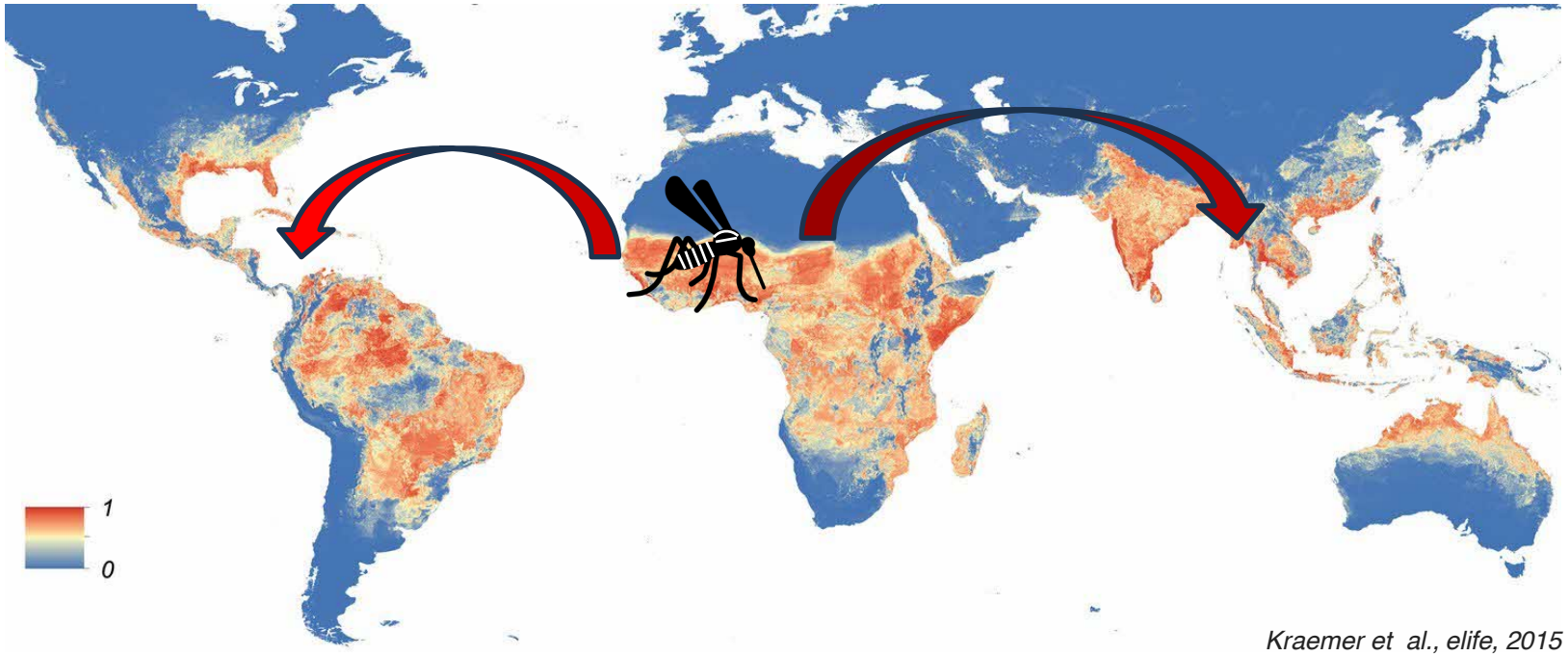
- Around for more than 50 million years

Transmit a range of pathogens:
Malaria (Anopheles)
Filariasis (Culex)
West Nile virus (Culex)
Japanese encephalitis virus (Culex)
Dengue virus
Chikungunya virus
Zika virus
Yellow Fever virus

(Aedes)

Aedes aegypti - family Culicidae, order Diptera

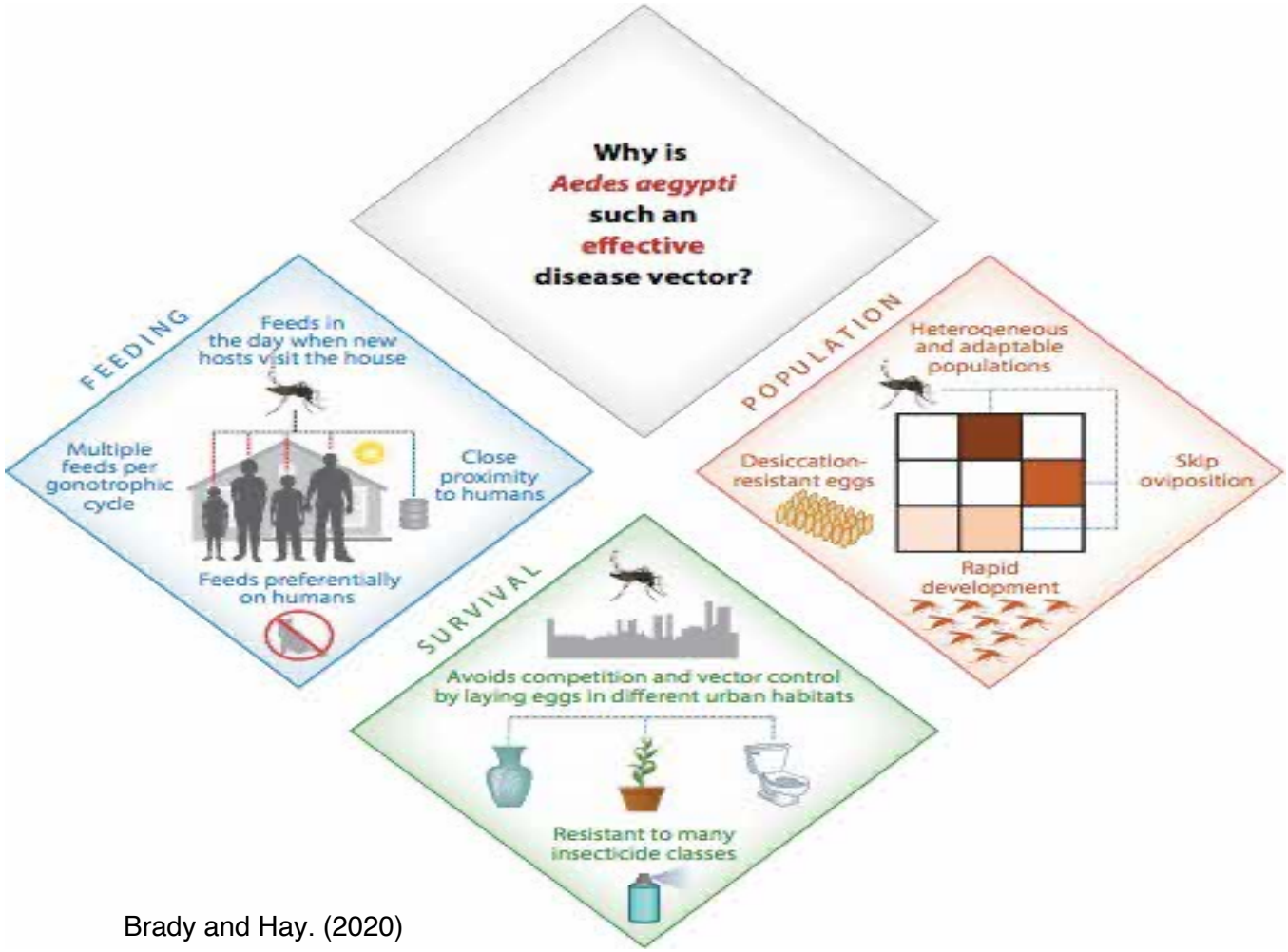
Ae. aegypti was transported from Africa during the slave trade in the 15th through the 19th centuries to the New World and spread into Asia through commercial exchanges in the 19th century.



***Aedes aegypti* distribution**

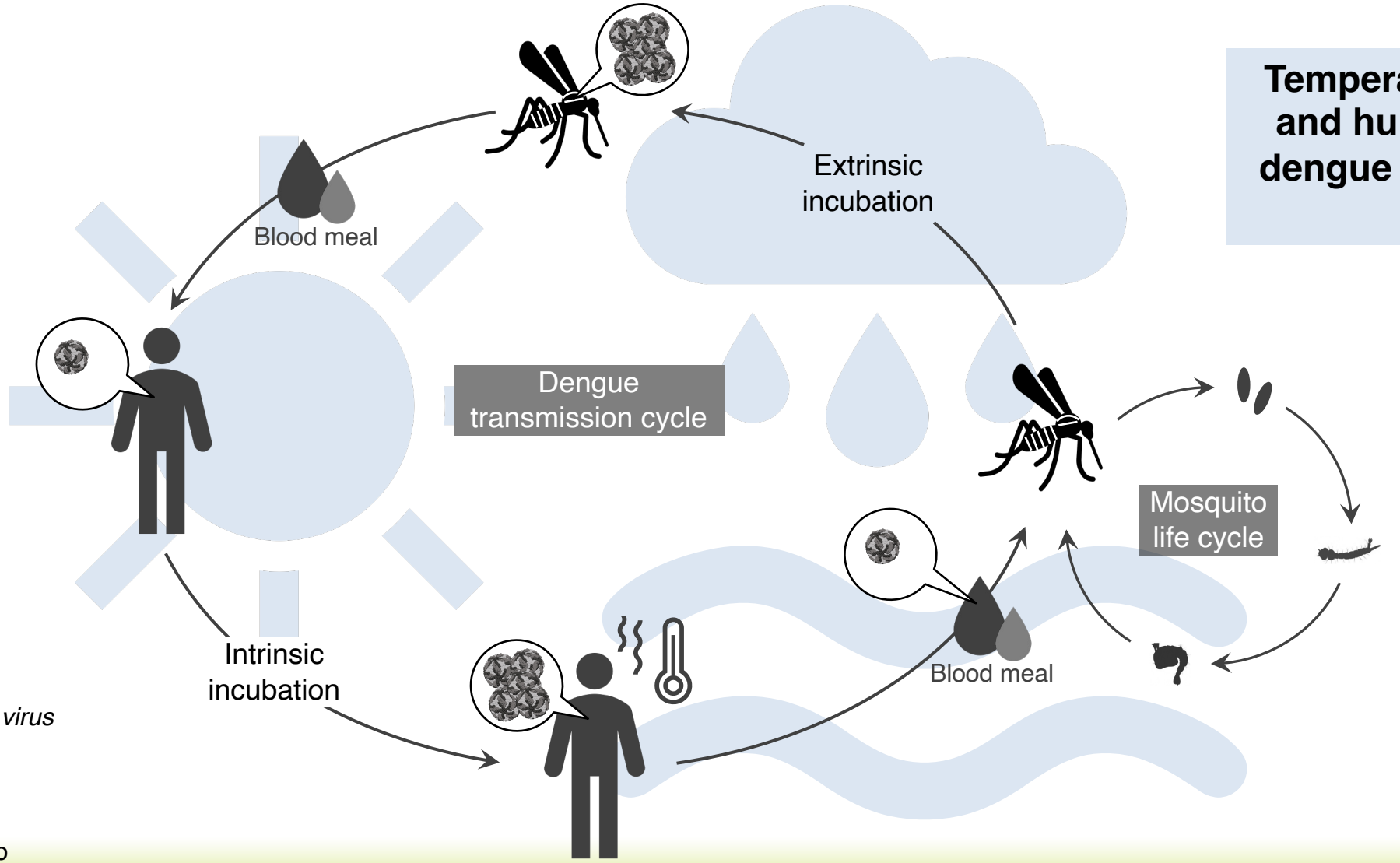
Kraemer et al., elife, 2015

Aedes aegypti - Vector of YFV, DENV, Zika virus, Chikungunya virus



Brady and Hay. (2020)

The climate can affect many points in the dengue transmission cycle



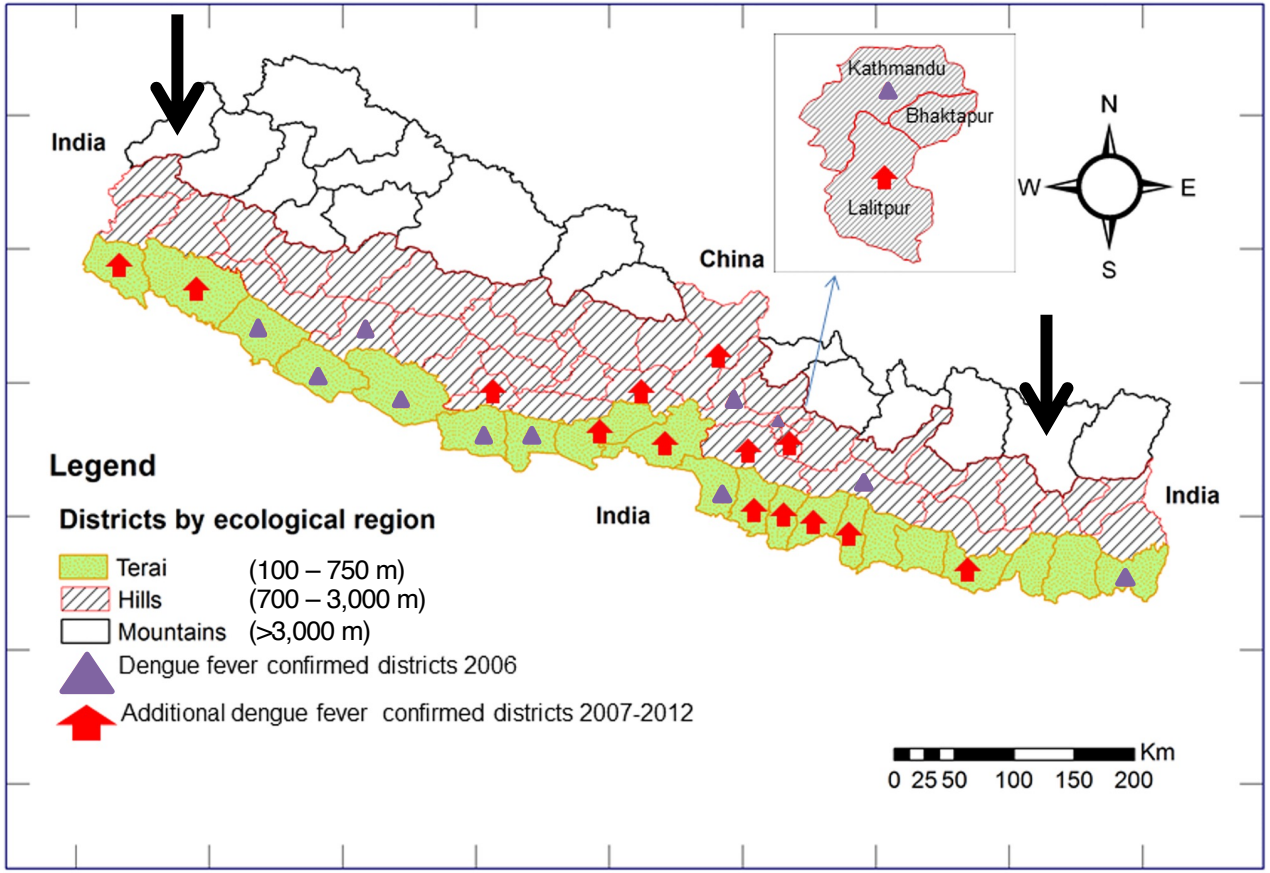
Temperature, rainfall and humidity affect dengue transmission cycle

Dengue virus (DENV)

Aedes mosquito

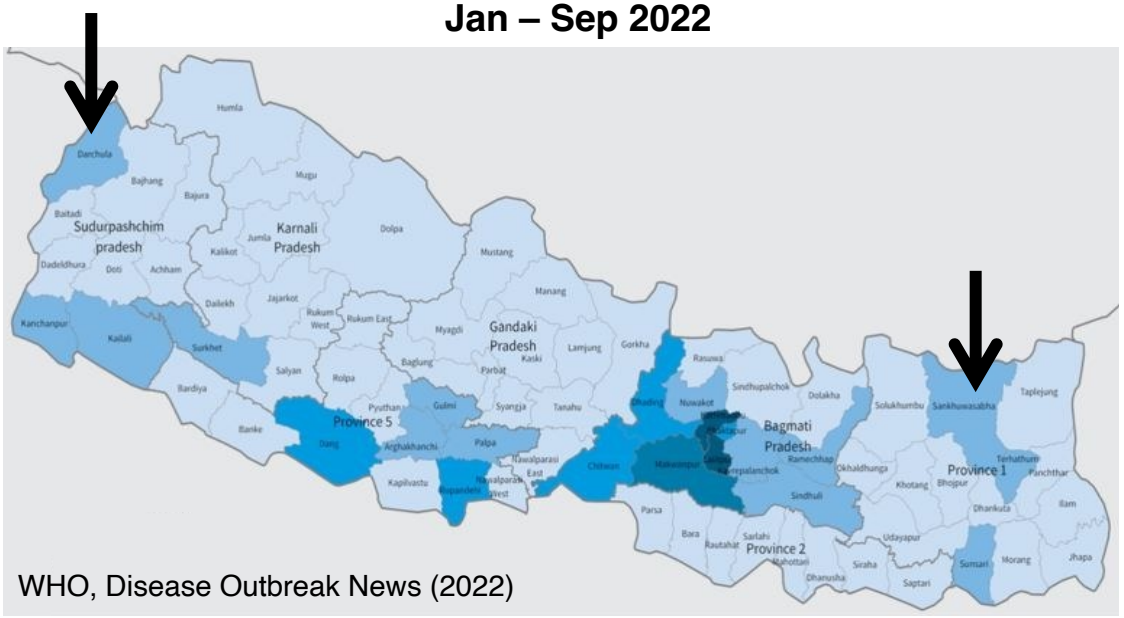
Ae. aegypti is climbing new heights… and so is dengue

Nepal witnesses worst outbreak yet, with more cases in higher elevations



Dhimal et al. (2015)

Jan – Sep 2022

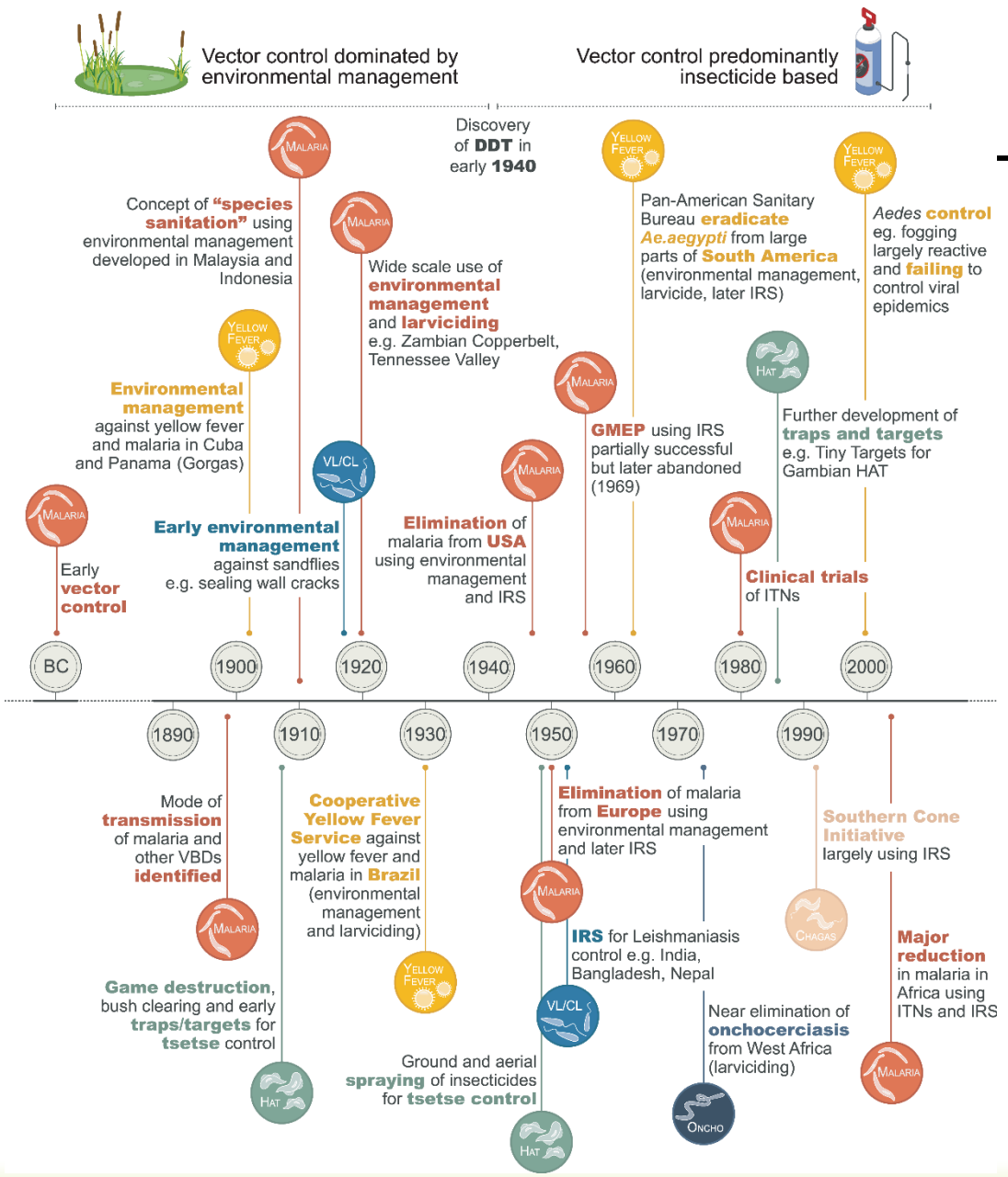


WHO, Disease Outbreak News (2022)

Cases

- 1 – 100
- 101 – 300
- 301 – 1,500
- 1,501 – 3,000
- > 3,000

- **Spread to all districts**
- **Spread to areas >3,000 m elevation**



Vector control through the ages…

Many successful eradication campaigns e.g. in Central and South America in the 1950s to 1960s and Cuba in 1981 were unsustainable due to the lack of long-term political and financial support for national mosquito control program after the period of mosquito eradication.

Aedes control e.g. fogging by insecticides is largely reactive and fails to control viral epidemics.

Surveillance data is important in any mosquito control program!!!

Why is vector surveillance important?

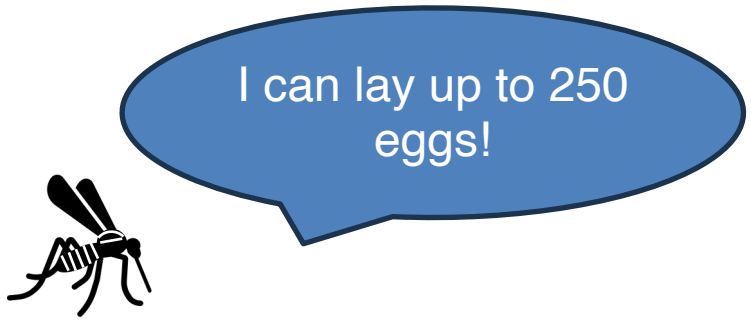
- Tracking mosquito populations in areas of potential risk.
- Surveillance on *Ae. aegypti* density is important in determining factors related to dengue transmission, in order to prioritize areas and seasons for vector control.
- Selection of appropriate surveillance strategies are based upon outcome/objective, also taking into consideration time, resources, and infestation levels.
- Additionally, vector surveillance is required to sustain the control measures and detect any increase in vector density

Dengue control in Singapore

- A vector control program that centered on **source reduction** and **education** was initiated following the emergence of DHF in the early 1960s.

- Reduction of Ae. aegypti population from 48% in 1966 to <5% in 1970s, as measured by the Aedes House index, which is the percentage of inspected premises found to have containers with A. aegypti larvae or pupa, followed by a 15-year period of low dengue incidence.

- Although Aedes HI was further suppressed to ~1%, the incidence of dengue surged during the 1990s and continued till present day.



Ho et al, 2023

A perfect storm for dengue

Connectivity and major travel hub

Warm and humid climate

Construction Sites

Aging Buildings

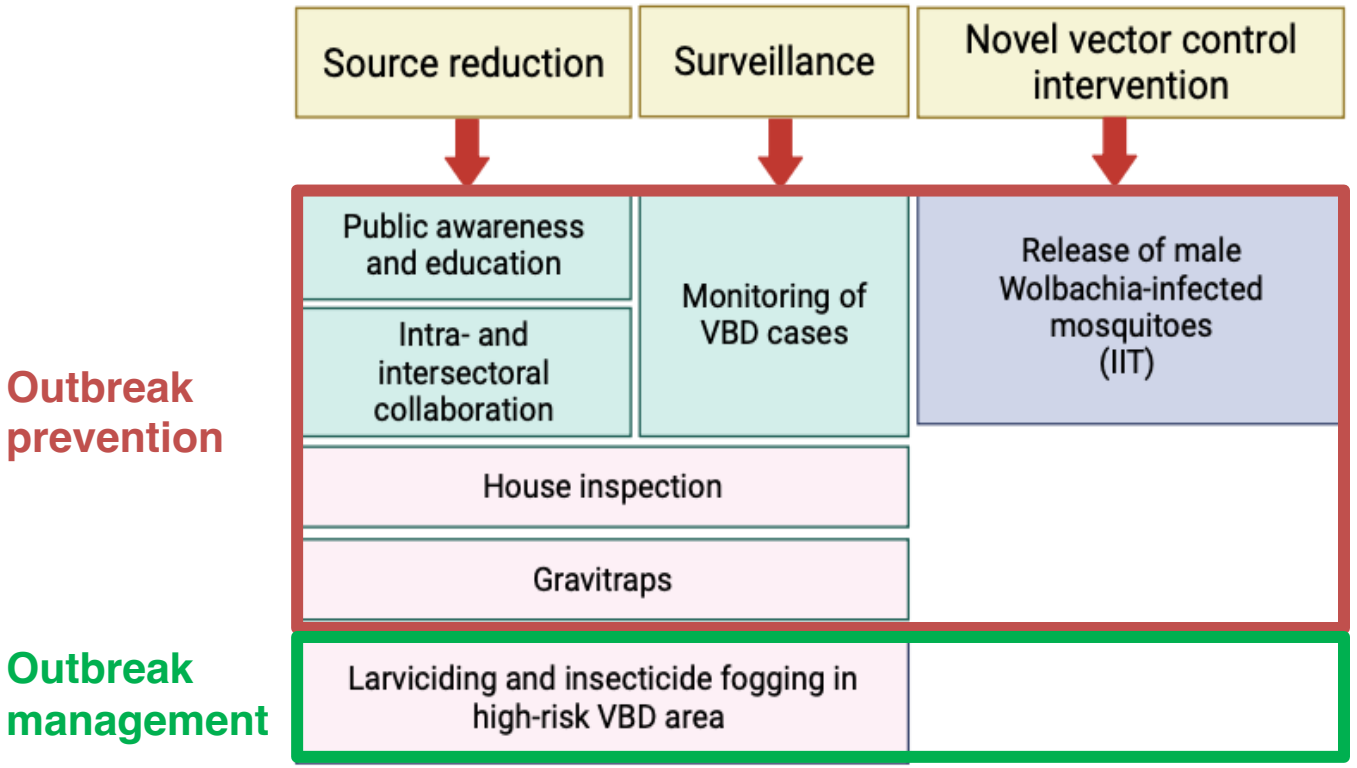
Increasing urbanization and population density

Aedes albopictus, less efficient vector

Aedes aegypti, efficient vector, urban dweller

Strategies for mosquito control in Singapore

Outbreak of dengue, Zika or other mosquito-borne disease, is related to the simultaneous occurrence of the mosquito vector, circulating virus, and susceptibility of the human population.



Ae. aegypti surveillance in Singapore

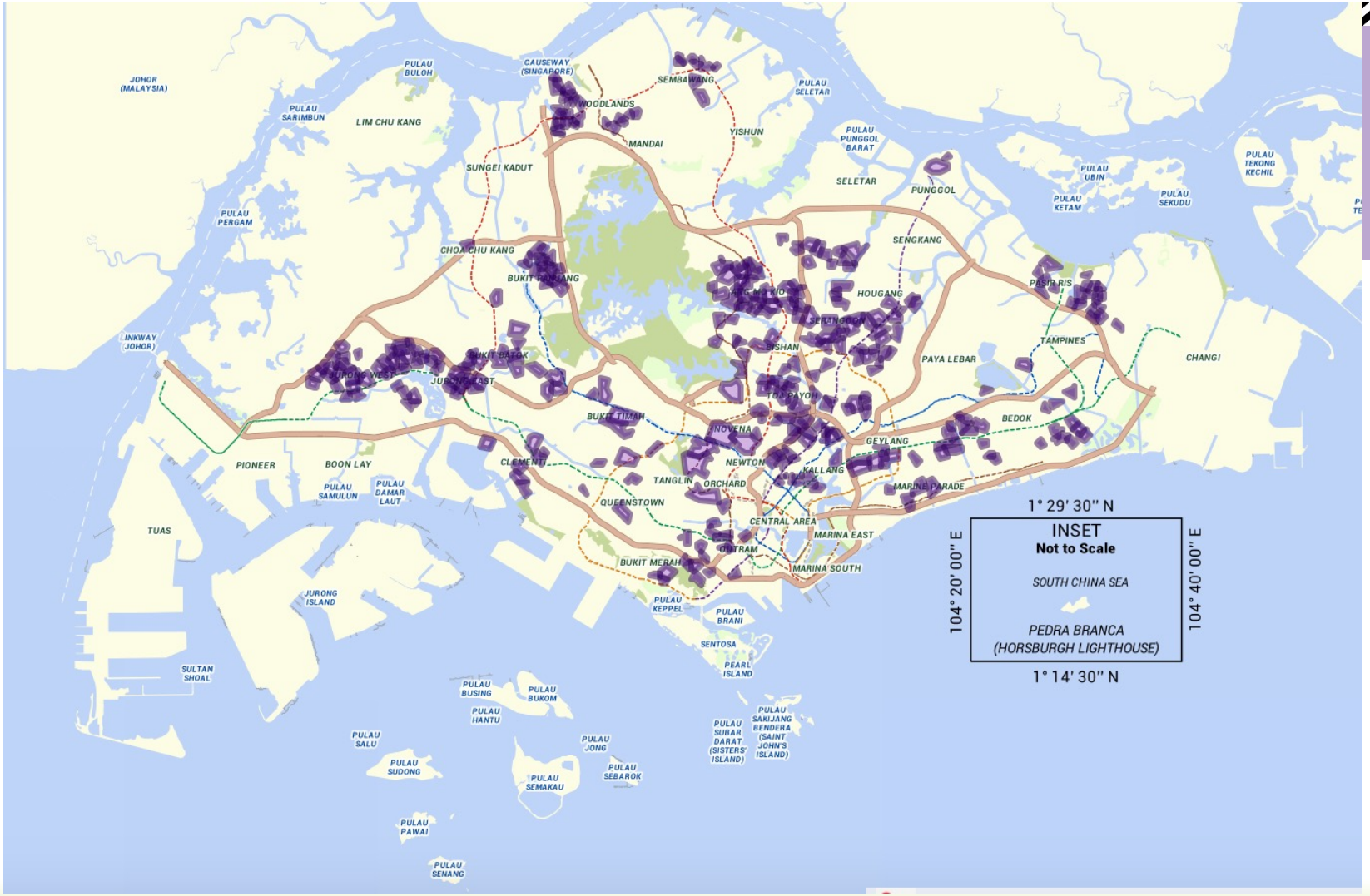
Gravitrap surveillance data - an indication of the adult population of female *Ae. aegypti* in the community

$$Gravitrap\ aegypti\ Index\ (GAI) = \frac{Total\ number\ of\ female\ adult\ Ae.aegypti}{Number\ of\ functional\ Gravitrap}$$

The National Environment Agency has deployed about 80,000 Gravitraps at public and landed housing estates around Singapore.

Updated once a month on NEA website.

Ae. aegypti surveillance in Singapore

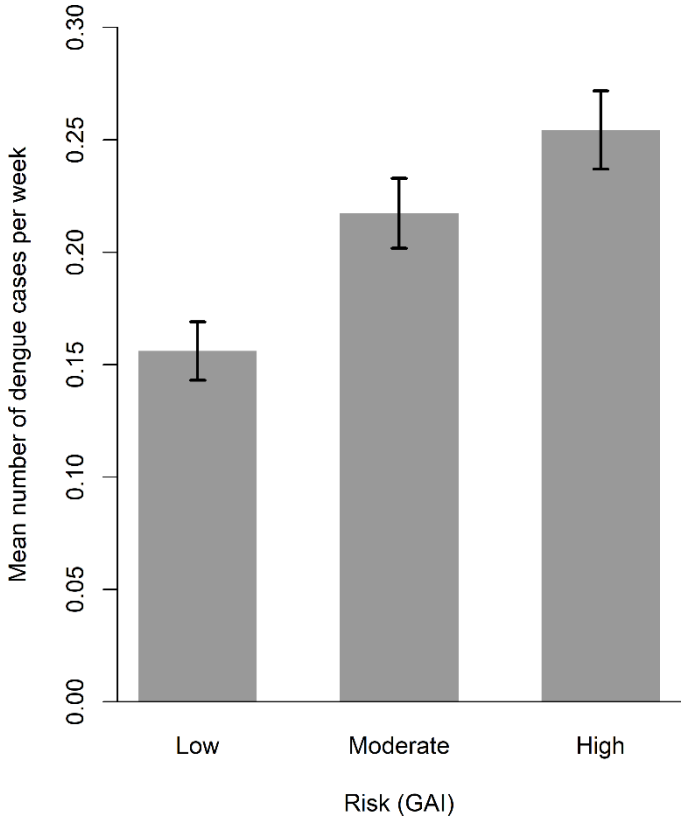


The sharing of mosquito population data serves to promote proactive preventive measures in reducing the mosquito population and risk of dengue transmission.

Outbreak prevention

Ae. aegypti surveillance in Singapore

Areas with higher *Aedes aegypti* mosquito population may have a higher risk of dengue transmission, especially during the dengue season.



Sites with high GAI were associated with a higher risk of dengue transmission (Sept 2013-Sept 2016)

Ong et al., 2020

Gravitrap deployment and its impact on dengue cases

- Besides being an efficient surveillance tool, Gravitrap may have an impact on dengue transmission, hypothetically due to the removal of infected mosquitoes.
- Identification of other species of mosquitoes, e.g. *Ae. albopictus* and *Culex* mosquitoes
- Mosquito samples readily available for DENV/ZIKV testing when required to identify virus strain that is causing outbreak.

DENV surveillance in Singapore

Increased house inspections in a dengue cluster

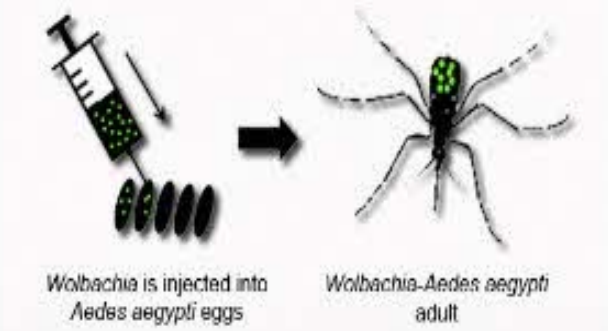
- House inspections are conducted routinely and at increased frequency in cluster areas by the Environmental Public Health Operations team to detect potential breeding sites in residential units.
- Source-reduction activities are facilitated by legislation and law enforcement.
- The Operations team can enter homes to conduct inspections and vector control, and residents are fined at least S$200 (US$145) if aquatic stages of vectors are found on their premises

The use of mosquito surveillance to test efficacy of novel vector control interventions

Project Wolbachia

Wolbachia is a safe, naturally occurring bacterium found in more than 60% of insect species, including butterflies, bees, dragonflies and some species of mosquitoes

How is *Wolbachia* introduced into *Aedes aegypti*?

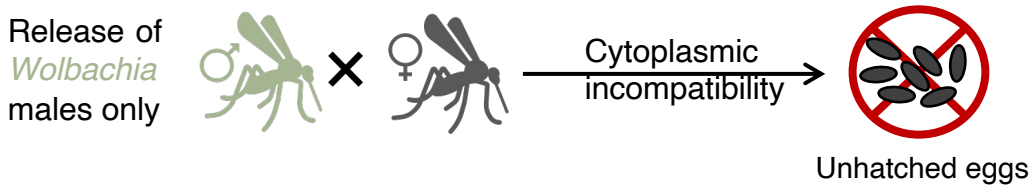


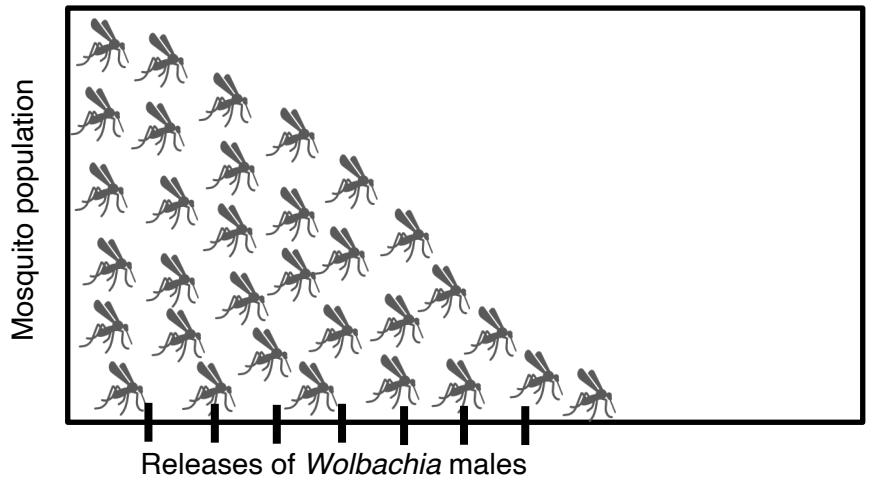
- *Wolbachia* is not found in *Aedes aegypti* in the field.
- *Wolbachia* is introduced into *Aedes aegypti* eggs via microinjection.
- Female *Wolbachia-Aedes aegypti* mosquitoes that emerge from these eggs will pass *Wolbachia* to their offspring (maternal transmission).
- This process allows us to produce *Wolbachia-Aedes* mosquitoes easily.

NEA website

Suppression strategy

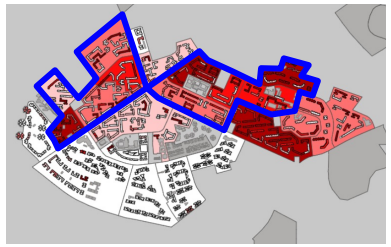
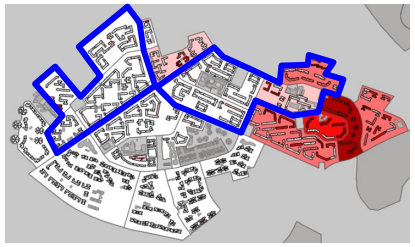
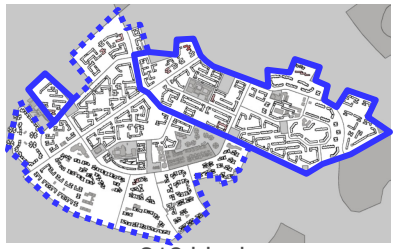
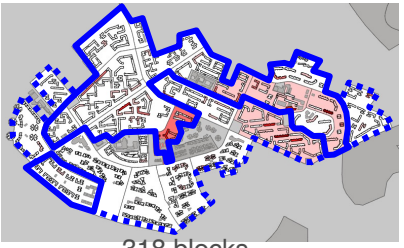
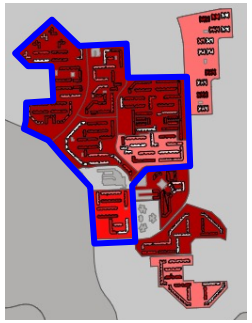
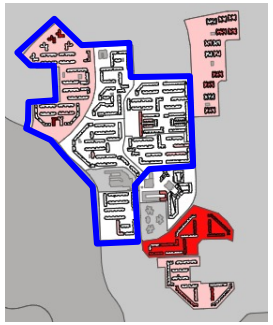
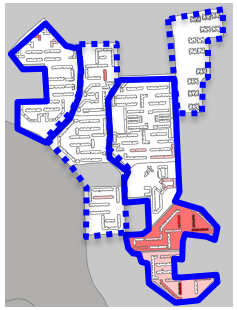
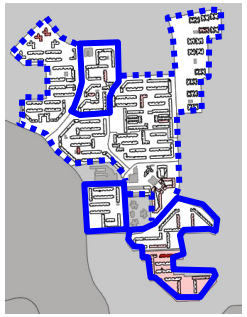
Goal: Reduce mosquito population to a level that inhibits disease transmission





Targeted approach at Choa Chu Kang and Bukit Batok

"Eraser" effect on *Ae. aegypti* population

Sites	Jun 2020	Jun 2021	Jun 2022	May 2023
Choa Chu Kang	 113 blocks (9,675 homes)	 113 blocks (9,675 homes)	 318 blocks (30,708 homes)	 318 blocks (30,708 homes)
Bukit Batok	 94 blocks (7,830 homes)	 94 blocks (7,830 homes)	 133 blocks (12,161 homes)	 133 blocks (12,161 homes)

Legend:

Risk of large dengue cluster formation			
Risk	Low	Moderate	High
GAI[1]	<0.05	0.05-0.1	>0.1
Increase in risk	1X	4X	10X

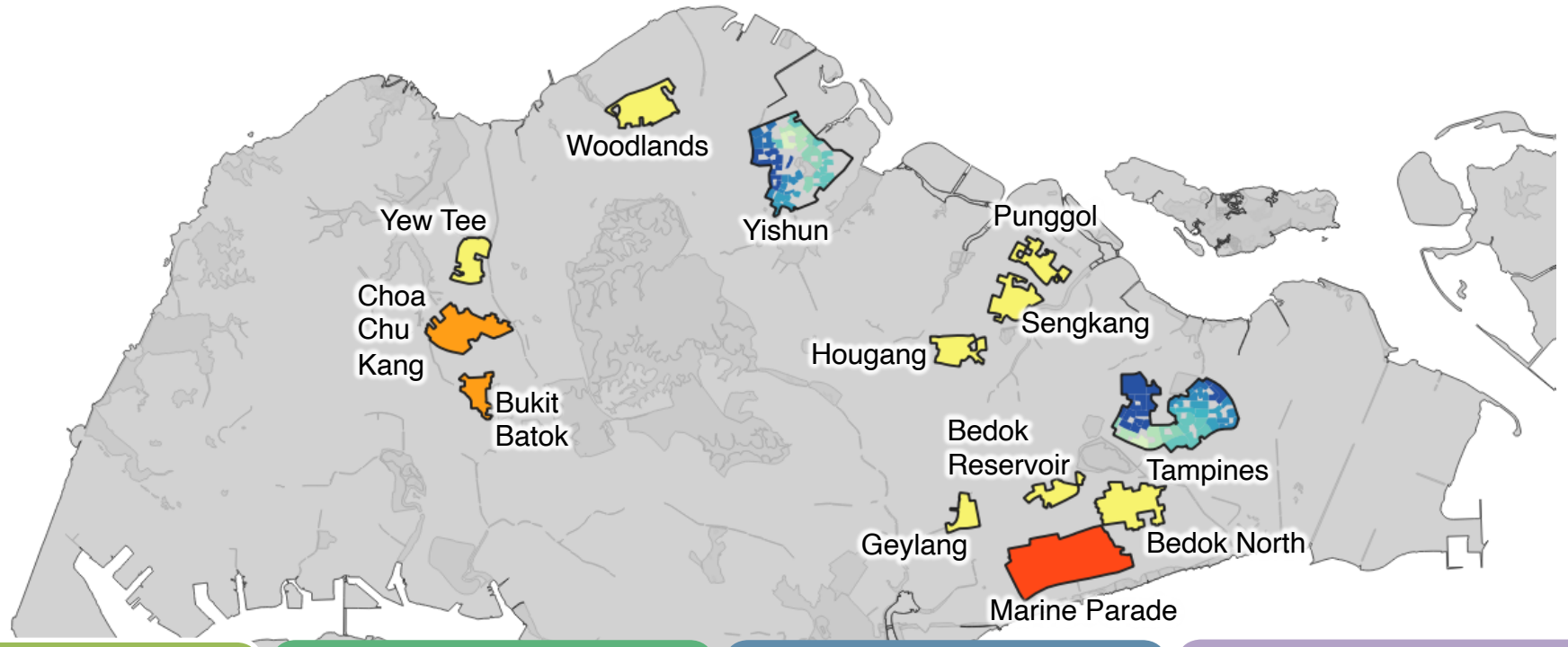
Release area (weekly releases since May 2020 in Choa Chu Kang and Jun 2020 in Bukit Batok)

No release, under monitoring

[1] Gravitrap *Ae. aegypti* index (GAI, average number of female *Aedes aegypti* caught per functional Gravitrap)

Overview of current *Wolbachia-Aedes aegypti* release sites

Total coverage of > 300,000 households in 30% of all HDB blocks & 9% of landed homes



Study sites

Historical high dengue risk level and high *Aedes aegypti* mosquito population (main vector for dengue)

- Rolling carpet approach (1,405 HDB blocks, 135,920 households)
- Targeted approach (451 HDB blocks, 42,869 households)
- Landed estate study (5 km², ~18,000 households)
- Multi-site field study (1,498 HDB blocks, 153,346 households)

2012-2016 — Groundwork
- Laboratory feasibility studies
- Risk assessment
- Community engagement

2016-2017 — Phase 1: Small-scale field study to understand mosquito behaviour in high-rise residential setting
- 39 HDB blks; 3,941 households
- 1 landed estate; 216 households

2018-2019 — Phase 2: Develop tactics to improve release strategies & mitigate risks
- 76 HDB blks; 7,056 households

2019 -2022 — Expanded field study to demonstrate sustainability over larger areas
- 1,856 HDB blks; 178,789 households
- 5 km²; ~18,000 households

2022 onwards — Multi-site field trial to determine impact on dengue cases
- 3,354 HDB blks; 350,473 households
- 5 km²; ~18,000 households

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