

# IMPERIAL

A review on the effect of precipitation and water availability on *Aedes* mosquitoes life history traits

# Importance of precipitation and Aedes life history traits relationship

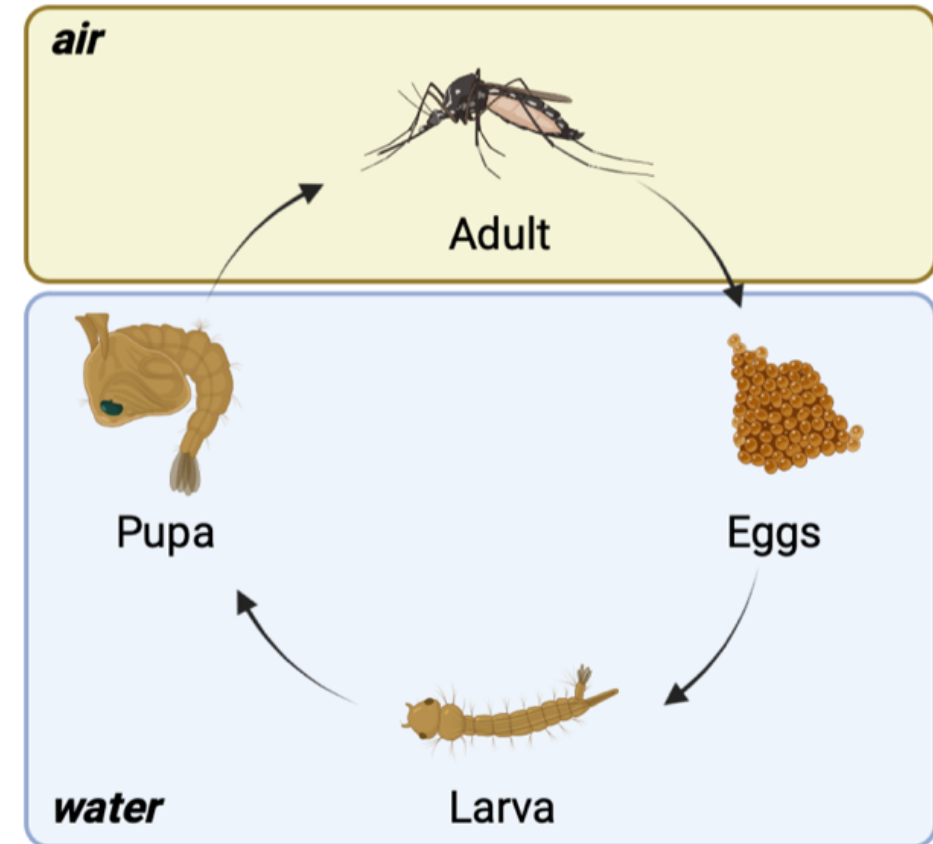
- Need rainfall for creation and maintenance of breeding sites
- Amount of rainfall affects life history traits (survival, etc.)



- Rainfall used in models to predict Aedes population dynamics
- Second most important climatic variable in both correlative and mechanistic models

## Why is the effect of rainfall important in mechanistic models?

- Require knowledge on the causal relationships in biology
- Translate those relationships into differential equations that make up a system



General lifecycle of Aedes species

(made with [www.Biorender.com](http://www.Biorender.com))

# How are mechanistic models incorporating precipitation to date?

## Eggs

- **Egg hatching** is triggered by first precipitation event in spring (Tran et al., 2013)
- **Egg hatching rate** is a function of daily precipitation (Valdez et al., 2018; Khan et al., 2023)

## Larvae & pupae

- **Environmental carrying capacity** is a function of daily precipitation (Metelmann et al., 2019)
- **Survival & mortality** are a function of precipitation (Morin et al., 2015)

## Adults

- **Egg laying rate** is a function of cumulative precipitation (Wang et al., 2016)

Is there any laboratory evidence for the relationships between precipitation and *Aedes* life history traits?

# Search strategy: laboratory evidence on rainfall-Aedes traits relationship

Search date: 12/02/2024

Number of reviewers: 4

Databases:

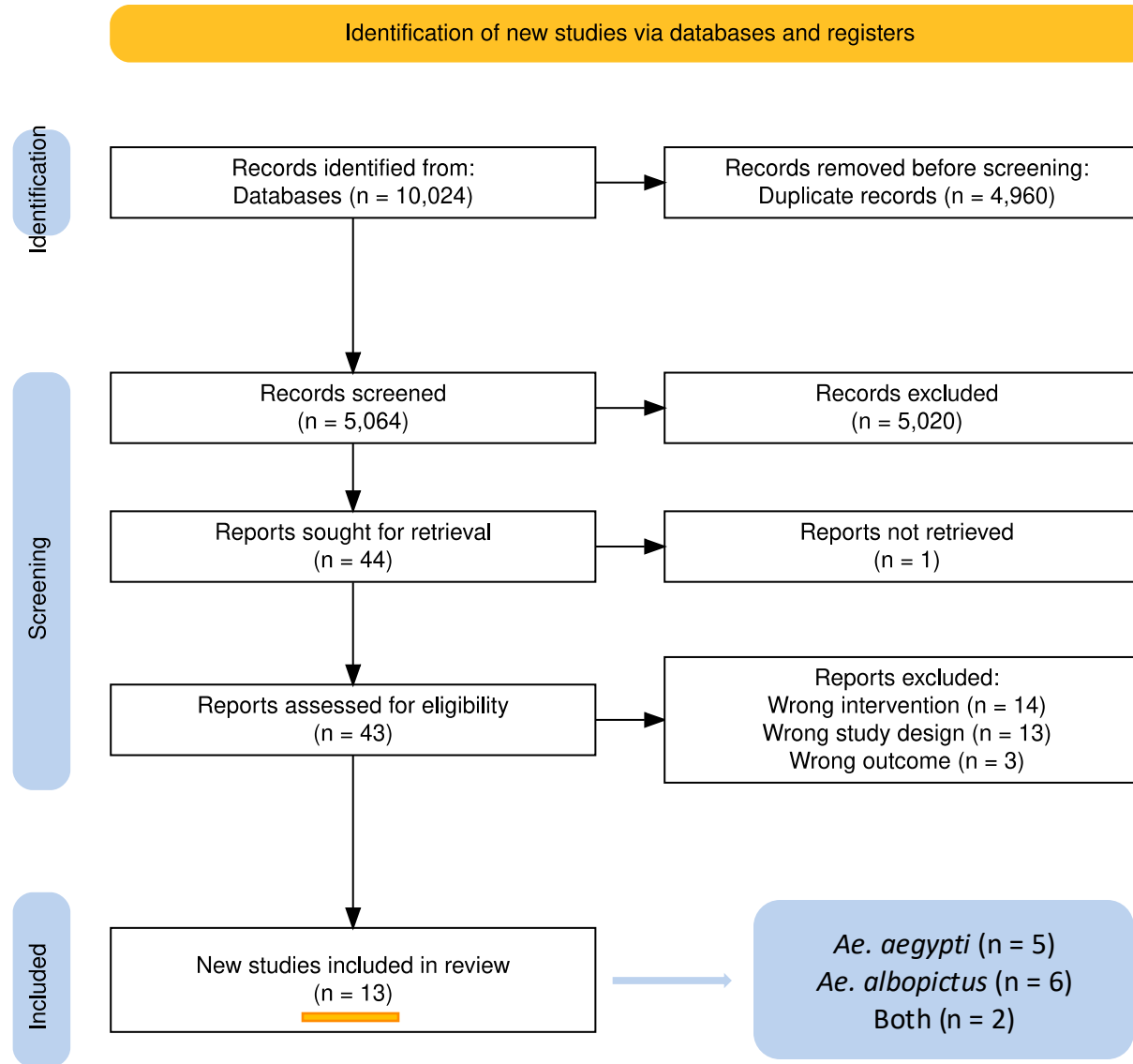
- Embase
- Scopus
- Web of Science

Inclusion criteria:

- Laboratory experiments
- Rainfall, evaporation
- No time, location, or language restrictions

Topics	Keywords
<i>Aedes aegypti</i>	" <i>Aedes aegypti</i> " OR "Yellow Fever mosquito" OR " <i>Stegomyia aegypti</i> "
	<b>OR</b>
<i>Aedes albopictus</i>	" <i>Aedes albopictus</i> " OR "Tiger mosquito" OR " <i>Stegomyia albopicta</i> " OR "forest mosquito"
	<b>OR</b>
<i>Aedes japonicus</i>	" <i>Aedes japonicus</i> " OR "Asian Bush mosquito" OR "Asian Rock Pool mosquito" OR " <i>Ochlerotatus japonicus</i> " OR " <i>Hulecoeteomyia japonica</i> "
	<b>OR</b>
<i>Aedes koreicus</i>	" <i>Aedes koreicus</i> " OR "Korean Bush mosquito" OR " <i>Ochlerotatus koreicus</i> " OR " <i>Hulecoeteomyia koreica</i> "
	<b>AND</b>
Precipitation	"Rain" OR "Precipitation" OR "Water" OR "Humidity" OR "Moisture" OR "Shower" OR "Flood"

# PRISMA chart: laboratory evidence on rainfall-Aedes traits relationship



# Results

## Survival

- Precipitation
  - Length exposure
  - Water speed
- Water availability
  - No evaporation
  - Evaporation

## Development

- Precipitation
  - Length exposure
- Water availability
  - No evaporation
  - Evaporation

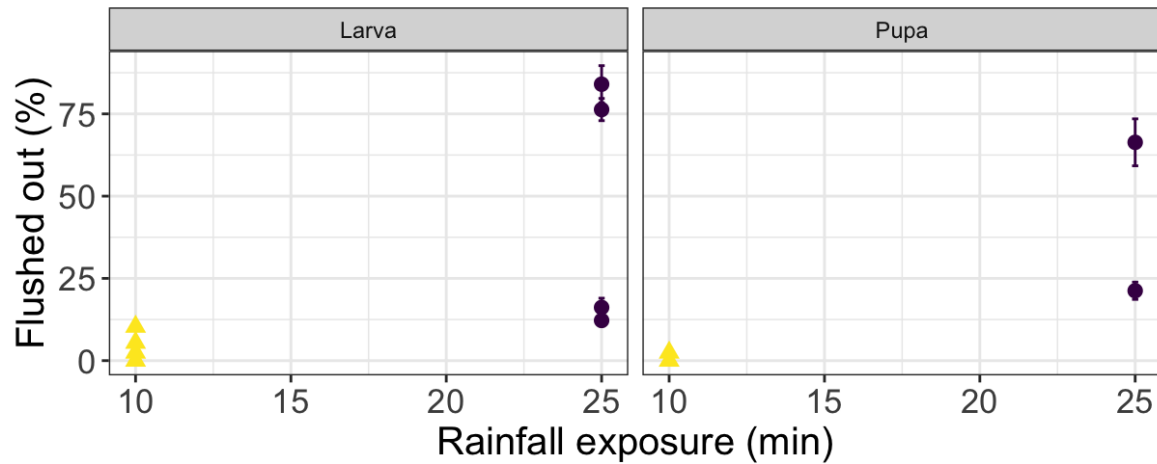
## Reproduction

- Water availability
  - No evaporation
  - Evaporation

# Survival

# Prolonged exposure to precipitation may cause higher mortality for *Ae. albopictus* immature stages, but not for *Ae. aegypti*

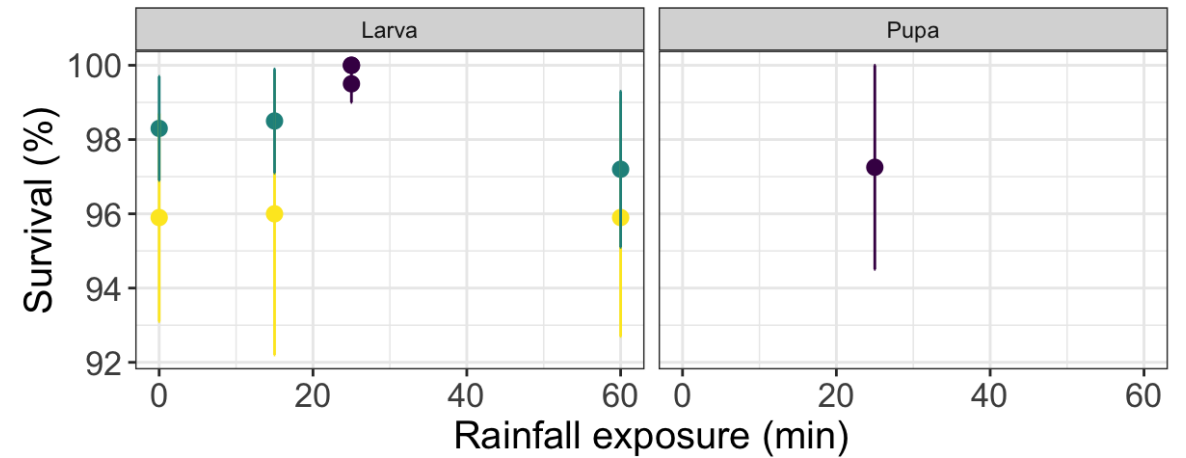
*Ae. albopictus* (field, 1 study, Penang Island Malaysia)



Container      Rainfall quantity

● Large   ● Small   ● High flow (62 mm)   ▲ Low flow (6 mm)

*Ae. aegypti* (field, 1 study, Mae Scot Thailand)



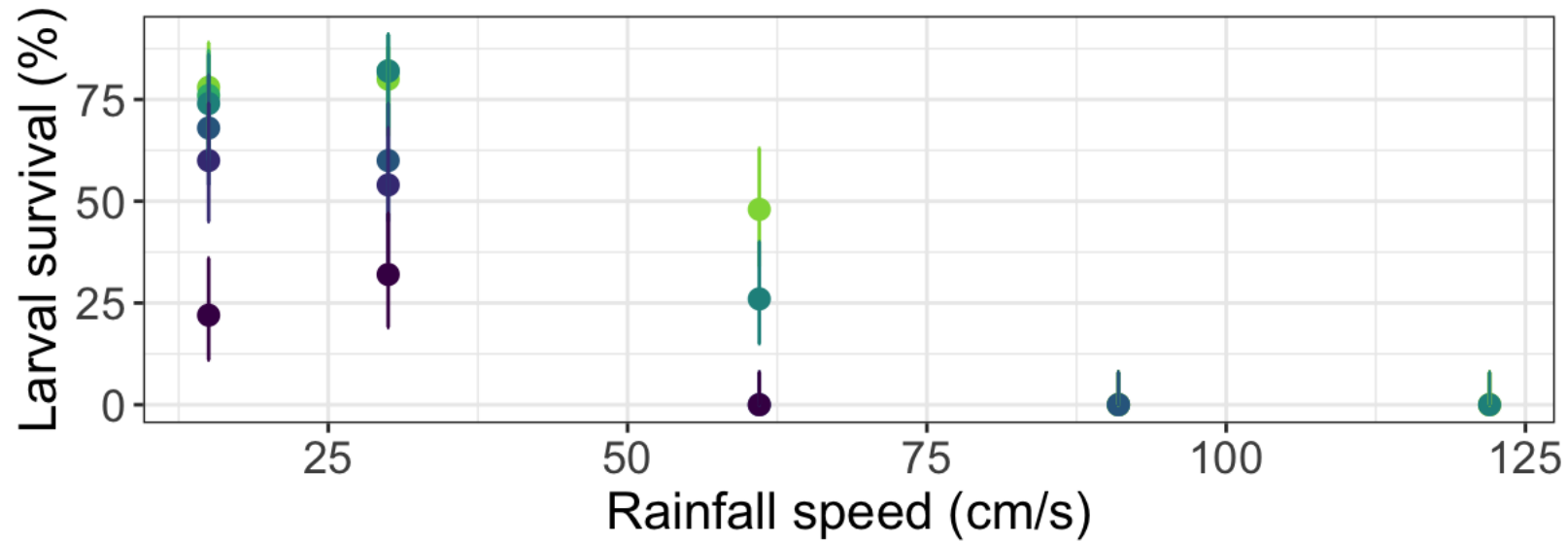
Temperature (°C)

● 16   ● 24   ● 25



# Heavier precipitations cause higher mortality for *Ae. aegypti*

*Ae. aegypti* (laboratory, 1 study)

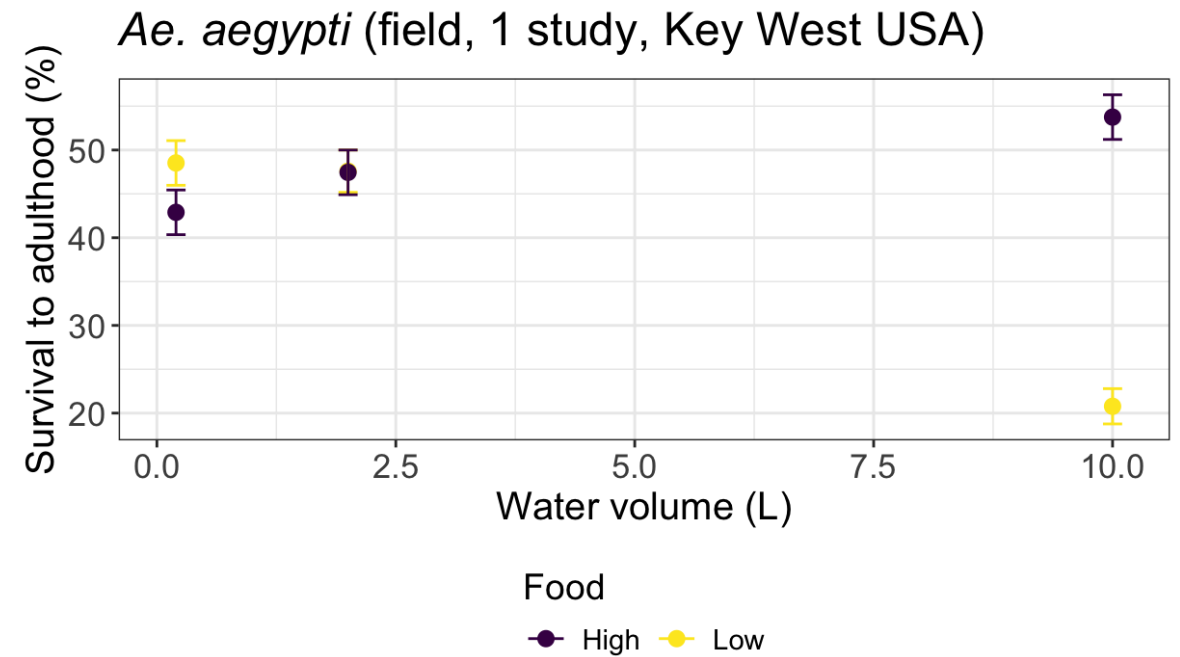
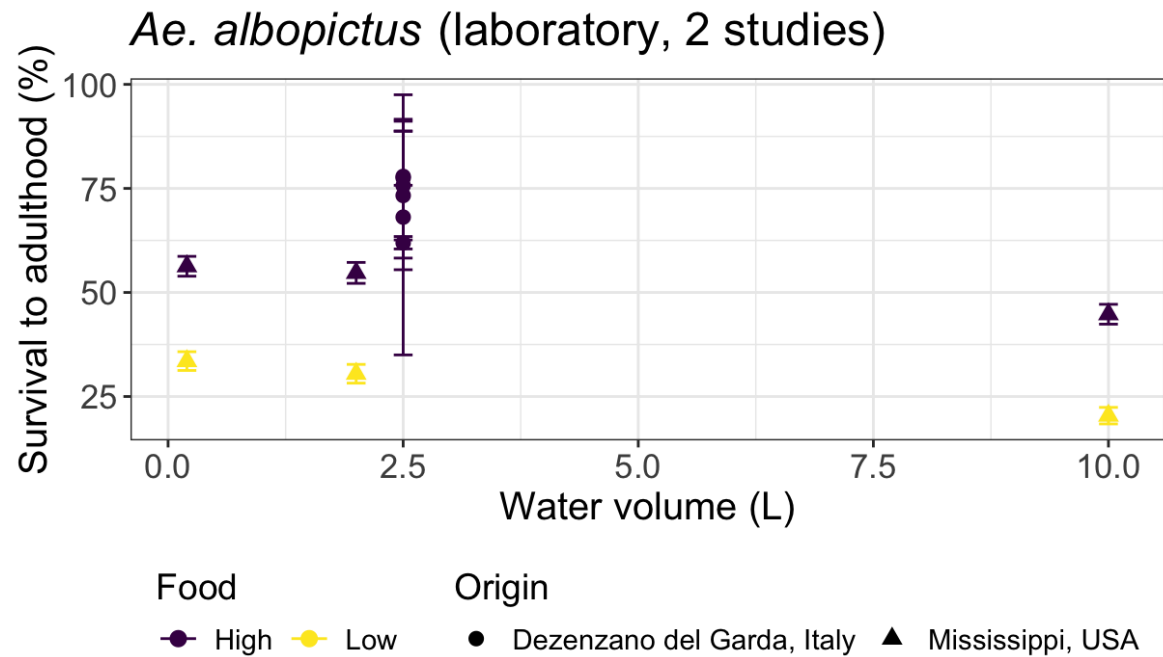


Duration (h)

4 18 48 72

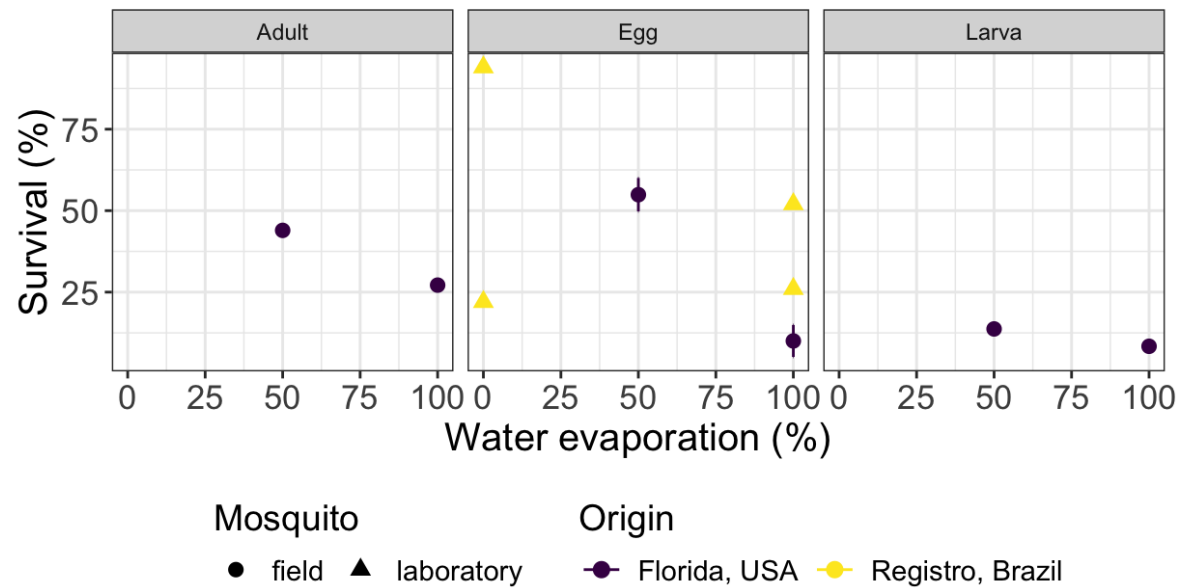
8 24 60

# Higher water volumes (no evaporation) cause higher mortality for *Ae. albopictus*, but not for *Ae. aegypti*

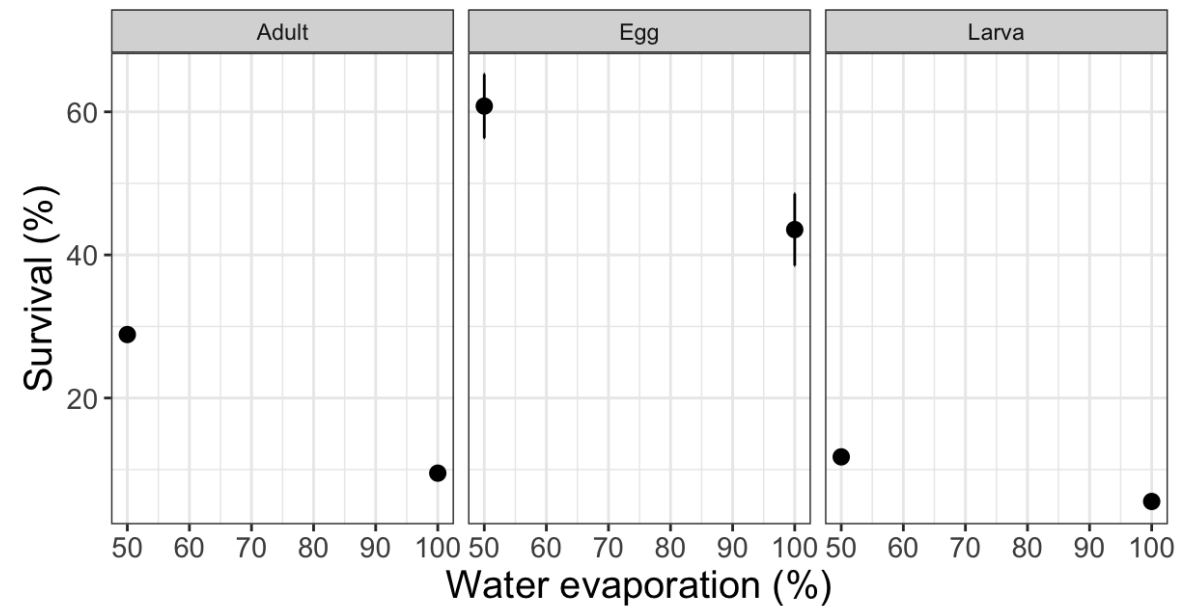


# Higher levels of evaporation lead to a decrease in the survival of mosquitoes

*Ae. albopictus* (2 studies)



*Ae. aegypti* (field, 1 study, Florida USA)



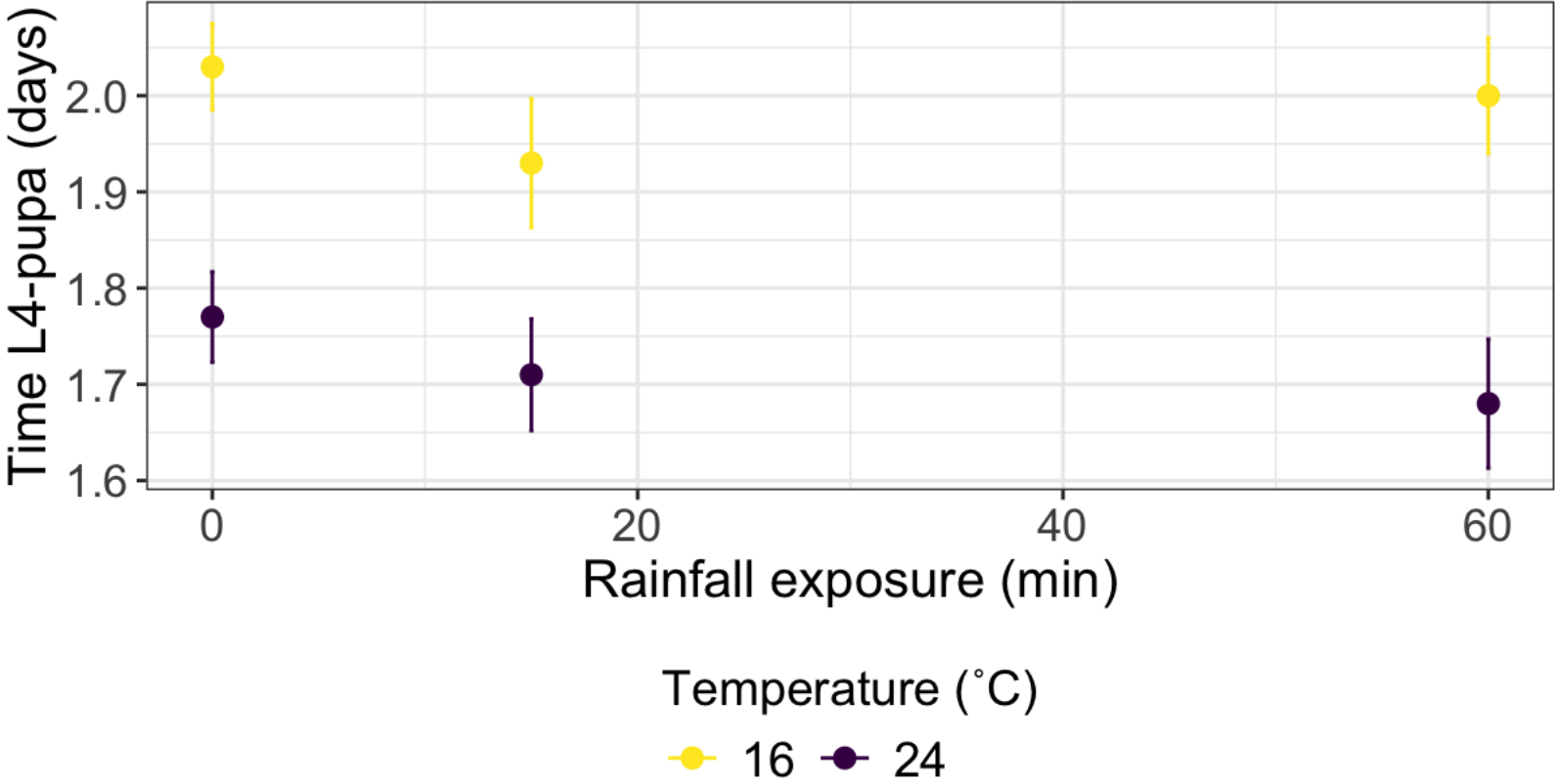
# Effects of rainfall and evaporation on Aedes traits

Outcome	Exposure	<i>Ae. albopictus</i>	<i>Ae. aegypti</i>
SURVIVAL	Longer precipitation	↓ survival (1) ?	no effect (1)
	Heavier precipitation	↓ survival (1) ?	↓ survival (1)
	↑ water volume	↓ survival (2)	↑ survival (1)
	↑ evaporation	↓ survival (2)	↓ survival (1)

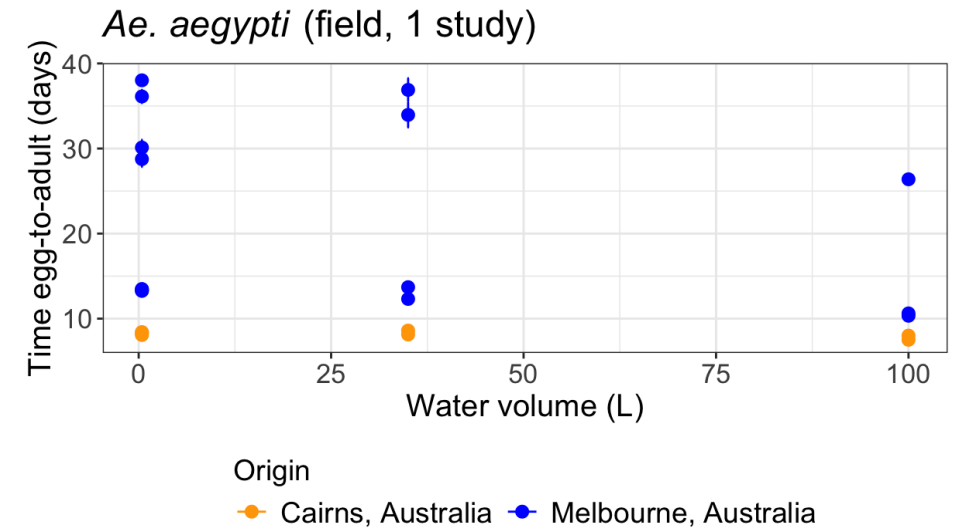
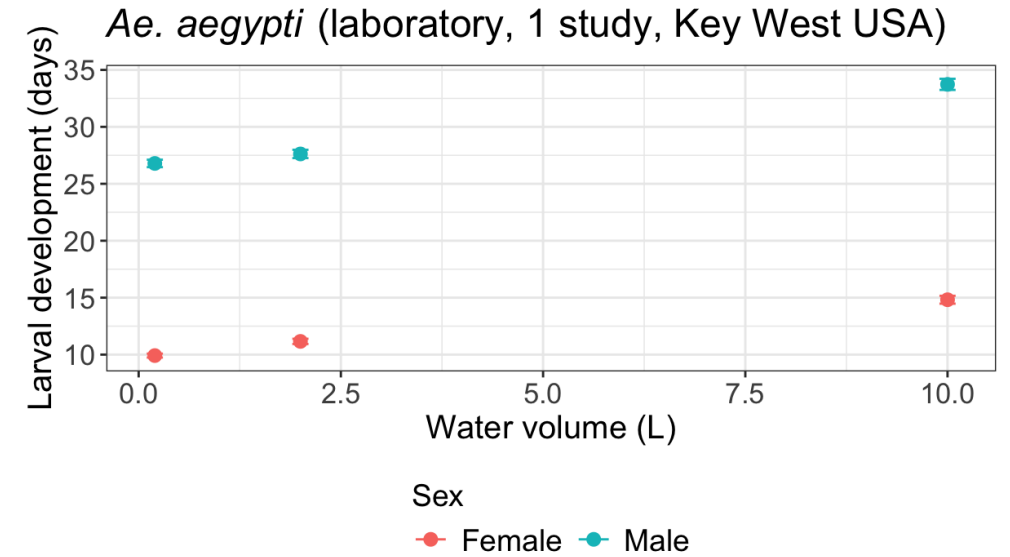
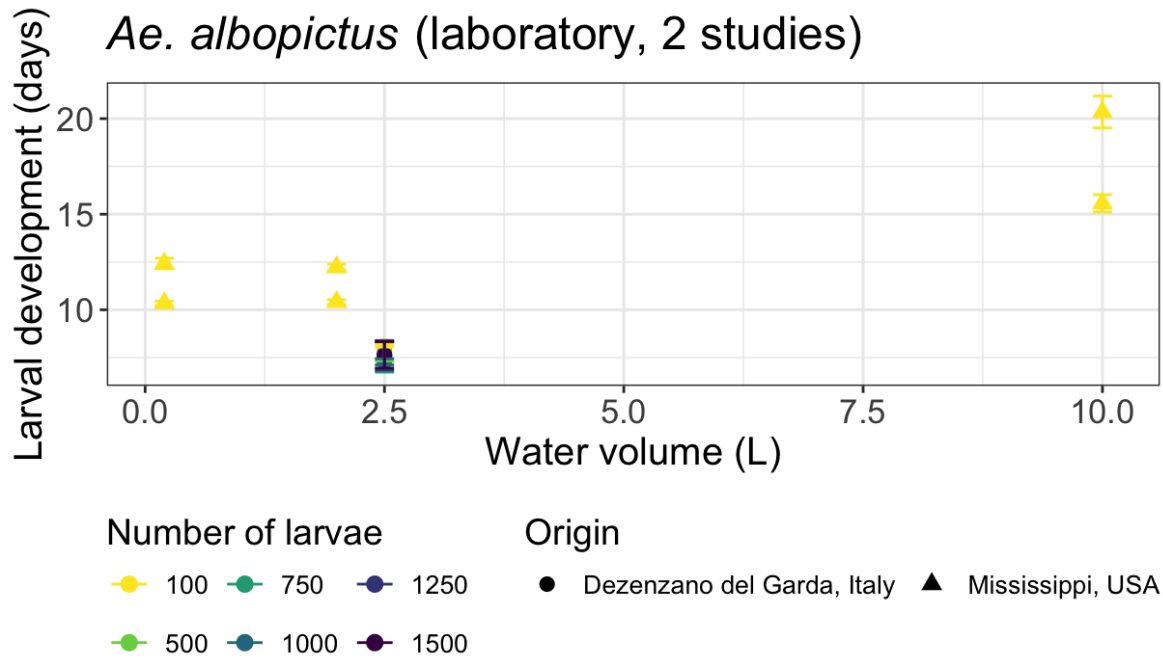
# Development

# Prolonged exposure to precipitation does not significantly impact *Ae. aegypti* development

*Ae. aegypti* (field, 1 study, Mae Scot Thailand)

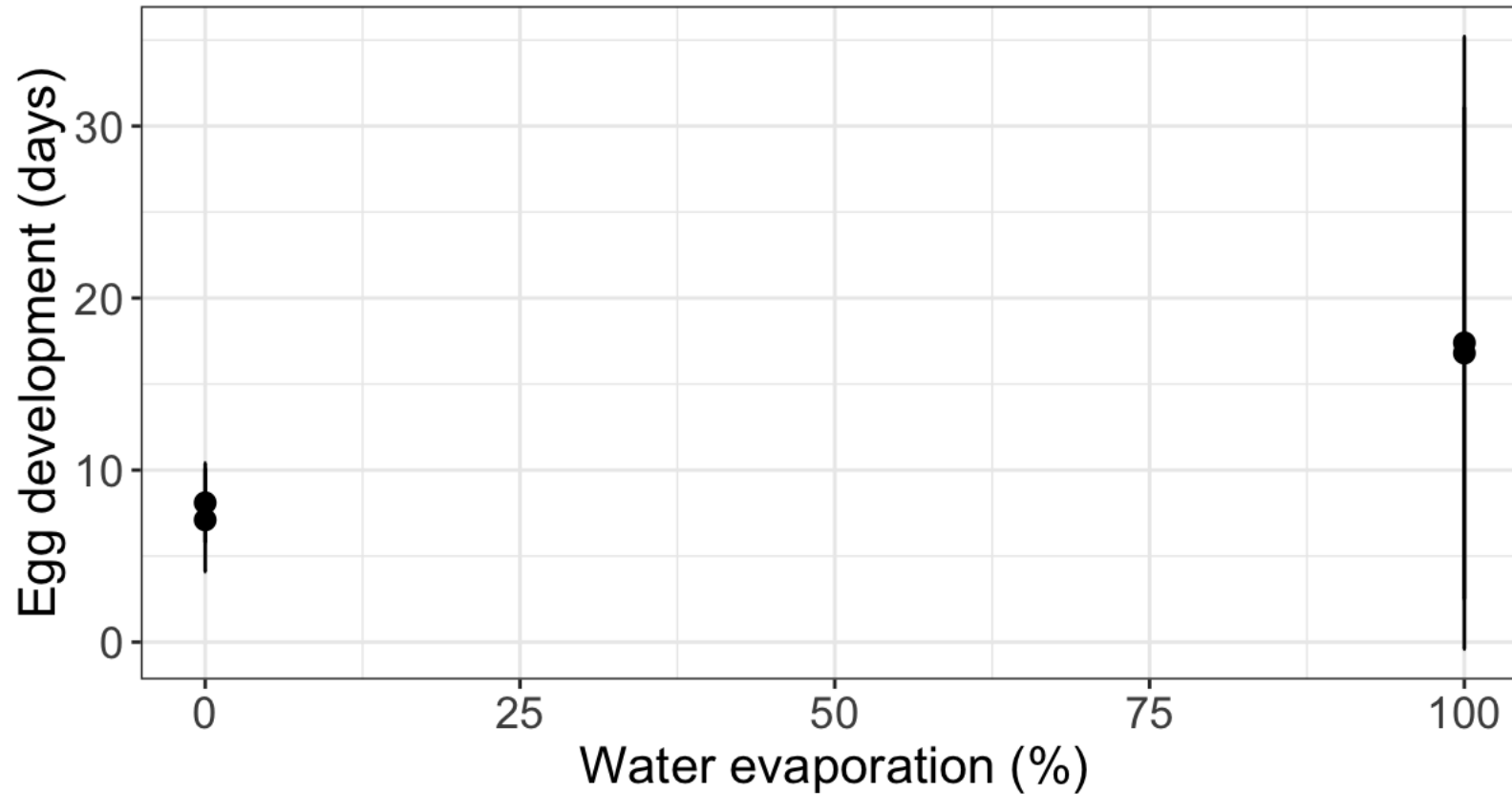


# Higher water volumes (no evaporation) slow down larval development for *Ae. albopictus*, but it's unclear for *Ae. aegypti*



# Higher levels of evaporation do not significantly impact *Ae. albopictus* egg developmental time

*Ae. albopictus* (laboratory, 1 study, Registro Brazil)





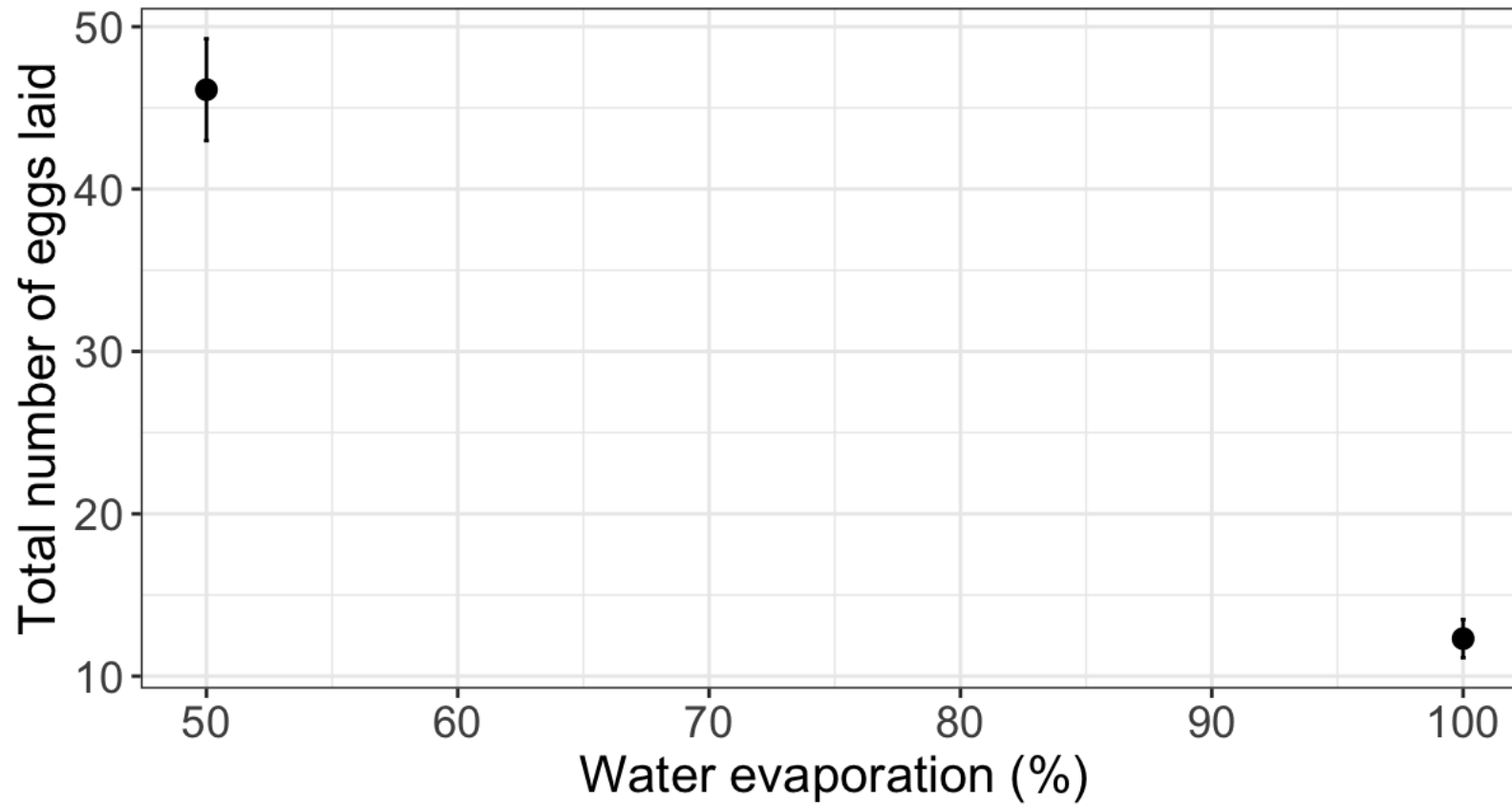
# Effects of rainfall and evaporation on Aedes traits

Outcome	Exposure	<i>Ae. albopictus</i>	<i>Ae. aegypti</i>
SURVIVAL	Longer precipitation	↓ survival (1) ?	no effect (1)
	Heavier precipitation	↓ survival (1) ?	↓ survival (1)
	↑ water volume	↓ survival (2)	↑ survival (1)
	↑ evaporation	↓ survival (2)	↓ survival (1)
DEVELOPMENT	Longer precipitation	-	no effect (1)
	↑ water volume	↑ larval time (2)	unclear (3)
	↑ evaporation	no effect (1)	-

# Reproduction

# Higher levels of evaporation lead to a decrease in *Ae. albopictus* egg laying

*Ae. albopictus* (field, 1 study, Penang Island, Malaysia)



# Huge gap in literature: not many studies per exposure/outcome

Outcome	Exposure	<i>Ae. albopictus</i>	<i>Ae. aegypti</i>
SURVIVAL	Longer precipitation	↓ survival (1) ?	no effect (1)
	Heavier precipitation	↓ survival (1) ?	↓ survival (1)
	↑ water volume	↓ survival (2)	↑ survival (1)
	↑ evaporation	↓ survival (2)	↓ survival (1)
DEVELOPMENT	Longer precipitation	-	no effect (1)
	↑ water volume	↑ larval time (2)	unclear (3)
	↑ evaporation	no effect (1)	-
REPRODUCTION	↑ evaporation	↓ eggs (1)	-

# My experiments on *Ae. albopictus* at Fondazione Edmund Mach

Effect of evaporation on survival to adulthood



Effect of heavy rainfall on immediate larval survival  
(Scaled version of catch basin)



# Acknowledgements



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## Collaborators:

Daniele Arnoldi  
Enrico Inama  
Yiran Wang

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