

# The impacts of climate-adapted rice cultivation on malaria vector ecology

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# The link between rice and malaria

- **Rice agroecosystems provide habitats conducive to malaria vector breeding<sup>1</sup>**
  - Higher vector densities and biting rates in associated communities<sup>2</sup>
  - Increased malaria incidence in communities adjacent to rice cultivation<sup>3</sup>
- **Africa is increasing its rice production capacity**

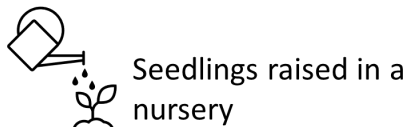
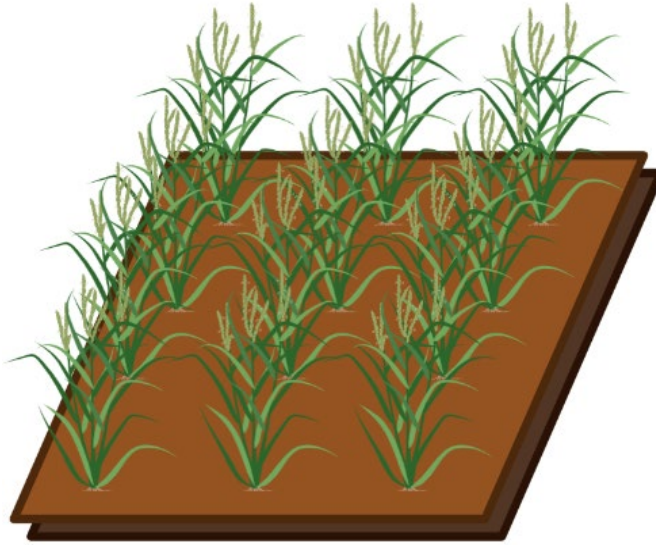


# What is SRI?

- System of Rice Intensification.
- A “set of interdependent agronomic practices that modify current plant, soil, water, and nutrient management” <sup>4</sup>.
- A climate-adapted methodology that aims to increase rice yields whilst reducing agricultural inputs.

# What is SRI?

## SRI Rice



Seedlings raised in a nursery



Alternate wet and dry irrigation



Planting of single seedlings per hill



Regular hand/tool weeding



Wide grid spacing of plants



Promotion of organic fertilisers

## Non-SRI Rice



Broadcast sowing of seeds



Rainfed/irrigated flooded fields



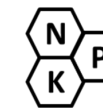
Multiple seedlings per hill



Water controlled weeds/no weeding



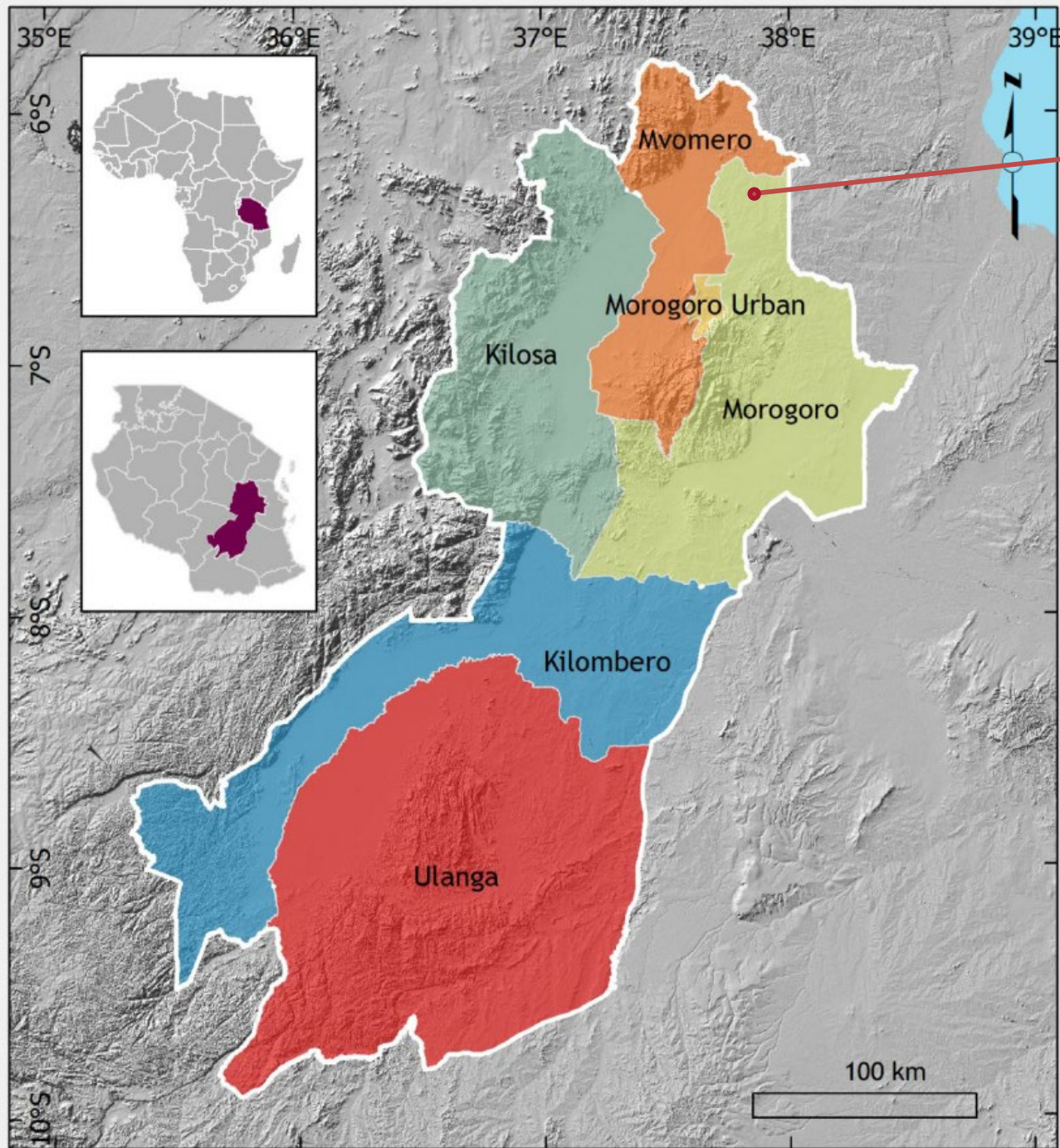
Non-uniform plant distribution



Use of industrial fertilisers

The SRI agroecosystem is a  
fundamentally **different** environment





## Mkindo irrigation scheme, Tanzania - Morogoro

- Four SRI and four non-SRI fields.
  - Each field divided into four transects, with four sample points along each.
  - Sampling commenced two weeks prior to rice planting and finished two weeks after harvest (Jan – May 2022).
  - Three consecutive sampling days per week via larval dipping and emergence trapping.

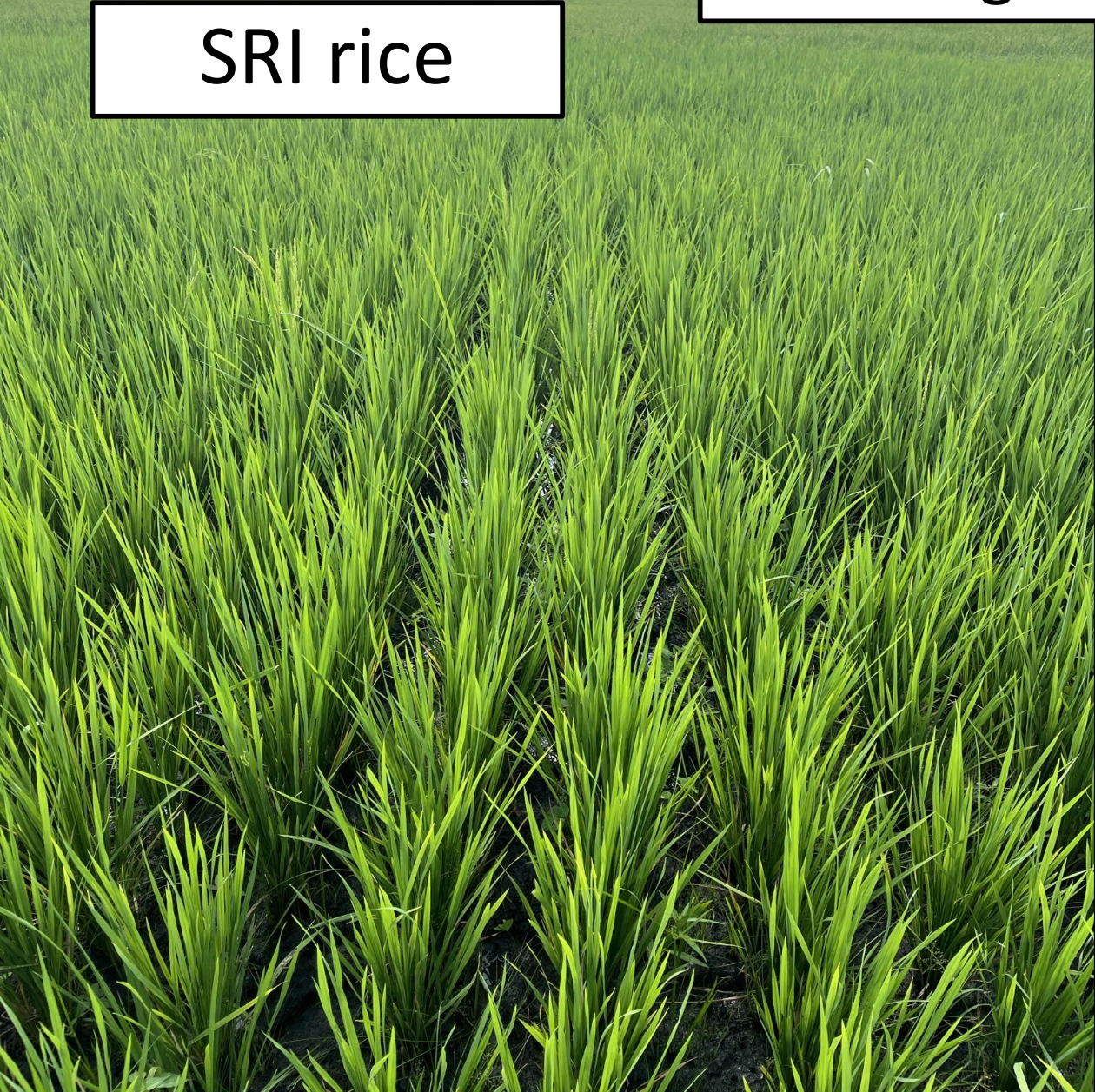
Image:

Ojoyi MM, Antwi-Agyei P, Mutanga O, Odindi J, Abdel-Rahman EM. An Analysis of Ecosystem Vulnerability and Management Interventions in the Morogoro Region Landscapes, Tanzania. Tropical Conservation Science. 2015;8(3):662-680. doi:10.1177/194008291500800306



Mkindo irrigation scheme,  
Morogoro, Tanzania

SRI rice



Non-SRI rice

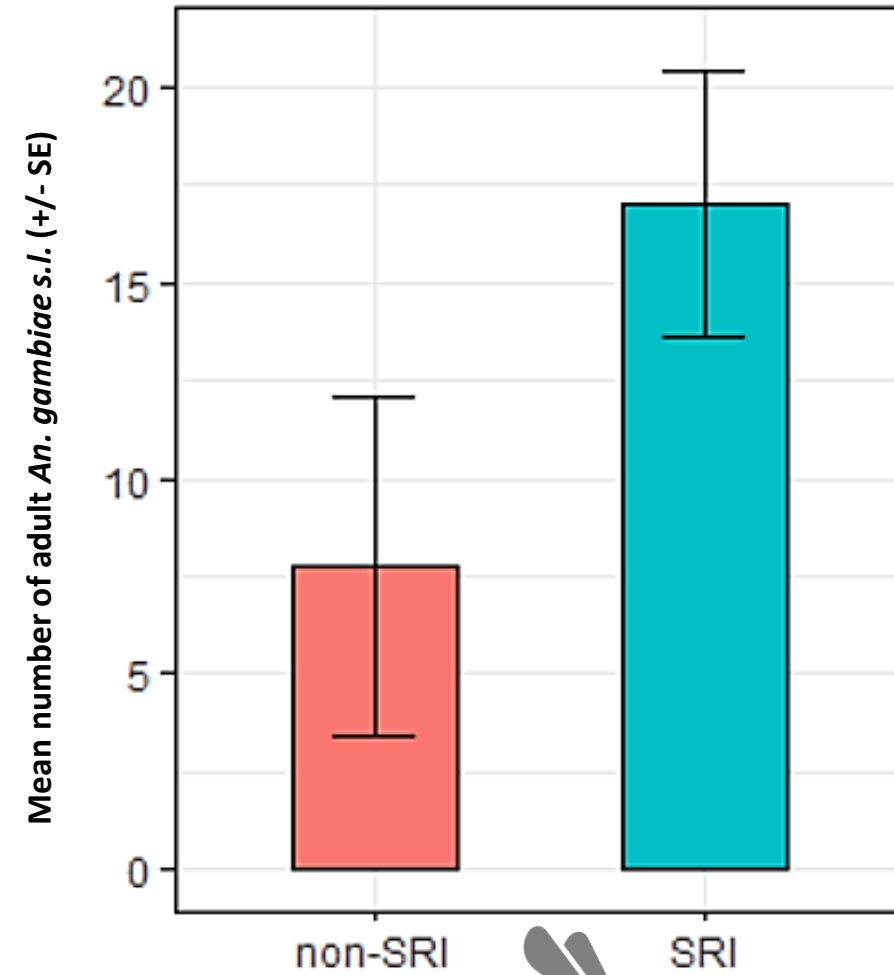
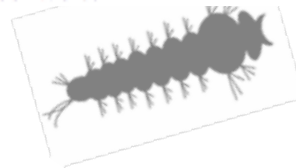
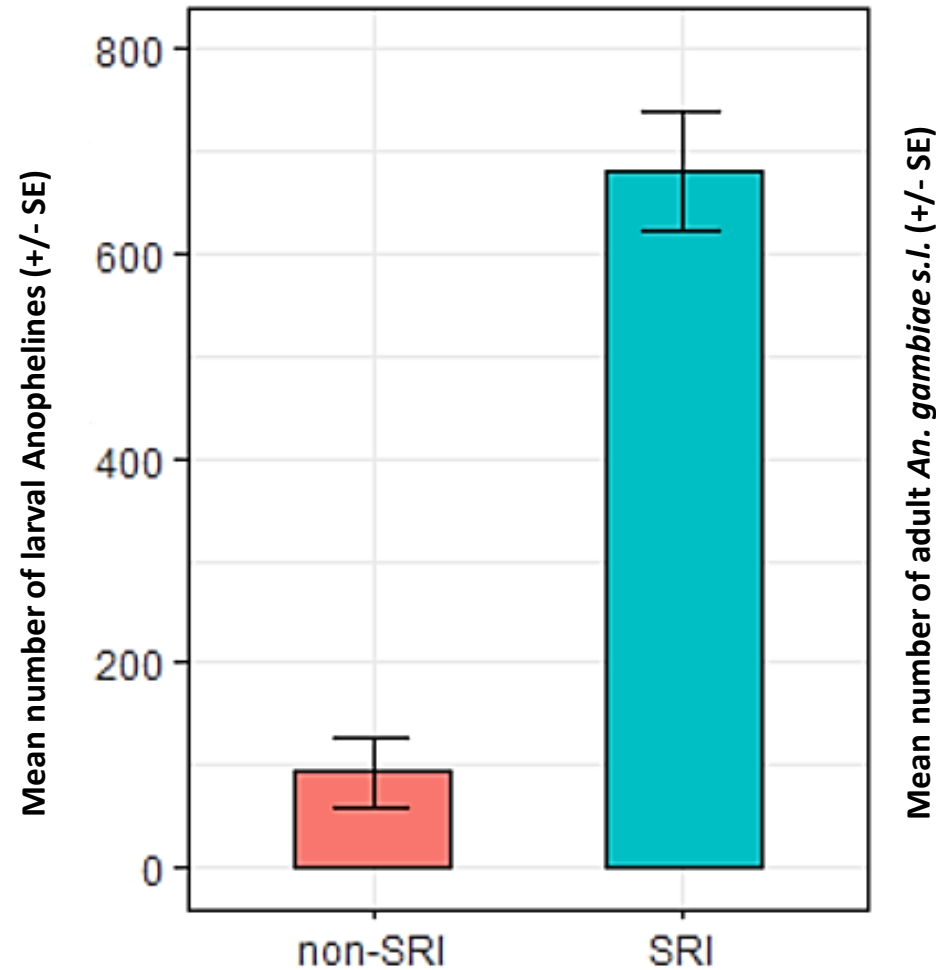




# Vector bionomics: Larval and adult density

*Preliminary data and analysis*

- SRI is associated with **higher** vector densities and productivity.

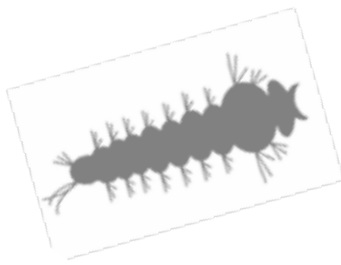
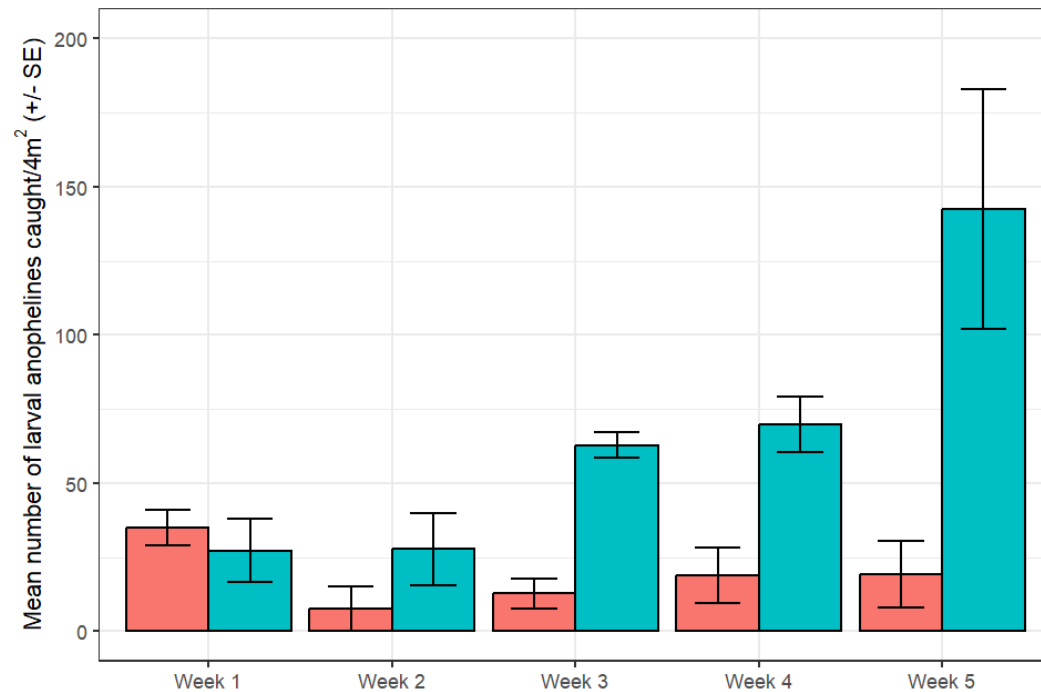




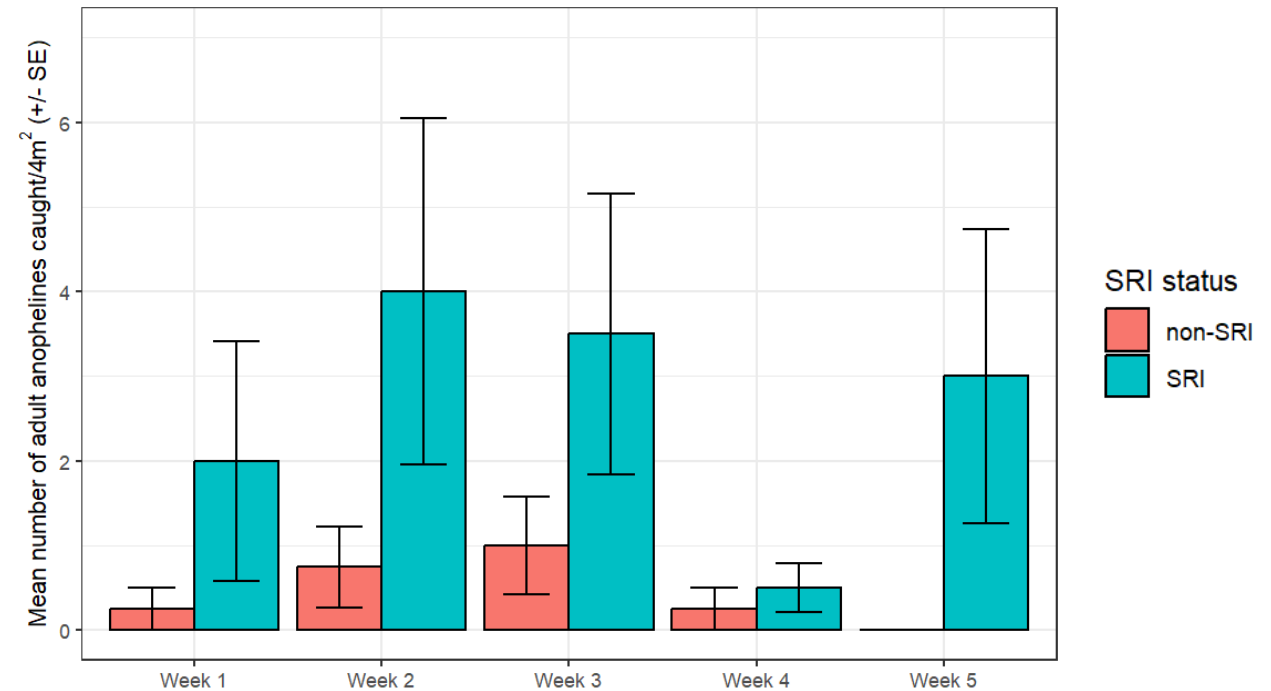
# Larval and adult density over time

Preliminary data and analysis

## Counts of Anopheline larvae over time

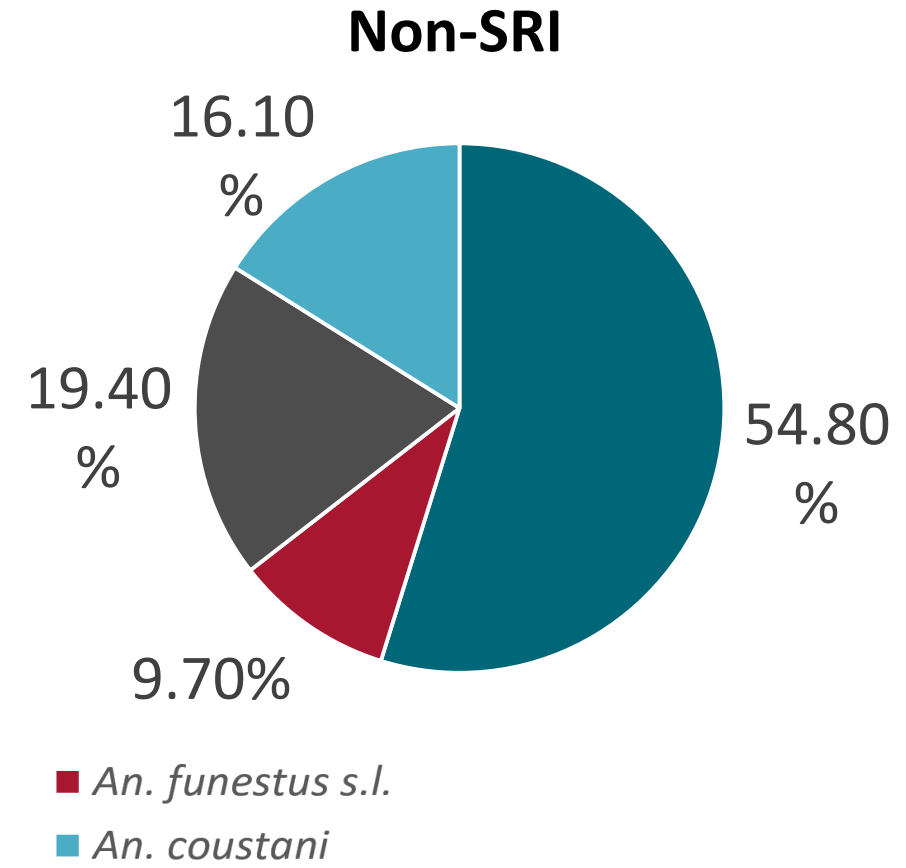
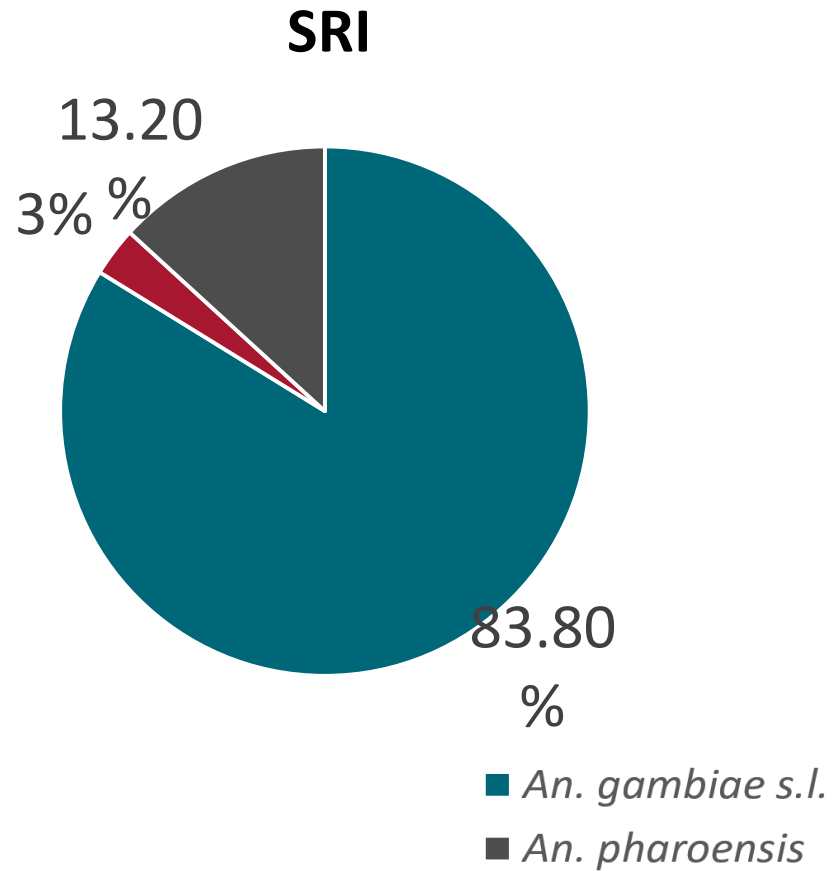


## Counts of *An. gambiae s.l.* adults over time



# Vector bionomics: Species composition

*Preliminary data and analysis.*

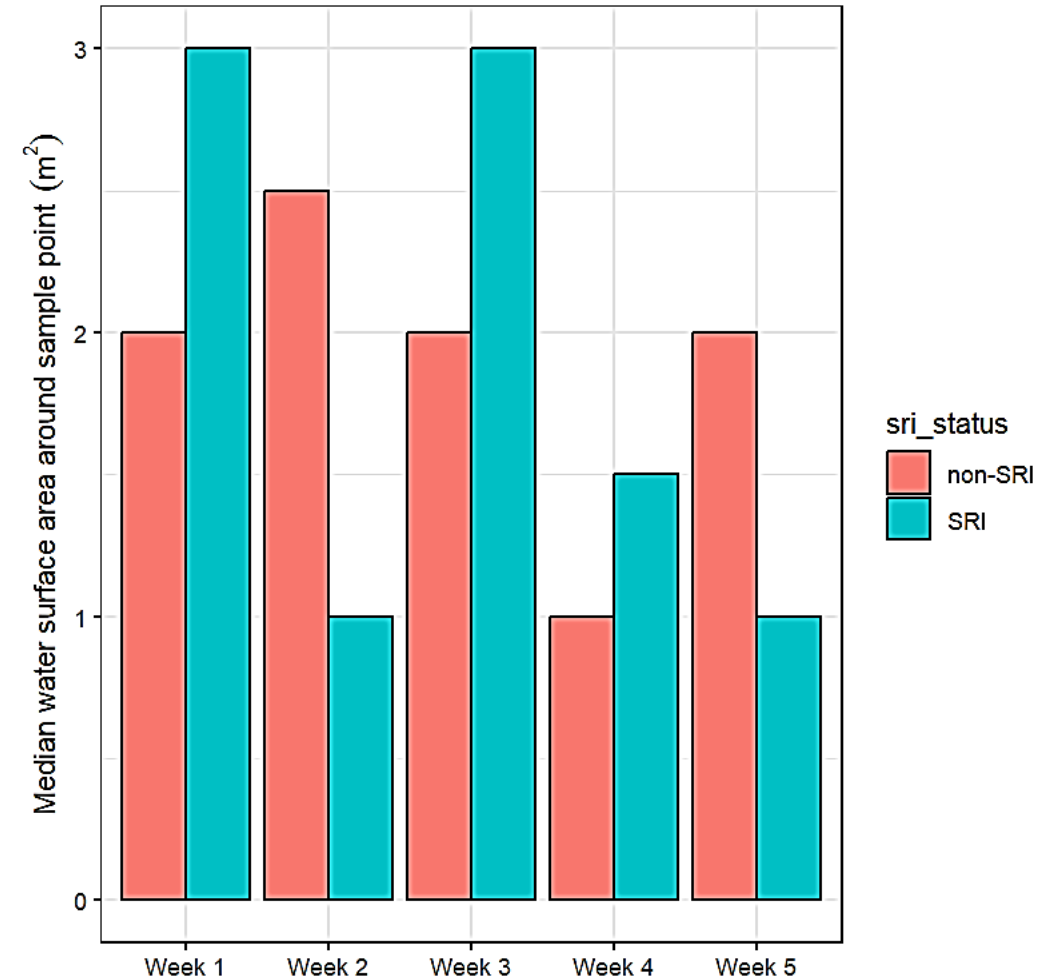




# Surface water characteristics

*Preliminary data and analysis*

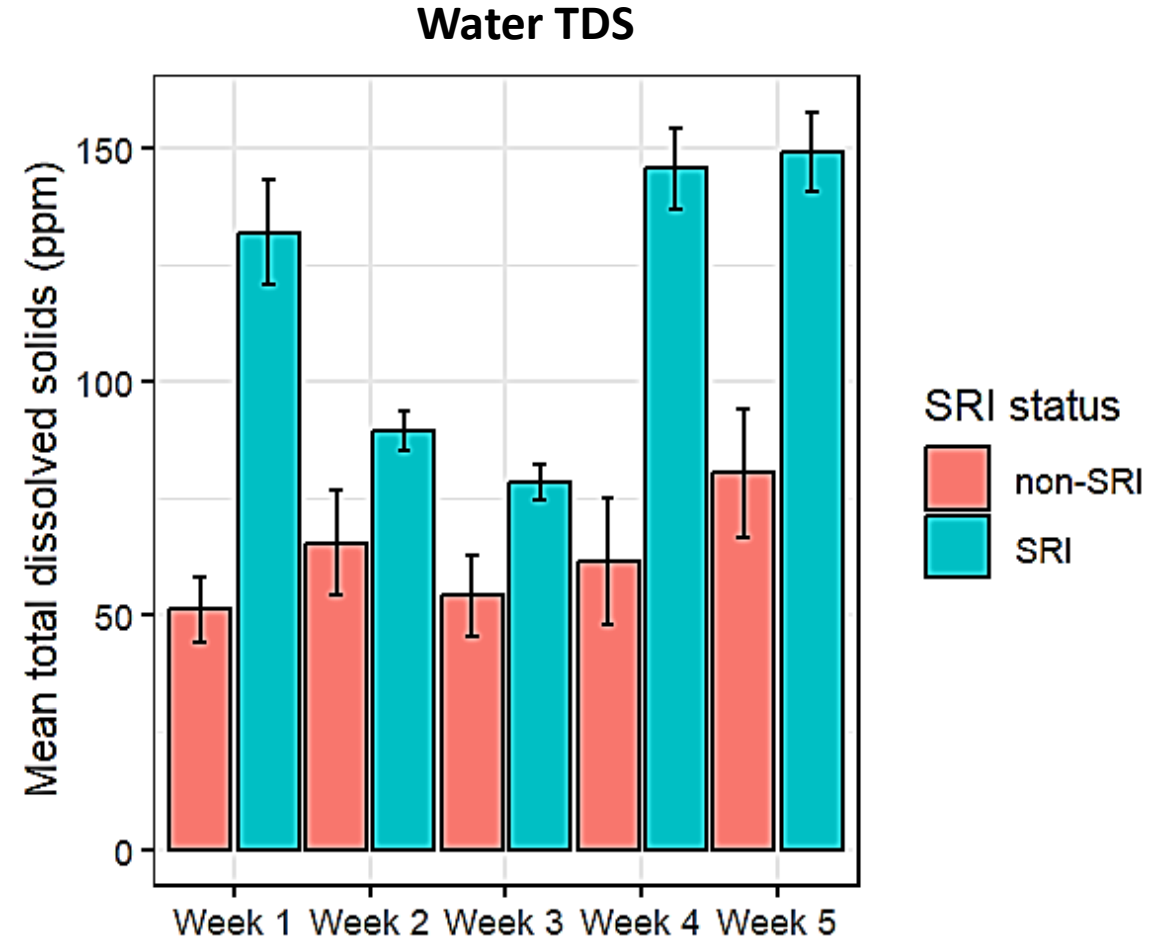
- Available surface area of water was more variable in SRI fields, compared to non-SRI, over time.
  - Reflecting the use of AWD.



# Water physicochemistry

*Preliminary data and analysis*

- No appreciable differences in pH, dissolved oxygen, salinity, or temperature.
- **TDS** generally higher in SRI and more variable over time.





# SRI and malaria transmission

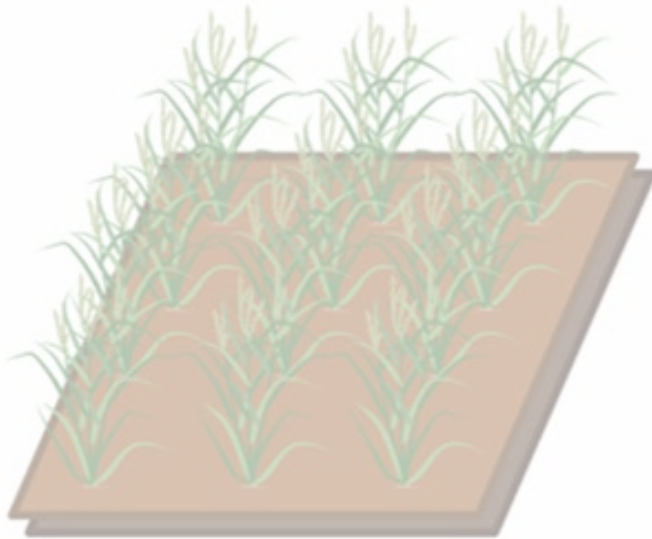
- The SRI agroecosystem appears to be a more productive habitat for malaria vectors.
  - Increased **vector densities** = enhanced **biting rates** and malaria transmission.
- Why is this occurring? Canopy structure; predator ecology; habitat availability; habitat attractivity.

$$V = \frac{ma^2bp^N}{-\log_e(p)}$$

*Vectorial capacity*

# Impact of organic fertilisers (OFs)

## SRI Rice



Seedlings raised in a nursery



Alternate wet and dry irrigation



Planting of single seedlings per hill



Regular hand/tool weeding

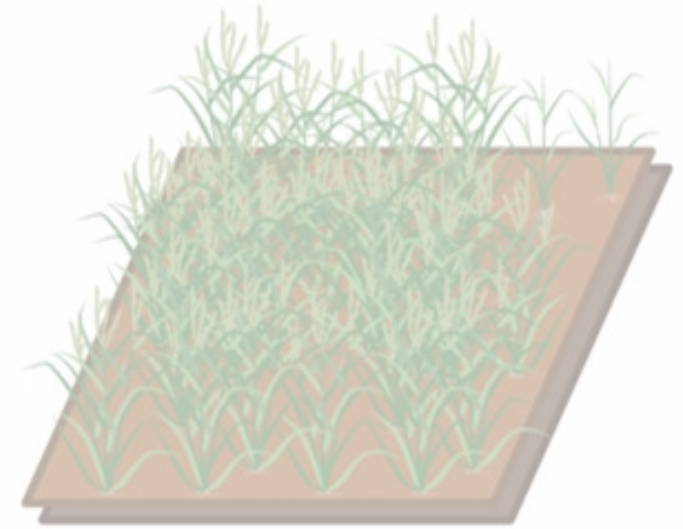


Wide grid spacing of plants



Promotion of organic fertilisers

## Non-SRI Rice



Broadcast sowing of seeds



Rainfed/irrigated flooded fields



Multiple seedlings per hill



Water controlled weeds/no weeding



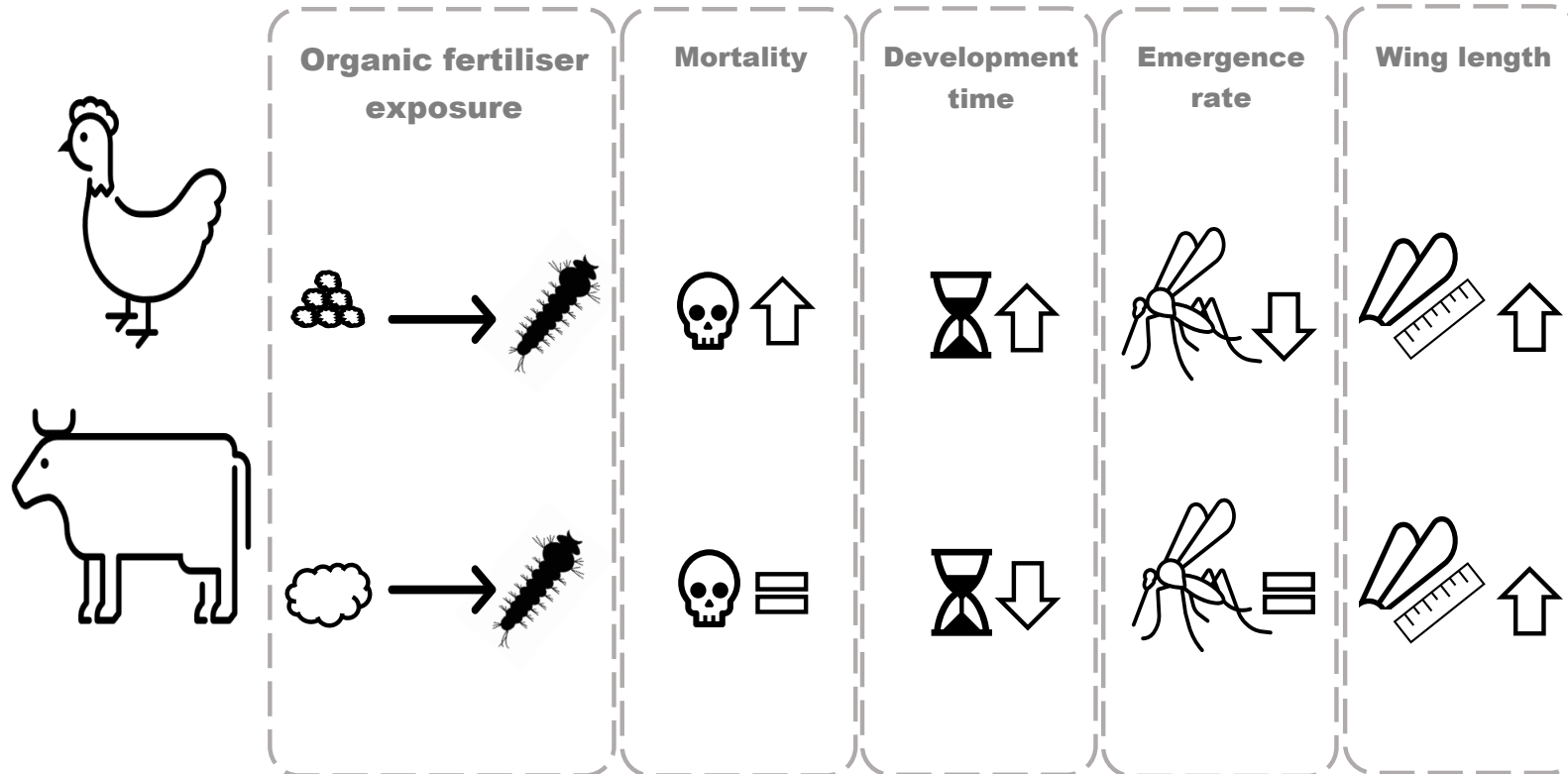
Non-uniform plant distribution



Use of industrial fertilisers



# Impact of OFs on developing larvae



- Larval exposure to **chicken** dung may reduce *An. gambiae s.l.* fitness and population density.
- Whereas **cow** dung may enhance *An. gambiae s.l.* fitness and increase population density.

# Malaria transmission and OFs

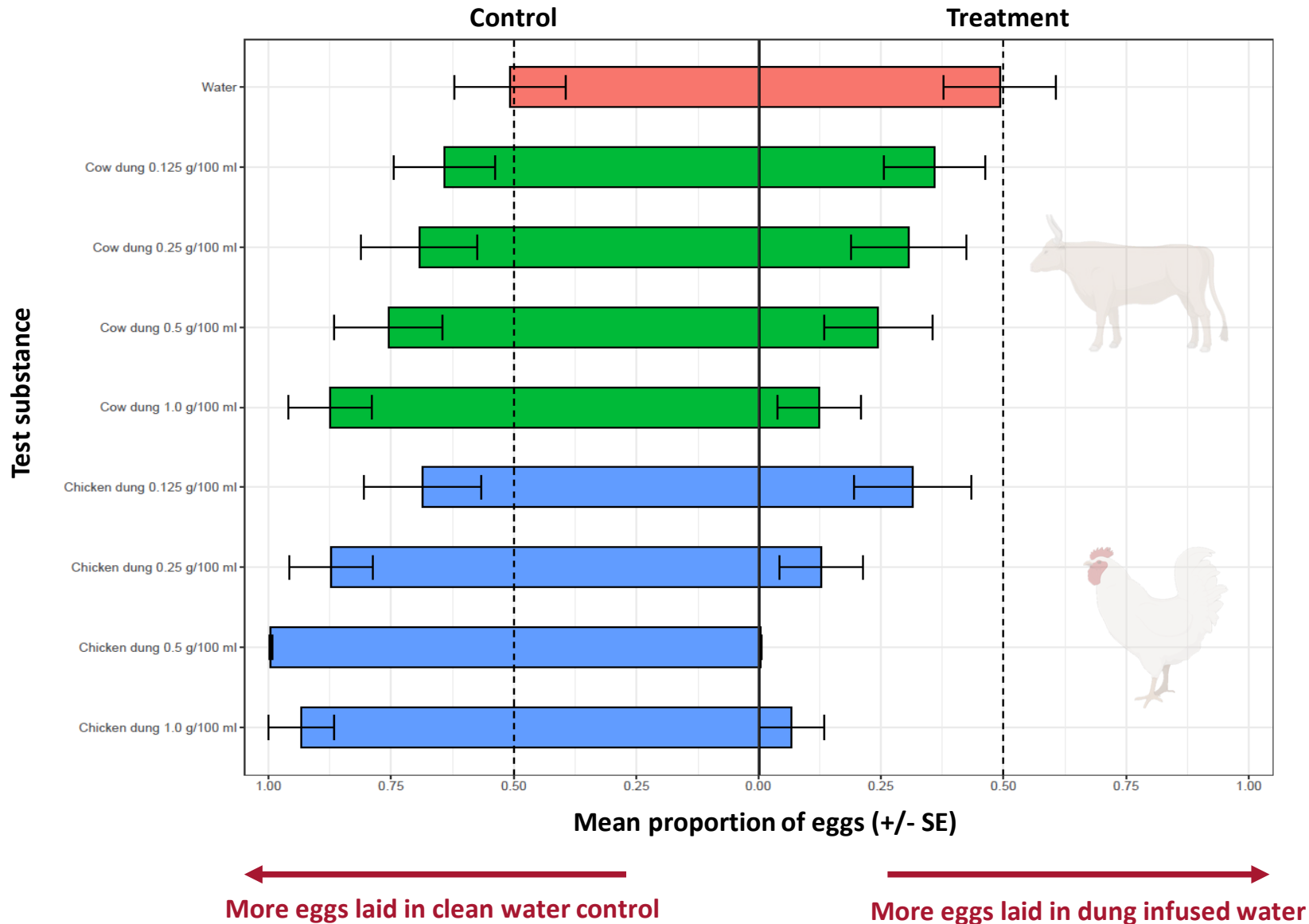
- Larval survival and adult production are key determinants of **vector density**.
- Adult body size is positively associated with increased **likelihood of daily survival**.
- Cow dung may enhance vectorial capacity, whilst chicken dung may suppress.

$$V = \frac{ma^2bp^N}{-\log_e(p)}$$

*Vectorial capacity*



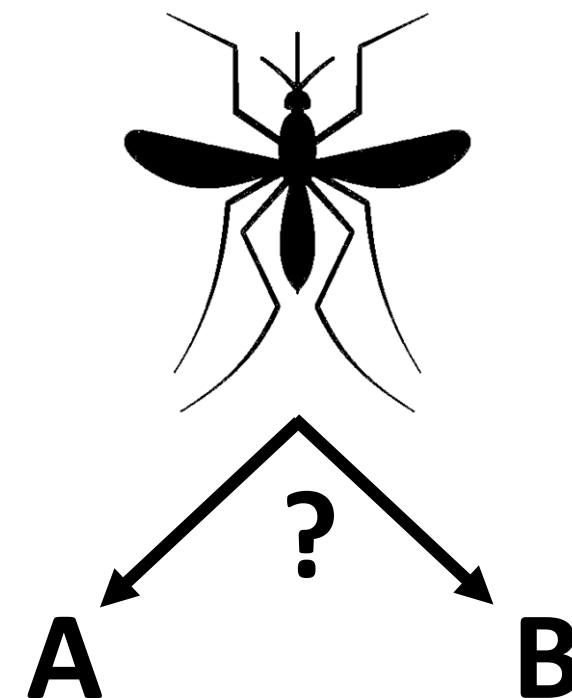
# Effects of OFs on oviposition



- Significantly fewer eggs laid in both cow and chicken dung infusions, with greater effect at higher concentrations.
- Both cow and chicken dung demonstrated a putative deterrent effect.
- Relatively, chicken dung was more deterrent.

# Egg distribution and OFs

- Though both dung types resulted in reduced oviposition rates, the effects are complex.
  - Dung application may reduce a site's attractiveness.
  - If both cow and chicken dung are applied in a given area, greater oviposition may occur in those treated with cow dung.
  - If there is a gradient in dung application across a landscape, vector density may be increased where dung application is lowest.



# Key takeaways

- **SRI practice may **unintentionally exacerbate** malaria transmission burden.**
  - We need to focus on rice intensification methods that don't concurrently intensify malaria.
- **Organic fertiliser application may affect vectorial capacity via modulation of vector life history traits.**
- Both cow and chicken dung may deter oviposition.
  - Chicken dung may be used for vector suppression, cow dung should be avoided.



# Thank you

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3. Chan K, Tusting LS, Bottomley C, Saito K, Djouaka R, Lines J. Malaria transmission and prevalence in rice-growing versus non-rice-growing villages in Africa: a systematic review and meta-analysis. *Lancet Planet. Health.* 2022;6:e257–69.
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