Rice cultivation practices and malaria vector ecology: the need for cross-sector collaboration

Harrison Hardy – PhD student

Natural Resources Institute

University of Greenwich

Contact:

harrison.lambert@greenwich.ac.uk

@HardyMedEnto

The link between rice and malaria

- **Rice agroecosystems provide habitats conducive to malaria vector breeding[1]**

  - Higher vector densities and biting rates in associated communities[2]

  - Increased malaria incidence in communities adjacent to rice cultivation[3]

- **Africa is increasing its rice production capacity**

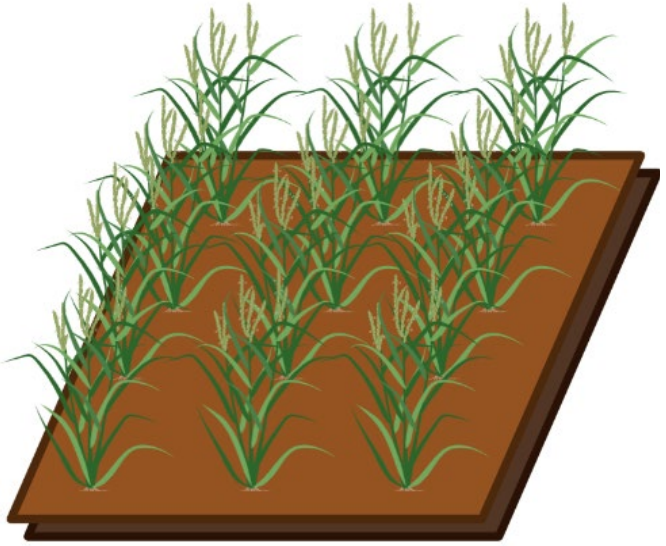
What is SRI?

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

What is SRI?

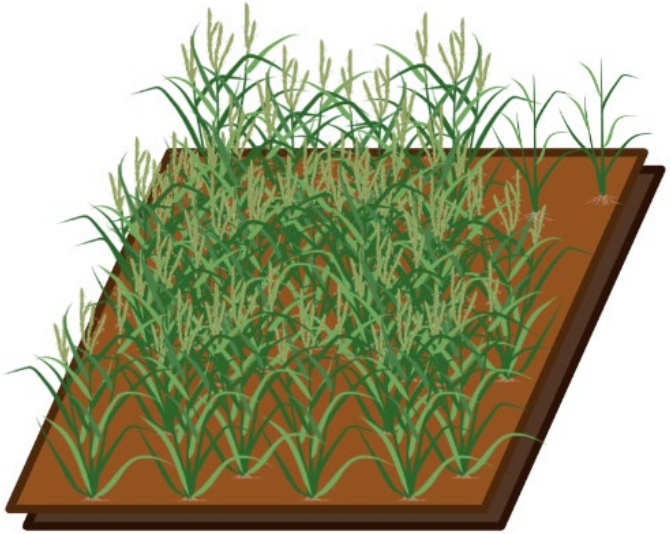
UNIVERSITY of GREENWICH
NRI | Natural Resources Institute

SRI Rice



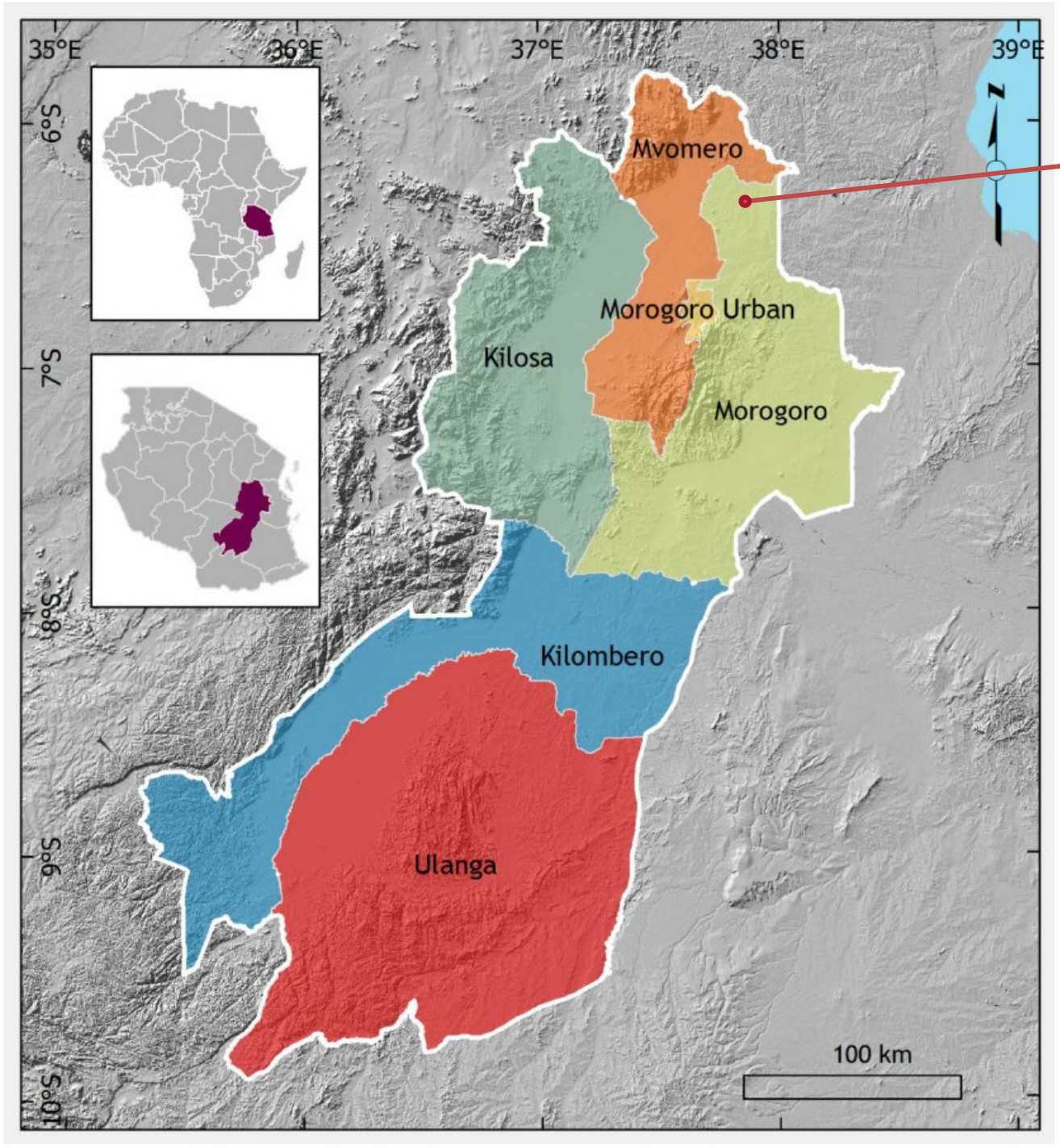
- Seedlings raised in a nursery
- Alternate wet and dry irrigation
- Planting of single seedlings per hill
- Regular hand/tool weeding
- Wide grid spacing of plants
- Promotion of organic fertilisers

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

- Four SRI and four non-SRI fields.

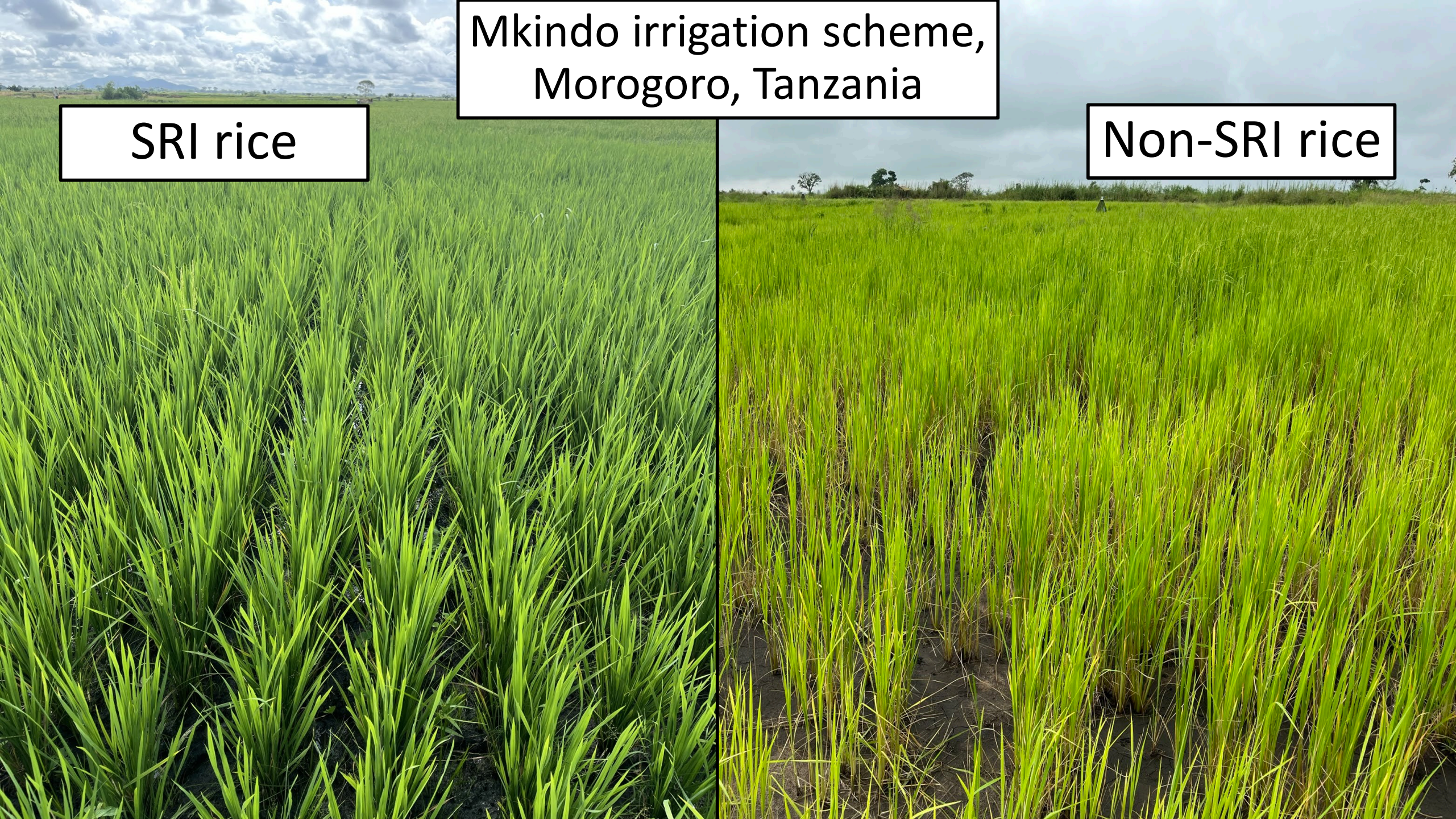
- Morogoro

- 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

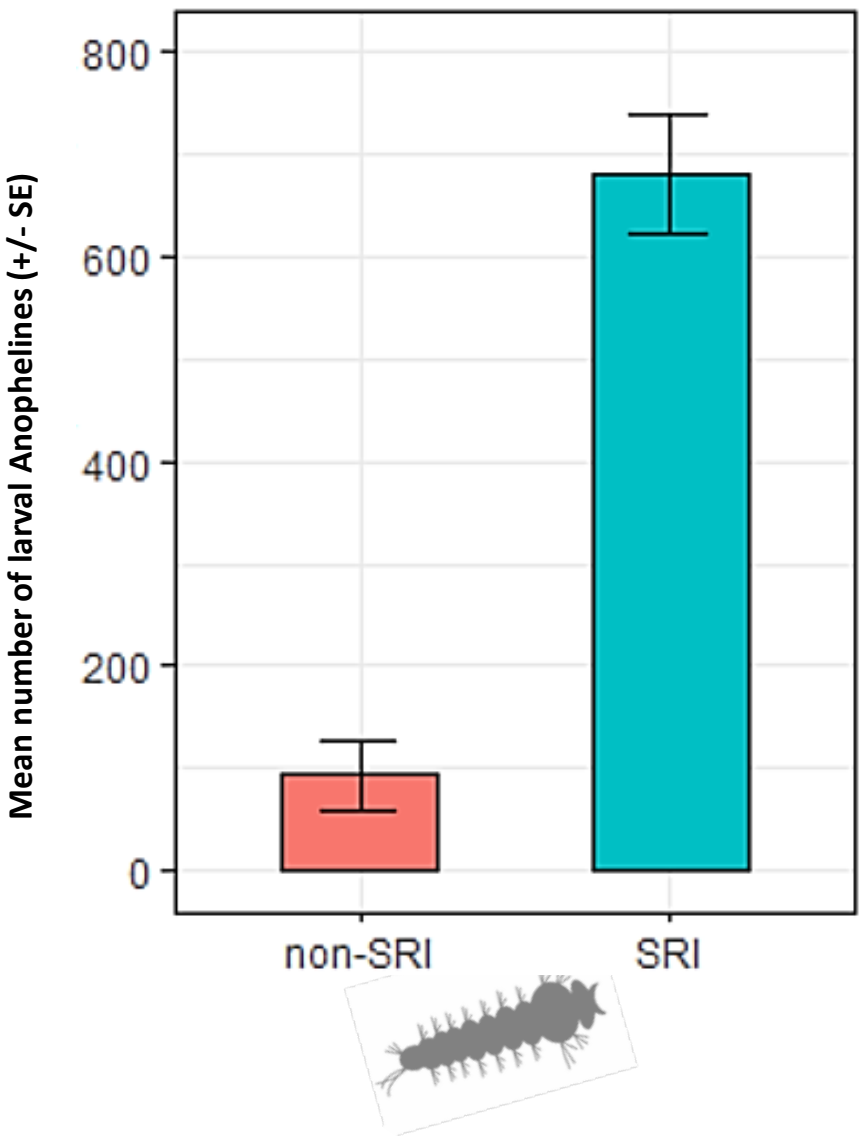
Vector bionomics: Larval and adult density

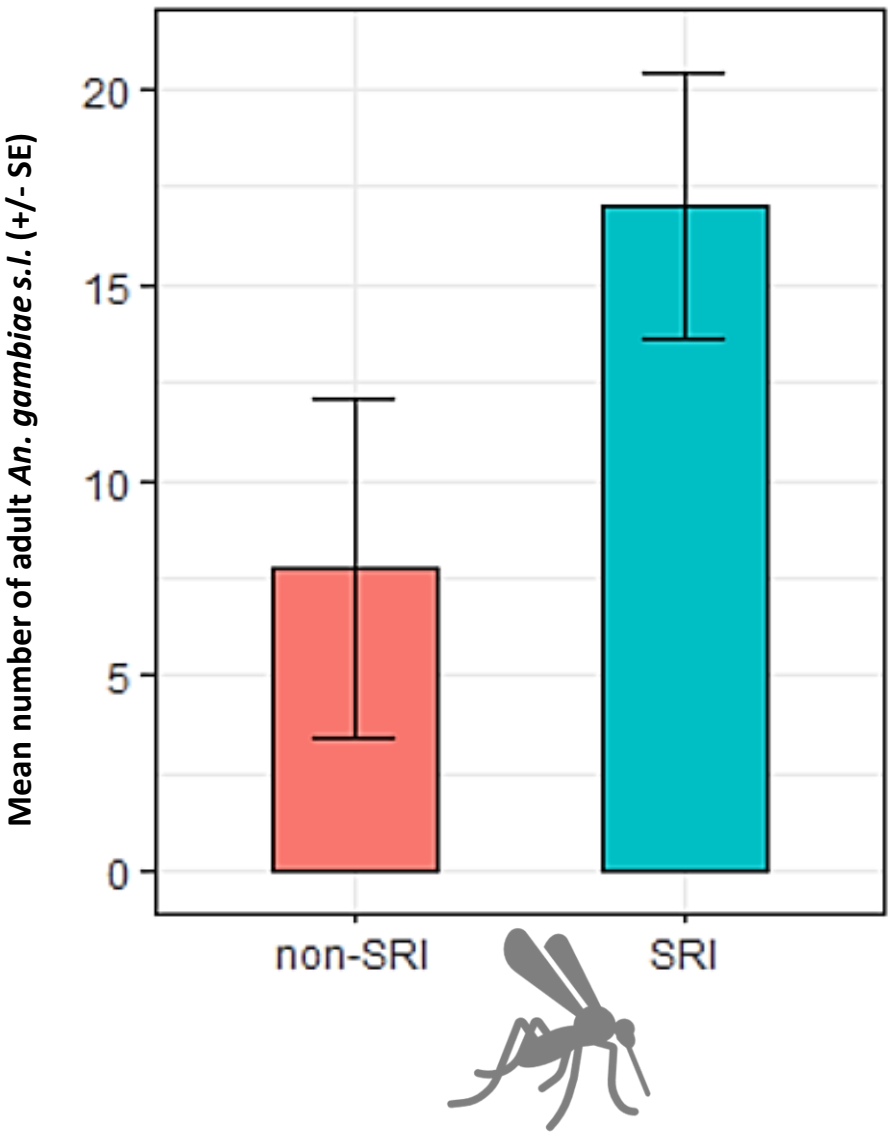
Preliminary data and analysis

UNIVERSITY of GREENWICH

NRI | Natural Resources Institute

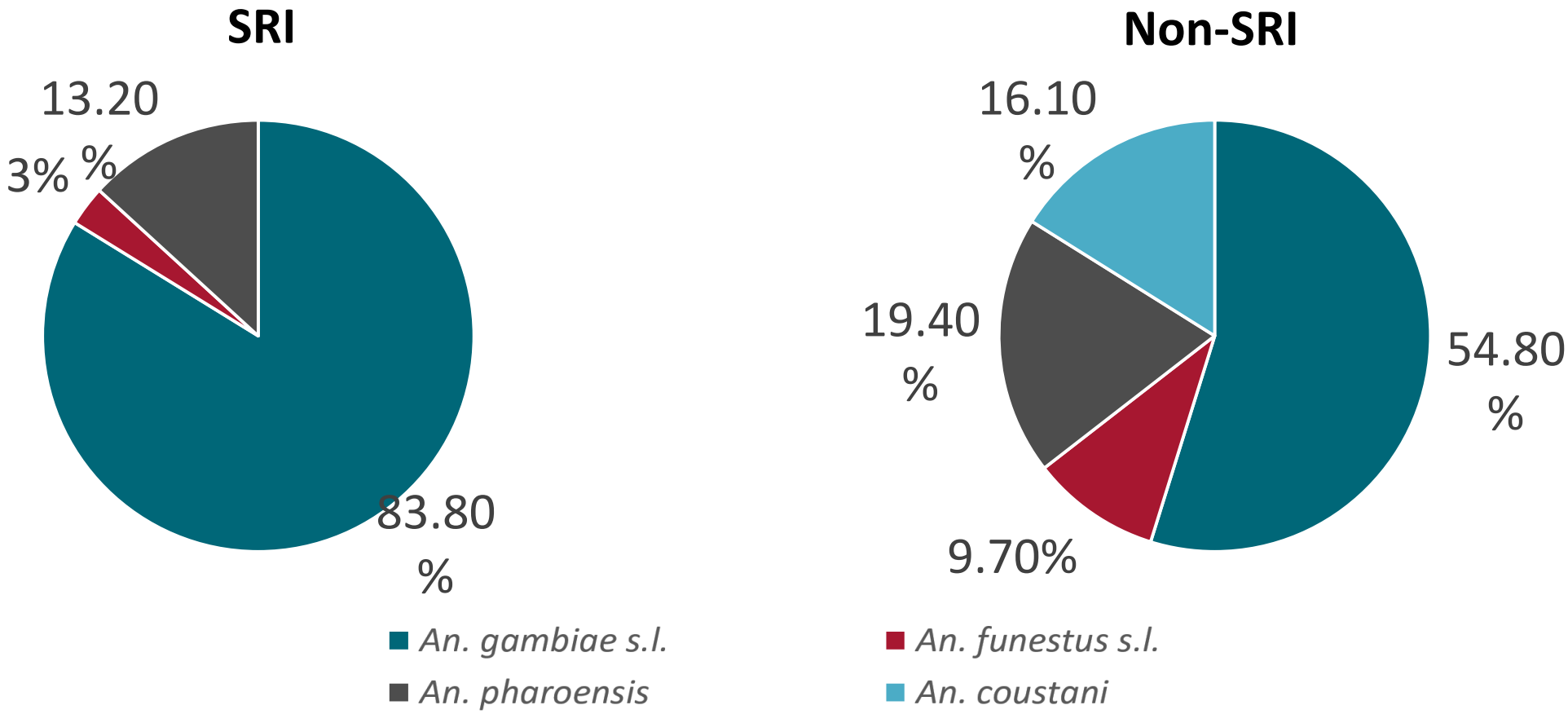
- SRI is associated with higher vector densities and productivity.





Vector bionomics: Species composition

Preliminary data and analysis.



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.

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

Vectorial capacity

- **Rice cultivation practice can affect vector populations and therefore malaria transmission.**

Medical entomologists and rice agronomists working together

UNIVERSITY of GREENWICH

NRI | Natural Resources Institute

- Rice production contributes to the malaria problem, and alternative practices can modulate this relationship.

- Currently, there is limited interaction between public health/entomology and the rice production sector.

- **How can we move forward together?**

Cross sector collaboration

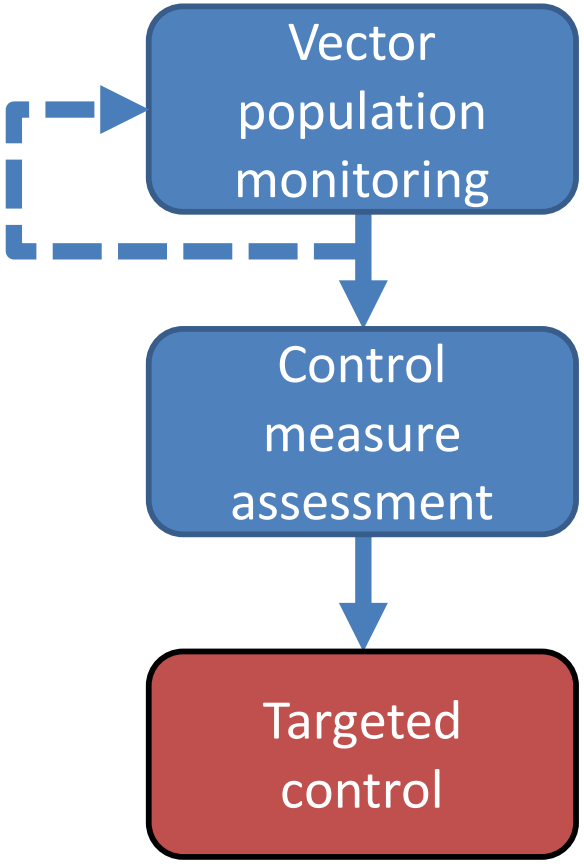
- Rice fields can act as a mosquito reservoir that undermines malaria elimination and control efforts.
- Collaboration between those seeking to intensify rice production and those working towards malaria elimination is required.
- Rice farmers must be part of the conversation.

Routine vector population monitoring

- A need for cost effective, simple, and time-efficient methods with targeted control, if needed.

  - Larval sampling creates difficulties with specimen transport and species identification.

  - Emergence traps may provide a reliable alternative for regular monitoring.



Mosquito emergence trap

Hardy, H., *et al.* (2022)

Floating emergence trap

Fillinger, U., *et al.* (2009)

Aquatic emergence trap - NHBS

https://www.nhbs.com/aquatic-emergence-trap

Integrative control methods

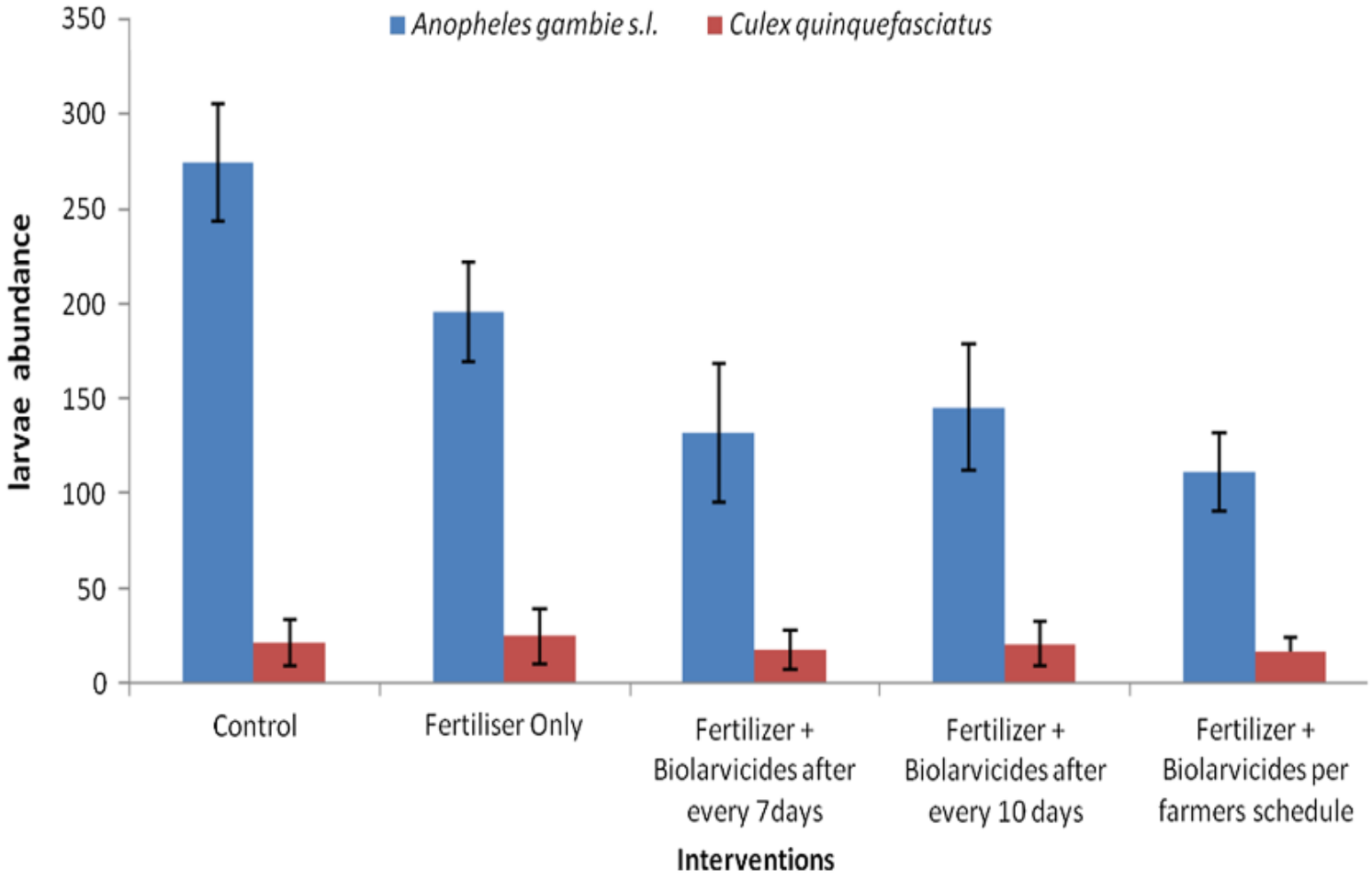
- The promotion of mosquito control strategies that do not impinge on rice productivity.

  - Bti application in tandem with fertilisers.

  - Application of organic fertilisers with larvicidal qualities such as chicken manure.

  - AWD schedules sufficient to reduce mosquito populations.

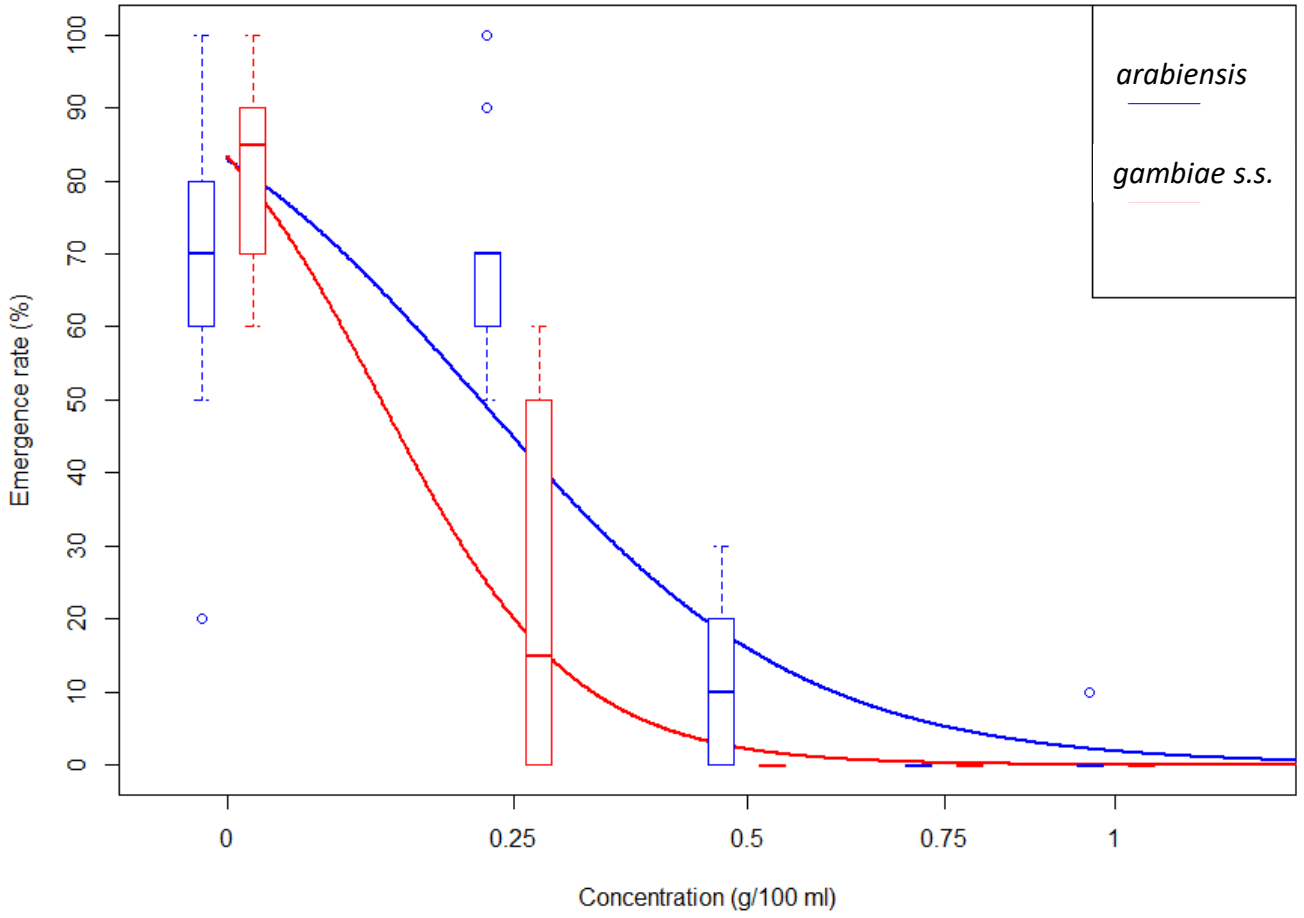
Bti/fertiliser integration



- Bti mixed with fertiliser significantly reduced *An. gambiae s.l.* abundance.
- Rice yields were not affected.
- Greatest reduction was found when following normal fertiliser schedule.

Mazigo, H. D., *et al*. (2019) Malaria mosquito control in rice paddy farms using biolarvicide mixed with fertilizer in Tanzania: semi-field experiments, Malaria Journal, 18(1), p. 226.

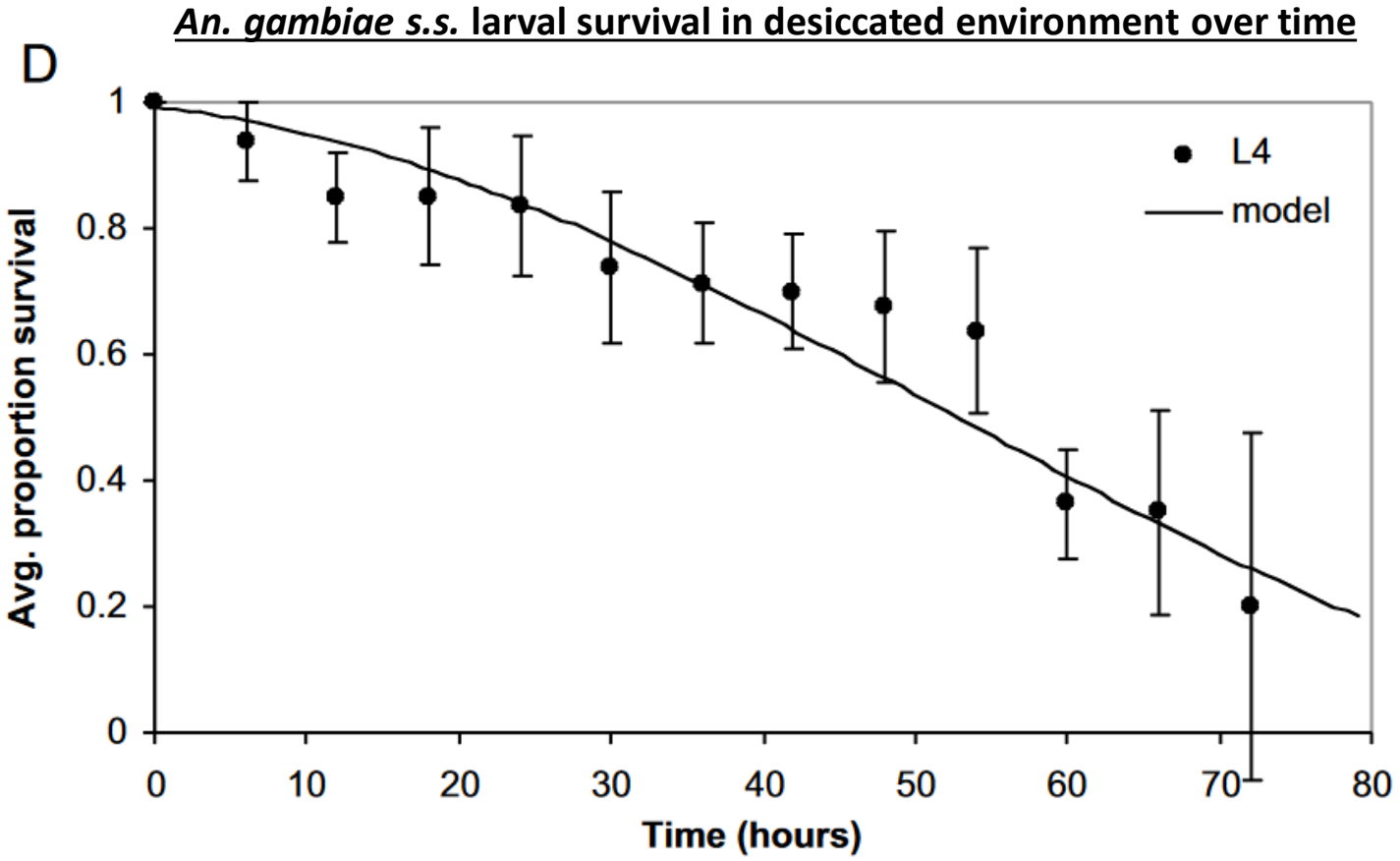
Organic fertilisers – Chicken dung



Hardy, H., *et al.* (2022) Manure and mosquitoes: life history traits of two malaria vector species enhanced by larval exposure to cow dung, whilst chicken dung has a strong negative effect, *Parasites & Vectors*, 15(1), p. 472.

- Chicken dung exposure significantly reduces *An. gambiae s.l.* adult production.
- Chicken dung is an effective fertiliser for rice.
- Promotes predators of mosquitoes **and** rice pests.

Mosquitocidal AWD schedules



Koenraadt, C. J., *et al.* (2003) Egg hatching, larval movement and larval survival of the malaria vector *Anopheles gambiae* in desiccating habitats, *Malaria Journal*, p. 9.

- Where AWD is applied, irrigation schedules are highly variable.
- Up to five dry days may be required to kill 100% of larvae.
- Effects on crop yield should be considered, but SRI research suggests AWD is beneficial.

Key messages

- Rice cultivation increases malaria transmission and cultivation practices can modulate this relationship.
- Involvement of the rice production sector is critical for reducing malaria vector populations and mosquito control.
- Rice agronomists, medical entomologists, and policy makers must work together.
- Available mosquito control interventions should be applied, but they must not impinge on rice production.

Thank you

- Roll Back Malaria
- Supervisors:
  - Dr Frances Hawkes (NRI)
  - Prof Richard Hopkins (NRI)
  - Prof Ladslaus Mnyone (SUA)
- Funding from UKRI Expanding Excellence in England – Food & Nutrition Security Initiative
- Godfrey Katusi (SUA) – Field work collaborator
- Ephrahim Norbert (SUA) – Field work collaborator
- Stephen Young (NRI) – Stats guru
- Dr Simon Springate and Natalie Morley (NRI) – insectary and lab support

RBM Partnership To End Malaria

UKRI Research England

UNIVERSITY of GREENWICH

NRI | Natural Resources Institute

SOKOINE UNIVERSITY OF AGRICULTURE · 1984 · ARDHI NI HAZINA

Contact:

harrison.lambert@greenwich.ac.uk

@HardyMedEnto

References:

1. *Muturi EJ, Shililu J, Jacob B, Gu W, Githure J, Novak R. Mosquito species diversity and abundance in relation to land use in a riceland agroecosystem in Mwea, Kenya. J. Vector Ecol. 2006;31:129–37.*
2. *Mboera, L. E. G., Bwana, V. M., Rumisha, S. F., Stanley, G., Tungu, P. K. and Malima, R. C. Spatial abundance and human biting rate of Anopheles arabiensis and Anopheles funestus in savannah and rice agro-ecosystems of central Tanzania, Geospatial Health. 2015;10(1), pp. 26–31.*
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.*
4. *Thakur, A. K., Uphoff, N. T. and Stoop, W. A. (2016) Scientific Underpinnings of the System of Rice Intensification (SRI): What Is Known So Far?, In Advances in Agronomy, Elsevier, pp. 147–179.*