The impact of organic fertilisers on the two dominant malaria vector species of Africa

Harrison Lambert[1], Prof Richard Hopkins, Dr Frances Hawkes[3]

[1] Postgraduate research student – Department of Agriculture, Environment, and Health – Natural Resources Institute.
[2] Professor of pest Behaviour, Head of Agriculture, Environment, and Health department – Natural Resources Institute.
[3] Senior Research Fellow - Department of Agriculture, Environment, and Health – Natural Resources Institute.

Background

Organic fertilisers, including animal manure/dung, are non-industrially produced materials suitable for agriculture [1]. Their use is promoted in the System of Rice Intensification (SRI), a climate change-adapted method for cultivating rice with reduced inputs and higher yields. In addition, many resource poor farmers may use organic fertilisers to supplement or fully replace industrial fertilisers [2].

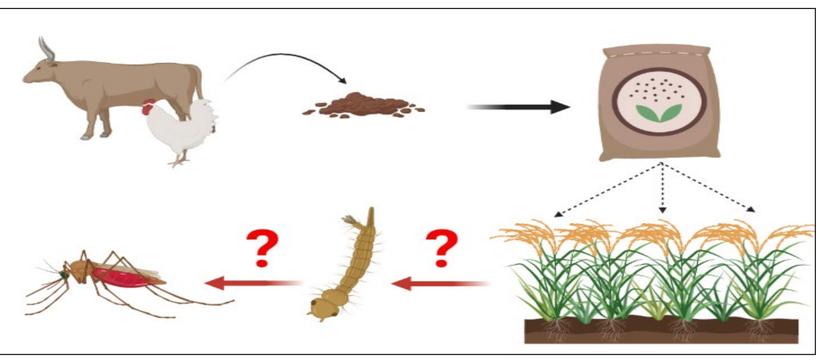
This has implications on malaria because rice irrigation can provide habitat for mosquito larvae. Little is understood about the impact of organic fertilisers on mosquito ecology in the context of SRI [3].

Previous research indicates organic fertilisers may benefit Anopheline larvae by offering a supplementary food source [4] and stimulating egg-laying [5].

It is important to understand whether SRI may have unintended impacts on mosquito abundance and potential knock-on effects on malaria transmission, to support transitions towards sustainable and climate-adapted agricultural techniques.

Aims

1. Determine the impact of chicken dung and cow dung on the survival, development, and body size (wing length as proxy [6]) of juvenile *An. arabiensis* and *An. gambiae s.s.*
2. Determine the effect of varying treatment concentration on the previously outlined parameters.



Methods

- *An. arabiensis* and *An. gambiae s.s.* exposed to cow dung and chicken dung in water.
- Randomized complete block design laboratory assays consisting of 10 larvae and measured fertiliser dose.
- Each fertiliser tested at 0.25, 0.5, 0.75, and 1.0 g/100 ml, and a control, with 10 replicates.
- Larvae fed fish flakes at 0.3 mg/larva; experiment conditions representing natural climate (light: dark 12:12hr; 25°C, 75% RH).

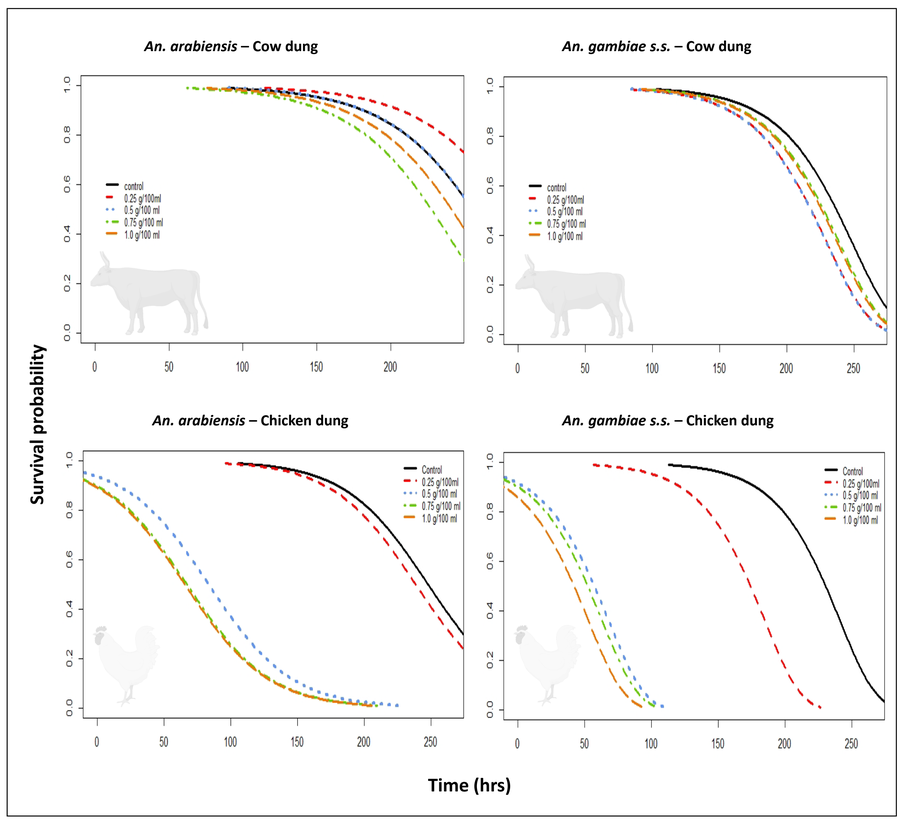


Figure 1: Survival of *An. arabiensis* and *an. gambiae s.s.*

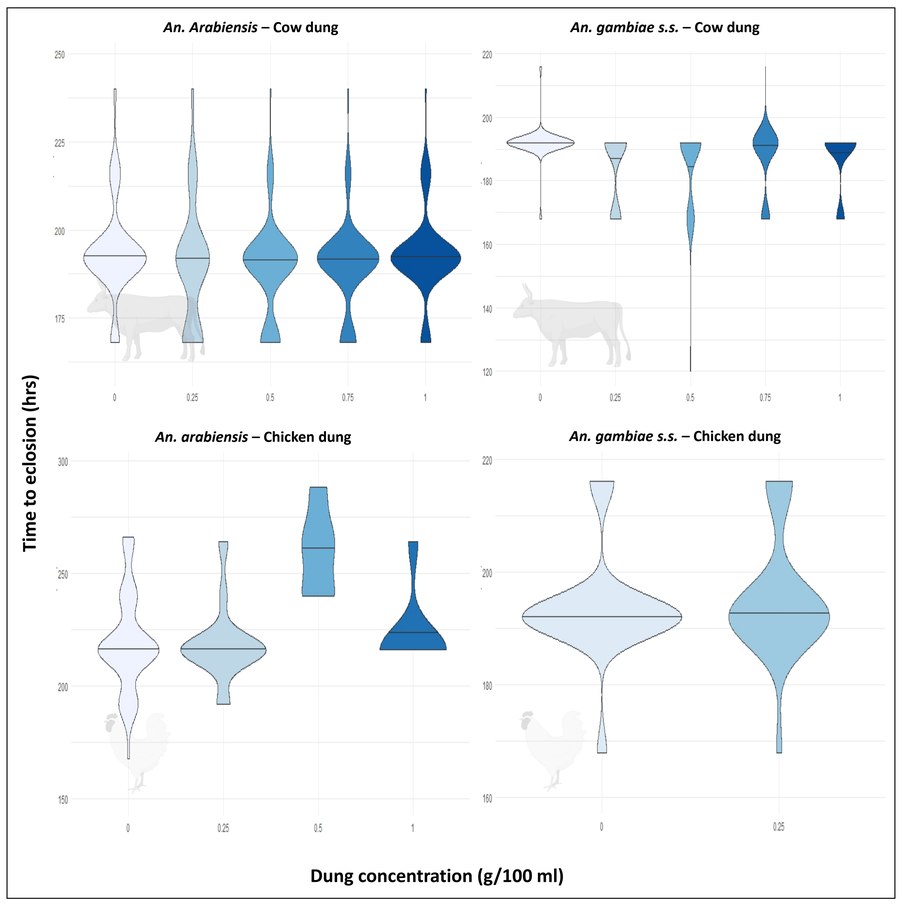


Figure 2: Development rate of *An. arabiensis* and *An. gambiae s.s.*

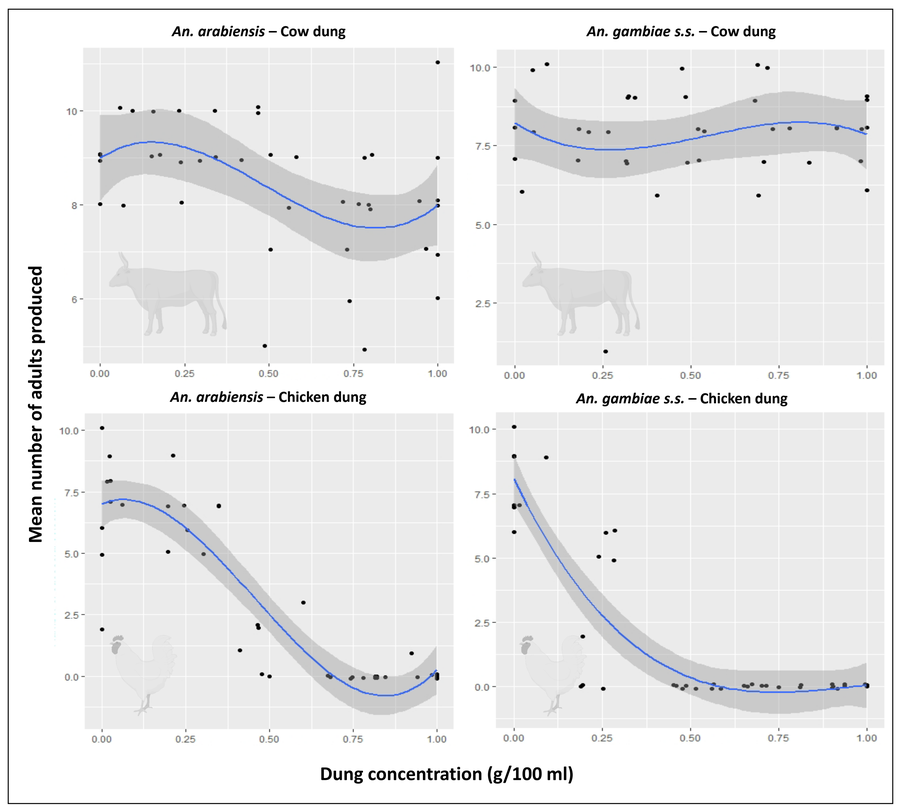


Figure 3: Adult production of *An. arabiensis* and *An. gambiae s.s.*

Results

Survival (Fig. 1)

- Cow dung caused no sig. diff. in survival in *An. arabiensis* and *An. gambiae s.s.*
- Significantly lower survival from 0.5 g/100 ml of chicken dung in *An. arabiensis* (P = <0.05) and across all concentrations in *An. gambiae s.s.* (P = <0.01).

Production of adults (Fig. 3)

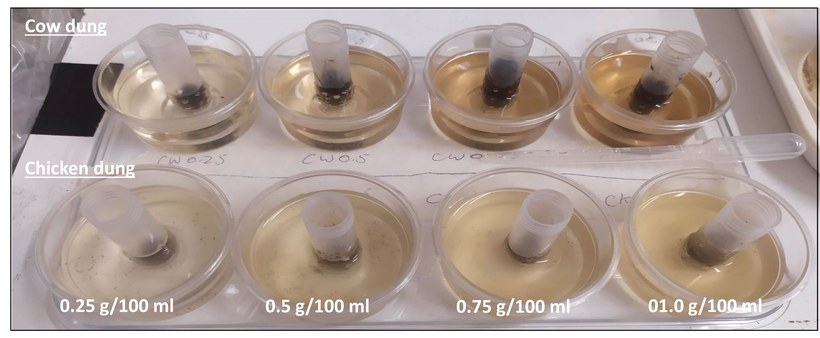
- Cow dung concentration not a sig. predictor of adult production.
- Chicken dung concentration is a sig. predictor of adult production (P = <0.05).
- No adults produced at 0.75 g/100 ml in *An. arabiensis* with chicken dung, and none in *An. gambiae* above 0.25 g/100 ml.

Development (Fig. 2)

- No sig. diff. in development across all concentrations of cow dung in *An. arabiensis* but sig. faster development across all concentrations in *An. gambiae s.s.* (P = ≤0.01).
- Chicken dung caused sig. slower development in *An. arabiensis* at 0.5 g/100 ml. No sig. diff. in development in *An. gambiae s.s.* at 0.25 g/100 ml.

Wing length

- Preliminary experiments show wing length sig. increases in *An. gambiae s.s.* treated with cow and chicken dung (P = <0.05).



Conclusions

- *An. arabiensis* survival, adult production, and development are not impacted by cow dung.
- *An. gambiae s.s.* survival and adult production is not impacted by cow dung; however, development rate is increased.
- Survival and adult production are lower in both species when exposed to chicken dung. Development slower in *An. arabiensis* at intermediate concentrations.
- *An. arabiensis* seem to have a higher tolerance of low concentrations of chicken dung.
- Adult body size may increase as a result of exposure to cow and chicken dung.
- Cow dung as an organic fertiliser for rice may increase vector abundance. However, chicken dung may reduce abundance and, therefore, malaria-burden.

References

1. 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.
2. Dahiru, M. (2018) System of Rice Intensification: A Review, p. 13.
3. Jeanrenaud, A. C. S. N., Brooke, B. D. and Oliver, S. V. (2019) The effects of larval organic fertiliser exposure on the larval development, adult longevity and insecticide tolerance of zoophilic members of the Anopheles gambiae complex (Diptera: Culicidae), Hülsen, T. (ed.), PLOS ONE, 14(4), p. e0215552.
4. Jeanrenaud, A. C. S. N., Brooke, B. D. and Oliver, S. V. (2019) The effects of larval organic fertiliser exposure on the larval development, adult longevity and insecticide tolerance of zoophilic members of the Anopheles gambiae complex (Diptera: Culicidae), Hülsen, T. (ed.), PLOS ONE, 14(4), p. e0215552.
5. Buxton, M., Cuthbert, R.N., Dalu, T., Nyamukondiwa, C. and Wasserman, R.J., 2020. Cattle-induced eutrophication favours disease-vector mosquitoes. Science of The Total Environment, p.136952.
6. Lyimo, E. O. and Takken, W. (1993) Effects of adult body size on fecundity and the pre-gravid rate of Anopheles gambiae females in Tanzania, Medical and Veterinary Entomology, 7(4), pp. 328–332.

Contact

For more information, contact:

Harrison Lambert

Postgraduate research student
Natural Resources Institute, UK
Harrison.lambert@greenwich.ac.uk