Improving Malaria Transmission Risk Models

Temitayo O. Adanlawo, Kerri L. Miazgowicz, and Dr. Courtney C. Murdock

Introduction

Current malaria transmission risk models predict that the relationship between malaria risk and temperature is both positive and linear. However, mosquito and parasite traits responsible for malaria transmission display a non-linear trend with increasing temperature. This has resulted in an inconsistency with malaria’s predicted incidence rates and disease actualization. Furthermore, this discrepancy can be linked to the lack of quality data across different temperatures for Anopheles stephensi. Past studies conducted:

- Used data substitutes (diff. species & pathogens) to generate thermal performance curves.
- Found the largest uncertainty in risk prediction was associated with bite rate (q), fecundity (EFD), and daily probability of mortality (µ).

This experiment aims to enhance the data available for A. stephensi (an important vector of malaria) across relevant temperatures, and thus, improve the transmission risk model.

The Rₐ equation is used to predict the number of resulting cases from a single infection. This experiment aims to improve the precision of the Rₐ Equation using temperature-dependent functions for fecundity, mortality, and bite rate.

Methods and Materials

Life Table Study (N = 180)

- Fecundity (Eggs per Female per Day)
- Mortality (# of dead & when at different temperature treatments)
- Bite Rate (# of occurrences mosquito takes a blood meal)

Results

Mosquitoes at the mid temperatures (24°C, 28°C, and 32°C) had the highest EFD values.

Mosquitoes at higher temperatures have higher biting rates than those at lower temperatures.

Discussion

This experiment demonstrates:

- Mortality, fecundity, and bite rate are all interconnected.
- Notably, longevity plummets as temperature increases.

Mortality and bite rate play significant roles in the overall population size of the mosquito vector, because those with decreased longevity have a smaller time span to bite, lay eggs, and reproduce. This alters the density of mosquitoes to humans which is a factor in the transmission risk equation.

Conclusion: This experiment generated a robust data set comprising of important A. stephensi life history traits essential for generating improved malaria transmission risk models which incorporate a temperature-dependent mechanistic framework and essentially filling the knowledge gap there once was about Anopheles spp. mosquitoes.

Future Directions

1. Generate thermally-dependent function for three traits measured

\[ R_0(T) = \sqrt{\frac{\text{EFD}_{\text{P}} \times \text{MDR}_{\text{B}} \times \text{Bce}_{\text{v}} \times \text{PDR}}{\text{N}_{\text{R}}}} \]

2. Apply model to the ‘real’ world

- Better accuracy in determining risk of transmission in malaria-susceptible areas.

Acknowledgements

Many thanks to the Murdock Lab, the Population Biology of Infectious Diseases at the University of Georgia, the Odum School of Ecology, and The College of Veterinary Medicine.

Thank you to Howard University, my family, and friends.

Funding is provided by the National Science Foundation & the National Institute of Health.

NIH R01 1R01AI110793-01A1

Contact

Temitayo O. Adanlawo
Email: tayoadanlawo@gmail.com

References

1. Mordcaei et. al, 2013
2. World Health Organization
3. Johnson et. al, 2014