

MODELLING THE DEMOGRAPHY AND CONTROL OF DISEASE-CARRYING  
TROPICAL MOSQUITOES IN NORTHERN AUSTRALIA

By

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## Statement of Originality

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\*DE LITTLE, S. C., BOWMAN, D. M. J. S., WHELAN P. I., BROOK, B. W. & BRADSHAW, C. J. A. 2009. Quantifying the drivers of larval density patterns in two tropical mosquito species to maximize control efficiency. *Environmental Entomology*, 38:4, 1013-1021.

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## **Abstract**

Mosquito-borne pathogens constitute a major burden of disease for humans globally, and are predicted to increase in range and incidence given climate change projections based on 21<sup>st</sup> Century emissions scenarios for greenhouse gases. Understanding the contributions of environmental variation and density feedback to changes in vector population abundance is essential for designing effective control programmes and predicting disease outbreaks in humans. In my thesis I outline a population ecologist's five-step plan for mosquito control, and define the parameters needed to create spatially explicit demographic models of mosquito population dynamics using an example disease-vector system in Darwin, Northern Territory, Australia. My spatio-temporal models of larval abundance treat two important vector species in the Northern Territory: *Aedes vigilax* and *Culex annulirostris*. I show how larval habitats used by the saltwater-influenced breeder *Ae. vigilax* and the obligate freshwater breeder *Cx. annulirostris* are separated both spatially and temporally in a tidally influenced swamp. I identify adult abundance in the previous month as the most important temporal driver of larval densities in both species, providing a clear dynamical link between the two main life phases in mosquito development: the aquatic larval stage and the mobile adult stage. My field experiments show that the main vector control programme in the Northern Territory, aerial larvicide application, is effective at suppressing adult emergence of *Ae. vigilax*, whereas other possible larval control measures such as vegetation removal via burning or slashing are not as effective in this context. My experiments reveal that current larval sampling procedures alone are inadequate for quantifying larval abundance or adult emergence. Further manipulation experiments show that reducing *Ae. vigilax* larval densities results in the emergence of larger adults, and that this relationship between larval density and adult emergence size is tempered by environmental conditions such as changes in nutrient levels across different larval habitats. Mosquito body size is linked to vital rates such as fertility and adult survival that are important determinants of disease transmission probability. My measurements of body size of remotely trapped female *Ae. vigilax* adults reveal evidence for longer survival time since

emergence in larger adults, and together these findings define an important mechanism of density feedback in mosquito populations; competition for resources at the larval stage results in smaller adult emergence sizes, and therefore, lower adult survival and fertility. My block-bootstrapped generalised linear models of a widespread tropical and subtropical disease in Australia – Ross River virus – show that environmental proxies of adult vector abundance, rather than trapped vector abundance data, are the most accurate predictors for the highest priority health statistic: wet season outbreaks of Ross River virus cases. These results demonstrate that quantifying the environmental determinants of variation in larval habitat quality and the subsequent production of adults provides the means to construct models that are likely more accurate for predicting disease transmission than expensive residential vector monitoring systems. Given that low-income tropical developing countries are the hardest hit by mosquito-borne diseases, cost-effective solutions to deal with the current and future burden of mosquito-borne disease are of paramount importance to global human health.

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The contributed datasets include:

- i. *Aedes vigilax* and *Culex annulirostris* larval abundance data, water presence data, monthly *Ae. vigilax* and *Cx. annulirostris* adult abundance data and monthly spraying hours data for the Leanyer/Holmes Jungle swamp complex spanning November 2000 to December 2006 (Chapter 2).
- ii. Monthly counts of laboratory-confirmed cases of Ross River virus infections in the Darwin region notified to the Northern Territory Centre for Disease Control, and monthly *Ae. vigilax* and *Cx. annulirostris* adult abundance data from 11 locations around Darwin spanning January 1991 to December 2007 (Chapter 5).

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“The mosquito’s a clever little bastard. You can track him for days and days until you really get to know him like a friend. He knows you’re there, and you know he’s there. It’s a game of wits. You hate him, then you respect him, then you kill him.”

– Roy Spim, Mosquito Hunter.

Mosquito Hunter’s Sketch, Monty Python’s Flying Circus





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