

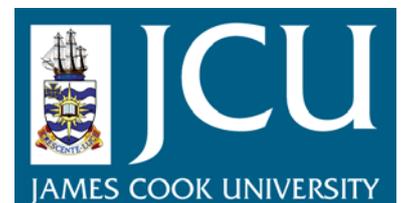
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**The BG-Sentinel™ trap as a suitable tool
for *Aedes aegypti* surveillance in Far North
Queensland, Australia**

Thesis submitted by

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in January 2010

for the degree of Doctor of Philosophy

in the School of Public Health, Tropical

Medicine & Rehabilitation Sciences

James Cook University

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Tamara S. Ball

February 12, 2010
Date

Statement on the Contribution of Others

Sections of the work presented in this thesis were completed with the assistance of other researchers. The contributions of others to this thesis and to future publishable outcomes of the research undertaken during my candidature are acknowledged below.

Nature of Assistance	Contribution	Names, Titles, and Affiliations of Co-Contributors
Intellectual support	Editorial assistance	Dr. Scott Ritchie, James Cook University, QLD
Financial support	Field research, Stipend, and Grant	Financial support for this research and my stipend was provided by the Foundation for the National Institutes of Health through the Grand Challenges in Global Health Initiative.
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Tamara S. Ball

January, 2010

Scott A. Ritchie

January, 2010

Declaration on Ethics

The research presented and reported in this thesis was conducted within the guidelines for research ethics outlined in the *National statement on Ethics Conduct in Research Involving Humans (1999)*, the *Joint NHMRC/AVCC Statement and Guidelines on Research Practice (1997)*, the *James Cook University Policy on Experimentation Ethics. Standard Practices and Guidelines (2001)*, and the *James Cook University Statement and Guidelines on Research Practice (2001)*. The proposed research methodology received clearance from the James Cook University Experimentation Ethics Review Committee (approval number H2250).

February 12, 2010

Tamara S. Ball

Date

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In Memory of Professor Chris Curtis

List of Publications from this Thesis

Publications incorporated into the thesis:

BALL, T.S., RITCHIE, S. A. (2010) Sampling biases of the BG-Sentinel™ trap with respect to physiology, age, and body size of adult *Aedes aegypti*. *Journal of Medical Entomology* 47(4): 649-656. (Chapter 2)

BALL, T.S., RITCHIE, S. A. (2010) Evaluation of the BG-Sentinel™ trap trapping efficacy for *Aedes aegypti* in a visually competitive environment. *Journal of Medical Entomology* 47(4): 657-663. (Chapter 3)

Abstract

Aedes aegypti is the vector of dengue fever in far north Queensland where dengue outbreaks occur each year. The most recent outbreak in 2008/2009 saw all four serotypes of the virus circulating in the region with 1025 reported cases. Surveillance of the vector population is an important component of vector control and therefore dengue management. There are several tools that are currently used to measure the *Ae. aegypti* population, and like any sampling method, these tools need to be better understood and refined in order to achieve measurable outcomes in the field. The value of these tools lies in their sampling efficacy, and ultimately in how well we use them and understand the data that they produce—our ability to accurately interpret data from a very limited subsample of the field population.

Each sampling tool presents certain biases. Once these biases are defined, methods used to estimate population size and structure can be calibrated accordingly, resulting in more accurate and complex estimates of the vector population. Currently there are control strategies being developed that involve manipulation of *Ae. aegypti* in the adult stage (e.g. the use of the bacterial endosymbiont *Wolbachia* to shorten the lifespan of the vector population). These novel strategies demand adult sampling tools to measure changes in population size, structure (age, sex ratio) and ultimately the success of the program. The BG-Sentinel™ trap (BGS) is a proven tool that successfully samples the *Ae. aegypti* adult population. A series of mark-release-recapture experiments with adult *Ae. aegypti* were conducted in a large outdoor flight cage and an indoor setting in far north Queensland, to investigate the sampling biases of this particular trap. Biases were investigated across several categories, including: i) mosquito age ii) sex iii) physiological status and iv) body size. Biases were not detected across age groups or body sizes. A significant bias was detected across physiological groups: nulliparous females were recaptured at a significantly lower rate than all other groups except blood-fed parous females which were also recaptured at a low rate by the BGS. Males were recaptured at a higher rate than all groups, but only a significant difference in recapture rates was observed between males and nulliparous females. The sampling bias of the BGS is measurable and can be used to

generate more accurate estimates of the adult population and its attributes when sampling the field population.

Once the sampling biases of the BGS were defined, the efficacy of the trap within a competitive visual environment was investigated. The impact of the visual environment on trapping efficacy was of particular interest due to the visual cues used by the BGS to attract *Ae. aegypti*. Four to five day old males and nulliparous females were released into a semi-controlled room to evaluate the effect of the presence, reflectance, and distribution of surrounding harbourage sites on BGS trapping efficacy. Low-reflective (dark) harbourage sites near the BGS had a negative effect on both male and nulliparous female recapture rates. However, a more pronounced effect was observed in males. The distribution (clustered vs. scattered) of dark harbourage sites did not significantly affect recapture rates in either sex. In a subsequent experiment, the impact of oviposition sites on the recapture rate of gravid females was investigated. Although gravid females went to the oviposition sites and deposited eggs, the efficacy of the BGS in recapturing gravid females was not compromised. *Aedes aegypti* sampling in the field will mostly occur in the urban environment, whereby the BGS will be amongst oviposition sites and dark harbourage areas in the form of household items and outdoor clutter. In addition to understanding sampling biases of the BGS, estimations of the adult population size and structure can be further adjusted based on an understanding of the impact of the visual environment on trap captures. Outcomes from this suite of experiments provide us with important considerations for trap deployment and interpretation of *Ae. aegypti* samples from the BGS trap.

In order to understand what the BGS field samples convey about the field population, BGS field data were correlated with field population estimates generated by a weather-driven container-inhabiting mosquito simulation model (CIMSIM). This model uses container data as well as weather data to create a life table that estimate the daily population size of *Ae. aegypti* from the number of eggs to the number of adults. This particular model was recently validated and calibrated for this region. A widespread survey of premises over an 11ha area was undertaken in

February (wet season) and August (dry season) of 2007. This area was divided into ten ~1ha sections for which individual data were generated both from the model and from the BGS. One hundred and fifty-nine and 152 of 176 premises were inspected for containers during the wet and dry season, respectively. Sixty-seven BGS traps were set out during the wet season and 72 during the dry season over a 24h period. BGS data were correlated with the outputs generated by the CIMSiM model. A positive correlation between the BGS and the model outputs was observed during the wet season, but not during the dry season. Widespread trapping with the BGS over longer periods of time may reveal a stronger or weaker relationship between trap and model. Whatever the relationship between trap and model may be, interpretation of adult sampling data with the BGS needs to be further pursued in order to achieve measurable outcomes that can assist in achieving long term success in dengue control strategies.

Table of Contents

Statement of Access	2
Electronic Copy	3
Statement of Originality	4
Statement on the Contribution of Others	5
Declaration on Ethics	6
Acknowledgements	7
List of Publications	9
Abstract	10
Table of Contents	13
List of Tables	16
List of Figures	17
Chapter 1. Introduction and literature review	20
1. Introduction.....	21
2. Literature review.....	27
2.1 Sampling the egg population.....	27
2.1.1 Standard ovitraps.....	27
2.1.2 Lethal and biodegradable ovitraps.....	28
2.2 Larval / pupal sampling.....	30
2.2.1 Funnel trap.....	30
2.2.2 Estimating productivity from sampling larvae and pupae.....	30
2.2.3 Larval / pupal indices.....	31
2.3 Adult sampling.....	32
2.3.1 Human landing catches.....	32
2.3.2 Backpack aspirators.....	33
2.3.3 Visual traps.....	34
2.3.3.1 Sticky ovitraps.....	34

2.3.3.2 Resting boxes.....	35
2.3.3.3 The Fay-Prince trap (Bi- and Omni-Directional.....	36
2.3.3.4 The BG-Sentinel™.....	38
2.4 Conclusions.....	40
Chapter 2. Sampling biases of the BG-Sentinel™ trap with respect to physiology, age, and body size of adult <i>Aedes aegypti</i>.....	41
1. Introduction.....	42
2. Materials and Methods.....	43
2.1 Physiological bias.....	43
2.2 Age bias.....	45
2.3 Body size bias.....	47
3. Results.....	50
3.1 Physiological bias.....	50
3.2 Age bias.....	50
3.3 Body size bias.....	51
4. Discussion.....	54
Chapter 3. Evaluation of BG-Sentinel™ trap trapping efficacy for <i>Aedes aegypti</i> in a visually competitive environment.....	58
1. Introduction.....	59
2. Materials and Methods.....	61
2.1. Effect of presence/absence/reflectance of competing harbourage sites.....	61
2.2. Effect of the distribution of competing harbourage sites.....	64
2.3. Effect of oviposition sites on recapture of gravid females.....	65
3. Results.....	67
3.1. Effect of presence/absence/reflectance of competing harbourage sites.....	67
3.2. Effect of the distribution of competing harbourage sites.....	68
3.3. Effect of oviposition sites on recapture of gravid females.....	70

4. Discussion.....	70
Chapter 4. Does the BG-Sentinel trap reflect absolute abundance of <i>Aedes aegypti</i>: correlations between trap collections and simulation model population estimates?.....	73
1. Introduction.....	74
2. Materials andMethods.....	77
3. Results.....	81
4. Discussion.....	93
Chapter 5. General discussion and future directions.....	95
1. General discussion and future directions.....	96
References.....	101

List of Tables

Chapter 1

Table 1.1. Dengue outbreaks in North Queensland from 1990-2005 (Table modified from the Dengue fever management plan for North Queensland 2005-2010.....	26
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Chapter 4

Table 4.1. BGS trap data for females in February (wet season) and August (dry season) 2007.....	83
Table 4.2. BGS trap data for males in February (wet season) and August (dry season) 2007.....	83
Table 4.3. Density of each key container type across ten study sections.....	84
Table 4.4. Correlation between CIMSIM per hectare population size estimate and the corresponding hectare data of the mean number of adults collected by the BGS.....	85

List of Figures

Chapter 1

Figure 1.1. A distribution map of <i>Aedes aegypti</i> and dengue activity in Queensland, Australia.....	25
Figure 1.2. The bi-directional (A) and omni-directional (B) Fay-Prince traps.....	37
Figure 1.3. Diagram of the BG-Sentinel™ trap showing components and airflow through the trap.....	39

Chapter 2

Figure 2.1. A. Exterior of the outdoor flight cage at JCU. B. Interior of flight cage showing internal shelter, foliage, and competing resting sites.....	49
Figure 2.2. Preliminary data of mean wing-lengths (\pm SE) indicate two discrete body sizes within both female and male <i>Ae. aegypti</i> reared from egg to adult at 20 and 30°C.....	49
Figure 2.3. Mean number of individuals recaptured by the BGS trap within a flight cage over a 24h period.....	52
Figure 2.4. A. Mean recapture rate of parous females across 3 age groups. B. The percentage of females with zero eggs from each age group.....	53
Figure 2.5. A. Mean wing-lengths of released mosquitoes reared at 20 and 30°C. B. No significant difference in the mean body size observed between recaptured and non-recaptured females.....	53

Chapter 3

Figure 3.1. Low and high reflectance harbourage sites in the surrounding environment of the BGS.....	64
Figure 3.2. A. BGS and ‘clustered’ harbourage area treatment. B. BGS and ‘scattered’ harbourage area treatment.....	65

Figure 3.3. BGS recapture rates of female and male <i>Ae. aegypti</i> released in a room in the presence of low-reflectance (black) and high-reflectance (white) harbourage areas.....	68
Figure 3.4. BGS mean recapture rates of male and female <i>Ae. aegypti</i> amongst ‘clustered’ and ‘scattered’ attractive low-reflective (black) harbourage areas.....	69
Chapter 4	
Figure 4.1. Figure from Williams et al. (2008) illustrating the validation of the CIMSiM model calibration of pupal productivity of four sentinel key containers in greater Cairns, Australia.....	76
Figure 4.2. Parramatta Park study site in Cairns, QLD divided into ten sections ranging in area from 0.9-1.6 hectares.....	80
Figure 4.3. Mean wet season population estimates for male or female <i>Ae. aegypti</i> with ‘random’ and ‘fixed’ food delivery settings.....	86
Figure 4.4. Dry season population estimates for male or female <i>Ae. aegypti</i> with random and fixed food delivery options.....	86
Figure 4.5. CIMSiM predicted population outputs of <i>Ae. aegypti</i> correlated with the mean number of females captured by the BGS during the wet season.....	87
Figure 4.6. CIMSiM predicted population outputs of <i>Ae. aegypti</i> correlated with the mean number of males captured by the BGS during the wet season.....	88
Figure 4.7. CIMSiM predicted population outputs of <i>Ae. aegypti</i> correlated with the mean number of males and females captured by the BGS during the wet season.....	89
Figure 4.8. CIMSiM predicted population outputs of <i>Ae. aegypti</i> correlated with the mean number of females captured by the BGS during the wet and dry season.....	90
Figure 4.9. CIMSiM predicted population outputs of <i>Ae. aegypti</i> correlated with the mean number of males captured by the BGS during the wet and dry season.....	91

Figure 4.10. CIMSiM predicted population outputs of *Ae. aegypti* correlated with the mean number of combined males and females captured by the BGS during the wet and dry season..... 92