# MATHEMATICAL ANALYSIS OF PARASITE DYNAMICS OF LYMPHATIC FILARIASIS USING RANGE MODELLING AND OTHER APPROACHES IN RELATION TO OBSERVATIONAL DATA FROM SRI LANKA



by

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2011

The work described in this thesis was carried out by me under the supervision of Prof. D. A. Tantrigoda, Dr. S.K. Boralugoda and Dr. S.S.N. Perera and a report on this has not been submitted in whole or in part to any University or any other institution for another Degree/Diploma.

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We certify that the above statement made by the candidate is true and that this thesis is suitable for submission to the University for the purpose of evaluation.

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**Resubmission of the Ph.D. thesis after minor corrections**

Hereby I resubmit my Ph.D. thesis incorporating minor corrections recommended by the examiners at the viva-voce examination held on 9th January 2013. Required certification by the supervisors and the Head of the Department is also included here.

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We certify that the Ph.D. thesis of N.C. Ganegoda is resubmitted herewith incorporating the minor corrections suggested by the examiners.

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## ABSTRACT

Some observational data regarding Lymphatic Filariasis transmission are available over a long period of time in Sri Lanka although the data collection is not in a systematic way. However, these data had not been properly utilised to analyse parasite dynamics regarding Lymphatic Filariasis. Aim of this study is to develop and validate a comprehensive mathematical model to facilitate model-based analysis of parasite dynamics. Range modelling approach has been used here, where we can incorporate whatever reliable bounds available instead of seeking exact distributions of data. Furthermore, several mathematical tools and techniques have been designed to facilitate validation and model-based analysis. These tools are applicable outside the epidemiology of Lymphatic Filariasis too.

Dynamics of filarial parasites consists of two phases as dynamics in vector mosquito and dynamics in human host. Ultimately, overall population level dynamics of vector mosquitoes and humans are needed to establish a complete framework for the model. In the vector mosquito phase of the model, mosquito-parasite interactions and parasite

development within mosquito body are mathematically formulated via a system of differential equations. Here, corresponding phase plane trajectories illustrate possible dynamics subject to the range modelling tactics used for variables and parameters. For the phase of human host, incorporation of hyperbolic saturating function to cope with saturation as well as boosting associated with immune response is the key feature. Furthermore, this boosting has been equipped with a numerical scheme that maintains realistic values for adult parasite population.

The model is validated using three approaches as behavioural validity, numerical validity and simulation validity. Structure for validating the effect of history of infection is one of the main developments in behavioural validity. It is based on 'almost everywhere' principle in measure theory. Technique of decomposed error and wavelet-based central measure are the highlights of both numerical and simulation validity. In addition, an index to compare the effectiveness of main anti-filarial treatment programmes has been formulated here. It is structured as an application of eigenvectors. Next, model-based simulation experiments pave the way for assessing model applicability along with the possibility of using it as a decision support system. To achieve such needs, a computational flow has been adopted to design a computer simulation package for the overall model.

Three major aspects of a typical applied mathematical research namely modelling, analysis and computation have been covered by the present study showing how far mathematics can benefit real world problem solving. On the other hand, mathematical tools and techniques developed in this study show how an interdisciplinary research allows mathematics to have its own developments.