Engineering and Physical Sciences Research Council

University of Exeter

Engineering and Physical Sciences Research Council Doctoral Landscape Award

PROJECT TITLE: Efficient Bayesian inference for infectious disease models

Lead Supervisor: Trevelyan McKinley

Co-Supervisors: Theo Economou

Webpage: https://experts.exeter.ac.uk/24334-tj-mckinley

Project details: Infectious diseases can result in significant welfare and conservation costs to human and animal populations, and where they infect livestock or are zoonotic they can also have substantial impacts on the farming industry and public health respectively. Performing robust statistical inference for infectious disease systems is challenging, requiring cutting-edge computational methods, which are difficult to implement and scale. As such, improving the efficiency of these methods could have substantial impacts for improving the utility of such methods for understanding mechanisms of disease spread, and informing disease management and response strategies. This studentship will build upon recent work that utilised a new advance in computational statistical inference methods—the individual forward filtering backward sampling (iFFBS) algorithm—in order to fit dynamic transmission models of bovine tuberculosis (bTB) infection to individual-level data in wild badgers. This project utilised a unique long-term ecological survey of bTB in badgers from Woodchester Park in Gloucestershire, and has successfully integrated key complex processes such as age-dependent mortality with censoring, stochastic capture-mark-recapture data, imperfect diagnostic testing and spatio-temporal meta-population structures. This work has provided unique biological insights into the epidemiology of this important disease in a wildlife reservoir, and the iFFBS framework provides a flexible, powerful and efficient way to fit models to infectious disease data sets in small- to medium-size populations where individual-level data is available. This PhD project will develop this methodological framework further, with various avenues that could be pursued, for example: using different sampling schemes to allow the iFFBS algorithm to be made more efficient in larger populations and thus extending its utility to a wider range of problems; utilising recent advances in performing Bayesian model choice with the iFFBS sampler and applying these to quantify the weight-of-evidence in favour of competing models; embedding model discrepancy into the inference framework to account for unobserved and unmodelled sources of infection and interaction; integrating recent advances in model diagnostics, such as latent class residuals, which could be readily utilised within this framework for diagnosing model misspecification. Within the context of bTB spread in badgers, these methodological advances would allow us to build models to understand important epidemiological questions, such as whether there are sex- or age-specific impacts on key parameters such as transmission potential or the probability of being a superspreader; infection-related changes in mortality risk; or whether more sophisticated between-group transmission structures could be incorporated. They would also allow us to build models to understand key questions for disease management. Current models have been fitted to data retrospectively, and there is potential for future work to explore key questions relating to the efficacy of potential management strategies such as targeted vaccination by performing simulations using the fitted model parameters. These algorithms would also have much wider

applicability than just bTB, and could thus become a useful tool in modellers' toolboxes when in comes to modelling infectious disease systems in general.

Project Specific requirements: This project will suit students with an interest in developing and implementing computational methods, preferably with a background in mathematics, statistics or computer science, or an equivalent STEM subject area. A background in R / C / C++, or a similar programming language is essential.

Potential PhD programme of study: PhD in Clinical & Biomedical Sciences or PhD in Mathematics (to be determined)

Department: Clinical and Biomedical Sciences

Location: RILD Building

Please direct project specific enquiries to: Please contact Trevelyan McKinley (t.mckinley@exeter.ac.uk).

Please ensure you read the entry requirements of programme to which you are applying.

To apply for this project please click here.