Mathematical modelling of disease spread in honeybees: American foulbrood in the UK

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Background

Bees are considered extremely important in agriculture for the pollination services they provide, with over 70% of important crops worldwide being bee-pollinated. The honeybee has been in a state of decline at a global scale for 30 years now. Among the factors responsible for this, disease stands out as a major contributor, with such pathogens as the Varroa mite, European foulbrood (EFB) and American foulbrood (AFB) considered to be endemic in various regions throughout the world. The monetary impact of the recent global decline has been estimated to be in the billions of pounds, and research has been carried out to understand and prevent further declines (see Vanbergen et al., 2013). This project is motivated by recent work at Warwick to model the spread of EFB in the UK. Thanks to collaborations with the National Bee Unit (NBU, part of the government Food and Environment Research Agency), we have high-resolution spatial data showing the incidence of a variety of diseases in the UK since 1993. We hope to use existing model frameworks constructed at Warwick (see Datta et al., 2013) to develop a model for simulating the spread of AFB over the last 20 years in the UK.

Objectives

We will use an extensive dataset, detailing the dates, owners and locations of visits made to apiaries in the UK in the period 1993-2012, and the AFB status at each inspection, to try to understand the transmission dynamics of AFB. Using a previously constructed epidemiological model, which takes into account both spatial spread and owner-based network spread of disease, we will use a rigorous likelihood scheme to reconstruct the epidemic, and thus calculating parameter values in the model. We will then use the output to simulate "future" epidemics, and employ a range of control strategies to test the effectiveness of the current UK regime compared to a variety of alternative methods for controlling the size of epidemics.

Activities for the student

Mathematical epidemiology is extremely important in the real world, and the proposed project has great potential importance. The student will work in close conjunction with both supervisors to construct the statistical model to capture the transmission process, and the mathematical individual-based model for simulating new epidemics. There will be the opportunity to meet and work with our collaborators at the NBU, and to find out more about how research output can develop into policy. There is a large community of academics involved in epidemiological research in the WIDER centre (Warwick Infectious Disease Epidemiology Research), and the student will be encouraged to interact with Ph.D. students and staff at the weekly meetings.
Link for WIDER webpage: http://www2.warwick.ac.uk/fac/cross_fac/wider/

Skills learned

This project would ideally suit students interested in the outputs of applied mathematics, in particular ecological modelling and epidemiology. The student will engage in cutting-edge interdisciplinary research, involving the interpretation of large datasets, construction of mathematical models, statistical inference of parameters and computer simulations (using Matlab, any previous experience would be useful). Interaction with other researchers and government agencies will be encouraged, and ideally publication of any interesting results will follow.

References

Vanbergen et al. (2013), 'Threats to an ecosystem service: pressure on pollinators'.
Link: http://nora.nerc.ac.uk/501453/7/N501453PP.pdf
Datta et al. (2013), 'Modelling the spread of American foulbrood in honeybees'.
Link: http://rsif.royalsocietypublishing.org/content/10/88/20130650.full