Evolutionary Ecology Research, 2002, **4**: 109–131

Costs and benefits of fighting infection in locusts

Shea N. Gardner[1] and Matthew B. Thomas[2]*

[1]*Biology and Biotechnology Research Program, Lawrence Livermore National Laboratory, PO Box 808, L-452, Livermore, CA 94551-0452, USA and* [2]*NERC Centre for Population Biology and CAB1 Bioscience, Imperial College at Silwood Park, Ascot, Berks SL5 7PY, UK*

ABSTRACT

Locusts and grasshoppers are truly cosmopolitan pests. In an effort to reduce the environmental side-effects of current chemical control practices, several programmes around the world are developing biopesticides, based on fungal entomopathogens, for locust and grasshopper control. Unfortunately, these biocontrol products have achieved mixed success. One of the principal reasons is that locusts are active behavioural thermoregulators, enabling them, under certain environmental conditions, to elevate their body temperatures to levels where fungal growth is suppressed. Here we develop a dynamic behavioural model to predict how locust thermoregulatory behaviour influences disease development. We use the model to explore what the overall consequences of infection might be (i.e. the net effect of disease capturing elements of both pathogen development and host defence) under different conditions in terms of locust mortality, fecundity and crop damage. We modelled two empirical fungal entomopathogens, *Metarhizium anisopliae* var. *acridum* and *Beauveria bassiana*, together with two hypothetical pathogens representing a temperature generalist and a temperature specialist. The model leads to predictions that the effects of a fungal biocontrol agent are strongly mediated by environmental temperature and host behaviour. The positive control effects are manifested through direct mortality and also sub-lethal effects on feeding and fecundity that result from modifications in behaviour associated with host defence and optimization of locust fitness. *M. anisopliae* var. *acridum* is predicted to provide the best control of locusts and the specialist fungus to provide the worst. Under hotter conditions, *B. bassiana* is predicted to provide substantially worse biocontrol than the other fungal strains. These predictions match well with empirical data. In addition, the model reveals the possibility for locusts to balance the costs of host defence through selective expression of behavioural fever in response to individual fungal diseases. We conclude that models like this one may facilitate prospective evaluation of biocontrol and advance our understanding of the role of behaviour and thermal ecology in insect–pathogen interactions.

Keywords: *Beauveria bassiana*, behavioural fever, biocontrol, dynamic state variable model, entomopathogenic fungi, locusts and grasshoppers, *Metarhizium anisopliae* var. *acridum*, thermoregulation.

* Author to whom all correspondence should be addressed. e-mail: m.thomas@cabi.org