

Costs and benefits of fighting infection in locusts

Shea N. Gardner¹ and Matthew B. Thomas^{2*}

¹Biology and Biotechnology Research Program, Lawrence Livermore National Laboratory, PO Box 808, L-452, Livermore, CA 94551-0452, USA and ²NERC Centre for Population Biology and CABI 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
Consult the copyright statement on the inside front cover for non-commercial copying policies.



www.evolutionary-ecology.com

***Evolutionary Ecology Research* is delighted that you wish to consult one of its articles.**

You may if your library or laboratory subscribes.

Ask your librarian or library committee why your place does not already subscribe to the low-cost journal that is publishing splendid science in a socially responsible manner. *EER*'s low prices have helped librarians to rein in the indefensible cost increases that have reduced our access to science all over the world! Just ask our partners at [SPARC](#) — the Scholarly Publishing & Academic Resources Coalition of the Association of Research Libraries.

Or maybe you should just remind the folks who order your journals to contact us and subscribe! You need — and they should support — the journal that:

- Invented the instant publication of reviewed, revised and accepted e-editions.
- Vests the copyrights of all articles in their authors while preserving the rights of educational and research groups to use its material in classes, seminars, etc. at no additional cost.
- Maintains a unified data-base of articles, thus doing away with your need to worry about issue numbers, author order, and other such impediments to easy access.
- Provides *Webglimpse* so that you can search any word, place, species, variable, phrase or author in any article *EER* has ever published.
- Pioneered e-only subscriptions while maintaining, at the same time, a traditional print edition, too.

Some 10,000 readers per week have it right. *EER* is the place to go for great science, responsible publication policies and easy access!

[Click here for the Table of Contents](#) of the most recent issue of *Evolutionary Ecology Research*

[Click here for full access to a sample issue](#) of *Evolutionary Ecology Research*

[Click here for SUBSCRIPTION INFORMATION](#)