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Thermal plasticity and microevolution enhance establishment success and persistence of a water hyacinth biological control agent

Tamzin C. Griffith[1], Iain D. Paterson[1]*, Candice A. Owen[1] & Julie A. Coetzee[1,2]
[1]Centre for Biological Control (CBC), Department of Zoology and Entomology, Rhodes University, PO Box 94, Grahamstown 6140, South Africa, and [2]Department of Botany, Rhodes University, PO Box 94, Grahamstown 6140, South Africa

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Abstract

Aspects of the thermal physiology of the water hyacinth biological control agent *Eccritotarsus catarinensis* Carvalho (Hemiptera: Miridae) have been extensively investigated over the past 20 years to understand and improve post-release establishment in the field. Thermal physiology studies predicted that the agent would not establish at a number of cold sites in South Africa, where it has nonetheless subsequently established and thrived. Recently, studies have begun to incorporate the plastic nature of insect thermal physiology into models of agent establishment. This study determined whether season and locality influenced the thermal physiology of two field populations of *E. catarinensis*, one collected from the hottest site where the agent has established in South Africa, and one from the coldest site. The thermal physiology of *E. catarinensis* was significantly influenced by season and site, demonstrating a degree of phenotypic plasticity, and that some post-release local adaptation to climatic conditions has occurred through microevolution. We then determined whether cold acclimation under laboratory conditions was possible. Successfully cold-acclimated *E. catarinensis* had a significantly lower critical thermal minimum (CT_{min}) compared to the field cold-acclimated population. This suggests that cold acclimation of agents could be conducted in the laboratory before future releases to improve their cold tolerance, thereby increasing their chance of establishment at cold sites and allowing further adaptation to colder climates to occur in the field. Although the thermal tolerance of *E. catarinensis* is limited by local adaptations to climatic conditions in the native range, the plastic nature of the insect's thermal physiology has allowed it to survive in the very different climatic conditions of the introduced range, and there has been some adaptive change to the insect's thermal tolerance since establishment. This study highlights the importance of plasticity and microevolutionary processes in the success of biological control agents under the novel climatic conditions in the introduced range.

Introduction

Almost 37% of all weed biocontrol agent releases fail to result in establishment (Schwarzländer et al., 2018). A high proportion of these failures is attributed to climatic incompatibility between the agent and the new environment in the introduced range (Byrne et al., 2002; Robertson et al., 2008; Cowie et al., 2016). Because all weed biocontrol agents are ectotherms, the agent's body temperature is directly influenced by the environmental temperature, which consequently affects traits that directly affect survival and fitness (Angilletta et al., 2002; Sinclair et al., 2015), and hence the ability of the agent to establish and control the target weed (Angilletta et al., 2002). The fitness traits affected may be linked to locomotion, foraging ability, reproductive output, immune function, and developmental time, all of which are very important for the efficacy of a biocontrol agent (Angilletta et al., 2002).

*Correspondence: Iain D. Paterson, Centre for Biological Control (CBC), Department of Zoology and Entomology, Rhodes University, PO Box 94, Grahamstown 6140, South Africa.
E-mail: i.paterson@ru.ac.za