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Could enemy release explain invasion success of *Sagittaria platyphylla* in Australia and South Africa?

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ABSTRACT

Sagittaria platyphylla (delta arrowhead) is an emergent aquatic macrophyte native to southeastern United States of America that has been introduced into Australia and South Africa as an ornamental pond and aquarium plant. Compared to plants in the native range, *S. platyphylla* in the introduced range have greater reproductive capacity and form extensive infestations that dominate shallow waterbodies. One explanation for the invasive success of *S. platyphylla* in introduced countries is that plants are devoid of biotic pressures that would regulate population abundance in their native range (the enemy release hypothesis). We previously reported on field surveys that documented the number of pathogens and insect herbivores associated with *S. platyphylla* in native and introduced ranges. Here, we quantify the damage caused by these natural enemies to *S. platyphylla* in the two ranges. As predicted, damage to plants caused by pathogens and insect herbivores was much greater in the native than the introduced range at both the plant and population level. In introduced regions herbivory was low (less than 10%) in every plant part, while in North America insect damage to fruiting heads was 46% (of fruiting heads attacked), damage to leaves was between 33 to 57%, and internal herbivore damage to petioles and the inflorescence scapes was 56% and 43% respectively. Pathogen damage to leaves was between 39 to 57% of leaves per plant affected, compared to 9% in Australia and 8% in South Africa. This lack of biotic resistance from herbivores and disease may have facilitated *S. platyphylla* invasion in Australia and South Africa.

1. Introduction

Since Charles Darwin first proposed the enemy release hypothesis (ERH) over 150 years ago (Darwin, 1859), ecologists have debated the theories of biological invasions and as a result, several hypotheses have been postulated. But the ERH still remains the most widely cited and is based on the assumption that non-native species, when liberated from herbivores, pathogens and endophytes upon introduction into a new region, gain a substantial competitive advantage over natives that are themselves experiencing top-down regulation from their own natural enemies (Evans, 2008; Keane and Crawley, 2002; Liu and Stiling, 2006).

If the ERH was broadly applicable, then most exotic plant species should become invasive when released from herbivore pressure in their new environment (Maron and Vilà, 2001). Yet in Australia, only 10% of the 2700 known alien plant species introduced into Australia since European settlement have become serious pests of agriculture and the environment (Groves et al., 2005), a proportion that accords with the 'tens' rule proposed by Williamson and Fitter (1996). Clearly, the ERH does not hold for all cases and there is growing evidence to suggest that interrelated causes such as disturbance, resource availability and niche opportunities contribute to invasion success (Mack et al., 2000; Shea and Chesson, 2002; Hierro et al., 2005; Catford et al., 2009; van Kleunen et al., 2014).

Classical biological control is predicated on the underlying assumptions of the ERH (Liu and Stiling, 2006), yet few studies have specifically tested the ERH as an *a priori* assessment for determining the likely success of a new biocontrol program. While recent studies have

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