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Analysis

Economic Outcome of Classical Biological Control: A Case Study on the *Eucalyptus* Snout Beetle, *Gonipterus platensis*, and the Parasitoid *Anaphes nitens*

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ABSTRACT

Despite the importance of invasive pests, few studies address the costs and benefits of the strategies used to control them. The present work assesses the economic impact of the *Eucalyptus* snout beetle, *Gonipterus platensis*, and the benefits resulting from its biological control with *Anaphes nitens* in Portugal, over a 20-year period. Comparisons were made between the real situation (with *A. nitens*) and three scenarios without biological control: 1) replacement of *Eucalyptus globulus* by resistant eucalypts; 2) insecticide use; and 3) offset of yield losses by imported wood. A cost-benefit analysis was performed to evaluate a programme that aimed to accelerate *A. nitens* establishment. Although *A. nitens* provides adequate pest control in several regions, 46% of the area planted with eucalypts is affected by the beetle, causing wood losses of 648 M euros over 20 years. Losses in the three hypothetical scenarios were estimated at 2451 M-7164 M euros, resulting in benefits from biological control of 1803 M–6516 M euros, despite the fact that only partial success was achieved. Anticipating biological control by just one, two, or three years resulted in benefit-cost ratios of 67, 190, and 347, respectively. Because nonmarket values were not accounted for, these figures are likely underestimated.

1. Introduction

Invasive alien species pose a major threat to natural and managed ecosystems, and can have substantial ecological and economic impacts. Biological invasions by insects alone cost at least 70 billion US dollars per year globally, but this value is greatly underestimated due to the lack of reliable cost assessments (Bradshaw et al., 2016). Classical biological control (CBC) is a particularly useful strategy to manage non-native species that attain pest status in their introduced range due to the absence of natural enemies (Kenis et al., 2017). Between 1870 and 2010, 2384 species of natural enemies have been introduced for CBC of insect pests worldwide, leading to the control of 172 of 588 target pests (Cock et al., 2016). Despite the high number of programmes undertaken, analyses weighing economic costs and benefits of CBC have hardly been assessed (Greathead, 2003; Kenis and Branco, 2010; Naranjo et al., 2015). The scarcity of economic studies arises from many causes, including lack of funding for post-release monitoring, long periods from release until full field establishment of the biological control agent, difficulty in assessing impacts of CBC programmes, or difficulty in assigning monetary values to externalities (Cock et al., 2015; McFayden, 2008). In addition, when successful control is achieved the problem disappears and the focus shifts to other problems (Paine et al., 2015).

Gonipterus platensis (Marelli) (Coleoptera: Curculionidae) is one of three species from the Australian genus *Gonipterus* that were accidentally introduced in other parts of the world, where they became pests of eucalypts (Hurley et al., 2016; Mapondera et al., 2012). CBC with the egg parasitoid *Anaphes nitens* (Girault) (Hymenoptera: Mymaridae) has been the strategy most commonly used to reduce *Gonipterus* spp. populations. This natural enemy was first used in South Africa, in 1926 (Tooke, 1955). It was also introduced in New Zealand, North and South America, and Europe (Arzone and Vidano, 1978; Hanks et al., 2000; Tooke, 1955). Good results were obtained with *A. nitens* in many countries, but complete success was not always achieved, especially in

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