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The risk of classical biological control in Florida

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Abstract

Classical biological control in Florida dates from 1899, when *Rodolia cardinalis* (Mulsant) was introduced and controlled an infestation of the adventive (=nonindigenous) species *Icerya purchasi* Maskell. We list 60 invertebrates (59 insects and one nematode) imported into and established in Florida up until and including 2003. No vertebrates have been imported and established for classical biological control. All targets of successful introductions except one were adventive pest insects and weeds. The exceptional target was a widespread aphid, whose introduced biological control agent had no obvious effect. Using many sources of information, we consider the effects, both potential and realized, of established classical biological control agents, on non-target species in Florida. Our goal was to provide a substantiated record and an example analysis. Florida, with high numbers of invasive species, is a microcosm of worldwide classical biological control. We recognized six levels of host range of agents and concluded that 24 agents potentially have native species in their host range. Our analysis suggests that fewer than 10 introduced agents are likely to have produced population changes in non-target organisms and, of these, fewer than four are likely to have produced substantial population changes. No species has had a documented substantial effect on a non-target species in Florida. Such evidence might accrue in future, however, if searched for diligently.

Keywords: Biocontrol; Non-target effects; History of biocontrol; Animal biocontrol agents; Invertebrate biocontrol agents; Insect biocontrol agents; Nematode biocontrol agents

1. Introduction

The record of arrival of insect species in Florida is relatively well known compared with other regions (e.g., Frank and McCoy, 1992, 1993, 1994, 1995a,b; Boender, 1995; Thomas, 1995; Frank et al., 1997). A much cited paper by Bennett (1993) [see other contributions in Florida Entomologist 72, 1–64; 73, 1–119; 74, 1–59; 75, 1–83; 76, 1–113; 77, 1–84; 78, 1–55, available free on the internet <http://www.fcla.edu/FlaEnt//> by courtesy of FES] was the first to consider the potential effects of these species on the native biota of Florida. Other relatively early papers on non-target effects of classical biological control agents were by Howarth (1983, 1991), Pimentel et al. (1984), Samways (1988, 1994), and several other authors listed in Hawkins and Marino (1997). Subsequently, interest in non-target effects of biological control agents has risen sharply, statewide, nationally, and internationally, and classical biological control efforts have come under increasingly sharp criticism for having unwanted non-target effects.

The latest review of the insect species (deliberately) introduced (Frank and McCoy, 1990) into Florida dates from 1993 (Frank and McCoy, 1993). Almost all introductions were classical biological control agents. In this review, we list and discuss classical biological control agents that were introduced and established in Florida up to and including 2003, ignoring those species not considered established (see Frank and McCoy, 1993), and the targets of those agents. We consider both potential and realized non-target effects of these. Our goal is to provide a substantiated record, to eliminate as much speculation as is currently possible, and to provide an example of this

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type of analysis. Although our emphasis is on Florida's record, the region is a microcosm for worldwide classical biological control.

2. Materials and methods

We reduced and corrected an earlier list of insects introduced into Florida (Frank and McCoy, 1993) to those that established in Florida as classical biological control agents, and incorporated taxonomic nomenclatural changes. We then added later records up to and including 2003 as well as records for animals other than insects. Finally, we searched for evidence of non-target effects of introduced biological control agents in Florida by examining the biological control literature (e.g., Bennett, 1993; Follett and Duan, 2000; Howarth, 2000; Lynch and Thomas, 2000; Wajnberg et al., 2001; Van Driesche and Reardon, 2004), questioning colleagues, and searching databases (entomological literature databases, the internet, and the ROBO database of USDA-ARS).

We categorized the classical biological control agents by host range, recognizing six levels of specialization, but we recognize that this categorization is imperfect given the unstable, developing classification of most insect taxa.

Large differences in the amount of pre-release testing of biological control agents of weeds and of arthropods caused us to use different criteria to define host range. We defined host ranges for weed biological control agents as the composite of the potential host range as determined in pre-release laboratory testing and the realized host range as determined in the field based on the ability of the host to support agent development. We defined host ranges for arthropod biological control agents based on all available records, as pre-release host range testing of these agents was seldom if ever a requirement for introduction until a decade ago (see Van Driesche and Bellows, 1996). Unpublished data compiled at the Florida Department of Agriculture, Division of Plant Industry, Gainesville were particularly useful for this. We included host/prey records from all parts of the world, except when it could be shown that the host/prey does not occur in Florida; even so, such records were used to assess the range of host specialization.

We categorized the targets of the classical biological control agents by origin. Any species established in nature in a specified area is either native or adventive [i.e., species that are not native, and, therefore, arrived in the region of interest from elsewhere (Frank and McCoy, 1990)] to that area. The word adventive includes immigrant and introduced, so does not specify the means of arrival, although the distinction between immigrant and introduced species clearly is important in assessing potential effects on native biotas (Ruesink et al., 1995). For historico-political reasons, species believed to be present in Florida at the time of arrival of Columbus in the New World (AD 1492) are considered native, and any that are believed to have arrived after that date as adventive. Assignment of labels as native and adventive requires inferences to be made from other evidence, however, as Florida's insect fauna in AD 1492 was undocumented.

We modeled our analysis of non-target effects after a paper by Stiling and Simberloff (2000), in which they addressed the fundamental questions of what is the host range of released natural enemies? what portion of the native biota is susceptible to non-target effects? how frequent are non-target effects of biological control agents? and what are the strengths of the non-target effects (Stiling and Simberloff, 2000, pp. 32–33)? We considered only agents introduced to, and established in, Florida for biological control purposes, although we acknowledge that agents introduced elsewhere may subsequently have immigrated to Florida (e.g., McEvoy and Coombs, 2000). We considered only direct non-target, although we acknowledge the potential importance of indirect effects (e.g., Neuenschwander and Markham, 2001; Hoddle, 2004). We considered only agents that became established, although we acknowledge that agents can have non-target effects whether they establish or not (e.g., Hawkins and Marino, 1997; Lynch and Thomas, 2000; Lynch et al., 2002), and that agents that do establish can, in some ways, potentially cause less harm (see Hawkins et al., 1999). More than 150 agents have been introduced in classical biological control programs in Florida, and agents that have failed to establish on their targets include herbivorous and predacious species with relatively broad potential host ranges (Frank and McCoy, 1993, 1994). Finally, in our assessment we do not always distinguish between agents introduced against plant or animal target species, although we acknowledge that the two kinds of agents may tend to differ in rates of establishment, chances for ecological segregation, method of host selection, and other ways that influence the likelihood of non-target effects (e.g., Frank and McCoy, 1993; Hoddle, 2004; Van Driesche, 2004). Such issues will be addressed elsewhere (Frank and McCoy, in preparation).

3. Results and discussion

3.1. Established biological control introductions and their targets

The current list of established biological control introductions includes 59 insect species and one nematode (Table 1). Fifty-nine insect species, however, are less than 0.5% of the estimated 12,500 insect species in Florida (Frank and McCoy, 1995b). In contrast, it is estimated that 2.4% of south Florida's birds, 16% of fishes, 22% of amphibians, 23% of mammals, 27% of plants, and 42% of reptiles, are adventive, many of them (deliberately) introduced (Frank and McCoy, 1995a; Frank et al., 1997). We consider each of the species below, bringing up-to-date the information on those species reviewed previously (Frank and McCoy, 1993) and newly reviewing those species introduced since the previous review.