Risk assessment of *Gratiana boliviana* (Chrysomelidae), a potential biocontrol agent of tropical soda apple, *Solanum viarum* (Solanaceae) in the USA

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Summary

*Solanum viarum* (Solanaceae), known by the common name tropical soda apple, is a perennial prickly weed native to north-eastern Argentina, south-eastern Brazil, Paraguay, and Uruguay, that has been spreading at an alarming rate in the USA during the 1990s. First detected in the USA in 1988, it has already invaded more than 1 million acres (ca. 400,000 ha) of improved pastures and woody areas in nine states. Initial field explorations in South America for potential biocontrol agents were initiated in June 1994 by University of Florida researchers in collaboration with Brazilian and Argentinean scientists. The leaf beetle *Gratiana boliviana* (Chrysomelidae) was evaluated as a potential biocontrol agent of tropical soda apple. The only known hosts of this insect are *S. viarum* and *Solanum palinacanthum*. Open field experiments and field surveys were conducted to assess the risk of *G. boliviana* using *Solanum melongena* (eggplant) as an alternative host. In an open field (choice-test) planted with tropical soda apple and eggplant there was no feeding or oviposition by *G. boliviana* adults on eggplant. Surveys conducted (1997–2002) of 34 unsprayed fields of eggplant confirmed that this crop is not a host of *G. boliviana*. Based on these results, the Florida quarantine host-specificity tests, the open field tests in Argentina, and the lack of unfavourable host records in the scientific literature, we concluded that *G. boliviana* is safe to release for biocontrol of tropical soda apple. A petition submitted for field release to the Technical Advisory Group (TAG) for Biological Control Agents of Weeds was unanimously approved on April 2002, and an APHIS permit for field release was issued in May 2003. Field releases in Florida were initiated on 14 May 2003.

Keywords: *Gratiana boliviana*, risk assessment, Solanaceae, weed biocontrol.

Introduction

Tropical soda apple is a perennial weed, native to South America, that has been spreading throughout Florida at an alarming rate during the 1990s. The pasture land infested in 1992 was estimated as approximately 150,000 acres (1 acre = ca. 0.4 ha)(Medal et al. 1996, Mullahey et al. 1993), and this infested area increased to more than 750,000 acres in 1995–96 (Mullahey et al. 1997). Currently, the infested area is estimated at more than one million acres (Medal et al. 2002a). Tropical soda apple was first reported in the USA in Glades County, Florida in 1988 (Coile 1993, Mullahey & Colving 1993). This weed is also present in Alabama, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Puerto Rico (Bryson & Byrd Jr. 1996, Dowler 1996, Mullahey et al. 1997), although infestations in these states have not reached high levels. The potential range of tropical soda apple in the United States can extend even further based on studies of the effects of temperature and photoperiod conducted by Patterson (1996) in controlled environmental chambers. This invasive exotic weed was placed on the Florida and Federal Noxious Weed Lists in 1995, and is listed as one of the most invasive species in Florida by the Florida Exotic Pest Plant Council (1999).
In addition to invading pasture lands and reducing cattle carrying capacity (Mullahey et al. 1993), tropical soda apple is a host of at least six viruses that affect vegetable crops including tomato, tobacco, and pepper (McGovern et al. 1994a, McGovern et al. 1994b, McGovern et al. 1996). Tropical soda apple is also an alternative host of several major insect pests such as the silverleaf whitefly, Bemisia argentifolii Bellows and Perring (Homoptera: Aleyrodidae), a worldwide pest of many field, horticultural, and ornamental crops; the Colorado potato beetle, Leptinotarsa decemlineata (Say) (Coleoptera: Chrysomelidae), a major foliage feeder of potato in North America; the tomato hornworm Manduca quinquemaculata (Haworth) (Lepidoptera: Sphingidae), and the tobacco hornworm, Manduca sexta (L.), major pests of tomato and tobacco; and several other polyphagous insects such as the southern green stink bug, Nezara viridula (L.) (Heteroptera: Pentatomidae); the tobacco budworm, Helicoverpa virescens (Fabr.) (Lepidoptera: Noctuidae); and the suckfly, Tupiocoris notatus (Distant) (Heteroptera: Miridae) (Medal et al. 1999, Sudbrink et al. 1999, Habeck et al. 1996). Although it is very difficult to estimate the real (direct and indirect) economic losses due to this invasive weed, Mullahey (unpublished data) estimated the annual production loss to Florida ranchers in 1993 at US$11 million.

Native to Brazil, Paraguay, north-east Argentina, and Uruguay (Nee 1991), tropical soda apple has spread into other parts of South and Central America (confirmed growing in Nicaragua, but its presence in Honduras and Costa Rica is unconfirmed). This weed has also spread into other regions including the Caribbean (confirmed in Puerto Rico), Africa, India, Nepal, and China (Chandra & Srivastava 1978, Coile 1993). The rapid spread in south Florida can be partially attributed to the plant’s high reproductive potential (Akanda et al. 1996, Pereira et al. 1997), and effective seed dispersal by cattle and wildlife, such as deer, feral hogs, raccoons, and birds that feed on fruits (Mullahey et al. 1993, Bryson et al. 1995, Brown et al. 1996). One tropical soda apple plant can produce an average of 41,000 to 50,000 seeds with a germination rate of at least 75% (Mullahey et al. 1993, Pereira et al. 1997). Infested areas are increasing rapidly, making this a national problem rather than just a Florida problem.

Management practices for tropical soda apple in Florida pastures are based on herbicide applications combined with mechanical (mowing) practices (Mislevy et al. 1996, Sturgis & Colvin 1996, Akanda et al. 1997, Mislevy et al. 1997). These control tactics provide temporary weed suppression, and costs are estimated at US $75.00 per acre to control dense infestations of tropical soda apple (Mullahey et al. 1996). In addition to being expensive, application of chemicals is not always feasible in rough terrain or inaccessible areas.

A biological control project on this highly invasive non-native weed was initiated in 1997 by J. Medal (University of Florida) in collaboration with R. Pitelli (Universidade Estadual Paulista, Jaboticabal campus, Brazil), and D. Gandolfo (USDA-ARS South American Biological Control Laboratory, Hurlingham, Buenos Aires province, Argentina). Host-specificity tests and field surveys were conducted from 1997 to 2002 to determine the suitability of the leaf beetle Gratiana boliviana Spaeth (Chrysomelidae) for biological control of tropical soda apple. In this article we report the results of an open-field experiment conducted with G. boliviana exposed to tropical soda apple and eggplant (choice test) in Misiones, Argentina, and a survey of eggplant fields in South America to assess the specificity and safety of G. boliviana as a biocontrol agent of tropical soda apple in the USA.

**Material and methods**

**Field experiment in Argentina**

An open-field experiment (choice) was conducted at the Instituto Nacional de Tecnología Agropecuaria (INTA)-Agriculture Experimental Station in Cerro Azul, Misiones province, Argentina. A natural population of G. boliviana was monitored in a field planted with tropical soda apple and eggplant (cultivars: Black Beauty and Long Purple). The tropical soda apple plants tested were transplanted from fields close to the area, and the eggplants were grown from seeds obtained from a commercial supplier of local varieties. They were planted in pots held in a greenhouse and then transplanted to the field on December 6, 1999 when approximately 10–15 cm in height. Fifty plants of each of the two species tested (total:100 plants) were randomly assigned in five replicates of 20 (10 of each species). All plants were thoroughly examined once a week (from January 5 to April 3, 2000) and feeding, number of beetles, and oviposition on the plants were recorded.

**Field surveys in Argentina, Brazil, Paraguay, and Uruguay**

Thirty-four eggplant fields inside the area of distribution of G. boliviana were surveyed from January 1997 to March 2002 in Argentina (16), Brazil (16), Paraguay (1), and Uruguay (1). These fields were not treated with pesticides during the growing season, or were fields where fungicides and/or insecticides were applied to eggplants only at the beginning of the growing cycle. The number of eggplants in the fields surveyed varied from 6 to approximately 1200. All plants were thoroughly examined above ground for insects when the field had fewer than 100 plants. When there were more than 100 plants, a sample of 50 to100 plants was randomly selected to have representatives from most of the areas in each field. Insect specimens found on plants were collected, identified, or sent to specialists for identification or confirmation.
Results

Field experiment in Argentina

In the open-field planted with tropical soda apple and eggplants in an area with a natural population of tropical soda apple and G. boliviana growing in the proximity, there was no feeding or oviposition by G. boliviana adults on either of the two eggplant cultivars (Black Beauty and Long Purple) during their vegetative and reproductive stages of growth. Almost all tropical soda apple plants that were thoroughly examined once a week (from January 5 to April 3, 2000), showed some leaf-feeding damage (5–20% of the leaf area) by G. boliviana. A total of 16 G. boliviana adults, 26 larvae and 21 eggs were found on tropical soda apple plants, but no G. boliviana stages were found on the eggplants.

Field surveys in Argentina, Brazil, Paraguay, and Uruguay

In the field surveys of insects attacking eggplant in 34 fields, no G. boliviana were found feeding on this crop (Table 1). Insects found feeding on eggplant included mainly the leaf-feeding beetle Diabrotica speciosa Germar (Coleoptera: Chrysomelidae), the green peach aphid Myzus persicae (Sulz.) (Heteroptera: Aphididae), the tobacco hornworm Manduca sexta (Lepidoptera: Sphingidae), and an unidentified species of spider-mite (Acari: Tetranichidae). Four of the eggplant fields in Argentina and Brazil were examined at least once a month for insects during their vegetative and reproductive stages of development. Larvae, pupae and adults of G. boliviana were found on tropical soda apple plants that were growing intermixed, or close to (sometimes a few metres away) the eggplant fields. The South American growers that have been growing eggplant for many years have also never found G. boliviana attacking their crops.

Discussion

The field release of a non-indigenous leaf feeding insect to control tropical soda apple in the continental USA should have little negative effect on non-target organisms. No adverse impacts are expected on the six solanaceous species listed as threatened or endangered in Hawaii and Puerto Rico (US Fish and Wildlife Service 1997). Indirect beneficial effects on wildlife populations may be expected due to recolonization by native plants that have been displaced by the rapidly growing and highly competitive tropical soda apple plants.

The eggplant fields surveyed in South America, and the host range tests conducted in quarantine in the USA and in South America (Gandolfo et al., 1999, Medal et al., 2002b) indicated that G. boliviana is safe to release. Occasional temporary feeding might occur on some very closely related Solanum species such as Solanum torvum Sw. (on the Federal Noxious Weed list, introduced from West Africa) and on S. elaeagnifolium Cav. (an important weed in agricultural areas in North America) (Medal et al. 2000, Medal et al. 2001). Based on the surveys of 34 unsprayed eggplant fields reported here, noticeable damage to eggplant seems unlikely. Further field and laboratory experiments conducted in Argentina (Gandolfo et al., unpublished data) and the lack of unfavourable host records in the scientific literature also corroborate the specificity and safety of G. boliviana. Therefore, control of tropical soda apple by this leaf beetle is not expected to have any significant, long-term negative impacts on non-target organisms.

The petition to release the South-American tortoise beetle G. boliviana for the control of tropical soda apple in the USA was approved and a permit was issued by the USDA-APHIS in May 2003. Field releases in Florida were initiated on 14 May 2003.

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Table 1. Eggplant fields surveyed in Argentina, Brazil, Paraguay and Uruguay.

<table>
<thead>
<tr>
<th>Location</th>
<th>Plants checked/total plants</th>
<th>Date</th>
<th>G. gratiana</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Misiones (13 fields)</td>
<td>6–100/6–800</td>
<td>Feb 98/Jan 00</td>
<td>0</td>
</tr>
<tr>
<td>Buenos Aires (3 fields)</td>
<td>20/20</td>
<td>Dec 98/March 00</td>
<td>0</td>
</tr>
<tr>
<td>Brazil</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>São Paulo (7 fields)</td>
<td>40–100/40–1200</td>
<td>Jan 97/June 98</td>
<td>0</td>
</tr>
<tr>
<td>(9 fields)</td>
<td>7–100/7–640</td>
<td>Nov 98/March 01</td>
<td>0</td>
</tr>
<tr>
<td>Paraguay</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Itapua (1 field)</td>
<td>40/40</td>
<td>January 2000</td>
<td>0</td>
</tr>
<tr>
<td>Uruguay</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Canelone (1 field)</td>
<td>100/600</td>
<td>April 1999</td>
<td>0</td>
</tr>
</tbody>
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References


