Arthropod Community Associated with Tropical Soda Apple and Natural Enemies of Gratiana boliviana (Coleoptera: Chrysomelidae) in Florida

Authors: Diaz, R., Hibbard, K., Samayoa, A., and Overholt, W. A.

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Tropical soda apple, *Solanum viarum* Dunal (Solanaceae), is a 1.5-m-tall perennial shrub native to tropical regions of South America. First reported in Florida in 1988, tropical soda apple rapidly became a major weed in pastures and conservation areas across the southeastern United States (Mullahey 1996). In pastures, tropical soda apple competes with forages resulting in reduced stocking rates (Mullahey et al. 1998). Florida ranchers spent an average of $844 per acre on chemical and mechanical control costs on tropical soda apple in 2006 (Thomas 2007). Additionally, this plant is an alternate host of several diseases of solanaceous crops (McGovern et al. 1994; Adkins et al. 2007).

A biological control program of tropical soda apple was initiated in 1994, and several natural enemies were collected in Brazil, Argentina and Paraguay (Medal et al. 1996), including *Gratiana boliviana* Spaeth (Coleoptera: Chrysomelidae). This host specific beetle was first released into Florida in May 2003, and by 2008 approximately 180,000 beetles had been released (Overholt et al. 2009). Experiments conducted in central Florida demonstrated that beetle populations increased during the summer and remained very low during the coldest months of the year from Dec to mid-Mar (Overholt et al. 2010). Beetle populations were more abundant on plants located in open pastures compared to those in shaded hammocks (Diaz et al. 2011). In a four-year study, Overholt et al. (2010) demonstrated that tropical soda apple densities decreased by 90% two yr after beetle release. Survival from egg to adult in closed cages was 51% compared to 15% in open cages (Manrique et al. 2011), thus revealing the impact of biotic factors on *G. boliviana* populations. Because of the presence in Florida of many solanaceous plants, we inventoried the herbivores associated with tropical soda apple with the hypothesis that many would expand their host ranges to include the novel resource. Additionally, because of the importance of *G. boliviana* as a biological control agent of tropical soda apple, we inventoried its natural enemies in Florida.

Arthropods were collected from 2004 to 2011 at two *G. boliviana* mass rearing facilities in Fort Pierce, Florida and from several natural infestations on ranches or conservation areas in central and south Florida. Collection methods for insect herbivores and predators included hand catching, aspiration, rearing, and the use of beating cloths. Lepidopteran larvae found feeding on tropical soda apple were reared in the laboratory until adult emergence and then identified. Parasitoids were reared from *G. boliviana* pupae, and field observations of predation were made. Entomopathogens of *G. boliviana* were identified using light microscopy by Dr. Drion Boucias at the University of Florida, and arthropods were identified by personnel at the Florida Department of Agriculture and Consumer Services, Division of Plant Industry (DPI), Gainesville, Florida, and the Systematic Entomology Laboratory, United States Department of Agriculture, Beltsville, Maryland. All arthropods collected from tropical soda apple from 1994 to 2011 are included in the DPI database.

A total of seven mite species and 75 species of insect herbivores were collected from tropical soda apple in Florida (Table 1). The host specificity of these species ranged from *Solanum* specialists to generalists and included major pests of agricultural crops as well as ornamental plants. The high diversity of insect herbivores found in this study is explained in part by the presence of close tropical soda apple relatives in Florida, including 27 species in the genus *Solanum* and 31 species in other genera of Solanaceae (Wunderlin & Hansen 2008). Based on field observations, tropical soda apple is an attractive host for many agriculturally important insect pests such as *Leptinotarsa decemlineata* (Say) and *L. juncta* (Germar) (Chrysomelidae), *Manduca sexta* L. (Sphingidae), *Bemisia tabaci* (Gennadius) (Aleyrodidae), *Aphis gossypii* Glover (Aphididae) and *Lineodes integra* Zeller (Pyralidae) (Table 1), and therefore may serve as a reservoir on which pest populations may increase before moving into crops.

A total of one mite species, 19 species of spiders and 30 species of predatory insects were found on tropical soda apple (Table 2). Predators observed feeding on *G. boliviana* larvae and pupae included *Geocoris punctipes* (Say) (Lygaeidae), *Sinea* sp. (Reduviidae), *Perillus bioculatus* (Fabricius), *Stiretrus anchorage* (Fabricius) (Pentatomidae), *Tupiocoris notatus* (Distant) (Miridae), *Solenopsis invicta* Buren (Formicidae), and the spider *Peucetia viridans* (Hentz) (Oxyopidae). The mirid species found in this study are facultative predators,
**TABLE 1. HERBIVOROUS ARTHROPODS ASSOCIATED WITH TROPICAL SODA APPLE, *SOLANUM VIARUM*, IN FLORIDA.**

| Order: Family        | Species                        | Importance          |
|---------------------|--------------------------------|---------------------|
| Acari: Acaridae     | Undetermined                   |                     |
| Acari: Eriophyidae  | *Aceria* sp.                   | pest of tomato      |
| Acari: Tarsonemidae | *Tarsenemus* sp.               | pest of crops       |
| Acari: Tenuipalpidae| *Aceria* sp.*Aculops lycopersici* (Massee) | pest of tomato      |
| Acari: Tenuipalpidae| *Brevipalpus californicus* (Banks) | pest of citrus      |
| Acari: Winterschmidtiidae | *Tetranychus evansi* Baker and Pritchard | pest of crops |
| Coleoptera: Anthicidae | *Acanthinetus argentinu* (Pic) | pest of crops       |
| Coleoptera: Cerambycidae | *Styloleptus biustus* (LeConte) | pest of crops       |
| Coleoptera: Chrysomelidae | *Diabrotica undecimpunctata* Barber | pest of crops       |
| Coleoptera: Curculionidae | *Faustinus cubae* (Boheman) | pest of Solanum spp. |
| Coleoptera: Elateridae | *Conoderus rudis* Brown | pest of sweet potato |
| Coleoptera: Languridae | *Loberus* sp. | pest of crops       |
| Coleoptera: Latridiidae | Undetermined |                       |
| Coleoptera: Phalacridae | Undetermined |                       |
| Coleoptera: Tenebrionidae | *Bothrotes canaliculatus* (Say) | pest of crops       |
| Diptera: Agromyzidae | *Liriomyza trifolii* (Burgess) | pest of crops       |
| Diptera: Cecidomyiidae | Undetermined |                       |
| Diptera: Chloropidae | Undetermined |                       |
| Diptera: Ephydridae | *Leptopsilopa similis* (Coquillett) | pest of Solanum spp. |
| Diptera: Lauxaniidae | *Camptoprosopella verticalis* (Loew) | pest of crops       |
| Diptera: Muscidae | *Atherigona orientalis* Schiner | fruit fly           |
| Hemiptera: Aleyrodidae | *Bemisia tabaci* (Gennadius) | pest of crops       |
| Hemiptera: Alydidae | *Trialeurodes abutilonea* (Haldeman) | pest of crops       |
| Hemiptera: Anthocoridae | *Aphis gossypii* Glover | pest of crops       |
| Hemiptera: Aphididae | *Prospia bicincta* (Say) | pest of grasses     |
| Hemiptera: Cercopidae | *Clastoptera xanthocephala* Germar | pest of crops       |
| Hemiptera: Coccidae | *Prosapia bicuspidata* (Say) | pest of grasses     |
| Hemiptera: Coreidae | *Phthia picta* (Drury) | pest of grasses     |
| Hemiptera: Delphacidae | *Delphacodes* sp. |                       |
| Hemiptera: Dictyopharidae | Undetermined |                       |
| Hemiptera: Lygaeidae | *Isshodermus brunipennis* (Germar) | pest of crops       |
| Hemiptera: Membracidae | *Paromius longulus* (Dallas) | pest of tomato      |
| Hemiptera: Miridae | *Collaria oculata* (Reuter) | pest of tomato      |
| Hemiptera: Pentatomidae | *Dicyphus minimus* Quaintance | pest of tomato      |
| Hemiptera: Pseudococcidae | *Macconellicoccus hirsutus* (Green) | pest of crops       |
| Hemiptera: Pyrrhocoridae | *Planococcus citri* (Risso) | pest of crops       |
| Hymenoptera: Halictidae | *Niesthrea sidea* (Fabricius) | pest of crops       |
| Lepidoptera: Arctiidae | *Augochloropsis metallica* (Fabricius) | pest of crops   |
| Lepidoptera: Gelechiidae | *Enigmogramma basigera* (Walker) | pest of crops       |

1Field observations in Florida suggested that insect populations could increase rapidly on tropical soda apple.
### TABLE 1. (CONTINUED) HERBIVOROUS ARTHROPODS ASSOCIATED WITH TROPICAL SODA APPLE, *Solanum viarum*, IN FLORIDA.

| Order: Family | Species | Importance |
|---------------|---------|------------|
| Lepidoptera: Nymphalidae | Heliconius charithonia (L.) | pest of tomato |
| Lepidoptera: Pyralidae | Lineodes integras Zeller1 | pest of Solanaceae |
| Lepidoptera: Sphingidae | Manduca sexta L.1 | |
| Lepidoptera: Tortricidae | Platynota flavedana Clemens | |
| Orthoptera: Tettingoniidae | Undetermined | |

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### TABLE 2. PREDATORS, PARASITIDS AND ENTOMOPATHOGENS FOUND ON TROPICAL SODA APPLE PLANTS, *Solanum viarum*, OR RECOVERED FROM *Gratiana boliviana* IN FLORIDA.

| Order: Family | Species | Functional Group |
|---------------|---------|-----------------|
| Acari: Ascidae | Undetermined | predator |
| Araneae: Anyphaenidae | Undetermined | predator |
| Araneae: Araneidae | Acanthhepeira sp. | predator |
| Araneae: Salticidae | Peucetia viridans (Hentz) | predator |
| Araneae: Theridiidae | Thiodina sp. | predator |
| Coleoptera: Carabidae | Celleida decora (Fabricius) | predator |
| Dictyotera: Mantidae | Leucauge argyra (Walckenaer) | predator |
| Hemiptera: Anthocoridae | Xylocoris vicarius (Reuter) | predator |
| Hemiptera: Lygaeidae | Geocoris punctipes (Say)1 | predator |
| Hemiptera: Miridae | Engytagus modestus (Distant)1 | facultative predator |
| Hemiptera: Pentatomidae | Podisus macronatus Uhler | predator |
| Hemiptera: Reduviidae | Stiretrus anchorago (Fabricius)1 | predator |
| Hymenoptera: Braconidae | Undetermined | parasitoid |
| Hymenoptera: Ceraphronidae | Undetermined | parasitoid |
| Hymenoptera: Chalcidae | Conura side (Walker)2 | parasitoid |
| Hymenoptera: Eulophidae | Aprostocetus nr. cassidis2 | parasitoid |
| Hymenoptera: Eupelmidae | Brasema sp.2 | parasitoid |
| Hymenoptera: Formicidae | Camponotus tortuatus Emery | predator |
| Hymenoptera: Formicidae | Cremaflagaster sp. | predator |
| Hymenoptera: Formicidae | Cyphomyrmex sp. | predator |
| Hymenoptera: Formicidae | Dolichoderus pustulatus Mayr | predator |
| Hymenoptera: Formicidae | Pseudomyrmex cubaensis (Forel) | predator |

1Predator observed feeding on *G. boliviana*.
2Parasitoid reared from *G. boliviana* pupae.
3Disease recovered from infected *G. boliviana*.
and they comprised up to 95% of the predators found on tropical soda apple in central Florida (Manrique et al. 2011). Pupal parasitoids of *G. boliviana* included *Conura side* (Walker) (Chalcididae), *Brasema sp.* (Eupelmidae), and *Aprostocetus nr. cassidis* (Eulophidae). Because *C. side* also attacks lepidopteran larvae (Mitchell et al. 1997) and because of the taxonomic uncertainty of *Brasema sp.* and *Aprostocetus nr. cassidis*, we cannot conclude that any specialist natural enemies attack *G. boliviana* in Florida. The exploitation of *G. boliviana* by these parasitoids was reported three yr after its release in Florida (K. Hibbard, unpublished data). This relatively short time to host exploitation is similar to that which has been documented in other weed biological control programs (Hill & Hulley 1995; Kula et al. 2010, but see Christensen et al. 2011). Two parasitoids have been reported attacking the native *Gratiana pallidula* (Boheman) in Arkansas, i.e., a eulophid, *Tetrastichus*, and a chalcid, *Conura sanguineiventris* (Cresson) (Rolston et al. 1965). However, these were not found attacking *G. boliviana* in Florida. Entomopathogens recovered from *G. boliviana* included *Nosema* sp. (Microspora: Nosematidae), *Matties oryzaeophili* (Ormières, Loubes, and Kuhl) (Phyllum: Bacteria), and *short gram-negative bacteria* (Orthoptera: Gryllidae) in open and shaded habitats. Environmental control agent of tropical soda apple.

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