

Establishment, spread and initial impacts of *Gratiana boliviana* (Chrysomelidae) on *Solanum viarum* in Florida

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Summary

Solanum viarum Dunal (Solanaceae) is an invasive perennial shrub in southeastern USA. Native to South America, it was first found in Florida in 1988, and it has already invaded more than 400,000 ha of grasslands and conservation areas in 11 states. Currently recommended control tactics for this weed in pastures are based on herbicide applications combined with mechanical (mowing) practices. These control tactics provide a temporary solution and can cost as much as \$188/ha for dense infestations of the weed. A biological control project against *S. viarum* was initiated in 1997. After 3 years of intensive host-specificity testing, the South American leaf beetle *Gratiana boliviana* was approved for field release by the United States Department of Agriculture (USDA)-Animal and Plant Health Inspection Service (APHIS)-Plant Protection and Quarantine (PPQ) in 2003, and its release in Florida began in summer 2003. Up to now, approximately 120,000 beetles have been released in 25 counties in Florida. The beetles established at virtually all the release sites in Florida. Beetle dispersal has been based on plant availability with annual dispersal from 1.6 to 16 km/year from the release sites. Initial impacts of the beetles range from 30% to 100% plant defoliation. The fruit production declined from 40 to 55 fruits per plant in summer 2003, when beetles were released, to zero or a few deformed fruits (one to four per plant) 2 years post release in five of the release sites monitored. Mass rearing, field release and post-release evaluation of *G. boliviana* and the target plant will continue during 2008.

Keywords: invasive plant, weed biological control, monitoring.

Introduction

Solanum viarum Dunal (Solanaceae) is a perennial shrub from South America that has been spreading throughout Florida at an alarming rate during the last two decades. The pastureland infested in 1992 was estimated in approximately 60,000 ha (Mullahey *et al.*,

1993), and this infested area increased to more than 300,000 ha in 1995–1996 (Mullahey *et al.*, 1997). Currently, the infested area is estimated at more than 400,000 ha (Medal *et al.*, 2004; Medal, 2005). *S. viarum* was first reported in the United States in Glades County, FL, in 1988 (Coile, 1993; Mullahey and Colvin, 1993). This weed also is present in Alabama, Arkansas,

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Georgia, Louisiana, Mississippi, North Carolina, Pennsylvania, South Carolina, Tennessee, Texas and Puerto Rico (Bryson and Byrd, 1996; Dowler, 1996; Mullahey *et al.*, 1997; Medal *et al.*, 2003). However, infestations in these states have still not reached high levels. The potential range of *S. viarum* in the United States can be extended 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.

In addition to its invasion of pasture lands and reduction of cattle carrying capacity (Mullahey *et al.*, 1993), *S. viarum* is a host of at least six viruses that affect vegetable crops including tomato, tobacco and pepper (McGovern *et al.*, 1994a,b, 1996). Furthermore, it is also an alternate host for agricultural pests such as the Colorado potato beetle, *Stilodes* (= *Leptinotarsa*) *decemlineata* (Say) (Coleoptera: Chrysomelidae), a major defoliating insect pest of potato in North America; tomato hornworm *Manduca quinquemaculata* (Haworth) (Lepidoptera: Sphingidae), a major pest of tomato and tobacco plants; and the silverleaf whitefly *Bemisia argentifolii* Bellows and Perring (Homoptera: Aleyrodidae), one of the most troublesome insect pests worldwide of many field and vegetable crops (Habeck *et al.*, 1996; Medal *et al.*, 1999). Although it is very difficult to determine the real (direct and indirect) economic losses due to this invasive weed, Mullahey *et al.* (1996) estimated the annual production loss to Florida ranchers was US\$11 million in 1993.

Native to southern Brazil, Paraguay, northeastern Argentina and Uruguay (Nee, 1991), *S. viarum* has spread into other parts of South and Central America including Mexico, Nicaragua, Honduras and Costa Rica (J. Medal, personal communication). This weed also has spread into other regions including the Caribbean (confirmed in Puerto Rico), Africa, India, Nepal and China (Chandra and Srivastava, 1978; Coile, 1993). The rapid spread in Florida can be partially attributed to the 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 the fruits (Mullahey *et al.*, 1993; Bryson *et al.*, 1995; Brown *et al.*, 1996).

One *S. viarum* plant can produce on average from 100 to 160 fruits and 41,000 to 50,000 seeds with a germination rate of at least 75% (Mullahey *et al.*, 1993; Pereira *et al.*, 1997). The extent of the infestation is increasing rapidly in the United States, making this a national rather than just a Florida problem.

Current management practices for *S. viarum* in Florida are based on herbicide applications combined with mechanical (mowing) practices (Mislevy *et al.*, 1996, 1997; Sturgis and Colvin, 1996; Akanda *et al.*, 1997). These control tactics provide temporary weed suppression at an estimated cost of US\$185/ha to control dense infestations of *S. viarum* (Mullahey *et al.*, 1996). In ad-

dition to being expensive, the application of herbicides is not always feasible in rough terrain or inaccessible areas.

A biological control project on this highly invasive non-native weed was initiated in January 1997 by the University of Florida in collaboration with the Universidade Estadual Paulista, Jaboticabal campus, Brazil; Universidade Federal do Paraná in Curitiba, Brazil; Universidade Regional de Blumenau, Santa Catarina state, Brazil; Universidade Centro-Oeste, in Irati, Paraná state, Brazil; Instituto Nacional de Tecnología Agropecuaria (INTA-Cerro Azul), Misiones province, Argentina; and the United States Department of Agriculture (USDA)-Agricultural Research Service (ARS) Biological control laboratory in Hurlingham, Buenos Aires province, Argentina. Foreign explorations in South America identified several insects as potential biological control agents of *S. viarum* including three leaf beetles, *Gratiana boliviana* Spaeth, *Mettriona elatior* Klug and *Gratiana graminea* Klug (Chrysomelidae) and the flower-bud weevil *Anthonomus tenebrosus* (Boheman) (Curculionidae). These potential agents were initially selected for screening because of the extensive foliage/flower bud plant damage attributed to these beetles in their native range (Medal *et al.*, 1996, 1999, 2006). Two other promising biological control candidates that are currently undergoing open-field host-specificity tests in Brazil are the leaf beetle *Platyphora* sp. and a flea beetle (Chrysomelidae) (H. Medal, unpublished data).

G. boliviana was approved for field release in the United States by USDA-Animal and Plant Health Inspection Service (APHIS)-Plant Protection and Quarantine (PPQ) in May 2003. A high level of specificity and significant defoliation of *S. viarum* was indicated in host-specificity tests (Gandolfo *et al.*, 1999, 2007; Medal *et al.*, 2002, 2004). Field releases of *G. boliviana* in the United States began in May 2003. Requests for field releases of the leaf-feeder beetles *M. elatior* and *G. graminea* in the United States were submitted to TAG (Technical Advisory Group for Biological Control Agents of Weeds) in September and October 2006, respectively.

Release of *G. boliviana* in Florida

A total of 120,000 beetles have been released in 25 Florida counties since the summer of 2003. Florida counties where beetles have been released are shown in Fig. 1. The number of beetles released at each location varied from 30 to 2000 based on beetle availability and density of the *S. viarum* infestation.

A new release technique was used for the first time in the *S. viarum* biological control project. *S. viarum* plants that were infested with beetles (approximately 100 per plant) in the greenhouse at the Southwest Florida rearing facility in Immokalee were taken to the field and transplanted in October 2005 and August 2006 in

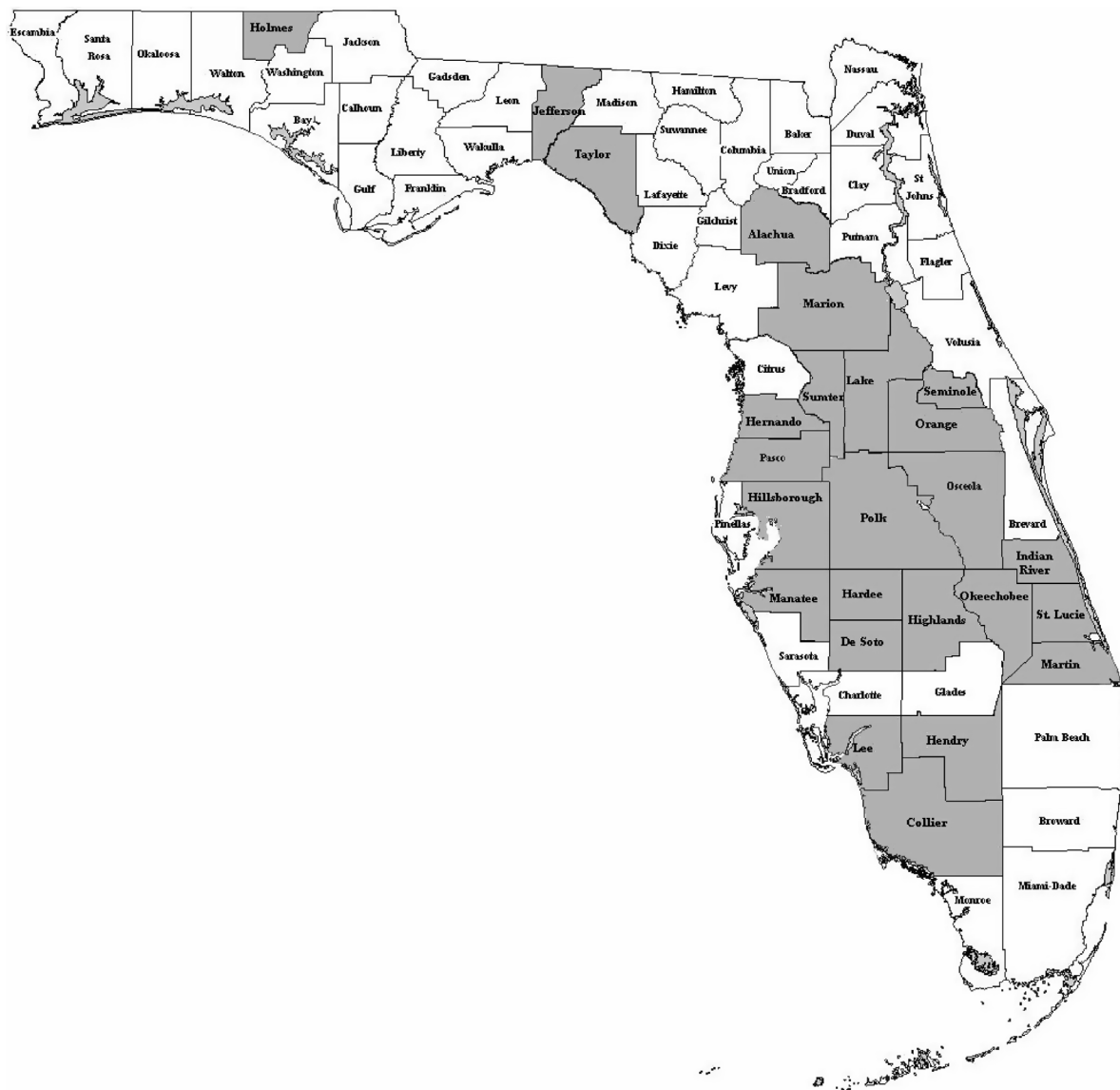


Figure 1. Florida counties (dark) where *Gratiana boliviana* have been released during the period 2003–2007.

Lee County, Florida. This has proven to be an efficient technique with less labor involved for insect field release. Beetle releases have been made both on private and public lands. The *G. boliviana* demand by cattle ranchers for field release each year exceeded the beetle production by our team of collaborators. We plan to increase the beetle production in 2007 by establishing field insectaries at different locations in Florida. Cattle ranchers interested in obtaining beetles for release in their farms are being provided with adult beetles, and we are conducting monthly or bimonthly post-release evaluations on the dispersion of the beetles, on the extent of the feeding damage and changes in the beetle population at selected release sites. The post-release evaluations also include observations on possible non-target effects on closely related plant species growing in the release area and on the regeneration of native

plant species and/or improved pastures that have been displaced by the *S. viarum* plants.

Post-release evaluations of *G. boliviana* in Florida

Evaluation of the feeding effects of the beetles on *S. viarum* plants (percent defoliation, fruit production) and number of beetles on plants began in the summer of 2003–2004 in Polk and Okeechobee counties, in St. Lucie and Okeechobee counties and in Collier and Hendry counties. Monitoring also was initiated at the Eagle Creek Conservation area in Orange County by K. Peterman (Environmental Scientist) and J. Medal. For the post-release evaluation in Polk County, where approximately 1000 beetles were released in August

2003, 20 marked plants within 100 m of the initial release site have been thoroughly examined every 2 to 3 months since the summer of 2003. The estimated (visual) defoliation increased on average from 46% (December 2003) to 94% (December 2004), and it was directly associated with the increase in number of adults and immature beetles observed on the plants during the same period, except from August to December 2004 when the number of beetles decreased. In 2005, the plant defoliation was high on average from 69% to 96%. At least half of the 20 marked plants were unable to regrow after complete defoliation by the beetles in the previous year and also due to the competition by other plant species. The number of *S. viarum* fruits produced per plant defoliated by the beetles has significantly decreased with none or very few small fruits compared with the large number of fruit (40–55) observed during the summer of 2003 at the time the beetles were released. Most of the plants on the 4-ha release site have been replaced by other plant species including bahiagrass (*Paspalum notatum* Flueggé), *Rubus* sp., dayflower (*Commelina diffusa* Burm), Caesar weed (*Urena lobata* L.), air-potato (*Dioscorea bulbifera* L.), roadside flatsedge (*Cyperus sphaelatus*, Rottb.), oak (*Quercus* sp.) and other herbaceous vegetation. The estimated *S. viarum* density at the release area (4 ha) at the end of November 2005 was only 5–10%, which is significantly lower than the initial population density (80% to 90%) that was observed in the summer 2003 before the beetles were released. The relatively low number (<100) of beetles recorded on the 20 marked *S. viarum* plants on each monitoring date in 2005 can be attributed to beetle dispersal to *S. viarum* plants as far as 1600 m away (September 2005) from the initial release site. Dispersal of the beetles was associated with the low availability of foliage on the *S. viarum* plants at the release site caused by extensive beetle defoliation during the previous growing season. Dispersal ability of the beetles at five of the Florida release sites ranged from 1.6 to 16 km/year. After 3 years post-release at the Polk County site, beetle defoliation is having a great impact. Fruit production has declined to one to five deformed or no fruits per plant if the beetles start feeding on the plants before fruit formation. Follow-up studies include observations on possible non-target effects on closely related plant species growing in the release area. To date, no non-target effects (J. Medal, personal communication) have been observed even on plants in the same genus such as the non-natives red soda apple (*Solanum capsicoides* All.), wetland nightshade (*Solanum tampicense* Dunal) and turkey berry (*Solanum torvum* Sw.) that are growing intermixed with or in close proximity to *S. viarum*.

Conclusion

Post-release evaluations of the South-American leaf-beetle *G. boliviana*, first biological control agent whose

releases in Florida began in summer 2003 against the invasive non-native spiny shrub *S. viarum*, have indicated an extensive weed defoliation and reduction of fruit production in five of the release sites monitored. The beetle established at almost all the release sites and is spreading to adjacent weed-infested areas. Field observations also confirmed the specificity of the beetle on the target weed, and to date, no non-target effects have been observed even on plants closely related.

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