Natural Enemies of Brazilian Peppertree (Sapindales: Anacardiaceae) from Argentina: Their Possible Use for Biological Control in the USA

Authors: Mc Kay, Fernando, Oleiro, Marina, Cabrera Walsh, Guillermo, Gandolfo, Daniel, Cuda, James P., et al.

Source: Florida Entomologist, 92(2) : 292-303

Published By: Florida Entomological Society

URL: https://doi.org/10.1653/024.092.0213

NATURAL ENEMIES OF BRAZILIAN PEPPERTREE (SAPINDALES: ANACARDIACEAE) FROM ARGENTINA: THEIR POSSIBLE USE FOR BIOLOGICAL CONTROL IN THE USA

FERNANDO MC KAY[1], MARINA OLEIRO[1], GUILLERMO CABRERA WALSH[1], DANIEL GANDOLFO[1*], JAMES P. CUDA[2] AND GREGORY S. WHEELER[3]
[1]South American Biological Control Laboratory, USDA-ARS, Hurlingham, Argentina
E-mail: fmckay@speedy.com.ar

*Deceased

[2]Entomology & Nematology Department, Institute of Food & Agricultural Sciences, University of Florida, P.O. Box 110620, Gainesville, Florida 32611-0620

[3]Invasive Plant Research Laboratory, USDA/ARS, University of Florida, 3225 College Avenue, Ft. Lauderdale, Florida 33314

ABSTRACT

Brazilian peppertree (*Schinus terebinthifolius* Raddi, Anacardiaceae) is a perennial tree native to Argentina, Brazil, and Paraguay. The plant was introduced into the USA before 1900. Originally grown as an ornamental, Brazilian peppertree is now considered an noxious plant in Hawaii and Florida, where it is ranked among the most important threats to biodiversity in natural areas. Recent surveys conducted in northeastern Argentina recovered one fungus associated with distorted leaves and 36 phytophagous insects collected on Brazilian peppertree. A leaf-feeding notodontid moth, a new species of gracillariid leaf blotch miner, and a stem-boring weevil have been selected for further studies to determine their potential as biological control agents of Brazilian peppertree in the USA. The results of these surveys are summarized herein and descriptions are included of the insects that are considered most promising for biological control of this weed.

Key Words: foreign exploration; classical biological control; *Schinus terebinthifolius*; host range; invasive weed; Florida Everglades

RESUMEN

Schinus terebinthifolius Raddi, (Anacardiaceae) es un árbol perenne nativo de Argentina, Brasil, y Paraguay. Introducido en los Estados Unidos antes de 1900, como especie ornamental, *S. terebinthifolius* es considerada una planta nociva en los estados de Florida y Hawaii, donde amenaza la biodiversidad de áreas naturales. Inspecciones de campo recientes en el noreste de Argentina revelaron la presencia de un hongo asociado a hojas deformadas y 36 artrópodos fitófagos recolectados de *S. terebinthifolius*. Un Notodontidae desfoliador, un Gracillariidae minador de las hojas, y un Curculionidae minador del tallo han sido seleccionados para realizar estudios que determinen su potencial como agentes de control biológico de *S. terebinthifolius* en los Estados Unidos. El presente trabajo resume el resultado de las inspecciones de campo y las descripciones de los artrópodos considerados más promisorios para el control biológico de *S. terebinthifolius* en los Estados Unidos.

Translation by the authors.

Brazilian peppertree (*Schinus terebinthifolius* Raddi, Anacardiaceae) is a Neotropical species whose native range extends along the Atlantic coast of Brazil, from Recife south to Rio Grande do Sul, and west to north-eastern Argentina and adjacent Paraguay (Barkley 1944, 1957, unpublished data). This species has been introduced to many countries around the world as an ornamental (Morton 1978; Panetta & McKee 1997). Currently, Brazilian peppertree is listed as a prohibited plant and a noxious weed in Florida, and is considered an invasive species in Florida, California, Texas, and Hawaii (Randall 2000; HSASC 2001; FLEPPC 2005; USDA, NRCS 2009). In its exotic range, the tree decreases the biodiversity of infested natural areas by aggressively invading a variety of coastal and upland habitats (Mytinger & Williamson 1987; Gann et al. 2001). In Florida, infestations of Brazilian peppertree are estimated to occupy over 283,400 ha in central and south Florida (Wunderlin & Hansen 2003; Cuda et al. 2006). Brazilian peppertree constitutes not only a threat to natural areas but also to agriculture and cattle production in Florida and Hawaii (Morton 1978; Ewel 1986; Yoshioka & Markin 1991). In Florida, it is an important alternate host for the exotic diaprepes root weevil, *Diaprepes abbreviates* (L.), a serious pest of citrus and ornamentals (McCoy et al. 2003). This species produces allelopathic compounds that suppress the growth of other plant species (Gogue et al. 1974; Morgan & Overholt 2005, Donnelly et al. 2008). Brazilian peppertree is also suspected of causing allergic reactions and respiratory illnesses in sensitive humans from volatiles released by the leaves, flowers, and fruit (Morton 1978). Conservation organizations consider Brazilian peppertree a high-priority target due to its already widespread occurrence and great potential to expand its range (Randall 1993).

Biological control of Brazilian peppertree has a long history; efforts began in Hawaii in the 1950s and resulted in the release of 3 insect species: a gall-forming caterpillar, *Crasimorpha infuscata* Hodges (Lepidoptera: Gelechiidae), a defoliating caterpillar, *Episimus utilis* Zimmerman (Lepidoptera: Tortricidae), and a seed-feeding beetle, *Lithraeus atronotatus* (Pic) (Coleoptera: Bruchidae) (Davis & Krauss 1962; Krauss 1962, 1963; Hight et al. 2002). Only the last 2 species established field populations in Hawaii, but they are exerting only negligible control of the weed population (Hight et al. 2002). In Florida, exploration for biological control agents of this weed was initiated in the 1980s and 1990s. Surveys of the insect fauna associated with Brazilian peppertree in its adventive Florida range found 115 insect species, most of which were generalists or potential agricultural pests and thus were unsuitable as biological control agents for biological control (Cassani 1986; Cassani et al. 1989).

Exploration in the native range of Brazilian peppertree in South America revealed the presence of at least 200 species of natural enemies (Bennett et al. 1990; Bennett & Habeck 1991). Three insects were selected for further studies in Florida: the leaf-feeding sawfly *Heteroperreyia hubrichi* Malaise (Hymenoptera: Pergidae), the sap-sucking thrips *Pseudophilothrips ichini* Hood (Thysanoptera: Phlaeothripidae), and the defoliating caterpillar *E. unguiculus* Clarke (= *E. utilis*, Rozowski & Brown 2008) (Medal et al. 1999; Hight et al. 2002; Martin et al. 2004). To date, none of these biological control candidates has been released in Florida. The only known stenophagous herbivore feeding on Brazilian peppertree in the continental USA is a seed-feeding wasp, *Megastigmus transvaalensis* (Hussey) (Hymenoptera: Torymidae). This adventive wasp, which attacks *Rhus* spp. in its native range of South Africa, probably entered Florida with the gourmet pink peppercorn trade (Habeck et al. 1989; Scheffer & Grissell 2003). It has been found in Florida and Hawaii and causes on average 30% mortality to Brazilian peppertree seeds (Wheeler et al. 2001). However, the continuous spread of Brazilian peppertree motivated the search for additional natural enemies against this weed. Explorations were conducted in northern Argentina, an area that had not been surveyed previously, and seems to be the most likely center of origin of the *Schinus* genus, with 22 of the 30 known species (Barkley 1944; Muñoz 2000). The results of these surveys indicate that Argentine Brazilian peppertree populations harbor natural enemies not previously reported. In this paper we present biological notes, distribution, and host records of selected natural enemies of Brazilian peppertree found in Argentina. We also discuss their potential as biological control agents against Brazilian peppertree in the USA.

Materials and Methods

Exploration

The surveyed area was selected considering published distribution records of *S. terebinthifolius* in Argentina (Muñoz 2000). Extensive exploratory trips were made along the main roads of the provinces of Entre Ríos, Corrientes, Misiones and Formosa, in the northeast of Argentina, between Mar 2004 and Jan 2007 (Fig. 1). In total, 18 surveys were conducted with 125 sites inspected. Most sites were visited twice a year to account for seasonal variations in herbivore presence and abundance. Brazilian peppertree plants occurred as large isolated trees in undisturbed areas or as shrubby stands on disturbed roadsides, where they are periodically cut and grow back from the coppiced stumps. Insects were collected by visual inspection, beating sheets, and by rearing infested plant material (e.g., fruits, leaves, limbs, galls) for subsequent emergence in the laboratory. Insect species were considered to be "very rare", "rare" or "common" if present in less than 10%, 10-30%, and more than 30% of the sampled sites, respectively. Species designated as "abundant" were those that were found in high numbers when encountered, but were not necessarily common (e.g., "locally abundant"). Natural enemies were prioritized according to their perceived potential for control of Brazilian peppertree. The criteria used were their apparent specificity as determined from field observations (see next section), preliminary host specificity studies, published records and a subjective assessment of the ability of a species to damage the weed in terms of defoliation, or stunting growth.

Field Host Range

Populations of other members of the Anacardiaceae sympatric with *S. terebinthifolius* were inspected on a regular basis. These species included

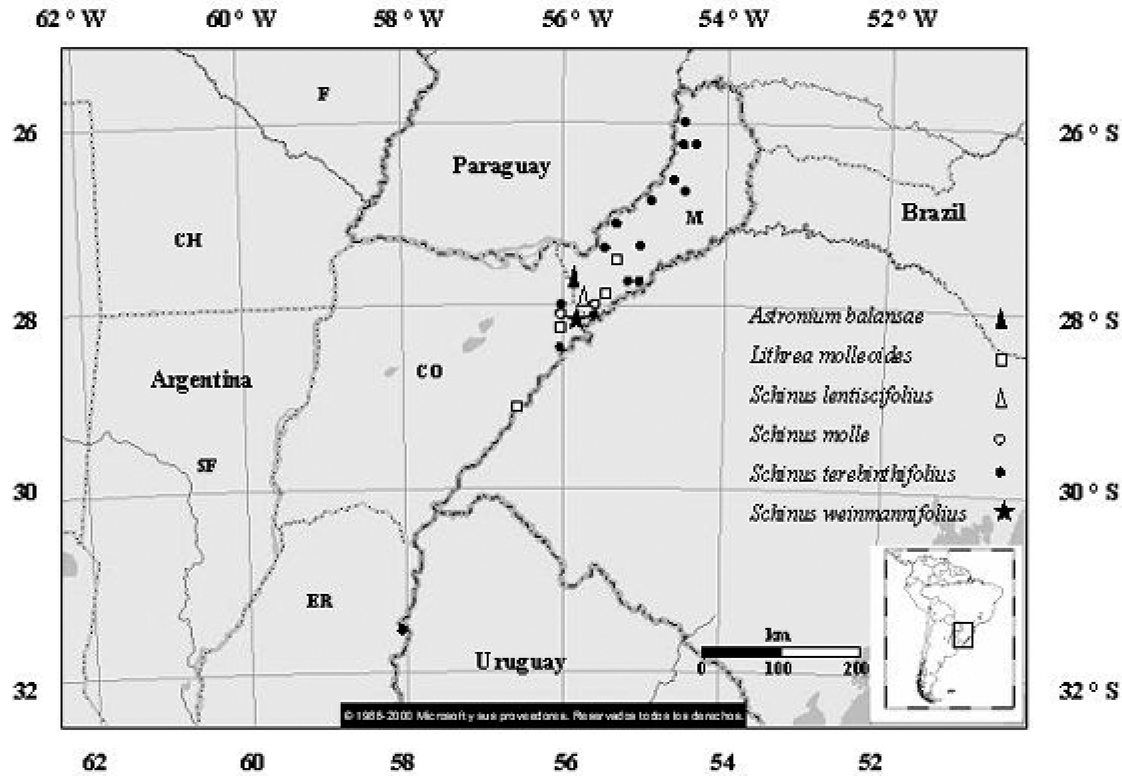

Fig. 1. Main collecting sites of *Schinus terebinthifolius* and other Anacardiaceae species in Northeastern Argentina (CO, Corrientes; CH, Chaco; F, Formosa; ER, Entre Ríos; M, Misiones; SF, Santa Fé).

Astronium balansae Engl., *Lithrea molleoides* (Vell.) Engl., *Schinus fasciculatus* (Griseb.) *Schinus lentiscifolius* March., *S. longifolius* (Lindl.) Speg., *Schinus molle* L. and *Schinus weinmannifolius* Engl. Voucher specimens of the plants and insects collected are deposited at the USDA-ARS-SABCL, Hurlingham, Argentina.

Preliminary Host-range Testing

Experiments were conducted on plant species in the Anacardiaceae and the Sapindaceae for their taxonomic relatedness to *S. terebinthifolius* and economic importance. Special attention was paid to the pistachio species, *Pistacia vera* L., Kerman cultivar, (pistachio) and *Pistacia integerrima* Stewart ex. Brandis (a species commonly used as rootstock of *P. vera*), which are chemically similar to Brazilian peppertree (Campello & Marsaioli 1975) and commercially important Anacardiaceae, especially in California (Siegel et al. 2008).

Fungus Associated with Distorted Leaves

Selected potted test plants (*L. molleoides*, *S. areira*, *P. integerrima* and *S. terebinthifolius*) were placed in 2 different field sites next to diseased *S. terebinthifolius* plants. Diseased plants have wrinkled and shrunken young leaves. Two branches of each test plant were tied to branches of living Brazilian peppertree plants that showed disease symptoms.

Tecmessa elegans Schaus (Lepidoptera: Notodontidae). No-choice larval survival was evaluated on 12 plant species in the Anacardiaceae: *A. balansae, L. molleoides, Mangifera indica* L. (mango), *P. vera*, *P. integerrima, Schinopsis balansae* Engl., *S. areira*, *S. lentiscifolius, S. molle,* and *S. terebinthifolius*, and the Sapindaceae *Cardiospermum grandiflorum* Sw. and *Serjania glabrata* Kunth. Tests were conducted in a growth chamber (25 ± 2°C: 60-80% RH; 16:8 L:D). In each replicate (5 to 10), 5 newly emerged larvae were placed in 0.7-L plastic containers with perforated lids and moist tissue paper. The larvae were fed bouquets of freshly excised leaves with their petioles inserted in 3.6-mL water picks with water.

Apocnemidophorus blandus (Pascoe) (Coleoptera: Curculionidae). The adult feeding preference of this weevil was studied in a choice test in outdoor conditions at the SABCL. Two potted plants of 5 species (*S. terebinthifolius*, *S. areira*, *M. indica*, *P. vera,* Kerman cultivar, and *P. integerrima*) of comparable height (1.5-2 m tall) and canopy size were placed in a circle in random order, inside a 7.2-m^3 walk-in cage. Eighty adult weevils were released in the center of the cage and allowed to feed for 60 d.

RESULTS

Exploration

In total, 37 phytophagous insects and one disease were found associated with *S. terebinthifolius* and other Anacardiaceae species in northeastern Argentina (Table 1). The insects belonged to the orders Hemiptera (1 species), Thysanoptera (1 species), Coleoptera (20 species), Lepidoptera (12 species), and Hymenoptera (3 species) (Table 1). Of these, 9 species were recorded on *S. terebinthifolius* in earlier surveys in Brazil (F. Bennett, Univ. of Florida, unpublished report; Krauss 1962; Davis & Krauss 1962, 1963; D' Araújo et al. 1968; Medal et al. 1999; Martin et al. 2004; Scheffer & Grissell 2003). Field observations, bionomic data, and comments on those species deemed to have potential as biological control agents are included below.

Fungal Associate

Schinus terebinthifolius plants with distorted and pock-marked leaves were observed at several sites. This condition is caused by an unidentified fungus associated with cellular distortion and hypertrophy (M. Rayamajhi, USDA/ARS, personal communication). Similar symptoms were observed on field-collected leaves of the congeneric species *S. weinmannifolius* and *S. lentiscifolius*. The disease incidence of *S. terebinthifolius* plants was not abundant, but fairly common. Noticeably, young plants seem to be more susceptible. Preliminary host specificity experiments showed that symptoms were only found on *S. terebinthifolius* and *L. molleoides* (Table 2). However, potted *L. molleoides* plants were grown under shade and high humidity, conditions in which this plant is rarely seen in the field. These conditions might have been conducive to transmission of this disease because under natural field conditions the symptoms were never seen on *L. molleoides* plants, even when they were growing near infected *S. terebinthifolius* plants. Further studies are underway to examine the identity and specificity of this fungal associate species.

Leaf Feeders

Paraleucothrips n. sp. (Thysanoptera: Thripidae). A new species of thrips was found damaging shoots of *S. terebinthifolius*. Large numbers of light orange larvae and adults were found on the unfolding leaves of young shoots of medium-sized young plants (1-2.5 m tall). Shoot tips of infested *S. terebinthifolius* plants appeared wilted, with the leaf surface somewhat wrinkled, and in most cases clear yellow dots were found that corresponded to the oviposition marks. In preliminary rearing attempts, we observed that larvae and adults preferentially colonized the shoots containing the most villous leaves.

Blotch Leaf Miner. The larvae of a leaf-mining gracillariid moth were observed feeding on the leaflets of *S. terebinthifolius* at several sites in Argentina. Three other species of Gracillariidae (*Gracillaria* sp., nr. *Parornix* sp. and *Phyllonorycter* sp.) were reported from earlier surveys conducted in Brazil (Krauss 1963; F. Bennett, Univ. of Florida unpublished report). However, specimens from Argentina do not match any known Gracillariidae and this species will be assigned to a recently created genus (D. Davis et al. Smithsonian Institution NMNH, unpublished data).

Females lay eggs singly on the adaxial surface of leaflets, either on the main or secondary leaflet veins. The neonate larva bores into the plant epidermis and makes a short mine (0.93 ± 0.08 mm; mean ± SD; n = 21) parallel to the leaf vein. After this initial slender mine, the larval mine turns 90° and continues forming an increasingly wider blotch mine in the leaf blade. The initial two thirds of a fully developed blotch mine are dark brown and the most distal third is light green. One fully developed mine may remove up to 40% of the leaflet photosynthetic tissue. Occasionally 2, but generally 1 blotch is found per leaflet. Mature larvae leave the blotch through a slit in the light colored part and spin a silk cocoon on the adaxial surface of the leaves. Although larvae of different developmental stages were present year-round, the highest numbers of larvae and cocoons were found during the winter (Jun-Aug). Although most Nearctic Gracillariidae probably undergo some kind of resting phase, those feeding on evergreen leaves apparently experience no true diapause but fed whenever temperatures or other conditions permit, producing 1 to 3 generations per year (Davis 1987). Similarly, the Neotropical Brazilian peppertree Gracillariidae moth described here apparently is present year-round. Occasionally large numbers of larvae were found in the same stage suggesting their populations respond in a synchronized way to environmental cues.

In our field surveys, leaf blotches produced by this species were found on, *S. fasciculatus*, *S. lentiscifolius*, *S. longifolius*, *S. terebinthifolius* and *S. weinmannifolius*. A similar, but unidentified, blotch mine was found on leaflets of *Astronium balansae*. Results so far indicate a preference for the *Schinus* spp. but host specificity tests are currently underway to confirm the safety of this insect as a biological control agent. These studies

TABLE 1. NATURAL ENEMIES COLLECTED ON BRAZILIAN PEPPERTREE (*SCHINUS TEREBINTHIFOLIUS*) AND OTHER ANACARDIACEAE SPECIES IN NORTHEASTERN ARGENTINA.

Natural enemies		Host plant	Attack site or mode	Stage collected[1]	Abundance
Fungal associate					
Unknown	Unknown	*S. terebinthifolius*	Distorts leaves		Common
Hemiptera					
Psyllidae	*Calophya terebinthifolii* or near	*S. terebinthifolius*	Leaf pit galls	A; N	Common
Thysanoptera					
Thripidae	*Paraleucothrips* n. sp.	*S. terebinthifolius*	Leaf feeder	E; N; A	Common/abundant (up to 200 specimens per site)
Coleoptera					
Bruchidae	*Lithraeus atronotatus* or near	*S. terebinthifolius*	Fruit feeder	A	Uncertain
Cerambycidae	*Compsibidion vanum*	*S. terebinthifolius*	Stem borer	L	Uncertain
	Ommata sp.				
Curculionidae	*Apocnemidophorus blandus*	*A. balansae* *L. molleoides* *S. lentiscifolius* *S. longifolius* *S. molle* *S. terebinthifolius* *S. weinmannifolius*	Leaf feeder	A	Common/abundant (up to 50 specimens per site)
	A. pipitzi	*L. molleoides* *S. molle* *S. terebinthifolius*	Leaf feeder	A	Rare
	A. rufescens	*L. molleiodes* *S. molle* *S. terebinthifolius*	Leaf feeder	A	Very rare
	Compsus sp.	*S. terebinthifolius*	Leaf feeder	A	Rare
	Conotrachelus sobrinus	*S. terebinthifolius*	Collected on flowers	A	Locally abundant (up to 40 specimens per site
	Centrinus argentinensis	*S. terebinthifolius*	Collected on flowers	A	Very rare
	Entimus imperialis	*S. terebinthifolius*	Collected on leaves	A	Very rare
	Hadromeropsis sp.	*S. terebinthifolius*	Collected by beating	A	Rare
	Linogeraeus sp. 1	*S. terebinthifolius*	Collected on flowers	A	Very rare
	Linogeraeus sp. 2	*S. terebinthifolius*	Collected on flowers	A	Very rare

[1]A, adults; E, eggs; L, larva; N, nymph; P, pupa.

TABLE 1. (CONTINUED) NATURAL ENEMIES COLLECTED ON BRAZILIAN PEPPERTREE (*SCHINUS TEREBINTHIFOLIUS*) AND OTHER ANACARDIACEAE SPECIES IN NORTHEASTERN ARGENTINA.

Natural enemies		Host plant	Attack site or mode	Stage collected[1]	Abundance
	Nicentrus sp.	*S. terebinthifolius*	Collected by beating	A	Very rare
	Xystus sp.	*S. terebinthifolius*	Collected on flowers	A	Very rare
	sp. 1	*S. terebinthifolius*	Collected on flowers	A	Very rare
	sp. 2	*S. terebinthifolius*	Collected on flowers	A	Very rare
	sp. 3	*S. terebinthifolius*	Collected on flowers	A	Very rare
Chrysomelidae	*Percolaspis varia* or near	*S. terebinthifolius*	Leaf feeder	A	Locally abundant (up to 80 specimens per site)
Clytrinae	*Thermesia auricapilla*	*S. terebinthifolius*	Leaf feeder	A	Common
Lepidoptera					
Gelechiidae	*Crasimorpha infuscata*	*S. terebinthifolius* *S. weinmannifolius*	Stem galls	L	Common/locally abundant (up to 20 specimens per site)
	sp. 1	*L. molleoides* *S. terebinthifolius*	Leaf miner	L	Common/locally abundant (up to 60 specimens per site)
Gracillariidae	Unknown genus sp. 1	*S. fasciculatus* *S. lentiscifolius* *S. longifolius* *S. terebinthifolius* *S. weinmannifolius*	Leaf blotch miner	L; P	Common/locally abundant (up to 300 specimens per site)
Mimallonidae	*Aceclostria mus*	*A. balansae* *L. molleoides* *S. terebinthifolius* *S. weinmannifolius*	Leaf feeder	L	Common
Nepticulidae	*Stigmella* sp.	*S. terebinthifolius* *S. weinmannifolius*	Leaf miner	L	Common
Noctuidae	*Paectes obrontunda*	*S. terebinthifolius*	Leaf feeder	L	Common
	Eutelia abscondens	*S. terebinthifolius*	Leaf feeder	L	Very Rare
Notodontidae	*Tecmessa elegans*	*S. terebinthifolius* *S. weinmannifolius*	Leaf feeder	E; L	Locally abundant (up to 80 specimens per site)
	Nystalea ebalea	*S. terebinthifolius*	Leaf feeder	L	Rare
Saturniidae	*Citheronia laocoon*	*S. terebinthifolius*	Leaf feeder	L	Rare
Sphingidae	*Protoambylyx strigilis*	*S. terebinthifolius*	Leaf feeder	L	Rare
Tortricidae	*Episimus unguiculus* (= *E. utilis*)	*S. terebinthifolius*	Leaf tier	L	Common/locally abundant (up to 40 specimens per site)

[1]A, adults; E, eggs; L, larva; N, nymph; P, pupa.

TABLE 1. (CONTINUED) NATURAL ENEMIES COLLECTED ON BRAZILIAN PEPPERTREE (*SCHINUS TEREBINTHIFOLIUS*) AND OTHER ANACARDIACEAE SPECIES IN NORTHEASTERN ARGENTINA.

Natural enemies		Host plant	Attack site or mode	Stage collected[1]	Abundance
Hymenoptera					
Pergidae	*Heteroperreyia hubrichi*	*S. terebinthifolius* *S. weinmannifolius*	Leaf feeder	E; L; A	Common/locally abundant (up to 200 specimens per site)
	H. jorgenseni	*S. lentiscifolius* *S. longifolius* *S. molle*	Leaf feeder	E; L; A	Common/locally abundant (up to 200 specimens per site)
Torymidae	*Megastigmus transvaalensis*	*S. areira* *S. terebinthifolius* *S. weinmannifolius*	Fruit feeder	P; A	Common/locally abundant (up to 50 specimens per site)

[1]A, adults; E, eggs; L, larva; N, nymph; P, pupa.

are being complemented with field host range surveys (F. M., unpublished data).

Tecmessa elegans. This moth was described by Schaus (1901) from specimens collected in Castro, Paraná state, Brazil without reference to host plant. *Tecmessa elegans* is known to occur in Argentina on *Lithrea brasilinensis* and *Lithrea* sp. and in Brazil on *Lithrea* sp. ("aroeira") (D'Araújo et al. 1968; Pastrana 2004) and *S. terebinthifolius* (F. Bennett, Univ. of Florida, unpublished report). In the present study, eggs and larvae of *T. elegans* were found at 7 sites in northeastern Argentina (Corrientes and Misiones provinces) feeding on *S. terebinthifolius* and the closely related species *S. weinmannifolius*, which constitute new host records for this species in Argentina. *Tecmessa elegans* adults (wingspan: 3 cm) are creamy white in color with 3 sinuous narrow dark lines across each forewing. They lay chalky white eggs in compact clusters of varying number (10-80 eggs). There are 5 instars; the first 3 are gregarious, and the last 2 are generally solitary. Larval color changes progressively from burgundy in the early instars to alternate yellow and burgundy rings in the latter instars. The larvae of *T. elegans* are voracious leaf-feeders. The first instars skeletonize the leaflets usually feeding on the abaxial surface. As larvae develop, they eat most of the leaf except the larger veins. In the field, although not very common, it is possible to find *S. terebinthifolius* plants with some of their branches totally defoliated by *T. elegans*, indicating the potential damage that could be caused by large populations of this moth. Mature larvae spin a debris-encrusted cocoon buried a few centimeters in soil where they pupate. Egg incubation period is approximately 10 d. The larval stage varies between 20 and 25 d, and the time between cocoon formation and adult emergence is approximately 20 d. The presence of eggs and larvae of *T. elegans* in the field extends approximately from Dec to Apr.

Several natural enemies were found emerging from different life stages of *T. elegans*. Eupelmidae (Chalcidoidea) wasps (*Anastatus* sp.) emerged from the eggs. Tachinid flies (*Lespesia* spp.) and 2 different wasps, *Glyptapanteles* sp. (Braconidae) and 1 Ichneumonidae (*Diradops* sp.) were reared from mature larvae. In some cases, the Ichneumonidae parasitoids were responsible for up to 90% of the larval mortality.

In the no-choice tests, neonate *T. elegans* survival and development to the adult stage was recorded on all of the native Argentinean Anacardiaceae (*A. balansae, L. molleoides, S. balansae, S. areira, S. lentiscifolius, S. molle,* and *S. terebinthifolius*) and also on the economically important *P. vera* and *P. integerrima* (Table 2). Only *M. indica* and the Sapindaceae species *C. grandiflorum* and *S. glabrata* were not suitable hosts as all larvae died within the first 72 h of testing. However, these conservative tests can produce false positive results that might lead to rejection of a safe agent (Marohasy 1998; Hill 1999). Additional tests will also be conducted including larval feeding choice tests, and oviposition choice tests in walk-in cages, and open field conditions. Moreover, this insect needs to be tested against the species of Anacardiaceae in North America. Results obtained will enable assessment of whether the risk posed by *T. elegans* on non-target species is acceptable.

Aceclostria mus Vuillot (Lepidoptera: Mimallonidae). This sack-bearing caterpillar was occasionally found feeding on leaves of *S. terebinthifolius* and *S. weinmannifolius*. It was also found occasionally on *A. balansae* and *L. molleoides*. The Mimallonidae comprise a small family restricted to the Neotropical region. The larvae feed mainly on leaves of Myrtaceae and Anacardiaceae (Pastrana 2004). Records show that *A. mus* was collected in Argentina on *Schinus* sp. (probably *S. fasciculatus*), and on *S. terebinthifolius* in Paraguay (Pastrana 2004). Unfortunately, the low numbers found in the field and the presence of Tachinidae parasitizing up to 30% of the larvae limited our possibilities to rear and evaluate this species in the laboratory. However, based on the available literature and field data, we consider that further studies should be pursued.

Heteroperreyia hubrichi. This defoliating sawfly has been intensively studied as a biological control candidate of Brazilian peppertree in Brazil and in quarantine facilities in Hawaii and Florida (Medal et al. 1999; Vitorino et al. 2000; Hight et al. 2003). This species was known to occur in Uruguay on *Schinus polygama* (Cav.) Cabrera, and in Argentina (Entre Ríos and Santa Fé provinces) without reference to host plant (Smith 1990). In surveys conducted in Argentina during 2004 and 2005, larvae of *H. hubrichi* were found at several sites in northeastern Argentina feeding on *S. terebinthifolius* and on the closely related species *S. weinmannifolius*. These findings constituted new host records for this species. Eggs and larvae of *H. hubrichi* were found from Apr to late Jun and again from Oct to Nov. According to our surveys, *H. hubrichi* has 2 generations per year in northeastern Argentina. Permits to release *H. hubrichi* in Hawaii have not been requested because host specificity studies showed that it may pose risks to the native Hawaiian sumac *Rhus sandwicensis* A. Gray (Hight et al. 2003). Even though *H. hubrichi* was found to be sufficiently host specific for release in Florida (Medal et al. 1999; Cuda et al. 2005), the presence of toxins in the larvae have prevented the issuance of a release permit (J. P. C., unpublished data).

According to Smith (1990), another sawfly species *Heteroperreyia jorgenseni* (Jörgensen) was recorded on *S. molle* in Argentina and Paraguay. During field surveys, *H. jorgenseni* was found not only on its known natural host but also on *S. lentiscifolius* and *S. longifolius*. Large numbers of eggs and larvae of *H. jorgenseni* were found in the field between Mar and Jun. Although *H. jorgenseni* was never found on *S. terebinthifolius* in the field, it was possible to rear it on this plant in the laboratory and obtain an F1 generation (D. G. & M. O., unpublished data). This species is not being developed for biological control of Brazilian peppertree.

Gall makers

Crasimorpha infuscata Hodges (Lepidoptera: Gelechiidae). Previously reported on *S. terebinthifolius* in Brazil (Krauss 1962, 1963; Davis & Krauss 1962), stem galls produced by this moth were found in the terminal branches of *S. terebinthifolius* and *S. weinmannifolius*, which constitute new host records for this species in Argentina. Galls (3-5 cm long; 0.7-0.9 cm wide) show 1 or 2 emergence windows covered with silk, observed as dark, rounded marks near the ends of the gall. Inside each gall a single grayish larva develops until pupation. Released in Hawaii numerous times, this moth apparently never established (Hight et al. 2002).

Stem borers

Apocnemidophorus blandus. This weevil was recorded on *S. terebinthifolius* in earlier surveys conducted in Brazil (F. Bennett, Univ. of Florida, unpublished report) and was also known from Paraguay and Uruguay without host plant records (Wibmer & O'Brien 1986). In Mar 2004, *A. blandus* was found feeding on *S. terebinthifolius* in northern Argentina. In the ensuing surveys, *A. blandus* was found at several sites feeding not only on *S. terebinthifolius* but also on the related species *A. balansae*, *L. molleoides, S. lentiscifolius, S. longifolius, S. molle* and *S. weinmannifolius*, which constitute new host records for this species. Adults of *A. blandus* are 0.7 to 1 cm in length, with the prothorax and anterior part of the elytra covered for the most part by white scales and with 2 small but distinct protuberances covered by black scales on the posterior third of the elytra. In the field, adults were found resting or feeding on the adaxial surface of leaves, and immediately dropped off the plants when disturbed. The feeding damage is generally concentrated on the margin of the leaves. When feeding, the adult weevils may totally perforate the leaves, or leave the epidermis undamaged. When this damage is old, this layer takes on a whitish coloration that resembles the general color of the insect which might help to conceal its presence.

No *A. blandus* larvae have been found in the field. Adults collected in the field and kept in outdoor cages containing potted *S. terebinthifolius* plants did not reproduce. Although they fed on leaves and survived for 1 to 3 months, no eggs were found on the leaves, stems, or roots. However, *A. blandus* eggs were found inside root fragments buried in wet peat moss in 1-liter plastic containers. The females exhibited a characteristic behavior as they prepared to oviposit, chewing a small hole in the root, and then depositing a single, rounded, yellowish egg. The hole was then covered with frass concealing the oviposition scar.

Two other *Apocnemidophorus* species, *A. pipitzi* (Faust) and *A. rufescens* (Pascoe), were collected on *S. terebinthifolius* in northeastern Argentina. Previously reported on *S. terebinthifolius* in Brazil (F. Bennett, Univ. of Florida, unpublished report), *A. pipitzi* was also known to occur in Argentina and Uruguay with no host records available (Wibmer & O'Brien, 1986). In the present study, *A. pipitzi* and *A. rufescens* were also found on *S. molle* and *L. molleoides*, which constitute new locality and host records for these species. Both *A. pipitzi* and *A. rufescens* were frequently found coexisting with *A. blandus* on the same plants, but in lower numbers. These adult weevils are leaf feeders and produce rounded feeding marks similar to those described for *A. blandus*. Recently, *A. pipitzi* was colonized in Florida under quarantine from adults collected in Paraguay (also a new locality record), and the larvae appear to be stem borers.

In preliminary feeding trials, adults of *A. blandus* fed on *S. terebinthifolius*, *S. areira* and both *Pistacia* species offered, showing no preference for any of the species (Table 2). The adult feeding on pistachio, an important crop in the San Joaquin valley in California (Duke 1989; Siegel et al. 2008) may preclude the use of this insect as a biological control agent in the USA. In addition, the fact that in the field, *A. blandus* was collected on most of the Anacardiaceae species coexisting with *S. terebinthifolius* may indicate an unacceptably broad host range. The field collections of *A. pipitzi* have been more limited due to its relative scarcity but suggest that the ecological host range of this species is not restricted solely to *S. terebinthifolius*. However, additional studies such as oviposition and larval development tests are needed to evaluate the potential of all these weevil species as biological control agents for *S. terebinthifolius*.

Discussion

After 3 years of intensive surveys in northeastern Argentina combined with our preliminary host-range studies, it is possible to obtain a prioritized list of potential biological control agents for Brazilian peppertree.

The leaf-feeding moth *T. elegans* is still considered a potential candidate for *S. terebinthifolius* biological control as long as its oviposition behaviour proves to be sufficiently host specific. The available literature records and field host data accumulated in Argentina and Brazil (D'Araújo et al. 1968; Pastrana 2004; F. Bennett, Univ. of Florida, unpublished report, G. S. W., unpublished data) suggest that this leaf-feeding moth has a narrow field host range. Under restricted conditions, many herbivorous insect species display extended host ranges (Harris & Zwölfer 1968; Wapshere 1989; Cullen 1990; Shepherd 1990; Olckers et al. 1995; McCoy et al 2003). The acceptance by *T. elegans* of *Pistacia* species and most of the native Anacardiaceae species included in the first host-specificity tests could be a result of the artificial conditions in cages. Future studies that clarify the present results should include: additional multiple-choice oviposition tests (walk-in cage), open-field trials involving releases of *T. elegans* in plots containing *Pistacia* and other non-target Anacardiaceae species, and extensive field surveys.

Three other prospective biological control agents, the leaf-mining Gracillariidae and the stem-boring weevils, *A. blandus* and *A. pipitzi* also feed and develop on several native Argentine Anacardiaceae. These species also accepted the economically important *Pistacia* species for oviposition (leaf-mining Gracillariidae), and feeding (*Apocnemidophprus* weevils) at least under some experimental designs. Again, additional field trials and walk-in cage tests should be conducted to determine if these are potential biological control candidates.

The unpublished biological data accumulated by these authors and others on Brazilian peppertree suggest that it may be difficult to find a completely monophagous species among the natural enemy fauna on Brazilian peppertree. The terpenoid chemical compounds obtained from the leaves and bark of *S. terebinthifolius* are very similar to those isolated from *Pistacia* species (G. S. W., unpublished data). In fact, they are even more similar than those isolated from other species of *Schinus* (Campello & Marsaioli 1975). This evidence, and the oligophagous habits of the Brazilian peppertree fauna, could prompt a discussion of the potential threat posed by these prospective agents to cultivated *Pistacia* species in the US. None of these natural enemies found on Brazilian peppertree are recorded pests of *Pistacia* plantations in Argentina. Moreover pistachio is cultivated in areas with climatic conditions (hot, dry summers and cool winters) very different from the ones that are suitable for Brazilian peppertree and its natural enemies (tropical conditions with high humidity). Due to these differences in climatic requirements it seems unlikely that the environmental conditions overlap between the *Pistacia* plantations in the US and these insects.

Although the present work targets the most promising known natural enemies associated with *S. terebinthifolius* populations in Argentina, surveys are not complete and are continuing throughout the plant's range in South America. New herbivore species found during field surveys in Brazil and Paraguay during 2006-2008 support this assertion (Razowski & Brown 2008). Additional explorations might be continued especially focused on seed feeders, flower feeders, and the stem and root borer guilds. We consider that classical biological control of Brazilian peppertree in the US based on the introduction of specific natural enemies from South America has great potential.

Acknowledgments

We appreciate the generous contributions of numerous workers to this effort. We thank Muñoz, J. D. Universidad Nacional de Entre Ríos, Paraná, Argentina for assistance with identification of the Anacardiaceae of Argentina. For the identification of different insect groups we thank O'Brien, C. (Curculionidae) Greenvalley, AZ, USA; Burckhardt, D. (Psyllidae) Naturhistorisches Museum, Switzerland; Cabrera, N. (Chrysomelidae) and Aquino, D. (Chalcidoidea) Museo de La Plata, Argentina; Avalos, S. (Tachinidae) Universidad de Córdoba, Argentina; Di Dorio, O. (Cerambycidae) Universidad de Buenos Aires, Argentina; Navarro, F. (Mimallonidae) Universidad Nacional de Tucumán, Argentina; Whitfield, J. (Braconidae) University of Illinois; Wahl, D. (Ichneumonidae) American Entomological Institute; Prinsloo G. (Torymidae) ARC-Plant Protection Research Institute; Becker V. O. (Gelechiidae) Instituto Iraçu, Reserva Serra Bonita, Brazil; Brown, J. W. (*Episimus*); Pogue, M. G. (*Nystalea ebalea, Protambulyx strigilis; Tecmessa elegans)*; Davis, D. R. (Gracillariidae), Nakahara, S. (*Paraleucothrips* n. sp.) Smith, D. R. (Symphyta) all from the USDA/ARS/SEL. For the identification of the fungal pathogen we thank Rayamajhi, M. USDA/ARS/IPRL Ft. Lauderdale, FL USA. We thank C. Cagnotti for technical assistance during this study. We thank S. Schooler (CSIRO), S. Hight (USDA-ARS-CMAVE), A. Peard Bugliani, and J. Briano (SABCL) for valuable comments and suggestions on the manuscript. This project was partially funded by Florida Department of Environmental Protection and South Florida Water Management District. This publication is dedicated to 2 great friends and colleagues, Daniel Gandolfo and Javier Jara, whose warm and generous spirits live on with us.

References Cited

BARKLEY, F. A. 1944. *Schinus* L. Brittonia 5: 160-198.

BARKLEY, F. A. 1957. A study of *Schinus* L. Lilloa 28: 5-110.

BENNETT, F. D., CRESTANA, L., HABECK, D. H., AND BERTI-FILHO, E. 1990. Brazilian peppertree - prospects for biological control, pp. 293-297 *In* E. S. Delfosse [ed.], Proc. VII Intl. Symp. Biol. Control of Weeds, 6-11. March 1988, Rome, Italy. Instituto Sperimentale per la Patologia Vegetale Ministerio dell' Agicoltura e delle Foreste, Rome/CSRIO, Melbourne, Australia. 701 pp.

BENNETT, F. D., AND HABECK, D. H. 1991 Brazilian peppertree—Prospectives for biological control in Florida, pp. 23-33 *In* T. D. Center, R. F. Doren, R. L. Hofstetter, R. L. Myers, and L. D. Whiteaker [eds.], Proc. Symp. Exotic Pest Plants, 2-4. November 1988, Miami, FL. U. S. Dept. Interior, National Park Service, Washington, DC. 387 pp.

CAMPELLO, J. D., AND MARSAIOLI, A. J. 1975. Terebenthifolic acid and bauerenone: new terpenoids ketones from *Schinus terebinthifolius*. Phytochemistry, 14: 2300-2302.

CASSANI, J. R. 1986. Arthropods on Brazilian peppertree, *Schinus terebinthifolius* (Anacardiaceae), in south Florida. Florida Entomol. 69: 184-196.

CASSANI, J. R., MALONEY, D. R., HABECK, D. H., AND BENNETT, F. D. 1989. New insect records on Brazilian peppertree *Schinus terebinthifolius* (Anacardiaceae), in south Florida. Florida Entomol. 72: 714-716.

CUDA, J. P., FERRITIER, A. P., MANRIQUE, V., AND MEDAL, J. C. [EDS.]. 2006. Florida's Brazilian Peppertree Management Plan, 2nd edition: Recommendations from the Brazilian Peppertree Task Force, Florida Exotic Pest Plant Council, April 2006. Available at http://ipm.ifas.ufl.edu/reports/BPmanagPlan.pdf.

CUDA, J. P., MEDAL, J. C., VITORINO, M. D., AND HABECK, D. H. 2005. Supplementary host specificity testing of the sawfly *Heteroperreyia hubrichi*, a candidate for classical biological control of Brazilian peppertree, *Schinus terebinthifolius*, in the USA. BioControl 50: 195-201.

CULLEN, J. M. 1990. Current problems in host-specificity screening, *In* E. S. Delfosse, [ed.], Proc. VII Intl. Symp. Biol. Control of Weeds, 6-11. March 1988, Rome, Italy. Instituto Sperimentale per la Patologia Vegetale Ministerio dell' Agicoltura e delle Foreste, Rome/CSRIO, Melbourne, Australia. 701 pp.

DAVIS, C. J., AND KRAUSS, N. L. 1962. Recent introductions for biological control in Hawaii - VII. Proceedings, Hawaiian Entomol. Soc. 18: 125-129.

DAVIS, R. D. 1987. Gracillariidae (Tinoidea), pp. 372-378 *In* F. W. Stehr [ed.], Immature insects. V. 1, Kendall/Hunt Publishing Company, Dubuqueque, IA. 754 pp.

D' ARAÚJO E SILVA, A. G., GONÇALVES, C. R., GALVÃO, D. M., GONÇALVES, A. J. L., GOMES, J., SILVA, M. N., AND DE SIMONI, L. 1968. Quarto catálogo dos insetos que vivem nas plantas do Brasil. Seus parasitos e predadores. Parte II, 1. Ministerio da Agricultura, Rio de Janeiro. 622 pp.

DONNELLY, M. J., GREEN, D. M., AND WALTERS, L. J. 2008. Allelopathic effects of fruits of the Brazilian pepper *Schinus terebinthifolius* on growth, leaf production and biomass of seedlings of the red mangrove *Rhizophora mangle* and the black mangrove *Avicennia germinans*. J. Exp. Marine Biol. and Ecol. 357: 149-156.

EWEL, J. 1986. Invasibility: lessons from South Florida, pp. 214-230 *In* H. A. Mooney and J. A Drake [eds.], Ecology of Biological Invasions of North America and Hawaii, Springer-Verlag, NY. 321 pp.

[FLEPPC] FLORIDA EXOTIC PEST PLANT COUNCIL. 2005. Florida Exotic Pest Plant Council's 2001 list of invasive species. Available at http://www..eppc.org/05list.htm.

GANN, G. D., BRADLEY, K., AND WOODMANSEE, S. W. 2001. Floristic Inventory of South Florida Database. Available at http://www.regionalconservation.org./

GOGUE, G. J., HURST, C. J., AND BANCROFT, L. 1974. Growth inhibition by *Schinus terebinthifolius*. HortScience 9: 301.

HABECK, D. H., BENNETT, F. D., AND GRISSELL, E. E. 1989. First record of a phytophagous seed chalcid from Brazilian peppertree in Florida. Florida Entomol. 72: 378-379.

HARRIS, P., AND ZWÖLFER, H. 1968. Screening of phytophagous insects for biological control of weeds. Canadian Entomol. 100: 295-303.

[HSASC] HAWAII STATE ALIEN SPECIES COORDINATOR. 2001. Hawaii's most invasive horticultural plants. Department of Land & Natural Resources and Division of Forestry & Wildlife. Honolulu, HI, USA. Available at http://www.state.hi.us/dlnr/dofaw/hortweeds/specieslist.htm.

HEPPNER, J. B. 2002. A Checklist of the Lepidoptera of Florida. Museum of entomology of FSCA (Gainesville). Available at http://www.fsca-dpi.org.

HIGHT, S. D., HORIUCHI, I., VITORINO, M. D., WIKLER, C., AND PEDROSA-MACEDO, J. H. 2003. Biology, host specificity tests, and risk assessment of the sawfly *Heteroperreyia hubrichi*, a potential biological control agent of *Schinus terebinthifolius* in Hawaii. BioControl 48: 461-476.

HIGHT, S. D., CUDA, J. P., AND MEDAL, J. C. 2002. Brazilian peppertree, pp. 311-321 *In* R. G. Van Driesche, S. Lyon, B. Blossey, M. S. Hoddle, and R. Reardon [eds.], Biological Control of Invasive Plants in the Eastern United States, USDA Forest Service, Morgantown, WV. 413 pp.

HILL, R. L. 1999. Minimizing uncertainty – in support of no-choice tests, pp. 1-10 *In* T. M. Withers, L. Barton Browne, and J. Stanley [eds.], Host Specificity Testing in Australasia. CRC for Tropical Pest Management, Brisbane, Australia. 98 pp.

KRAUSS, N. L. 1962. Biological control investigations on insect, snail and weed pests in tropical America, 1961. Proc. Hawaiian Entomol. Soc. 18: 131-133.

KRAUSS, N. L. 1963. Biological control investigations on Christmas berry (*Schinus terebinthifolius*) and Emex (*Emex* spp.). Proc. Hawaiian Entomol. Soc.18: 281-287.

MAROHASY, J. J. 1998. The design and interpretation of host specificity tests for weed biological control with particular reference to insect behaviour. Biocontrol News and Inf. 19: 13-20.

MARTIN, C. G., CUDA, J. P., AWADZI, K. D., MEDAL, J. C., HABECK, D. H., AND PEDROSA-MACEDO, J. H. 2004. Biology and laboratory rearing of *Episimus utilis* (Lepidoptera: Tortricidae), a candidate for classical biological control of Brazilian peppertree, *Schinus terebinthifolius* (Anacardiaceae), in Florida. Environ. Entomol. 33: 1351-1361.

MCCOY, C. W., STUART, R. J., AND NIGG, H. N. 2003. Seasonal life stage abundance of *Diaprepes abbreviatus* in irrigated and non-irrigated citrus plantings in central Florida. Florida Entomol. 86: 34-42.

MEDAL, J. C., VITORINO, M. D., HABECK, D. H., GILLMORE, J. L., PEDROSA, J. H., AND DE SOUSA, L. P. 1999. Host specificity of *Heteroperreyia hubrichi* Malaise (Hymenoptera: Pergidae), a potential biological control agent of Brazilian peppertree (*Schinus terebinthifolius*). Biol. Control 14: 60-65.

MORGAN, E. C., AND OVERHOLT, W. A. 2005. Potential allelopathic effects of Brazilian pepper (*Schinus terebinthifolius* Raddi, Anacardiaceae) aqueous extract on germination and growth of selected Florida native plants. Torrey Bot. Soc. 132**:** 11-15.

MORTON, J. F. 1978. Brazilian pepper-Its impact on people, animals and the environment. Econ. Bot. 32: 353-359.

MUÑOZ, J. D. 2000. Anacardiaceae, pp. 1-28 *In* A. T. Hunziker [ed.], Flora Fanerogámica Argentina 65. Conicet, Córdoba, Argentina.

MYTINGER, L., AND WILLIAMSON, G. B. 1987. The invasion of *Schinus* into saline communities of Everglades National Park. Florida Scientist 50: 7-12.

OLCKERS, T., ZIMMERMANN, H. G., AND HOFFMANN, J. H. 1995. Interpreting ambiguous results of host-specificity tests in biological control of weeds: assessment of two *Leptinotarsa sepecies* (Chrysomelidae) for the control of *Solanum elaeagnifolium* (Solanaceae) in South Africa. Biol. Control 5: 336-344.

PANETTA, F. D., AND MCKEE, J. 1997. Recruitment of the invasive ornamental, *Schinus terebinthifolius* is dependent upon frugivores. Australian J. Ecol. 22: 432-438.

PASTRANA, J. A. 2004. Los Lepidópteros argentinos. Sus plantas hospedadoras y otros sustratos alimenticios. K. Braun, G. Logarzo, H. A. Cordo, and O. R. Di Dorio (Coordinadores). Soc. Entomol. Argentina Eds. Viii + 334 pp.

RANDALL, J. M. 1993. Exotic weeds in North American and Hawaiian natural areas: The Nature Conservancy's plan of attack, pp. 159-172 *In* B. N. McKnight [ed.], Biological Pollution: The Control and Impact of Invasive Exotic Species. Indiana Academy of Sciences, Indianapolis, IN. 270 pp.

RANDALL, J. M. 2000. *Schinus terebinthifolius* Raddi, pp. 282-287 *In* C. C. Bossard, J. M. Randall, and M. C. Hoshovsky [eds.], Invasive Plants of California's Wildlands. University of California Press, Berkeley, CA. 360 pp.

RAZOWSKI, J., AND BROWN, J. W. 2008. New species, new combinations and new synonymies in Neotropical *Episimus* Walsingham, 1892 (Lepidoptera: Tortricidae: Olethreutinae). Acta Zool. Cracov. 51B: 83-144.

SCHAUS, W. 1901. A revision of the American Notodontidae. Trans. Entomol. Soc. London. 285: 257-346.

SCHEFFER, S. J., AND GRISSELL, E. E. 2003. Tracing the geographical origin of *Megastigmus transvaalensis* (Hymenoptera: Torymidae): an African wasp feeding on a South American plant in North America. Mol. Ecol. 12: 415-421.

SHEPHERD, R. C. H. 1990. Problems which arise with the host-specificity testing of insects. *In* E. S. Delfosse, [ed.], Proc. VII Intl. Symp. Biol. Control of Weeds, 6-11. March 1988, Rome, Italy. Instituto Sperimentale per la Patologia Vegetale Ministerio dell' Agicoltura e delle Foreste, Rome/CSRIO, Melbourne, Australia. 701 pp.

SIEGEL, J. P., KUENEN, L. P. S., BRADLEY, S. H., NOBLE, P., RICHARD, G., YOKOTA, G. Y., KRUGNER, R., AND KENT, M. D. 2008. Postharvest survival of navel orangeworm assessed in pistachios. California Agric. 62 (1): 30-35.

SMITH, D. R. 1990. A synopsis of the sawflies (Hymenoptera, Symphyta) of America south of the United States: Pergidae. Rev. Brasileira Entomol. 34: 7-200.

USDA, NRCS. 2009. The PLANTS Database (http://plants.usda.gov, 19 February 2009). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

VITORINO, M. D., PEDROSA-MACEDO, J. H., AND CUDA, J. P. 2000. Biology and Specificity Tests of the Sawfly - *Heteroperreyia hubrichi* Malaise, 1955 (Hymenoptera: Pergidae) a Potential Biological Control Agent for Brazilian Peppertree—*Schinus terebinthifolius* Raddi (Anacardiaceae), pp. 645-650 *In* N. R. Spencer, [ed.], Proc. X Intl. Symp. Biol. Control of Weeds, 4-9. July 1999, Bozeman, MT. USDA-ARS/ Montana State University, Bozeman. 1030 pp.

WHAPSHERE, A. J. 1989. A testing sequence for reducing rejection of potential biological control agents for weeds. Ann. Appl. Boil. 114: 515-526.

WHEELER, G. S., MASSEY, L. M., AND ENDRIES, M. 2001. The Brazilian peppertree drupe feeder *Megastigmus transvaalensis* (Hymenoptera: Torymidae): Florida distribution and impact. Biol. Control 22: 139-148.

WIBMER, G. J., AND O'BRIEN, C. W. 1986. Annotated checklist of the weevils (Curculionidae *sensu lato*) of South America (Coleoptera: Curculionoidea). Mem. American Entomol. Inst. 39. The American Entomological Institute, Gainesville, FL. 563 pp.

WUNDERLIN, R. P., AND HANSEN, B. F. 2003. Guide to the Vascular Plants of Florida. second edition. University Press of Florida, Gainesville, FL. 796 pp.

YOSHIOKA, E. R., AND MARKIN, G. P. 1991. Efforts of biological control of Christmas berry *Schinus terebinthifolius* in Hawaii, pp. 377-385 *In* T. D. Center, R. F. Doren, R. L. Hofstetter, R. L. Myers, and L. D. Whiteaker [eds.], Proc. Symp. Exotic Pest Plants, 2-4. November 1988, Miami, FL. U.S. Dept. Interior, National Park Service, Washington, DC. 387 pp.