Biocontrol bites biocontrol: potential interference of the Brazilian peppertree biological control thrips *Pseudophilothrips ichini* (Thysanoptera: Phlaeothripidae) by *Montandoniola confusa* (Hemiptera: Anthocoridae)

Dale A. Halbritter[1,], Min B. Rayamajhi[1], and Gregory S. Wheeler[1]*

Abstract

Large-scale field releases of biological control agents to help manage the highly invasive Brazilian peppertree began in Jul 2019, with the first releases of the thrips *Pseudophilothrips ichini* (Hood) (Thysanoptera: Phlaeothripidae) in southern Florida. Release sites were routinely monitored for agent establishment and impacts on the target weed. Within 5 mo, we noted a pirate bug, *Montandoniola confusa* Streito & Matocq (Hemiptera: Anthocoridae), feeding on an adult *P. ichini* thrips in an outdoor garden plot. Interestingly, this pirate bug is itself a biological control agent introduced to control a confamilial thrips pest of ornamental *Ficus* (Moraceae) trees. Instances of pirate bug predation on *P. ichini*, both inside our rearing facility and at field sites, have continued and are detailed herein. The average number of thrips produced in our rearing facility was reduced in cages that had pirate bug invasions compared to cages free of pirate bugs. Considerations for the continued biological control efforts of Brazilian peppertree are discussed.

Key Words: *Gynaikothrips*; pirate bug; predation; *Schinus terebinthifolia*

Resumen

Las liberaciones de campo a gran escala de agentes de control biológico para ayudar a controlar el agresivo invasor pimentero brasileño comenzaron en julio del 2019, con las primeras liberaciones de los trips *Pseudophilothrips ichini* (Hood) (Thysanoptera: Phlaeothripidae) en el sur de la Florida. Se monitorearon de manera rutinaria los sitios de liberación para determinar el establecimiento del agente y los impactos sobre la maleza objetivo. Dentro de los 5 meses, notamos una chinche pirata, *Montandoniola confusa* Streito & Matocq (Hemiptera: Anthocoridae), alimentándose de un adulto de *P. ichini* en una parcela de jardín al aire libre. Curiosamente, este insecto pirata es en sí mismo un agente de control biológico introducido para controlar una plaga de la misma familia de trips en árboles ornamentales de *Ficus* (Moraceae). Los casos de depredación de chinches piratas en *P. ichini*, tanto dentro de nuestras instalaciones de crianza como en los sitios de campo, han continuado y se detallan en este documento. El número promedio de trips producidos en nuestra instalación de crianza se redujo en las jaulas que tenían invasiones de chinches piratas en comparación con las jaulas libres de chinches piratas. Se discuten las consideraciones para continuar los esfuerzos de control biológico del pimentero brasileño.

Palabras Clave: *Gynaikothrips*; chinche pirata; depredación; *Schinus terebinthifolia*

Pseudophilothrips ichini (Hood) (Thysanoptera: Phlaeothripidae) is native to Brazil and was selected as a biological control agent of Brazilian peppertree, *Schinus terebinthifolia* Raddi (Anacardiaceae), in Florida (Habeck et al. 1994; Cuda et al. 2004; Wheeler et al. 2016a; Wheeler et al. 2017). *Pseudophilothrips ichini* was approved by the US Department of Agriculture, Animal and Plant Health Inspection Service, Riverdale, Maryland, USA, for field release in Florida in May 2019 (Wheeler et al. 2022). Brazilian peppertree is a woody shrub to small, multi-stemmed tree that is highly invasive in Florida in both urban and natural landscapes (McJunkin 1977; Loope & Dunevitz 1981; Cunningham 1991; Schmalzer 1995; Schmitz et al. 1997; Rodgers et al. 2014). *Pseudophilothrips ichini* has 2 larval instars and they feed in groups along with adults on tender flushing leaves and stems. First instars are yellow to pale orange, second instars are bright orange, and adults are black, averaging 0.7 mm, 1.0 mm, and 2.5 mm in length, respectively (Wheeler et al. 2016b). As part of our surveys for *P. ichini* establishment and spread at release sites, as well as in mass rearing operations, we have noted novel interactions between *P. ichini* and naturalized arthropods. This is the first formal report documenting predation of *P. ichini* in a field setting by an oligophagous thrips predator, specifically one that is a biological control agent for the Cuban laurel thrips, *Gynaikothrips ficorum* (Marchal) (Thysanoptera: Phlaeothripidae), on cultivated *Ficus* spp. (Moraceae).

[1]USDA-ARS Invasive Plant Research Laboratory, Fort Lauderdale, Florida 33314, USA; E-mail: dale.halbritter@usda.gov (D. A. H.), min.rayamajhi@usda.gov (M. B. R.), greg.wheeler@usda.gov (G. S. W.)
*Corresponding author; E-mail: dale.halbritter@usda.gov

Gynaikothrips ficorum and *Gynaikothrips uzeli* (Zimmerman) (Thysanoptera: Phlaeothripidae) induce leaf galling in *Ficus* spp. and are both native to Southeast Asia (Anathakrishnan 1978; Mound et al. 1995; Mound & Marullo 1996). *Gynaikothrips uzeli* was first detected in Florida in 2003 (Held et al. 2005) whereas *G. ficorum* has been present in the continental US since 1877 or earlier (Denmark 1967). The adults of both species are typically black and closely resemble adults of *P. ichini* and, given their ability to disperse by flight and occasional proximity of host plants, they have been encountered on Brazilian peppertree with *P. ichini* as discussed herein.

An anthocorid initially described as *Montandoniola moraguesi* (Puton) (Hemiptera: Anthocoridae) was collected in the Philippines and released in the 1960s in Bermuda (Leighton 1978) and Hawaii (Funasaki 1966) as a biological control agent for *G. ficorum*. However, after a taxonomic revision of *M. moraguesi*, it was likely that initial releases of the agent were of *Montandoniola confusa* Streito & Matocq (Hemiptera: Anthocoridae) (Pluot-Sigwalt et al. 2009). Adults are 1.9 to 2.5 mm in length, black, and the hemelytra have a clear central patch, with a central dark stripe on the membranous portion (Pluot-Sigwalt et al. 2009); nymphs are red (Fig. 1). It was not until 1990 that *M. confusa* (= *moraguesi*) was first reported in Florida (Bennett 1995), likely arriving through ornamental commerce or natural dispersal. Dobbs and Boyd (2006) later confirmed its establishment in South Florida, now occurring in peninsular Florida in areas where exotic *Ficus* spp. are cultivated.

We routinely visited 2 field sites in Florida, 1 located near Quail Heights in Miami-Dade County and the other at a Brazilian peppertree garden plot at the USDA-ARS Invasive Plant Research Laboratory in Davie, Broward County, to survey *P. ichini* thrips populations and Brazilian peppertree foliage. *Pseudophilothrips ichini* were released first onto 103 saplings at the Broward County field site in Jul 2019, with routine releases and surveys continuing every 1 to 3 mo. *Pseudophilothrips ichini* were released first at the Miami-Dade County field site in Feb 2020, which was invaded by mature Brazilian peppertrees. We surveyed 5 m sections along transects each mo and immediately before subsequent thrips releases, which continued every 1 to 2 mo thereafter. Incidence of *M. confusa* were noted during visits to the field sites but were not systematically surveyed in a designated study.

Additionally, we mass reared *P. ichini* at the Invasive Plant Research Laboratory where we occasionally encountered natural *M. confusa* invasions in our rearing cages. To examine the impact of pirate bugs on beneficial thrips, we compared *P. ichini* production in cages with and without *M. confusa*. There were 48 uninvaded and 16 invaded large outdoor screen cages, 23 uninvaded and 6 invaded indoor acrylic boxes, and 12 uninvaded and 3 invaded indoor acrylic cylinders (for rearing protocols and cage descriptions, refer to Halbritter et al. [2021]). We used a 1-way ANOVA to compare thrips yields (fold productivity: number of F_1 per number of F_0) from *M. confusa*-invaded cages to that from uninvaded cages spanning Feb to Nov 2021.

We first documented the *M. confusa*-*P. ichini* interaction in the Broward County field site, the garden plot of Brazilian peppertree saplings, on 30 Dec 2019. One adult *M. confusa* was seen feeding on an adult *P. ichini* on a sapling at the edge of the plot (Fig. 2A). In the survey mo prior to first noting *M. confusa*, *P. ichini* densities in the plot were low, with an average of 20% of branches in the canopy of each sapling having at least 1 thrips. A *M. confusa* feeding on a *P. ichini* was sighted again in Mar 2021 and, at that time, an average of 3% of branches in sapling canopies had *P. ichini* detected on them.

We first documented an *M. confusa*-*P. ichini* interaction in the natural habitat at the Miami-Dade County field site in Feb 2020. During this sighting, a *M. confusa* had entered a vial containing *P. ichini* brought from the laboratory for the first field release at the site. The vial had been opened and tied to a branch to allow thrips to disperse when the pirate bug was later noticed inside the vial on a leaf covered with adult *P. ichini*. Predation was not observed, but the *P. ichini* appeared agitated and routinely displayed a defensive behavior (Mound 2004) of curling their abdomens over their heads and jabbing their terminal setae in the direction of anything approaching them, including other *P. ichini*. Additional *M. confusa* sightings occurred at this site in Mar, Jun, and Jul 2021 as bycatch from *P. ichini*-targeted surveys, where only 2 to 3 *P. ichini* individuals were observed on foliage in each of the of Brazilian peppertree infestations.

It was not until Feb 2021 that *M. confusa* were first detected in 1 of our rearing cages. The *M. confusa* likely evaded standard pest treatment and detection on our nursery plants, entered the rearing cage on the plants, and subsequently built up to high numbers. This occurred in 1 of our large outdoor screen cages, with eggs and hundreds of *M. confusa* adults and nymphs noted in that cage at the time of *P. ichini* collection. Since implementing more stringent *M. confusa* screening and eradication strategies, we continued to note an occasional instance of *M. confusa* in a rearing cage, including in our 2 smaller indoor cage types, but nothing on the scale of the hundreds found earlier. Both adult and nymphal *M. confusa* have been observed feeding on both adult and larval *P. ichini* (Fig. 2). Cages invaded by *M. confusa* produced significantly lower yields of *P. ichini* (7.7-fold) than uninvaded cages (11.1-fold) ($F = 4.04$; df = 1, 88; $P = 0.047$).

The potential entry of *P. ichini* to the *Montandoniola-Gynaikothrips-Ficus* food web could be an interesting new component of the biological control of Brazilian peppertree and an example of non-target effects of agent introductions. At first glance, *M. confusa* resemble dark, tubuliferan thrips where the dark band on the bug's hemelytral membrane resembles the abdomen and tube of its prey. Adult *Montandoniola* spp. may mimic their thrips prey (Yasunaga et al. 2015), potentially reducing the perceived threat, as also has been shown with mirid predators of lace bugs (Yasunaga et al. 1997). *Montandoniola confusa* (= *moraguesi*) can be found residing in galls with *G. uzeli*, along with *G. ficorum* and other inquilines like *Liothrips* Uzel sp., and *Androthrips* Karny (both Thysanoptera: Phlaeothripidae) (Mound et al. 1995). The wolf in sheep's clothing tactic potentially employed by *M. confusa* may help facilitate the inclusion of *P. ichini* in its diet, because we have noted *M. confusa* nymphs resting among larval *P. ichini* aggregations in rearing cages.

Our efforts to minimize *M. confusa* invasions in rearing operations likely reduced the predator's greater potential impact. More drastic impacts of *M. confusa* on *G. uzeli* were documented in Arthurs et al. (2011), where pirate bugs reduced thrips populations by 95% in a greenhouse. In a natural field setting, Reimer (1988) documented predation on *Liothrips urichi* Karny (Thysanoptera: Phlaeothripidae) by *M. confusa* (= *morageusi*) and suggested it may impact the effectiveness of the thrips, which were introduced in Hawaii as a biological control agent of the weed *Clidemia hirta* (L.) D. Don (Melastomataceae). Given mass rearing of *P. ichini* is well underway and we are still in the early stages of the field establishment of the agent (Wheeler et al. 2022), *M. confusa* should be closely monitored in captive rearing operations and for potential impacts on established wild populations of *P. ichini*. The potential associations between cultivated *Ficus* spp., *Gynaikothrips*, *P. ichini*, and predation by *M. confusa* in field settings warrants future research. Selecting sites that do not have *Ficus* spp. nearby may be a strategy to reduce impacts of the predator on agent establishment and performance.

Fig. 1. (A) Dorsal view of a point-mounted adult specimen of *Montandoniola confusa* collected on Brazilian peppertree in an outdoor garden plot in Davie, Broward County, Florida, USA, on 2 Feb 2020; (B) dorsal view of a point-mounted late nymphal instar specimen of *M. confusa* collected in an indoor thrips colony rearing cage on 20 Aug 2021.

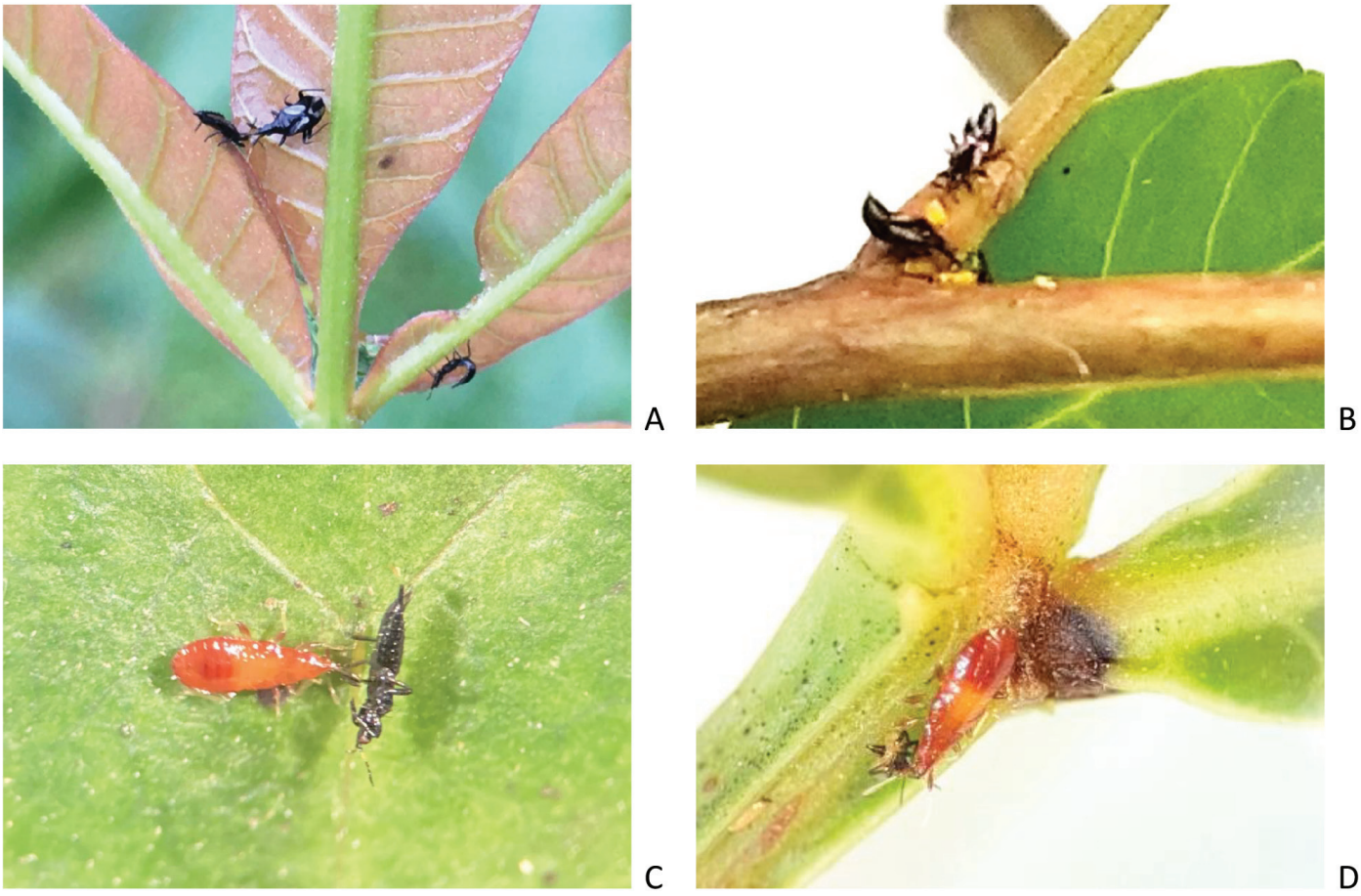

Fig. 2. Cases of predation on *Pseudophilothrips ichini* by *Montandoniola confusa*: (A) adult *M. confusa* feeding on an adult *P. ichini* in a garden plot on 30 Dec 2019; (B) adult *M. confusa* feeding on larval *P. ichini* in a laboratory colony on 24 Aug 2021; (C) nymphal *M. confusa* feeding on an adult *P. ichini* in a laboratory colony on 16 Aug 2021; and (D) nymphal *M. confusa* feeding on a larval *P. ichini* in a laboratory colony on 22 Nov 2021. Photo credit for plate B: Jenna Owens; photo credit for plate D: Carly Cogan.

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