JHR 87: 503–521 (2021)
doi: 10.3897/jhr.87.76191
https://jhr.pensoft.net

RESEARCH ARTICLE

JOURNAL OF Hymenoptera RESEARCH
A peer-reviewed open-access journal
The International Society of Hymenopterists

Psix striaticeps (Dodd) (Hymenoptera, Scelionidae): an Old World parasitoid of stink bug eggs arrives in Florida, USA

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Academic editor: Zachary Lahey | Received 11 October 2021 | Accepted 8 November 2021 | Published 23 December 2021

http://zoobank.org/CA77B398-3072-4E25-9D3F-E966A61CD6FF

Citation: Birkmire S, Penca C, Talamas EJ, Moore MR, Hodges AC (2021) *Psix striaticeps* (Dodd) (Hymenoptera, Scelionidae): an Old World parasitoid of stink bug eggs arrives in Florida, USA. In: Lahey Z, Talamas E (Eds) Advances in the Systematics of Platygastroidea III. Journal of Hymenoptera Research 87: 503–521. https://doi.org/10.3897/jhr.87.76191

Abstract
Psix striaticeps (Dodd) is an egg-parasitoid wasp previously known only from the Old World. We report this species from twelve counties in Florida, which are the first records in the Western Hemisphere. It was collected in yellow cylinder traps and reared from the eggs of three stink bug species: *Nezara viridula* L., *Chinavia marginata* (Palisot de Beauvois), and *Piezodorus guildinii* (Westwood). A COI barcode analysis found a 100% match between the Floridian population and a specimen from South Africa. The prospects of using *Ps. striaticeps* as a biological control agent against exotic stink bugs are discussed.

Keywords
biological control, adventive species, host records, DNA barcoding

Introduction

Parasitoid wasps are important regulators of host populations, and for this reason are often used for biological control in agricultural ecosystems (Tillman 2011; Ogburn et al. 2016; de Freitas Bueno et al. 2020). Augmentative control of exotic pests using native parasitoids is sufficient in some cases, and others may require classical biological control: the introduction of exotic, coevolved parasitoids. We initiated a study to characterize the parasitoid fauna associated with two exotic stink bug pests in Florida, the southern green stink bug *Nezara viridula* L. (1758) and the brown marmorated stink bug *Halyomorpha halys* (Stål, 1855) (Hemiptera, Pentatomidae), in order to determine if augmentative control is an option for management for these pests.

Nezara viridula is a polyphagous pest, first reported in the United States by Distant (1880) and first detected in Florida in 1920 (Drake 1920). It affects the production of many food and fiber crops but prefers legumes such as soybean (Panizzi and Meneguim 1988). It is considered to be a pest in a number of states, but has a distribution mostly limited to the southern United States (Turnipseed and Kogan 1976). The species has been detected in states outside of this region including Texas, California and Washington (Hoffman et al. 1987; Equivel et al. 2018). Numerous egg-parasitoids have been reported from *N. viridula* in the southeastern United States (Tillman 2011), but no detailed studies have been conducted to characterize its parasitoid fauna in Florida.

Halyomorpha halys is a well-known, widespread invasive pest in North America (Haye and Weber 2017). The species is broadly polyphagous, recorded from over 200 species of host plants (Bernon et al. 2004; Lee et al. 2013; Haye et al. 2014; Bergmann et al. 2016). The first detection of the species in the United States occurred around 1996 in Allentown, Pennsylvania (Hoebeck and Carter 2003). The initial detection of *Hal. halys* within an agricultural system in Florida occurred in a peach orchard in Lake County during 2016, and increasing numbers of *Hal. halys* were collected through trapping efforts in 2017 and 2018 (Penca and Hodges 2018). During 2018, detection of eggs and nymphs at one of the field trapping locations resulted in a limited distribution pest status declaration for Lake County by regulatory personnel at the Florida Department of Agriculture and Consumer Services, Division of Plant Industry (FDACS-DPI). Natural enemies of *Hal. halys* were reviewed by Abram et al. (2017), but *Hal. halys* was not established in Florida at the time, and consequently a direct assessment of its egg parasitoids in the state was not included.

Tillman (2011) and Tillman et al. (2020) characterized the parasitoids attacking eggs of *N. viridula* and *Hal. halys* in Georgia and Alabama, which are adjacent to Florida. Tillman (2011) reported six species associated with *N. viridula* eggs in agricultural ecosystems including *Hadronotus obesus* (Masner, 1983), *Trissolcus basalis* (Wollaston, 1858), *Tr. brochymenae* (Ashmead, 1881), *Tr. thyantae* Ashmead, 1893, *Telenomus podisi* Ashmead, 1893 (Hymenoptera, Scelionidae), and *Ooencyrtus* spp. (Hymenoptera, Encyrtidae). These species were all reared from naturally occurring stink bug egg masses found in corn, peanut and cotton farmscapes in Georgia. Sentinel egg masses were deployed by Tillman (2020) in areas where wild populations of *Hal. halys* are present, utilizing both fresh and frozen *Hal. halys* egg masses. Frozen egg masses do not have the risk of introducing nymphs into the field and can increase the likelihood of successful parasitism by inhibiting the immune response of the eggs against parasitoid eggs and larvae (Haye et al. 2015). Eleven parasitoid species, including two new associations, emerged from *Hal. halys* egg masses deployed by Tillman et al. (2020) and included *Ooencyrtus* spp., *Acroclisoides sinicus* (Huang & Liao, 1988) (Hymenoptera, Pteromalidae), *Anastatus reduvii* (Howard, 1880), *A. mirabilis* (Walsh & Riley, 1869) (Hymenoptera, Eupelmidae), *Te. podisi*, *Tr. brochymenae*, *Tr. eddesae* (Fouts, 1920), *Tr. euschisti* (Ashmead, 1893), *Tr. solocis* Johnson, 1985 and *Had. obesus*. Except for *A. mirabilis*, *Tr. solocis*, and *Had. obesus*, each of these parasitoid species have been recovered from wild *Hal. halys* egg masses (Tillman, unpublished data).

Trissolcus japonicus (Ashmead, 1904) is an egg parasitoid that coevolved with *Hal. halys* and is adventive in the United States (Talamas et al. 2015). This species is not yet approved for release by federal agencies, but it has been used as a biological control agent, via within-state releases, in states where it has established on its own. (Jentsch 2017; Lowenstein et al. 2019; Milnes and Beers 2019). *Trissolcus japonicus* was recently recovered in North Carolina (stopBMSB.org), indicating that it is slowly but steadily moving south from the mid-Atlantic region. Because *H. halys* populations are still low in Florida, detection of *Tr. japonicus* in the state might enable management early enough to avoid the large-scale impacts that have afflicted other regions.

Although we have yet to find *Tr. japonicus* in Florida, our surveys nonetheless detected an adventive parasitoid wasp that may be of consequence.

Materials and methods

Sentinel egg masses

Sentinel egg masses of *Hal. halys* and *N. viridula* were deployed at three agricultural sites in Lake County, Florida, between March and August of 2021. Deployments were conducted weekly from March to June with a shift to bi-weekly deployments starting in July due to a shortage of eggs. For all but one week where egg mass availability was low, 120 egg masses were deployed per week. Of the 120 egg masses, approximately half were *Hal. halys* eggs and half *N. viridula* eggs.

The first site, located in Okahumpka, FL (28.744666N, – 81.895032E), includes 8 acres where uncertified organic practices are utilized. The farm is surrounded by woodlands, and over 120 varieties of crops are rotated within the farm seasonally. The second site, located in Clermont, FL (28.629214N, – 81.76725E), includes 69.4 acres of muscadine grapes, but the study was conducted in a 25.4-acre plot of the vineyard. The vineyard used integrated pest management practices that include conventional pesticides. The vineyard is bordered by a thin strip of forest and is adjacent to a lake. The third site, located in Lady Lake, FL (28.927383N, – 81.904568E), is a 2.5-acre orchard of peach trees within a residential community. It has a border of weedy plants and hardwood trees. The past management style was conventional with some organic practices. However, management practices did not occur during this study.

The *N. viridula* egg masses were sourced from a colony at the University of Florida's Entomology and Nematology Department. The stink bugs were reared in mesh cages (39.9 cm × 39.9 cm × 61.0 cm). They were fed a diet of tomatoes, peanuts, baby carrots, and sweet corn on a Monday, Wednesday, Friday schedule. The photoperiod in the rearing rooms was 16L:8D, and the average temperature and relative humidity were 24.5 °C and 42%, respectively.

The *Hal. halys* egg masses were sourced from a quarantine colony at FDACS-DPI and the New Jersey Department of Agriculture (NJDA) Phillip Alampi Beneficial Insect Lab. The FDACS-DPI colony of *H. halys* was reared in round, mesh-ventilated, polystyrene containers of various sizes. The temperature and relative humidity were ±1 °C and ±5% of the conditions in Medal et al. (2012), respectively. The colony was fed a diet of whole sweet corn, snap peas, peanuts, and organic baby carrots.

The NJDA colony of *Hal. halys* was reared in quarantine according to protocols by Dorsey and Lovero (2014) and was fed a diet designed by Cohen (2000). Eggs were shipped to FDACS-DPI and were either directly frozen or reared to adulthood according to the protocols described above.

All egg masses were frozen at -80 °C prior to their deployment and were glued using Elmer's glue to 1.5 × 1.5 cm squares of waterproof paper (Rite in the Rain, Tacoma, WA). The sentinel egg mass cards were then pinned to the undersides of the leaves of plants within the crop field and at its periphery. If the egg masses could not be pinned directly to plants, they were clipped to orange and yellow flags which were staked approximately 12 cm above the ground. These measures were taken to reduce damage to plant products that would eventually be sold.

The egg masses were left in the field for 72 hours, then returned to the lab where they were recounted, and predation damage was documented. The egg masses were then placed into small petri dishes sealed with parafilm and stored in a quarantined room. The temperature and relative humidity in this room were 26.5 °C and 48%, respectively. The photoperiod in this room was 16L:8D. The egg masses were checked daily for parasitoid emergence, which often occurred between 20–25 days of storage and were stored for a total of 30 days before being discarded. Reared parasitoids were stored in 95% ethanol prior to identification.

Collection of wild stink bug egg masses

A single, wild stink bug egg mass, unidentified at the time, was collected on a squash plant in Lake County, on May 25th, 2021. The egg mass was brought back to the lab for assessment of parasitism and identification of the stink bug species via COI barcoding.

Eggs, nymphs and adults of the redbanded stink bug *Piezodorus guildinii* (Westwood, 1837) were collected from an unmanaged planting of hairy indigo (*Indigofera hirsuta* L.) located at the University of Florida Plant Science Research and Education Unit in Marion County, Florida (29.4079530 N, 82.1459287 W). Eggs were hand collected and placed into 10-dram plastic vials until eclosion, after which the emerged *Pi. guildinii* nymphs were transferred to a larger cage for rearing. This was done to prevent accidental introduction of egg parasitoids into the main *Pi. guildinii* colony as the dark color of *Pi. guildinii* eggs makes it difficult to identify parasitism. Collections were made throughout the spring and summer of 2018.

Yellow cylinder trap

Yellow, 3D-printed cylinder traps (Figure 1) were deployed in Florida by the Cooperative Agricultural Pest Survey (CAPS Program) throughout the year to monitor for exotic pests, especially psyllids in a variety of agricultural ecosystems (Snyder et al. 2019). These traps also serve well for collecting other insects that are attracted to yellow, and residues were screened for parasitoid wasps. The preservative in the collection tube (Figure 1B) was propylene glycol (Prestone LoTox) with salt.

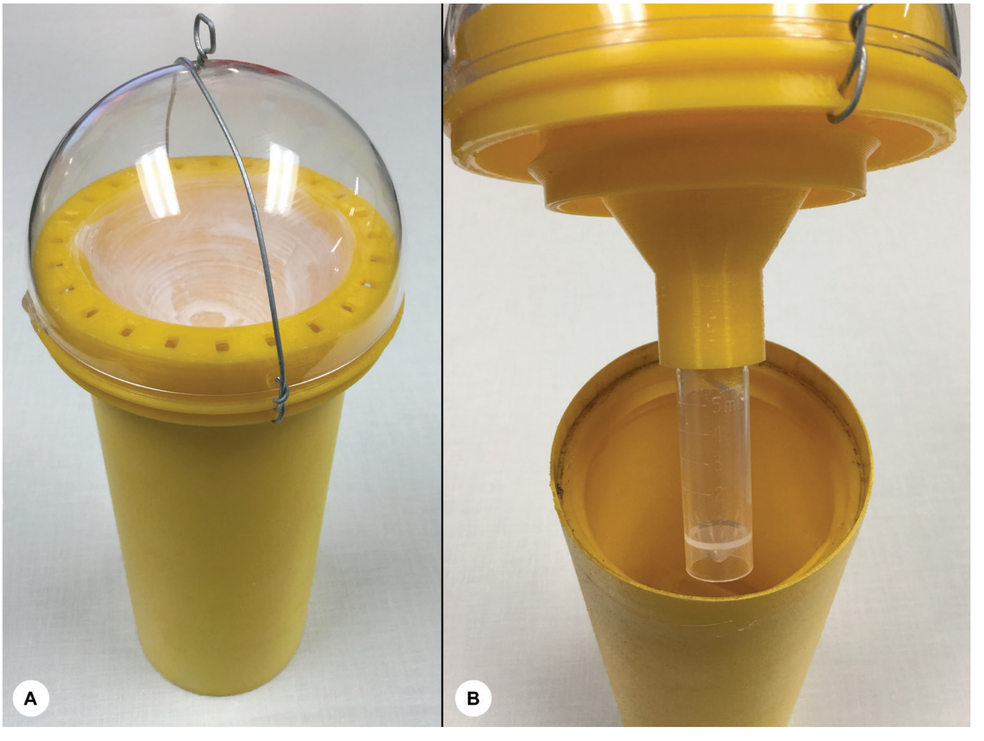


Figure 1. Yellow cylinder trap employed by CAPS Program in Florida **A** exterior view of trap; the inside of the funnel is coated with Insect-a-Slip **B** interior of trap where insects are preserved in a vial containing propylene glycol and salt.

Material examined

The collection data and images associated with the specimens examined were deposited in the database of the Museum of Biological Diversity, The Ohio State University (mbd-db.osu.edu), and a DarwinCore archive file is provided in Suppl. material 1. Collecting unit identifiers associated with specimens are listed by county below.

Psix striaticeps: 54 females, 3 males, deposited in Florida State Collection of Arthropods (FSCA). **Florida: Alachua Co.** (FSCA 00095801, 00095797); **Brevard Co.** (FSCA 00095791–00095792, 00095830); **Hardee Co.** (FSCA 00034061, 00034693, 00034696); **Hillsborough Co.** (FSCA 00095795–00095796, 00095798, 00095800);

Lake Co. (FSCA 00094219, 00094237); **Lee Co.** (FSCA 00095788–000-5789); **Marion Co.** (FSCA 00095892–00095894); **Miami-Dade Co.** (FSCA 00095831); **Orange Co.** (FSCA 00034688–00034689, 00095793–00095794, 00095813–00095823); **Pinellas Co.** (FSCA 00095826–00095827, 00095790); **St. Johns Co.** (FSCA 00095799, 00095803–00095809, 00095811–00095812, 00095828–00095829, 00095891, 00095896–00095899); **St. Lucie Co.** (FSCA 00095824–00095825).

Morphological identification

Specimens of *Psix striaticeps* were identified using the key to *Psix* species by Johnson and Masner (1985).

Molecular analysis

Genomic DNA was nondestructively isolated from the whole adult specimens using the Qiagen DNeasy kit (Hilden, Germany) as described by Giantsis et al. (2016). The host eggs were pulverized prior to analysis and genomic DNA was isolated using the Qiagen DNeasy kit (Hilden, Germany) as described by Giantsis et al. (2016). Polymerase chain reaction (PCR) was carried out to amplify the DNA barcode region of the Cytochrome Oxidase Subunit I (COI) using the LCO/HCO primers of Folmer et al. (1994). For the host eggs, the PENT_F2/HCO primer was used as described by Gariepy et al. (2014). The PCR was performed in a 25 µl reaction volume using the KAPA HiFi Hotstart Ready Mix (Roche) per the manufacturer's standard protocol. PCR conditions were as follows: 95°C for 2 min, followed by 32 cycles of 95 °C for 30 s, 50 °C for 40 seconds, 72 °C for 1 min with a final extension at 72 °C for 7 min. All PCR products were electrophoresed through an agarose gel (1.5%) and were purified and prepared for sequencing using BigDYE Xterminator (Applied Biosystems) per the manufacturer's protocol. Products were then sequenced in both directions at FDACS-DPI, Gainesville, Florida. Chromatograms were then trimmed in Sequencher 5.4.6. and assembled into contigs. Amino acids were translated using MEGA7 (Kumar et al. 2016). Data was deposited in GenBank under accession numbers OK157284–OK157305, OK327010–OK327011 (Table 1).

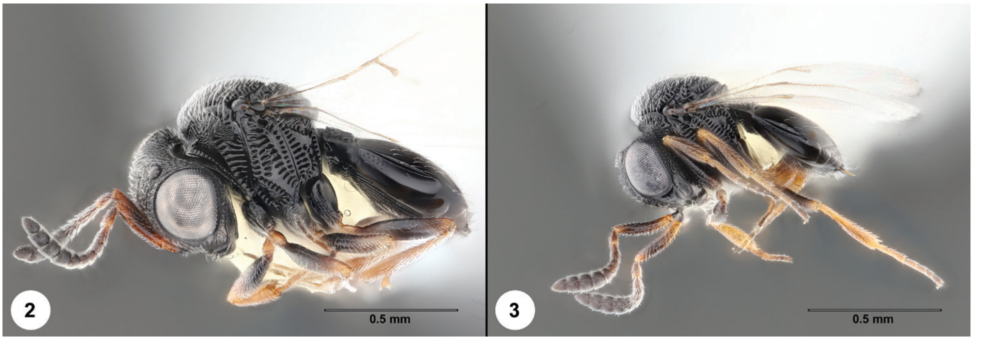
Both GenBank (Altschul et al. 1990) and BOLD (Ratnasingham and Hebert 2007) were queried, and sequences for the *Psix* group of genera (*Psix* Kozlov & Lê, *Paratelenomus* Dodd, *Nirupama* Nixon) barcodes were downloaded from BOLD. Based on the phylogenetic topology of Chen et al. (2021), a species of *Telenomus* was selected as an outgroup for the neighbor-joining analysis. DNA barcodes were aligned using MUSCLE with default settings as implemented in MEGA7 (Tamura et al. 2013). Neighbor-joining of DNA barcodes was performed in MEGA7 using K2P distance (Kimura 1980) with 10,000 bootstrap replicates. The resulting Newick tree file (Suppl. material 2.) was altered in the Interactive Tree of Life (Letunic and Bork 2021) portal to collapse terminal clusters and apply bootstrap support values to branches.

Results

We collected specimens of *Ps. striaticeps* from twelve counties in Florida (Table 1, Figure 14). In two counties, *Ps. striaticeps* was reared from stink bug egg masses, in nine it was collected in yellow cylinder traps, and in one it was collected by an unspecified method. The specimens that emerged from eggs of *Pi. guildinii* (Figure 10), Marion County, 2018, are the earliest record of the species in Florida. In Lake County, 2021, *Ps. striaticeps* emerged from a sentinel *N. viridula* egg mass and a wild egg mass that was determined by its COI sequence to be *Chinavia marginata* (Palisot de Beauvois, 1817) (Figure 9).

Table 1. Locality data, collection method, collecting unit identifiers, and GenBank accession numbers for *P. striaticeps* and *C. marginata* collected in Florida.

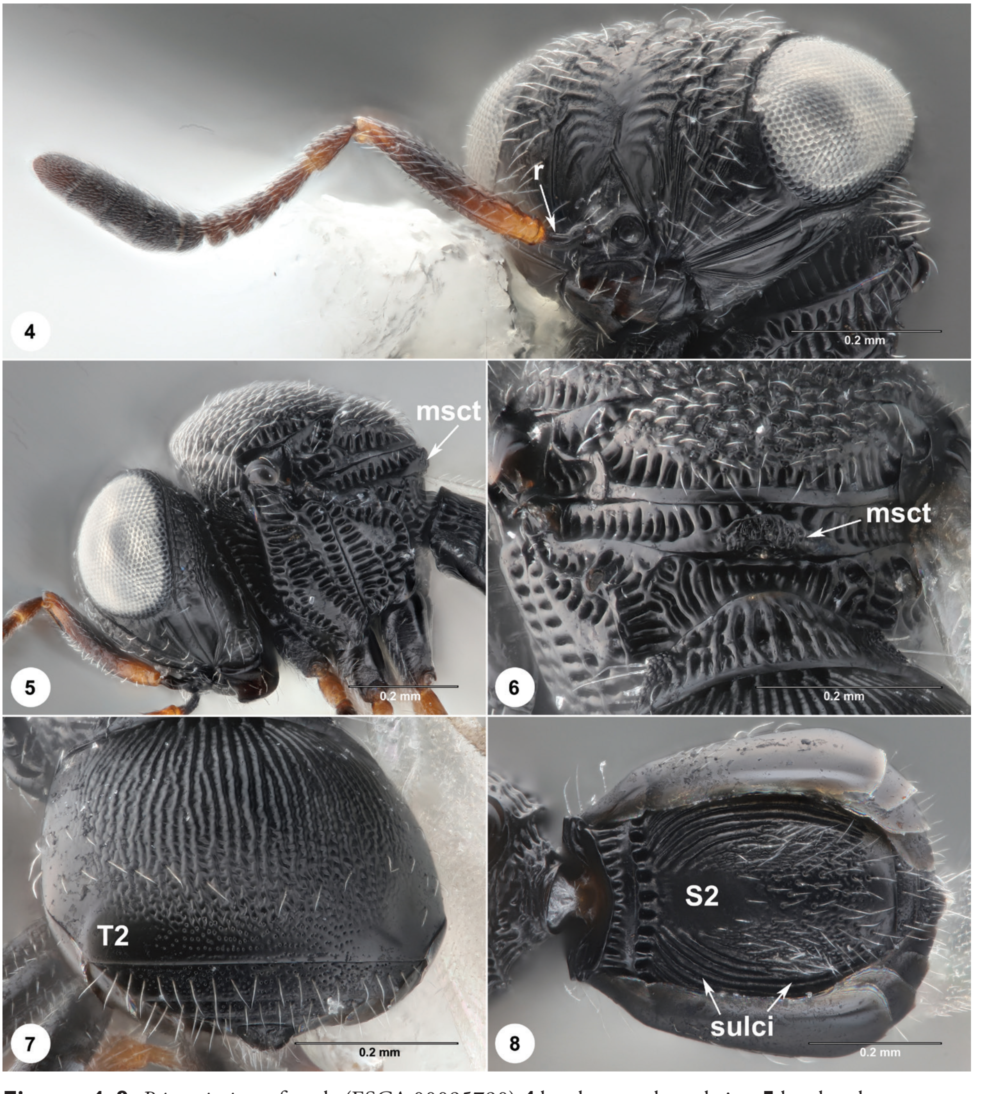
Species	County	Collecting method	Collecting Unit Identifier	Genbank accession number
C. marginata	Lake	hand collected (egg mass)	FSCA 00095810A	OK157305
Ps. striaticeps	Lake	hand collected (in egg mass)	FSCA 00095810B	OK157288
	Alachua	yellow cylinder trap	FSCA 00095797	OK157292
	Brevard	yellow cylinder trap	FSCA 00095792	OK157299
	Brevard	yellow cylinder trap	FSCA 00095791	OK157300
	Hillsborough	yellow cylinder trap	FSCA 00095796	OK157293
	Hillsborough	yellow cylinder trap	FSCA 00095795	OK157294
	Lake	ex. wild *C. marginata* egg mass	FSCA 00094237	OK157284
	Lake	ex. wild *C. marginata* egg mass	FSCA 00093806	OK157286
	Lake	ex. sentinel *N. viridula* egg mass	FSCA 00094219	OK157285
	Lee	yellow cylinder trap	FSCA 00095789	OK157295
	Lee	yellow cylinder trap	FSCA 00095788	OK157296
	Marion	ex. wild *Piezodorus guildinii* egg mass	FSCA 00095892	OK157303
	Marion	ex. wild *Piezodorus guildinii* egg mass	FSCA 00095893	OK157304
	Miami-Dade	not specified	FSCA 00095831	OK157289
	Orange	yellow cylinder trap	FSCA 00095793	OK157301
	Orange	yellow cylinder trap	FSCA 00095794	OK157302
	Pinellas	yellow cylinder trap	FSCA 00095790	OK157290
	Pinellas	yellow cylinder trap	FSCA 00095827	OK157291
	St. Johns	yellow cylinder trap	FSCA 00095799	OK157287
	St. Lucie	yellow cylinder trap	FSCA 00095824	OK157297
	St. Lucie	yellow cylinder trap	FSCA 00095825	OK157298



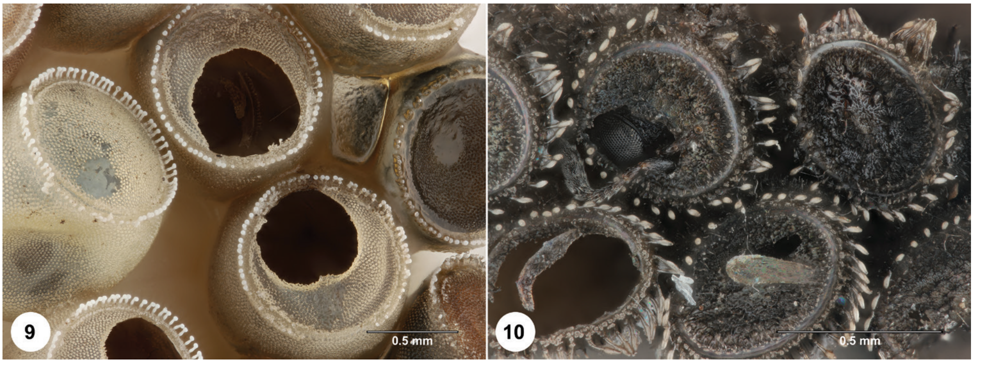
Figures 2–3. *Psix striaticeps,* habitus, lateral view. Images are presented at identical scale size to illustrate intraspecific size variation **2** female (FSCA 00095801) **3** female (FSCA 00095798).

Morphological identification

We identified specimens as *Ps. striaticeps* based on the following characters in the key to species by Johnson and Masner (1985): radicle black; frons without submedian carina; width of frons greater than height of compound eyes; metascutellum (dorsellum) protruding weakly; ventral lip of metascutellum punctulate; posterior margin of T2 punctulate; lateral sulci on S2 widely separated; area between sulci on S2 covered with large seta-bearing punctures (Figures 4–8).



Figures 4–8. *Psix striaticeps*, female (FSCA 00095790) **4** head, anterolateral view **5** head and mesosoma, lateral view **6** mesosoma, posterior view **7** metasoma, posterodorsal view **8** metasoma, ventral view. msct: metascutellum; r: radicle; S2: second metasomal sternite; T2: second metasomal tergite.



Figures 9–10. Wild, parasitized egg masses **9** *Chinavia marginata* (FSCA 00095810) **10** *Piezodorus guildinii* (FSCA 00095895).

DNA barcoding

Our analysis of COI sequences retrieved two clades of *Ps. striaticeps* that differ from each other by approximately 2.5% K2P distance (Suppl. material 3.). One of the specimens in BIN:BOLD:ADV1998 was identified by Taekul et al. (2014), and the specimens that match the Floridian population were previously unidentified (BIN:BOLD:ADX9028) (Figure 11). The Floridian specimens are identical to each other and to one of the specimens from South Africa (KMPUD3236-19).

The wild egg mass of *C. marginata* (Figure 9) was identified by a BOLD query that matched its COI sequence to specimens from Costa Rica (99.8%; BIN BOLD:AEE5175). *Chinavia marginata* occurs in Florida, the West Indies, and the southwestern US south to northern South America (Rolston 1983).

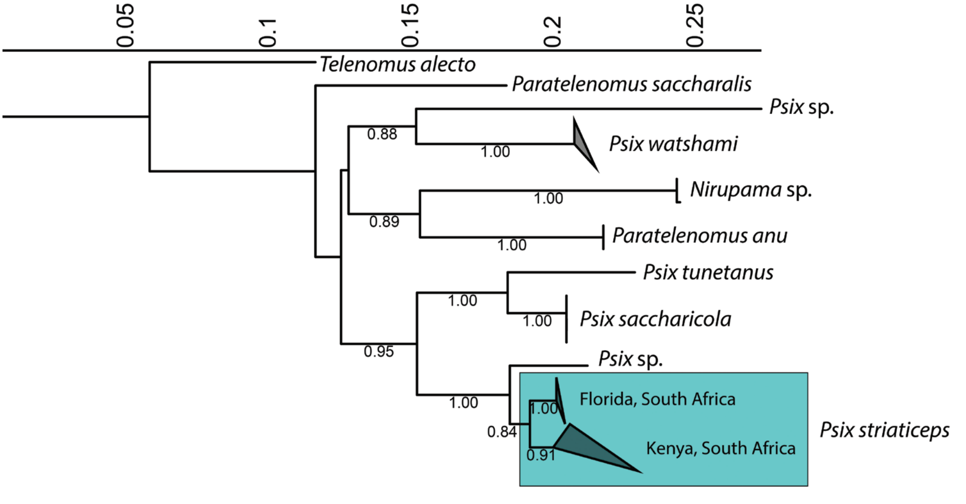
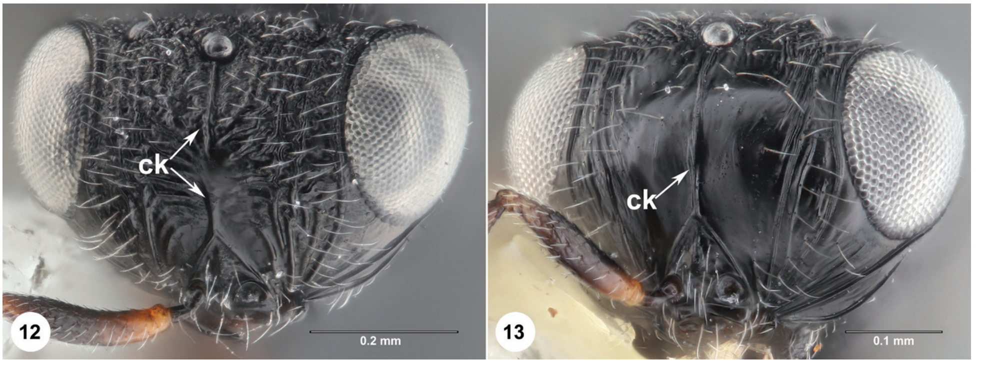


Figure 11. K2P Neighbor-joining tree of COI for *Psix* group of genera. Bootstrap support values over 80 are labelled on the branches.

Identification of *Nearctic Psix*

The two species of *Psix* that are now found in the Nearctic can be separated by sculptural differences on the frons: lateral to the central keel, the frons in *Ps. striaticeps* is rugulose (Figure 12) and in *Ps. tunetanus* it is smooth (Figure 13).



Figures 12–13. 12 *Psix striaticeps*, female (FSCA 00095790), head, anterior view **13** *Psix tunetanus*, female (FSCA 00095802), head, anterior view. ck: central keel.

Discussion

During the past decade, classical biological control has been actively pursued for three invasive pentatomoid bugs in the United States, *Megacopta cribraria* F., 1798, *Hal. halys*, and *Bagrada hilaris* (Burmeister, 1835). For each pest, scelionid egg parasitoids tested in quarantine have been found to be adventive prior to approved release. *Paratelenomus saccharalis* (Dodd, 1914), a parasitoid of *M. cribraria*, was detected in the southeastern United States by Gardener et al. (2013), and reared from *M. cribraria* egg masses in Georgia, documenting the first occurrence of this species in the western hemisphere. This was followed by *Tr. japonicus* (Talamas et al. 2015), a parasitoid of *Hal. halys*, and then by parasitoids of *B. hilaris* eggs, *Tr. hyalinipennis* Rajmohana & Narendran, 2007 and *Gryon aetherium* Talamas, 2021 (Ganjisaffar et al. 2018; Hogg et al. 2021, Talamas et al. 2021). Before this recent spate of introductions, Johnson and Masner (1985) reported *Ps. tunetanus* (Mineo & Szabo 1979) in the southwestern United States. *Psix tunetanus* is originally an Old World species, found in Saudi Arabia, Tunisia, the Ivory Coast, and Gambia. It was suggested by Johnson and Masner (1985) that it arrived in the New World via shipments of Mediterranean plants into the region during the 20^{th} century. We suspect that the introduction of *Ps. striaticeps* followed a similar pathway. The uniformity of the COI barcodes from Florida specimens of *Ps. striaticeps* suggests a single introduction.

Phenology

Johnson and Masner (1985) reported that *Ps. striaticeps* was collected year-round in Zimbabwe, suggesting that it is multivoltine and possibly polyphagous. Our data on *Ps. striaticeps* in Florida supports these ideas. Specimens were collected in yellow cylinder traps continuously from December 2020 to August 2021. The females of *Ps. striaticeps* in Figures 2–3 are presented at identical scale size, and the specimen in Figure 2 is 1.5 times as long as the specimen in Figure 3. This size variation is consistent with *Ps. striaticeps* parasitizing eggs of various stink bug species, which vary in the size of their eggs, directly affecting the size of the parasitoid (Medal and Smith 2015). In Florida, *Ps. striaticeps* has been reared from the eggs of *Pi. guildinii*, *N. viridula*, and *C. marginata*, indicating that it is at least oligophagous.

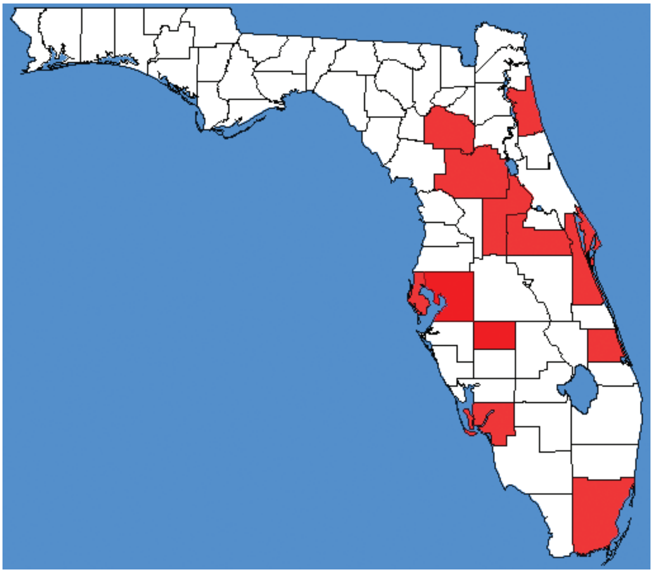


Figure 14. Distribution map indicating the counties (red) in Florida where *Ps. striaticeps* has been collected.

Establishment

The twelve counties where we identified *Ps. striaticeps* span peninsular Florida from north to south and include localities on the Atlantic and Gulf coasts (Figure 14). The earliest record is from 2018 in Marion County, followed by a single specimen collected in a hemp plantation in Miami-Dade County in 2019. The broader distribution that we detected in 2021 demonstrates the importance of continuous monitoring programs, such as CAPS, and their value for detecting a range of insects. Given that *Ps. striaticeps* is widespread in Florida and has been in the state for at least three years, we consider this species to be well-established.

Pest management

The establishment of *Ps. striaticeps* in Florida has implications for stink bug management and ecology. It offers the prospect of biological control of *N. viridula*, from which it has been recorded previously (Johnson and Masner 1985), but the nontarget effects of *Ps. striaticeps* are yet unknown. Johnson and Masner (1985) also reported *Acrosternum acutum* (Dallas, 1851) (Pentatomidae) and *Clavigralla scutellaris* (Westwood, 1842) (as *Acanthomia brevirostris* Stål, 1873) (Coreidae) as hosts, indicating that its host range includes at least two superfamilies of true bugs. It has yet to be determined if *Ps. striaticep*s can parasitize *Hal. halys* eggs, and if it does, there is the possibility of its use for biological control of this species, particularly because there may be a suitable match in the phenologies of these species. *Halyomorpha halys* typically has two generations per year in mild climates, but in warmer climates, such as Florida, the species can give rise to several more generations per year (Hoffman 1933; Kistner 2017). Part of this effect may be that warmer climates tend to be at lower latitudes and have less drastic changes in daylight hours, and *Hal. halys* nymphs have been found to develop faster with a 12L:12D photoperiod than 15L:9D (Musolin et al. 2019; McDougall et al. 2021). Another factor is the year-round availability of host plants. Sweet corn, grown throughout the winter, is one of the top grossing crops in Florida and is a known host of *Hal. halys* (Poplin 2013). Tomatoes also have two cropping seasons in Florida, providing a second, economically important host for *H. halys* (Sargent et al 2014; Zoebel et al. 2016). Because the data from this study and from Johnson and Masner (1985) suggest that *Ps. striaticeps* is multivoltine as well, it may be able to provide control throughout the year. The logical next step is to determine the host range of *Ps. striaticeps*. This includes determining if it can parasitize *Hal. halys* eggs, if it targets beneficial stink bugs such as *Euthyrhynchus floridanus* (L., 1767) and *Podisus maculiventris* (Say, 1831), and how it might impact other native species of true bugs.

Acknowledgments

Sarah Birkmire and Amanda Hodges were supported by the University of Florida, IFAS Entomology and Nematology Department, University of Florida, IFAS Entomology and Nematology Department DPM Program, and USDA-APHIS-PPQ Plant Protection Act funding for projects AP19PPQFO000C508 and AP20PPQFO000C390: Characterization of Brown Marmorated Stink Bug Establishment in Florida to Support Biological Control and Mitigation. Personnel from the University of Florida, Entomology and Nematology Department, DPM Program and Biosecurity Research and Extension Laboratory that supported this work through insect rearing, preparation of sentinel egg masses, checking sentinel egg masses for parasitoids, and field collection included: Jennifer Carr, Heather Kalaman, Adam Pitcher, Jordyn Diaz, and Cameron Zuck.

Sarah Birkmire is a co-enrolled MS in Entomology and Nematology and DPM student. This research is a component of her MS thesis in Entomology and Nematology, and committee members include: Dr. Norman Leppla, Dr. Cindy McKenzie, Dr. Lance Osborne, and Dr. Glynn Tillman.

Elijah Talamas and Matthew Moore were supported by the Florida Department of Agriculture and Consumer Services-Division of Plant Industry (FDACS-DPI). We have many employees of FDACS-DPI to thank: Cheryl Roberts and Lynn Combee assisted in generating sequence data; Sara Ferguson, Alejandro Montoya, Susan Halbert and Natalie McGathey sorted and point mounted parasitoids. Julieta Brambila (USDA-APHIS-PPQ) also sorted samples. We also express our thanks to members of the CAPS Program who collected samples: Krystal Ashman, Robert Leahy, Scott Weihman, Max Carfagno, and Douglas Gaskill. Additional FDACS-DPI employees partnered with the University of Florida who should be acknowledged include Dr. Eric Rohrig, Dr. Mrittunjai Srivastava, Daniel Freed, Dr. Nicole Benda, and Stephanie Dowling.

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Supplementary material 1

DarwinCore

Authors: Elijah J. Talamas

Data type: occurences

Explanation note: DarwinCore archive of specimen collection data.

Link: https://doi.org/10.3897/jhr.87.76191.suppl1

Supplementary material 2

Tree

Authors: Matthew R. Moore

Data type: Tree file.

Explanation note: Unedited tree file of COI analysis.

Link: https://doi.org/10.3897/jhr.87.76191.suppl2

Supplementary material 3

Matrix

Authors: Matthew R. Moore

Data type: Spreadsheet.

Explanation note: Matrix of genetic distance calculations.

Link: https://doi.org/10.3897/jhr.87.76191.suppl3