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Identification of planthoppers (Hemiptera: Delphacidae) intercepted on aquarium plants in Florida and elucidation of a potential pathway for exotic aquatic and semiaquatic pests

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Abstract. Recent shipments of aquarium plants to pet stores in five Florida counties were found to be infested with an exotic delphacid planthopper. Rearing adult males allowed identification by morphological analysis. Molecular analysis confirmed that it was the same as authoritatively identified reference specimens of the planthopper, *Opiconsiva anacharsis* (Fennah) (**new combination**) (Hemiptera: Delphacidae), first reported from Florida in 1989 and known to be established only in Broward County. The host plants, *Echinodorus* spp. Rich. ex Engelm. (Alismatales: Alismataceae), originally from Thailand, were sold in enclosed plastic cylinders that provided a suitable environment for maintaining the planthoppers. Attempts to trace the shipment histories to these stores suggested a circuitous multi-state pathway leading to a Broward County, Florida, business that receives aquatic plants from Southeast Asia. While the infestation of these plants may have occurred in Florida, trade in semi-emergent aquatic plants is shown to be a potential pathway for introduction for insect pests.

Key words. *Harmalia anacharsis*, regulatory entomology.

Introduction

Florida has many adventive arthropods (Frank and McCoy 1992, 1995). Reasons include Florida's climate, ranging from temperate to subtropical, that allows insects to become established, high numbers of visitors and recent immigrants who may bring plants and plant products, high diversity of ornamental plants used in landscaping, and commerce in plant products to serve over 20 million residents. Florida is an international gateway providing plant products destined for the entire USA. One of the primary focuses of the Florida Department of Agriculture and Consumer Services, Division of Plant Industry (DPI) is to identify exotic pests and diseases early enough to prevent establishment in the state and potential spread to other locations. Knowledge of introduction pathways can be used to design science-based regulations to prevent future establishment of exotic pests.

Kennedy et al. (2012) listed 128 delphacid planthoppers known in Florida. Of those, two are definitively adventive (*Opiconsiva anacharsis* (Fennah) and *Perkinsiella saccharicida* Kirkaldy), and two others (*Sogatella kolophon* (Kirkaldy) and *Metadelphax propinqua* (Fieber)) are probably adventive (Meagher et al. 1991; Wooten et al. 1993; Gonzon and Bartlett 2007; Hamilton 2010; Bartlett et al. 2014). On the other hand, *Metadelphax propinqua*, based on its widespread distribution (Bartlett et al. 2014), could be a circumtropical species (Stephen W. Wilson, University of Central Missouri, personal communication 2020). Since Bartlett et al. (2014), three additional adventive species (*Tarophagus colocasiae* (Matsumura), *Opiconsiva tangira* (Matsumura), and *Pissonotus muiri* Van Duzee) have been reported (Halbert and Bartlett 2015; Halbert 2016a, b), and an additional species was introduced as a biological control agent (*Megamelus scutellaris* Berg; Tipping et al. 2014). *Harmalia anacharsis* recently was transferred into *Opiconsiva* Distant by Huang et al. (2017) because the genus *Harmalia* Fennah was found to be a derived lineage nested within *Opiconsiva*, making *Harmalia* a junior subjective synonym. Because Huang et al. (2017) did not specify new combinations, this appears to be the first explicit use of the **new combination** *Opiconsiva anacharsis* (Fennah).

Opiconsiva anacharsis was discovered in Broward County, FL in 1989 (Wooten et al. 1993) and is considered to be established in the county. It is widely distributed across the Pacific islands and southeast Asia, where it feeds on aquatic plants. It is known from rice fields but is not considered a pest of the crop (Wooton et al. 1993). The only observed host plants in Florida, based on DPI records, are species in *Echinodorus* Rich. ex Engelm. (Alismatales: Alismataceae) and *Nymphaea* (L.) (Nymphaeales: Nymphaeaceae). So far, Florida records are restricted to Broward County, and recent finds in pet stores are interceptions. The original source of Florida's Broward County population of *O. anacharsis* is unknown. Here we report possible interceptions of *O. anacharsis* associated with aquatic plants from Thailand for use in aquariums.

Materials and Methods

DPI inspectors routinely inspect businesses that sell plants and plant products, including pet stores. Any live insects and infested plants found during these inspections are submitted to DPI Entomology staff for identification.

Several intercepted containers of host materials (Fig. 1A), all marked "Product of Thailand," with live reproducing colonies of *O. anacharsis* were held in the DPI Maximum Security Quarantine (BSL 2) for several days to obtain adult males from the colonies. Specimens were preserved in 70% or 95% ethanol, for morphological and molecular analysis, respectively.

Specimens of intercepted delphacids were identified using available literature (e.g. Fennah 1969), and by comparison with authoritatively identified reference specimens in the Florida State Collection of Arthropods, Gainesville, FL, USA (FSCA). For delphacids, adult males are necessary for confident identification. Abdomens of male specimens were removed, gently heated in 10% KOH, rinsed in water, and stored in glycerin in microvials. Each microvial was attached by a silicone plug to the pin that holds the rest of the specimen. Voucher specimens were deposited in the FSCA. After removing the planthoppers, all remaining material was autoclaved for disposal.

Recently intercepted and Florida established *O. anacharsis* specimens were DNA extracted using the Qiagen DNeasy Blood and Tissue Kit. PCRs were conducted using the standard COI barcoding primers LCO1490 and HCO2198 (Folmer et al. 1994). Purified PCR products were sequenced at DPI on an Applied Biosystems SeqStudio Genetic Analyzer using BigDye Terminator v3.1 chemistry. Sequence traces were trimmed and assembled into contigs in Sequencher 5.4.6 (Gene Codes Corporation). Newly generated sequences (GenBank accessions: MN922322–MN922327) were aligned in MEGA7 (Kumar et al. 2016) using the default settings of MUSCLE (Edgar 2004). Sequences were queried to BOLD (Ratnasingham and Hebert 2007) and GenBank using BLASTn (Altschul et al. 1990).

Results

Five samples of *O. anacharsis* were submitted from *Echinodorus* spp. plants sold in pet stores for use in aquariums (Fig. 1A). All the plants were marked "Product of Thailand." The samples came from stores in five different Florida counties, including Broward County, where the only known established population occurs. The plants were packaged in sealed clear plastic cylinders. Each cylinder had an inner container filled with gel and pearlite to sustain the roots. Four of the samples had live, reproducing colonies of *H. anacharsis* in at least one container. In one sample, the insects were dead, and the plant was in poor condition.

Insects were identified morphologically using male genitalic characters (viz. Fennah 1969) (Fig. 1 B-D). Molecular sequences of the intercepted *O. anacharsis* were found to be a 100% match with a specimen from the established Florida population of *O. anacharsis*. BOLD contained only one close match (99.8%) to our new sequences, which was an unidentified delphacid from Bangladesh (GMBCH3433-15; BIN BOLD: ACZ2094). GenBank BLASTn searches did not yield any additional sequence matches.

Discussion

Our attempts to trace the source of the infested plants revealed a possible pathway that was long and circuitous. It led first to Arizona, then to California, and then back to a business in Broward County, Florida, that receives thousands of aquatic plants from southeastern Asia monthly. Although the plants were clearly marked "Product of Thailand," it is possible that the infestation came from the established population in Broward County, FL. A subsequent survey of the *Echinodorus* plants at the business revealed a single adult male *O. anacharsis*.

These interceptions indicate movement of aquarium plants could be a pathway of introduction for planthoppers (both from foreign sources and from other states). This pathway is the likely source of Florida's established population of *O. anacharsis*.

Other insects are suspected to have come to Florida on aquarium plants, including two species of Asian corixid bugs (Polhemus and Rutter 1997; Polhemus and Golia 2006). Our first experience with pet stores as a pathway for exotic insect interceptions came in 2016, when several species of Asian wood-boring beetles were found in sticks from China sold as chew toys for pet rodents (Skelley 2016). Subsequent inspections of aquatic plants sold for aquariums intercepted a soft scale, *Coccus moestus* De Lotto (Stocks 2016), a thrips, *Copidothrips octarticulatus* (Schmutz) (Williams 2016), and a moth, *Paraponyx* sp. (Hayden 2016). The scale, *C. moestus*, is recorded from several Caribbean, African, and Asian countries and, along with aquatic plants, infests several important fruit tree species and ornamental plants (García Morales et al. 2020). The thrips, *C. octarticulatus*, is an Asian species that has been moving globally, but is not known from Florida and is a potential agricultural pest. The moth, *Paraponyx* sp. is known from aquatic plants.

Southeast Asia has several serious delphacid pests, especially in rice (Wilson and O'Brien 1987; Wilson and Claridge 1991; Wilson 2005). It is possible that planthopper pests more serious than *O. anacharsis* could follow the aquarium plant pathway and be unintentionally introduced into Florida and other states.

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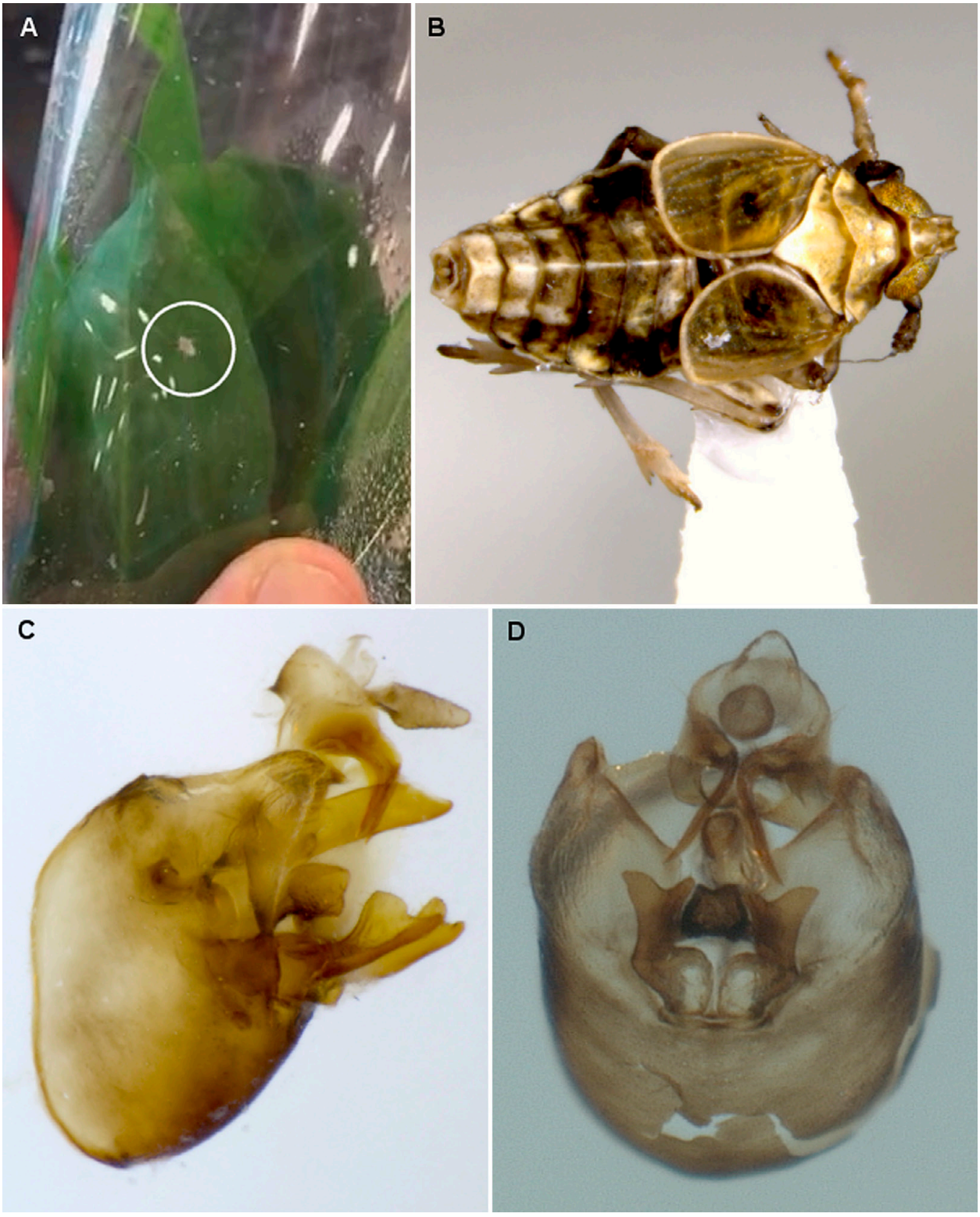

Figure 1. *Opiconsiva anacharsis* (Fennah). **A)** *Opiconsiva anacharsis* on *Echinodorus* sp. plant as sold in stores. Photograph by Melanie Cain, DPI. **B)** Adult female dorsal habitus. Photograph by Jade S. Allen, DPI. **C)** Male genital capsule, lateral view. Photograph by Jade S. Allen, DPI. **D)** Male genital capsule, posterior view. Photograph by Susan E. Halbert, DPI.