FIRST REPORTS OF SIX PLANTHOPPERS (HEMIPTERA: FULGOROIDEA: *TAGOSODES, DELPHACODES, PAREUIDELLA, NILAPARVATA, ASARCOPUS, BRUCHOMORPHA*) IN TEXAS[1]

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ABSTRACT: We present the first records of six fulgoroid species in Texas. *Tagosodes wallacei* (Muir and Giffard, 1924) (Delphacidae) is recorded from Texas (**new state record**), Belize, Honduras, and Ecuador (**new country records**). *Delphacodes puella* (Van Duzee, 1897) (Delphacidae), *Pareuidella magnistyla* (Crawford, 1914) (Delphacidae), *Nilaparvata wolcotti* Muir and Giffard, 1924 (Delphacidae), and *Asarcopus palmarum* Horvath, 1921 (Caliscelidae) are recorded from Texas (**new state records**). Also, a *Bruchomorpha* species (Caliscelidae) is reported from Texas that is either *B. costaricensis* Schmidt, 1927 or an undescribed species. Distributional commentary is provided for the aforementioned species, as well as *Isodelphax basivitta* (Van Duzee, 1909).

KEY WORDS: Auchenorrhyncha, Fulgoromorpha, Delphacidae, Caliscelidae

INTRODUCTION

Planthoppers (Hemiptera: Auchenorrhyncha: Fulgoroidea) are taxonomically challenging and encompass many species of agricultural concern around the world (Wilson, 2005). Planthoppers are phloem-feeders and implicated as vectors of plant pathogens, including mostly viruses but also phytoplasmas (Nault, 1994, Ammar and Nault, 2002, Arocha et al., 2005). Modern trade routes provide a means for their spread (e.g., the spotted lanternfly, *Lycorma delicatula* (White, 1845), into Pennsylvania; Barringer et al., 2015), and monocultures subsequently provide breeding grounds for vulgarization. Such is the case all over the world for all manner of pests, and this has been observed with countless introductions, eradications, control programs, and newly established and spreading pests (e.g., pest accounts in Stickney et al., 1950)—making documentation of their distribution of critical importance.

Since delphacid planthoppers have numerous pestiferous associations around the world (Wilson and O'Brien, 1987; Wilson et al., 1994; Urban et al., 2010), understanding their distribution is vital to circumvent misidentifications and facilitate surveillance. With approximately 2,100 species, Delphacidae is one of the largest and most economically important planthopper families, particularly considering the number of known and possible pests (Cixiidae has more species

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– ~2,500 – but fewer reported pests; Urban et al., 2010; Bourgoin, 2017). In fact, 85 delphacids are recognized as economically significant pests, 30 of which vector 28 plant viruses and pathogens (Wilson, 2005; Urban et al., 2010). In contrast, the Caliscelidae are a small family (226 species, Bourgoin, 2017), whose members are seldom reported as pests (excepting the datebug *Asarcopus palmarum* Horvath, 1921), but nonetheless may be transported internationally (e.g., *Asarcopus palmarum* and *Caliscelis bonellii* (Latreille, 1807) to the US) (Essig, 1926; O'Brien, 1967, 1988; Bartlett et al., 2014).

Tracking pest species is of strategic importance. Recently, *Tagosodes orizicolus* (Muir, 1926) (Delphacidae), a key New World rice pest and plant virus vector, was reported in high numbers in Texas where it had been infrequently encountered (Way et al., 2016). The sugarcane planthopper, *Perkinsiella saccharicida* Kirkaldy, 1903, a native of the Indo-Malayan region, was discovered in Hawaii in 1900 (where it became an important pest; Zimmerman, 1948), Florida in 1982 (Sosa, 1985), Texas in 1989 (Meagher et al., 1989), and is now widespread in the New World (Bartlett et al., 2014). *Nilaparvata lugans* (Stål, 1854), the brown planthopper, is a leading threat to rice production in many parts of Asia, and a vector of rice grassy stunt tenuivirus and rice ragged stunt oryzavirus (e.g., Zheng et al., 2014; Wang et al., 2014); it has been intercepted at US ports, but so far not established in the New World.

Of course, the spread of pests does not rely entirely on monocultures or agroecosystems. Secondary host plants include non-commodity species in natural habitats and, at times, species occur undocumented until comprehensive studies are conducted. Examples of our ever-expanding knowledge and/or ever-expanding distributions of planthopper species include Bartlett et al. (2011; increasing the known planthoppers of Delaware by 55 spp.), Kennedy et al. (2012; adding 16 spp. to the known fauna of Florida), and Bartlett et al. (2014), adding nearly 800 new planthopper US state records. Bartlett and Kunz (2015) likewise added new country records for Delphacidae from Costa Rica, Panama, and Nicaragua (26, 9, and 2 new records respectively). Both Florida and Costa Rica are historically heavily collected, yet much clearly remains to be discovered (or simply documented). Before 2007, the genus *Nilaparvata* was not even known from the United States, an instance considered "puzzling" by Bartlett (2007).

Here we report new distributional records for planthoppers in Texas. The known planthopper fauna for Texas currently stands at 91 genera and 275 species, the third largest US state fauna (after California and Florida; Bartlett et al., 2014). The new records result primarily from USDA traps set in high traffic, disturbed environments (along Texas-Mexico international bridges and inspection stations), and traps set in natural environments (in or adjacent to State Parks and protected areas). We supplement these records with distributional species data (including new records) from the Tri-Trophic Thematic Collection Network database (Collaborative Research: Plants, Herbivores, and Parasitoids: A Model System for the study of Tri-Trophic Associations; http://tcn.amnh.org/) to provide updated distributions for each species.

METHODS

Specimen collections were made near the international Texas-Mexico border crossings. Traps (mostly light traps) were placed at international Texas-Mexico border crossings at Progreso, Pharr, Los Indios and Brownsville, and inspection stations/docks at Pharr and Los Indios. Traps were maintained by Adrien Cisneros (Technician), Alejandro Garza (Plant Health Safeguarding Specialist), and various interns. One set of traps was managed by the Los Indios Plant Inspection Station work unit (Los Indios, Texas; United States Department of Agriculture, APHIS, PPQ). After pre-screening for "target pests" (by David McCoy; Entomologist/Identifier), samples were delivered to the senior author (Leavengood). Collections included in the present work were made for two collecting seasons (March-November, 2015-2016). A second set of traps was set by the senior author in Estero Llano State Park, where sweep samples were also taken (May-September 2016). Occasional blacklighting and Malaise trapping were also conducted at Casa Santa Ana (Alamo, Texas; private property managed by John and Judy McClung). The present work does not include specimens collected at Casa Santa Ana; however, new taxa and potentially new records from this locality are currently under investigation by Bartlett.

After sorting taxa pertinent to this study, specimens were sent to the second author (Bartlett) for preparation, identification, and databasing. Prepared specimens were provided with a 2D barcode label and data captured using "Arthropod Easy Data Capture" (Schuh et al., 2010; Schuh, 2012; Arthropod Easy Capture, 2013). These data are visualized at Discover Life (www.discoverlife.org) and made publicly available through iDigBio (https://www.idigbio.org/). Additional specimen data were harvested from the Tri-Trophic Thematic Collection Network database ("TCN database"; Collaborative Research: Plants, Herbivores, and Parasitoids: A Model System for the study of Tri-Trophic Associations; http://tcn.amnh.org/) by the second author. Photographs and measurements of pinned specimens (except *Asarcopus palmarum*) were taken using a digital imagery system consisting of a Nikon SMZ1500 microscope, Nikon Digital Sight DS-U1 camera, and NIS Elements Imaging software (version 3.0). Maps were composed using SimpleMappr (http://www.simplemappr.net/; Shorthouse, 2010).

The third author (Vitanza-Hedman) made the initial discovery of *Asarcopus palmarum* Horvath in Texas and photographed the species using a Canon 7D with a Canon MP-E 65mm lens and a Yongnuo ring flash (Yongnuo YN-14EX-C Macro Ring Lite), and edited with Adobe Lightroom version 6.

New records for US states and countries are noted in bold as **new state/country record** in the **Distribution** and **Specimens Examined** sections. Locality data for new locality records are recorded verbatim (a TCN data output function) under "Specimens Examined."

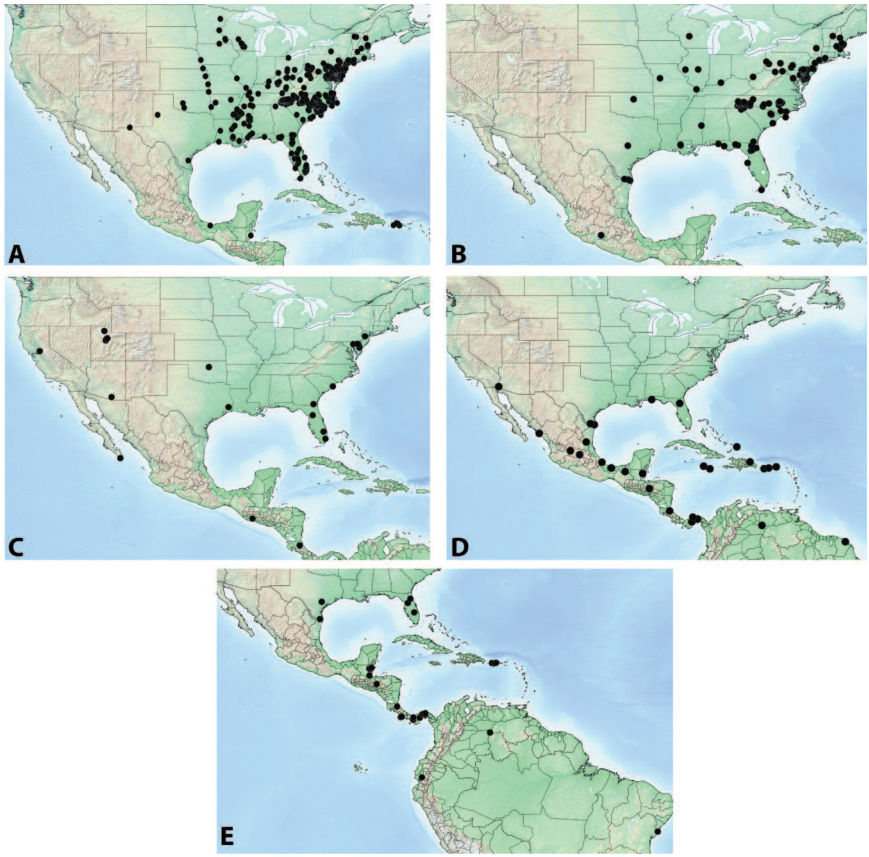

Fig. 1. Distribution maps based on TCN database and current study. A. *Delphacodes puella* based on 4,656 georeferenced records; B. *Isodelphax basivitta* based on 804 georeferenced recods; C. *Nilaparvata wolcotti* based on 61 georeferenced records (excluding Paraguay record); D. *Pareuidella magnistyla* based on 56 georeferenced records; E. *Tagosodes wallacei* based on 62 georeferenced records.

All specimens produced by the senior author were deposited in the UDCC. Specimen depositories are abbreviated with the following codens:

BYUC Monte L. Bean Life Science Museum, Provo, Utah.

FSCA Florida State Collection of Arthropods, Gainesville, Florida.

SEMC Snow Entomological Museum, University of Kansas, Lawrence, Kansas.

LBOB Lois B. O'Brien, private collection in Tucson, AZ, associated with Arizona State University.

NCSU North Carolina State University Insect Collection, Raleigh, North Carolina.

TAMU Texas A & M University, College Station, Texas.

UDCC University of Delaware Insect Research Collection, Newark, Delaware.

UKIC University of Kentucky, Lexington, Kentucky.

USNM National Museum of Natural History, Washington, D.C.

RESULTS

Six planthopper species (4 Delphacidae, 2 Caliscelidae) new to Texas are reported below with comments on the southernmost distribution records of the delphacid *Isodelphax basivitta*.

Delphacodes puella (Van Duzee, 1897) (Delphacidae; Fig. 2A)

Distribution (Fig. 1A): USA (AL, AR, CA, CT, DC, DE, FL, GA, IA, IL, IN, KS, KY, LA, MA, MD, ME, MI, MO, MS, NC, NE, NH, NJ, NY, OH, OK, OR, PA, RI, SC, TN, **TX [new state record]**, VA, VT, WA), Canada (ON, NS, QC), Bermuda, Cuba, Jamaica, Puerto Rico, Mexico (Veracruz), and Venezuela (Bartlett et al., 2014; records in Brazil, Australia, and Hawaii were reported in error).

Discussion: This species is the most commonly encountered delphacid species in the eastern United States (4,690 TCN specimen records, representing ~14% of the 34,427 databased delphacid specimens as of March 2017), and it was reported as the most abundantly collected planthopper in the Great Smoky Mountains National Park (Gonzon et al., 2007). However, its abundance is attenuated to the south and its southern limits remain unclear. It is sparsely reported in Mesoamerica, the Caribbean, and northern South America (where it might easily be confused with other taxa, especially members of the genus *Chionomus* Fennah). Very little is known of its biology, and although it is likely to be a grass feeder, its recorded hosts are *Galinsoga parviflora* Cav. (Asteraceae) and *Panicum capillare* L. (Poaceae; witchgrass) (Wilson et al., 1994).

Specimens Examined: USA: Texas [new state record]: Kenedy Co.: Sarita, 27-Nov-11 (1 male, NCSU); Hockley Co.: 2.4 mi S of Levelana, 4-Oct-04, R. Turnbow (1 female, UDCC); El Paso Co.: El Paso, 6021 Isabella Dr., 1-12-Jul-14, S.T. Dash (1 female, UDCC).

Isodelphax basivitta Van Duzee, 1909 (Delphacidae; Fig. 2B)

Distribution (Fig. 1B): USA (AL, AR, AZ, CA, CO, CT, DC, DE, FL, GA, IA, IL, IN, KS, LA, MA, MD, ME, MI, MO, MN, MS, NC, NE, NH, NJ, NV, NY,

OH, OK, PA, SC, TN, TX, VA, WI) and Canada (AB, MN, ON, QC) (Bartlett et al., 2014).

Discussion: We report the two southernmost records for this species in Cameron County, Texas. The nearest records were collected in Travis County, Texas (over 300 miles north). Both southern records (Los Indios and Brownsville) are from Texas-Mexico border cities. Thus, it would be reasonable to expect this species occurs in northern Mexico (within 610 m of the Los Indios site). In the TNC database, there is a specimen from Mexico [Michoacán, Carácuaro, 31-Aug-38, L. J. Lipovsky (1 male, NCSU)], that may be valid but this record requires verification. The biology of this species is poorly known, but this species is associated with water primrose (*Ludwigia* sp.) (S. W. Wilson, unpublished data).

Specimens Examined: USA: Texas: Cameron Co.: Brownsville, 9-Dec-10 (1 male. NCSU); Los Indios PIS, Los Indios, 26-May-8-Jun-16, J. M. Leavengood, Jr., D. McCoy, A. Cisneros, A. Garza, Black Light (1 male, UDCC); Hidalgo Co., Pharr Import Lot near [Pharr-Reynosa] international bridge, 25.Sep-6.Oct.2016, J. M. Leavengood Jr., D. McCoy, A. Cisneros, A. Garza (7 males, 6 Females, UDCC); Travis Co.: Austin, Brackenridge Field Laboratory, 17-Jun-99, C. R. Nelson (1 male, 3 females, BYUC).

***Nilaparvata wolcotti* Muir and Giffard, 1924** (Delphacidae; Fig. 2D)

Distribution (Fig. 1C): USA (AZ, CA, CO, DE, FL, GA, MD, NJ, OK, **TX [new state record]**, UT), Mexico (Veracruz), Costa Rica, and Puerto Rico (Bartlett et al., 2014; Bartlett and Kunz, 2015 *erratum*).

Discussion: The genus *Nilaparvata* (and 4 species) were first reported in the United States in 2007 (Bartlett, 2007). *Nilaparvata* is an important genus in agroecosystems as *N. lugens*, the brown planthopper, is a vector of Rice Ragged Stunt and Rice Grassy Stunt diseases and a major pest of rice in the Old World (e.g., Wilson and Claridge, 1991). However, New World *Nilaparvata* are not recorded from rice. *Nilaparvata wolcotti* was previously reported from sugarcane (*Saccharum officinarum* L.) and malojillo grass (*Panicum molle* Swartz) (e.g., Bartlett, 2007); Bartlett has taken this species in abundance in vacuum samples from bulrush (*Schoenoplectus americanus* (Pers.) Volk. ex Schinz & R. Keller) in Delaware. Co-occurring on bulrush were the delphacids *Penepissonotus bicolor* Beamer, 1950, and *Pentagramma vittatifrons* (Uhler 1876).

Specimens Examined: USA: Texas [new state record]: Hardin Co.: 3 mi W of Silsbee, Highway 397, Sandylands Preserve, 23-24-Jun-99, C. R. Nelson (1 male, BYUC).

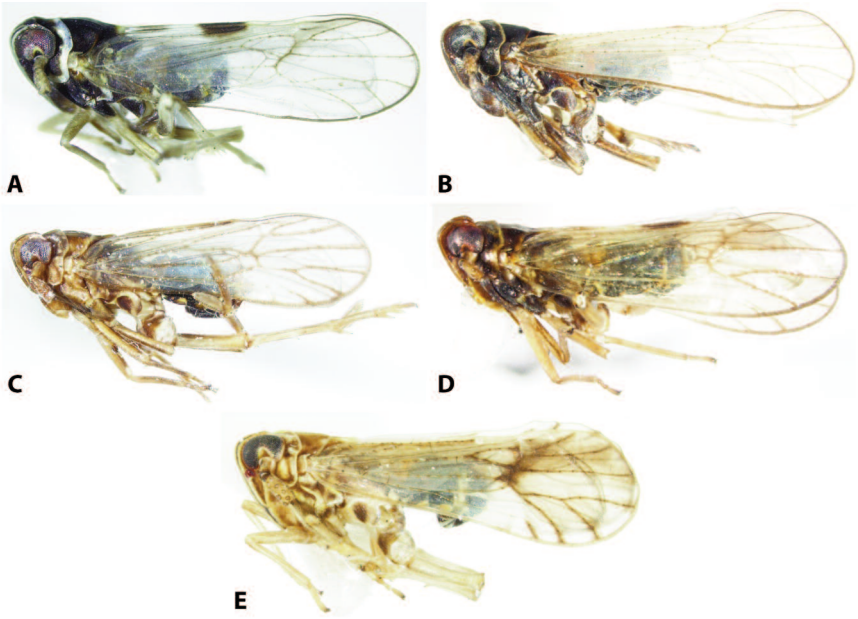

Fig. 2. Delphacid species reported from Texas (males). A. *Delphacodes puella*; B. *Isodelphax basivittata*; C. *Pareuidella magnistyla*; D. *Nilaparvata wolcotti*; E. *Tagosodes wallacei*.

***Pareuidella magnistyla* (Crawford, 1914)**
(formerly *Euides*, see Kennedy et al., 2012, Delphacidae; Fig. 2C)

Distribution (Fig. 1D): USA (AZ, GA, NC?, **TX [new state record]**), Costa Rica, Mexico (Guerrero, Sinaloa, Veracruz), Panama, Cuba, Dominican Republic, Grenada, Puerto Rico, St. Thomas, Turks & Caicos, and Venezuela (updated from Bartlett et al., 2014).

Discussion: These new records from south Texas come as no surprise despite the limited known distribution in Mexico. Our knowledge of Mexican Delphacidae is scant and current specimen data (and historic taxonomic efforts) have focused on collections north of Mexico. This species is widespread in the Caribbean and Mesoamerica to northern South America and should be expected in extreme southern United States. Specimens of this species previously reported from North Carolina and those currently in the TCN database from North Carolina are probably the very similar, and more northerly distributed, *Pareuidella weedi* (Van Duzee, 1897). Members of this genus come readily to lights and no host plants are recorded for any of its species.

Specimens Examined: USA: Texas [new state record]: Cameron Co.: Brownsville, 23-Jun-08, light trap (1 male, NCSU); Cameron Co.: Veterans Bridge, Brownsville, 1-10.iv.2016, J. M. Leavengood Jr., D. McCoy, A. Cisneros, A. Garza (2 males, UDCC).

***Tagosodes wallacei* (Muir and Giffard, 1924)** (Delphacidae; Fig. 1E)
= *Delphacodes ardentis* Beamer, 1948
(synonomy by Bartlett et al., 2014: 147)

Distribution (Fig. 2E): USA (FL, LA, MS, **TX [new state record]**), Cayman Islands (Grand Cayman), Cuba, Dominica, Puerto Rico, **Belize [new country record]**, Costa Rica, Mexico (Guerrero), **Honduras [new country record]**, Nicaragua, Panama, Bolivia, Brazil, Colombia, **Ecuador [new country record]**, French Guiana, Guyana, Paraguay, Peru, Surinam, Uruguay, Venezuela, and Trinidad (updated from Bartlett et al., 2014).

Discussion: Species of this genus are of economic concern because *Tagosodes orizicolus* (recently reported in high abundance in Texas rice) is a vector of tenuivirus Rhbv, causing hoja blanca disease that is recognized, in part, by "hopper burn" (Way et al., 2016). In the present case (*T. wallacei*), the Texas record is from the southernmost extreme of the state (i.e., Cameron County), which brings to question whether its distribution extends northeastward to Louisiana. However, new country records for Belize and Honduras suggest the possible southward extension of the Mexican (Guerrero; only record) population to the Nicaragua-to-South America populations.

Specimens Examined: BELIZE [new country record]: Belize: "Pine Savannah" nr Belize Zoo, 07 Jan 2003, C. R. Bartlett (1 male, UDCC); Western Highway near Belize Zoo, 06 Jan 2003, C. R. Bartlett (1 male, 1 female; UDCC); 07 Jan 2003, C. R. Bartlett (1 male, UDCC). **Cayo:** Pooks Hill, nr Teakettle Bank, 85 m, 08 Jul 2003, C. R. Bartlett (1 male, UDCC); near Georgeville, 08 Jan 2003, C. R. Bartlett (1 male, UDCC); near Teakettle Bank, Pook's Hill, 85 m, 07 Jul 2003, C. R. Bartlett, light trap (1 female, UDCC). **Toledo:** Rio Temas[h], Sep 1937, A. J. White (2 females, UDCC); July 1937, A. J. White (2 males, UDCC); May 1937, A. J. White (1 female, UDCC); Aug 1937, A. J. White (1 female, UDCC). **BRAZIL: Bahia:** Conde, Agricultural Aurantiaca, 04 Aug 2016, Eliana Passos, *Cocos nucifera* L. (Arecaceae) (1 male, UDCC). **ECUADOR [new country record]: Guayas:** Guayaquil Co.: El Triunfo, 60 km E of Guayaquil, 11 Feb 1973, M. A. Deyrup (1 male, NCSU). **HONDURAS [new country record]: Comayagua:** Comayagua, 10 Oct 1966, J. M. Matta, light trap (1 male, FSCA). **USA: Texas [new state record]:** Cameron Co.: Los Indios PIS, Los Indios, 26 May 2016 - 08 Jun 2016, J. M. Leavengood Jr., D. McCoy, A. Cisneros, A. Garza (1 male, UDCC). San Patricio Co.: 15 km NE Sinton, Welder Refuge, San Patricio County, Texas, 20 m, Mar 2004, S. & J. Peck (1 male, UDCC).

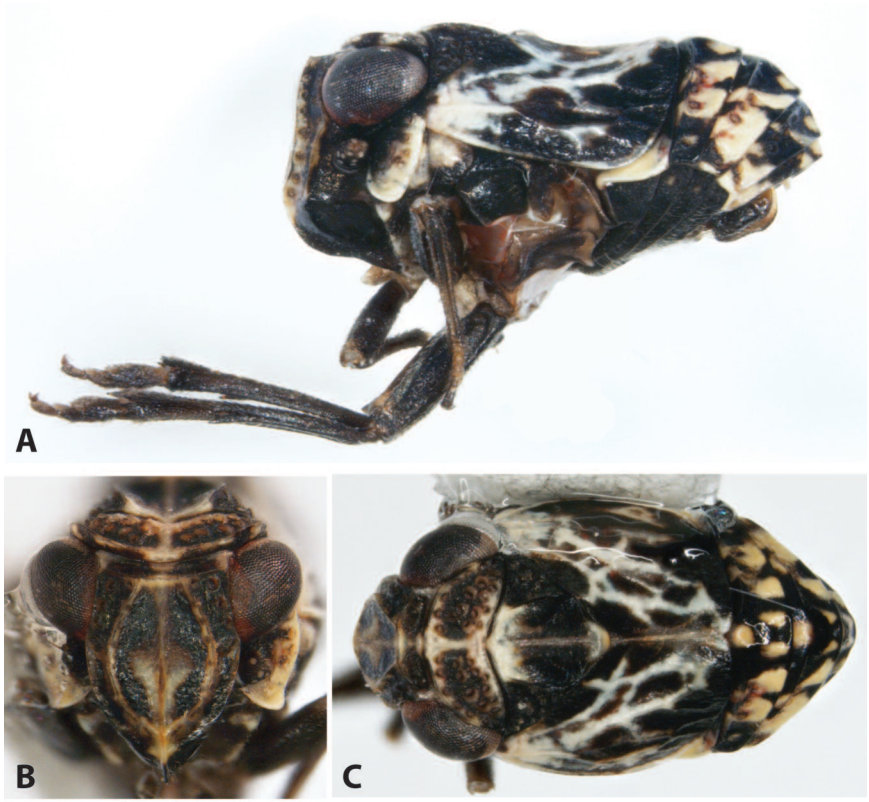

Fig. 3. *Bruchomorpha* sp. near *costaricensis* (Texas, Hidalgo Co., Estero Llano Grande State Park). A. lateral view; B. frontal view; C. dorsal view.

***Asarcopus palmarum* Horvath, 1921** (Caliscelidae; Figs. 4A-E)

Distribution: USA: AZ, CA, **TX [new state record];** Egypt, Algeria, Sudan, Mali, Ethiopia, Israel, and India (Essig, 1926; Quayle, 1938; Stickney et al., 1950; Gnezdilov and Bourgoin, 2009).

Discussion: The "datebug" or "date fulgorid" is adventive to the US. It was described from Egypt by Horvath (1921) (despite Mohammad and Hussain [1996] report of a "first record" in Egypt). It was first recognized attacking crown leaves of date palm in Indio, southern California (and in the Western Hemisphere) in May 1923 (erroneously noted as "1924" in Essig 1926, but 1923 in McAtee 1926, and 1922 in Stickney et al. 1950). McAtee (1926) suggested that it was introduced along with date palm. Stickney et al. (1950) reported this species was common in the Yuma District, Arizona, and that it was found near

Laredo, Texas (without specifying if this was in Texas or Mexico, or if it was during a commodity inspection or pest interception). Stickney et al. (1950) provided a thorough overview of the behavior, control, and diagnosis of this species (Wilson et al., 1994). This species was found on a Canary Island Date Palm (*Phoenix canariensis* Hort. ex Chabaud) by the third author. Specimens were collected and deposited in TAMU, UDCC, the Arizona Department of Agriculture, the University of Arizona, and sent to USDA personnel (Steven Lingafelter and Jason Botz) for reference. *Asarcopus palmarum* is not usually considered an important pest, but their feeding may damage young palms, particularly when near older palms with *Asarcopus* populations (Blumberg, 2008).

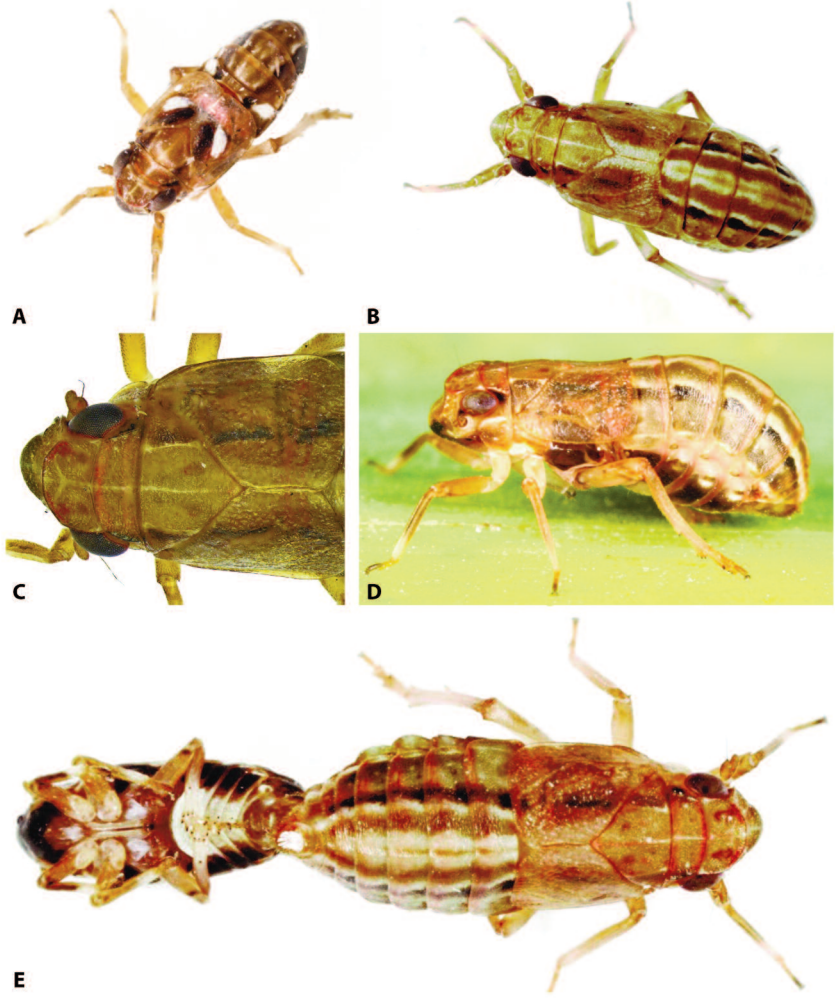

Fig. 4. *Asarcopus palmarum* (El Paso, Texas). A. male habitus; B. female habitus; C. dorsal view of head and thorax, female; D. female on host; E. pair, in copula.

Specimens Examined: USA: Texas [new state record]: El Paso Co., El Paso, Tony Tejeda Drive, 31.735381, -106.303496, 28 May 2016, Salvador Vitanza, ex: Canary Island Date Palm (7 macropterous females, 4 brachypterous females, 2 brachypterous males, 1 brachypterous pair in copula; UDCC).

Remarks: In El Paso, Texas, specimens on *P. canariensis* were frequently found on the upper leaf surface of the induplicate (V-shaped) leaflets near the rachis. *Asarcopus palmarum* was most abundant in mid canopy, near the trunk, and rarely found on the oldest leaves. Brachypterous females were present throughout the year, but difficult to find during the warmest months (June-August). Macropterous females were detected in April and May; while brachypterous males were encountered only from December to May (pers. obs. S. Vitanza-Hedman).

***Bruchomorpha* sp. near *costaricensis* Schmidt, 1927** (Caliscelidae; Figs. 3A-C)

Discussion: These specimens were collected along dusty edge habitat among various weedy plant species. Caliscelids are nearly all grass feeders (excepting *Asarcopus*). It does not appear to be any of the species treated by Doering (1939) or Caldwell (1945), but most similar to *Bruchomorpha costaricensis* Schmidt, 1927, which has not been reported outside of Costa Rica. We are seeking type material (reported by Schmidt to be in the Stettiner Museum [National Museum Szczecin in Poland], but apparently now are in the national museum in Warsaw) to confirm the identification, but we consider it more likely that this represents an undescribed species.

Specimens Examined: USA: Texas: Hidalgo Co.: Estero Llano Grande StPk, service road W of Grebe Marsh, 11-Aug-16, J. M. Leavengood Jr., (2 males, 2 females, 4 nymphs; UDCC); same, 14 May 2016 (2 female, 1 male; UDCC); same, 6 Aug 2016 (1 nymph, UDCC).

Remarks: Nymphs and selected adults have been retained in alcohol for molecular work. A similar specimen has also been examined from Mexico (Jalisco, near Zapopan, N 20° 44′, W 103° 30′ 5 May 2013, Gustavo Moya-Raygoza; 1 female, UDCC).

DISCUSSION

Most records from south Texas were from traps on international import docks/lots and plant inspection stations (including around the USDA building) besieged by pavement, vast parking lots, and frequently mowed grass plots with little to no surrounding trees. Despite the high traffic zones of human disturbance (and prevalent vehicle exhaust fumes), we recorded species not previously known from Texas. However, there is a strong association between delphacid planthop-

pers and graminoids (especially grasses) (Wilson et al., 1994; Urban et al., 2010). As such, the more heavily collected regions of the Lower Rio Grande Valley like the Sabal Palm Grove and state parks may produce numerous new discoveries (e.g., Leavengood et al., 2012; King, 2015), but collection bias has apparently overlooked the local grass-feeding planthoppers. It is, of course, favorable for general collecting purposes to focus on more pristine than disturbed habitats. Most interesting is, given this grass-feeding behavior, these new records in south Texas probably do not indicate "spread" of these species, but rather previously undetected native species. These new records may not be surprising, but it remains alarming that there is such systematic unpredictability of which delphacid planthopper genera/species are capable of vectoring various plant viruses (Urban et al., 2010). Thus, the introduction of an invasive delphacid pest harboring a plant virus, even in small numbers, may be eradicated or controlled or could fail to establish; but the indigenous delphacids may hold the potential to vector the same plant virus despite being distantly related genera!

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