

Contribution to the knowledge of flat bugs (Hemiptera: Heteroptera: Aradidae) from the Miami Plant-Health Inspection Station Entomological Collection, with notes on species

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Abstract

We report on some interesting flat bug species deposited in the Miami Plant-Health Inspection Station Entomological Collection located in Miami, Florida, U.S.A. Our report includes 35 specimens belonging to 24 species from ten genera distributed across four subfamilies: Aneurinae, Aradinae, Carventinae, and Mezirinae. The genera *Aradus*, *Mezira*, *Dysodius*, and *Neuroctenus* represent most of the diversity in the Miami Entomology Collection. These specimens were originally detected on unknown commodities, predominately from Honduras, Costa Rica, and Colombia. Taxonomic and natural history information of each taxon are provided. Color figures of dorsal habitus are also provided, including several color-images absent in the literature, such as *Dysodius lunatus* and *Hesus humeralis*.

Key words. Flat bugs, Neotropical, Heteroptera, natural history collection, flat bug diversity and distribution.

Zusammenfassung

Wir berichten über einige interessante Arten der Rindenwanzen (Aradidae), die in der Pflanzengesundheitsinspektionsstation in Miami, Florida, USA, hinterlegt sind. Unser Bericht umfasst 35 Exemplare, die zu 24 Arten aus zehn Gattungen gehören, die auf vier Unterfamilien verteilt sind: Aneurinae, Aradinae, Carventinae und Mezirinae. Die Gattungen *Aradus*, *Mezira*, *Dysodius* und *Neuroctenus* machen den größten Teil der Arten in der Entomologischen Sammlung in Miami aus. Diese Exemplare wurden ursprünglich auf unbekannten Waren entdeckt, die überwiegend aus Honduras, Costa Rica und Kolumbien stammten. Zu jedem Taxon werden taxonomische und naturkundliche Informationen bereitgestellt. Außerdem werden farbige Darstellungen des dorsalen Habitus bereitgestellt, darunter mehrere Farbfotos, die in der Literatur nicht zu finden sind, wie beispielsweise von *Dysodius lunatus* und *Hesus humeralis*.

Resumen

Se presentan algunos registros de especies interesantes de chinches de corteza (Aradidae) depositadas en la Colección Entomológica de la Estación de Inspección de Sanidad Vegetal de Miami, Florida, EE. UU. El estudio comprende 35 ejemplares correspondientes a 24 especies de diez géneros, distribuidos en cuatro subfamilias: Aneurinae, Aradinae, Carventinae y Mezirinae. Los géneros *Aradus*, *Mezira*, *Dysodius* y *Neuroctenus* constituyen la mayor proporción de la diversidad representada en dicha colección. Los especímenes

fueron detectados originalmente en mercancías no identificadas, procedentes principalmente de Honduras, Costa Rica y Colombia. Para cada taxón se proporciona información taxonómica y de historia natural. Asimismo, se incluyen ilustraciones en color del hábito dorsal, entre ellas varias imágenes inéditas en la literatura, como las correspondientes a *Dysodius lunatus* y *Hesus humeralis*.

Introduction

Flat bugs (Aradidae) are an enigmatic group of Heteroptera found in soil, litter, and under bark, often red to dark brown in coloration (COSCARÓN & CONTRERAS 2015), and feed predominately on fungi associated with conifers, deciduous trees, evergreen trees, and shrubs (GOßNER et al. 2007, HEISS & PÉRICART 2007), with one species considered a pest on scots pine (HELIÖVAARA 1982, 1984, RAITIO 1992). Over the past 100 years, taxonomic catalogues of flat bugs have been published (CHAMPION 1897–1901, KORMILEV & FROESCHNER 1987, HENRY 2009, GREBENNIKOV & HEISS 2018), providing species lists and classifications. These studies have included KORMILEV & FROESCHNER (1987), cataloguing the world fauna of flat bugs at 1,798 species in 211 genera; HENRY (2009), who documented 1,931 species in 233 genera; COSCARÓN & CONTRERAS (2012), who catalogued 509 species in 80 genera from the Neotropics; and unpublished data of the second author, who estimated the global flat bug diversity to be as high as 2,050 species in 285 genera. Our contribution is an addendum to these catalogues of flat bugs based on material deposited in the Miami Plant-Health Inspection Station Entomology Collection.

Material and methods

Our paper focuses on the identification of intercepted Aradidae taxa at Miami Port from 1961 to 2018. These specimens are preserved and housed at the Plant-Health Inspection Station Entomological Collection as reference material for future analyses and investigations.

Taxa are ordered alphabetically by subfamily, genus, and species. For classification of subfamilies, we followed USINGER & MATSUDA (1959) and SCHUH & SLATER (1995). For genera and species, we followed KORMILEV & FROESCHNER (1987), HEISS & PÉRICART (2007), HEISS & MORAGUES (2009), HEISS (2012), and COSCARÓN & CONTRERAS (2012). For every taxon, the following information is provided: systematics, distribution, diagnostic characters (if applicable), sex of specimen, color images of dorsal habitus, and additional notes.

Twenty-four species were photographed from the Miami Collection, except for *Aradus hieroglyphicus*, which was photographed by the second author. Individual images or “slices” of the dorsal habitus were photographed with a Nikon DS camera DS-L3 (Nikon Instruments Inc., Melville, NY, U.S.A.) and NIS-Elements Version 3.3 software. A single composite image was stacked from these “slices” using the image processing software Helicon Focus 6 (Helicon Soft Inc., Kharkiv, Ukraine), with the exception of *A. hieroglyphicus*. Post-stacking alterations to all images were made in Adobe Photoshop Elements Version 12 (Adobe Inc., San Jose, CA, U.S.A.).

Results

In our study we documented 35 specimens belonging to 24 species from ten genera distributed across four subfamilies: Aneurinae, Aradinae, Carventinae, and Mezirinae. All taxa were identified to genus, and 16 (67%) to species (Tab. 1). All genera and species from the Miami entomology collection are listed below, along with their subfamily, distribution, and notes.

Tab. 1. List of Aradidae identified from the Miami Plant-Health Inspection Station Entomology Collection. Cargo and countries of origin are provided for each taxon.

Taxa	N	Country	Commodity	Transport
<i>Aneurillus</i> sp.	1	Colombia	unknown	maritime
<i>Aradus abbas</i> BERGROTH, 1891	1	Italy	ceramic tile	maritime
<i>Aradus</i> nr. <i>abbas</i> BERGROTH, 1891	1	Honduras	unknown	maritime
<i>Aradus betulae</i> (LINNAEUS, 1758)	1	Romania	unknown	maritime
<i>Aradus compressicornis</i> STÅL, 1873	1	Ecuador	<i>Aster</i> sp.	air cargo
<i>Aradus falleni</i> STÅL, 1860	1	Dominican Rep.	<i>Ananas</i> sp.	maritime
<i>Aradus falleni</i> STÅL, 1860	1	Honduras	<i>Cucumis melo</i>	maritime
<i>Aradus falleni</i> STÅL, 1860	2	Honduras	misc cargo	maritime
<i>Aradus falleni</i> STÅL, 1860	1	Panama	unknown	maritime
<i>Aradus</i> cf. <i>gracilicornis</i> STÅL, 1873	1	Honduras	<i>Citrillus lanatus</i>	maritime
<i>Aradus hieroglyphicus</i> SAHLBERG, 1878	1	Italy	ceramic tile	maritime
<i>Brachyrhynchus membranaceus</i> (FABRICIUS, 1798)	2	Costa Rica	<i>Solidago</i> sp.	air cargo
<i>Brachyrhynchus membranaceus</i> (FABRICIUS, 1798)	1	Indonesia	crating	maritime
<i>Dysodius crenulatus</i> (STÅL, 1862)	1	Costa Rica	<i>Sechium edule</i>	maritime
<i>Dysodius lunatus</i> (FABRICIUS, 1794)	1	Honduras	<i>Musa</i> sp.	maritime
<i>Dysodius lunatus</i> (FABRICIUS, 1794)	1	Costa Rica	<i>Draecena</i> sp.	air cargo
<i>Hesus humeralis</i> HEISS, 2009	1	Peru	unknown	maritime
<i>Iralunelus</i> sp.	1	Colombia	<i>Solidago</i> sp.	air cargo
<i>Iralunelus</i> sp.	1	Colombia	<i>Aster</i> sp.	air cargo
<i>Iralunelus</i> sp.	1	Colombia	<i>Mentha</i> sp.	air cargo
<i>Mezira</i> cf. <i>lata</i> (CHAMPION, 1898)	1	Colombia	<i>Solidago</i> sp.	air cargo
<i>Mezira lobata</i> (SAY, 1832)	1	Costa Rica	<i>Heliconia</i> sp.	air cargo
<i>Mezira</i> sp. 1	1	Guatemala	unknown	maritime
<i>Mezira</i> sp. 2	1	Guatemala	live plants	maritime
<i>Neoproxius gypsatus</i> (BERGROTH, 1898)	1	Costa Rica	<i>Erygium foetidum</i>	air cargo
<i>Neuroctenus</i> cf. <i>amplus</i> CHAMPION, 1898	1	Mexico	unknown	maritime
<i>Neuroctenus litigiousus</i> (STÅL, 1862)	1	Costa Rica	<i>Zingiber</i> sp.	maritime
<i>Neuroctenus rubiginosus</i> (BERGROTH, 1887)	2	Honduras	unknown	maritime
<i>Neuroctenus</i> sp. 1	1	Honduras	unknown	maritime
<i>Neuroctenus</i> sp. 1	1	Honduras	<i>Sechium edule</i>	maritime
<i>Neuroctenus</i> sp. 2	1	Honduras	<i>Tillandsia</i> sp.	maritime
<i>Paraneurus</i> sp.	1	Florida, USA	unknown	air cargo

Aneurinae DOUGLAS & SCOTT, 1865

Aneurillus sp. (Fig. 1)

Material examined. 1 ♀, Colombia.

Notes. *Aneurillus* is represented by two species, both from the Neotropics. One is *A. doesburgi* KORMILEV, 1974 from Suriname and the other is *A. dillerorum* HEISS & SCHMOLKE, 2016 from Peru. This single female cannot be assigned to either of these species as females lack morphological characters in delimiting species.

Iralunelus sp. (Fig. 2)

Material examined. 2 ♀♀, 1 ♂, Colombia.

Notes. Nineteen species are currently recognized within *Iralunelus*, all of which are Neotropical (CONTRERAS & COSCARÓN 2012). Species of *Iralunelus* have a broad geographical range, extending from Central America to South America and the Caribbean.

Paraneurus sp. (Fig. 3)

Material examined. 1 ♀, Florida, U.S.A.

Notes. *Paraneurus* and its related genus *Aneurus* are some of the most diverse genera in the Western Hemisphere, with 31 species in the genus *Aneurus*. Both genera are distributed in the Caribbean, Central, and North America. Although alpha-taxonomy of *Aneurus* and *Paraneurus* is published, a phylogenetic revision of the genera is currently lacking. Moreover, testing the monophyly and identifying synapomorphies of these genera are needed to determine placement of species in *Aneurus* (PICCHI 1977) and *Paraneurus* (JACOBS 1986) before species-level determinations can be made.

Aradinae BRULLÉ, 1836

Aradus abbas BERGROTH, 1891 (Fig. 4)

Material examined. 1 ♂, Italy.

Notes. *Aradus abbas* BERGROTH, 1889 is Nearctic in distribution and restricted to Canada and the United States, including Alaska (MATSUDA 1977, HEISS 2010). *Aradus abbas* is not indigenous to Italy or the Mediterranean region, implying that this “Italian” specimen probably came from the Miami area (FROESCHNER 1988). Although the origin of this specimen is dubious, literature has documented that *A. abbas* has been recorded in other temperate regions like Guangzho, China, possibly arriving on timber (HEISS 2010).

Aradus nr. abbas BERGROTH, 1891 (Fig. 5)

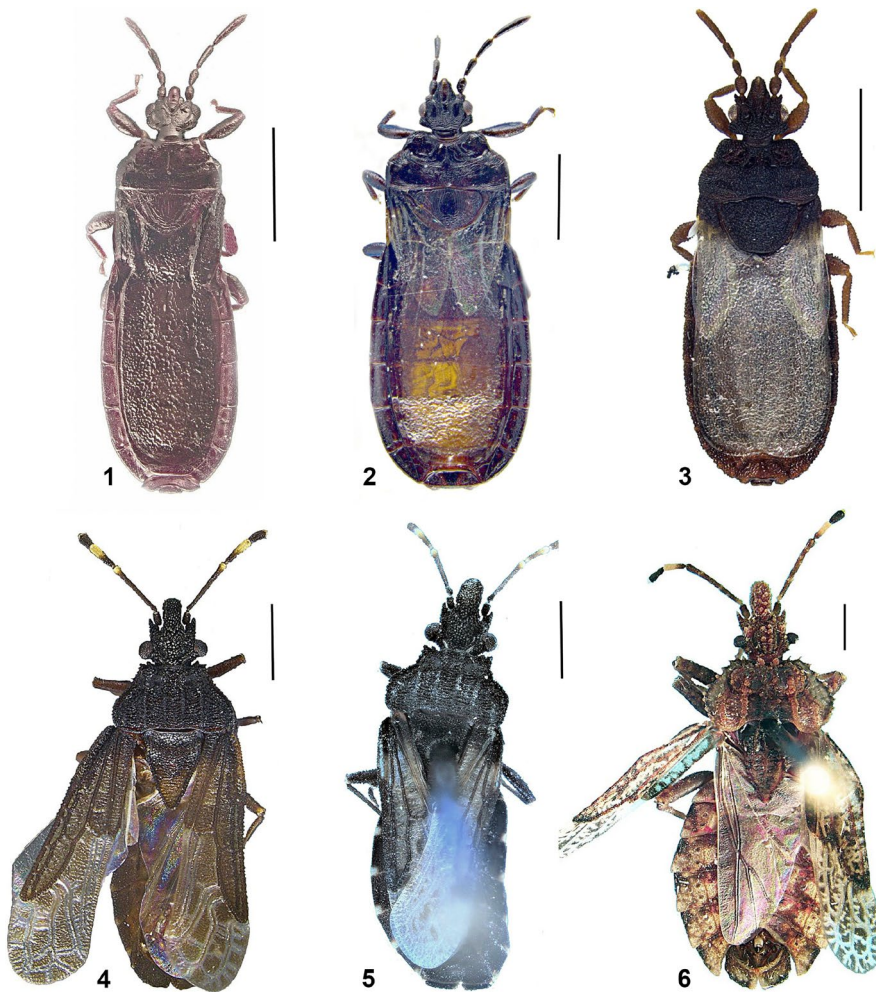
Material examined. 1 ♀, Honduras.

Notes. The specimen was intercepted on commodities from Honduras. Although it shares the characteristic coloration of antennal segments II and III (apex of II and apical half of III yellowish) associated with *A. abbas*, additional specimens are needed to confirm the species. Thus, we tentatively assigned this specimen to “*A. nr. abbas*”.

Aradus betulae (LINNAEUS, 1758) (Fig. 6)

Material examined. 1 ♂, Romania.

Notes. *Aradus betulae* is indigenous to the Euro-Siberian region. It is a widespread species with a range stretching from Europe to the Far East. Specimens of *A. betulae* have been documented on *Fomes fomentarius* (L.) Fr. (Polyporaceae) (GOßNER et al. 2007).



Figs 1–6. (1) *Aneurillus* sp., ♀ (Colombia); (2) *Iralunelus* sp., ♀ (Colombia); (3) *Paraneurus* sp., ♀ (USA); (4) *Aradus abbas*, ♂ (Italy); (5) *Aradus* near *abbas*, ♀ (Honduras); (6) *Aradus betulae*, ♂ (Romania). Scales = 1 mm.

Aradus compressicornis STÅL, 1873 (Fig. 7)

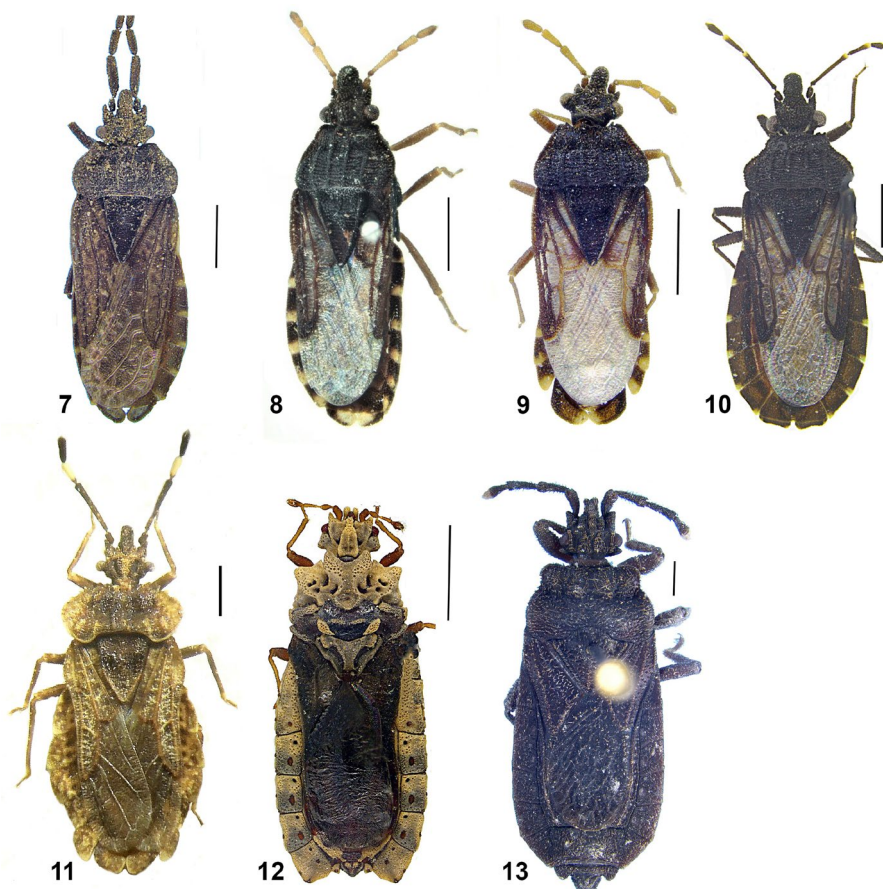
Material examined. 1 ♀, Ecuador.

Notes. *Aradus compressicornis* is a rare Neotropical species restricted to South America. It has been recorded from Colombia, Peru, and Venezuela (HEISS 1993).

Aradus falleni STÅL 1860 (Figs 8, 9)

Material examined. 1 ♂, Dominican Republic (Fig. 8); 2 ♂♂, 1 ♀, Honduras (Fig. 9); 1 ♀, Panama.

Notes. *Aradus falleni* displays considerable variation in antenna length, pronotum, connexivum, and coloration (Figs 8, 9). *Aradus falleni* is widespread throughout the Neotropics, including Brazil, Cuba, Guatemala, Mexico, and Panama (MATSUDA 1977).



Figs 7–13. (7) *Aradus compressicornis*, ♀ (Ecuador); (8) *Aradus falleni*, ♂ (Dominican Republic); (9) *Aradus falleni*, ♂ (Honduras); (10) *Aradus* cf. *gracilicornis*, ♀ (Honduras); (11) *Aradus hieroglyphicus*, ♀ (Italy); (12) *Neoproxius gypsatus*, ♂ (Costa Rica); (13) *Brachyrhynchus membranaceus*, ♀ (Guatemala). Scales = 1 mm.

Aradus cf. *gracilicornis* STÅL, 1873 (Fig. 10)

Material examined. 1 ♀, Honduras.

Notes. *Aradus gracilicornis* is geographically restricted to the Caribbean and Mexico, more specifically to Cuba, Mexico, and South Bimini Islands (HEISS 1993). The specimen we examined shares the dorsal habitus of *A. gracilicornis*. However, antennae of *A. gracilicornis* are thicker and the apices of antennal segments II and III are yellowish, not uniformly dark colored.

Aradus hieroglyphicus SAHLBERG, 1878 (Fig. 11)

Material examined. 1 ♀, Italy.

Notes. *Aradus hieroglyphicus* is East-Palearctic in distribution, including Kazakhstan, China, Korea, Russia, and the Ukraine (HEISS 2001, 2010, KANYUKOVA & VINOKUROV

2007, 2010), yet no confirmed records exist of *A. hieroglyphicus* in the Mediterranean, suggesting a possible introduction into Italy.

Carventinae USINGER, 1950

Neoproxius gypsatus (BERGROTH, 1898) (Fig. 12)

Material examined. 1 ♂, Costa Rica.

Notes. The genus *Neoproxius* is entirely Neotropical (USINGER & MATSUDA 1959, COSCARÓN & CONTRERAS 2012, HEISS & MORAGUES 2013), with *N. gypsatus* known from Brazil, Bolivia, Guatemala, French Guyana, Panama, Peru, and Venezuela.

Mezirinae OSHANIN, 1908

Brachyrhynchus membranaceus (FABRICIUS, 1798) (Fig. 13)

Material examined. 1 ♀, Indonesia; 2 ♀♀, Costa Rica; 1 ♀, Guatemala.

Notes. Although *Brachyrhynchus* is native to Southeast Asia, *B. membranaceus* was recently introduced into the Western Hemisphere in 2005 and has since spread throughout the Western Hemisphere, including the Bahama Islands, Costa Rica, Cuba, Dominican Republic, Honduras, Jamaica, and Panama (HENRY et al. 2013).

Dysodius crenulatus (STÅL, 1862) (Fig. 14)

Material examined. 1 ♀, Costa Rica.

Notes. *Dysodius crenulatus* is Neotropical. Its geographic range extends from Mexico, Costa Rica, Guatemala, and Panama to Colombia (BLÖTE 1965, HEISS 1990, COSCARÓN & CONTRERAS 2012). All *Dysodius* species can be recognized by their large size and extended anterior-humeral processes (see Fig. 14).

Dysodius lunatus (FABRICIUS, 1794) (Fig. 15)

Material examined. 1 ♂, Costa Rica; 1 ♀, Honduras.

Notes. *Dysodius lunatus* has a geographic range that extends from Mexico, Guatemala, Costa Rica, Honduras, Panama into Colombia, Ecuador, British Guyana, French Guyana, Brazil, Bolivia, Argentina (HEISS 1990). The image (Fig. 15) represents the first color photo of the dorsal habitus of *D. lunatus* in scientific literature.

Hesus humeralis HEISS, 2009 (Fig. 16)

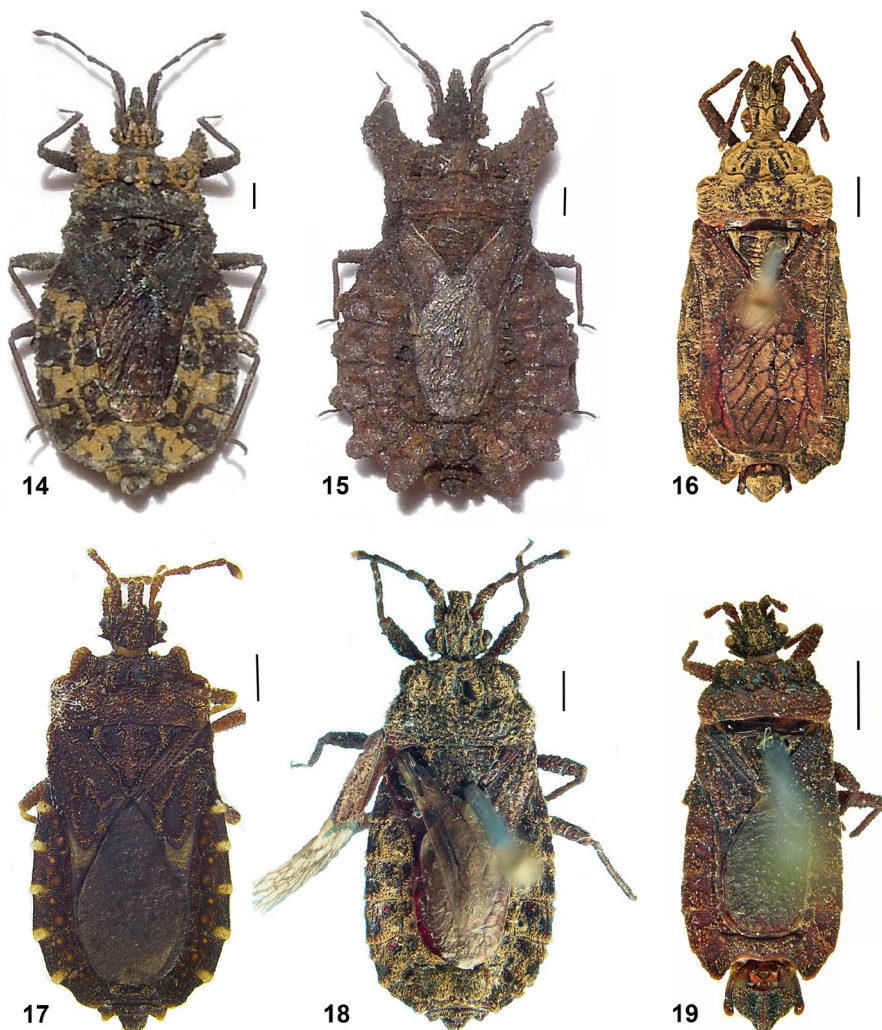
Material examined. 1 ♂, Peru.

Notes. *Hesus humeralis* is endemic to South America and is known from Brazil, Colombia, French Guyana, and Peru (HEISS 2009). The image (Fig. 16) represents the first color photo of the dorsal habitus of *H. humeralis* in scientific literature.

Mezira cf. *lata* (CHAMPION, 1898) (Fig. 17)

Material examined. 1 ♀, Colombia.

Notes. *Mezira* is the most speciose genus within Neotropical Mezirinae, with 110 species currently described (CONTRERAS & COSCARÓN 2012). So far, no recent revision or key has been published for *Mezira*, except by KORMILEV (1971), who recognized 87 species. Therefore, with a single female and no revision of *Mezira*, we cannot identify the specimen with confidence.



Figs 14–19. (14) *Dysodius crenulatus*, ♀ (Costa Rica); (15) *Dysodius lunatus*, ♀ (Costa Rica); (16) *Hesus humeralis*, ♂ (Peru); (17) *Mezira* cf. *lata*, ♀ (Colombia); (18) *Mezira lobata*, ♀ (Costa Rica); (19) *Mezira* sp. 1, ♂ (Guatemala). Scales = 1 mm.

Mezira lobata (SAY, 1832) (Fig. 18)

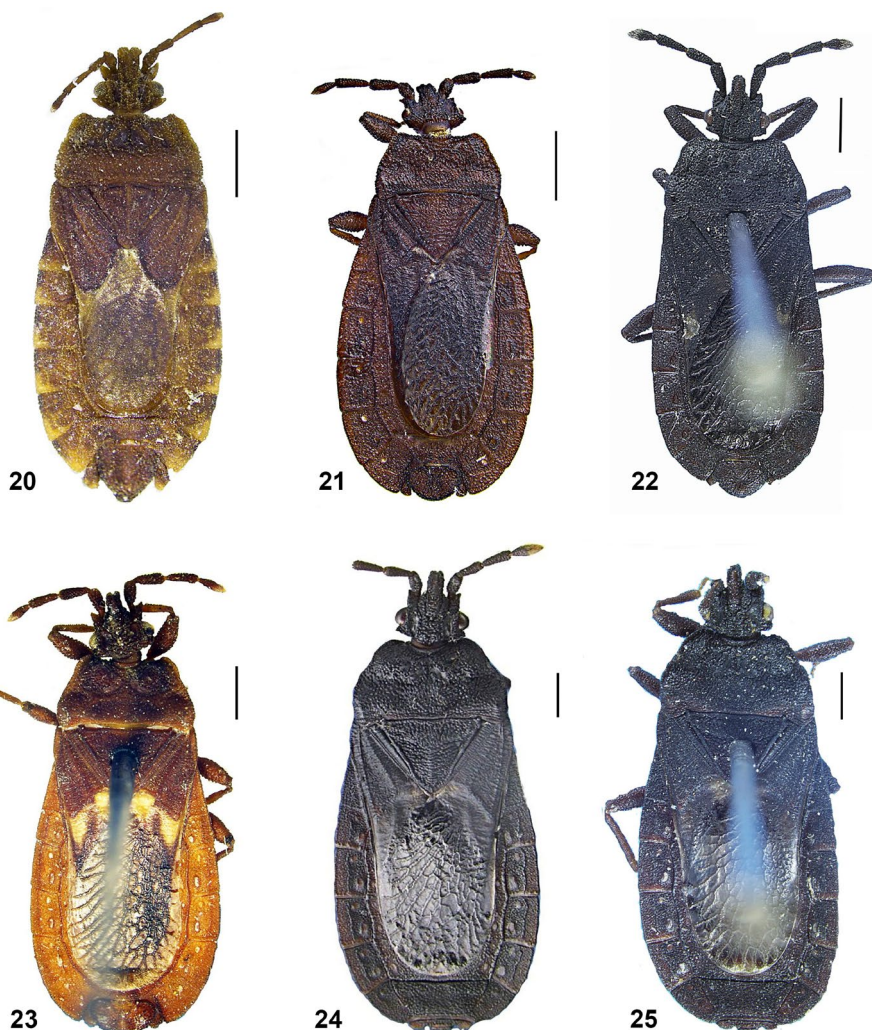
Material examined. 1 ♀, Costa Rica.

Notes. *Mezira lobata* is North American in distribution, including Mexico (KORMILEV 1975).

Mezira sp. 1 (Fig. 19)

Material examined. 1 ♂, Guatemala.

Notes. With limited material and without taxonomic revision for Neotropical species of *Mezira*, we cannot identify this specimen beyond the genus level.



Figs 20–25. (20) *Mezira* sp. 2, ♂ (Guatemala); (21) *Neuroctenus* cf. *amplus*, ♂ (Mexico); (22) *Neuroctenus litigiousus*, ♂ (Costa Rica); (23) *Neuroctenus rubiginosus*, ♂ (Honduras); (24) *Neuroctenus* sp. 1, ♂ (Honduras); (25) *Neuroctenus* sp. 2, ♀ (Honduras). Scales = 1 mm.

Mezira sp. 2 (Fig. 20)

Material examined. 1 ♂, Guatemala.

Notes. See notes of *Mezira* cf. *lata*.

Neuroctenus cf. *amplus* CHAMPION, 1898 (Fig. 21)

Material examined. 1 ♂, Mexico.

Notes. *Neuroctenus amplus* is known from Mexico (KORMILEV 1975), although neighboring countries may also harbor this species.

Neuroctenus litigiosus (STÅL, 1862) (Fig. 22)

Material examined. 1 ♂, Costa Rica.

Notes. *Neuroctenus litigiosus* is distributed throughout the Neotropics, specifically in Mexico, Guatemala, Costa Rica, Panama, and Bolivia (BLÖTE 1965, COSCARÓN & CONTRERAS 2012).

Neuroctenus rubiginosus (BERGROTH, 1887) (Fig. 23)

Material examined. 1 ♂, 1 ♀, Honduras.

Notes. *Neuroctenus rubiginosus* is found throughout the Neotropics, including Cuba, Bolivia, Colombia, Peru, and Mexico (KORMILEV 1975).

Neuroctenus sp. 1 (Fig. 24)

Material examined. 2 ♀♀, Honduras.

Notes. *Neuroctenus* is Neotropical in distribution. KORMILEV (1973) published a taxonomic key of 26 species. Forty years later, COSCARÓN & CONTRERAS (2012) added eleven more species, yielding a total of 37 taxa, suggesting that a revision of *Neuroctenus* is required in reconciling the taxonomy between these authors (KORMILEV 1973, COSCARÓN & CONTRERAS 2012). Because no current revision exists that includes female characters, we are not confident in assigning a species name.

Neuroctenus sp. 2 (Fig. 25)

Material examined. 1 ♀, Honduras.

Notes. Without a revision of *Neuroctenus* and a female specimen, we cannot make an accurate species-level determination.

Future considerations

Although material from the Miami Entomology Collection provides some information on possible pathways of flat bugs entering Miami ports-of-entry, we feel that our data are anecdotal, and examining pathways are beyond the scope of our study. Moreover, the countries associated with these taxa may be dubious as these insects may have arrived in these countries or detected and later intercepted at Miami ports by other means. Including larger datasets and more computationally intensive analyses are needed to adequately explore the pathways facilitating the movement of these flat bugs. A study by SMITH-PARDO & BEUCKE (2015) based on a large US Department of Agriculture dataset gave an overview to pathways of intercepted Aradidae on imported cargo at USA port environs. A judicious examination of museum specimens is also needed to determine whether the taxa we identified originated from the countries listed in our study.

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Disclaimer

The findings and conclusions in this publication are those of the author(s) and should not be construed to represent any official USDA or U.S. Government determination or policy.

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