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Pennsylvania planthoppers
(Hemiptera: Auchenorrhyncha: Fulgoroidea):
relative abundance and incidental catch
using novel trapping methods

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Pennsylvania planthoppers (Hemiptera: Auchenorrhyncha: Fulgoroidea): relative abundance and incidental catch using novel trapping methods

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Abstract. We present an abundance-based checklist of Pennsylvania planthoppers (Hemiptera: Auchenorrhyncha: Fulgoroidea) compiled from available literature and 13,718 specimens. A substantial portion of the latter were bycatch from Lindgren funnel and panel traps intended to intercept wood-boring beetle species, and a directed survey for the spotted lanternfly (*Lycorma delicatula* (White)). The known planthopper fauna of Pennsylvania consists of 10 families, 54 genera and 139 species including 34 new state species records (and 12 new genera). In an attempt to assess the level of completeness of this survey, we compiled an abundance-based checklist of planthopper species found in states adjacent to Pennsylvania and found similar numbers of planthopper species for each state (viz. Delaware 138 species, Maryland 147, New Jersey 145, New York 162 and Ohio 126), but the cumulative species list is comprised of 240 planthopper species, suggesting that the inventory for Pennsylvania and all adjacent states may be substantially incomplete.

Key words. Biodiversity, Fulgoromorpha, *Lycorma*, checklist, sample methods.

Introduction

The planthopper (Hemiptera: Auchenorrhyncha: Fulgoroidea) diversity of Pennsylvania has not been directly assessed since Wirtner (1904). Bartlett et al. (2011) listed Pennsylvania species ancillary to their treatment of Delaware planthoppers (excluding Delphacidae), updated by Bartlett et al. (2014) in their review of North American planthoppers. The previously reported planthopper diversity of Pennsylvania is 106 species in 42 genera and 10 families (Bartlett et al. 2011, 2014; Barringer et al. 2015).

Planthoppers are collected most often by sweeping, beating, malaise traps and at lights. Vacuum sampling is reputed to be the most effective method of obtaining planthopper diversity and abundance (at least in grasslands), followed by sweeping, and then other methods (Wilson et al. 1993; Stewart 2002; Holzinger et al. 2003; Hamilton 2012). Each method contributes a differing representation of the planthopper fauna. For example, Gonzon et al. (2007) found both observed and predicted planthopper biodiversity differed between sweep samples, malaise traps and combined sample methods (predictably, with brachypterous forms undersampled by malaise traps).

Here we compile Pennsylvania planthopper specimen records by county, and present new state records. This was partly motivated by the Pennsylvania Department of Agriculture (PDA) Entomology Department's 2011–2015 surveys and specimens from their collection [PADA] in Harrisburg, PA. The PDA surveys were directed at monitoring invasive species, primarily coleopteran wood destroying pests, but provided an unexpectedly abundant auchenorrhynchan bycatch using methods not usually associated with planthopper collecting. In addition, we used data from all available planthopper specimens from the NSF sponsored Tri-Trophic Thematic Collection Network and sought to database Pennsylvania planthoppers from regional collections. Our goals are to provide abundance-based, specimen vouchered,

planthopper records for Pennsylvania, examine planthopper distribution within the state, and report new state records.

Materials and Methods

All available adult Pennsylvania planthopper specimens were examined, identified (as needed), given a 2D barcode label, and data captured using “Arthropod Easy Data Capture” (Schuh et al. 2010; Schuh 2012; Arthropod Easy Capture 2013). Only specimens that could be reliably identified to species are included and reported here, thus females of some taxa are underrepresented where confirmatory diagnostic features rely on association with males. Planthopper specimens from the PDA Entomology Department’s 2011-2015 surveys were extracted, mounted, identified, databased, and deposited in PADA and a synoptic collection at the UDCC. The PDA spotted lanternfly (*Lycorma delicatula* (White)) records from 2014-2017 were also included with representative specimens in PDA and the Smithsonian Institution National Museum of Natural History.

We expressly databased all planthoppers from regional collections for this project, listed below. All planthopper specimen data captured as of January 2018 in the NSF sponsored “Tri-Trophic Thematic Collection Network” (Tri-Trophic TCN; <http://tcn.amnh.org/>) were used, although we excluded records when conspicuously in error. With these data, we also compiled an abundance-based list of species from states adjacent to Pennsylvania to identify species that have the potential to be found in Pennsylvania. Despite this, we did not attempt to also database collections from these states (except AMNH and UDCC). These data are available at Discover Life (www.discoverlife.org) and via the iDigBio (www.idigbio.org) specimen portal. Planthopper nomenclature follows Bartlett et al. (2014), updated as needed (viz. Kennedy and Bartlett 2014; Bartlett and Webb 2014). Plant host nomenclature follows the USDA Plants Database (plants.usda.gov). Authors of included species are provided in Tables 1, 2 and 5 and are not otherwise duplicated in the text. Pennsylvania specimen data were compiled from the following collections (abbreviations following Arnett et al. 1993):

AMNH American Museum of Natural History, New York, NY;
ANSP Academy of Natural Sciences of Drexel University, Philadelphia, PA;
CMNH Carnegie Museum of Natural History, Pittsburgh, PA;
INHS Illinois Natural History Survey, Champaign, IL;
LBOB Lois O’Brien collection, Tucson, AZ (associated Arizona State University, Tucson, AZ);
NCSU North Carolina State University, Raleigh, NC;
PADA Pennsylvania Department of Agriculture, Harrisburg, PA;
PSUC Pennsylvania State University, Frost Entomological Museum, State College, PA;
SEMC University of Kansas Biodiversity Institute (Snow Entomological Museum), Lawrence, KS;
UDCC University of Delaware Insect Reference Collection, Newark, DE;
UKYC University of Kentucky, Department of Entomology, Lexington, KY;
URIC University of Rhode Island, Kingston, RI;
USNM Smithsonian Institution National Museum of Natural History, Washington DC;
WFBM University of Idaho, W.F. Barr Entomological Collection, Moscow, ID;
WSU Washington State University, Maurice T. James Entomological Collection, Pullman, WA.

For purposes of presentation, abundance-based records from the 66 (of 67) counties in Pennsylvania were segregated by species and county into four arbitrary geographic regions (northwest, northeast, southwest and southeast). Counties are abbreviated in these tables using the three-letter codons given in Appendix 1. The first and last recorded specimen collection date of each Pennsylvania planthopper species is also presented to provide information on species seasonality. When a species is known from a single collection, only a single date is provided; where available specimens provided no date information, “No data” was indicated; when the date information is vague or incomplete, only the month is provided.

Trapping methods. Methodology for PDA Lindgren funnel and panel traps was provided in Barringer (2015); the number of traps by year and their general geographic distribution follows. Panel traps: in 2011, 1,418 traps were hung in central and eastern Pennsylvania; the following year saw 717 traps

in eastern Pennsylvania. This trapping regime followed the leading edge of emerald ash borer (EAB) (*Agrilus planipennis* Fairmaire) (Coleoptera: Buprestidae) detections across the state. Surveys for EAB were not continued after 2012 when their range encompassed two thirds of the state. Lindgren funnels: there were 72 traps across Pennsylvania in 2011; in 2012 and 2013 there were 184 and 198 traps respectively, with over half each year in the southeastern portion of the state; in 2014 and 2015, 244 and 330 traps respectively were deployed across the state with a third focused in the southeastern corner. The placement of these traps was heavily influenced by the walnut twig beetle (*Pityophthorus juglandis* Blackman) (Coleoptera: Curculionidae) distribution and the thousand cankers disease quarantine.

Planthoppers were extracted (by LEB) as bycatch from samples of various agricultural pest surveys intended primarily for wood-boring beetle species (Barringer 2015). Because it was not initially recognized in 2011 that the surveys would contain an unusual abundance of planthoppers, the planthopper bycatch was better extracted and preserved in subsequent years (2012-2015). The families Flatidae and Acanaloniidae were not retained in 2011 because these taxa preserve poorly in fluids, and their utility as geographic records in this project was only subsequently recognized. In 2014-2016, planthoppers were elevated to the status of a survey target so all PDA taxonomists screened and retained specimens. Specimens were also retained from other trapping methods as encountered by the author (LEB), but no systematic screening was applied.

Results

Of 13,718 Pennsylvania planthopper specimens examined, we found 10 families, 51 genera and 115 species (Table 1). This species count includes *Nilaparvata*. Distant (Delphacidae), a genus represented by a single unidentified female specimen. Not included is a putatively new species in the genus *Cixidia* Fieber (Achilidae). Also, *Otiocerus coquebertii* var. *rubidus* Osborn (Derbidae, Figure 3A) is included in the table but not counted as a separate species because the nominative species was also found (Figure 3B). Also excluded was a specimen of *Tangia breviceps* (Metcalf and Bruner) (Tropiduchidae) from PSUC, whose label indicated it was collected at State College, PA, but that species (in the US) only occurs in southern Florida. In addition to the Pennsylvania species reported from specimens in Table 1, 24 species (and three genera) were reported in Bartlett et al. (2014) from literature records (Table 2), for a total of 54 genera and 139 species now reported from Pennsylvania.

Table 1. Pennsylvania planthopper species based on specimens including specimen count and dates of detection (species indicated by * are new state records).

	Specimen count	First record	Last record
Acanaloniidae			
<i>Acanalonia bivittata</i> (Say)	138	3-Jul	17-Oct
<i>Acanalonia conica</i> (Say)	607	6-Jul	13-Nov
Achilidae			
<i>Catonia carolina</i> Metcalf	41	10-Aug	16-Oct
<i>Catonia cinctifrons</i> (Fitch)	4	10-Aug	4-Sep
<i>Catonia lunata</i> Metcalf*	1	10-Jul	
<i>Catonia nava</i> (Say)	128	17-Jul	9-Oct
<i>Catonia pini</i> Metcalf *	1	29-Sep	
<i>Catonia pumila</i> Van Duzee	36	29-Jul	29-Oct
<i>Cixidia brittoni</i> (Metcalf)	1	11-Aug	16-Aug
<i>Cixidia colorata</i> (Van Duzee)*	2	1-Aug	25-Aug
<i>Cixidia fusca</i> (Walker)	4	10-Jul	4-Aug

	Specimen count	First record	Last record
<i>Cixidia opaca</i> (Say)	1	9-Sep	
<i>Cixidia variegata</i> (Van Duzee)	74	24-Aug	30-Oct
<i>Syneccoche dimidiata</i> (Van Duzee)	86	9-Jul	16-Oct
<i>Syneccoche grisea</i> (Van Duzee)	9	13-Aug	5-Sep
<i>Syneccoche impunctata</i> (Fitch)	73	21-Jun	11-Sep
Caliscelidae			
<i>Bruchomorpha oculata</i> Newman	73	11-Jun	10-Oct
Cixiidae			
<i>Cixius angustatus</i> Caldwell*	5	1-May	
<i>Cixius coloepeum</i> Fitch	33	16-May	14-Jun
<i>Cixius misellus</i> Van Duzee	4	3-Sep	7-Sep
<i>Cixius nervosus</i> (Linnaeus)	278	29-May	17-Sep
<i>Cixius nike</i> Kramer	2	June	15-Jul
<i>Cixius pini</i> Fitch	66	12-May	4-Sep
<i>Cixius prodotes</i> Kramer *	5	14-May	
<i>Haplaxius pictifrons</i> (Stål)	42	22-Jun	22-Sep
<i>Haplaxius radialis</i> (Osborn)*	3	28-Jun	18-Aug
<i>Haplaxius xyron</i> (Kramer)*	1	June	
<i>Melanoliarius chuliotus</i> (Ball)*	4	17-Jun	12-Jul
<i>Melanoliarius placitus</i> (Van Duzee)	239	17-Jun	31-Aug
<i>Melanoliarius quinquelineatus</i> (Say)	32	24-Jun	10-Oct
<i>Melanoliarius sablensis</i> (Caldwell)	29	22-Jun	8-Jul
<i>Oecleus borealis</i> Van Duzee	31	7-Jun	16-Jul
<i>Pintalia vibex</i> Kramer*	7	3-Jul	26-Jul
Delphacidae			
<i>Bakerella cinerea</i> Beamer	1	20-Aug	
<i>Bakerella cornigera</i> Beamer	14	18-Sep	
<i>Bakerella penefusca</i> Beamer	2	20-Aug	
<i>Copicerus irroratus</i> Swartz	7	4-May	10-Nov
<i>Delphacodes caerulea</i> Beamer*	5	12-Jun	27-Aug
<i>Delphacodes pacifica</i> (Crawford)*	1	20-Sep	
<i>Delphacodes puella</i> (Van Duzee)	340	2-Jul	16-Nov
<i>Delphacodes recurvata</i> Beamer	14	30-May	18-Sep
<i>Flavoclypeus andromedus</i> (Van Duzee)	7	14-Sep	26-Oct
<i>Flavoclypeus nitens</i> (Muir and Giffard)	6	16-May	13-Sep
<i>Isodelphax basivitta</i> (Van Duzee)	25	2-Jul	17-Sep
<i>Javesella incerta</i> (Van Duzee)*	2	15-Jun	
<i>Javesella pellucida</i> (Fabricius)	35	May	26-Aug
<i>Kelisia curvata</i> Beamer	1	8-Oct	
<i>Kelisia flava</i> Beamer	2	19-Aug	21-Aug
<i>Kosswigianella lutulenta</i> (Van Duzee)	88	22-May	16-Nov

	Specimen count	First record	Last record
<i>Kosswegianella perusta</i> Beamer*	14	31-Jul	27-Aug
<i>Liburniella ornata</i> (Stål)	130	5-Jun	26-Oct
<i>Megamelus davisi</i> Van Duzee	12	3-Jul	4-Jul
<i>Megamelus hamatus</i> Beamer*	1	May	
<i>Metadelphax propinqua</i> (Fieber)*	2	13-Sep	16-Sep
<i>Muellerianella laminalis</i> (Van Duzee)	61	19-Jun	16-Nov
<i>Muirodelphax arvensis</i> (Fitch)	138	16-May	28-Sep
<i>Muirodelphax parvulus</i> (Ball)*	2	No data	
<i>Nilaparvata</i> sp. *	1	15-Jul	
<i>Nothodelphax lineatipes</i> (Van Duzee)	9	23-Jun	11-Oct
<i>Pareuidella weedi</i> (Van Duzee)*	3	23-Apr	Sept
<i>Penepissonotus bicolor</i> Beamer*	1	2-Jul	
<i>Peregrinus maidis</i> (Ashmead)*	14	23-Aug	11-Oct
<i>Phyllodinus nervatus</i> Van Duzee	30	15-Jun	4-Jul
<i>Pissonotus aphidioides</i> Van Duzee	4	24-Jul	
<i>Pissonotus basalis</i> Van Duzee	3	18-Jun	
<i>Pissonotus binotatus</i> Spooner	1	14-Sep	
<i>Pissonotus brunneus</i> Van Duzee	36	10-Jun	23-Sep
<i>Pissonotus dorsalis</i> Van Duzee	1	10-Jul	
<i>Pissonotus flabellatus</i> (Ball)	8	3-Jul	15-Sep
<i>Pissonotus guttatus</i> Spooner	3	10-Jun	16-Sep
<i>Pissonotus marginatus</i> Van Duzee	14	29-Jun	18-Sep
<i>Pissonotus niger</i> Morgan and Beamer	1	2-Jul	
<i>Pissonotus piceus</i> (Van Duzee)	24	6-Aug	25-Sep
<i>Pissonotus tumidus</i> Morgan and Beamer	1	No data	
<i>Prokelisia marginata</i> (Van Duzee)*	1	4-Jun	
<i>Stenocranus (Codex) brunneus</i> Beamer*	1	9-Oct	
<i>Stenocranus (Codex) dorsalis</i> (Fitch)	5	15-Jun	9-Oct
<i>Stenocranus (Codex) lautus</i> Van Duzee	71	6-Jun	11-Oct
<i>Stenocranus (Codex) vittatus</i> (Stål)*	1	18-Aug	
<i>Stobaera pallida</i> Osborn	8	14-Jul	
<i>Stobaera tricarinata</i> (Say)	46	July	30-Oct
<i>Yukonodelphax bifurca</i> Beamer*	1	13-Sep	
Derbidae			
<i>Anotia kirkaldyi</i> Ball	94	28-Jun	22-Nov
<i>Anotia robertsonii</i> Fitch	1	2-Oct	
<i>Anotia westwoodi</i> Fitch	6	2-Jul	17-Sep
<i>Apache degeeri</i> (Kirby)	33	22-Jul	17-Sep
<i>Cedusa bedusa</i> McAtee*	1	No data	
<i>Cedusa cedusa</i> McAtee*	1	23-Sep	
<i>Cedusa gedusa</i> McAtee	3	23-Jun	27-Jul

	Specimen count	First record	Last record
<i>Cedusa incisa</i> (Metcalf)	6	23-Jun	14-Aug
<i>Cedusa kedusa</i> McAtee*	1	10-Jul	
<i>Cedusa maculata</i> (Van Duzee)	1	24-Aug	
<i>Cedusa vulgaris</i> (Fitch)	26	25-Jun	5-Sep
<i>Neocenchrea heidemanni</i> (Ball)*	1	25-Aug	
<i>Omolicna uhleri</i> (Ball)*	11	25-Aug	24-Oct
<i>Otiocerus abbotii</i> Kirby*	6	9-Jul	10-Aug
<i>Otiocerus coquebertii</i> Kirby	17	16-Jun	20-Sep
<i>Otiocerus coquebertii</i> var. <i>rubidus</i> Osborn*	3	16-Jun	9-Sep
<i>Otiocerus kirbyii</i> Kirby*	1	22-Jul	
<i>Otiocerus wolfii</i> Kirby	5	29-Apr	21-Sep
<i>Patara vanduzeei</i> Ball	5	5-Sep	25-Sep
<i>Sayiana sayi</i> (Ball)*	1	10-Aug	
<i>Shellenius balli</i> (McAtee)*	1	28-Jul	
Dictyopharidae			
<i>Phylloscelis atra</i> Germar	64	20-Jul	30-Sep
<i>Phylloscelis pallescens</i> Germar	15	12-Aug	19-Aug
<i>Rhynchomitra microrrhina</i> (Walker)	6	21-Jul	14-Sep
<i>Scolops angustatus</i> Uhler*	4	28-Jul	27-Aug
<i>Scolops pungens</i> (Germar)	8	25-Jul	1-Sep
<i>Scolops sulcipes</i> (Say)	126	12-Jun	14-Oct
Flatidae			
<i>Flatormenis proxima</i> (Walker)	206	15-Jun	30-Oct
<i>Metcalfa pruinosa</i> (Say)	473	1-Jul	4-Nov
<i>Ormenoides venusta</i> (Melichar)	115	14-Jul	17-Oct
Fulgoridae			
<i>Lycorma delicatula</i> (White)	8701	9-May	24-Nov
Issidae			
<i>Thionia bullata</i> (Say)	40	17-Jul	19-Sep
<i>Thionia elliptica</i> (Germar)	61	6-Jun	20-Sep
<i>Thionia simplex</i> (Germar)	417	17-Jul	16-Oct

The family Fulgoridae was the most numerous family collected (8,701 specimens, 63.4% of total specimen count) but was only represented by a single species, *Lycorma delicatula* (Table 3). *Lycorma delicatula* is an invasive species and the subject of a targeted survey, control, and eradication effort (Barringer et al. 2015; Dara et al. 2015; Barringer and Smyers 2016; Liu and Mottern 2017). The next four most numerous families were Delphacidae (8.7%), Flatidae (5.8%), Cixiidae (5.7%) and Acanaloniidae (3.4%). With regard to species diversity, Delphacidae (42.4% of species count), Derbidae (17.8%), Cixiidae (14.4%) and Achilidae (11.9%) were the best represented. Excluding *L. delicatula*, the 5 most abundant species were *Acanalonia conica* (Say) (Acanaloniidae, 607 specimens, 4.4% of total specimen count), *Metcalfa pruinosa* (Say) (Flatidae, 473, 3.4%), *Thionia simplex* (Germar) (Issidae, 417, 3.0%), *Delphacodes puella* (Van Duzee) (Delphacidae, 340, 2.5%) and *Cixius nervosus* (L.) (Cixiidae, 278, 2.0%).

Table 2. Pennsylvania planthopper species not in Table 1 reported from literature records in Bartlett et al. (2014)

Family	Species
Acanaloniidae	<i>Acanalonia servillei</i> Spinola
Achilidae	<i>Cixidia pallida</i> (Say)
	<i>Cixidia septentrionalis</i> (Provancher)
Caliscelidae	<i>Aphelonema (Nenema) histronia</i> (Stal)
	<i>Fitchiella robertsoni</i> (Fitch)
Cixiidae	<i>Bothriocera cognita</i> Caldwell
	<i>Cixius apicalis</i> Metcalf
	<i>Cixius stigmatus</i> (Say)
	<i>Haplaxius wheeleri</i> (Wilson)
	<i>Melanoliarius ecologus</i> (Caldwell)
	<i>Melanoliarius humilis</i> (Say)
	<i>Melanoliarius montanus</i> (Metcalf)
	<i>Pentastiridius cinnamomeus</i> (Provancher)
Delphacidae	<i>Kelisia axalis</i> Van Duzee
	<i>Kelisia retrosa</i> Beamer
	<i>Kelisia spinosa</i> Beamer
	<i>Javesella opaca</i> (Beamer)
	<i>Pissonotus spooneri</i> Morgan and Beamer
	<i>Stenocranus acutus</i> Beamer
Derbidae	<i>Anotia burnetii</i> Fitch
	<i>Anotia fitchi</i> (Van Duzee)
	<i>Otiocerus amyotii</i> Fitch
	<i>Otiocerus stollii</i> Kirby
Dictyopharidae	<i>Scolops perdix</i> Uhler

New species records for Pennsylvania include representatives from five of the ten families present in the state. Of the 54 genera now reported, 12 were new (*Metadelphax* Wagner, *Nilaparvata*, *Pareuidella* (Metcalf), *Penepissonotus* Beamer, *Peregrinus* Kirkaldy, *Prokelisia* Osborn, *Yukonodelphax* Wilson (Delphacidae), *Neocenchrea* Metcalf, *Omolicna* Fennah, *Sayiana* Ball, *Shellenius* Ball (Derbidae), and *Pintalia* Stal (Cixiidae)), and 34 of the 115 species were not previously reported in PA (indicated by * in Table 1). Collection records (specimen data) can be found via the iDigBio (www.idigbio.org) specimen portal.

The total number of county-level specimen records is 13,687, with an additional 31 records having no county level information (Table 4A–D). Specimen records were unevenly distributed throughout the state, with the northwest represented by 328 specimens (Table 4A), northeast by 488 specimens (Table 4B), southwest by 999 specimens (Table 4C) and southeast by 3,183 specimens plus 8,689 *L. delicatula* (i.e., 11,872 specimens; Table 4D). The southeast and northeast regions were also the only region to have representatives of all ten families. The southwest has nine families, as the range of *Lycorma delicatula* does not yet extend into it. The northwest has eight families with Fulgoridae and Caliscelidae absent.

In an attempt to assess the planthopper species that may be found in Pennsylvania but have not yet been recorded, we compiled an abundance-based list of planthopper species from states immediately adjacent to Pennsylvania (Table 5) from specimens recorded in the Tri-Trophic TCN, and added to that literature-based records. The number of species found in states adjacent to Pennsylvania totals 240 based on 11,030 specimen records and the available literature. This includes 40 new state records demarcated in Table 5. Based on specimen records, the most abundant five species in adjacent states

Table 3. Taxonomic distribution of investigated Pennsylvania planthopper specimens and species.

Family	# specimens	# species	% specimens	% specimens (excl. <i>Lycorma</i>)	% species
Acanaloniidae	745	2	5.4%	14.8%	1.7%
Achilidae	461	14	3.4%	9.2%	11.9%
Caliscelidae	73	1	0.5%	1.5%	0.8%
Cixiidae	781	17	5.7%	15.6%	14.4%
Delphacidae	1198	50	8.7%	23.9%	42.4%
Derbidae	224	21	1.6%	4.5%	17.8%
Dictyopharidae	223	6	1.6%	4.4%	5.1%
Flatidae	794	3	5.8%	15.8%	2.5%
Fulgoridae	8701	1	63.4%		0.8%
Issidae	518	3	3.8%	10.3%	2.5%
Total	13718	118	100%	100%	100%

are *Delphacodes puella* (Delphacidae) (1,649 specimens), *Liburniella ornata* (Stål) (Delphacidae) (506 specimens), *Kosswigianella lutulenta* Beamer (Delphacidae) (470 specimens), *Flatormenis proxima* (Walker) (Flatidae) (455 specimens), and *Melanoliarius placitus* (Van Duzee) (Cixiidae) (362 specimens). Four species were excluded from Table 4. This includes *Macrotomella carinata* Van Duzee (Delphacidae; 1 New Jersey record), an uncommon southern species (Florida, Texas, Mesoamerica, Bahamas, Cuba, Jamaica; Bartlett et al. 2014) which is more likely to be a vagrant or mislabeled specimen than from the autochthonous fauna (similarly for Missouri and Illinois records). *Tarophagus colocasiae* (Matsumura) (a taro planthopper, Delphacidae; 2 specimens New York) was also excluded; it is an Indomalayan species only recently established in Florida, Jamaica and apparently Cuba (Halbert and Bartlett 2015); these specimens may have been port interceptions. *Bruchomorpha dorsata* Fitch (Caliscelidae, several specimen and literature records) is a species of the central and southern states whose eastern records are probably a similar undescribed *Bruchomorpha* Newman that we have examined, which differs from *B. dorsata* mostly by structures of the male genitalia. Finally, *Delphacodes furcata* (Provancher) (Delphacidae, literature record from New Jersey) is a species *incertae sedis*, plausibly a synonym of *Muirodelphax arvensis* (Fitch) (Bartlett et al. 2014). *Pissonotus delicatus* (Delphacidae) is doubtfully retained in Table 4 as this species is principally western, with most eastern records likely to be misidentifications of *Pissonotus binotatus* Spooner (see Bartlett and Deitz 2000). Databased specimens of *Laccocera* Van Duzee (Delphacidae) were identified only to genus; while *Laccocera vittipennis* Van Duzee was reported from New York (e.g., MacGillivray and Houghton 1903), there appear to be no modern records.

Notable species records from states adjacent to Pennsylvania include *Pissonotus divergens* Bartlett (Delphacidae, Figures 3I, 3J), a long series of which was collected by the junior author in Delaware and Maryland from *Artemisia vulgaris* L. (common wormwood, Asteraceae). *Ribautodelphax pusilla* Emeljanov (Delphacidae), previously reported in Bartlett et al. (2014), was collected from *Phalaris arundinacea* L. (reed canarygrass, Poaceae). *Delphacodes caerulata* Beamer (Figures 3G, 3H) and *D. nigripennata* Beamer (Delphacidae) were collected by vacuuming native grasslands in northern Delaware. New records of *Cixidia confusa* (Beirne) (Achilidae) are reported from New Jersey and New York based on specimens in the Tri-trophic TCN database. In this case, we are reporting these records although we have not seen these specimens and cannot definitively verify the identifications, although occurrence of this species is plausible.

	County															Total
	BFD	CAR	COL	LKW	LUZ	LYC	MRO	NUM	PIK	SNY	SUL	SUQ	TIO	UNN	WAY	
Delphacidae																
<i>Bakerella cinerea</i>									1							1
<i>B. penefusca</i>									2							2
<i>Delphacodes puella</i>							4								1	5
<i>D. recurvata</i>													2			2
<i>Flavoclypeus andromedus</i>							3									3
<i>Kelisia flava</i>							1									1
<i>Kosswigianella lutulenta</i>					1		3		1			1				6
<i>Liburniella ornata</i>						1	1								3	5
<i>Muirodelphax arvensis</i>					1		3					1				5
<i>M. parvula</i>							2									2
<i>Nothodelphax lineatipes</i>			2													2
<i>Pissonotus aphidioides</i>							4									4
<i>P. basalis</i>		3														3
<i>P. brunneus</i>							5									5
<i>P. dorsalis</i>					1											1
<i>P. marginatus</i>							2									2
<i>P. piceus</i>							2									2
<i>P. tumidus</i>							1									1
<i>Stenocranus (Codex) dorsalis</i>													1			1
<i>Stobaera tricarinata</i>															1	1
Derbidae																
<i>Anotia kirkaldyi</i>													10			10
<i>Apache degeeri</i>			2		1		3		1					1		8
<i>Cedusa gedusa</i>									1							1
<i>C. incisa</i>	1		1													2
<i>C. vulgaris</i>			1			1	4									6
<i>Omolicna uhleri</i>							1									1
<i>Otiocerus coquebertii</i>				1		1					1					3
<i>O. coquebertii</i> var. <i>rubidus</i>			1													1
<i>O. wolfii</i>			1								1					2
<i>Patara vanduzeei</i>			1					1								2
Dictyopharidae																
<i>Phylloscelis atra</i>					1											1
<i>Scolops sulcipes</i>						1					5				4	10
Flatidae																
<i>Flatormenis proxima</i>			1	1		1		3		2						8

	County																Total	
	ALL	ARM	BVR	BED	BLR	CAM	CEN	FAY	FUL	GRN	HUN	IND	JUN	MIF	SOM	WAS		WML
<i>S. sulcipes</i>	14	2					16				6	4	3				1	46
Flatidae																		
<i>Flatormenis proxima</i>	9	1					19	3			2	1			1			36
<i>Metcalfa pruinosa</i>	28	1					58					1				2		90
<i>Ormenoides venusta</i>	2																	2
Issidae																		
<i>Thionia bullata</i>	11						4										9	24
<i>T. elliptica</i>				3					3									6
<i>T. simplex</i>	15		3	10							3		3				11	45
Totals	296	8	42	32	25	6	286	115	6	1	20	13	53	5	3	8	80	999

Table 4D. Number of planthopper specimens by county and species for southeastern Pennsylvania.

	County																	Total
	ADM	BRK	BUK	CHR	CUM	DAU	DEL	FKN	LNC	LEB	LEH	MGY	NHM	PER	PHL	SUK	YRK	
Acanaloniidae																		
<i>Acanalonia bivittata</i>		1	12	5		14	1	12	5	3		1		2	10	1	5	72
<i>A. conica</i>	1	8	25	9	47	107	9		19	7	10	93	8	1	17	6	16	383
Achilidae																		
<i>Catonia carolina</i>		1	1	1	12	14	1			1					1			32
<i>C. cinctifrons</i>					1	1												2
<i>C. nava</i>						2		3	2		5	3	1				1	17
<i>C. pumila</i>						16				12		1						29
<i>Cixidia colorata</i>								1										1
<i>C. opaca</i>								1										1
<i>C. variegata</i>				2		67		2										71
<i>Synecdoche dimidiata</i>						6					1	2				7		16
<i>S. impunctata</i>						53		1										54
Caliscelidae																		
<i>Bruchomorpha oculata</i>	1	2		8		4		27		7							1	50
Cixiidae																		
<i>Cixius angustatus</i>						4												4
<i>C. coloepeum</i>											4							4
<i>C. nervosa</i>									1									1
<i>C. nervosus</i>		11		1	1	10		20	1	2	1	2	3	1		13	1	67
<i>C. nike</i>						1												1
<i>C. pini</i>		2		4	1	3		2	1	1	4		2			7	1	28
<i>C. prodotes</i>											5							5

	County																		Total
	ADM	BRK	BUK	CHR	CUM	DAU	DEL	FKN	LNC	LEB	LEH	MGY	NHM	PER	PHL	SUK	YRK		
<i>P. piceus</i>				8				2						12					22
<i>Prokelisia marginata</i>				1															1
<i>Stenocranus (Codex) brunneus</i>							1												1
<i>S. (C.) lautus</i>			9	36		2		4	3			1							55
<i>Stobaera pallida</i>							8												8
<i>S. tricarinata</i>				7		5		5	1	3		1						3	25
<i>Yukonodelphax bifurca</i>				1															1
Derbidae																			
<i>Anotia kirkaldyi</i>		4	2	5	4	31				1	2	1	5				1	56	
<i>A. robertsonii</i>												1						1	
<i>A. westwoodi</i>			1	4		1												6	
<i>Apache degeeri</i>					3	5			1								2	11	
<i>Cedusa cedusa</i>		1																1	
<i>C. kedusa</i>											1							1	
<i>C. vulgaris</i>						7		2						1				10	
<i>Neocenchrea heidemanni</i>				1														1	
<i>Omolicna uhleri</i>	1	1	1			1			2		1	1					2	10	
<i>Otiocerus coquebertii</i>		1																1	
<i>O. kirbyii</i>								1										1	
<i>O. wolfii</i>												1						1	
<i>Patara vanduzei</i>						1												1	
Dictyopharidae																			
<i>Phylloscelis atra</i>		3				13		13				2						31	
<i>P. pallescens</i>							11		4									15	
<i>Rhynchomitra microrhina</i>				5											1			6	
<i>Scolops angustatus</i>						3		1										4	
<i>S. pungens</i>								5										5	
<i>S. sulcipes</i>		1	15	4		10	10	8	3	1		3		4	6	1	3	69	
Flatidae																			
<i>Flatormenis proxima</i>	1		14	21	1	43	3	11	14		8	10	3	4	20		6	159	
<i>Metcalfa pruinosa</i>	1	10	10	4	20	117	2	15	20	3	8	72	18	1	8	10	9	328	
<i>Ormenoides venusta</i>		5	2	4	3	11		1	8	3	7	23	16		24	4	2	113	
Fulgoridae																			
<i>Lycorma delicatula</i>		7175	139	123			4		138	90	453	491	71		1	4		8689	
Issidae																			
<i>Thionia bullata</i>			2	3			1			4							4	14	
<i>T. elliptica</i>					1	1										30		32	
<i>T. simplex</i>		8	2	17	100	46	26	1	1	7	11	42	6		4	7	7	285	
Totals	11	7293	287	703	214	665	320	191	228	190	522	774	143	39	99	116	77	11872	

Discussion

From 13,718 Pennsylvania planthopper specimens, we report 115 species, including 34 new Pennsylvania state records, plus 24 species from literature records (total 139 Pennsylvania planthopper species). As might be expected (viz. Raczkowski and Wenzel 2007), the Pennsylvania specimen records were aggregated near institutional entomology collections (i.e., Academy of Natural Sciences of Drexel University, Carnegie Museum of Natural History, Pennsylvania Department of Agriculture, Pennsylvania State University). Since these institutions are located in the southern part of the state, the north is less-well represented in collections. Another factor may be that the southeast has greater habitat variation, including the coastal plain physiographic region, not found elsewhere in the state (EPA 2013).

Among the 24 species recorded in the literature but not found among specimens in this survey (Table 2), most are definitively (e.g., *Haplaxius wheeleri* (Wilson)) or plausibly (e.g., *Melanoliarus ecologus* (Caldwell)) (both Cixiidae) present in PA, including some specialized species (e.g., *Fitchiella robertsoni* (Fitch), Caliscelidae, see Bess 2005; *Javesella opaca* (Beamer), Delphacidae, see Wheeler 2003) not readily found by passive trapping or general collecting. Some species are historic records for which modern verification would be desirable (e.g., *Acanalonia servillei* Spinola, Acanaloniidae; *Anotia burnetii* Fitch, Derbidae) or species that might be easily misidentified (e.g., *Stenocranus acutus* (Uhler) is probably a misidentification of *S. brunneus* Beamer, Delphacidae). Two records are possibly the result of issues with alpha taxonomy: *Kelisia axalis* Van Duzee (Delphacidae) was widely reported in older literature prior to Beamer's (1945, 1951) revisions of the genus, and *Scolops perdix* Uhler (Dictyopharidae) is doubtfully diagnosed from *S. pungens* (Germar) based on color. The validity and diagnostic features of these taxa should be reevaluated.

As the list of species from adjacent states demonstrates, this Pennsylvania inventory is likely not comprehensive; however, it probably represents all the species that might be readily obtained through general collecting and passive methods. Species missing from the PA list are mostly specialized species (in host or habitat) that would need to be directly targeted or are infrequently encountered or poorly known taxa that might be most readily found and recognized by a knowledgeable specialist. An example of ecological specialists that are poorly represented among the PA species list are the *Spartina*-feeding saltmarsh planthoppers (e.g., the genera *Spartidelphax* (Beamer), *Prokelisia*, *Neomegamelanus* McDermott, *Tumidagena* McDermott) that might be found in the southeast corner of the state (e.g., at the John Heinz National Wildlife Refuge at Tinicum). Also, additional *Kelisia* Fieber species might be found by targeting sedges and rushes, especially *Carex* L. and *Scirpus* L.

A factor in the uneven geographic distribution of planthopper records is *Lycorma delicatula*, which is currently the focus of a survey and eradication program by PDA and USDA. The reported 8,689 records of this species is reflective of outbreak population levels and focused survey efforts. No other planthopper had this collection mandate from PDA. *Lycorma* records in new counties are expected to increase, even within the context of an eradication program. *Lycorma* has now been reported from states aside from Pennsylvania (viz. Delaware, New York, New Jersey and Virginia), with indicated records in Table 5. Established populations have only been found in Virginia to date, which are undergoing eradication efforts.

From states adjacent to Pennsylvania, we report 240 species (including 40 new records) from 11,030 planthopper specimens, 101 more species than found in Pennsylvania. Some species are unlikely to be found in Pennsylvania, such as *Keyflana hasta* Beamer (Delphacidae, a specialist on blackrush, *Juncus roemerianus* Scheele) and *Poblicia fuliginosa* (Olivier) (Fulgoridae, a *Rhus* spp. L. feeder in the east), both of which reach their northernmost distribution in the southern portion of the included study area. Nonetheless, we speculate that an additional 70 or so planthopper species might be found in a complete survey of Pennsylvania planthoppers, with most of these infrequently encountered or ecological specialists. However, the number of planthopper species now known from Pennsylvania (139, Tables 1 and 2) is similar to those known from adjacent states (Table 5, viz. Delaware 138 species, Maryland 147, New Jersey 145, New York 162 and Ohio 126), suggesting that the fauna may already be well documented.

Two alpha-taxonomic issues were noted in this study. One was the striking contrast between *Otiocerus coquebertii* Kirby and the subspecies *O. c.* var. *rubidus* (Figures 3A,B, Derbidae). We feel that it should be investigated whether these represent distinct species rather than color variants. Unfortunately,

species in this genus are defined based on color patterns despite the prevalence of sexual dimorphism (viz. *Otiocerus stollii* Kirby; Bartlett et al. 2014), and such an investigation may require redefinition of species based on genitalia to confirm diagnostic value of color features. Second, the cixiid species *Cixius coloepeum* Fitch and *C. pini* Fitch are very similar, with no external diagnostic features; only those of male genitalia (viz. the relative lengths of the lower subapical process on the right side of the aedeagal shaft and the degree of convexity of the basoventral margin of the aedeagus) are used to distinguish these two species (Kramer 1981). We have found that these features possess substantive variation and the two species are readily conflated, suggesting that the diagnostic features between these taxa be reevaluated.

The trapping techniques used by PDA exhibited a substantive influence on the observed species composition of Pennsylvania planthoppers versus those of adjacent states. The PDA trapping techniques were intended to capture wood-boring beetles, but incidentally captured substantial numbers of Acanaloniidae (esp. *Acanalonia conica*), Achilidae, Flatidae, Cixiidae and Issidae. The abundance of *Thionia simplex* (Issidae) was entirely unexpected and this outcome appears to result from this species being unusually susceptible to PDA survey methods. The differing species composition of the most abundant species in Pennsylvania (Figure 1) versus adjacent states (Figure 2) may be attributed to the PDA sample methodology. For example, among the family Issidae, there were three species recorded from the region (*Thionia simplex*, *T. bullata* (Say) and *T. elliptica* (Germar)). In Pennsylvania, the number of specimens we recorded of these species was 417, 40, and 61 respectively, while in adjacent states these numbers were 44, 35, and 3.

In an attempt to investigate the efficacy and taxon composition of PDA methodology versus that of other collection methods, we compiled tallies of Pennsylvania planthopper taxa collected by various methods as reported on specimen label information in the Tri-Trophic TCN (Table 6). In our findings, sweeping appears to be the best method for Delphacidae, while funnel traps for Acanaloniidae, Cixiidae, and Issidae appear to be the preferable method. Vacuum sampling in comparative studies has been shown to be more effective, but our limited sample size of records using this technique is too small to compare (Page 2017). Flatidae and Achilidae, woody or semi-woody feeders, are also more prevalent in funnel trapping records but to a lesser extent. Panel traps did not show any strong trapping trends, nor perform better than funnels in its best category with Derbidae. We feel these data (while interesting) are compromised by lacking any measure of sampling effort for all techniques aside from those used by PDA.

The mechanical aspects of both traps utilized by PDA were the likely mechanism for capture, which has shown to be an important factor when targeting wood boring beetles (McIntosh et al. 2001; Graham et al. 2012). The presentation of a strong visual silhouette, large trapping surface, trap placement in canopies, and flight intercept properties should be more important than pheromones, which likely do not attract Fulgoroidea. All lures used were either pheromones directed at specific taxa (Coleoptera) or lures designed to mimic damaged or weakened trees (Coleoptera or Hymenoptera). Planthopper courtship typically utilizes substrate-borne vibrations using a tymbal (or other structures; e.g., Claridge and de Vrijer 1994) so pheromones should not interfere or attract these taxa. There may be some synergy between the tree volatiles and planthopper aggregation, but this was not explored.

Planthoppers collected by the PDA sample techniques appear to best represent larger taxa that are associated with woodlands. Poorly represented are ground dwelling or grass-feeding taxa such as Caliscelidae and Delphacidae (many of which may be brachypterous) that dwell meters below traps. One advantage of the PDA surveying is that the sampling period (April to November) extended the reported phenology for several species. Many of the species observed in early spring appear to overwinter as adults (or late instar nymphs). The life histories of most Pennsylvania planthoppers are not documented in detail, but are assumed to be univoltine, except for Delphacidae which are mostly multivoltine, with few taxa possibly bivoltine (e.g., *Bruchomorpha occulata* Newman, *Cixiis nervosa* (L.); Bartlett et al. 2011).

Large scale trapping efforts for specific pests (e.g., Asian longhorn beetle, *Anoplophora glabripennis* Motschulsky) (Coleoptera: Cerambycidae) are valuable sources of bycatch and taxonomic information. While it is generally unfeasible to identify all taxa due to limitations in funding, time, and expertise, smaller targeted approaches can be applied. Bycatch, while difficult to use in a systematic fashion, can be valuable in elucidating such areas as range, distribution, host association, potential lures, and life history. Interest in a taxonomic group by a specialist, interested individual, or collaborator given a tractable amount of material a valuable resource that should continue to be encouraged.

Table 5. List of planthopper species from states adjacent to PA. Numbers indicate the number of specimen records in the Tri-Trophic TCN plus specimen records from PDA; “L” indicates the species is recorded from the state in literature available (see Bartlett et al. 2014), although no specimen records were; **bold italic numbers** indicate new state records, question mark indicates record doubtful or questioned in literature; “*” is used for official *Lycorma* records not yet documented in literature.

Taxon	DE	MD	NJ	NY	OH	Comment
Acanaloniidae						
<i>Acanalonia bivittata</i> (Say)	50	67	85	100	8	
<i>Acanalonia conica</i> (Say)	197	41	30	23	9	
<i>Acanalonia servillei</i> Spinola		2		L		
Achilidae						
<i>Catonia bicinctura</i> Van Duzee			L		L	
<i>Catonia carolina</i> Metcalf	99	7	6		L	
<i>Catonia cinctifrons</i> (Fitch)	6	1	7	5	1	
<i>Catonia lunata</i> Metcalf		L	L	8	L	
<i>Catonia nava</i> (Say)	11	4	4	L	L	
<i>Catonia picta</i> Van Duzee	11		8	2		
<i>Catonia pini</i> Metcalf			L			
<i>Catonia pumila</i> Van Duzee	L	2	3	2	1	
<i>Cixidia brittoni</i> (Metcalf)				1		
<i>Cixidia colorata</i> (Van Duzee)				1		
<i>Cixidia confusa</i> (Beirne)			2	2		
<i>Cixidia fusca</i> (Walker)	1	1	5	4		
<i>Cixidia opaca</i> (Say)	1	5	2	1		
<i>Cixidia pallida</i> (Say)			1	L		
<i>Cixidia septentrionalis</i> (Provancher)			L	5		
<i>Cixidia slossonae</i> (Van Duzee)			2	3		
<i>Cixidia variegata</i> (Van Duzee)	1	L	4	6	L	
<i>Syneccoche dimidiata</i> (Van Duzee)		1	2	12	L	
<i>Syneccoche grisea</i> (Van Duzee)		1		3	L	
<i>Syneccoche impunctata</i> (Fitch)	2	2	8	4	2	
Caliscelidae						
<i>Aphelonema</i> (A.) <i>decorata</i> (Van Duzee)			L			
<i>Aphelonema</i> (A.) <i>simplex</i> Uhler	55	L	5		L	
<i>Aphelonema</i> (Nenema) <i>histrionica</i> (Stål)		2		2		
<i>Aphelonema</i> (Nenema) <i>rugose</i> (Ball)		L?	3			
<i>Bruchomorpha jocosa</i> Stål			4			
<i>Bruchomorpha oculata</i> Newman	62	78	5	14	3	
<i>Bruchomorpha pallidipes</i> Stål	L	1	5	1	2	
<i>Bruchomorpha tristis</i> Stål			L	L	L	
<i>Fitchiella robertsonii</i> (Fitch)		L		L	L	
Cixiidae						
<i>Bothriocera cognita</i> Caldwell	48	1	15			

Taxon	DE	MD	NJ	NY	OH	Comment
<i>Bothriocera drakei</i> Metcalf	4	L		1	L	
<i>Bothriocera maculata</i> Caldwell	1	L	L			
<i>Cixius angustatus</i> Caldwell	L	1			L	
<i>Cixius apicalis</i> Metcalf				L	L	
<i>Cixius caldwelli</i> Kramer					L	
<i>Cixius coloepeum</i> Fitch		2	9	7	L	
<i>Cixius misellus</i> Van Duzee			1	17	L	
<i>Cixius nervosus</i> (Linnaeus)	46	4	1	30	5	
<i>Cixius nike</i> Kramer				5	L	
<i>Cixius pini</i> Fitch	1	29	L	1	L	
<i>Cixius prodotes</i> Kramer					L	
<i>Cixius quebecensis</i> Beirne				L		
<i>Cixius stigmatus</i> (Say)			L	2	L	
<i>Haplaxius enotatus</i> (Van Duzee)		L				
<i>Haplaxius fulvus</i> (Osborn)				L	L	
<i>Haplaxius glyphis</i> (Kramer)				L		
<i>Haplaxius ovatus</i> (Ball)	4	L	L			
<i>Haplaxius pictifrons</i> (Stål)	183	3	3	4	L	
<i>Haplaxius pusillus</i> (Van Duzee)			L			
<i>Haplaxius radialis</i> (Osborn)	8	31		L	L	
<i>Haplaxius wheeleri</i> (Wilson)			L			
<i>Haplaxius xyron</i> (Kramer)				L		
<i>Melanoliarius aridus</i> (Ball)					L	
<i>Melanoliarius chuliotus</i> (Ball)	1				L	
<i>Melanoliarius ecologus</i> (Caldwell)	78	4	1		L	
<i>Melanoliarius humilis</i> (Say)	L	L	7	1	L	
<i>Melanoliarius montanus</i> (Metcalf)	1	L	L	L	L	
<i>Melanoliarius placitus</i> (Van Duzee)	332	25	5	L	L	
<i>Melanoliarius quinquelineatus</i> (Say)	15	1	7	11	L	
<i>Melanoliarius sablensis</i> (Caldwell)	5	1	L	L	L	
<i>Oecleus borealis</i> Van Duzee	2	6	4	7	L	
<i>Oecleus productus</i> Metcalf	L	L				
<i>Pentastiridius cinnamomeus</i> (Provancher)	L		2	1		
<i>Pintalia delicata</i> (Fowler)		L				
<i>Pintalia vibex</i> Kramer	2					
Delphacidae						
<i>Bakerella bullata</i> Beamer		1				
<i>Bakerella cornigera</i> Beamer	9					
<i>Bakerella muscotana</i> Beamer				1		
<i>Bakerella penefusca</i> Beamer			2			

Taxon	DE	MD	NJ	NY	OH	Comment
<i>Copicerus irroratus</i> Swartz	L	17			1	
<i>Criomorphus inconspicuus</i> (Uhler)			L	L?		
<i>Delphacodes acuministyla</i> Dozier	20	2	9			
<i>Delphacodes balli</i> Muir and Giffard					1	
<i>Delphacodes caerulea</i> Beamer	4					
<i>Delphacodes mcateeii</i> Muir and Giffard	5	1	2			
<i>Delphacodes nigripennata</i> Beamer	2					
<i>Delphacodes penepuella</i> Beamer				L		
<i>Delphacodes puella</i> (Van Duzee)	759	550	308	12	20	
<i>Delphacodes recurvata</i> Beamer	49	1	3			
<i>Delphacodes shermani</i> (Metcalf)		23				
<i>Delphacodes trimaculata</i> Beamer		1				
<i>Delphacodes truncata</i> Beamer	2	1				
<i>Elachodelphax (Aschedelphax) bifida</i> (Beamer)				L		
<i>Elachodelphax (Aschedelphax) borealis</i> Hamilton				L		
<i>Elachodelphax (Aschedelphax) paransera</i> (Beamer)				1		
<i>Falcotoya sagae</i> (Beamer)		L		1		
<i>Flavoclypeus andromedus</i> (Van Duzee)	77	198	18		L	
<i>Flavoclypeus nitens</i> (Muir and Giffard)	9	23	2	1	1	
<i>Isodelphax basivitta</i> (Van Duzee)	250	10	41	4	L	
<i>Isodelphax nigradorsum</i> (Crawford)		2	2	1	L	
<i>Javesella atrata</i> (Osborn)	2			L	2	
<i>Javesella dolera</i> (Spooner)				1		
<i>Javesella incerta</i> (Van Duzee)				1	L	
<i>Javesella opaca</i> (Beamer)				L		
<i>Javesella pellucida</i> (Fabricius)	28	1	L	8	3	
<i>Kelisia axialis</i> Van Duzee		2	L	1	1	
<i>Kelisia curvata</i> Beamer	6	3	1		1	
<i>Kelisia flava</i> Beamer	100	L	2	2		
<i>Kelisia pectinata</i> Beamer	8		2			
<i>Kelisia spinosa</i> Beamer	3					
<i>Kelisia vesiculata</i> Beamer			1			
<i>Keyflana hasta</i> Beamer		1				
<i>Kosswigianella analis</i> (Crawford)				1		
<i>Kosswigianella lutulenta</i> (Van Duzee)	173	240	9	42	6	
<i>Kosswigianella perusta</i> (Beamer)		5		5	L	
<i>Laccocera</i> sp.				5		<i>L. vittipennis</i> Van Duzee previously reported from NY

Taxon	DE	MD	NJ	NY	OH	Comment
<i>Liburniella ornata</i> (Stål)	219	192	51	28	16	
<i>Megamelus bifidus</i> Beamer				42		
<i>Megamelus davisi</i> Van Duzee	40	6	42	5	86	
<i>Megamelus distinctus</i> Metcalf				4	5	
<i>Megamelus falcatus</i> Beamer				1		
<i>Megamelus flavus</i> Crawford				1		
<i>Megamelus hamatus</i> Beamer	1	L				
<i>Megamelus inflatus</i> Metcalf				L		
<i>Megamelus lobatus</i> Beamer	12	L	1			
<i>Megamelus lunatus</i> Beamer	21			L		
<i>Megamelus metzaria</i> Crawford	1			L		
<i>Megamelus paleatus</i> (Van Duzee)	24			L		
<i>Megamelus unguulatus</i> Beamer	32		1	1		
<i>Metadelphax propinqua</i> (Fieber)	28	9	1	1	L	
<i>Muellerianella laminalis</i> (Van Duzee)	104	27	15	1	2	
<i>Muirodelphax arvensis</i> (Fitch)	92	60	9	40	20	
<i>Muirodelphax atralabis</i> (Beamer)	53	2	3	2		
<i>Muirodelphax luteus</i> (Beamer)	16	3				
<i>Muirodelphax parvulus</i> (Ball)	12	L	1	1		
<i>Neomegamelanus elongatus</i> (Ball)	23	L	22	1		
<i>Neomegamelanus spartini</i> (Osborn)	25	L	14	L	L?	
<i>Nilaparvata</i> sp.	3	1				
<i>Nilaparvata gerhardi</i> (Metcalf)	L		L			
<i>Nilaparvata wolcottii</i> Muir and Giffard	25	2	2			
<i>Nothodelphax foveata</i> (Van Duzee)			L	3	L	
<i>Nothodelphax lineatipes</i> (Van Duzee)	27	7	25	4	1	
<i>Nothodelphax serrata</i> (Beamer)				1		
<i>Nothodelphax slossonae</i> (Ball)	23		3			
<i>Paraliburnia kilmani</i> (Van Duzee)		19		L	L	
<i>Pareuidella weedi</i> (Van Duzee)	11		1	4		
<i>Penepissonotus bicolor</i> Beamer	23	L				
<i>Pentagramma bivittata</i> Crawford					L	
<i>Pentagramma douglasensis</i> Penner				L	1	
<i>Pentagramma vittatifrons</i> (Uhler)	72	L	11	1	L	
<i>Peregrinus maidis</i> (Ashmead)	20		1	1	L	
<i>Phyllodinus nervatus</i> Van Duzee	33	10		2	L	
<i>Pissonotus albovenosus</i> Osborn	38	L	L	1		
<i>Pissonotus aphidioides</i> Van Duzee	2	L	1	L	L	
<i>Pissonotus basalis</i> Van Duzee	L		1	4	L	
<i>Pissonotus binotatus</i> Spooner	49	9	31			

Taxon	DE	MD	NJ	NY	OH	Comment
<i>Pissonotus brunneus</i> Van Duzee	76	41	34	19	1	
<i>Pissonotus concolor</i> Bartlett				L		
<i>Pissonotus delicatus</i> Van Duzee			1	L	L	
<i>Pissonotus divergens</i> Bartlett	52	150				
<i>Pissonotus dorsalis</i> Van Duzee		L		2	L	
<i>Pissonotus flabellatus</i> (Ball)	11	21	2	5	2	
<i>Pissonotus guttatus</i> Spooner	4	2		2	L	
<i>Pissonotus marginatus</i> Van Duzee	10	20	1	6	L	
<i>Pissonotus niger</i> Morgan and Beamer		5		2		
<i>Pissonotus piceus</i> (Van Duzee)	189	12	8	7	L	
<i>Pissonotus radiolus</i> Bartlett			2			
<i>Pissonotus spooneri</i> Morgan and Beamer				2	L	
<i>Pissonotus tumidus</i> Morgan and Beamer		2		1		
<i>Prokelisia crocea</i> (Van Duzee)	51		L	L	L	
<i>Prokelisia dolus</i> Wilson	103	17	16	2		
<i>Prokelisia marginata</i> (Van Duzee)	180	8	63	28		
<i>Ribautodelphax pusilla</i> Emeljanov	125			3		
<i>Saccharosydne saccharivora</i> (Westwood)		8				
<i>Sogatella kolophon</i> (Kirkaldy)	6	21	2	1		
<i>Spartidelphax detectus</i> (Van Duzee)	139	10	61	1	3	
<i>Spartidelphax penedetectus</i> (Beamer)			L			
<i>Stenocranus (Codex) brunneus</i> Beamer	12	4				
<i>Stenocranus (Codex) delicatus</i> Beamer	1		5		11	
<i>Stenocranus (Codex) dorsalis</i> (Fitch)		L	10	2	L	
<i>Stenocranus (Codex) lautus</i> Van Duzee	216	26	27	2	10	
<i>Stenocranus (Codex) vittatus</i> (Stål)		4				
<i>Stenocranus (Stenocranus) felti</i> Van Duzee			2	5		
<i>Stobaera pallida</i> Osborn	33	3	16	2		
<i>Stobaera tricarinata</i> (Say)	11	10	10	6	3	
<i>Syndelphax alexanderi</i> (Metcalf)	38	10	55			
<i>Syndelphax fulvidorsum</i> (Metcalf)	1					
<i>Tumidagena minuta</i> McDermott	22	L	5	L		
<i>Yukonodelphax bifurca</i> (Beamer)	2					
Derbidae						
<i>Anotia bonnetii</i> Kirby			L	L	L	
<i>Anotia burnetii</i> Fitch				L		
<i>Anotia kirkaldyi</i> Ball	10	8			2	
<i>Anotia robertsonii</i> Fitch	10	6	L			
<i>Anotia uhleri</i> (Van Duzee)				1	L	
<i>Anotia westwoodi</i> Fitch	7	L	L	2	L	

Taxon	DE	MD	NJ	NY	OH	Comment
<i>Apache degeeri</i> (Kirby)	32	3	7	5	3	
<i>Cedusa bedusa</i> McAtee					L	
<i>Cedusa carolinensis</i> Flynn and Kramer	L	L				
<i>Cedusa cedusa</i> McAtee	11	L		L	L	
<i>Cedusa chuluota</i> Ball			L			
<i>Cedusa edentula</i> (Van Duzee)		2	L		L	
<i>Cedusa gedusa</i> McAtee		L	L	1		
<i>Cedusa hedusa</i> McAtee		L		1	L	
<i>Cedusa incisa</i> (Metcalf)		13	L	2	1	
<i>Cedusa kedusa</i> McAtee	21	5	L		1	
<i>Cedusa maculata</i> (Van Duzee)		L	1	L	1	
<i>Cedusa mallochi</i> McAtee	L	L			L	
<i>Cedusa obscura</i> (Ball)		L	5	1		
<i>Cedusa olseni</i> Flynn and Kramer				L		
<i>Cedusa redusa</i> McAtee	13	L				
<i>Cedusa shawi</i> Flynn and Kramer		L				
<i>Cedusa vulgaris</i> (Fitch)	1	1	6	13	1	
<i>Neocenchrea heidemanni</i> (Ball)	3	1	L		L	
<i>Omolicna mcateei</i> (Dozier)	2					
<i>Omolicna uhleri</i> (Ball)	3	1	2	1	L	
<i>Otiocerus abbotii</i> Kirby				2	L	
<i>Otiocerus amyotii</i> Fitch			L	11	1	
<i>Otiocerus coquebertii</i> Kirby	2	L	L	5	L	
<i>Otiocerus coquebertii</i> var. <i>rubidus</i> Osborn				1	L	
<i>Otiocerus francilloni</i> Kirby	1		L	L	L	
<i>Otiocerus kirbyii</i> Fitch	1	1	1	L		
<i>Otiocerus reaumurii</i> Kirby	2			L	L	
<i>Otiocerus stollii</i> Kirby	L		1	5	L	
<i>Otiocerus wolffi</i> Kirby	12	2	L	3	2	
<i>Patara vanduzeei</i> Ball	4	1	1	1	L	
<i>Sayiana sayi</i> (Ball)				L		
<i>Shellenius balli</i> (McAtee)		1			L	
<i>Sikaiana harti</i> (Metcalf)	1	2				
Dictyopharidae						
<i>Mitrops dioxys</i> (Walker)		L	L			
<i>Phylloscelis atra</i> Germar		L	L	1	1	
<i>Phylloscelis pallescens</i> Germar		1	24	L	L	
<i>Phylloscelis rubra</i> Ball			24	L		
<i>Rhynchomitra lingula</i> (Van Duzee)	21	6	15	5		
<i>Rhynchomitra microrhina</i> (Walker)	56	6	5	48		

Taxon	DE	MD	NJ	NY	OH	Comment
<i>Scolops angustatus</i> Uhler	8	4	4	17	2	
<i>Scolops perdix</i> Uhler	6	L	14	8	L	
<i>Scolops pungens</i> (Germar)	1	L	24	L	1	
<i>Scolops sulcipes</i> (Say)	91	58	31	84	9	
Flatidae						
<i>Flatormenis proxima</i> (Walker)	158	75	128	79	15	
<i>Metcalfa pruinosa</i> (Say)	74	66	66	94	15	
<i>Ormenoides venusta</i> (Melichar)	51	21	12		4	
Fulgoridae						
<i>Cyrpoptus belfragei</i> Stål	7	1			L	
<i>Lycorma delicatula</i> (White)	*		*	*		Reported
<i>Poblicia fuliginosa</i> (Oliver)		1			L	
Issidae						
<i>Thionia bullata</i> (Say)	3	19	5	7	1	
<i>Thionia elliptica</i> (Germar)		3	L		L	
<i>Thionia simplex</i> (Germar)	27	15	2		L	
Sum specimens	5684	2447	1590	1028	288	
Count of species	138	147	145	162	126	

Table 6. Pennsylvania planthopper specimen numbers by family (excluding Fulgoridae) and reported collecting method. The 'Light' column combines all light collecting methods (e.g., mercury vapor, UV light, light trap, blacklight); N indicates number of specimens, including those for which collection method was not specified.

	N	Light	Beat	Fog	Hand coll.	Malaise Trap	Sweep	Vac.	PDA samples		Pitfall	Pan trap
									Funnel Trap	Panel Trap		
Acanaloniidae	745	5				3	22		597	12	2	
Achilidae	461	52	2			23			282	22	1	10
Caliscelidae	73						14		1		2	6
Cixiidae	781	1	1	1		7	6		673	10		1
Delphacidae	1198	48	5		2		614	30	8		17	21
Derbidae	224	9	1		1	3	17		50	48		1
Dictyopharidae	223						27		2		3	3
Flatidae	794	26			1	7	15		291	18		
Issidae	518				1	2	2		403	16		
Total	5017	141	9	1	5	45	717	30	2307	126	25	42
Diversity genera: species	51:117	19:23	5:5	1:1	4:4	10:11	31:45	6:6	27:51	9:13	9:13	6:11

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Appendix 1

Pennsylvania county abbreviations used in Table 4.

County	Codon
Adams	ADM
Allegheny	ALL
Armstrong	ARM
Beaver	BVR
Bedford	BED
Bradford	BFD
Berks	BRK
Blair	BLR
Bucks	BUK
Butler	BUT
Cambria	CAM
Cameron	CMN
Carbon	CAR
Centre	CEN
Chester	CHR
Clarion	CLR
Clearfield	CLF
Clinton	CNT
Columbia	COL
Crawford	CWD
Cumberland	CUM
Dauphin	DAU
Delaware	DEL

County	Codon
Elk	ELK
Erie	ERE
Fayette	FAY
Franklin	FKN
Forest	FOR
Fulton	FUL
Greene	GRN
Huntingdon	HUN
Indiana	IND
Jefferson	JEF
Juniata	JUN
Lackawanna	LKW
Lancaster	LNC
Lawrence	LAW
Lebanon	LEB
Lehigh	LEH
Luzerne	LUZ
Lycoming	LYC
McKean	MCK
Mercer	MER
Mifflin	MIF
Monroe	MRO
Montgomery	MGY

County	Codon
Montour	MTR
Northampton	NHM
Northumberland	NUM
Perry	PER
Philadelphia	PHL
Pike	PIK
Potter	POT
Schuylkill	SUK
Snyder	SNY
Somerset	SOM
Sullivan	SUL
Susquehanna	SUQ
Tioga	TIO
Union	UNN
Venango	VEN
Warren	WAR
Washington	WAS
Wayne	WAY
Westmoreland	WML
Wyoming	WYM
York	YRK

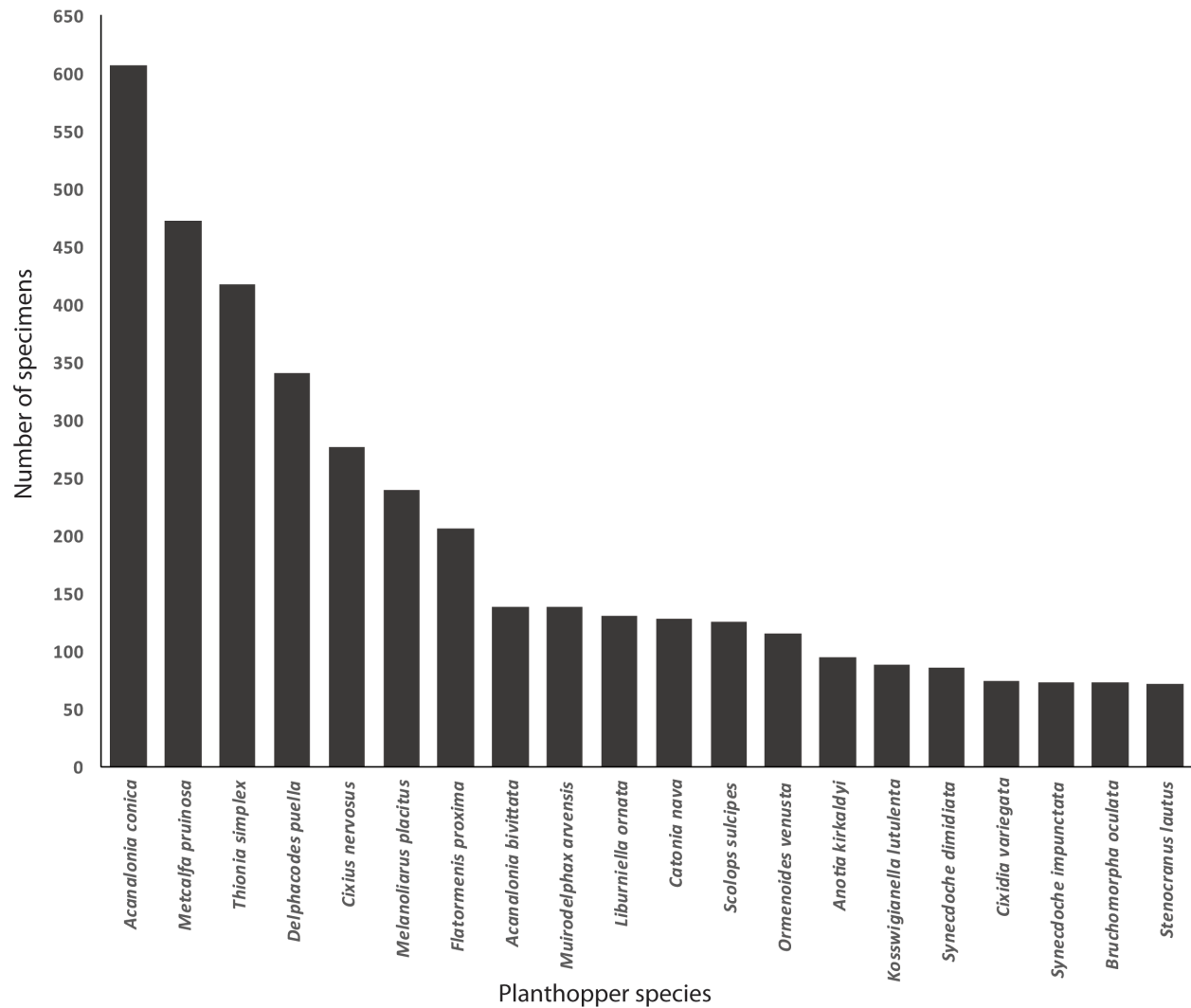


Figure 1. Most abundant 20 planthopper species for Pennsylvania (excluding *Lycorma delicatula*) based on tally of specimens.

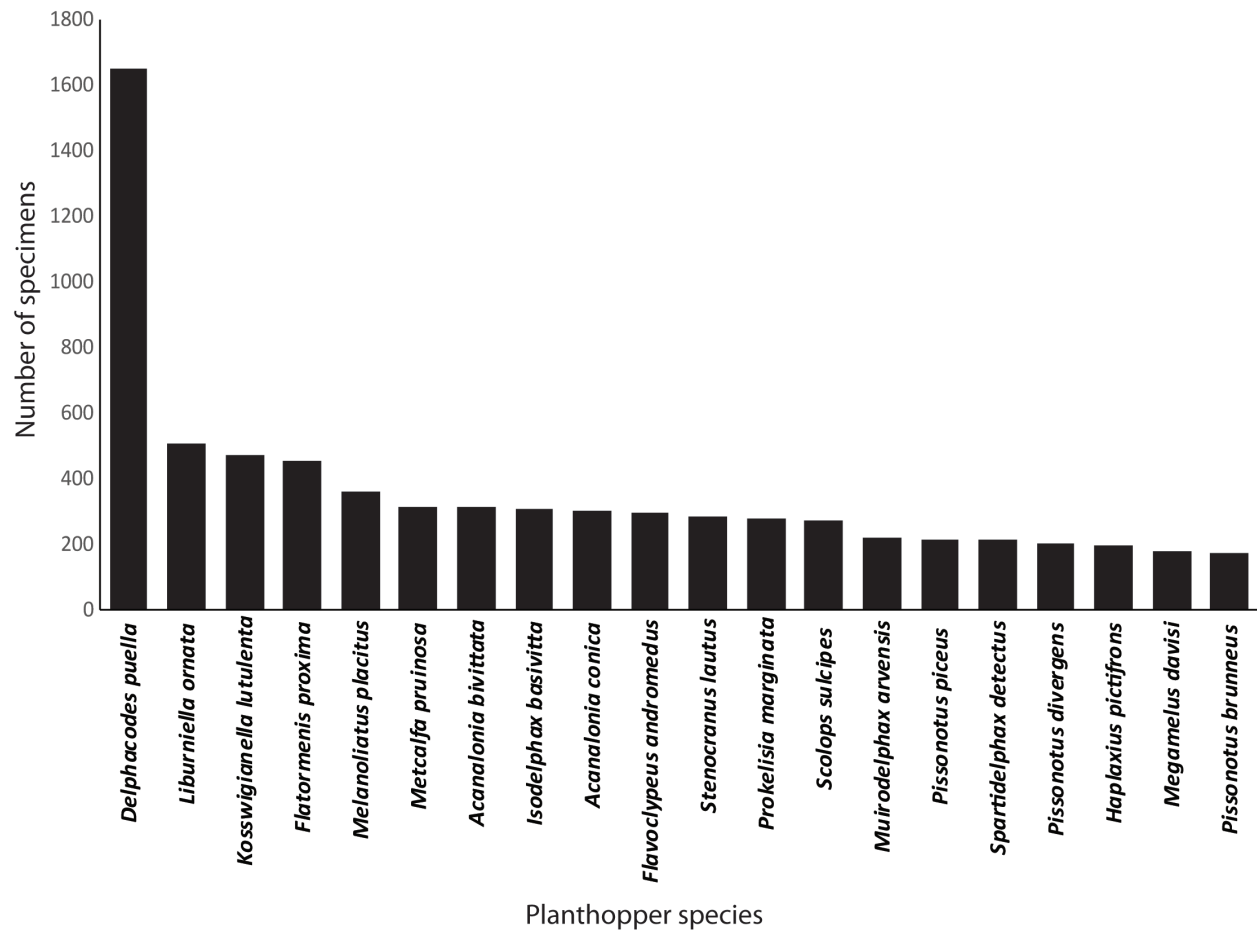


Figure 2. Most abundant 20 planthopper species for states adjacent to Pennsylvania based on tally of specimens.

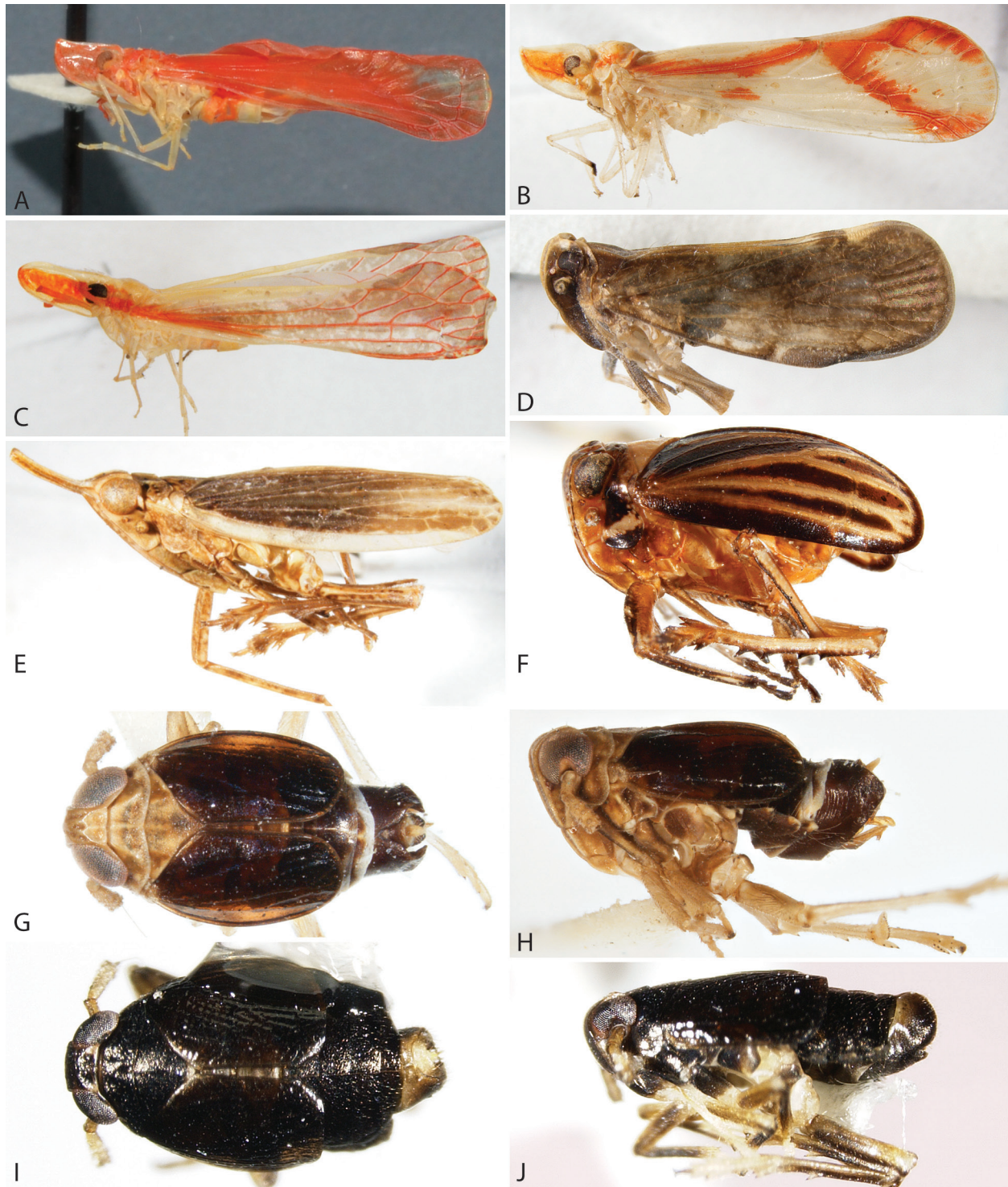


Figure 3. Habitus of planthopper species. **A)** *Otiocerus coquebertii* var. *rubidus* Osborn. **B)** *Otiocerus coquebertii* Kirby. **C)** *Shellenius ballii* (McAtee). **D)** *Pintalia vibex* Kramer. **E)** *Scolops angustatus* Uhler. **F)** *Phylloscelis atra* Germar. **G-H)** *Delphacodes caerulata* Beamer (Paratype). **I-J)** *Pissonotus divergens* Bartlett.

