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Synopsis of the remarkable family Phloeidae (Hemiptera: Pentatomoidea): species identification, chromatic polymorphism and updated distribution

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ABSTRACT

The Neotropical family Phloeidae includes three species within two genera, *Phloea* Lepeletier and Serville, 1825 and *Phloeophana* Kirkaldy, 1908, distributed in South America. Due to their large size and notable morphological features, such as cryptic colouration, extreme body flattening and lateral expansions around the body, these insects became known as Neotropical bark bugs. These characteristics also make them easily recognisable; nonetheless, the correct identification of the species is still tricky, even more so for the nymphs. In this work, we clarify the identity of the species, present new diagnoses for the family, both genera and all species, and provide an updated identification key to both adults and nymphs of the three species. We also describe and illustrate chromatic variation in *Phloea subquadrata* Spinola, 1837, and high-resolution photos of the three species and important diagnostic characters are provided. Literature information is synthesised and updated, and an exhaustive synonymic list is provided for the three species, including two nomenclatural corrections: *Phloeocoris paradoxus* Burmeister, 1835 is removed from synonymy with *Phloeophana longirostris* (Spinola, 1837) and considered a new junior synonym of *Phloea corticata* (Drury, 1773); and *Phlaea paradoxa* Signoret, 1863 is removed from synonymy with *Phloea corticata* and considered a new junior synonym of *Phloeophana longirostris*. Lastly, we review the distribution of the species based on collection specimens and citizen science data and, for the first time, present distribution maps for the three species of Phloeidae.

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Citizen science; colour variation; cryptic colouration; iNaturalist; Neotropical bark bugs; Neotropical Heteroptera

Introduction

The family Phloeidae is a remarkable group of true bugs (Hemiptera: Heteroptera) known as Neotropical bark bugs (Salomão and Vasconcellos-Neto 2010) due to their extremely flattened body, their cryptic colouration and the lateral foliaceous expansions in the mandibular plates, pronotum, hemelytra and abdominal segments. The eyes are divided into dorsal and ventral sections, separated by an annulus without ommatidia (Figure 17, black arrow). These characteristics allow these bugs to camouflage themselves in the bark of the trees where they live (Rider *et al*. 2018). Interesting ecological features presented by

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the phloeids include gregarious behaviour in *Phloea*, maternal care (with females covering the eggs and carrying the nymphs in the abdominal venter during the first instars) (Brien 1930; Hussey 1934; Guilbert 2003), and the liquid 'jets' secreted by the adults (de Magalhães 1909; Leston 1953; Rider *et al*. 2018; Schuh and Weirauch 2020), possibly for elimination of excessive water from continuous feeding (Salomão *et al*. 2012). These characteristics resulted in several studies concerning chemical (da Fonseca *et al*. 2016, 2017), developmental (Bernardes *et al*. 2005) and ecological (Guilbert 2003; Salomão and Vasconcellos-Neto 2010) data in the last several decades.

The phloeids have long been recognised as a suprageneric assemblage of species, dating back to Amyot and Serville (1843), under the name 'Phléides'. At that time, these authors also included the cryptic genus *Coriplatus* White, currently recognised in Pentatomidae: Discocephalini. More than a century later, Leston (1953) discussed the characteristics of the group, supporting it as a family group in Pentatomoidea, a classification recognised by other previous authors (eg Stål 1872; China 1933). Phloeids share the following synapomorphies with other pentatomoids (Grazia *et al*. 2008): long scutellum, claval commissure obsolete with claval apices close but not contiguous, paired abdominal trichobothria on urosternites II–VII, and tergite VIII covering IX in females. Leston (1953) discussed several characters which 'together, are sufficient to warrant family status for the group . . . ' (p. 131): general body shape, three-segmented antennae (Figure 15), eyes divided into two parts (Figure 17), visible 2nd abdominal spiracle, and the unique male genitalia with complete 8th segment. Despite their acceptance as a pentatomoid, the composition of Phloeidae and their phylogenetic relationships are still part of an ongoing debate (Bianchi *et al*. 2021; Roca-Cusachs *et al*. 2022).

The number of species included in the family has changed in the past 100 years (Rider *et al*. 2018). Traditionally, three species included in two genera were considered: *Phloea corticata*, *Phloea subquadrata* and *Phloeophana longirostris*. Distant (1906), whilst describing the monotypic genus *Serbana* Distant, 1906, placed it in the Phloeinae (= Phloeidae), a classification followed by some authors (eg Kirkaldy 1909, 1913; da Costa-Lima 1940; Schwertner and Grazia 2015) and supported by Grazia *et al*. (2008) (see also Schuh and Weirauch 2020). The only species included in this genus, *Serbana borneensis* Distant, 1906, is endemic to Borneo. However, Leston (1953) presented evidence for the inclusion of *Serbana* within the family Pentatomidae, in the monotypic subfamily Serbaninae (Leston 1953; Lent and Jurberg 1965; Rider *et al*. 2018). More recently, *S. borneensis* was recovered as the sister group of the remaining Pentatomidae (Roca-Cusachs *et al*. 2022), bringing support to the hypothesis of Leston (1953).

Earlier authors (eg Burmeister 1835) raised nomenclatural issues concerning the nomenclature of *Phea. corticata* and *Phna. longirostris*, and generated some confusion afterwards (see Leston 1953). Kirkaldy (1909) introduced another confusion regarding the distribution of *Phloea* (discussed below). More recently, Salomão *et al*. (2012) also raised some doubts about the distribution of *Phloea* when they wrongly attributed the occurrence of both species in Bahia state, Brazil, based on Guilbert (2003). Moreover, distributional data for Phloeidae species is sparse and, in earlier published works (from the eighteenth century to the twentieth) they mainly referred to the country (eg Brazil) and not more precise localities or regions. In recent references, distributions for both genera have been mostly given as Brazil, mainly to the Atlantic Rain Forest (eg Schwertner and Grazia 2015; Rider *et al*. 2018), or more generally as 'restricted to South America' (Schuh

and Weirauch 2020). Historically, however, more restricted, and disjunct, distribution reported the presence of Phloeidae in Argentina (Kirkaldy 1909), Chile (Amyot and Serville 1843) and French Guiana (de Magalhães 1909), but without specific localities. Those represent unconfirmed (Argentina and Chile) or at most casual (French Guiana) records (Lent and Jurberg 1965), and many authors prefer to consider the species restricted to Brazil (Rider *et al*. 2018).

Allied to these problems, the family has not received detailed taxonomic treatment since Lent and Jurberg (1965). They reviewed and redescribed the family and included genera and species. Despite their invaluable contribution, identification of the species can be tricky for those not familiarised with these bugs, mainly due to the cryptic nature of the species. With all these questions in mind, the objectives of this work are to clarify the identity of the species included in Phloeidae, revise the nomenclature and correct nomenclatural mistakes, and update the distribution of the species. We provide the original diagnosis of the family, genera and species, including an updated identification key, which allow the recognition of both adults and nymphs. We also describe chromatic polymorphism in *Phea. subquadrata* individuals, which is reported for the first time in the family. High-resolution photographs of all species and diagnostic characters of the family are provided. Lastly, the distribution of the three species is reviewed and updated using data from collections and citizen science projects, whose contributions are highlighted and discussed. For the first time, distribution maps are presented for all species of Phloeidae.

Materials and methods

Morphological study

The examined specimens are dried, pinned and deposited in the following institutions: Museu de Zoologia, Universidade de São Paulo, São Paulo, Brazil (MZUSP); Museo de La Plata, Buenos Aires, Argentina (MLP). The identity of the species was confirmed through comparisons of external genitalia of both males and females. The pygophores were removed and treated for 24 h with a 10% potassium hydroxide (KOH) solution before dissection, examination and posterior preservation in small vials with glycerine; the whole abdomens of the females were removed, and the female genitalia were dissected after the same treatment; both pregenital and genital segments of the females were stored in small vials with glycerine after examination. Morphological study was carried out using a Nikon SMZ18 stereomicroscope. We follow Tsai *et al*. (2011) for terminology of the general morphology, Grazia *et al*. (2008) in their usage of the term 'foliations' for body expansions, Kment and Vilímová (2010) for the scent efferent system, and Zhou and Rédei (2020) for the female genitalia. Photographs were taken using a coupled Nikon D7200 camera at MZUSP, stacked and processed in the software Adobe Photoshop 2023; photographed specimens are noted with '*' in the examined material; specimens with chromatic variation are also indicated in the examined material with '~' or '^' (see the text for association between pattern and sign). New synonymies are presented as '**syn. n**.'

The type of *Cimex corticatus* Drury, 1773 (= *Phloea corticata*) could not be located in the NHMUK (Natural History Museum, London, UK) collection (Mick Webb, personal communication); furthermore, we could not examine the types of *Phloea longirostris* Spinola, 1837

(= *Phloeophana longirostris*) and *Phloea subquadrata* Spinola, 1837, deposited at the Museo Regionale di Scienze Naturali, Torino, Italia (MRSN), but the original descriptions are sufficient to recognise the species. We examined photos from non-type material deposited at the Bishop Museum, Hawaii, USA (BPBM); Museum für Naturkunde, Berlin, Germany (MfN); and Natural History Museum, London, UK (NHMUK). As these specimens were readily identified from the photos, they are included under the 'material examined' sections. All Phloeidae observations uploaded to the iNaturalist website (https://www.inaturalist.org/) as of 24 May 2023 were surveyed; each record was assessed for identification or confirmation by the first author.

Distribution

Distributional data is presented here from north to south for countries, states/provinces and municipalities/cities of each state/province. Some specimens had no collection labels and are listed as such in the material examined. Additionally, iNaturalist observations examined include the numeric observation code right after the observer nickname; this code can be used to access these observations when typed (or pasted) after the website link https://www.inaturalist.org/observations/. New distributional records are highlighted as '[**new rec.**]'. The distribution map was built using the software QGIS (Qgis.org 2023); we follow the terrestrial ecoregions of Olson *et al*. (2001). Exact geographical coordinates were not available for most of the collection specimens examined or literature data and, in these cases, georeferenced data were estimated based on the centroid of the respective municipalities or localities, obtained from https://www.fallingrain.com/world/ (Falling Rain Software Ltd). All georeferenced data are presented from north to south in Tables 3–5.

Results

A total of 160 specimens were studied, of which 57 were identified as *Phea. corticata* (22♂, 20♀ and 15 nymphs), 91 as *Phea. subquadrata* (32♂, 22♀ and 37 nymphs) and 12 as *Phna. longirostris* (7♂, 4♀, 1 nymph). The number of specimens from iNaturalist observations examined is presented in the respective sections below.

Taxonomy

Family PHLOEIDAE Amyot and Serville, 1843

(Figures 1–17)

Included genera

Phloea Lepeletier and Serville, 1825: 110. Type species: *Phloea cassidoides* Lepeletier and Serville, 1825: 111, by monotypy.

Phloeophana Kirkaldy, 1908: 123. Type species: *Phloeophana longirostris* (Spinola, 1837): 265, by original designation.

Diagnosis

Body strongly flattened; mandibular plates, pronotum, base of hemelytra and abdominal segments III–VII presenting lateral foliaceous expansions (Figures 1–14). Dorsal colouration cryptic, venter dark brown. Antennae three-segmented (Figure 15), mostly covered dorsally by head foliations, segment I straight, segment III curved. Compound eyes divided into dorsal and ventral sections separated by a portion without ommatidia (Figure 17). Rostrum reaching at least base of abdominal segment IV. Scutellum bearing an apical tongue-like lobe reaching at least middle of abdominal segment IV. Ostioles located near lateral margins of metapleura (Figure 16, black arrow). Abdominal trichobothria present in pairs, located laterad of spiracular line on small, yellowish tubercles on segments III–VII. Females bearing an extra pair of foliations on laterotergites VIII (eg Figures 1, 3, 5); in males, segment VIII is receeded within segment VII and presents spiracles.

Distribution

French Guiana (Saint-Laurent-du-Maroni, Cayenne), Brazil (Amapá, Pará, Bahia, Minas Gerais, Espírito Santo, São Paulo, Rio de Janeiro, Paraná, Santa Catarina, Rio Grande do Sul), Argentina (Misiones).

Genus *Phloea* Lepeletier and Serville, 1825 (Figures 1–4, 7–14)

Included species

Phloea corticata (Drury, 1773): 76
Phloea subquadrata Spinola, 1837: 276

Diagnosis

Body foliations in contact with each other (Figures 1–4, 7–14), not bearing setae on outer margins. Foliaceous expansions of head in contact with each other in front of clypeus, presenting one lateral concavity. Eyes not bearing interommatidial sensillae. Rostrum reaching at most base of abdominal segment V (Figures 9, 10). Scutellum triangular, with tongue-like apical lobe reaching middle of abdominal segment IV; scutellum covering a small basal portion of wing membranes. Hemelytral membranes representing about 1/2 of hemelytra length; veins with reticulated pattern at most forming basal cells. In females, expansions of laterotergites VIII do not exceed posteriorly expansions of segment VII (Figures 1, 3, 7, 9).

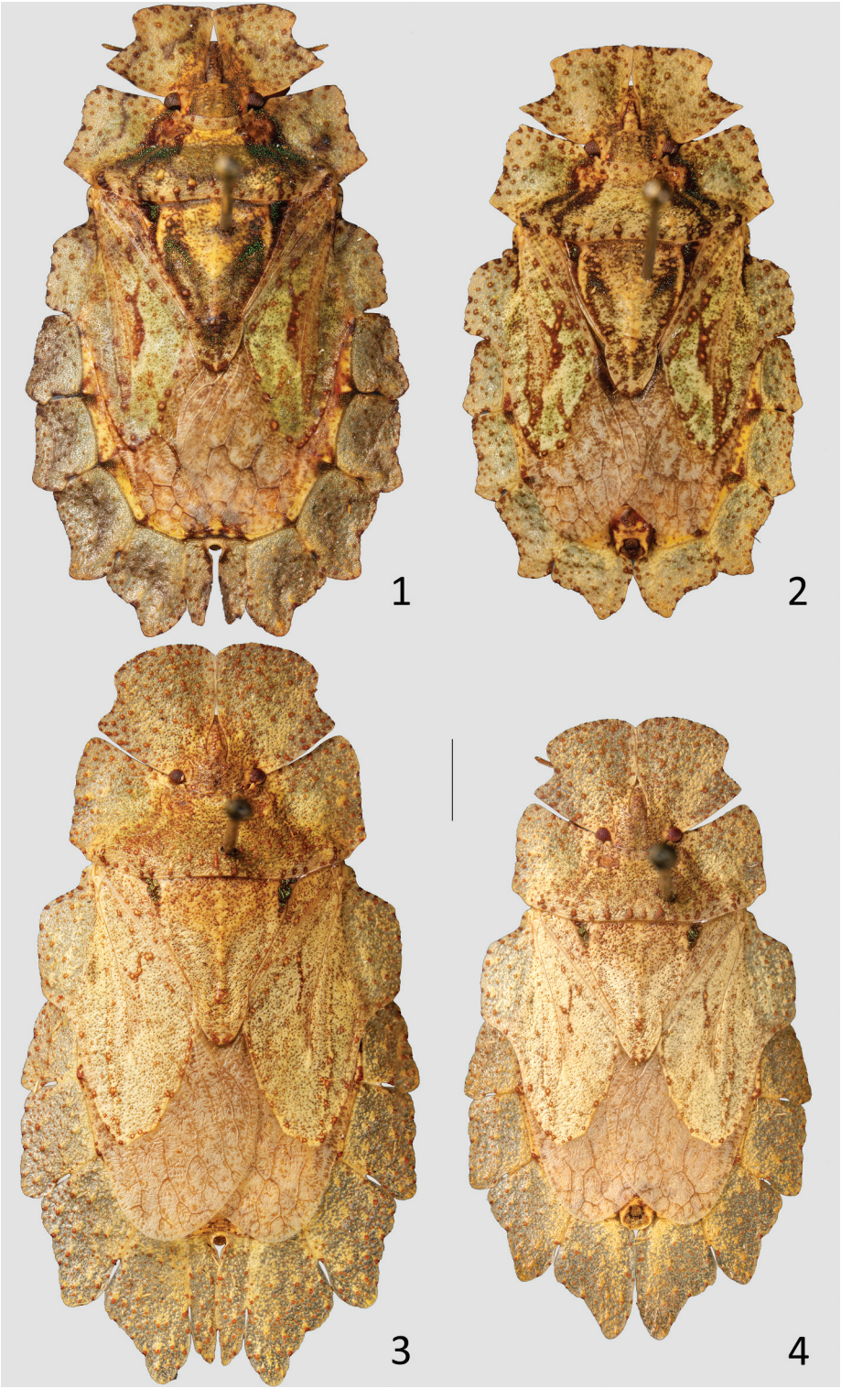
Phloea corticata (Drury, 1773) (Figures 1, 2, 11, 12)

1773 *Cimex Corticatus* Drury: 76, 77, pl. XL, fig. 2

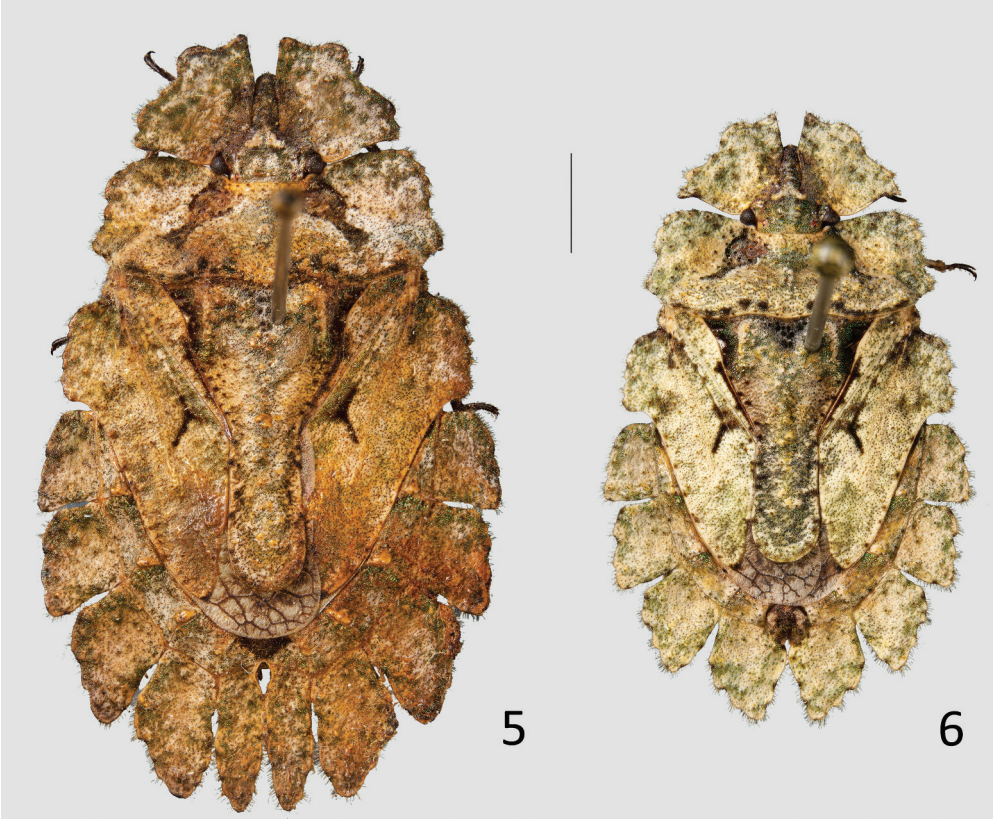
1825 *Phloea cassidoides* Lepeletier and Serville: 111; Spinola 1837: 265, 275, 276; Guérin-Meneville 1838: 345, figs. 5, 5a, 5b

1834 *Paracoris paradoxus* Hahn: 93, 94, pl. LVIII, figs. A–D, 178a, b

1835 *Phloeocoris corticatus* Burmeister: 371, 372



Figures 1–4. Dorsal habitus of *Phloea* spp., adults. (1) *P. corticata*, female; (2) *P. corticata*, male; (3) *P. subquadrata*, female; (4) *P. subquadrata*, male. Scale bar = 3 mm.

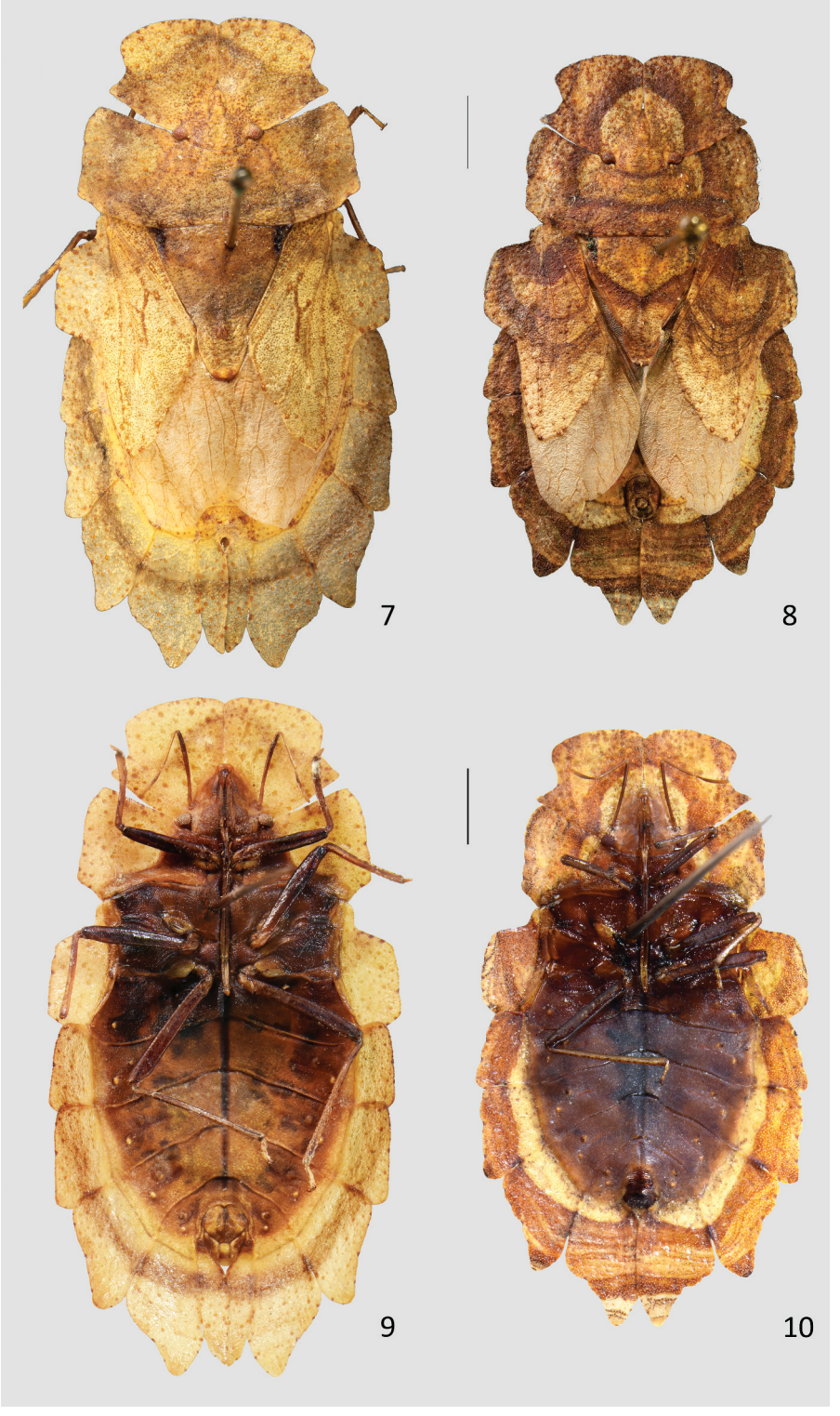


Figures 5, 6. Dorsal habitus of *Phloeophana longirostris*, adults. (5) Female; (6) male. Scale bar = 3 mm.

1835 *Phloeocoris paradoxus* Burmeister: 372. **syn. n.**
1835 *Phloea corticalis* Brullé (1835): 344
1837 *Paracoris paradoxa* Spinola: 265
1840 *Phlaea corticalis* Blanchard (1840): 114
1843 *Phloea corticata* Amyot and Serville: 117, 118; Schiödte 1845: 19; Dallas 1851: 149; Dohrn 1859: 11; Stål 1872: 4; Lethierry and Severin 1893: 82; Breddin 1896: 21; Sharp 1899: 545, fig. 259; von Ihering 1909: 129, 130, fig. B; Kirkaldy 1909: 252; de Magalhães 1909: 238, 239, 257, 258; Brien 1930: 1; da Costa-Lima 1940: 46, fig. 230; Leston 1953: 133, figs. 15, 16; Lent and Jurberg 1965: 123, 132–139, 141, figs. 2, 3, 8, 11, 12, 15, 16, 17, 19–27, 34, 38–40, 47, 48, 53; Schuh and Slater 1995: figs. 74.1A, 74.2E; Guilbert 2003: 61–63, fig. 3; Bernardes *et al*. 2005: 415; Grazia *et al*. 2008: 936, 965, figs. 7f, 11a; Grazia and Schwertner 2011: 716; Grazia *et al*. 2012: 394; Salomão *et al*. 2012: 321–337; Schwertner and Grazia 2015: 825; da Fonseca *et al*. 2016: 1459; Martins *et al*. 2016: 358, fig. 1; Coscarón 2017: 247; da Fonseca *et al*. 2017: 1905; Rider *et al*. 2018: fig. 2.25G; Schuh and Weirauch 2020: 499, fig. 100.1A
1844 *Phloeocoris Cassidoides* Herrich-Schäffer (1844): 38

Diagnosis

Dorsum with many small yellowish tubercles with dark outline; head with many green iridescent punctures between and in front of eyes and in mesial margins of head foliations



Figures 7–10. Chromatic variation of *Phloea subquadrata*, adults. (7) Female, dorsal view; (8) male, dorsal view; (9) female, ventral view; (10) male, ventral view. Scale bars = 3 mm.

(well visible in Figures 11, 12). Pronotum with 2 + 2 distinct dark brown lines, diagonally oriented from posterior part of the eyes to anterolateral angles of hemelytra, each line densely punctuated with green iridescent spots. Scutellum basal angles with 1 + 1 dark fovea and lateral margins lined in black, with iridescent punctures; hemelytra corium mostly greenish, with a Y-shaped dark-brown mark. Anterolateral portion of connexiva with a dark marking and many iridescent spots. Anterior margins of head foliations straight, mesial margins overlapped near apex; anterior pronotal margin almost straight, lateral margins concave and slightly serrated. Hemelytra costa before foliation thin and straight; hemelytral membrane with dark veins forming basal cells. Connexiva visible dorsally when wings are in repose; foliations of laterotergites V–VII laterally serrated and acuminated postero-laterally; foliations of laterotergites VIII in females separated (Figure 1).

Distribution

FRENCH GUIANA. Saint-Laurent-du-Maroni [**new rec.**] (Saül, Maripasoula), Cayenne [**new rec.**] (Régina). **BRAZIL**. Amapá [**new rec.**] (Serra do Navio), Pará, Bahia (Caeté-Açu [**new rec.**], Camamu [**new rec.**], Porto Seguro [**new rec.**]), Minas Gerais (Ibituruna [**new rec.**]), Espírito Santo (Jaguaré, Linhares, Rio Bananal, Domingos Martins [**new rec.**], Cachoeiro de Itapemirim [**new rec.**], Alegre [**new rec.**]), São Paulo (Jundiaí, São Sebastião [**new rec.**], Iporanga [**new rec.**], Cananeia [**new rec.**]), Rio de Janeiro (Itatiaia [**new rec.**], Cachoeiras de Macacu [**new rec.**], Duque de Caxias [**new rec.**], Magé [**new rec.**], Nova Iguaçu [**new rec.**], Rio de Janeiro [originally cited as Guanabara state], Niterói [**new rec.**], Angra dos Reis [**new rec.**]), Paraná (Ponta Grossa [**new rec.**], Morretes [**new rec.**], Paranaguá [**new rec.**]), Santa Catarina (Itapoá [**new rec.**], Joinville [**new rec.**], Navegantes [**new rec.**], Apiúna [**new rec.**], Florianópolis [**new rec.**], Garopaba [**new rec.**]), Rio Grande do Sul [**new rec.**] (São Leopoldo).

Examined material

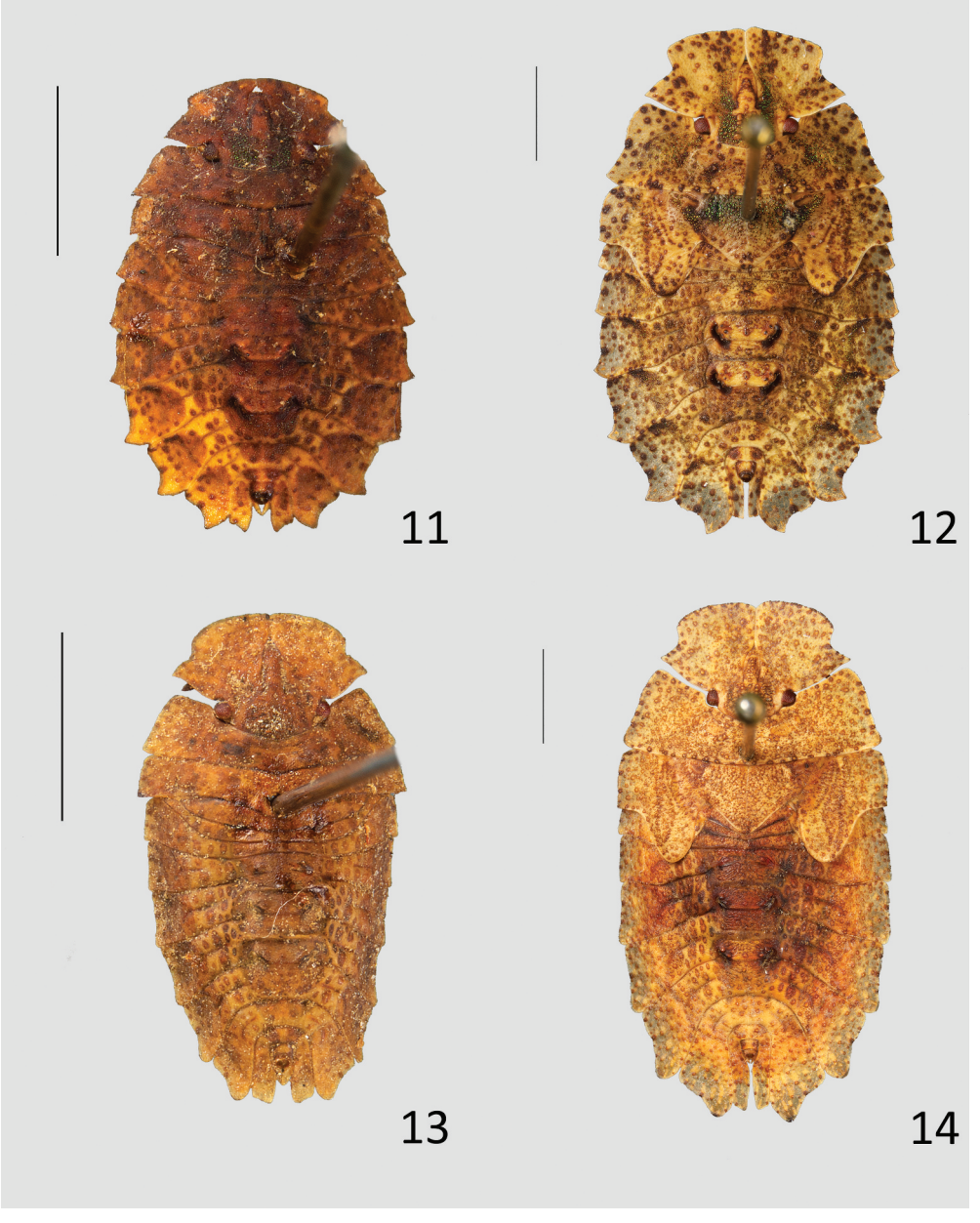
BRAZIL. Amapá: Serra do Navio, August 1959, coll. Bicelli (2♂, 1♀ MZUSP); September 1959, coll. Bicelli (1♂ MZUSP); Serra do Navio, Igarapé Sucurijú, October 1959, coll. Bicelli (1♀ MZUSP). Bahia: Camamu, Barcelos do Sul, 14.032111°S, 39.050250°W, 23 March 2023, colls. V.M. Ghirotto, P.W. Engelking, E.W. Engelking (5♂, 1♀, 4 nymphs MZUSP). Espírito Santo: Alegre, Fazenda Jerusalém, 13 November 1914 (1♂, 1♀ MfN). São Paulo: São Sebastião, 11 March 1982, coll. V. Gomes (1♀ MZUSP); Cananeia, Ilha do Cardoso, 2 March 1993, coll. A. Mesa, E. Zefa, P. Garcia (2♂, 1♀ MZUSP). Rio de Janeiro: Duque de Caxias, Xerém, 7 February 1961, coll. Evangelista (1 nymph* MZUSP); 15 November 1961, coll. Evangelista (1♂, 1♀*, 2 nymphs MZUSP); Nova Iguaçu, Tinguá, November 1969, coll. Zikán (1♂, 1♀ MZUSP); Rio de Janeiro, 29 January 1924, coll. F.X. Williams (3♂, 3♀ BPBM); Rio de Janeiro, Corcovado, October 1965, coll. Alvarenga (1♂* MZUSP); Rio de Janeiro, Santa Teresa, 9 August 1940, coll. Diniz G. Gomes (1♀ MZUSP); Niterói, Praia de Itaipú, 5 February 1961, coll. Evang. Ribeiro and Dirce. Martins (1♂ MZUSP). Paraná: Ponta Grossa, December 1946, coll. J. Junior (1♂, 1♀ MLP); Morretes, 25.352241°S, 48,888329°W, 20 August 2022, coll. E.B. Crispino (1♀ MZUSP). Santa Catarina: Joinville, coll. S.V. Schmalz (1♂, 1♀ MfN). 1♂ labelled as 'Amerika' (MfN). 2♀ labelled as 'Brasilien' (MfN). 1♂, 2♀, 1 nymph labelled as 'Bahia' (MfN). 1 nymph labelled as 'Rio de Janeiro' (MfN). 1♀ labelled as 'Rio' [de Janeiro?] (MfN). 7 nymphs (1*) without labels (MZUSP).

iNaturalist observations

FRENCH GUIANA. Saint-Laurent-du-Maroni: Saül, 18 February 2023, observer 'christian marty', 149774000 (1♂); Maripasoula, Mont Itoupé, zone coeur du Parc Amazonien de Guyane, 12 March 2017, observer 'Sébastien SANT', 68559724 (1♀). Cayenne: Régina, 7 February 2020, observer 'andriusp', 39030520 (1 nymph). **BRAZIL**. Bahia: Caeté-Açu, 2 January 2023, observer 'Shirley Oliveira', 160820431 (4 adults, sex not determined, 10+ nymphs); Porto Seguro, 45810-000 [postal code], 9 March 2023, observer 'Joyce Araújo', 150694382 (1♀). Minas Gerais: Ibituruna, 24 October 2021, observer 'amanda leal', 99289514 (20 nymphs). Espírito Santo: Domingos Martins, 2 February 2023, observer 'Roberto de Oliveira Silva', 148069296 (1♀); Cachoeiro de Itapemirim, 6 October 2022, observer 'Douglas Eduardo Rocha', 137803700 (1♀). São Paulo: São Sebastião, Praia da Jureia, 7 March 2021, observer 'Tamiris Pereira Lima', 70844237 (1♀); Iporanga, 18330-000 [postal code], 3 March 2014, observer 'Ericson Cernawsky Igual', 107906488 (1 nymph). Rio de Janeiro: Itatiaia, 26 April 2010, observer 'Paula Romano', 128373767 (25+ nymphs); Cachoeiras de Macacu, trilha do circuito dos lagos na REGUA, 5 April 2023, observer 'piskomantis', 153559898 (1♂); Cachoeiras de Macacu, Funchal, 6 July 2018, observer 'Bernardo Ferraz', 54323687 (1♂); Magé, Pau Grande, 12 April 2022, observer 'Eric Freitas de Abreu', 111199022 (1♂); Rio de Janeiro, Camorim, 22 October 2020, observer 'Raony de Abreu', 66060718 (1 nymph); Angra dos Reis, 20 December 2009, observer 'edvandroab-reuribeiro', 129489840 (1♂, 1♀); 8 January 2018, observer 'phillipengelking', 54495330 (1♀); 5 February 2018, observer 'Projeto Mantis', 38794384 (1♀); Angra dos Reis, Aventureiro, 18 February 2018, observer 'phillipengelking', 54444869 (1 adult, sex not determined). Paraná: Paranaguá, Raia, 83206-110 [postal code], 12 October 2019, observer 'Leonardo von Linsingen', 68163799 (1♀). Santa Catarina: Itapoá, 2 September 2021, observer 'Allan Clé', 93419586 (1♀); Navegantes, 16 May 2023, observer 'André Ambrozio', 161991785 (28 nymphs); Apiúna, 27 August 2022, observer 'Vanessa Claudino Bitencourt', 155593704 (1♂); Florianópolis, 29 December 2022, observer 'Davi_Ramos', 147714897 (1♀); 21 April 2023, observer 'Lucas Pescador Barcelos', 155918483 (10+ nymphs); Florianópolis, Rua da Lua Cheia, 29 December 2020, observer 'jbugoni', 67277322 (1♂); Garopaba, 14 September 2022, observer 'Nicoly.f.f', 135589553 (1♂).Rio Grande do Sul: São Leopoldo, 93125 [postal code], 25 March 2021, observer 'Romulo Cenci', 72045302 (1♂).

Phloea subquadrata Spinola, 1837
(Figures 3, 4, 7–10, 13, 14)

1837 *Phloea subquadrata* Spinola: 276, 277; Dallas 1851: 149; Dohrn 1859: 11; Stål 1872: 4; Lethierry and Severin 1893: 82; von Ihering 1909: 129, 130, fig. A; Kirkaldy 1909: 252; de Magalhães 1909: 239, 240, 257, 258; Brien 1930: 1; da Costa-Lima 1940: 46; Cott 1940: 97, 323, figs. 41.1–3; Leston 1953: 133, figs. 13, 17, 18; Lent and Jurberg 1965: 123, 125, 139, 140, 141, figs. 4, 5, 9, 13, 14, 18, 24, 25, 35, 36, 41–43, 49, 50, 54; Rolston and McDonald 1979: 190, figs. 3, 22–24; Schuh and Slater 1995: fig. 74.2H; Guilbert 2003: 61–63, figs. 1–3; Bernardes *et al*. 2005: 415–419, figs. 1–13; Grazia *et al*. 2008: 936, 938, figs. 22, 29; Salomão and Vasconcellos-Neto 2010: 1724–1729; Grazia and Schwertner 2011: 708, 716; Grazia *et al*. 2012: 394, fig. 28.96; Salomão *et al*. 2012: 321–337; Schwertner and Grazia 2015: 825, figs. 25.1c, 25.36,



Figures 11–14. Dorsal habitus of *Phloea* spp., nymphs. (11) *P. corticata*, second instar; (12) *P. corticata*, fifth instar; (13) *P. subquadrata*, second instar; (14) *P. subquadrata*, fifth instar. Scale bars = 3 mm.

25.37; da Fonseca *et al*. 2016: 1459–1464; Martins *et al*. 2016: 358; da Fonseca *et al*. 2017: 1905–1910; Musolin and Saulich 2018: 539; Schuh and Weirauch 2020: 498–500, fig. J

1844 *Phloeocoris Subquadrata* Herrich-Schäffer (1844): 38

Diagnosis

Dorsum presenting many small orangish-copper coloured tubercles; head with few green iridescent punctures in front of eyes and near mesial margins of head foliations. Pronotum with 2 + 2 almost indistinguishable lines present, oriented diagonally from posterior part of eyes to anterolateral angles of hemelytra, few scattered small iridescent punctures present on each side. Scutellum with 1 + 1 dark-reddish, iridescent green fovea on basal angles; hemelytra coria concolor with body, with a thin, Y-shaped mark (sometimes barely distinguishable). Anterolateral portions of connexiva without iridescent spots. Anterior margins of head foliations round and convex, mesial margins contiguous right after clypeus; anterior pronotal margin curved anteriorly, pronotal angles rounded and lateral margins slightly undulated or convex. Hemelytra costa before foliations small and rounded; wing membranes with many wrinkle markings, veins highly branched and rarely forming closed cells. At most narrow portions of connexiva are visible when wings are at repose. Body foliations undulated laterally and rounded postero-laterally in segments IV–VII; in females, foliations of laterotergites VIII overlapped (Figures 3, 7, 9).

Chromatic polymorphism

Most individuals (82) presented a pale yellow body colour with many small orangish-copper tubercles scattered irregularly, some regions of body and pronotum a bit darker, and a dark brown venter (Figures 3, 4, 13, 14). Two females (listed with a '~' in the examined material) presented a main body colour similar to the individuals mentioned above, but with a distinct dark, diagonal line in head foliations and a concolorous line in the abdomen foliations encircling the body (Figure 7); dark lines are also visible ventrally (Figure 9). A male (Figure 8) and a female (indicated with a '^' in the examined material) had a darker body colour, with many ring-like patterns (similar to plant growth rings) in different shades of orange and brown extending through head, head foliations, pronotum and, more conspicuously shaped as rings, on hemelytra, scutellum and body foliations; ventrally, ring patterns are also visible in foliations (Figure 10).

Distribution

BRAZIL. Bahia (Itabuna), Minas Gerais (Juiz de Fora [**new rec.**], Itamonte [**new rec.**], Conceição dos Ouros [**new rec.**]), Espírito Santo (Jaguaré, Linhares, Rio Bananal, Alegre [**new rec.**]), São Paulo (Rio Claro [**new rec.**], Anhembi [**new rec.**], Botucatu [**new rec.**], Jundiaí, São Paulo [**new rec.**], Cotia [**new rec.**], Ibiúna [**new rec.**], São Lourenço da Serra [**new rec.**]), Rio de Janeiro (Itatiaia [**new rec.**]), Paraná (Tibagi [**new rec.**], Antonina [**new rec.**], Campina Grande do Sul [**new rec.**], Curitiba [**new rec.**], Guaratuba [**new rec.**]), Santa Catarina [**new rec.**] (Blumenau, Seara, Nova Veneza), Rio Grande do Sul (Mato Castelhano [**new rec.**], São Domingos do Sul [**new rec.**], Cruz Alta [**new rec.**], Viamão). **ARGENTINA** [**new rec.**]. Misiones (San Pedro).

Examined material

BRAZIL. Espírito Santo: Alegre, Fazenda Jerusalém, 4 December 1911, coll. J.F. Zikán (2♂ MfN). São Paulo: Rio Claro, FEENA, 23 June 2016, coll. V.M. Ghirotto (1♀ MZUSP); Anhembi, Fazenda Barreiro Rico, 17–18 June 1989, coll. F. Mello (28 nymphs MZUSP); Botucatu, 10 April 1969, coll. A. Mantovan (8♀ MZUSP); São Paulo, Cidade Universitária, 1958, coll. H. Reichardt (7♂, 1♀, 1 nymph MZUSP); São Paulo, Santo Amaro, Capão Redondo, em

jaboticabeira [host plant], 1 December 1963, coll. L.T. Filho (1♂ MZUSP); São Paulo, Santo Amaro, 19 December 1961, coll. E.X. Rabello (3♂, 3 nymphs (2*) MZUSP); 20 December 1961, coll. E.X. Rabello (1♂, 5♀ (1*) MZUSP); São Paulo, Santo Amaro, em jaboticabeira [host plant], 20 December 1961, coll. E.X. Rabello (10♂ (1*) MZUSP); São Paulo, Santo Amaro, Sítio São Francisco, em jaboticabeira [host plant], 28 November 1965. coll. L.T.F. (3♂ (1*~), 1♀~, 1 nymph MZUSP). Santa Catarina: Blumenau, 3 February 1956, coll. Oleh Gabrusewicz (2♀^ (1*), 2 nymphs MZUSP); Seara, Nova Teutônia, 27.183333°S, 52.383333°W, 27 November 1935, coll. Fritz Plaumann (1♀ MfN). 1♂ labelled as 'Rio de Janeiro' (MfN). 8 specimens without labels (4♂, 3♀, 1 nymph MZUSP).

iNaturalist observations

BRAZIL. Minas Gerais: Juiz de Fora, Jardim Lermitage, 12 October 2021, observer 'Pedro Aguiar', 101743593 (50 nymphs); Itamonte, 37466-000 [postal code], 5 February 2023, observer 'palmas', 148115634 (20 adults, sex not determined, 5 nymphs); Conceição dos Ouros, 37548-000 [postal code], 25 November 2017, observer 'Wilder Gomes', 40834168 (19 nymphs). São Paulo: São Paulo, Granja Julieta, 21 January 2022, observer 'Rodrigo Dios', 105319503 (1♂); São Paulo, Parque do Estado, 2 May 2023, observer 'Bruno Aranda', 159190143 (15 nymphs); São Paulo, 11 April 2022, observer 'amandabignami', 111080334 (4♀); São Paulo, Santo Amaro, 11 July 2021, observer 'Rodrigo Dios', 86575793 (1♂); Cotia, Rua Santo Amaro, 9 July 2021, observer 'victorcastanho', 86351464 (1♂); Ibiúna, 18150-000 [postal code], 20 February 2023, observer 'andré', 152366569 (1♀); São Lourenço da Serra, Despezio, 06890-000 [postal code], 12 October 2019, observer 'Felipe Giani', 65616970 (1♂). Rio de Janeiro: Itatiaia, 18 April 2010, observer 'Paula Romano', 128371970 (21 nymphs). Paraná: Tibagi, 11 December 2021, observer 'Phillip Schuster', 102942958 (3 nymphs); Antonina, 23 October 2017, observer 'David Barros Muniz', 85679169 (1♂); Campina Grande do Sul, 26 June 2021, observer 'Maristela Zamoner', 84727618 (23 adults, sex not determined, 2 nymphs); Curitiba, rua Teodoro Makiolka, 82220-000 [postal code], 26 August 2022, observer 'Leonardo Fogaça', 132394959 (60 nymphs); Curitiba, 19 March 2023, observer 'marinavm', 152855587 (20 nymphs); Curitiba, UFPR – Campus Centro Politécnico, 26 January 2022, observer 'Phillip Schuster', 105642492 (1♀); Curitiba, Boqueirão, 81750-070 [postal code], 26 January 2023, observer 'Adolf Carl Krüger', 147525835 (1♀); Guaratuba, Reserva Bicudinho-do-brejo, 14 December 2013, observer 'Carlos Otávio Gussoni', 37936895 (3♀, 9 nymphs). Santa Catarina: Nova Veneza, 3 December 2018, observer 'João Gava Just', 18816629 (1♂, 1♀). Rio Grande do Sul: Mato Castelhano, 9 September 2021, observer 'Caroline Ribeiro', 94762848 (22 nymphs); São Domingos do Sul, 5 September 2021, observer 'Ricardo Brugnera', 93927958 (4♂, 4♀); São Domingos do Sul, 99270-000 [postal code], 18 April 2019, observer 'Ricardo Brugnera', 63584155 (5♂, 5♀, 38 nymphs); Cruz Alta, 18 December 2021, observer 'Fernando Sessegolo', 103254283 (2 adults in copula, 3♂, 2 adults, sex not determined, 18 + nymphs). **ARGENTINA**. Misiones: San Pedro, 11 April 2021, observer 'DIEGO.J.PALACIOS.R', 102930766 (20+ adults, sex not determined).

Genus *Phloeophana* Kirkaldy, 1908

Included species

Phloeophana longirostris (Spinola, 1837): 265

Diagnosis

Body foliations mostly separated from each other and bearing many setae on outer margins. Foliaceous expansions of head widely separated in front of clypeus, with two large lateral undulations and two smaller ones. Eyes bearing interommatidial sensillae on dorsal section. Rostrum reaching valvifers VIII in females, exceeding base of pygophore in males. Scutellum very long, reaching base of abdominal segment VI, almost attaining apex of coria; scutellum covering almost half of wing membranes. Hemelytral membranes representing no more than 1/4 of hemelytra length and presenting dark veins, which form a reticulated pattern with many closed cells. In females, expansions of laterotergites VIII in contact with each other mesially for 1/3 of its length and exceeding expansions of segment VII.

Phloeophana longirostris (Spinola, 1837) (Figures 5, 6, 15–17)

1837 *Phloea longirostris* Spinola: 265, 276; Dallas 1851: 149, 150; Dohrn 1859: 11; Stål 1872: 4; Lethierry and Severin 1893: 82; Pérez 1904: 429; von Ihering 1909: 130

1843 *Phloea paradoxa* Amyot and Serville: 115, 118; de Magalhães 1909: 239–246, 248–257; Brien 1930: 1–6, figs. I–VI

1844 *Phloeocoris longirostris* Herrich-Schäffer (1844): 38

1863 *Phlaea paradoxa* Signoret: 546. **syn. n.**

Figures 15–17. Diagnostic characters for the family, as seen in *Phloeophana longirostris*. (15) Head, ventral view; (16) evaporatorium, black arrow indicating ostiole; (17) head and pronotum, lateral view, black arrow indicating annulus without ommatidia. Scale bars = 3 mm.

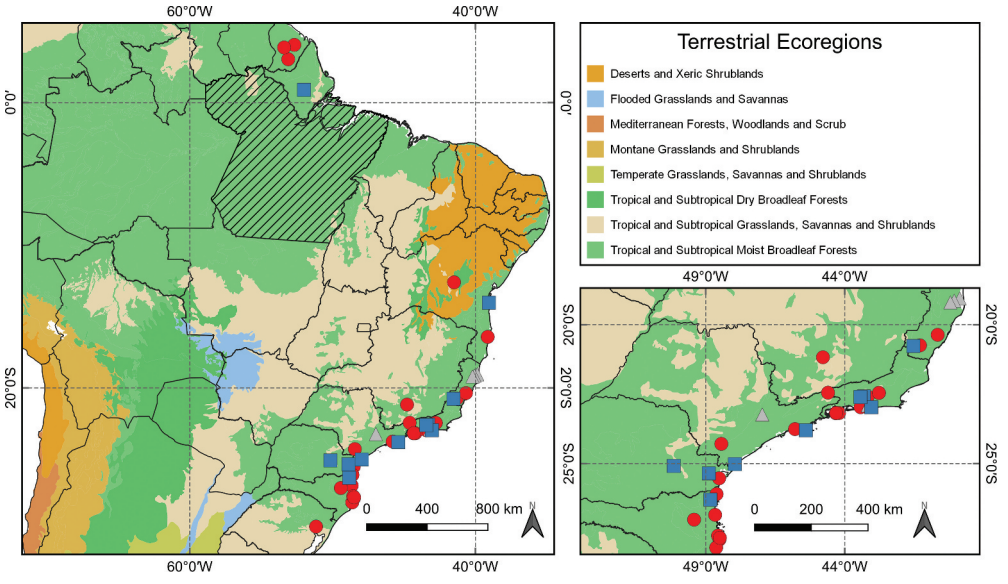


Figure 18. South America map containing distributional data for *Phloea corticata*. The diagonally dashed state (Pará) represents a state-level record. Grey triangles represent records from the literature; blue squares represent collection records; red circles represent iNaturalist records.

1908 *Phloeophana longirostris* Kirkaldy: 123–124; Kirkaldy 1909: 252; Hussey 1934: 140, 142, 143; Leston 1953: 121, 133, figs. 1–12, 14; Lent and Jurberg 1965: 123, 140, 141, figs. 1, 6, 7, 10, 28–33, 37, 44–46, 51, 52, 55; Lent and Jurberg 1966: 1–4, figs. 1–10; Schuh and Slater 1995: figs. 74.1B, 74.2A–D, 74.2F, 74.2G; Guilbert 2003: 61; Bernardes *et al*. 2005: 415, 419; Grazia *et al*. 2008: 936; Grazia and Schwertner 2011: 716; Grazia *et al*. 2012: 394; Salomão *et al*. 2012: 321–337; Schwertner and Grazia 2015: 825, figs. 25.2, 25.35; da Fonseca *et al*. 2016: 1459; Martins *et al*. 2016: 358; da Fonseca *et al*. 2017: 1905–1910; Rider *et al*. 2018: figs. 2.1, 2.16F; Schuh and Weirauch 2020: 498–500, figs. B–I

1935 *Phlaeophana longirostris* Bequaert (1935): 182

1940 *Phloeophana paradoxa* Costa-Lima, 1940: 46, 47, fig. 229

Diagnosis

Many green iridescent punctures present all over dorsum including head, pronotum, scutellum, coria, abdominal tergites and foliations. Whole dorsum bearing setae; long setae visible in lateral margins of foliations and pronotum. Pronotum with two dark marks, one on each side, projected posteriorly and diagonally from eyes, but not reaching posterior margin of pronotum. Dark fovea present on scutellum, each one extending posteriorly along scutellum outer margin. Coria concolor with body, each presenting a dark Y- or more commonly T-shaped mark and a dark line extending into second half of inner clavus margin.

Distribution

BRAZIL. Minas Gerais [**new rec.**] (Nova Lima), Espírito Santo (Linhares), São Paulo (São José dos Campos [**new rec.**], Jundiaí, Araçariguama [**new rec.**], São Paulo), Rio de Janeiro

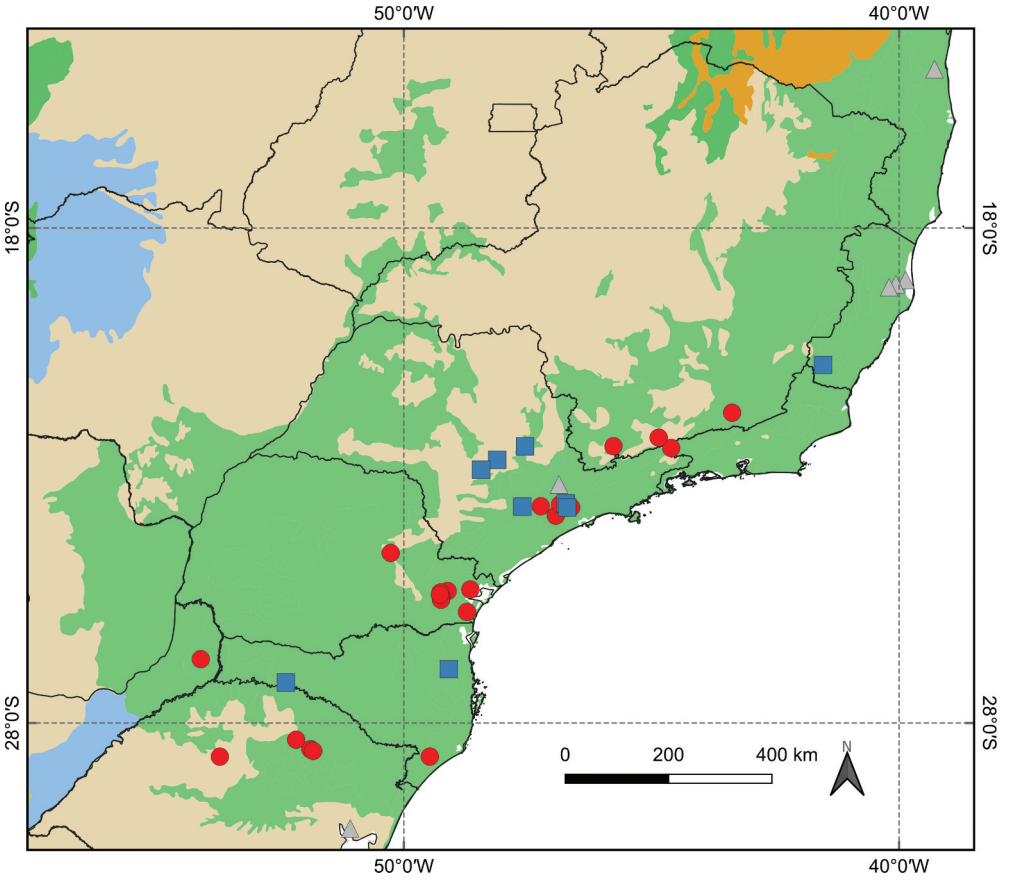


Figure 19. Distributional data of *Phloea subquadrata*. Ecoregions as in Figure 18. Grey triangles represent records from the literature; blue squares represent collection records; red circles represent iNaturalist records.

(Cachoeiras de Macacu [**new rec.**], Rio de Janeiro [as Guanabara state]), Paraná [**new rec.**] (Bituruna), Santa Catarina [**new rec.**] (São Bento do Sul), Rio Grande do Sul [**new rec.**] (Sarandi).

Examined material

BRAZIL. São Paulo: Jundiaí, RBM Serra do Japi, 23.235783°S, 46.9327°W, 3 January 2014, 20h30m, coll. R. Carrenho (2♂ (1*) MZUSP). Santa Catarina: São Bento do Sul, Rio Vermelho, March 1961, coll. Dirings (1♀* MZUSP). 1♂ labelled as 'Brasilien' (MfN), coll. Lhotzky. 1♂ labelled as 'Brasil' (MfN). 1♂, 1 nymph labelled as 'Rio de Janeiro' (MfN). 1♂ labelled as 'St. Cruz' [we were unable to find this locality, possibly in Rio de Janeiro] (MfN). 4 specimens without labels (3♀, 1♂ MZUSP).

iNaturalist observations

BRAZIL. Minas Gerais: Nova Lima, 25 November 2022, observer 'Bruno Bertholino', 149921805 (1♀). São Paulo: São José dos Campos, Jardim Apolo, 12243-150 [postal code], 29 November 2020, observer 'clara_rocha', 65846471 (1♀); Jundiaí,

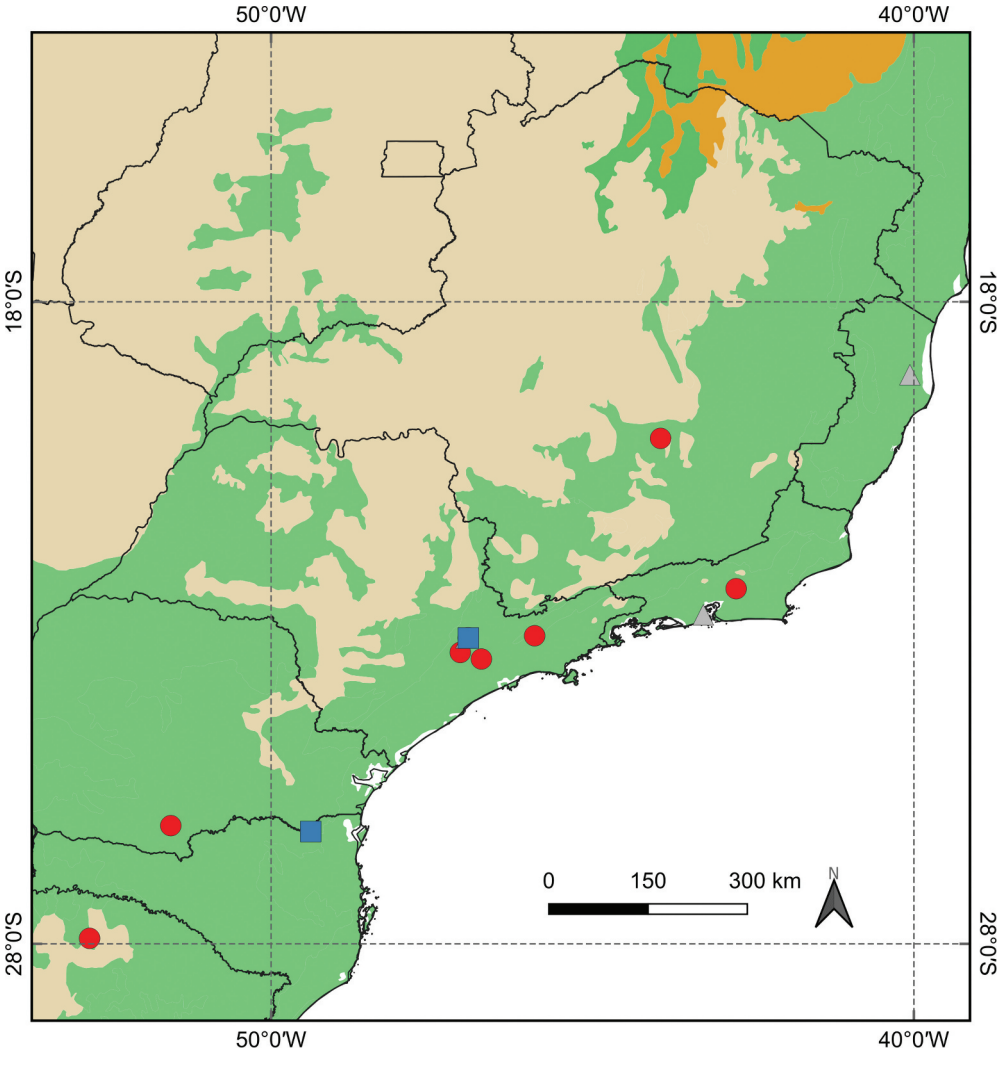


Figure 20. Distributional data of *Phloeophana longirostris*. Ecoregions as in Figure 18. Grey triangles represent records from the literature; blue squares represent collection records; red circles represent iNaturalist records.

26 November 2006, observer 'eneaschr', 100976033 (1 nymph); Araçariguama, 18147-000 [postal code], 6 November 2022, observer 'Tiago Lubiana', 141415102 (1 nymph); São Paulo, Cidade Universitária Armando Salles de Oliveira, 28 April 2023, observer 'José Valério', 157359454 (1♀). Rio de Janeiro: Cachoeiras de Macacu, 28680-000 [postal code], 14 February 2019, observer 'Phil Benstead', 21907432 (1♀). Paraná: Bituruna, 84640-000 [postal code], 18 September 2021, observer 'Joseane Derengoski', 113160386 (1♀). Rio Grande do Sul: Sarandi, 29 December 2021, observer 'Romulo Cenci', 103931645 (1 nymph).

Identification key for adults and nymphs of Phloeidae

1 Whole dorsum presenting many setae; head foliations widely separated from each other and with large undulations; scutellum very long, reaching anterior limit of segment VI; hemelytra membranes small (no more than 1/4 of hemelytra length), partially covered by the scutellum, and with many closed cells; body foliations not contiguous with each other ..... ***Phloeophana longirostris*** **(**Spinola 1837)

- Dorsum not presenting setae; head foliations contiguous or overlapped for some of its extension; scutellum reaching at most middle of segment IV; hemelytra membranes representing around 1/2 of hemelytra length and with basal or no cells at all; body foliations contiguous with each other for at least part of its length 2

2 Body colours generally brighter and darker; body presenting many tubercles with dark outline; anterior margins of head foliations almost straight and overlapped anteriorly; first antennal segment shorter than 2nd and 3rd together; pronotum with two dark, conspicuous lines; scutellum with dark, iridescent fovea and two dark, iridescent markings on the sides; coria presenting dark, Y-shaped marks; wing membranes presenting basal cells; body foliations from segments IV–VII acuminated posteriorly ..... ***Phloea corticata*** **(**Drury 1773)

- Body colours generally lighter, paler (different colour morphs may be found, see Figures 7–10); body presenting many orangish-copper coloured tubercles; head foliations convex anteriorly and contiguous medially; first antennal segment at least as long as 2nd and 3rd together; pronotum with two faint lines; scutellum with dark-reddish iridescent fovea; coria presenting, at most, a faint Y-shaped mark; wing membranes wrinkled and veins largely branching but not forming closed cells; body foliations always rounded posteriorly ..... ***Phloea subquadrata*** Spinola 1837

Discussion

Morphology and species identification

After Lent and Jurberg (1965) the classification and taxonomy of the family did not receive much attention, and only recently have its species been included in phylogenetic studies based in sound methodology (Grazia *et al*. 2008; Roca-Cusachs *et al*. 2022). In this contribution, we provide updated diagnoses and an updated identification key for adults and nymphs based on external morphological features. We also provide tables of morphological characters that allow for the identification of both genera (Table 1) and *Phloea* species (Table 2). Our main objective was to establish diagnoses for the genera and species without ambiguity and make the identification of each of them acessible to anyone, even to untrained eyes. The correct identification of the species is quite possible merely from looking at good photographs, without the need for examination of genitalia.

Nymphs and adults of both species of *Phloea* share many characteristics and, therefore, are distinguishable even in earlier instars: *P. corticata* nymphs (Figures 11, 12) are generally darker in colour and have a wider body than *P. subquadrata* nymphs (Figures 13, 14); *P. corticata* nymphs have the foliations of abdominal segments V–VII postero-laterally

Table 1. Morphological differences between *Phloea* and *Phloeophana*.

Character	*Phloea*	*Phloeophana*
Iridescent punctures, amount and distribution	Fewer punctures in specific locations	More punctures, all throughout the body
Dorsal and lateral setae, presence	Absent	Long setae present
Head foliations, number of undulations	One undulation present	Two large undulations and two smaller ones present
Head and body foliations, relative position	Contiguous or overlapped for at least part of its length	Separated
Interommatidial sensillae, presence	Absent	Present in dorsal section of the eyes
Rostrum length	Reaching at most base of abdominal segment V	Reaching genital segments
Scutellum length	Reaching middle of abdominal segment IV	Reaching base of abdominal segment VI
Ratio of membrane to hemelytra length	Membrane length is around 50% of hemelytra length	Membrane length is around 25% of hemelytra length
Wing venation	Reticulated, at most forming basal cells	Reticulated, forming many closed cells

Table 2. Morphological differences between *P. corticata* and *P. subquadrata*.

Character	*Phloea corticata*	*Phloea subquadrata*
Body colour	Generally brighter, darker	Generally lighter, paler
Dorsal tubercles, colour	Yellowish with dark outline	Orangish-copper
Head foliations, shape and relative position	Anteriorly straight and overlapped	Anteriorly convex, contiguous medially
Wing and pronotum markings	Darker, distinct from body colour	Paler, almost indistinguishable from body colour
Antennal segment I	Shorter than segments II + III	At least as long as II + III
Membranes venation	Forming basal cells	Not forming closed cells

acutely acuminated, whereas in *P. subquadrata* the foliations of abdominal segments are postero-laterally rounded.

Chromatic polymorphism

Colour polymorphism is very well known among heteropteran species, some of which are associated with important crops, as is the case for *Nezara viridula* (Linnaeus) (Vivan and Panizzi 2002; Ferrari *et al*. 2010). In Pentatomoidea, intraspecific colour variation has been described for nymphs and adults (Schwertner *et al*. 2002; Brugnera *et al*. 2019), and also includes extreme cases like melanic specimens (Esquivel *et al*. 2015; Taszakowski *et al*. 2020). Many explanations have been offered for this variability, such as predator avoidance, mating strategies and diet influence (Schwertner *et al*. 2002; Forero *et al*. 2010). Genetic mutations responsible for intraspecific colour variations were described for *Pyrrhocoris apterus* (Linnaeus), a model organism used in physiological and genetic experiments (Socha 2011).

For some species of Pentatomoidea, large intraspecific chromatic polymorphism has already been described and new colour morphs are described almost on a regular basis. For instance, for *Pachycoris torridus* (Scopoli) at least 30 colour patterns have been documented (Souza-Firmino *et al*. 2016), which has led to great taxonomic confusion and resulted in several misidentifications, including the description of eight different

species (Souza *et al*. 2012). To avoid this taxonomic confusion and to correctly establish the identity of species with great variability, thorough morphological works dealing with such species are necessary (Forero *et al*. 2010; Schmitz and Barcellos 2018). The chromatic variation described here for *Phea. subquadrata* adults were the first cases for this cryptic family of true bugs.

The chromatic variation described here preserves the cryptic camouflaged appearance of the individuals. Previous studies have associated colour polymorphism in true bugs with diet (Schwertner *et al*. 2002) and sexual selection (Punzalan *et al*. 2010), but this seems to not be the case here. For instance, the dark ring-like patterns (Figures 8, 10) were found in two individuals, a male and a female, collected on the same day, at the same location and in the same host tree as other individuals bearing the colours usually found in the species (Figures 3, 4, 13, 14). Regarding the individuals with dark diagonal lines in the foliations (Figures 7, 9), no inferences can be made since no males were available, no host plant information was provided and no other individuals collected in the same location are available in the MZUSP collection, except for nymphs which present similar colour to nymphs from other locations.

Nomenclature and synonymic list

In the first half of the nineteenth century, Hahn (1834) proposed the name *Paracoris paradoxus* Hahn for *Phloea corticata* (Drury) (see Hahn's fig. 178, pl. LVIII). In a clear misinterpretation of Hahn's work, Burmeister (1835) proposed the genus *Phloeocoris* Burmeister for two species: *Phloeocoris corticatus* (Drury) and *Phloeocoris paradoxus* (Hahn). He was, therefore, applying two names to the same species (*Phloea corticata*). At the time of Hahn's and Burmeister's works, *Phloeophana longirostris* had yet to be described by Spinola (1837). Therefore, *Phloeocoris paradoxus* is here removed from synonymy with *Phloeophana longirostris* and is proposed as a new junior synonym of *Phloea corticata*. In the material from the MfN examined in this work, we found one specimen of *Phloeophana longirostris* labelled as '*Paracoris parad*. Hahn' and '*Phloea longirostris* Spin'. on the same label, indicating that whoever identified this specimen in the past missapplied Hahn's name, as did Burmeister (1835).

Amyot and Serville (1843), in another misinterpretation, considered *Phloeocoris paradoxus* to be a synonym of *Phloeophana longirostris*, which they treated as *Phloea paradoxa* (Hahn). Later workers (de Magalhães 1909; Brien 1930; da Costa-Lima 1940) followed Amyot and Serville (1843) and used *Phloea paradoxa* or *Phloeophana paradoxa* when treating *Phloeophana longirostris*.

Signoret (1863), revising Chilean Hemiptera, wrote about *Phlaea paradoxa* (Hahn) being distributed in the country. So far, this name has been considered a junior synonym of *Phloea corticata* (Lent and Jurberg, 1965); however, he was referring to the species *Phloeophana longirostris*, since he cited the Chilean record of this species presented by Amyot and Serville (1843) (see discussion above). So, *Phlaea paradoxa* is removed from synonymy with *Phloea corticata* and proposed as a new junior synonym of *Phloeophana longirostris*. This would transfer the Chilean record from *Phloea corticata* to *Phloeophana longirostris*; this record, however, remains doubtful, and the presence of Phloeidae in Chile is still in need of validation.

In his catalogue, Kirkaldy (1909) reported *Phloea corticata* from Argentina, Brazil and Chile, and *P. longirostris* from Brazil, without information on localities. Apparently, Kirkaldy confused the record in Chile provided by Amyot and Serville (1843) from *Phloea paradoxa* (= *Phloeophana longirostris*) with *Phloea corticata*, since he cited Amyot and Serville but stated *P. longirostris* is distributed only in Brazil, contrary to what had been published. Therefore, the Chilean record would correctly pertain to *P. longirostris*, not *P. corticata*. Also, we could not find any previous record of *P. corticata* in Argentina; thus, this constitutes a new record for this species at that time (Kirkaldy 1909).

Distribution

Lent and Jurberg (1965) and Salomão *et al*. (2012) reviewed Phloeidae distribution, and presented the most up-to-date knowledge on the group. Nonetheless, only a few locality records are currently available, and as mentioned the distribution records were mostly given as country or state/province records. Recent textbook publications (eg Schwertner and Grazia 2015; Rider *et al*. 2018) only give general distributional information, such as 'Brazil' or 'tropical Brazil'.

According to the literature, *P. corticata* was known from the Brazilian states of Pará (PA), Bahia (BA), Minas Gerais (MG), Espírito Santo (ES), São Paulo (SP), Rio de Janeiro (RJ), Paraná (PR) and Santa Catarina (SC), and only five records were available at the municipality level: Jaguaré, Linhares and Rio Bananal in ES (Guilbert 2003; Martins *et al*. 2016); Jundiaí, SP (Salomão *et al*. 2012); and Rio de Janeiro, RJ (Lent and Jurberg 1965). *Phloea subquadrata* was reported from BA, MG, ES, SP, RJ, PR and Rio Grande do Sul (RS) states, and locality records included Itabuna, BA (Guilbert 2003); Jaguaré, Linhares and Rio Bananal, ES (Guilbert 2003; Martins *et al*. 2016); Jundiaí, SP (Bernardes *et al*. 2005); and Viamão, RS (Bernardes *et al*. 2005). *Phloeophana longirostris* was recorded in the states of ES, SP and RJ; locality records included Linhares, ES (Martins *et al*. 2016); Jundiaí and São Paulo, SP (Salomão *et al*. 2012; da Fonseca *et al*. 2017); and Rio de Janeiro, RJ (Pérez 1904).

As discussed above, some authors reported the presence of Phloeidae in French Guiana, Chile and Argentina. That was briefly discussed by Lent and Jurberg (1965), but the records in those countries were not considered valid in later works (Salomão *et al*. 2012; Rider *et al*. 2018). Distribution data for other countries besides Brazil derived from reports from the nineteenth (Amyot and Serville 1843) and early twentieth (de Magalhães 1909; Kirkaldy 1909) centuries, and subsequent authors who included these records merely cited historical data (eg Coscarón 2017), without new evidence to support it. Surprisingly, more than a century later new evidence allows us to revalidate French Guiana and Argentina as occurrence records for Phloeidae. Based on citizen science data, *P. corticata* was observed in three localities of French Guiana (Table 3); San Pedro (Misiones Province, Argentina) represents a new country record for *P. subquadrata*. Nonetheless, the presence of *P. corticata* in Argentina cannot be confirmed at present, and the Chilean record for the family (Amyot and Serville 1843; Pérez 1904) remains doubtful.

Salomão *et al*. (2012) reported both *Phloea* species from Itabuna municipality, Bahia, referencing Guilbert (2003) as the source. Indeed, Guilbert (2003) reported both species for two localities near Linhares, ES (Jaguaré and Rio Bananal municipalities), but only *Phloea subquadrata* for Itabuna, BA. Therefore, only the latter was reported for Bahia state.

Table 3. Georeference data for *Phloea corticata*. iNat = observations from iNaturalist website.

Country, state/ province	Municipality	Locality	Coordinates (lat, long)	Source
French Guiana, Saint-Laurent-du -Maroni	Saül	–	3.862786°N, 53.391782°W	iNat – 149774000
French Guiana, Saint-Laurent-du -Maroni	Maripasoula	Mont Itoupé, zone coeur du Parc Amazonien de Guyane	3.039957°N, 53.104135°W	iNat – 68559724
French Guiana, Cayenne	Régina	–	4.045656°N, 52.677575°W	iNat – 39030520
Brazil, Amapá	Serra do Navio	–	0.895833°N, 52.001944°W	Collection
Brazil, Pará	–	–	–	Lent and Jurberg (1965)
Brazil, Bahia	Caeté-Açu	–	12.59594249°S, 41.49747893°W	iNat – 160820431
Brazil, Bahia	Camamu	Barcelos do Sul	14.032111°S, 39.050250°W	Collection
Brazil, Bahia	Porto Seguro	–	16.42443167°S, 39.13665278°W	iNat – 150694382
Brazil, Minas Gerais	Ibituruna	–	21.171168°S, 44.784199°W	iNat – 99289514
Brazil, Espírito Santo	Jaguaré	Linhares Forest Reserve	19.050000°S, 39.866667°W	Guilbert (2003)
Brazil, Espírito Santo	Linhares	Reserva Natural Vale	19.136987°S, 40.063444°W	Martins *et al.* (2016)
Brazil, Espírito Santo	Rio Bananal	Sooretama Biological Reserve	19.200000°S, 40.200000°W	Guilbert (2003)
Brazil, Espírito Santo	Domingos Martins	–	20.36257026°S, 40.65820802°W	iNat – 148069296
Brazil, Espírito Santo	Cachoeiro de Itapemirim	Pacotuba	20.74199873°S, 41.29419632°W	iNat – 137803700
Brazil, Espírito Santo	Alegre	–	20.7667°S, 41.5333°W	Collection (MfN)
Brazil, São Paulo	Jundiaí	Serra do Japi	23.233333°S, 46.966667°W	Salomão *et al.* (2012)
Brazil, São Paulo	São Sebastião	Praia da Jureia	23.756819°S, 45.789767°W	iNat – 70844237
Brazil, São Paulo	São Sebastião	–	23.8001°S, 45.3984°W	Collection
Brazil, São Paulo	Iporanga	–	24.289466°S, 48.438648°W	iNat – 107906488
Brazil, São Paulo	Cananeia	Ilha do Cardoso	25.0167°S, 47.9500°W	Collection
Brazil, Rio de Janeiro	Itatiaia	–	22.446223°S, 44.601052°W	iNat – 128373767
Brazil, Rio de Janeiro	Cachoeiras de Macacu	Trilha do circuito dos lagos na REGUA	22.452655°S, 42.77084667°W	iNat – 153559898
Brazil, Rio de Janeiro	Cachoeiras de Macacu	Rod. João Goulart, 2 – Funchal	22.453521°S, 42.770316°W	iNat – 54323687
Brazil, Rio de Janeiro	Duque de Caxias	Xerém	22.57883°S, 43.31399°W	Collection
Brazil, Rio de Janeiro	Magé	Pau Grande	22.586283°S, 43.174328°W	iNat – 111199022
Brazil, Rio de Janeiro	Nova Iguaçu	Tinguá	22.60336°S, 43.43608°W	Collection
Brazil, Rio de Janeiro	Rio de Janeiro	–	22.906389°S, 43.172500°W	Lent and Jurberg (1965)
Brazil, Rio de Janeiro	Rio de Janeiro	Camorim	22.969711°S, 43.428322°W	iNat – 66060718
Brazil, Rio de Janeiro	Niterói	Praia de Itaipú	22.97035°S, 43.04613°W	Collection
Brazil, Rio de Janeiro	Angra dos Reis	–	23.174294°S, 44.305458°W	iNat – 38794384
Brazil, Rio de Janeiro	Angra dos Reis	–	23.177642°S, 44.308957°W	iNat – 54495330
Brazil, Rio de Janeiro	Angra dos Reis	–	23.17895°S, 44.20528°W	iNat – 129489840
Brazil, Rio de Janeiro	Angra dos Reis	Aventureiro	23.184693°S, 44.319374°W	iNat – 54444869
Brazil, Paraná	Ponta Grossa	–	25.0833°S, 50.1500°W	Collection (MLP)

(*Continued*)

Table 3. (Continued).

Country, state/ province	Municipality	Locality	Coordinates (lat, long)	Source
Brazil, Paraná	Morretes	Porto de Cima	25.352241°S, 48.888329°W	Collection (uploaded to iNat – 11608893)
Brazil, Paraná	Paranaguá	Raia	25.527434°S, 48.518029°W	iNat – 68163799
Brazil, Santa Catarina	Itapoá	–	26.097173°S, 48.610448°W	iNat – 93419586
Brazil, Santa Catarina	Joinville	–	26.3000°S, 48.8333°W	Collection (MfN)
Brazil, Santa Catarina	Navegantes	–	26.84572°S, 48.661847°W	iNat – 161991785
Brazil, Santa Catarina	Apiúna	–	27.0177°S, 49.41898333°W	iNat – 155593704
Brazil, Santa Catarina	Florianópolis	–	27.59443959°S, 48.55692867°W	iNat – 147714897
Brazil, Santa Catarina	Florianópolis	–	27.67168°S, 48.49278667°W	iNat – 155918483
Brazil, Santa Catarina	Florianópolis	Rua da Lua Cheia	27.73832°S, 48.508563°W	iNat – 67277322
Brazil, Santa Catarina	Garopaba	–	28.026042°S, 48.624921°W	iNat – 135589553
Brazil, Rio Grande do Sul	São Leopoldo	–	29.72213°S, 51.155732°W	iNat – 72045302

In this contribution, we present for the first time distribution maps (Figures 18–20) for the three species of Phloeidae, including several new records. Georeferenced data is presented in Tables 3–5. The distribution of *P. corticata* (Figure 18) is extended both northwards (French Guiana and AP state, Brazil) and southwards (RS state, Brazil); we also report the first municipality records for this species in the states of BA, MG, PR and SC. For *P. subquadrata* (Figure 19), a distributional gap between PR and RS states in southern Brazil was filled by reporting specimens from SC state. We also report the first record of this species in Argentina (Misiones) and the first municipality records in the brazilian states of MG, RJ and PR. Finally, for *P. longirostris* (Figure 20) we extend the known distribution by reporting the first specimens from the south-western state of MG and from the southern region of Brazil (PR, SC and RS states). So far, *P corticata* is the only Neotropical bark-bug whose distribution includes both the Amazon and Atlantic rainforests.

Citizen science contributions

Biological sciences have been benefiting from the data of 'amateur scientists' for centuries. The main differences between professional scientists and amateurs were thoroughly discussed by Brunelle (1997), mainly consisting in the payment professional scientists receive for their work; another point discussed was the amount of knowledge and/or expertise, expected to be greater in professional scientists (but this is not always the case in the opinion of that author). Oberhauser and Prysby (2008) used the term 'citizen science' for projects in which, at least mostly, no professional scientists take part. In this context, many historical collections and bodies of entomological data were built by amateur or citizen scientists

Table 4. Georeference data for *Phloea subquadrata*. iNat = observations from iNaturalist website.

Country, state/ province	Municipality	Locality	Coordinates (lat, long)	Source
Brazil, Bahia	Itabuna	–	14.794100°S, 39.281740°W	Guilbert (2003)
Brazil, Minas Gerais	Juiz de Fora	Jardim Lermitage	21.73304029°S, 43.37093253°W	iNat – 101743593
Brazil, Minas Gerais	Itamonte	–	22.23638393°S, 44.85265452°W	iNat – 148115634
Brazil, Minas Gerais	Conceição dos Ouros	–	22.41083497°S, 45.766857°W	iNat – 40834168
Brazil, Espírito Santo	Jaguaré	Linhares Forest Reserve	19.050000°S, 39.866667°W	Guilbert (2003)
Brazil, Espírito Santo	Linhares	Reserva Natural Vale	19.136987°S, 40.063444°W	Martins *et al.* (2016)
Brazil, Espírito Santo	Rio Bananal	Sooretama Biological Reserve	19.200000°S, 40.200000°W	Guilbert (2003)
Brazil, Espírito Santo	Alegre	–	20.7667°S, 41.5333°W	Collection (MfN)
Brazil, São Paulo	Rio Claro	FEENA	22.412347°S, 47.551368°W	Collection
Brazil, São Paulo	Anhembi	Fazenda Barreiro Rico	22.684272°S, 48.116074°W	Collection
Brazil, São Paulo	Botucatu	–	22.8835°S, 48.4415°W	Collection
Brazil, São Paulo	Jundiaí	Reserva Ecológica da Serra do Japi	23.183333°S, 46.866667°W	Bernardes *et al.* (2005)
Brazil, São Paulo	São Paulo	Cidade Universitária	23.562929°S, 46.731919°W	Collection
Brazil, São Paulo	São Paulo	Capão Redondo, Santo Amaro	23.6324°S, 47.6091°W	Collection
Brazil, São Paulo	São Paulo	Granja Julieta	23.6382658°S, 46.7044515°W	iNat – 105319503
Brazil, São Paulo	São Paulo	Parque do Estado	23.64654188°S, 46.62043382°W	iNat – 159190143
Brazil, São Paulo	São Paulo	–	23.64856667°S, 46.69484667°W	iNat – 111080334
Brazil, São Paulo	São Paulo	Santo Amaro	23.6500°S, 46.7000°W	Collection
Brazil, São Paulo	São Paulo	Santo Amaro	23.6536633°S, 46.7066927°W	iNat – 86575793
Brazil, São Paulo	Cotia	Rua Santo Amaro	23.58585882°S, 46.84397528°W	iNat – 86351464
Brazil, São Paulo	Ibiúna	Cachoeira	23.622838°S, 47.235249°W	iNat – 152366569
Brazil, São Paulo	São Lourenço da Serra	Despezio	23.81321097°S, 46.932541°W	iNat – 65616970
Brazil, Rio de Janeiro	Itatiaia	–	22.44610399°S, 44.60109501°W	iNat – 128371970
Brazil, Paraná	Tibagi	–	24.56683239°S, 50.26498284°W	iNat – 102942958
Brazil, Paraná	Antonina	–	25.30506299°S, 48.65732631°W	iNat – 85679169
Brazil, Paraná	Campina Grande do Sul	–	25.3359°S, 49.11591667°W	iNat – 84727618
Brazil, Paraná	Curitiba	Rua Teodoro Makiolka, 4519	25.36473025°S, 49.2597707°W	iNat – 132394959
Brazil, Paraná	Curitiba	–	25.408025°S, 49.27073333°W	iNat – 152855587
Brazil, Paraná	Curitiba	UFPR – Campus Centro Politécnico	25.44852644°S, 49.24102541°W	iNat – 105642492
Brazil, Paraná	Curitiba	Boqueirão	25.51277581°S, 49.24975045°W	iNat – 147525835
Brazil, Paraná	Guaratuba	Reserva Bicudinho-do-brejo	25.75661°S, 48.72463°W	iNat – 37936895
Brazil, Santa Catarina	Blumenau	–	26.9156°S, 49.0936°W	Collection
Brazil, Santa Catarina	Seara	Nova Teutônia	27.183333°S, 52.383333°W	Collection (MfN)

(*Continued*)

Table 4. (Continued).

Country, state/ province	Municipality	Locality	Coordinates (lat, long)	Source
Brazil, Santa Catarina	Nova Veneza	–	28.68148994°S, 49.47456741°W	iNat – 18816629
Brazil, Rio Grande do Sul	Mato Castelhano	–	28.3404882°S, 52.17575602°W	iNat – 94762848
Brazil, Rio Grande do Sul	São Domingos do Sul	–	28.5316446°S, 51.8864899°W	iNat – 63584155
Brazil, Rio Grande do Sul	São Domingos do Sul	–	28.56549667°S, 51.83153°W	iNat – 93927958
Brazil, Rio Grande do Sul	Cruz Alta	–	28.68255434°W, 53.7161845°W	iNat – 103254283
Brazil, Rio Grande do Sul	Viamão	Colégio N. Sra. das Graças	30.133333°S, 51.083333°W	Bernardes *et al.* (2005)
Argentina, Misiones	San Pedro	–	26.7125249°S, 54.10192438°W	iNat – 102930766

Table 5. Georeference data for *Phloeophana longirostris*. iNat = observations from iNaturalist website.

Country, state/ province	Municipality	Locality	Coordinates (lat, long)	Source
Brazil, Minas Gerais	Nova Lima	–	20.12675345°S, 43.94183423°W	iNat – 149921805
Brazil, Espírito Santo	Linhares	–	19.136987°S, 40.063444°W	Martins *et al.* (2016)
Brazil, São Paulo	São José dos Campos	Jardim Apolo	23.200463°S, 45.9007739°W	iNat – 65846471
Brazil, São Paulo	Jundiaí	–	23.23160168°S, 46.93489651°W	iNat – 100976033
Brazil, São Paulo	Jundiaí	Serra do Japi	23.233333°S, 46.966667°W	Salomão *et al.* (2012)
Brazil, São Paulo	Jundiaí	RBM Serra do Japi	23.235783°S, 46.9327°W	Collection
Brazil, São Paulo	Araçariguama	–	23.46074774°S, 47.05778405°W	iNat – 141415102
Brazil, São Paulo	São Paulo	Cidade Universitária Armando Salles de Oliveira	23.562855°S, 46.72888°W	iNat – 157359454
Brazil, Rio de Janeiro	Cachoeiras de Macacu	–	22.4677572°S, 42.76682265°W	iNat – 21907432
Brazil, Rio de Janeiro	Rio de Janeiro	–	22.8751°S, 43.2775°W	Lent and Jurberg (1965)
Brazil, Paraná	Bituruna	–	26.1576792°S, 51.56070139°W	iNat – 113160386
Brazil, Santa Catarina	São Bento do Sul	Rio Vermelho	26.249444°S, 49.383056°W	Collection
Brazil, Rio Grande do Sul	Sarandi	–	27.91318°S, 52.82398797°W	iNat – 103931645

(Oberhauser and Prysby 2008). The advent of digital photography, and more recently its popularisation, has greatly expanded access to science as we know it (Marshall 2008). Nowadays, the increasing number of high-quality websites dedicated to sharing and identifying scientific data on biodiversity (such as iNaturalist, used in this work) represent an extremely powerful and useful tool to expand the study of organisms in general and insects more specifically (Goula *et al*. 2012). The value of the observations posted on these websites come mainly from three aspects (Goula *et al*. 2012): shooting date; georeferenced data; and features used to identify specimens, in many cases with the aid of specialists.

In the last few years, several papers have been published demonstrating the potential that citizen science projects and websites have for mapping neglected species of high conservation priority or to enhance our knowledge on species diversity and distribution (Goula *et al*. 2012; Zapponi *et al*. 2017). More recently, invasive species of Heteroptera have been identified from such records, demonstrating how citizen science data, available in online databases, have become useful even to applied sciences (Eger *et al*. 2020; Lupoli *et al*. 2020; Brugnera *et al*. 2021; Çerçi *et al*. 2021; Forero 2021). The availability of data from online resources speeds up the identification of potential invasive species, and detection of these species with the traditional steps of collection, identification and publications processes might otherwise have taken much longer.

Phloeidae species, as shown above, are easily recognisable through photographs and in online databases, such as iNaturalist. For other taxa, however, these tools should be used with caution. For instance, many Pentatomidae species are distinguishable only through dissection and examination of their genitalia. This is the case for *Halyomorpha halys* (Stål), a species considered an emerging pest that is rapidly expanding its distribution globally (Kment *et al*. 2021). Species of the genus *Halyomorpha* Mayr are very similar-looking morphologically and some of them coexist; their correct identification lies in the examination of the genitalia, only recently described for *H. halys* (Vétek *et al*., 2014). Therefore, identification through photographs is not advised in areas of coexistence of more than one species (Kment *et al*. 2021), but it is still feasible in areas where *Halyomorpha* does not occur naturally (Cianferoni *et al*. 2019; Hess *et al*. 2022).

Here, citizen science data has proven extremely useful and relevant to the knowledge of the distribution of such remarkable, although cryptic, species. Most points presented in the distribution maps (Figures 18–20) stem from iNaturalist, a citizen science website. Progressively, biodiversity science is becoming a more relevant issue in society, increasing scientific knowledge in general and possibly aiding in species conservation, a point argued by Fontaine *et al*. (2021) and agreed upon by us. We expect to see even more contributions by citizen science projects in the future, highlighting the importance of the integration between science and society as well.

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