RENAN CARRENHO

Lygaeoidea (Insecta: Hemiptera): taxonomy, diversity and distribution in Brazil, with a review of the tribe Lethaeini in the Neotropics

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Single Volume

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Advisor: Cristiano Feldens Schwertner, PhD

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ABSTRACT

The most diverse family of the Lygaeoidea (Hemiptera: Heteroptera) is Rhyparochromidae, especially for the Neotropical region. Most rhryparochromids species inhabit ground litter, and exhibit seed predation behavior, eequiring specialized sampling techniques. Because of their minute size, they are relatively neglected. This work is focused on the study of the diversity of the Lygaeoidea from Brazil, with emphasis in the tribe Lethaeini of the Americas. We show that *Lethaeus lepidus* is a junior synonym of *Petissius spinipes* with significant implications for the representation of *Lethaeus* in the New World. Followed by diagnosis, keys for genera and species, and new records distributional maps for the tribe in the Americas. In a broader context, a phylogeny for the Lethaeini with morphological data is inferred in order to test the monophyly of the New World generic group including all lethaeini genera with one iridescent are on the base of the head, and the relationship between them. Additionally, we discuss the the classification and the relationship of the all Lethaeini genera currently known in the New World. As a result, Lethaeini is found to be non-monophyletic in the analyses. This is observed because one representative of the tribe Antillocorini was nested within American genera. Additionally, American Lethaeini genera did not form a monophyletic group, nor did the group of genera with one iridescent area on the base of the head. The relationships between genera showed changes under analyses. However, the monophyly of the genera some genera was consistently supported in the analyses.

Keywords: Biodiversity. Entomology. True bugs. Rhyparochromidae. Systematics.

RESUMO

A família mais diversa de Lygaeoidea (Hemiptera: Heteroptera) é Rhyparochromidae, especialmente na região Neotropical. A maioria das espécies de rhryparochromids habita a serrapilheira e exibe comportamento de predação de sementes, exigindo técnicas de coletas especializadas. Devido ao seu tamanho diminuto, eles são relativamente negligenciados. Este trabalho se concentra no estudo da diversidade de Lygaeoidea no Brasil, com ênfase na tribo Lethaeini das Américas. Demonstramos que *Lethaeus lepidus* é sinônimo júnior de *Petissius spinipes*, com implicações significativas para a representação de *Lethaeus* no Novo Mundo. Seguido por diagnósticos, chaves para gêneros e espécies e novos mapas de distribuição de registros para a tribo nas Américas. Em um contexto mais amplo, uma filogenia para o Lethaeini com dados morfológicos é inferida para testar a monofilia do grupo genérico do Novo Mundo, incluindo todos os gêneros de Lethaeini com uma área iridescente na base da cabeça e a relação entre eles. Além disso, discutimos a classificação e a relação de todos os gêneros de Lethaeini atualmente conhecidos no Novo Mundo. Como resultado, verificou-se que o Lethaeini não é monofilético nas análises. Isso é observado porque um representante da tribo Antillocorini estava inserido entre os gêneros americanos. Além disso, os gêneros americanos de Lethaeini não formaram um grupo monofilético, nem o grupo de gêneros americanos com uma área iridescente na base da cabeça. As relações entre os gêneros mostraram mudanças nas análises. No entanto, a monofilia de alguns gêneros foi consistentemente apoiada nas análises.

Palavras-chave: Biodiversidade. Entomologia. Percevejo. Rhyparochromidae. Sistemática.

GENERAL INTRODUCTION

The Heteroptera Suborder (Order Hemiptera) comprises over 45,000 described species, distributed in 91 families that occur in all continents, except Antarctica (Henry 2017). Commonly known as true bugs, this suborder is the most diverse of hemimetabolic insects and shows a wide variety of habits, such as phytophagous, hematophagous, predatory and ectoparasites of spider webs, which allowed the occupation of a wide range of ecological niches (Weirauch & Schuh 2011, Schuh & Weirauch 2020). Pentatomomorpha is the second most diverse group among the seven lineages of Heteroptera.

The infraorder Pentatomomorpha has six superfamilies, Aradoidea, Coreoidea, Idiostoloidea, Lygaeoidea, Pentatomoidea and Pyrrhocoroidea (Weirauch *et al*. 2018). After Pentatomoidea, Lygaeoidea is the second largest group, with 4,732 species and 811 genera across currently 16 families. The classification of Lygaeoidea has changed over time and several Lygaeidae subfamilies were received family status (Henry 1997, 2017). Its monophyly is supported by reduced venation of the hemelytra membrane, lacking closed cells and swollen fore femora in the basal groups (Henry 1997).

The current families recognized, Berytidae, Blissidae, Colobathristidae, Cymidae, Geocoridae, Heterogastridae, Lygaeidae, Ninidae, Oxycarenidae, Pachygronthidae, Piesmatidae and Rhyparochromidae, occur in the Neotropical region; the Heterogastridae is the only family that has no record in Brazil (Henry *et al.* 2015; Dellapé & Henry 2023). Slater (1964) and Slater & O'Donnell (1995) made available a two-volume catalogue of the Lygaeidae sensu lato for the world. The Berytidae was catalogued by Henry & Froeschner (1998). Two major resources, which represent compilations from this literature, are available online: the Lygaeoidea Species File (Version 5.0/5.0) for the world's species; and regarding on the diversity of Lygaeoidea and other taxa in Brazil, the Taxonomic Catalogue of the Fauna of Brazil.

This widespread group exhibit interesting feeding habits, with most species being phytophagous, but also including predatory of small invertebrate (e.g. Geocoridae) and hematophagous species (e.g. Rhyparochromidae: Cleradini) (Correa, 1956; Henry *et al.* 2015; Weirauch 2018; Weirauch & Schuh 2020). Found in diverse habitats, such as litter, trunks, and associated with grass stems (Slater & Baranowski 1990; Weirauch & Schuh 2020). In addition, members of Lygaeoidea hold significant economic importance and serve as model organisms.

Several species within the Lygaeoidea are economically important. For instance, the berytid *Parajalysus andinus* (Horváth) is known for its contribution as a cacao pollinator,

while the blissid *Blissius leucopterus* (Say) is recognized as an important pest of cereals, mainly in Brazil. The rhyparochromid *Elasmolomus pallens* (Dallas) is associated with peanuts in several countries, and the species of lygaeis of the genus *Nysius* (Dallas) are frequently identified as pests of cotton and corn in Brazil. Additionaly, *Oncopeltus (Erythrischius) fasciatu*s (Dallas) is commonly used as an insect model in laboratory studies (Henry 1997; Chipman 2017; Henry et al. 2015; Schaefer & Panizzi 2000; Sweet 2000). These are some examples that highlight Lygaeoidea as an interesting subject for biodiversity, agricultural and systematics studies.

The most diverse family of the Lygaeoidea is Rhyparochromidae, with over 2,000 described species and hundreds still unknown, especially for the Neotropical region, where only few specialists are dedicated to the taxonomy of the group (Henry *et al.* 2015). Most rhryparochromids species inhabit ground litter, and exhibit seed predation behavior, demanding specific sampling methods. Because of their minute size, they are relatively neglected (Ashlock 1964; Slater and Baranowski 1990; O'Donnell 2001; Cervantes and Gamez 2006; Dellapé et al., 2015; Schwertner et al. 2020).

Two subfamilies are recognized, Plinthisinae and Rhyparochrominae (Henry 1997). With 14 tribes, Rhyparochrominae is the largest subfamily of Lygaeoidea (Dellapé & Henry 2023). Within Rhyparochrominae, the Lethaeini is a diverse tribe among rhyparochromids, comprising 41 genera and 194 species worldwide (Dellapé & Henry 2023). In Americas, the tribe has 13 genera and known 56 species known. Despite their prominence in the Americas, our understanding of the diversity, distribution and biology of most Lethaeini species remains limited.

The lack of organized and basic information on species, whether in the form of original data or compilations from the literature, increases the necessity of conducting inventories and faunistic assessments for the expansion of biodiversity knowledge. The organization and provision of information on neglected insect groups are crucial for the characterization, conservation, and management of the natural resources to which these organisms are related. In this context, terrestrial true bug specialists are scarce in Brazil, and the group and its interactions in the natural environment are known to a very limited extent (Weirauch & Schuh 2011). For Lygaeiodea, the situation is intensified, given that a significant portion of the group is comprised of families considered neglected, lacking taxonomists trained in Brazil.

My contribution, in this thesis, is focused on the study of the diversity of the Lygaeoidea from Brazil, with emphasis in the tribe Lethaeini of the Americas. A new

synonymy of an important species of *Lethaeus*, the only Neotropical representative of the genus in the Lethaeini, is provided, with new records. Followed by diagnosis, keys for genera and species, and new records distributional maps for the tribe in the Americas. In a broader context, a phylogeny for the Lethaeini with morphological data is inferred in order to test a monophyly hypothesis within a group of genera that are diverse in the Neotropics and are only found in the Americas. A more detailed overview of the chapters and their structure are described below.

Structure of the thesis

This thesis is divided into three chapters, each focusing on specific taxonomic aspects whitin the Lygaeoidae, with emphasis on the Rhyparochromidae tribe Lethaeini. The formatting of each chapter follows the structure employed by the journals and editorials to which they were submitted or are intended for submission.

The first chapter entitled "A new synonymy in the Lethaeini of the Neotropics (Heteroptera: Rhyparochromidae), with new country records for *Petissius spinipes* (Stål)", was submitted for publication in Studies on Neotropical Fauna and Environment. In this study we have showed that *Lethaeus lepidus* White is a junior synonym of *Petissius spinipes* Stål. The findings have significant implications for the representation of *Lethaeus* in the New World, since *L. lepidus* was previously known as the only representative of the type genus to be present in the region. Our study reveals a comprehensive update about the distribution of *P. spinipes* in the Neotropics, uncovering numerous new locality records that fill a substantial geographic gap in our knowledge. By reporting the species for the first time in Brazil and documenting its presence across 12 Brazilian states, we have considerably expanded its range. Distribution map and high-definition illustrations of the species, along with its diagnostic characters, are included in the manuscript. The findings of this chapter were submitted for publication in Studies on Neotropical Fauna and Environment and are considered in the following chapters.

In the second chapter, we conducted a study focusing the diversity, diagnostics and distribution of Lethaeini in the Americas. Important resources to facilitate the identification of the group such as keys to genus and species, diagnoses, distribution maps including and new records, and the definition of four new species, are presented. The work uncovers the study of 473 specimens and includes 30 new country and 28 new state/province records, constituting about 20% of the total tribe records in the Americas.

In the third chapter, we deal with the phylogenetic classification of the tribe Lethaeini

using morphological data. This study aims to address this gap in the classification of the group by conducting a phylogenetic analysis. In this chapter, we studied representatives of all New World genera currently included in Lethaeini to test the hypothesis of monophyly of a clade empirically recognized within the tribe. Additionally, we addressed the relationships within species and genera in the Americas. In the study, Lethaeini was found to be non-monophyletic in the analyses This was observed because one representative of the tribe Antillocorini was nested within the Lethaeus group. Additionally, American Lethaeini genera did not form a monophyletic group, nor did the group of genera with one iridescent area on the base of the head. The relationships between genera showed changes under analyses. However, the monophyly of the genera *Bubaces, Cistalia*, and *Lipostemmata* was consistently supported in both analyses. These results highlight the need for further investigations into broader taxonomic groups within the tribe and the family as a whole.

Finally, as an appendix, we provide a a taxonomic compilation of the Lygaeoidea in Brazil. This appendix is an adaptation from my contribution to the book chapter to be published in the book Insetos do Brasil: Diversidade e Taxonomia. 2ª ed (Grazia et al. in press). The classification of Lygaeoidea families was based on Henry (1997) and Schuh & Weirauch (2020). As a result, when compared to the first edition, the following seven groups were considered as families: Blissidae, Cymidae, Geocoridae, Ninidae, Oxycarenidae, Pachygronthidae and Piesmatidae. We present a concise diagnoses of each family, with discussion of the aspects of feeding habits diversity and distribution in Brazil. The appendix also includes unpublished data on Lethaeini (Rhyparochromidae) from chapter two.

CONCLUDING REMARKS

This thesis is a comprehensive exploration of taxonomic aspects within the Lygaeoidea, with a specific focus on the Rhyparochromidae and the tribe Lethaeini. A taxonomic compilation of the Lygaeoidea in Brazil is provided, offering a concise overview of each family's characteristics, feeding habits, and distribution in Brazil. The new synonymy in the Lethaeini, with *Lethaeus lepidus* herein considered a junior synonym of *Petissius spinipes*, has significant consequences for the Neotropic representation of *Lethaeus*. This species was formerly recognized as the sole representative of the genus in the region. Furthermore, a thorough examination of the Lethaeini in the Americas provides valuable resources for identification in this group. It also resulted in a substantial addition of new state/province and country records. Lastly, a phylogenetic analysis of the tribe Lethaeini using morphological data offers insights into the tribe and broader classification. In the analyses, the tribe was found to be non-monophyletic and the hypothesis of the one iridescent area group in the Americas being monophyletic was not supported. However, the monophyly of the genera *Bubaces, Cistalia*, and *Lipostemmata* was consistently supported in the analyses.

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