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ECOSYSTEMS

Heteroptera research in Latin America and the Caribbean (Insecta, Hemiptera): status and perspectives in the 21st century

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Abstract: Latin American and the Caribbean regions (LAC) harbor one of the most biodiverse areas of the world, the Neotropics. True bugs (Hemiptera: Heteroptera) are a diverse lineage of insects, with more than 45,000 species, particularly speciose in the Neotropical region. True bugs are fundamental in the dynamics of natural and modified ecosystems, with several species critical to agriculture and public health. We compiled Heteroptera research in LAC from 1998–2022 using bibliographic databases. Productivity, collaborative networks, and the main topics studied were analyzed. A total of 1,651 Heteroptera studies from LAC were found, with continuous growth being 2021 the most prolific. Four categories (Taxonomy of extant species, Faunistic inventories and new records, Pest species biology, and Community ecology) represent most of the published research. About 60 percent of the records evaluated correspond to five families (Pentatomidae, Reduviidae, Coreidae, Miridae, and Rhyparochromidae). We emphasize the need to keep working on Heteroptera taxonomy because it will allow further advances in other areas such as phylogenetic analyses, biogeography, ecology, and natural history, among others. The results of our analyses characterize the current state of heteropterology in the region, establishing a baseline for future studies and efforts to broaden the knowledge of the group.

Key words: Bibliometrics, Neotropical region, databases, knowledge gaps, historical trends, community networks.

INTRODUCTION

Studies on scientific productivity and collaboration, through bibliometric analyses, help characterize the status and dynamics of the scientific knowledge production on a specific topic across a timeline and can be an excellent indicator of the structure of the scientific community (Abbasi & Altmann 2011, Grosso et al. 2021, Holman & Morandini 2019, Holman et al. 2018, Lee & Bozeman 2005, Levin & Stephan 1991). Understanding the structure and dynamics within an academic community could offer elements of analyses to reflect on its current practices, perspectives, and future goals. Such studies are particularly important in the Global South because researchers facing similar challenges across nations can implement strategies to resolve them (e.g., Armenteras 2021, Ramírez-Castañeda 2020). In Latin America and the Caribbean (LAC), these bibliometric analyses have helped understand approaches to science in different areas, from regional to country level (e.g., Almeida-Filho et al. 2003, Arbeláez-Cortés 2013, Monge-Nájera & Ho 2012, Rivera et al. 2021).

Currently, LAC comprises 33 countries and 15 dependencies and hosts one of the most biodiverse regions on Earth: the Neotropical region (Antonelli & Sanmartín 2011). This region comprises three sub-regions (i.e., Antillean, Brazilian, and Chacoan) and seven dominions (Morrone et al. 2022). Also, the Andean region and two transitional zones are hosted in the area, the Mexican transition zone and the South American transition zone (Echeverry & Morrone 2013, Morrone 2014, 2015, 2017, Morrone et al. 2022). With nearly 600 million people living in the region, biodiversity is a key asset that positively contributes to health, freshwater, and food security (IPBES 2018). Nonetheless, we face significant challenges concerning the sustainable use of natural resources and conservation (Carnaval 2020, Portillo-Quintero et al. 2015). Latin American countries share a common complex history reflected, among other things, in the use of a Romance language, either Spanish, Portuguese, or French, as their primary language. The adjacent Caribbean region has strong historical ties to Latin America but with its own linguistic and cultural characteristics.

Insects are the most diverse group of known organisms, with about one million species and many more still undescribed, which occupy all habitats and continents (Didham et al. 2013, García-Robledo et al. 2020, Stork 2018). Hemiptera is the fifth largest order of the class Insecta, of which true bugs (Heteroptera) are the most diverse suborder/lineage with more than 45,000 described species and are remarkably diverse in the Neotropical region (Henry 2017, Schuh & Weirauch 2020, Weirauch & Schuh 2011). Heteropteran feeding habits range from plant-feeding to predatory, including hematophagy and mycophagy (Henry 2017, Schuh & Weirauch 2020), thus, heteropterans are fundamental in the dynamics of natural ecosystems, with several species critical in agriculture and public health (Schaefer & Panizzi 2000, Panizzi & Grazia 2015).

As part of the Heteroptera researcher community in LAC, sharing a similar socio-political landscape, we recognize the importance of understanding the structure of our community to establish knowledge gaps, improve our research approaches, and prioritize research topics. The discovered patterns will be meaningful for the research community in LAC and anyone interested in deepening their knowledge about Heteroptera and biodiversity in general in the region.

Using tools for collecting and evaluating data about the researchers' output and their collaboration activities, we address five general aspects of Heteroptera research in LAC: a) What is the quantitative trend of productivity during the 24 years analyzed?; b) Which countries, institutions, and authors are most productive?; c) What are the academic production dynamic and its collaboration networks among countries, institutions, and authors?; d) Which are the main Heteroptera research topics (including topics most and least explored and their changes over time)?; e) Which are the main taxonomic groups studied in each topic (most and least explored families and their changes over time)? We aim to critically evaluate the current state of research on Heteroptera in LAC, establish a baseline for future evaluations of the discipline's status, identify key research areas and trends, and highlight the potential and neglected areas that could benefit from future research in the region.

MATERIALS AND METHODS

We reviewed the literature published from 1998 to 2022 in LAC in research topics dealing with Heteroptera. Emerging patterns by country, region, and discipline are presented and discussed. The time range selected considers as the starting point the year 1998 when the seminal first meeting of the International Heteropterists'

Society (IHS) (www.heteroptera.org) took place (July 14-18, 1998) at the American Museum of Natural History in New York, USA. It was the first worldwide Heteroptera official gathering of researchers, with an important participation of the LAC researcher's community. The literature search includes information up to June 2022. Given that the paper's audience is within LAC, automatic translations for the text of this paper (done in Google Translate) are provided as Supplementary Material in both Spanish and Portuguese (Additional File 1 https://zenodo.org/records/10645619 and Additional File 2 https://zenodo.org/records/10645638, respectively) (for rationale, see Ramírez-Castañeda 2020).

Search strategy

We searched the scientific literature from six different bibliographic indexing sources, Web of Science core collection, Scopus, SciELO, ProQuest Biological Science Database, and ProQuest Latin America & Iberia Database. In addition, we included Redalyc, an indexing system for LAC scientific journals of high scientific and editorial quality, which contains journals not usually indexed in other databases. The time range considered was between 1998 and June 13, 2022. The search strategy was designed with keywords oriented to retrieve information from the fields of title, abstract, and author keywords of the indexing source. For the construction of queries, we used the terms "Heteroptera" and the root of the names of the families within the suborder *sensu* Schuh and Weirauch 2020, in addition to Latin American and Caribbean localities (i.e., country names and dependencies) (see Appendix 1 for the complete search strategy). We excluded from the results information related to *Trypanosoma cruzi* Chagas (Euglenozoa: Kinetoplastea: Trypanosomatidae), the causal agent of American trypanosomiasis, a human disease transmitted mainly by kissing bugs (Heteroptera: Reduviidae: Triatominae). *Trypanosoma cruzi* has been extensively studied from a medical point of view (Telleria & Tibayrenc 2017), and we wanted to limit the searches to non-medical aspects of Triatominae species. Information retrieval techniques were applied for each information source, except in Redalyc, where a basic search for the term "Heteroptera" was used on the time range and manually filtered.

In this study, we were aware of the absence of some studies on Heteroptera from LAC using our search strategy. Arbeláez-Cortés (2013) discussed the effects of the studies based on keyword searches in major databases on the results and conclusions when some journals do not appear in the databases, and when some studies are absent in the search results due to inappropriate or incomplete keywords from the papers. This effect is called the 'degree of omission error' corresponding to fewer studies identified through the search process than the actual number of existing studies. Nonetheless, to allow data replicability, we chose not to include the absent papers manually since the impact on the results does not compromise the conclusions of our study.

The six bibliographic indexing sources or databases used here cover a broad universe of journals that include most scientific papers published in Heteroptera. The search strategy was designed with key terms covering all taxa, countries, and dependencies from LAC, which helped to minimize possible omissions by the authors and, therefore, the omission error. In addition, we call attention to authors about the effect of keyword selection in finding papers and its proper utilization in titles, abstracts, and keywords sections: it is important to include additional and relevant information (e.g., locality, biogeographic region, main methods) in querying fields, such as title, abstracts, and keywords.

Information management

The references recovered were downloaded in the bibliographic management formats RIS, BibTeX, and CSV. The metadata were processed using VantagePoint (VP) 14.1 (Search Technology Inc. 2022). Five datasets were generated (results of two ProQuest databases were exported and imported into a single file) and compiled. The total raw number of references was 3,710. Duplicate records were eliminated manually, and a detailed review was carried out in titles, abstracts, and references, completing all fields with the corresponding information. Records that did not correspond strictly to research being carried out on Heteroptera from LAC were not considered for the analyses.

After this filtering, the final database consisted of 1,651 studies on Heteroptera. The bibliographic fields of "country", "institutional affiliation" for all authors, and "author" were standardized using the VP software to generate tables and analysis matrices and identify relevant authors, their institutions, and collaboration patterns.

Data analyses

Data analysis was organized into three procedures: 1) productivity analysis; 2) collaboration networks; and 3) main topics and trends. We used the final database or "Heteroptera corpus" (see Additional File 3 at https://zenodo.org/records/10645568) for the productivity analysis and main topics. To analyze the taxonomic trends, we considered a subset of 1,504 references and filtered and counted the number of records belonging to each of the following categories: *Systematics*, *Biogeography and distribution*, and *Agricultural science*.

The productivity was analyzed by year, publication category/subcategory, and the participation by country of the researchers in the studies, using the affiliations reported by the authors. The researcher's affiliations correspond to the laboratory or institution where the study was developed and are not necessarily related to the researcher's nationality. Later, this information was plotted on a World map using Gephi version 0.9.2, specialized software for social network analysis (Bastian et al. 2009), indicating each country's contribution, and the cooperation degree on the scientific production.

For the collaboration networks analysis, co-occurrence matrices were constructed from VP software and then plotted in Gephi, which allowed us to visualize the levels of collaboration and influence exerted by each node (actor) within a network. Here, the actors are the countries, institutions (as institutional affiliations), and authors participating in scientific production. Institutions' networks were built with the top 50 most productive. Similarly, authors' networks were built with those with more than ten publications. We considered various measures to characterize the collaboration exerted by certain actors within collaborative networks on scientific productivity. Degree centrality is the number of connections a particular actor has (Freeman 1979, Vidgen et al. 2007). The higher the degree centrality value is, the more influence an actor has over its neighbors (Yang & Ding 2009). Weighted degree (WD) is similar to degree, but it also considers the weight of the connection (Zhai & Yan 2022). In our case, the weight corresponds to the number of collaborations between actors. Betweenness centrality is a measure that calculates the number of times an actor lies on the shortest path between other actors (Freeman 1979, Newman 2001). Thus, it helps to identify the participation of an actor within networks and can be interpreted as the degree of collaboration among actors (Newman 2005, Yang & Ding 2009). Eigenvector centrality shows that the importance of an actor is influenced by the importance of its neighbors (Vidgen et al. 2007, Yang & Ding 2009).

We analyzed each study individually to identify the research areas or topic trends reported in the scientific literature based on the defined corpus (1,651 studies). We classified the studies using five major topics or categories, with subcategories per major subject (Supplementary Material – Table SI). The classification was based on the information retrieved from the titles and abstracts of the studies. Each reference was assigned to one or two of the subcategories depending on the paper's emphasis; thus, the total number of categorizations totals over 2,000 items. Each of the ten most productive subcategories was plotted by year (1998–2022). To interpret the publication trend for each one through time, a linear regression and correlation squared values (R^2) were calculated from 1998 up to 2021 to avoid bias by having only half the data of 2022. To establish the interest by taxonomic groups, we recorded which family was the focus of each of the 1,504 studies, considering the information available in titles and abstracts. We did not classify 147 references because their scope comprised several families (studies focused on the infraorder or superfamily level), usually catalogs or faunistic inventories. Schuh & Weirauch (2020) were followed for the classification at the family level, for instance, in treating Carpintero's (2014) Lasiochilinae as a separate family from Anthocoridae.

RESULTS

Quantitative trending of Heteroptera productivity

Our search strategy recovered 1,651 studies (an average of 68,7 papers/year), with an evident and continuous growth in the time series analyzed. The year 2021 was the most prolific in number of publications, followed by 2013, with 122 and 107 papers, respectively (Fig. 1, Table SII). The average number of publications during the first ten years (40,9 papers/year) almost doubled in the following decade (82 papers/year).

Considering the number of documents produced in the first analyzed year, 1998 (n=32), and the most prolific year, 2021 (n=112), there was an increment of 381% in published studies. From 1998 to 1999 the number of published papers represented 4.11% of all publications (68 publications, 34 publications/year on average), between 2000 to 2009 was 28.4% (469 publications, 47 on average), between 2010 to 2019, 52.87% (873 publications, 87 papers on average), and between 2020 to mid-2022, 14.59% of the production (241 publications, 96 on average). Similarly, the number of authors publishing studies from LAC has been increasing over time. Between 1998 and 1999, the average number of authors per year was 54; between 2000 and 2009 was 99.4; from 2010 to 2019 was 209.7; and from 2020 to mid-2022 was 260 (see Additional File 4, https://zenodo.org/records/10645588). Regarding the published document typology, 91.16% of the publications correspond to research articles, 5.15% are review papers, 3.15% are scientific notes, and the remaining 2.16% correspond to conference papers, book chapters, letters, and short surveys (Table SIII).

Productivity per country, institution, and author

A productivity ranking of 60 countries (from all continents but Antarctica) was obtained, with 27 having at least five publications on Heteroptera from LAC (Table I). According to the affiliation reported by the authors, Brazil is the most productive country with 748 studies,

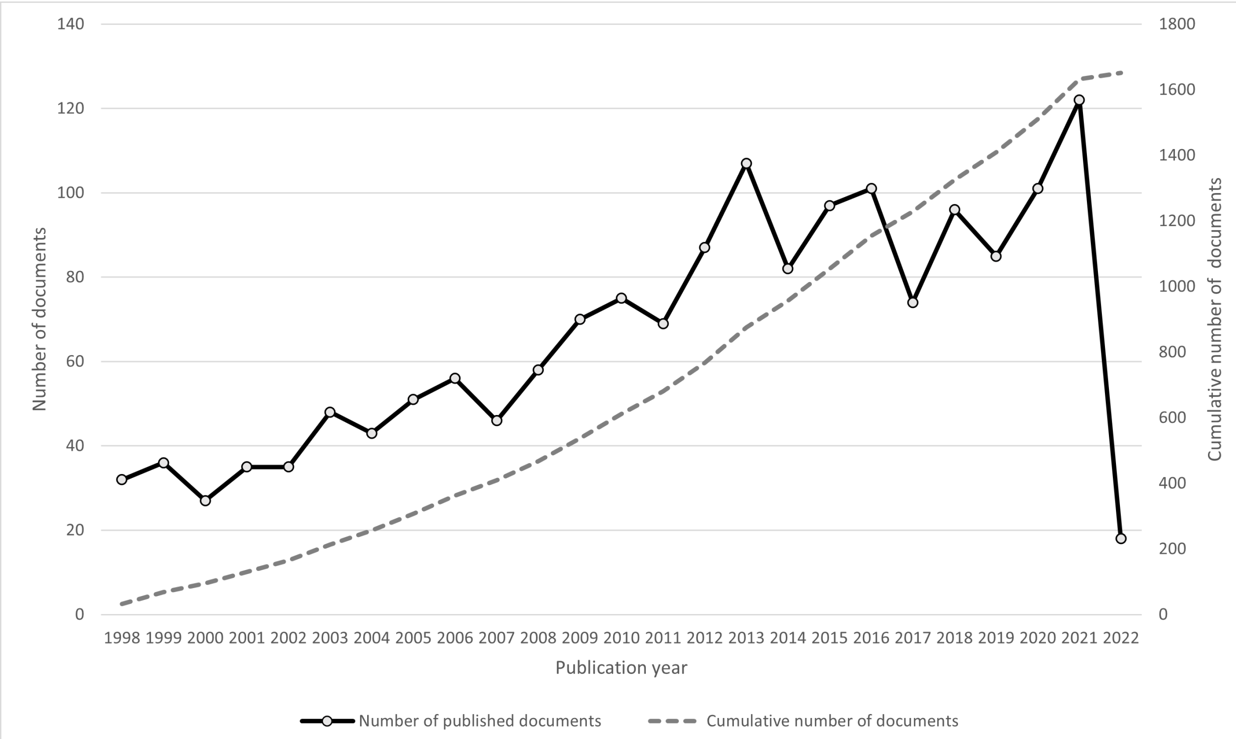

Figure 1. Number of published documents of Heteroptera from LAC from 1998 to mid-2022. Solid line shows the number of documents per year. Broken lines represent the cumulative number of documents.

followed by the USA, Argentina, Mexico, and Colombia. Of those countries with more than five contributions, those from LAC represent 44.4%, and seven of the first ten most productive countries are from LAC (Table I).

Our search strategy identified 600 institutions, of which 30 have contributed the most to the scientific production of Heteroptera studies from LAC (Table SIV). The ten most productive institutions are found in Argentina, Brazil, Mexico, and the USA. The top five institutions are as follows. In Brazil, the institutions that lead the productivity in Heteroptera were the Empresa Brasileira de Pesquisa Agropecuária -EMBRAPA- (157 studies), the Fundação Oswaldo Cruz -FIOCRUZ- (139 studies), and the Universidade Federal do Rio Grande do Sul -UFRGS- (132 studies). In Argentina and Mexico, the Universidad Nacional de La Plata -UNLP- (159 studies) and the Universidad Nacional Autónoma de México -UNAM- (147 studies) lead the productivity, respectively, in their countries.

A total of 2,312 authors were identified publishing on Heteroptera from LAC. Of this total, 1,678 authors (72.57%) have authored only one study each, and 634 authors (27.42%) have contributed with two or more studies each (Additional File 4, https://zenodo.org/records/10645588). Only 31 authors have published 20 or more studies each. The most prevalent researchers were Harry Brailovsky (UNAM, Mexico, n = 119), Jocelia Grazia (UFRGS, Brazil, n = 88), Felipe Figueiredo Moreira (FIOCRUZ, Brazil, n = 70), José Cola Zanuncio (UFV, Brazil, n = 66), Antonio Ricardo Panizzi (EMBRAPA, Brazil, n = 65), Pablo Dellapé (UNLP, Argentina, n = 57), and Hélcio Gil-Santana (FIOCRUZ, Brazil, n = 54) (Supplementary Material – Fig. S2, Table SV).

Table I. **Ranking of the authors' affiliation countries with at least five publications on Heteroptera from LAC between 1998-2022. Countries in bold are from LAC.**

Ranking	Author Affiliation Countries	Number of articles published
1	**Brazil**	748
2	United States	336
3	**Argentina**	256
4	**Mexico**	219
5	**Colombia**	128
6	**Chile**	66
7	France	54
8	**Costa Rica**	20
9	**Uruguay**	19
10	Austria	18
11	Czech Republic	16
12	United Kingdom	15
13	Belgium	14
14	Netherlands	13
15	Spain	12
16	Italy	11
17	**Venezuela**	10
18	Germany	10
19	**Cuba**	9
20	**Panama**	8
21	Poland	8
22	Switzerland	7
23	Denmark	7
24	**Peru**	7
25	Slovenia	7
26	Russia	6
27	**Bolivia**	5

Authorship and collaborative networks

The top five countries with the most international collaborations are Brazil, the USA, Argentina, Mexico, and Colombia (Table II). Brazil showed a high interaction with the USA, followed by a strong interaction with Colombia (Fig. 2, Table II). Nonetheless, the USA showed the highest number of collaborations with LAC countries.

A selection of the most productive institutions shows that the most influential institutions, as shown by their weighted degree centrality values, within a collaborative network (Fig. S1, Table SIV) are EMBRAPA (Brazil), FIOCRUZ (Brazil), the UNLP (Argentina), and the UFRGS (Brazil). These values are closely related to the productivity of each institution, as many of the more productive institutions are also the most influential ones (Table SIV). This also relates to productivity by country, as shown above. For example, EMBRAPA, which leads the scientific productivity in Brazil, has been working in close association with other Brazilian institutions such as the Universidade Federal do Paraná (UFPR) and the Universidade Federal de Viçosa (UFV) (Fig. S1). FIOCRUZ has been working closely with public education Brazilian institutions such as the Universidade Federal do Rio de Janeiro (UFRJ), Universidade Estadual Paulista (UNESP), and Universidade de São Paulo (USP) (Fig. S1). The UNLP has been working closely with the Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET). This institution is the main scientific employer in Argentina and usually corresponds to the second associated institution by an author (double association) because its function is not only to sponsor or foment research, but it is a research institution *per se*. Additionally, there are collaborations with the Universidad de Buenos Aires (UBA) and the Museo Argentino de Ciencias Naturales (MACN), among others. The UFRGS has been working with diverse Brazilian institutions, mostly public education institutions (Universidade de São Paulo, USP; Universidade Federal de São Paulo, UNIFESP) and foreign institutions (Fig. S1). Despite not being LAC institutions, both the Agricultural Research Service (USDA-ARS) and the Smithsonian Institution from the

Table II. Matrix of productivity co-occurrence per country for studies on Heteroptera of LAC between 1998-2022. Top five countries with most studies.

Total records	748	336	256	219	128
	Brazil	**United States**	**Argentina**	**Mexico**	**Colombia**
Brazil	748	63	16	6	36
United States	63	336	25	23	12
Argentina	16	25	256	6	2
Mexico	6	23	6	219	1
Colombia	36	12	2	1	128

USA, had been working in collaboration with several institutions from LAC and showed high productivity in studies of Heteroptera from LAC.

On the collaboration author networks, we identified 7 clusters corresponding to communities of research collaboration (Fig. S2, Table SV), of which five communities stand out. The most interactive community identified is organized around Jocelia Grazia (UFRGS) with 11 co-authors (WD = 99, pale green cluster); the second cluster by José Cola Zanuncio (UFV) with 8 co-authors (WD = 70, brown cluster); the third by Harry Brailovsky (UNAM) with 10 co-authors (WD = 67, orange cluster); the fourth by Felipe Ferraz Figueiredo Moreira (FIOCRUZ) with 12 co-authors (WD = 66, purple cluster); and the fifth cluster by Pablo M. Dellapé (UNLP) with 7 co-authors (WD = 61, blue cluster).

Main topics and topic trends

Of the 27 subcategories used to classify the 1,651 publications, only four have more than 150 papers, corresponding to *Taxonomy of extant species*, *Faunistic inventories and new records*, *Pest species biology*, and *Community ecology* (Fig. S3). Those dealing with the taxonomy of extant species alone represent about a third of all categorizations considered (662 of 2,038). Additionally, there were six subcategories, each comprising between 45 and 84 papers: *Population ecology*, *Morphology of immatures*, *Comparative morphology*, *Natural history*, *Insecticide evaluation*, and *Introduced species* (Fig. S3). Most papers of the data set analyzed were classified into one or two of these 10 subcategories (1,795 categorizations).

The four most published categories have similar publishing trends across the analyzed time series, in which all have increased the number of publications through time (Fig. 3, Fig. S4). The increase in the examined period of *Taxonomy of extant species* and *Faunistic inventories and new records* is strongly correlated with time (R^2 = 0.7258, R^2 = 0.7765 respectively; Fig. S4), whereas in *Pest species biology* and *Community ecology*, although slowly increasing with time, the correlation is not as strong (R^2 = 0.5639, R^2 = 0.3459, respectively; Fig. S4). The number of papers on the *Taxonomy of extant species* reached their maximum number of publications in 2021 (Fig. 3). A similar trend was found in the category *Faunistic inventories and new records*, with a similar uptake in 2021. *Pest species biology* had a maximum number of publications in 2019, whereas *Community ecology* peaked in 2020 (Fig. 3).

The following six most published subcategories have a similarly low average number of publications per year (about 3/year), with an even lower number for *Insecticide evaluation* (2.04/year) and *Introduced species* (1.8/year). Three different publication trends among these six categories can be identified

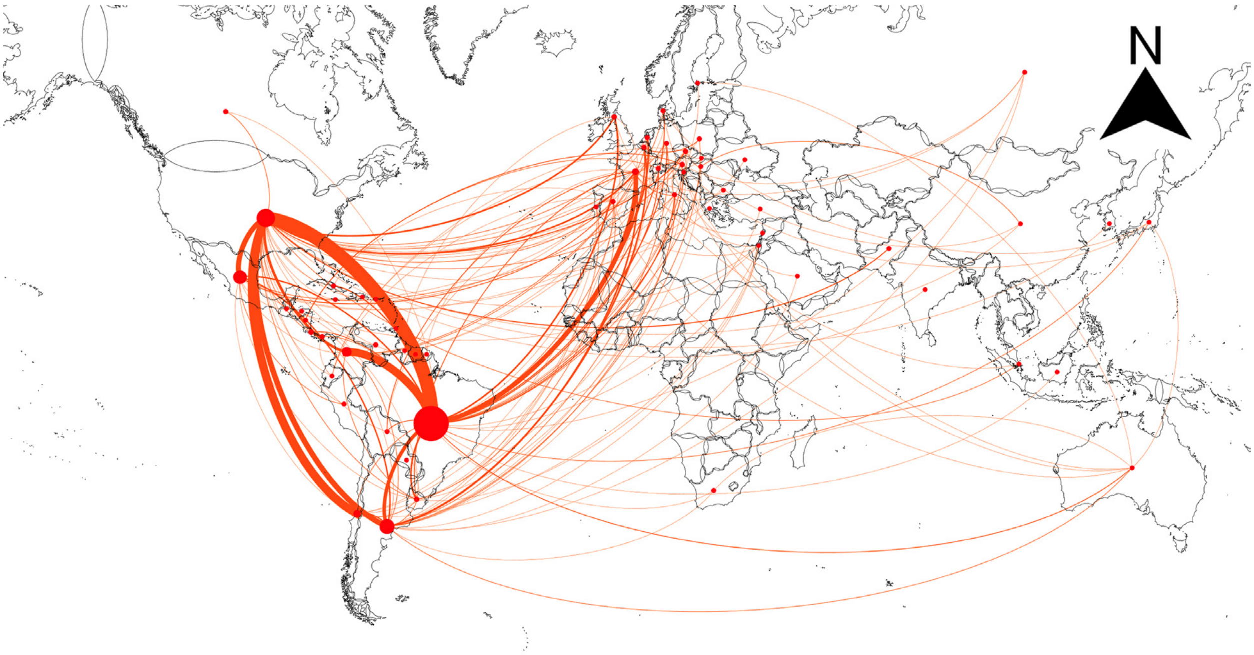

Figure 2. Countries' interactions network on Heteroptera research from LAC from 1998 to mid-2022. Width of lines indicates the number of publications shared by countries.

(Fig. S5, S6). In *Population ecology* the trend is to have a diminishing number of papers per year (10 in 1998, 0 in 2021). On the contrary, the trend in *Morphology of immatures*, *Comparative morphology*, *Insecticide evaluation*, and *Introduced species* is to have a slight increase in the number of publications with time. The subcategory of *Natural history* is the only one in which the publication trend was nearly constant during the time series analyzed (R^2 = 0.001). All the categories have low correlation values with the analyzed time series, about R^2 = 0.19 (Fig. S5), except in *Introduced species*, in which R^2 = 0.4453.

Taxonomic trends

Of the 88 current valid families (*sensu* Schuh & Weirauch 2020), 55 are recorded as the focus of Heteroptera studies in LAC (see Additional File 5 at https://zenodo.org/records/10645595). Most of the families with South American or Caribbean distribution have at least one publication, except for eight families of low diversity, for which no studies were published from 1998 to 2022: Macroveliidae, Hermatobatidae (Gerromorpha); Dipsocoridae (Dipsocoromorpha); Canopidae, Megarididae, Tessaratomidae, and Ninidae (Pentatomomorpha). Five families account for about 60 percent (62.1%) of all evaluated records: Pentatomidae -stink bugs- (29.3%), Reduviidae -assassin bugs- (15%), Coreidae -leaf-footed bugs- (7.8%), Miridae -plant bugs- (7%), and Rhyparochromidae -seed bugs- (3%) (Fig. S7).

Considering only the records on the *Systematics* category, the taxonomic focus for the studies is similar: Pentatomidae (14.3%), Reduviidae (13.5%), Coreidae (10.6%), and Miridae (9,4%), but in this case, the fifth position is occupied by Veliidae -riffle bugs- (8.2%). The records on the *Biogeography and distribution* category show again a similar composition: Reduviidae (20.7%), Pentatomidae (17%), Coreidae (10.3%), and Miridae (6.7%), but in this case, the fifth position is occupied by Gerridae -water striders- and Naucoridae -creeping water bugs- (5.5% each). In the *Agricultural Science*

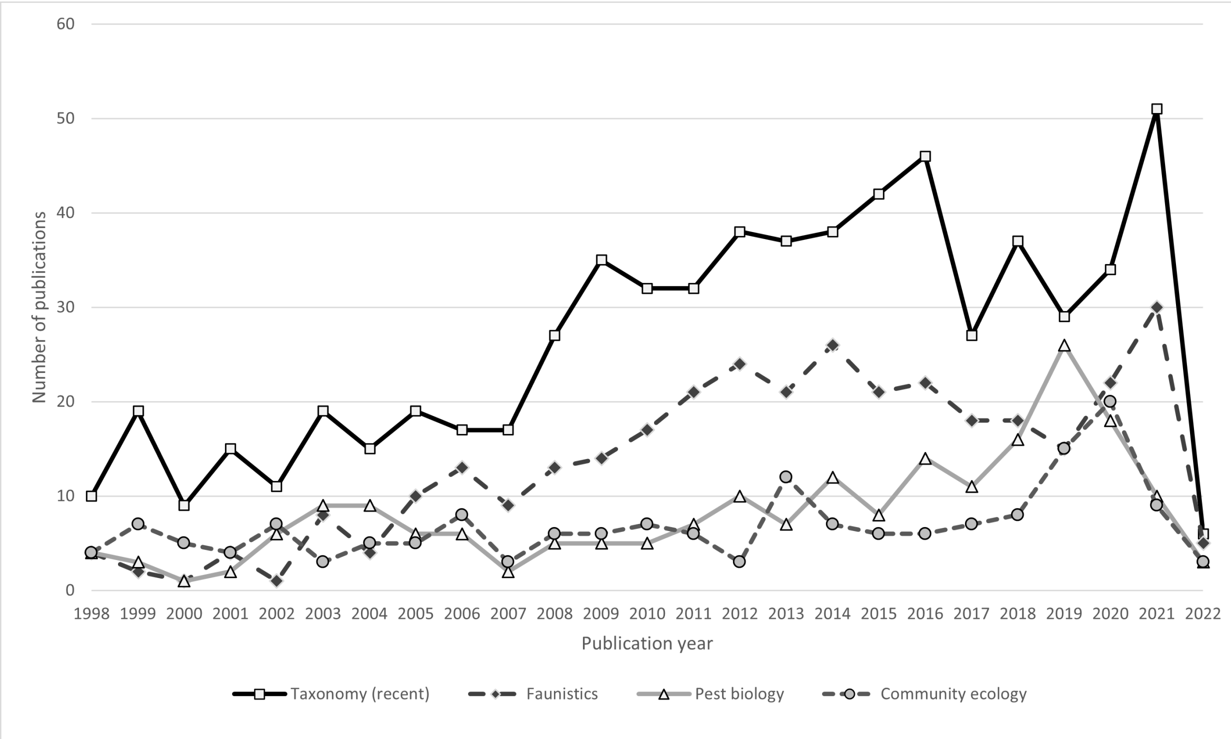

Figure 3. Number of publications per year on the four most productive topics on Heteroptera from LAC between 1998 to mid-2022, *Taxonomy of extant species*, *Faunistic inventories and new records*, *Pest species biology*, and *Community ecology*.

category, the number of studies and taxonomic focus is different: Pentatomidae (67.6%), Miridae (8.1%), Reduviidae (6.8%), Thaumastocoridae (4.1%), and Anthocoridae (3,2%).

DISCUSSION

We aimed to characterize the status of Heteroptera research in LAC during the last 24 years (1998 to mid-2022), highlighting key research areas and publication trends to identify neglected and potential research topics. Our analyses show that the research productivity on true bugs from LAC, measured as published research, has constantly been increasing, supported by collaborative networks of institutions and researchers interacting within and among countries from LAC and other geographic regions. The analyses also demonstrate that the topics more actively investigated are related to biodiversity and pest species biology.

Heteroptera productivity: trajectory and perspectives

Our analyses clearly show that the number of scientific papers on Heteroptera has greatly been increasing during the past 24 years, reaching its highest productivity in 2021 (Fig. 1). The increase is also evident in the number of researchers (Fig. S8) and the type and scope of lines of research (Figs. 3, S5). Four topics are highlighted by their more productive numbers and constant increase: *Taxonomy of extant species*, *Faunistic inventories and new records*, *Pest biology*, and *Community ecology*. We discuss some of the potential factors that could be affecting the sharp increase in research productivity of Heteroptera from LAC.

The annual increase in publications related to Heteroptera from LAC follows a global and regional trend (Dutrénit et al. 2021). Since the middle of the 20th century, there has been an exponential growth in the number of scientific publications (Fire & Guestrin 2019, Ware & Mabe 2015), with a recent increase as well in the number of researchers and scientific journals (Frith 2020, Ware & Mabe 2015). We need to be aware of the consequences of the widespread scientific culture of "publish or perish", which forces researchers to be prolific (Frith 2020, Kiai 2019, Van Dalen 2021). This might be affecting — consciously or not— LAC researchers. Numerous LAC countries have started to implement policies requiring scientists to publish more and in higher ranking (i.e., measured by different metrics such as JCR and Scopus percentile) journals to be competitive (Guzmán-Vásquez & Trujillo Dávila 2011, Sarthou & Araya 2015, Souza et al. 2016). Another reason might be the increased ease of communication among researchers. Nowadays, scientific data can be shared more easily electronically, including various types of data, improving the connectedness and, thus, collaboration among researchers physically set apart, as shown below.

Our analyses also show that the LAC-based researchers generated the largest proportion of the scientific research on Heteroptera in the region, usually collaborating with colleagues and institutions worldwide. For instance, the USA, which is the second country in production, mostly interacts with Brazil, Argentina, Mexico, and Colombia (see below). The high productivity of LAC countries is particularly interesting because, in general, LAC countries invest less in research than other developed and emerging countries (Ciocca & Delgado 2017, Lemarchand 2010), and the disparity in scientific productivity between developed countries and LAC countries in the number of scientific products is remarkable (Nature index 2022, SJR 2022).

Peak productivity of Heteroptera research from LAC was achieved in 2021. In part, this might be due to researchers' confinement because of COVID-19 in 2020–2021. Recent studies evidence the COVID-19 pandemic's effect on scientific research structure in the World and its possible long-term impacts (Gao et al. 2021). The COVID-19 pandemic did not negatively affect the Heteroptera research productivity, as 2021 had been the most productive year in our analysis. Nonetheless, the negative effects of the pandemic will not be shown probably until late 2022 or 2023, data which we did not analyze. Given the strict confinement laws in various countries in LAC, fieldwork and laboratory work were highly restricted, thus creating the right conditions for researchers to finish studies, mainly by allowing writing time for these unfinished projects. It still has to be shown the long-term effects of the pandemic on Heteroptera research in LAC, such as the lack of new enrollment of researchers and students or the impact on scientist women and parents, mainly mothers, for whom there is usually inequality in the distribution of domestic work and childcare (Bender et al. 2022, Pinho-Gomes et al. 2020, Ribarovska et al. 2021).

Latin American Heteropterists networking

Collaboration networks affect academic productivity and offer advantages to researchers as part of these collaborative efforts (Li et al. 2022). Our data suggest a tendency for collaborative and interregional work among just a few countries and institutions, but with an extensive participation of researchers (Figs. 2, S1; Table SV). However, considering the number of institutions (research and universities) and the megadiversity in LAC, the collaborative network is constituted by a small number of participants.

Productivity and collaborative networking are heterogeneous among LAC countries. Brazil, Argentina, Mexico, Colombia, and Chile are the top five most productive countries from LAC (Table I), each with its idiosyncrasies. Each of these countries invests different proportions of their gross domestic product (GDP) in research and development (R&D). Argentina, Chile, and Mexico invested similarly from 2010 to 2018, with values in 2018 ranging from 0.49% (Argentina) to 0.31% (Mexico). Brazil showed higher investment (1.26% in 2017), and Colombia invested the least (0.24% in 2018) (Chaimovich & Pedrosa 2021, Dutrénit et al. 2021). There seems to be a clear relationship between the GDP investments, R&D, the number of graduate programs, and the number of its students (Barreto 2014, Larivière 2012). For example, in Brazil, due to its higher R&D investment (Ciocca & Delgado 2017), scientific research takes place mostly in universities, mainly state and federal ones, and the students are incorporated in the academic networking productivity; a similar trend is observed in Argentina as well. Nonetheless, Heteroptera productivity from Mexico and Chile is mostly the result of single senior researcher efforts (see Table SV), and not from a hub of research institutions or graduate programs, thus suggesting that a high productivity output is not always a direct result of participation in collaborative networks. Likely, this high productivity results from multiple stable job conditions for researchers in Brazil and Argentina, unlike the situation in Colombia.

Three of the most productive institutions are from Brazil (Fig. S1), EMBRAPA, FIOCRUZ, and UFRGS; and one from Argentina (UNLP) (see also Table SIV). This agrees with the largest investment in R&D by these two countries in LAC. It is noteworthy that two of the most productive institutions in Brazil are research-oriented ones (EMBRAPA and FIOCRUZ), focusing on agricultural and biomedical research, and not universities, such as UFRGS (Table SIV). The most productive institutions in LAC tend mostly to collaborate with other institutions within their respective countries, and just a few implement international collaborations (Fig. S1). International collaborations are carried out mainly with institutions in the USA (Table II). For example, the USDA (USA) collaborates with several institutions and countries from LAC, present in the region with research nodes, laboratories, or sponsoring agreements in several areas.

The most productive authors from LAC are part of highly productive countries and institutions (Tables SIV, SV), indicating an interaction between R&D investment programs and academic productivity. Authors also participate in collaborative research networks (Fig. S2). These networks are primarily thematic, being mainly developed within countries, with a few extending their collaboration to other countries and researchers. This could imply that the nature of the research is preferentially carried out with a local or regional focus, with just a few groups encompassing a wider geographic scope. Except in the case of the most productive author on Heteroptera from LAC (Jocelia Grazia), probably related to a long research career, at least in Brazil and Argentina, a researcher's higher productivity closely follows their interaction with other colleagues (Table SV, weighted degree). This finding has significant consequences for the LAC Heteroptera research community because it promotes collaborative and networking projects, which is beneficial and needed.

The establishment of periodical reunions focused on Heteroptera could have influenced the researcher's community collaboration networks (i.e., IHS meetings and South American Workshops). Scientific meetings positively affect the production of papers and the number of co-authorships by encouraging interaction among colleagues (Kwok et al. 2018). From 1998 to date, LAC Heteropterists met in seven Quadrennial Meetings of the International Heteropterists' Society (IHS) and five South American Heteroptera Workshops, besides non-specific broad entomological or zoological events that often take place in South America, such as Argentinean, Brazilian, Colombian, and Latin American congresses of Entomology. It remains to be analyzed if more constant participation in these meetings is correlated with higher productivity, given the chances of meeting new researchers, or having fruitful exchanges of ideas.

International collaboration is also fostered by a wider interest in the Neotropical region, mainly by USA researchers. Besides being a region with massive biodiversity (Habel 2019, Reid 1998), LAC shares a biogeographical history with the Nearctic region (O'Dea et al. 2016). Thus, collaborative works with LAC institutions facilitate the exchange of knowledge, biological material, and regional-specific data (e.g., distributional data, host plants usage, behavior, etc.) with non-LAC researchers. This multinational collaboration between LAC and non-LAC researchers could result in more robust and broad results, but more equitable participation by LAC researchers is needed when working with researchers outside LAC (Armenteras 2021, Ocampo Ariza et al. 2023, Ramírez-Castañeda et al. 2022).

Heteroptera topics: trends and gaps of knowledge

Most of the research published on Heteroptera from LAC in the last 24 years is related to two distinct research areas, biodiversity and pest species biology (Fig. S3). The top two categories in productivity are related to the taxonomy and distribution of the Heteroptera fauna of LAC, with a constant increase in the number of publications per year (Fig. 3). This is likely a reflection of the poor knowledge of the Heteroptera in our region. We still lack adequate distributional information for most species, negatively impacting our understanding of the Neotropical Heteroptera fauna and hampering conservation efforts. Similarly, the strong focus given to the biology of pest species indicates the important role Heteroptera species play in agricultural production in LAC.

Estimates of global species diversity suggest that we have inventoried approximately one-tenth of the extant species. Despite various estimates being widely divergent, all agree that we are far from having adequate taxonomic knowledge of the biota (Engel et al. 2021, González-Oreja 2008). For Heteroptera, there are no particular studies dealing with biodiversity estimates. Still, in the most speciose family of Heteroptera (Miridae), it is assumed that at least half of the diversity remains undescribed (e.g., Cassis et al. 2006, Henry 2017), which is consistent with global diversity estimates for other organisms. Moreover, it is likely that a large proportion of this diversity will become extinct in the current and coming decades due to anthropogenic actions (Engel et al. 2021). In this critical situation, taxonomy should be a priority in research agendas (Dubois 2003, 2010), and immediate efforts must be dedicated to carrying out collaborative fieldwork and improving biological collections, while there is still time (Engel et al. 2021). The high number of taxonomic publications in Heteroptera from LAC is not an indicator that the group is well-known taxonomically; on the contrary, it is a sign of the need for more taxonomic research and not of an exhausted discipline.

Despite great efforts from researchers, solid taxonomic knowledge needs to be improved, or even built, for many Heteroptera taxa from

LAC. This situation helps explain the scarcity of published works of Heteroptera from LAC on topics such as phylogenetics, evolution, and biogeography (Fig. S3), where taxonomic data is critical to start inquiring about these disciplines. Even on those few relatively well-known heteropteran groups, such as the aquatic and semi-aquatic infraorders, the latter disciplines have been barely investigated. Not only these academic disciplines are impacted by an inadequate taxonomy of Heteroptera, but also in other areas such as environmental consultancy.

Community ecology is a category that has an important number of published studies, although the increase in the number of publications throughout the period analyzed has not been as strong as in other categories (Fig. S4). Researchers have been publishing very few studies in other ecological subjects (Fig. S3). This has serious consequences for the understanding of relevant complex ecological phenomena, such as the global decline in insect populations (Eggleton 2020, Raven & Wagner 2021, Wagner 2020) and ecosystem services (Martínez-Harms & Balvanera 2012, Millennium Ecosystem Assessment 2005). Given the mostly tropical location of LAC, studies focusing on these ecological aspects are vital and have far-reaching implications, thus strengthening the need for studies on these ecological disciplines.

After the first four most productive categories, there are six in which the number of publications is still relatively small (Fig. S3). In these, publications dealing with morphology show a trend with a slight increase during the analyzed period (Fig. S6), similar to the situation with publications on insecticide evaluation. This slight increase in publications dealing with morphology might be due to the ease and relatively cheap acquisition of data for different taxa compared to the more expensive molecular data. Nonetheless, these morphological data are not always incorporated into morphological phylogenetic analyses, as evidenced by the scarcity of morphology-based phylogenetic publications (Fig. S3). Research on introduced species has been more common in recent years (Fig. S6), likely a result of the negative impacts of exotic fauna on natural habitats and agricultural systems (Pyšek et al. 2020, Simberloff et al. 2013). Phytosanitary vigilance on exotic species carried out at the country or regional levels across LAC must be based on a sound worldwide taxonomic basis, calling for a more integrated exchange of information among taxonomic researchers worldwide. Natural history publications have remained constant in this analysis, probably due to the low priority given to this kind of data in many journals (Powers et al. 2021). Nonetheless, natural history data is the basis for hypothesis testing in ecology (Cotterill & Foissner 2010), and LAC as a region has great potential for acquiring high-quality data on the natural history of several groups of Heteroptera. The only category that shows a constant decline is the research focusing on population ecology, with the negative consequences mentioned above about the ecological knowledge of Heteroptera from LAC.

When analyzed by taxonomic focus, four families have been the center of Heteroptera research in LAC, Pentatomidae, Reduviidae, Coreidae, and Miridae (see Additional File 5 at https://zenodo.org/records/10645595). These families are mostly studied in two categories: *Systematics* and *Biogeography and distribution*. Miridae and Reduviidae are the two most speciose Heteroptera groups worldwide (Maldonado Capriles 1990, Schuh 2013), making them obvious groups for further systematic and biogeographic research. Miridae represents a curious case because despite being one of the highly published groups, it lacks active specialists in LAC. The emphasis on Pentatomidae and Coreidae could be related in part to their phytophagous habits with several species considered agricultural pests (Schaefer & Panizzi 2000). In addition, these families have been the focus of senior researchers in Brazil (Jocelia Grazia, Pentatomidae) and Mexico (Harry Brailovsky, Coreidae) (Table SV), thus the great publication output shown in the period analyzed. However, there are groups of intermediate diversity with economic importance that have been neglected in the region, as shown by the few publications, such as Tingidae, Cydnidae, or Thyreocoridae (see the Additional File 5 at https://zenodo.org/records/10645595). There are others in which just a few researchers are working, making advances challenging (e.g., Rhyparochromidae).

We have also identified knowledge gaps regarding the categories used in this analysis. In systematics, LAC research is lagging, particularly in the use of molecular data and in integrating it with other types of data, such as morphology or behavior. We identified 22 phylogenetic studies using morphological data, 9 with molecular data, and just 4 with combined data (Fig. S3). We still need to keep generating morphological, and other sorts of data, to be analyzed in a phylogenetic framework. We urge local and regional funding agencies to dedicate more resources to help reduce this gap. Despite the popularization of molecular data, mainly due to continuous descending costs, in particular genomic and transcriptomic data, it is still very expensive for researchers in LAC to generate these sorts of data. Because of the difficulty in integrating several types of data for phylogenetic analyses, other analyses have been affected (Fig. S3). This data should be strengthened and integrated with the incremental knowledge about the morphology, behaviors, and distribution of Heteroptera groups in LAC. There is an opportunity in this respect with the increasing availability of natural history specimen data, for instance via several databases (e.g., GBIF), and by country-level efforts. We suggest that when phylogenetic hypotheses are presented, an effort is to be made and use this information to generate additional analyses, such as ecological niche modeling, phylogeographical or biogeographical analyses, or morphological evolutionary trait analyses.

In the agricultural science category, the gap may lie in each country's relative effort to address local problems. As shown in our analyses, a few research centers (e.g., EMBRAPA in Brazil) are leading the generation of information regarding pest species. The opportunity may be to collaborate among country-level agricultural institutions to assess for various crops the set of species affecting those crops to then start researching how to manage those species within a particular country-level problematic. Integrating data from other disciplines, such as chemical ecology, might benefit these efforts. As mentioned above, ecological research on Heteroptera is only being carried out at the community ecology level, but other types of ecological assessments are lacking. We consider that there is a gap in evaluating the roles of different Heteroptera species within given Neotropical ecosystems. If we want to use Heteroptera species as bioindicators or biological control agents in integrated pest management plans, we need stronger ecological knowledge. Finally, we call attention to new research areas in Heteroptera, such as the study of symbiotic microorganisms or the use of novel molecular techniques, to keep strengthening the knowledge of Heteroptera in LAC.

Outlook and perspectives for Heteroptera studies in LAC

Our analysis shows that despite country-level and regional-level structural challenges regarding investment in R&D and graduate education, LAC shows great potential for significantly advancing our knowledge of the Heteroptera fauna in multiple disciplines.

We highlight the opportunities we have identified by the categories analyzed. Taxonomy is still an active and necessary area that will allow further developments in other areas, such as phylogenetic and biogeographic analyses, ecology, and pest species biology. We still have much to discover and learn in our region. We urgently need to propose phylogenetic hypotheses in all the taxonomic groups, particularly incorporating additional datasets besides adult morphology, such as immature morphology, morphometric, and molecular data. It can be achieved by reusing the morphological data already produced and by strengthening fieldwork to acquire tissue samples for molecular data regularly and systematically. Within a regional or intercontinental network of researchers, these data and tissues could be easily shared, and more robust hypotheses could be advanced.

Basic information such as species distribution and natural history data, though relatively easy to acquire, is extremely necessary to propose and test biogeographical and ecological hypotheses. Furthermore, these data will strengthen other disciplines, such as integrated pest management in agricultural science, particularly if biological control is to be implemented for several agricultural pest species.

Although little mentioned in our analysis, biological or natural history collections are the repositories for the wealth of data that researchers from LAC are producing in disciplines such as systematics or biogeography. There is an urgent need to have active and well-maintained natural history collections and active researchers (curators) investigating those collections. With the information contained in natural history collections and used by several other types of researchers and the general public, we will gain a better knowledge of Heteroptera and their distribution in LAC. Active biological collections are needed to rapidly document our vanishing biota.

A more integrated approach to research on Heteroptera is needed for LAC. Disciplines are more connected than ever, making it necessary for researchers in different areas to communicate and exchange data and ideas. Problems related to agricultural science, biodiversity conservation, evolution, and others, would be boosted with a more active flow of ideas.

Finally, we want to stress the importance of actively engaging in academic networks, be it meetings or focal working groups at the local or international level. Despite the megadiversity of Heteroptera in LAC, comparatively, the number of researchers participating in collaborative networks is still very small. This can be enhanced by encouraging graduate students to participate more actively in them. The vigorous exchange of ideas among researchers from different countries might help to further fund projects with a wider, international focus. In turn, this can result in more research being communicated, with a wider scope, generating novel avenues of inquiry.

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APPENDIX 1. Search strategy per bibliographic database of Heteroptera studies from Latin America and the Caribbean. Date of search and download of references June 13th, 2022. The total number of references was 3,710; the number of duplicated and deleted references was 2,059. The final total number of references used for the analyses is 1,651.

Bibliographic database	Query	Number of documents
Web of Science Core Collection (Core Collection contains information since 2001)	TS=(Heteroptera AND (belostomat* OR nep* OR gelastocor* OR ochter* OR corix* OR potamocor* OR naucor* OR notonect* OR ple* OR helotreph* OR mesoveli* OR hebr* OR hydrometr* OR macroveli* OR hermatobat* OR gerr* OR veli* OR ceratocomb* OR schizopter* OR dipsocor* OR aenictopeche* OR enicocephal* OR leptopod* OR sald* OR pachynom* OR reduvi* OR thaumastocor* OR mir* OR ting* OR vianaid* OR nab* OR lasiochil* OR plokiophil* OR lyctocor* OR anthocor* OR cimic* OR polycten* OR arad* OR termitaphid* OR idiostol* OR acanthosomat* OR canop* OR cydn* OR dinidor* OR megarid* OR pentatom* OR cyrtocor* OR phloe* OR platasp* OR scuteller* OR tessaratom* OR larg* OR pyrrhocor* OR alyd* OR core* OR rhopal* OR stenocephal* OR beryt* OR bliss* OR colobathrist* OR cym* OR geocor* OR lygae* OR nin* OR oxycaren* OR pachygront* OR piesmat* OR rhyparochrom*) AND (Beli?e OR "Costa Rica" OR "El Salvador" OR Guatemala OR Honduras OR M??ico OR Nicaragua OR Panam? OR Argentina OR Bolivia OR Bra?il OR Chile OR Colombia OR Ecuador OR "French Guiana" OR Guyana OR Paraguay OR Uruguay OR Per? OR Venezuela OR Surinam OR (Antigua NEAR/1 Barbuda) OR Aruba OR Bahamas OR Barbados OR "Cayman Islands" OR Cuba OR Dominica OR "Dominican Republic" OR Grenada OR Guadeloupe OR Haiti OR Jamaica OR Martinique OR "Puerto Rico" OR "Saint Barth?lemy" OR "St. Barth?lemy" OR (St. Kitts NEAR/1 Nevis) OR (Saint Kitts NEAR/1 Nevis) OR "St. Lucia" OR "Saint Lucia" OR (St. Vincent NEAR/1 the Grenadines) OR (Saint Vincent NEAR/1 the Grenadines) OR (Trinidad NEAR/1 Tobago) OR (Turks NEAR/1 Caicos Island*) OR "Virgin Island*" OR latinamerica* OR "latin america*" OR southamerica* OR "south america*" OR "central America*" OR caribbean) NOT Trypano*) AND PY=(1998-2022)	1.218

APPENDIX 1. Continuation.

Scopus	TITLE-ABS-KEY (heteroptera AND (belostomat* OR nep* OR gelastocor* OR ochter* OR corix* OR potamocor* OR naucor* OR notonect* OR ple* OR helotreph* OR mesoveli* OR hebr* OR hydrometr* OR macroveli* OR hermatobat* OR gerr* OR veli* OR ceratocomb* OR schizopter* OR dipsocor* OR aenictopeche* OR enicocephal* OR leptopod* OR sald* OR pachynom* OR reduvi* OR thaumastocor* OR mir* OR ting* OR vianaid* OR nab* OR lasiochil* OR plokiophil* OR lyctocor* OR anthocor* OR cimic* OR polycten* OR arad* OR termitaphid* OR idiostol* OR acanthosomat* OR canop* OR cydn* OR dinidor* OR megarid* OR pentatom* OR cyrtocor* OR phloe* OR platasp* OR scuteller* OR tessaratom* OR larg* OR pyrrhocor* OR alyd* OR core* OR rhopal* OR stenocephal* OR beryt* OR bliss* OR colobathrist* OR cym* OR geocor* OR lygae* OR nin* OR oxycaren* OR pachygront* OR piesmat* OR rhyparochrom*) AND (beli?e OR “Costa Rica” OR “El Salvador” OR guatemala OR honduras OR m??ico OR nicaragua OR panam? OR argentina OR bolivia OR bra?il OR chile OR colombia OR ecuador OR “French Guiana” OR guyana OR paraguay OR uruguay OR per? OR venezuela OR surinam OR (antigua W/1 barbuda) OR aruba OR bahamas OR barbados OR “Cayman Islands” OR cuba OR dominica OR “Dominican Republic” OR grenada OR guadeloupe OR haiti OR jamaica OR martinique OR “Puerto Rico” OR “Saint Barth?lemy” OR “St. Barth?lemy” OR (st. kitts W/1 nevis) OR (saint kitts W/1 nevis) OR “St. Lucia” OR “Saint Lucia” OR (st. vincent W/1 the grenadines) OR (saint vincent W/1 the grenadines) OR (trinidad W/1 tobago) OR (turks W/1 caicos island*) OR “Virgin Island*” OR latinamerica* OR “latin america*” OR southamerica* OR “south america*” OR “central America*” OR caribbean) AND NOT trypano*) PUBYEAR > 1997	1.184
SciELO.org Búsqueda tema y países del índice (Search subject and index countries Excludes South Africa and public health collection)	subject:(heteroptera) AND (belostomat* OR nep* OR gelastocor* OR ochter* OR corix* OR potamocor* OR naucor* OR notonect* OR ple* OR helotreph* OR mesoveli* OR hebr* OR hydrometr* OR macroveli* OR hermatobat* OR gerr* OR veli* OR ceratocomb* OR schizopter* OR dipsocor* OR aenictopeche* OR enicocephal* OR leptopod* OR sald* OR pachynom* OR reduvi* OR thaumastocor* OR mir* OR ting* OR vianaid* OR nab* OR lasiochil* OR plokiophil* OR lyctocor* OR anthocor* OR cimic* OR polycten* OR arad* OR termitaphid* OR idiostol* OR acanthosomat* OR canop* OR cydn* OR dinidor* OR megarid* OR pentatom* OR cyrtocor* OR phloe* OR platasp* OR scuteller* OR tessaratom* OR larg* OR pyrrhocor* OR alyd* OR core* OR rhopal* OR stenocephal* OR beryt* OR bliss* OR colobathrist* OR cym* OR geocor* OR lygae* OR nin* OR oxycaren* OR pachygront* OR piesmat* OR rhyparochrom*) AND NOT (trypano*) AND in:(“scl” OR “mex” OR “chl” OR “arg” OR “col” OR “cri” OR “cub” OR “per” OR “ury” OR “ven”) AND year_cluster:(“2022” OR “2021” OR “2020” OR “2019” OR “2018” OR “2017” OR “2016” OR “2015” OR “2014” OR “2013” OR “2012” OR “2011” OR “2010” OR “2009” OR “2008” OR “2007” OR “2006” OR “2005” OR “2004” OR “2003” OR “2002” OR “2001” OR “2000” OR “1999” OR “1998”)	442
ProQuest Biological Science Database ProQuest Latin America & Iberia Database	(TI,AB,SU(Heteroptera) AND TI,AB,SU(belostomat* OR nep* OR gelastocor* OR ochter* OR corix* OR potamocor* OR naucor* OR notonect* OR ple* OR helotreph* OR mesoveli* OR hebr* OR hydrometr* OR macroveli* OR hermatobat* OR gerr* OR veli* OR ceratocomb* OR schizopter* OR dipsocor* OR aenictopeche* OR enicocephal* OR leptopod* OR sald* OR pachynom* OR reduvi* OR thaumastocor* OR mir* OR ting* OR vianaid* OR nab* OR lasiochil* OR plokiophil* OR lyctocor* OR anthocor* OR cimic* OR polycten* OR arad* OR termitaphid* OR idiostol* OR acanthosomat* OR canop* OR cydn* OR dinidor* OR megarid* OR pentatom* OR cyrtocor* OR phloe* OR platasp* OR scuteller* OR tessaratom* OR larg* OR pyrrhocor* OR alyd* OR core* OR rhopal* OR stenocephal* OR beryt* OR bliss* OR colobathrist* OR cym* OR geocor* OR lygae* OR nin* OR oxycaren* OR pachygront* OR piesmat* OR rhyparochrom*) AND TI,AB(Beli?e OR “Costa Rica” OR “El Salvador” OR Guatemala OR Honduras OR M??ico OR Nicaragua OR Panam? OR Argentina OR Bolivia OR Bra?il OR Chile OR Colombia OR Ecuador OR “French Guiana” OR Guyana OR Paraguay OR Uruguay OR Per? OR Venezuela OR Surinam OR (Antigua NEAR/1 Barbuda) OR Aruba OR Bahamas OR Barbados OR “Cayman Islands” OR Cuba OR Dominica OR “Dominican Republic” OR Grenada OR Guadeloupe OR Haiti OR Jamaica OR Martinique OR “Puerto Rico” OR “Saint Barth?lemy” OR “St. Barth?lemy” OR (St. Kitts NEAR/1 Nevis) OR (Saint Kitts NEAR/1 Nevis) OR “St. Lucia” OR “Saint Lucia” OR (St. Vincent NEAR/1 the Grenadines) OR (Saint Vincent NEAR/1 the Grenadines) OR (Trinidad NEAR/1 Tobago) OR (Turks NEAR/1 Caicos Island*) OR “Virgin Island*” OR latinamerica* OR “latin america” OR “latin american” OR “latin americanist” OR “latin americans” OR southamerica* OR “south america” OR “south american” OR “south americans” OR “south americas” OR “central america” OR “central american” OR “central americans” OR “central americas” OR caribbean) NOT TI,AB,SU(Trypano*)) AND YR(1998-2022)	214
Redalyc	Heteroptera Search query between 1998-2022	652

SUPPLEMENTARY MATERIAL

Figure S1-S8.
Table SI-SV.

How to cite

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