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Soil fauna and ecosystem functions: Current knowledge and future perspectives in Latin America

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A B S T R A C T

Soil supports a large number of organisms that regulate multiple ecosystem functions globally. Nevertheless, research addressing soil fauna and ecosystem functioning in Latin America remains limited in scope and fragmented across countries, limiting our understanding of developing effective soil conservation strategies. This study assessed the geographical and biome distribution of research efforts, trends in scholarly networks, the taxonomic focus of soil fauna, ecosystem functions, and soil properties. We conducted a systematic literature review of 388 publications from 1989 to 2024, analyzing the relationships between soil fauna, ecosystem functions (e.g., litter decomposition, soil respiration, bioturbation, nutrient cycling), and soil properties (e.g., pH, soil organic carbon, macronutrients). Our analysis revealed a strong geographic bias, with most studies conducted in Brazil (42%) and tropical forests (67%), with scarce collaboration between Latin American countries. Most studies addressed macrofauna (68%), whereas meso- (25%) and microfauna (6%) received less attention. Most articles studied soil properties (84%) in comparison with ecosystem functions (41%). Decomposition was the most investigated soil function (23%), while others (e.g., fertility, bioturbation) were less studied. Our review highlights significant geographic and thematic gaps in soil fauna and ecosystem function studies. Promoting local and regional scientific networks could facilitate the exchange of research resources and taxonomic expertise for studying soil fauna and ecosystem functions in Latin America.

1. Introduction

Soil is a crucial reservoir of biodiversity, hosting approximately 59% of Earth's known species (Anthony et al., 2023). This biodiversity is essential for regulating multiple ecosystem functions and services, including soil structure maintenance, water infiltration (Brussaard, 2012), nutrient cycling and decomposition (Bardgett and van der Putten, 2014; Delgado-Baquerizo et al., 2020). Despite their importance, soil organisms have traditionally been ignored in environmental public policies and overlooked in conservation strategies (Parnell et al., 2025), especially in developing countries across the Global South. This is particularly concerning given that these regions harbor a substantial portion of the Earth's species, with 15 of the 17 megadiverse countries and 26 of 36 hotspots (Mittermeier and Mittermeier, 1997; Hoffman et al., 2016), yet data on soil biodiversity remains especially scarce (Brown et al., 2024; Guerra et al., 2020; Marín et al., 2022). This lack of

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research hampers a comprehensive understanding of the relationship between belowground communities and ecosystem functions, a topic that is essential for the development of effective soil conservation strategies in Latin America.

Among the diverse groups of soil organisms, soil fauna encompasses a wide range of species, which are classified based on their size into microfauna (e.g., nematodes; <100 μm), mesofauna (e.g., mites and springtails; 100 μm-2 mm), and macrofauna (e.g., insects, myriapods, molluscs, and earthworms; >2 mm) (Swift et al., 1979). Collectively, the global biomass of these soil fauna groups exceeds that of humans. According to Bar-On et al. (2018), the combined biomass of annelids (~0.2 Gt C), terrestrial arthropods (~0.2 Gt C), and nematodes (~0.02 Gt C) reaches approximately 0.42 Gt C. This total is seven times greater than the global human biomass (~0.06 Gt C). Beyond their biomass dominance, these organisms span all trophic levels, including detritivores, microbivores, predators, omnivores, and herbivores (Potapov et al., 2022a). In recent years, several global synthesis studies have provided critical insights into the global distribution, abundance, and diversity of soil fauna in general as well as of key animal groups, such as nematodes (van den Hoogen et al., 2019), springtails (Potapov et al., 2023), macrofauna (Lavelle et al., 2022), and earthworms (Phillips et al., 2019). Nevertheless, a consistent trend emerging from these efforts is the limited geographic scope of research, with some regions, particularly Latin America, being notably underrepresented (Guerra et al., 2020; but see Lavelle et al., 2022).

Substantial progress has been made in recent decades in reviewing macroecological studies to address knowledge gaps in soil biodiversity and ecosystem functioning. However, there are striking differences between global and regional reviews regarding the scope of the available research. When synthesizing information at a global scale, Guerra et al. (2020) found that only 0.3% of the analyzed data provided information on both soil biodiversity and ecosystem functioning. In contrast, a similar synthesis focusing on South America reported that 18% of the reviewed studies included both aspects (Marín et al., 2022). This discrepancy suggests that while integrated research is extremely scarce in the global literature, regional efforts in South America have achieved a higher degree of integration. Consequently, patterns emerging from global studies may not accurately reflect regional dynamics, emphasizing the need for localized ecological assessments. There is a growing need to investigate whether the findings from global-scale analyses such as Guerra et al. (2020) apply to regional contexts, especially in underrepresented and less-explored regions. In this context, language barriers may be a key factor in the underrepresentation of Latin American countries in global syntheses. Recent studies emphasize that overlooking non-English language science risks excluding critical data (Amano et al., 2023; Amano and Berdejo-Espinola, 2024; Arenas-Castro et al., 2024). Thus, any research published in either Spanish, the primary language in most Latin-American countries, or Portuguese, as in Brazil, may be overlooked.

Implementing effective conservation strategies in Latin America requires a clear understanding of the state of the art of scientific production on soil fauna and ecosystem functioning in the region. To date, no comprehensive research synthesis has been made on this topic. Latin America is known for its high biodiversity and the diversity of biomes, from extreme arid lands such as the Atacama desert to tropical rainforests in the Amazon (Eva et al., 2004). However, this region is undergoing significant land use changes, mainly driven by alarming deforestation rates to establish productive sites, with projections estimating that over 60% of its territory will be transformed into cultivated areas by 2100 (Catellanos et al., 2022). In addition to land use changes, the effects of fires, invasive species, and climate change threaten belowground biodiversity, including soil fauna (FAO et al., 2020).

Additionally, Latin America is one of the most socio-economic unequal regions in the world (Dutrénit et al., 2021). This inequality translates into significant disparities in scientific development. For instance, according to the latest UNESCO Science Report (Dutrénit et al., 2021), the region has only 593 researchers per million inhabitants, a significantly lower number compared to North America and Europe, with 4432 and 4069, respectively. Furthermore, within Latin America, the number of scientific publications in 2019 varied widely, ranging from 11 to 633 publications per million inhabitants, with Chile leading in scientific output per capita (Dutrénit et al., 2021). Differences in scientific production among countries in Latin America are influenced by several factors, including differences in financial resources, access to research grants, availability of laboratory infrastructure, equipment, and limited opportunities for international collaboration. For instance, investment in research and development in Latin America represents only 0.66% of GDP, significantly lower than that in North America (2.73%) and Europe (1.78%) (Dutrénit et al., 2021).

In Latin America, comprehensive systematic reviews focusing on soil fauna, functions, and properties are still needed to guide future research and monitoring efforts (Guerra et al., 2021). We conducted a systematic literature review focused on understanding the trends and scholarly networks related to soil fauna, functions, and properties in countries of Latin America; the geographical and ecological distribution of studies across the region's countries; the knowledge gaps in soil taxonomic groups, functions, properties; and the most commonly used taxonomic and functional community or population-level metrics in soil fauna research.

2. Methods

2.1. Literature search and inclusion criteria

We performed an exhaustive and systematic literature search in Scopus and Web of Science databases (up to 19th February 2024). We used the following keyword combination that linked soil fauna, functions and properties in Latin America countries: ["South America" OR Sudamerica OR "America do Sul" OR "Latin America" OR "Latinoamerica" OR Argentina OR Bolivia OR Brazil OR Chile OR Colombia OR "Costa Rica" OR Cuba OR "Dominican Republic" OR "Republica Dominicana" OR Ecuador OR "El Salvador" OR Guatemala OR Haiti OR Honduras OR Mexico OR Nicaragua OR Panama OR Paraguay OR Peru OR Uruguay OR Venezuela] AND [soil* OR belowground OR suelo* OR solo*] AND [animal* OR fauna* OR inverteb* OR arthropod* OR artropo* OR collembola OR springtail OR colembolo* OR acari OR mite* OR acaro* OR termit* OR isoptera OR earthworm* OR minhoca* OR annelida OR lombri* OR araneae OR spider* OR aran* OR nematod* OR isopoda OR coleoptera OR beetle* OR escarab* OR hormiga* OR formicidae OR formiga* OR enchytraeid* OR enquitrei*] AND ["nutrient cycling" OR "ciclado de nutrientes" OR "ciclagem de nutrientes" OR "organic matter" OR "materia organica" OR carbon* OR stabilization OR estabiliza* OR bioturba* OR transloca* OR "water infiltration" OR "infiltração de água" OR "infiltracion del agua" OR "soil structure" OR "estructura del suelo" OR "estrutura do solo" OR aggregates OR agregados OR "pore formation" OR "formação de poros" OR "formacion de poros" OR decomposi* OR descomp* OR herbivor* OR predation OR predação OR predacion OR fungivor* OR microbivor OR pathogen*]. In Scopus, we restricted our search to articles classified under agricultural, biological, and environmental sciences, while in Web of Science, we limited it to the Core Collection. The selected keywords allowed us to cover publications studying soil fauna and soil properties and functions in English, Portuguese, and Spanish. These searches retrieved 3108 potential studies. After removing duplicates, we thoroughly examined the articles by reviewing their titles, abstracts, and full texts to identify publications meeting the following eligibility criteria: (a) the study was conducted in a Latin American country, (b) it reported richness, diversity, abundance, and/or presence/absence of soil fauna groups, and (c) it included data on soil properties and/or functions. In addition, we included relevant papers indexed in the SciELO database to ensure a more comprehensive coverage of Latin American literature. Our final database comprised 388 studies that met these criteria (Figure S1; for the literature included, see the Appendix: Data sources).

2.2. Bibliometric analysis

We conducted a bibliometric analysis using Biblioshiny (version 3.04) (Aria and Cuccurullo, 2017) to assess temporal trends of scientific publications on soil fauna, functions, and properties in countries of Latin America from 1989 to 2024. To visualize the geographic distribution of the selected studies in the different biomes across Latin America, we extracted the location of the studies (coordinates) and generated a map using the *sf* (Pebesma and Bivand, 2023) and *ggplot2* (Wickham, 2016) packages in R. The *sf* package was employed to handle and manipulate spatial data of the studies, while *ggplot2* was used for plotting and customizing the map. Coordinates were used to accurately assign each sampling point to a biome, following Olson et al., (2001), using the RESOLVE Ecoregions database (Dinerstein et al., 2017) and the original colour coding for clarity. This database was also used to obtain the total biome area in Latin America, and then estimate how represented each biome was in the literature, as the number of articles per area. Also, we estimated the number of researchers per million inhabitants for each country. In addition, we analyzed international collaboration networks within Latin America and outside this region, based on affiliation data of co-authors in the dataset. Finally, we conducted a co-occurrence network of keywords analysis using VOSviewer (van Eck and Waltman, 2010) to examine the conceptual structure of the literature on our topic of interest. This method is widely employed in bibliometric reviews to identify major research themes, explore their relationships, and reveal key research clusters (Donthu et al., 2021). The analysis was based on keywords provided by authors in the original publications as well as indexed keywords curated by database systems. Only terms appearing at least 5 times in the dataset were included for analysis, resulting in a total of 42 keywords. Irrelevant terms were excluded, and synonymous terms representing the same concept were collapsed into a single term.

2.3. Systematic review

A systematic review was undertaken to examine soil fauna (taxonomic) groups, functions, and properties, including community- or population-level metrics within the context of soil fauna research. The following information was also extracted from selected articles: year of publication, country, taxonomic resolution of soil fauna, body size classification, feeding guilds, the soil fauna metrics measured (e.g., richness, diversity, abundance), and the respective soil functions and/or properties evaluated. We first gathered soil fauna into the most prevalent high-rank taxa reported in the literature: Acari, Annelida, Arachnida, Collembola, Crustacea, Diplura, Gastropoda, Insecta, Myriapoda, Nematoda, and Protura. Although Acari is part of Arachnida, we analyzed it separately because Acari is one of the most abundant and functionally diverse groups of soil mesofauna, contributing significantly to multiple ecosystem functions (Potapov et al., 2022a). When provided, finer taxonomic resolutions were also extracted (Table S1). Additionally, we classified soil fauna based on their body size, following (Swift et al., 1979), into: microfauna (<100 μm), mesofauna (100 μm-2 mm), and macrofauna (>2 mm). Also, we classified soil fauna into feeding guilds only when this information was explicitly provided by the authors. Four categories of feeding guilds were delimited: "detritivores", which included detritivores, bacterivorous, fungivores, and saprophages (following Potapov et al., 2022a); "natural enemies", which involved predators and parasitoids; "omnivores", those fauna groups feeding on two or more trophic levels; and "herbivores" for those fauna groups consuming live plant tissues. Finally, we considered the following soil fauna metrics: coarse taxonomic richness (e.g., richness at a coarse resolution: Class, Subclass, Order or Family level), species richness, diversity index (e.g., Shannon, Simpson or Pielou), activity (e.g., when articles indirectly evaluated the role of soil fauna in soil functions without measuring specific metrics of the organisms themselves), composition, biomass, coarse taxonomic abundance (e.g., abundance at a coarse resolution: Class, Subclass, Order or Family level), and feeding guilds abundance.

To visualize the proportion of studies performed on each soil fauna group, functions, and properties, Chord diagrams were generated using the R *circlize* package (Gu et al., 2014). Heatmaps were used to examine the frequency of studies that simultaneously evaluated specific soil fauna groups alongside multiple soil functions or properties. These analyses were conducted in R v.4.1.1 environment (R Core Team, 2019).

3. Results

3.1. Geographical and biome biases in research effort

We selected 388 studies on soil fauna and their relationship with soil functions and properties conducted across 15 countries of Latin America. The dataset reveals that certain biomes and countries were more extensively studied than others (Fig. 1A). Tropical and subtropical moist broadleaf forests occupy the largest area in Latin America and consequently, are the most studied biome in our database, with 55% of articles (Fig. 1B). This trend is followed by tropical and subtropical grasslands, savannas and shrublands, and tropical and subtropical dry forests, with 20% and 13% of studies, respectively (Fig. 1B). When accounting for the percentage of terrestrial land these biomes occupy in Latin America, we also found that tropical and subtropical moist broadleaf forests were the best represented (Fig. 1C). However, they were followed by tropical and subtropical dry forests, and mediterranean forests, woodlands, and scrub.

The distribution of scientific production across Latin American countries appears to be partially associated with differences in national research capacity. Brazil accounted for the largest proportion of studies in our dataset (42% of all studies), followed by Mexico (15%), Argentina (11%), Colombia (11%), and Costa Rica (4%) (Fig. 1D). In contrast, some countries remain largely unexplored in this research field, including Bolivia and Guatemala, for which we found no studies meeting our inclusion criteria. Nevertheless, it is important to note that some research on soil macrofauna has been conducted in Bolivia (Lavelle et al., 2022), although these studies did not satisfy the criteria required for inclusion in our systematic review. In addition, Uruguay, Paraguay, and Cuba each accounted for less than 1% of the total studies. These patterns reveal a strong geographic imbalance in research efforts across the region.

The strong variation in the number of researchers per million inhabitants across Latin American countries highlights substantial inequalities in scientific capacity (Fig. 1E). Mexico, Brazil, and Argentina emerge as leading countries in this research field, combining a high number of published articles with a relatively large researcher community (Fig. 1 D, E). Costa Rica also stands out for its high density of researchers per capita, suggesting considerable potential to contribute to future research in this field. However, the relationship between scientific production and the number of researchers per capita is not strictly proportional, indicating that additional factors, such as national research funding, institutional capacity, and the presence of established research networks, may further shape the distribution of scientific production in the region. Finally, we found a few disparities when considering the terrestrial surface area of each country, too. Despite leading the proportion of studies on our topic of interest, Brazil was not among the best-represented countries relative to their geographical area. This rank was led by Mexico, followed by Colombia (Fig. 1F).

3.2. Temporal trends and the development of scholarly networks

Our data showed an increase in publication rates since the mid-2000s, with the number of publications reaching a peak of 28 articles in 2018 (Fig. 2). However, the increase was not constant, with some

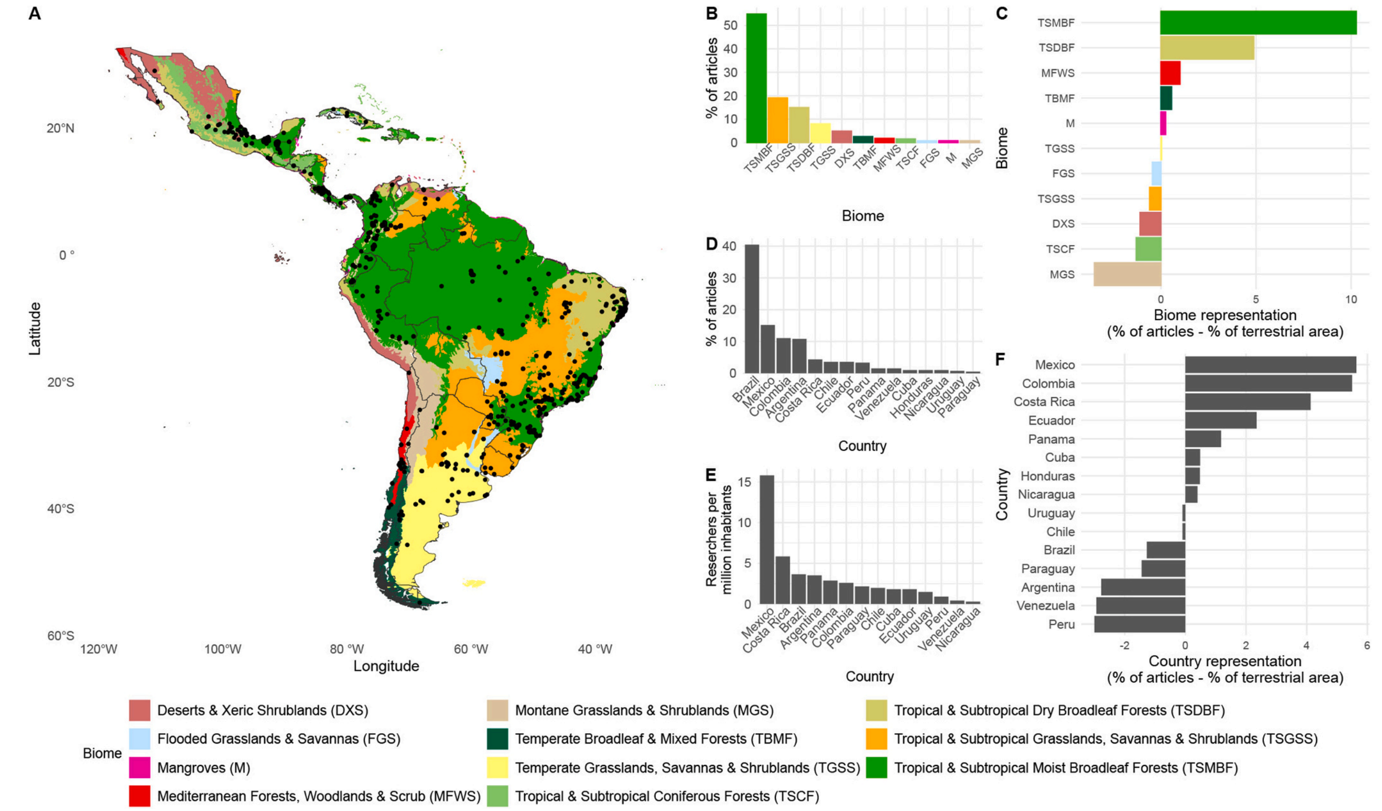

Fig. 1. Geographic distribution and biome representation of the articles included in this review. A) Location of the study sites, B) Percentage of articles per biome, C) Biome representation accounting for terrestrial coverage, D) Percentage of articles per country, E) Researchers per million inhabitants for each country., F) Country representation accounting for terrestrial coverage.

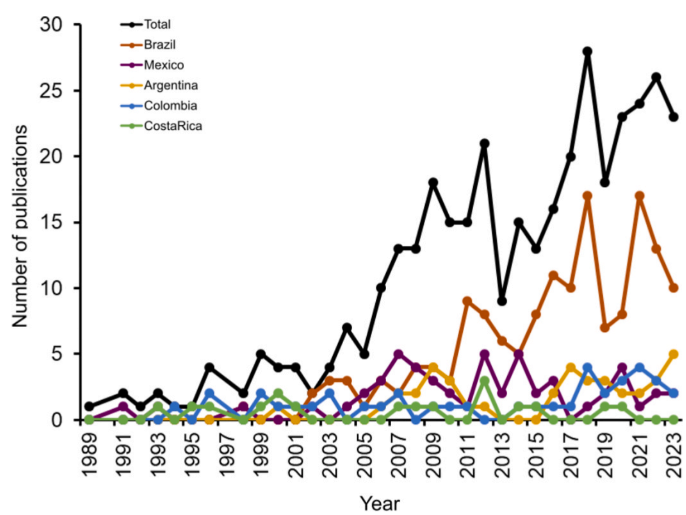

Fig. 2. Temporal trends showing the total number of studies on soil fauna, functions, and properties (1989–2023) in Latin America. The temporal trends in the most studied countries are also shown. Since the search covered only two months of 2024, these temporal trends include data only up to 2023.

years showing fewer (e.g., 2002, 2005, 2010, 2012) or equal (e.g., 2001, 2011) number of studies compared to the previous year. When considering the temporal trends of the five countries with the highest number of studies, Brazil played a central role in advancing this research topic in the region, as the peaks of publications in this country aligned with the overall trend. In contrast, Mexico, Argentina, and Colombia showed only minor fluctuations in their publication trends over time. Nevertheless, most of these countries have consistently published research since the mid-2000s, which suggests that the scientific community has maintained interest in this topic. The trend observed in Brazil may be linked to a strong network of universities and research institutions. In this sense, Santa Catarina State University and São Paulo University are leaders in this research field, each one contributing with 32 studies (Figure S2).

The collaboration network presented in Figure S3 illustrates the nature of collaborations within Latin America and between countries of Latin America and those in North America and Europe. There was scarce collaboration between countries of Latin America, with notable pairings such as Argentina-Colombia (n = 2) and Argentina-Costa Rica (n = 1). The most frequent collaborations involved countries outside the region, including Brazil-USA (n = 11), Colombia-France (n = 10), Colombia-Spain (n = 6), Argentina-USA (n = 5), and Brazil-Germany (n = 5). The importance of these international collaborations is also reflected in the principal research affiliations (Figure S2). Among the top 15 most productive institutions (by total publication count), several are located outside the region, including the University of California, Davis and Colorado State University (USA) and the University of Göttingen (Germany).

The co-occurrence network of keywords provides valuable insights into the research priorities of scientists studying soil fauna, functions, and properties in Latin America (Fig. 3). The most frequently occurring keywords were soil property (185), soil fauna (106), tropical forest (92), management (90), and diversity (86). These keywords were grouped into three clusters. Cluster 1 (red) contains 16 terms and gathers research focusing on tropical forests, restoration, conservation, and ecosystem functions. It also includes studies analyzing species richness and abundance of key macrofauna groups (e.g., Formicidae, Coleoptera). Additionally, the presence of nematodes highlights broader taxonomic considerations beyond macrofauna. This group of research topics highlights the contribution of tropical forest studies about soil

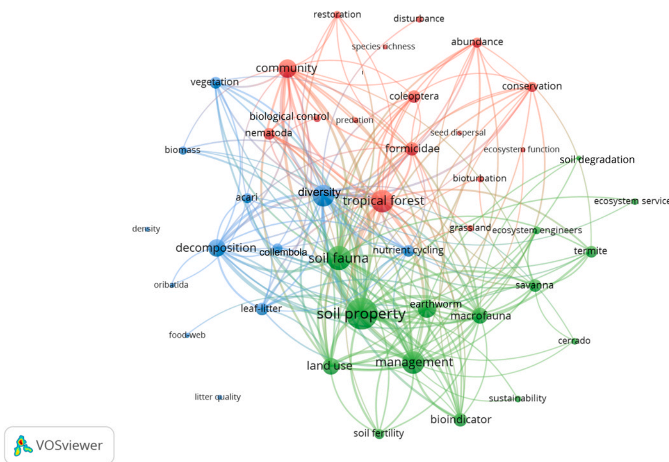

Fig. 3. Co-occurrence network of high-frequency authors and indexed keywords. A total of three identified clusters are depicted in different colors (red, green, and blue). In the network, each node represents a keyword, whereas the size of the node represents the occurrence of each keyword (i.e., the number of times that the keywords occur), and the thickness of the connecting line between each node is proportional to the frequency of co-occurrences between keywords.

fauna with a higher emphasis on preserving these ecosystems. In contrast, cluster 2 (green) contains 15 items and encompasses research focusing on soil fauna, soil properties, land use, management, and ecosystem services. Furthermore, this cluster highlights research on ecosystem engineers, particularly earthworms and termites. Key terms such as 'management', 'macrofauna', and 'bioindicator' reflect a focus on sustainable land management assessment. Also, the high frequency of occurrence of certain ecosystems, like Savanna and Cerrado within this cluster, suggests regional emphases in this research area. Finally, cluster 3 (blue) contains 11 terms, some of which are related to litter decomposition. Key mesofauna groups such as Acari and Collembola are central with terms such as diversity, leaf-litter, and nutrient cycling. The keywords gathered in this cluster highlight that most studies on litter decomposition are skewed to evaluate the contribution of mesofauna in this process.

3.3. Soil fauna, ecosystem functions, and soil properties

A total of 11 high-rank taxa and 51 finer taxonomic resolutions (Orders/Families) were studied in Latin America (Fig. 4). Soil fauna taxa were not evenly studied. The majority of the studies (68%) focused on macrofauna, with insects being the most widely studied group (210 studies), followed by Annelida (160 studies), and Arachnida (96 studies) (Fig. 4). Within insects, the studies primarily focused on ecosystem engineer groups (i.e., Coleoptera, Formicidae, and Isoptera). Within Annelida and Arachnida, Crassiclitellata and Araneae were the main focus, respectively. Additionally, 25% of the studies focused on mesofauna, such as Acari and Collembola, while only 6% examined microfauna, especially Nematoda. Some groups of soil fauna, including Enchytraeidae and certain Myriapoda taxa, were scarcely studied, representing 3–4% of the studies. Our synthesis reveals a significant gap in functional research; less than a quarter of the surveyed studies explicitly considered feeding guilds, with decomposers (15%) and natural enemies (15%) being the most studied groups. Abundance (59%), composition (26%), activity (29%), and diversity indices (22%) were the most commonly studied community or population-level metrics (Figure S4). Notably, the relatively lower frequency of composition and diversity metrics compared to total abundance suggests a prevailing limitation in taxonomic resolution. In many cases, organisms were identified at coarser levels (e.g., Class, Order, or Family) rather than species level, which often precludes a detailed examination of community

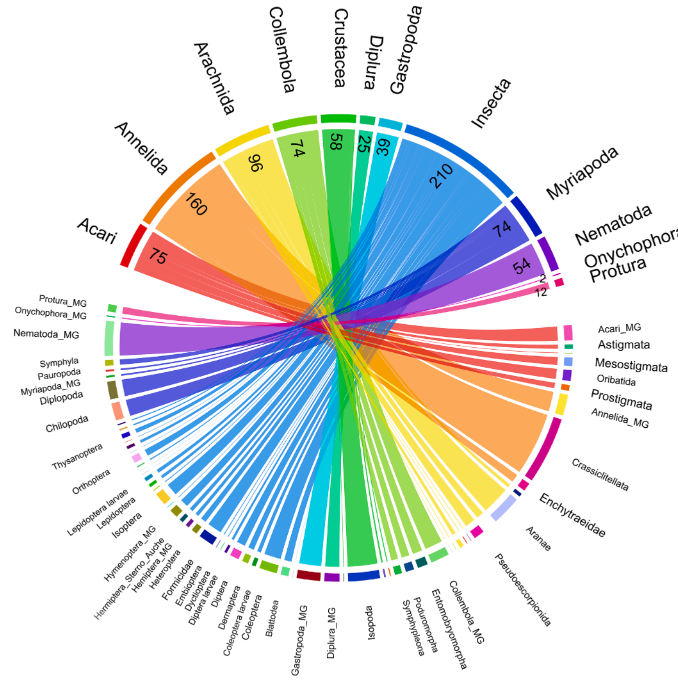

Fig. 4. Chord diagram showing the distribution of research effort across taxonomic hierarchies. The upper section represents higher-rank categories, while the lower section represents the most representative finer taxonomic levels (Order/Family). The width of the links (arcs) is proportional to the total number of studies conducted on each group. Numbers indicate the total number of studies for higher-rank groups. MG indicates multiple groups.

composition and complicates the assignment of specific feeding guilds.

In Latin American countries, ecosystem functions have been examined less extensively (153 studies) than soil properties (333 studies; Fig. 5). Among ecosystem functions, litter decomposition was the most frequently examined, accounting for 23% of the studies, followed by soil respiration (10%) and infiltration (9%). Fewer articles have evaluated fertilization (4%), dung removal (5%), and soil bioturbation (5%). In contrast, the most commonly analyzed soil properties were soil pH (54%), macronutrients (55%), and soil organic matter (SOM) or soil organic carbon (SOC) (37%).

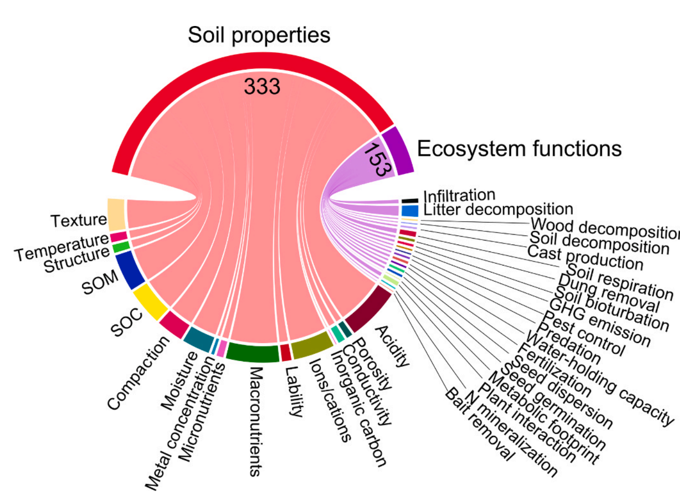

Fig. 5. Chord diagram showing the distribution of research effort between soil properties and ecosystem functions (upper section) and their specific components (lower section). The width of the links (arcs) is proportional to the total number of studies linking each property or function to its specific component. Numbers indicate the total number of studies within each higher-rank category.

The relationship between soil fauna groups and multiple soil functions is depicted in Figure S5A. Research on soil functions has predominantly focused on a narrower range of fauna groups and their interactions, leaving many combinations unexplored. Among ecosystem functions, litter decomposition emerged as the most extensively studied, particularly linked to Insecta (mainly Formicidae), Annelida (mainly Crassiclitellata), and mesofauna groups (e.g., Acari and Collembola). Abundance and activity were the most commonly studied soil fauna metrics associated with litter decomposition. Certain soil fauna groups, such as Diplura, Protura, Myriapoda, and Gastropoda, were minimally represented across most ecosystem functions, highlighting potential research gaps in understanding their ecological roles. Similarly, certain ecosystem functions have received limited attention, including cast production, dung removal, metabolic footprint, seed dispersal, and seed germination.

The relationship between soil fauna groups and multiple soil properties has received more attention than that of soil ecosystem functions (Figure S5B). The number of studies varied widely across soil properties and fauna groups, with some combinations receiving considerably more focus than others. For instance, most studies concentrated on properties such as soil pH, ions, macronutrients, compaction, moisture, soil texture, and SOC or SOM. These properties were frequently evaluated concerning macrofauna groups such as Annelida (mainly Crassiclitellata), Arachnida (excluding Acari), Insecta (mainly Formicidae and Isoptera), and mesofauna groups (Acari and Collembola). In contrast, Protura was comparatively less frequently studied, with only moderate attention paid to its associations with these soil properties. Regarding taxonomic metrics, soil fauna abundance was notably the most frequently studied.

4. Discussion

This review highlights significant gaps in our understanding of soil biodiversity in Latin America, particularly concerning certain taxonomic groups (e.g., Enchytraeidae, Acari, and various Myriapoda taxa) and essential ecosystem functions (e.g. nutrient cycling, dung removal, and soil bioturbation). Furthermore, we identified a notable scarcity of food-web and trait-based approaches, which are critical for moving beyond simple abundance metrics toward a functional understanding of soil systems. These research gaps are exacerbated by a strong geographic bias; while Brazil, Mexico, and Argentina lead the regional output, many other Latin American countries remain largely understudied.

To address the taxonomic, functional, and geographic imbalances in soil biodiversity research, it is essential to coordinate efforts that identify research gaps and guide future investigations in underrepresented regions and topics, particularly those related to soil fauna and ecosystem functions in Latin America. This systematic review represents the first comprehensive attempt to synthesize existing knowledge on this subject across the region. Strengthening the scientific basis for soil conservation is especially urgent in Latin America, a region facing accelerating deforestation, soil degradation, and biodiversity loss. Without the explicit recognition and protection of soil organisms and the ecological functions they support, conservation strategies risk neglecting a critical component of ecosystem health and long-term sustainability. Addressing this gap is critical for designing effective soil conservation and land management policies that incorporate belowground biodiversity.

4.1. Uneven research effort across biomes and countries

Our review reveals that certain biomes and countries were more extensively studied than others. The higher proportion of studies in forests, mostly tropical and subtropical ones, can be attributed to the increasing global efforts and funding to preserve these ecosystems. Because these biomes are recognized as critical carbon sinks and biodiversity hotspots, they have become primary targets for international research investment and REDD+ (Reducing Emissions from Deforestation and Forest Degradation) mechanisms (Myers et al., 2000; Fearnside, 2018). However, this has resulted in a forest bias in ecological literature, where high deforestation rates drive research attention, while other threatened but less charismatic biomes receive significantly less funding and monitoring (Overbeck et al., 2015). Among the least-represented biomes relative to their terrestrial area, we found montane grasslands and shrublands, tropical and subtropical grasslands, savannas and shrublands, and deserts and xeric shrublands. This trend shows a marked bias in studies on soil fauna, functions, and properties towards forest systems, while grassland systems remain underrepresented. However, these biomes also provide important ecosystem services such as carbon sequestration and water regulation (Gibbon et al., 2010; Ward et al., 2017), and are also being increasingly degraded by agricultural intensification and unsustainable practices (Oliver et al., 2017).

Although Brazil hosts the highest number of studies overall, most are concentrated in its southeastern region. Few investigations have focused on the Amazon Basin, despite its global ecological importance and prominence in international conservation agendas (Fearnside, 2018; Strand et al., 2018). This spatial bias may reflect the greater accessibility of field sites near urban centers in southeastern Brazil compared to the more remote Amazon region (Carvalho et al., 2023). Another possible influencing factor is the unequal allocation of research resources, potentially following population density and institutional presence (Carvalho et al., 2023; Stegmann et al., 2024). When accounting for the terrestrial surface area of each country, we also found striking disparities. While Brazil leads in the absolute number of studies, it is not among the best-represented countries relative to its land area. Mexico ranked highest in this regard, followed by Colombia, although both countries also showed a concentration of studies near densely populated areas (Berdegué and Soloaga, 2018; Cattaneo et al., 2022). Large portions of their national territories remain unsampled, consistent with prior findings highlighting the lack of baseline biodiversity data for soil fauna (Barois et al., 2022; Marín et al., 2022). Nevertheless, a recent global synthesis on soil macrofauna reported that Colombia had the highest number of sampling points worldwide, followed by Brazil, indicating growing efforts to close spatial knowledge gaps (Lavelle et al., 2022). Conversely, countries like Peru and Argentina are among the least represented relative to their geographical extension. The absence of Bolivia and Guatemala from the dataset likely reflects the lack of long-term, coordinated efforts and insufficient funding for biodiversity research, especially for studies on soil invertebrates (Fernández et al., 2015; Morales-Marroquín et al., 2022). This gap is further reinforced by limited participation in global scientific networks (Dangles et al., 2016; López Bedoya et al., 2024). However, it is worth noting that Bolivia was recently included in a global assessment of soil macrofauna, indicating emerging efforts to address these data gaps (Lavelle et al., 2022).

4.2. Emerging trends in soil fauna research

The observed increase in publication rates since the mid-2000s reflects a growing interest in research on soil fauna and ecosystem functions in Latin America. Among the countries with the highest research output, Brazil is the primary driver of regional trends, with peaks in publication aligning closely with the regional pattern. This central role may be attributed to Brazil's well-established academic infrastructure and the leadership of key institutions such as Santa Catarina State University and the University of São Paulo, both of which have contributed substantially to the field. Furthermore, the Brazilian government actively supports international collaboration through programs like CAPES (Coordination for the Improvement of Higher Education Personnel), which provides funding for research initiatives (Ramos, 2017). This sustained support for scientific activity has enhanced the growth of this research field in the country.

In relation to collaboration networks within Latin America and between Latin American countries and those outside the region, we found a marked scarcity of intra-regional collaboration. Most frequent partnerships involved countries outside Latin America. The collaborations observed between Latin American countries, particularly those leading research in this field, and countries in North America and Europe, may facilitate the exchange of information, expertise, and access to laboratory resources, all of which are crucial for advancing research on soil fauna, functions, and properties. In this context, strengthening networks with Spain and Portugal would be highly strategic; these countries not only share linguistic and historical ties with Latin America but also possess established research traditions that could further ease the exchange of taxonomic expertise and facilities. Notably, no collaborations were observed between Latin American countries and other regions, such as China or other Asian countries. For instance, China's growing investment in biodiversity research and technological advancements could offer complementary resources and insights into soil fauna studies, and other potential benefits of partnerships with these research hubs. Nonetheless, given the scientific financial constraints faced in Latin America (Ciocca and Delgado, 2017), promoting collaboration networks within the region could help reduce financial restrictions and strengthen regional research capacity in soil fauna. Another step in this direction would be that Latin American international organizations (like the Organization of American States, Mercosur, among others) provide funding for multi-lateral, multi-national research projects, as the European Union does. The development of joint training programs, workshops, and mentorship opportunities in this research field has the potential to strengthen local expertise significantly.

The co-occurrence network of keywords shows that new approaches in studies of soil fauna, functions, and properties are lacking or scarcely represented. For instance, emerging concepts such as soil fauna functional diversity remain underexplored in this region, as less than 1% of the studies have focused on this topic. The adoption of trait-based approaches in future research could significantly enhance our understanding of soil fauna, especially in regions like Latin America, where taxonomic identification is particularly challenging due to the lack of expertise in many soil fauna groups. Trait-based approaches can shed light on the response of soil fauna communities to environmental gradients or disturbances (e.g., rising temperatures, land use changes) as well as the effect of community composition on soil processes such as decomposition, nutrient cycling, etc (Bonfanti et al., 2024; Wagg et al., 2014). Also, the keyword 'food web' is identified as an emerging concept with limited representation in our dataset. The term "food web" first appeared in the literature we examined around 2007; however, most studies refer to the concept without conducting food-web analyses such as energy and carbon fluxes (Potapov et al., 2019). Given the critical role of soil food web structure in supporting many ecosystem functions, this term is expected to gain more attention in future studies in the Latin American region (Pérez-Roig et al., 2025). Overall, the co-occurrence network underscores the interconnectedness of the three clusters, highlighting the overlap between soil fauna research and broader ecological processes. Notably, soil fauna and soil properties emerge as central, bridging concepts within the network.

4.3. Linking soil fauna to ecosystem functions and soil properties

Soil fauna constitutes a major portion of biodiversity in ecosystems (Anthony et al., 2023; Orgiazzi et al., 2016). Although this review highlights that the scientific community in the region has made significant progress in research on soil biodiversity, properties and functions, these efforts remain fragmented and often concentrated on a few well-studied taxa. Several factors may contribute to this issue. The distribution of studies among soil fauna taxa, taking into account their body size, has concentrated on macrofauna, a pattern also found by Araujo et al. (2021). This is not surprising, as macrofauna are easier to identify compared to smaller organisms, such as Acari or Collembola, which require specialized taxonomic experts for proper identification (Decaëns, 2010). Therefore, the underrepresentation of many soil groups reflects the need for taxonomic expertise, particularly in underexplored regions (Guerra et al., 2020). This challenge is exacerbated by a global decline in the number of taxonomic experts, possibly driven by the increasing prioritization of publishing in high-impact journals (Páll-Gergely et al., 2024). Additionally, there may be a scarcity of published data in scientific journals, with valuable information instead contained in the gray literature as it has been shown for macrofauna data in Brazil (Brown et al., 2024).

In this review, we found that studies integrating soil fauna and ecosystem functions were less common than those examining soil fauna and soil properties, and these findings can be attributed to several factors. One major cause could be the limited access to expensive laboratory infrastructure needed for evaluating ecosystem functions and the high costs that represent making these measurements as compared to evaluating soil properties (Parnell et al., 2025). Additionally, standardized protocols for assessing many of these functions, such as nutrient cycling or decomposition, are lacking. However, since 2011, initiatives such as GLOSSAN (FAO), including some Latin American countries like Argentina, Brazil, Chile, and Colombia, have been working toward developing such protocols. Recognizing this gap presents an opportunity for future research to prioritize understudied functions (e.g., fertilization, dung removal, and soil bioturbation) and to establish collaborative regional networks in order to facilitate knowledge exchange and resource optimization in this field. Notably, most existing studies linking soil fauna and ecosystem functions describe patterns (Fernandez et al., 2022; Pompermaier et al., 2022), while fewer focus on the causal mechanisms by which soil fauna contribute to ecosystem functions (Moreno et al., 2020). Therefore, future research could greatly benefit from the adoption of trait-based approaches (de Bello et al., 2021; Bonfanti et al., 2024) or micro-, meso-, or macrocosm experiments on soil fauna impact on multiple ecosystem functions (Wagg et al., 2014), which would offer a more mechanistic understanding of the role of soil fauna on ecosystem functioning.

Global initiatives such as Soil BON Foodwebs (Potapov et al., 2022b) and Soil BON Earthworm (Ganault et al., 2024) have provided standardized sampling protocols for studying soil fauna and their functional roles across micro-, meso-, and macrofauna scales. These initiatives offer valuable tools that can be adapted to support regional-specific efforts tailored to the Latin American context. While such global efforts have been instrumental in fostering methodological consistency, the complex socio-environmental context of Latin America, characterized by its high diversity of biomes (Eva et al., 2004), the active role of local and Indigenous communities (Toledo, 2001), and persistent socio-environmental conflicts (Svampa, 2019), underscores the need for a complementary regional network dedicated to soil fauna and ecosystem functioning. A regional platform could promote the exchange of diverse forms of knowledge, support transdisciplinary collaboration, strengthen research capacities, and contribute to the co-production of context-relevant knowledge. The establishment of the mentioned network is essential for advancing inclusive and effective soil conservation strategies in Latin America and fostering the inclusion of regional research in global initiatives for monitoring soil biodiversity (Marín et al., 2025; Parnell et al., 2025). In this region, there are already successful collaborative strategies within existing networks, such as networks studying mycorrhizal fungi (Bueno et al., 2017), which could serve as a model for building a robust soil fauna network that addresses regional priorities.

5. Conclusion

In summary, our review reveals that significant taxonomic and functional gaps persist in Latin American soil ecology. In order to address this challenge, it is crucial to enhance regional scientific networks, thereby facilitating the sharing of research facilities, ecological modelling, taxonomic expertise, and the use of standardized methodologies. This could help mitigate some of the frequent financial and human resource limitations for integrated ecological research involving soil fauna and their functional impacts and importance for the delivery of ecosystem services.

Additionally, to promote the scientific capacity in the region, we recommend strengthening capacity-building initiatives. This includes creating training programs, developing taxonomic courses focused on understudied soil fauna groups, organizing workshops, and establishing mentorship opportunities for early-career researchers. The integration of local communities into soil biodiversity research and conservation initiatives is critical. Integrating participatory approaches, such as citizen science initiatives, can enhance public awareness and actively involve local communities in data collection, monitoring, and management of soil ecosystems. These initiatives are of special importance due to the underrepresentation of soil organisms, particularly soil fauna, in existing conservation programs (Guerra et al., 2021).

Furthermore, it is imperative to establish multidisciplinary collaboration networks among soil scientists, ecologists, economists, and policymakers. Such collaborations can drive innovative solutions, garner governmental and stakeholder support, and create a more robust funding environment for soil biodiversity research and conservation.

CRediT authorship contribution statement

George Brown: Writing – review & editing, Writing – original draft, Data curation. **César Marín:** Writing – review & editing, Writing – original draft. **María Fernanda Chiappero:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Data curation. **Camila Pérez-Roig:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Data curation, Conceptualization. **María Laura Moreno:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Formal analysis, Data curation, Conceptualization. **Martín Videla:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Methodology, Conceptualization. **José Camilo Bedano:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Conceptualization.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.pedobi.2026.151139.

Data availability

The data sources used in this review are provided as Supplementary Materials

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Tables

Table S1. List of taxonomic classification of soil fauna and their categories extracted from the studies obtained in the literature search.

Coarse Taxonomic Group	Fine Taxonomic Group
ACARI	Multiple groups
	Astigmata
	Oribatida
	Prostigmata
	Mesostigmata
	Ixodidae
ANNELIDA	Multiple groups
	Crassiclitellata
	Enchytraeidae
	~~Onychophora~~
ONYCHOPHORA	Multiple groups
ARACHNIDA	Multiple groups
	Araneae
	Opilionidae
	Pseudoescorpionida
	Ricinulei
	Schizomida
	Scorpionida
	Solifugae
	Uropygi
COLLEMBOLA	Collembola_Multiple groups
	Entomobryomorpha
	Poduromorpha
	Symphypleona
CRUSTACEA	Amphipoda

	Copepoda ~~Amphipoda~~ Isopoda Ostracoda
DIPLURA	Multiple groups
GASTROPODA	Multiple groups
INSECTA	Multiple groups Archaeognatha Blattodea Coleoptera Coleoptera_Larvae Dermaptera

Table S2. *Cont.*

INSECTA	Diptera Diptera_larvae Dyctyoptera Hemiptera_Sternorrhyncha_Auchenorrhyncha Hemiptera_Multiplegroups Hymenoptera_Multiple groups Isoptera Larvae_Multiple groups Lepidoptera Lepidoptera_Larvae Mantodea Mecoptera Neuroptera Orthoptera Plecoptera

	Psocoptera Siphonaptera Thysanoptera Thysanura Trichoptera
MYRIAPODA	Multiple groups Chilopoda Diplopoda Pauropoda Symphyla
NEMATODA	Nematoda
PROTURA	Protura

.

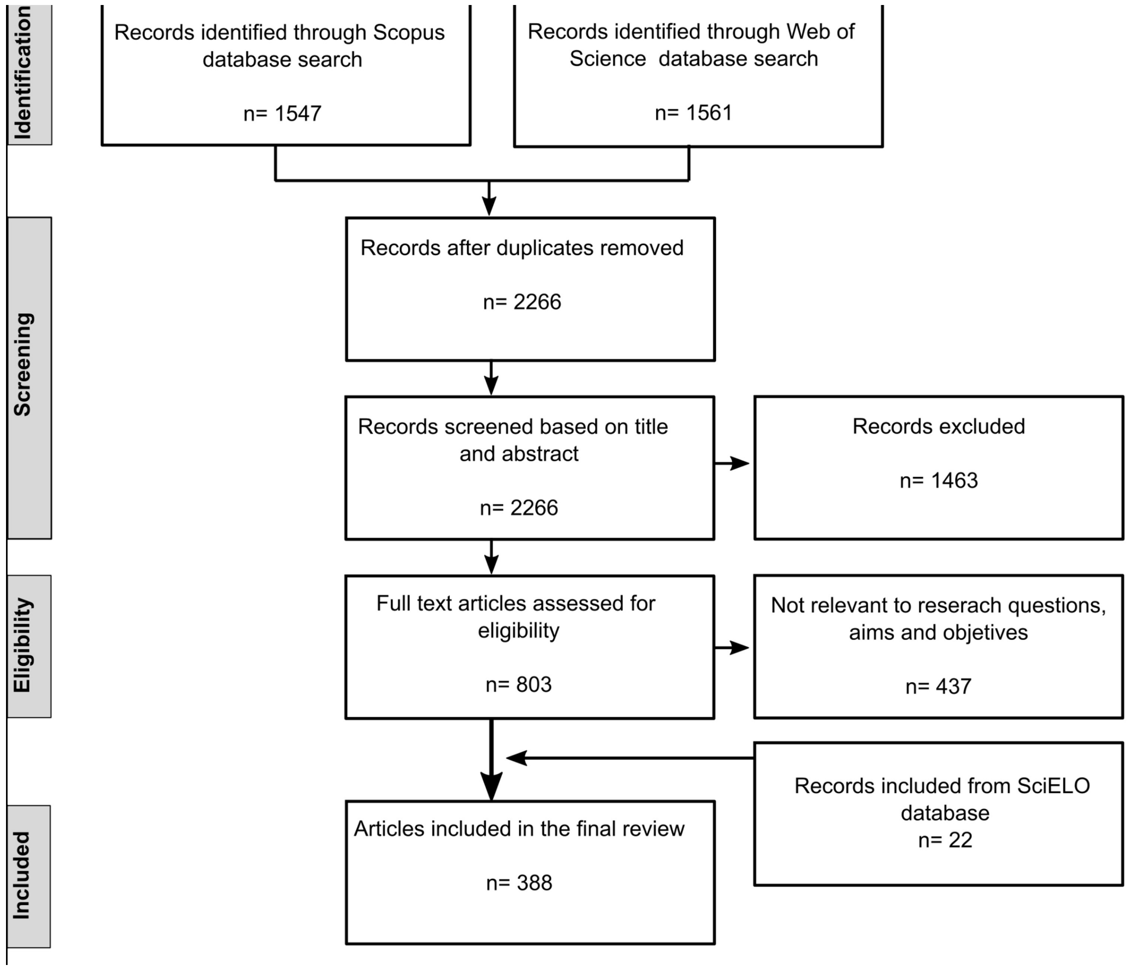

Figure S1. PRISMA flow diagram showing the steps leading to the inclusion of 368 studies in this bibliometric analysis.

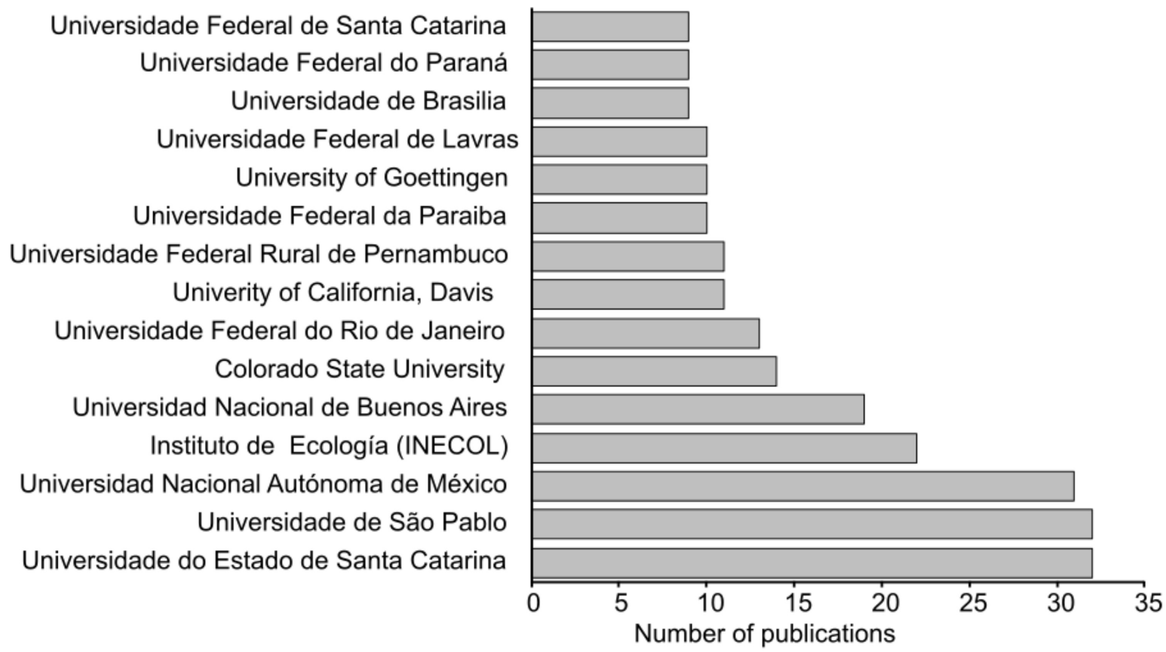

Figure S2. Most relevant affiliations of all co-authors for each paper.

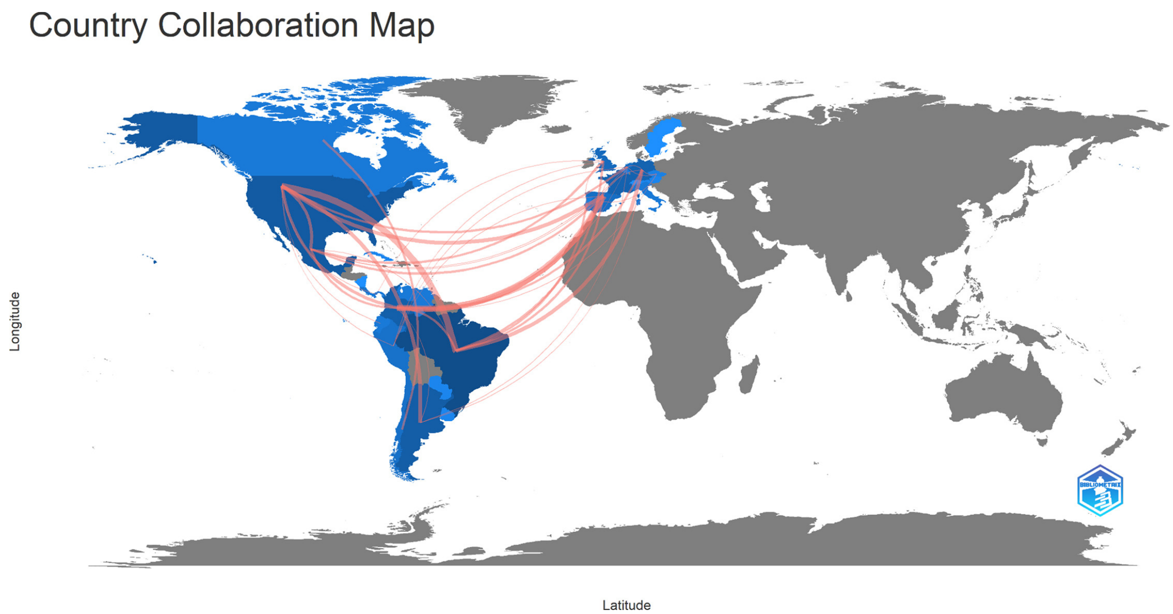

Figure S3. Countries collaboration map. The pink lines indicate research collaborations and the thickness of the line indicates the degree of collaboration.

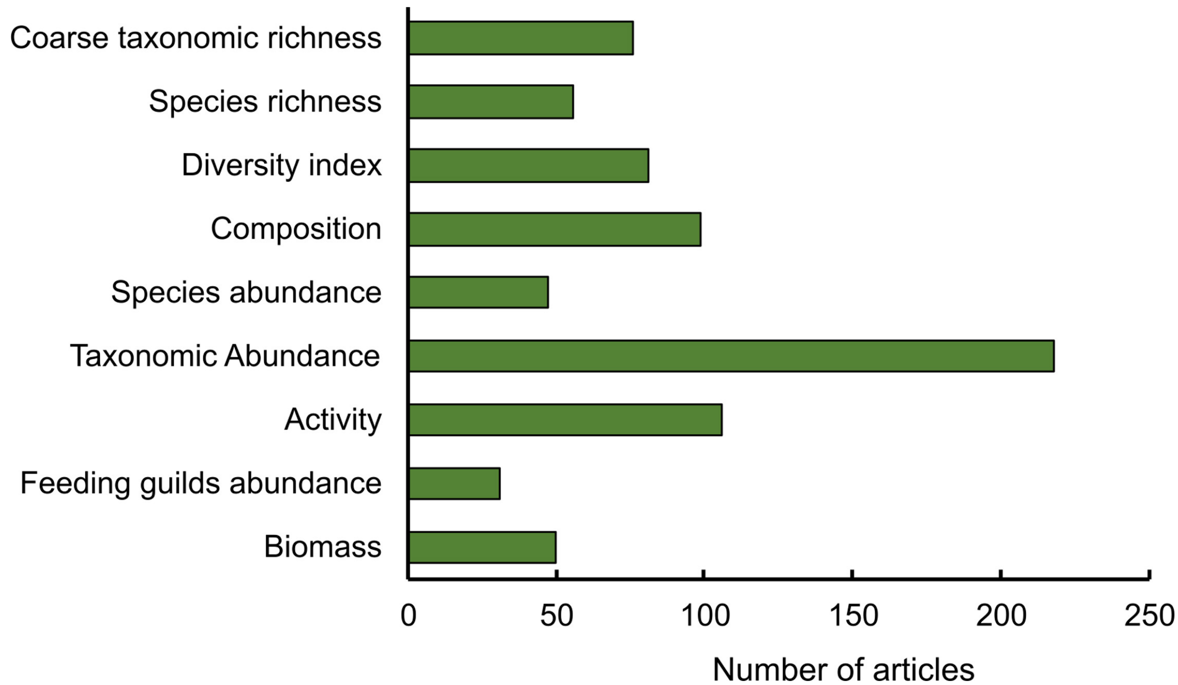

Figure S4. Number of studies evaluating community or population-level metrics on soil fauna in Latin America.

Figure S5. Heatmap of soil fauna, soil ecosystem functions (a), and properties (b). In soil functions, litter decomposition involves leaf litter and wood decomposition. Note: abundance and richness include both coarse (i.e., Order, Family, Genus) and fine (i.e., species) taxonomic classification.

Title: Dataset of study locations included in the review: “Soil fauna and ecosystem functions: current knowledge and future perspectives in Latin America”

Description:
This dataset compiles the geographic information of the studies included in the systematic review on soil fauna and ecosystem functions across Latin America.
Each record represents a unique sampling location reported in the corresponding study. When a single study included multiple sampling sites, each site is listed in a separate row but shares the same study index and bibliographic reference.

File name: Appendix1-Data sources.xlsx

Variable Description

Column name	Description
Index	Unique identifier for each study record
Reference APA	Complete bibliographic reference in APA format
Year	Year of publication of the study
Country	Country where the study was conducted
Latitude	Latitude (decimal degrees, WGS84) of the study site or sampling location.
Longitude	Longitude (decimal degrees, WGS84) of the study site or sampling location.
Biome	Biome classification of the study site was derived by overlaying the geographic coordinates onto the RESOLVE Ecoregions database (Dinerstein et al., 2017), following the biome framework of Olson et al. (2001). This approach ensured a consistent and spatially explicit biome assignment for all sampling locations.