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RESEARCH

Bibliometric review on microplastic contamination in the Pacific Alliance countries

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Abstract Microplastics, capable of absorbing persistent organic compounds, heavy metals, and emerging pollutants, are of global concern due to their potential to alter the behavior and metabolism of biota. In Latin America, the Pacific Alliance, comprising Mexico, Colombia, Peru, and Chile, stands out for its biological wealth and productive ecosystems, which account for 37% of the region's gross domestic product. The leaders of these countries expressed their concern about microplastic pollution and pledged to take joint action. We conducted an analysis of the scientific production of these countries and the collaborations of their researchers, focused on the period 2015–2023, using Scopus and SCImago. We observed that marine-coastal/wetland ecosystems are the most studied, with a focus on fish, and that Mexico leads in publications, followed by Colombia, Peru, and Chile. In addition, we note the absence of an inter-institutional group dedicated to microplastics research in these countries. We recommend promoting collaboration between academic institutions specialized in microplastic research and government agencies dedicated to the promotion of science and technology in the countries belonging to the Pacific Alliance.

Keywords Pacific Alliance · Scientometry · Publication analysis · Scopus · h-index · SCImago

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Introduction

Bakelite, a pioneer in its category, was developed in 1907, marking the beginning of the era of synthetic plastics (Thompson et al., 2009). Large-scale production of these materials began in 1950, reaching 1.7 million tons (PlasticsEurope, 2012; Thompson et al., 2009), and by 2020, global production rose to an impressive 367 million tons of plastics (PlasticsEurope, 2021). The first indications of the negative impacts of plastic became evident in the 1960s through reports of contaminated beaches and birds containing plastic in their digestive systems (Kenyon & Kridler, 1969; Rothstein, 1973). From the creation of this material through 2015, it is estimated that approximately 6.3 billion metric tons of plastic waste have been generated, ending up in natural environments, landfills, or incinerated (Geyer et al., 2017). Projections for the year 2050 indicate that the amount of plastic waste released into the environment could reach 12 billion metric tons (Geyer et al., 2017).

The burning of plastics during disposal generates toxic aerosols, such as polycyclic aromatic hydrocarbons, dioxins, and polychlorinated biphenyls (Wu et al., 2021). In addition, leachates from these materials can pose a risk to both biota and water resources (Li et al., 2022; Rezaei Adaryani & Keen, 2022). Inadequate end-of-life management of plastic waste, and lack of environmental awareness leading to improper disposal, has resulted in overwhelming environmental pressure (De-la-Torre et al., 2022; Geyer et al., 2017).

Contemporary studies categorize plastic debris according to their size, dividing them into macroplastics (larger than 25 mm), mesoplastics (5-25 mm), and microplastics (smaller than 5 mm) (Imhof et al., 2017; Jeyasanta et al., 2020). One of the first reports on the presence of microplastics was published in 2004 by examining plankton samples collected between 1960 and 1990 (Thompson et al., 2004). Microplastics can originate from the fragmentation of larger plastics (secondary microplastics) or be manufactured in small sizes for incorporation into other products (primary microplastics) (Browne et al., 2007; Guerranti et al., 2019; Salvador Cesa et al., 2017).

Their tiny size and ease of transport have led them to be identified in a wide variety of locations, including remote regions such as the Andes (Cabrera et al., 2020), polar areas (Mishra et al., 2021), drinking water (Shruti, Pérez-Guevara, & Kutralam-Muniasamy, 2020), food products (Shruti, Pérez-Guevara, Elizalde-Martínez, & Kutralam-Muniasamy, 2020), vertebrate and invertebrate organisms (devi Nanthini et al., 2022), and, surprisingly, in human blood (Leslie et al., 2022). In addition, microplastics have the ability to adsorb metals such as arsenic, chromium, and cadmium, as well as persistent organic compounds and emerging pollutants (Mammo et al., 2020), with documented adverse effects on biota, including metabolic alterations, liver damage, feeding disruption, movement disturbance, and behavioral changes (Anbumani & Kakkar, 2018).

Currently, there is an outstanding scientific production in the field of microplastics, with China and the USA being the leaders in this field (Sharma et al., 2022), while, in the Latin American context, nations such as Brazil, Mexico, and Argentina excel in research on this topic (Grillo et al., 2022). However, there is still a lack of consolidated data addressing the main contributors of this information, the collaborations among them, and the impact of their publications. In this review, we have conducted a scientometric analysis in the countries belonging to the Pacific Alliance, namely, Mexico, Colombia, Peru, and Chile, countries characterized by their abundant marine and floristic richness, as well as a high diversity of animal species (Bakun & Weeks, 2008; Ballesteros Navia et al., 2023; Ceballos, 2014).

In addition, these countries together account for 37% of the gross domestic product of Latin America and the Caribbean (Durán & Cracau, 2016). The Pacific Alliance has as one of its main objectives the cooperation and promotion of economies through the flow of capital, goods, services, and people (Alianza del Pacífico, 2022). It also has technical groups focused on the environment and sustainable growth, and promotes initiatives aimed at preserving the natural environment (Alianza del Pacífico, 2022). Recently, these countries signed the Presidential Declaration on the Sustainable Management of Plastics (Alianza del Pacífico, 2019), which includes joint measures to address the impact of microplastics.

In this context, our research aimed to assess both scientific production and trends in the study of microplastics, as well as collaborations between researchers from these four countries in aquatic and terrestrial ecosystems. Our review was carried out with the

objective of answering three fundamental questions: (1) which ecosystem, environmental compartment and biota is the most researched, (2) who are the main researchers in the Pacific Alliance countries in this field, and (3) how often and in what type of scientific journals do researchers from these four countries collaborate.

Materials and methods

A search was performed in the Scopus database (www.scopus.com) until August 13, 2023. First, the name of each country was entered, e.g., Peru, along with the following keywords: "microplastics OR microplastic OR microfibre OR nanoplastic." The terms were searched for within the title, abstract, and keywords. The studies spanned from 2015, which was when the Pacific Alliance came into force, until August 2023. The references of the articles found were also checked to examine other studies. We considered research conducted in two or more countries, but with samples from Peru, Colombia, Mexico, or Chile. In addition, we examined within the articles where plastic waste had been investigated in general hoping to find topics on microplastics. The criteria used to select the literature focused on contamination of water, air, soil, flora, and fauna. Reviews and conference proceedings were limited, and studies in controlled environments were excluded.

Collaborations between Pacific Alliance researchers were sought (i.e., participation within the research). The affiliation of each researcher was obtained from the published article. The first author and corresponding author of each publication found were selected. It is generally accepted that the first author is the one who makes the major contribution to the study, whose work involves design, data acquisition, analysis, and writing (Elsevier, 2020). On the other hand, the corresponding author is the one who does the communication from the time the paper is submitted to the journal until after publication and is also the one who usually has the most experience in the field (Elsevier, 2020).

The quartile of the journal in which they published, their category, country, and SJR (Scimago Journal Rank) were extracted from SCImago year 2022 (www.scimagojr.com). SCImago is a platform with indicators that store data from Scopus and is used to analyze the literature over time through scientometrics (Kurian et al., 2023).

The studies were organized by ecosystems: marine-coastal/wetlands such as beaches, bays, pelagic areas, estuaries, mangroves, marshes, rivers, and reservoirs. In terrestrial ecosystems, forest plantations, pastures, agricultural areas, savannas, rainforests, urban areas, industrial areas, and waste disposal areas were considered. In addition, the biota studied were grouped by phyla (generally for invertebrates) and into classes. The compartments evaluated and processed foods were also considered.

Results

In total, 120 papers on microplastics were found. However, as there were studies that included samples from two or more Pacific Alliance countries (i.e., Ory et al., 2018: Colombia, Peru and Chile; Jamieson et al., 2019: Peru and Chile; Perez-Venegas et al., 2020: Peru and Chile, and Aranda et al., 2022: Mexico and Colombia), it was decided to include these papers in all countries for which they had samples. For Chile, 21 papers were identified, Peru 23, Colombia 26, and Mexico 55.

Which is the most studied ecosystem, environmental compartment, and biota?

Most studies were conducted in the marine-coastal/wetland ecosystem ($n = 99$) and only 14 studies were conducted in terrestrial ecosystems. A single study by Gamarra-Toledo et al. (2023) was included in both terrestrial and marine-coastal/wetland ecosystems, as it collected samples from the coasts and the Andean zone of Peru. On the other hand, there were six papers that showed the results of microplastics in processed foods: fishmeal produced by Peru (Wang et al., 2022), bottled water from 12 brands from Santiago de Chile (Nacaratte et al., 2023), commercial ice cubes from 15 brands from Mexico City (Shruti et al., 2023), in dried fish products from Mexico (Kutralam-Muniasamy et al., 2023), in common beverages such as soft drinks, beer and energy drinks from Mexico (Shruti, Pérez-Guevara, Elizalde-Martínez, & Kutralam-Muniasamy, 2020), and in international and national milk brands from Mexico (Kutralam-Muniasamy et al., 2020).

The studies carried out in the Pacific Alliance countries did not focus exclusively on a particular environmental compartment or taxonomic group, but rather there were efforts to investigate different matrices and biota included (see supplementary material in the section on ecosystems using filters).

As for studies on environmental compartments, there were 31 papers focused on a single compartment such as sediments, followed by those dedicated to water, with 23 papers (Fig. 1). In addition, at least 13 publications included more than one environmental compartment (e.g., De-la-Torre et al., 2023; Garcés-Ordóñez et al., 2023; Ramírez-Álvarez et al., 2020) (Supplementary Material, Fig. 1).

On the other hand, the studies that also analyzed biota or only focused on biota were 51 and had the fish group as the most studied with 22 papers, followed by studies on mollusks and arthropods with seven and six publications, respectively (Fig. 1). Of these papers there were three publications that focused on more than one taxonomic group (i.e., arthropods and fish by Zavala-Alarcón et al. (2023); arthropods and mollusks by Hernández-Gutiérrez et al. (2021); birds and annelids by Huerta Lwanga et al. (2017).

Who are the main researchers on these topics in the Pacific Alliance?

In the case of Chile, 17 researchers occupied the position of first author and 16 of corresponding author. The researchers with the highest number of publications as first author were Corradini Fabio, Ory Nicolas Christian, Pérez-Venegas Diego J, and Pozo Karla with two papers each (Fig. 2). Peru had 17 first authors and 15 corresponding authors. De-la-Torre Gabriel Enrique presented the largest number of papers. Colombia had 16 first authors and 16 corresponding authors, with Garcés-Ordóñez Ostin presenting the most papers (Fig. 2). Finally, in Mexico, 41 authors were first authors and 32 corresponding authors. In Mexico, Shruti V.C. was the first author with six papers and Kutralam-Muniasamy Gurusamy was the corresponding author with the highest number of publications (Fig. 3).

As for the institutions to which the first authors of the publications belonged, in Chile, we found Millenium Nucleus Ecology and Sustainable Management of Oceanic Island (ESMOI) and Universidad Andrés Bello to be the most productive. In Peru, Universidad San Ignacio de Loyola led with seven papers. In Colombia, it was the Instituto de Investigaciones Marinas y Costeras José Benito Vives de Andres-INVEMAR. Finally, in Mexico, the National Autonomous University of Mexico had 13 publications as first authors (Fig. 4).

How often do researchers from these four countries collaborate with each other and in what type of journals do they publish?

There were seven papers in which there was collaboration between researchers from the Pacific Alliance. The paper by Ory et al. (2018) presented an analysis of microplastics in fish samples from countries such as Peru, Chile, and Colombia. Perez-Venegas et al. (2020) had otariid fecal samples from Chile and Peru. A study by Aranda et al. (2022) sampled molluscan feces from countries such as Mexico and Colombia. Two studies by Corradini et al. (2019), (2021) studied microplastics in soils of Chilean agroecosystems and a researcher affiliated with a Mexican institution participated in these two studies. On the other hand, the research by Garcés-Ordóñez, Saldarriaga-Vélez, Espinosa-Díaz, Patiño, et al. (2022) analyzed microplastic contamination in a lagoon complex in Colombia and there was a Chilean researcher among the authors. Finally, a study on microplastics in commercial fish in Peru led by Fernández-Ojeda et al. (2021) had the participation of a Colombian researcher (supplementary material).

Of the 120 publications, 39% ($n = 35$) of the papers were published in the journal Marine Pollution Bulletin, followed by Science of the Total Environment with 19% ($n = 23$) and Environmental Pollution with 11.6% ($n = 14$). Most of the journals were in countries such as the UK, the Netherlands, and Switzerland (Table 1). Furthermore, these studies were published in 39 journals, of which 54% ($n = 21$) belonged to Q1, 15% ($n = 6$) to Q2, 18% ($n = 7$) to Q3, and 13% ($n = 5$) to Q4 (Table 1). Journals such as Resources, Conservation and Recycling; Journal of Hazardous Materials and Environmental Pollution presented the highest impact measures according to SJR 2022. Other journals such as Revista Veterinaria, Revista de Investigaciones Veterinarias del Peru, and Revista de la Academia Colombiana de

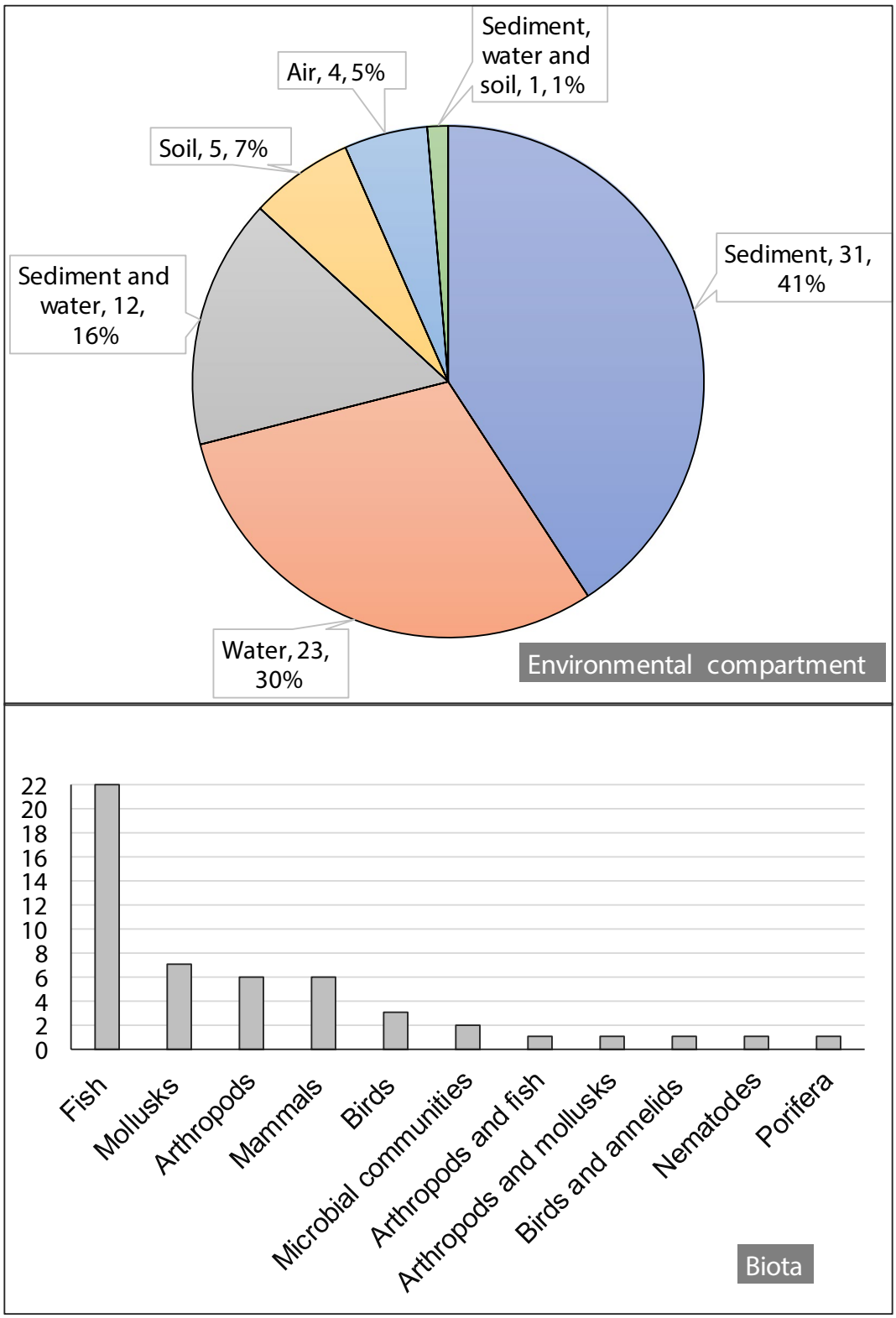

Fig. 1 Environmental compartments and biota in which studies have been conducted

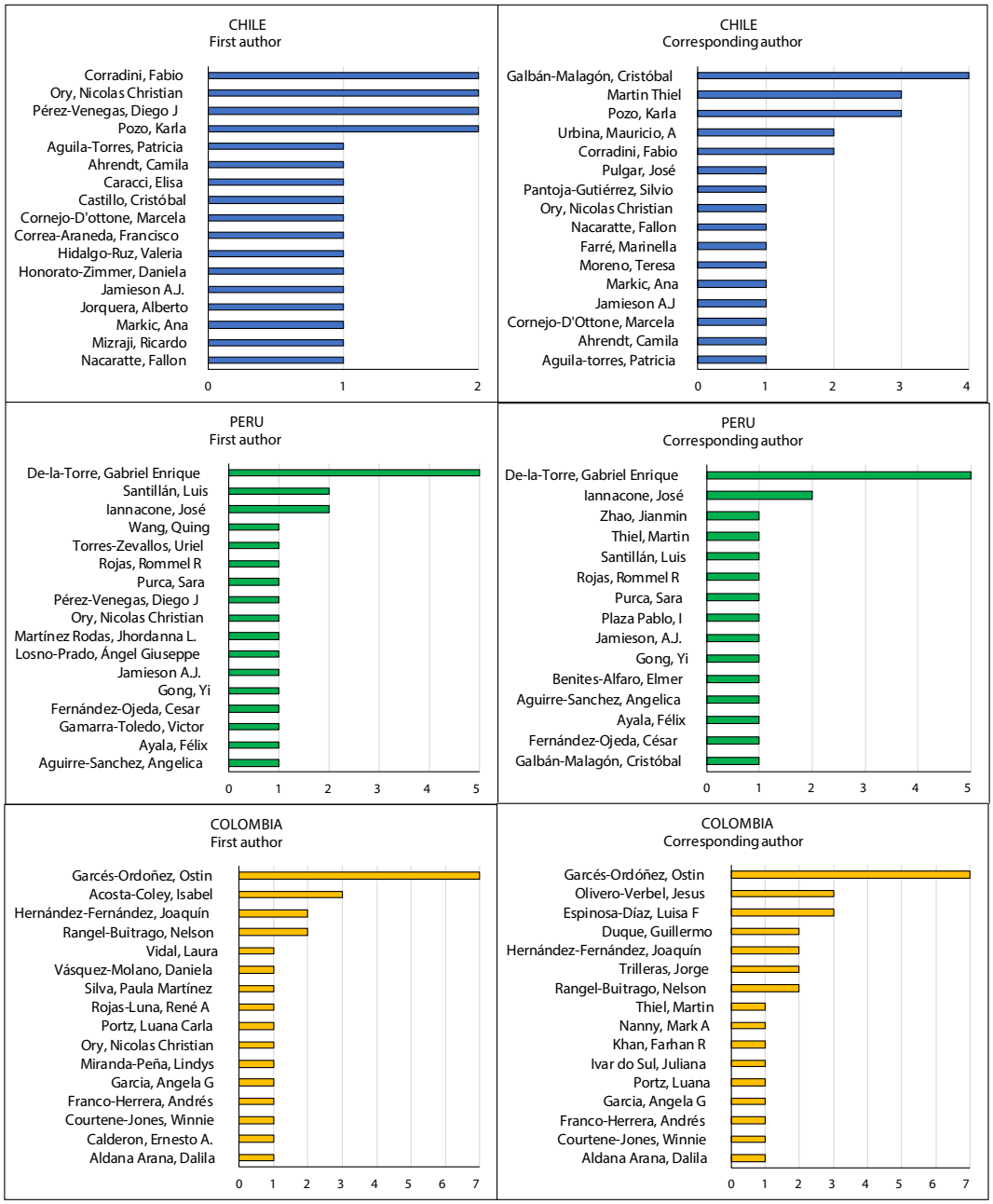

Fig. 2 Authors leading publications of studies in the Pacific Alliance countries

Ciencias Exactas, Físicas y Naturales presented the lowest impact measures (Table 1).

Discussion

Our results show that there is little collaboration among the Pacific Alliance authors; to our knowledge, there is no group formed by members of these four countries working together to understand or mitigate the impact of microplastics despite the Pacific Alliance presidential declaration on the sustainable management of plastics signed in Lima, Peru, which mentions commitments and concerns about preventing the impacts of microplastics on ecosystems, as well as strengthening among member countries

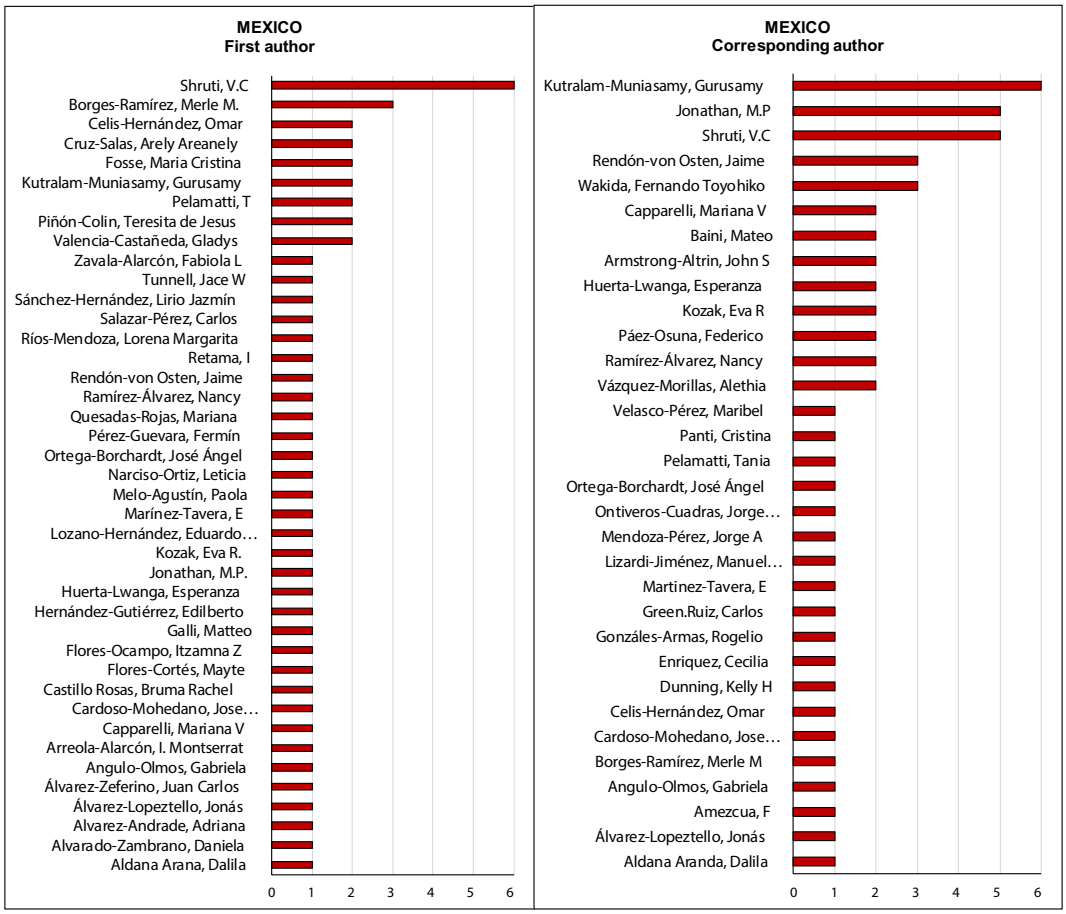

Fig. 3 Authors with work on microplastics in Mexico

through management, policies and knowledge sharing (Alianza del Pacífico, 2019). Although the Pacific Alliance is a relatively new agreement, which entered into force in July 2015, there is already research on microplastics in other regional contexts, such as the Red de Científicos de la Basura "ReCiBa," the "Red Investigación de Estresores Marino-Costeros en Latinoamérica y el Caribe – REMARCO," or the "Comisión Permanente del Pacífico Sur - CPPS." However, the number of research published in Scopus is low compared to countries of other alliances, such as Brazil of MERCOSUR, which has at least 116 publications on microplastics indexed in Scopus until the end of August 2023.

Although most studies on microplastics in the Pacific Alliance countries have focused on the coastal-marine ecosystem and wetlands (see Supplementary Material), this trend may be largely due to the limited interest of researchers in the terrestrial aspects of this problem, as noted by Malizia and Monmany-Garzia (2019). However, it is important to note that recent research, mostly conducted in Mexico, has begun to report on the presence of microplastics in processed foods. To date, no maximum allowable limits have been established for these types of products in these countries. Therefore, these studies could serve as a starting point for the development of regulatory policies in the future (Kutralam-Muniasamy et al., 2023; Shruti, Pérez-Guevara, & Kutralam-Muniasamy, 2020)

Regarding the study of biota, it is notable that most research has focused on fish as the main group of interest. However, it would be valuable for future research to broaden its scope of study to include other groups or phyla, such as porifera or birds, in order to enrich our knowledge of the impacts

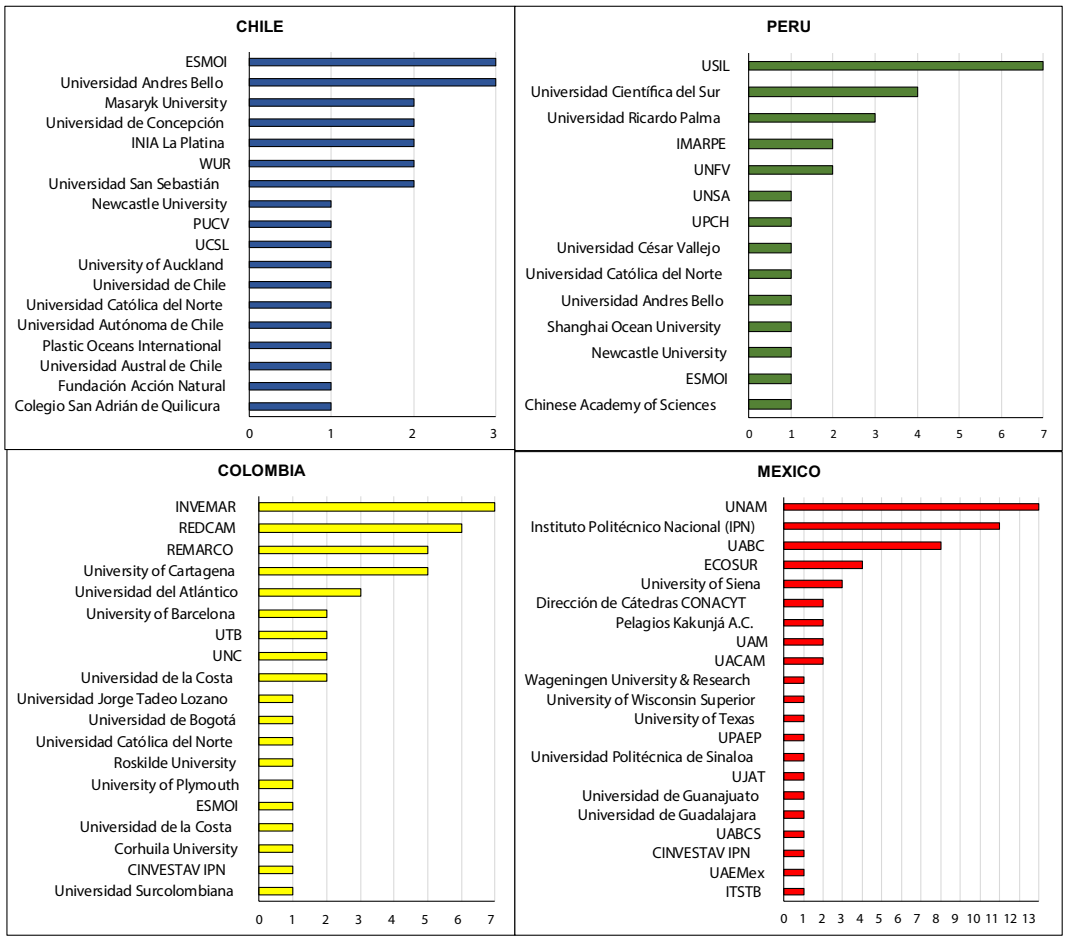

Fig. 4 Institutions that have conducted research on microplastics in the Pacific Alliance countries. Only the affiliations of the first authors have been taken into account. The abbreviations for Chile are ESMOI (Millennium Nucleus Ecology and Sustainable Management of Oceanic Island), WUR (Wageningen University & Research), PUCV (Pontificia Universidad Católica de Valparaíso), UCSL (University of Cassino and Southern Lazio); for Peru they are: USIL (Universidad San Ignacio de Loyola), IMARPE (Instituto del mar del Perú), UNFV (Universidad Nacional Federico Villareal), UNSA (Universidad Nacional San Agustin), UPCH (Universidad Peruana Cayetano Heredia), ESMOI (Millennium Nucleus Ecology and Sustainable Management of Oceanic Island); for Colombia they are: INVEMAR (Instituto de Investigaciones Marinas y Costeras José Benito Vives de Andréis), REDCAM (Red de Vigilancia para la Conservación y Protección de las Aguas Marinas y Costeras de Colombia), REMARCO (Red de Investigación de los Estresores Marino Costeros de Latinoamérica y el Caribe), UTB (Universidad Tecnológica de Bolívar), UNC (Universidad Nacional de Colombia), ESMOI (Millennium Nucleus Ecology and Sustainable Management of Oceanic Island); finally for Mexico they are: UNAM (Universidad Nacional Autónoma de México), UABC (Universidad Autónoma de Baja California), ECOSUR (El Colegio de la Frontera Sur), UAM (Universidad Autónoma Metropolitana), UACAM (Universidad Autónoma de Campeche), UPAEP (Universidad Popular Autónoma del Estado de Puebla), UJAT (Universidad Juárez Autónoma de Tabasco), UABCS (Universidad Autónoma de Baja California Sur), UAEMex (Universidad Autónoma del Estado de México), ITSTB (Instituto Tecnológico Superior de Tierra Blanca)

and effects of microplastics on the biota of these countries.

Our research reveals that scientific production in the field of the study of microplastics shows an outstanding leadership by Mexico, followed by Colombia, Peru, and, finally, Chile. In the case of Chile, which was the nation that generated the least production, we found that it was the country that

Table 1 Journals where studies on microplastics in the Pacific Alliance countries have been published. The category is where they presented the highest SJR score

Published in	Number of publications	Journal country	Best quartile	Category	SJR 2022
Marine Pollution Bulletin	35	UK	Q1	Aquatic science	1.49
Science of the Total Environment	23	Netherlands	Q1	Environmental chemistry	1.95
Environmental Pollution	14	UK	Q1	Health, toxicology, and mutagenesis	2.11
Environmental Science and Pollution Research	5	Germany	Q1	Health, toxicology, and mutagenesis	0.94
Chemosphere	4	UK	Q1	Chemistry (miscellaneous)	1.73
Boletin de Investigaciones Marinas y Costeras	3	Colombia	Q3	Animal science and zoology	0.23
Water (Switzerland)	2	Switzerland	Q1	Aquatic science	0.72
Environmental Monitoring and Assessment	2	Netherlands	Q2	Environmental science (miscellaneous)	0.63
Revista de Investigaciones Veterinarias del Peru	2	Peru	Q4	Veterinary (miscellaneous)	0.16
Aquatic Conservation: Marine and Freshwater Ecosystems	1	UK	Q1	Aquatic science	0.8
Royal Society Open Science	1	UK	Q1	Multidisciplinary	0.84
Acta Amazonica	1	Brazil	Q3	Agricultural and biological sciences (miscellaneous)	0.27
Acta Biológica Colombiana	1	Colombia	Q3	Agricultural and biological sciences (miscellaneous)	0.22
Revista Veterinaria	1	Argentina	Q4	Animal science and zoology	0.14
Polymers	1	Switzerland	Q1	Chemistry (miscellaneous)	0.72
Environmental Research	1	USA	Q1	Biochemistry	1.64
Molecules	1	Switzerland	Q1	Pharmaceutical science	0.7
Air, Soil and Water Research	1	USA	Q2	Environmental science (miscellaneous)	0.68
Journal of Hazardous Materials	1	Netherlands	Q1	Environmental chemistry	2.57
Scientific Reports	1	UK	Q1	Multidisciplinary	0.97
Chemical Engineering Transactions	1	Italy	Q3	Chemical engineering (miscellaneous)	0.24
Environmental Quality Management	1	UK	Q1	Management, monitoring, policy, and law	0.91
Mastozoologia Neotropical	1	Argentina	Q4	Animal science and zoology	0.2
Revista Internacional de Contaminacion Ambiental	1	Mexico	Q4	Pollution	0.19
Revista Peruana de Biologia	1	Peru	Q3	Agricultural and biological sciences (miscellaneous)	0.24
Revista de la Academia Colombiana de Ciencias Exactas, Fisicas y Naturales	1	Colombia	Q3	History and philosophy of science	0.16
Revista de Biologia Marina y Oceanografia	1	Chile	Q4	Aquatic science	0.2
Diversity	1	Switzerland	Q1	Agricultural and biological sciences (miscellaneous)	0.64
Sustainability (Switzerland)	1	Switzerland	Q1	Geography, planning and development	0.66
Water, Air, and Soil Pollution	1	Netherlands	Q2	Environmental engineering	0.55

Table 1 (continued)

Published in	Number of publications	Journal country	Best quartile	Category	SJR 2022
Acta Ichthyologica et Piscatoria	1	Poland	Q3	Animal science and zoology	0.34
Bulletin of Environmental Contamination and Toxicology	1	USA	Q2	Health, toxicology, and mutagenesis	0.57
Comparative Biochemistry and Physiology Part - C: Toxicology and Pharmacology	1	USA	Q1	Animal science and zoology	0.8
Ecological Indicators	1	Netherlands	Q1	Decision sciences (miscellaneous)	1.4
Environmental Toxicology and Pharmacology	1	Netherlands	Q1	Health, toxicology, and mutagenesis	0.94
Environments-MDPI	1	Switzerland	Q2	Ecology, evolution behavior, and systematics	0.66
Ocean and Coastal Management	1	UK	Q1	Aquatic science	1.13
Regional Studies in Marine Science	1	Netherlands	Q2	Animal science and zoology	0.51
Resources, Conservation and Recycling	1	Netherlands	Q1	Economics and econometrics	2.68

invested the most of its GDP in research, followed by Colombia, Mexico, and Peru (World Bank, 2022). Despite having the lowest number of studies, Chile presents 71% ($n = 15$) of its studies with adequate analytical techniques (e.g., spectroscopy) for the confirmation of microplastics. On the other hand, in Peru, we found that 61% ($n = 14$) of the publications included analytical techniques. Colombia had 73% ($n = 19$) of its studies with methods for polymer confirmation. Finally, in Mexico, 74% ($n = 41$) of the studies confirmed the presence of synthetic polymers. It is recommended that published articles on microplastics should include analytical techniques to confirm whether the suspected particles are indeed synthetic polymers (see Garcia-Garin et al. (2020)). However, countries such as Colombia and Peru mention that one of the limitations in these types of studies is the lack of rigor in this type of analysis (De-la-Torre et al., 2021; Garcés-Ordóñez et al., 2023). It is evident that inaccessibility to appropriate laboratory equipment and infrastructure represents a major barrier for researchers aiming to conduct research of sufficient analytical merit for international journals. In addition, it should be noted that in developing countries there are limitations in polymer identification studies due to lack of equipment and high equipment costs (Alimi et al., 2021; Garcés-Ordóñez, Saldarriaga-Vélez, Espinosa-Díaz, Canals, et al., 2022).

We have identified an interesting trend in the publication of studies conducted in the Pacific Alliance countries. Mainly, these studies tend to find their space in journals in the aquatic science category, which are predominantly found on the European continent. What stands out in this pattern is the marked preference for choosing renowned journals, those that boast a higher value in the SJR indicator. This selection behavior is supported by the results of a survey of 30,466 researchers, where it was highlighted that one of the most significant reasons for choosing a specific journal lay in its reputation (Research, Nature, 2015).

Collaborations between researchers from institutions affiliated to the Pacific Alliance countries were presented in a small number of papers, limited to only seven investigations. We believe that this can be explained in part by the geographic and thematic nature of the projects. For example, projects that required sampling in different regions of the bloc found it necessary to involve local researchers. This is clearly illustrated in research such as Ory et al. (2018), which involved researchers from Peru, Chile, and Colombia. Similarly, Perez-Venegas et al. (2020) had the collaboration of Chilean and Peruvian researchers, and Aranda et al. (2022) included Colombian and Mexican researchers in their work team. In addition, Garcés-Ordóñez, Saldarriaga-Vélez, Espinosa-Díaz, Patiño, et al. (2022) had the collaboration of scientists from Colombia and Chile, while Fernández-Ojeda

et al. (2021) benefited from the cooperation between Peru and Colombia in their research. On the other hand, it is interesting to note that two investigations focused on the study of microplastics in agroecosystem soils in Chile had the participation of a researcher of Mexican affiliation, which is evident in the works of Corradini et al. (2019) and (Corradini et al., 2021).

During our Scopus search, we identified a notable discrepancy in the retrieval of results, despite the implementation of keywords and the inclusion of references to the country. In particular, we noted that the article by Ory et al. (2018), with the keyword "microplastics" in its title, did not appear in the retrieved results. To address this limitation, we extended our search to the references of the analyzed articles. It is also relevant to note that some articles could not be located due to the absence of the keywords in the titles, abstracts, or keywords of the papers. In addition, we recognize a limitation in our review by not having explored other databases, such as Google Scholar, where literature resulting from collaboration between researchers from the four countries considered might exist. Therefore, we strongly recommend a thorough evaluation in Google Scholar as an integral part of future research, although caution should be exercised, as searches in this platform may yield less accurate results and include non-peer-reviewed gray literature. It should be noted that we justify our choice to use Scopus because of its extensive use in previous reviews related to microplastics (Nunes et al., 2023; Podbielska & Szpyrka, 2023; Zuri et al., 2023).

Conclusions and perspectives

The Pacific Alliance bloc of countries signed agreements in their fight against plastic waste pollution; however, to our knowledge, there are no organized technical groups or education networks that have evidenced the effects of microplastics on ecosystems or wildlife in these countries. In this sense, we encourage collaborative work between countries with greater technological capacity to better analyze plastic samples in countries with less capacity for analysis of microplastics in the Pacific Alliance and update the methodologies or techniques for field monitoring and thus be able to publish the work in specialized journals and indexed in international databases. In addition, we suggest the participation of scientists from terrestrial ecosystems to study inland species that face the threat of microplastics, since they are the least studied.

In addition, it is necessary to promote collaboration between already identified institutions actively working on the study of the impact of microplastics on the environment together with government institutions in charge of promoting science and technology in the Pacific Alliance member countries through the allocation of specific funds for collaborative research and the promotion of knowledge exchange platforms. For example, research training could be encouraged through academic and research institutions in the training of researchers specialized in microplastics through joint training programs and fellowships. This would help strengthen the region's knowledge base and technical capacity in this field. In addition to collaboration within the Pacific Alliance, member countries could seek alliances with other nations and international organizations working on similar issues. This would facilitate the exchange of information, resources, and best practices in microplastics management.

Author contribution Félix Ayala: conceptualization, methodology, formal analysis and investigation, visualization, writing — original draft preparation, wrote and edited the final version. Antia Rangel-Vega: conceptualization, formal analysis and investigation. Edgardo Quinde: conceptualization, formal analysis and investigation. Eddy Reyes: conceptualization, formal analysis and investigation. Martin Zeta-Flores: conceptualization, formal analysis and investigation. Juan Tume-Ruiz: conceptualization, formal analysis and investigation. Gabriel Enrique De-la-Torre: conceptualization, methodology, formal analysis and investigation, wrote and edited the final version.

Data availability The data published here are supplemented by bibliometric information in the supplementary material.

Declarations

Ethics approval All the authors have read, understood, and have complied as applicable with the statement on "Ethical responsibilities of Authors" as found in the "Instructions for Authors."

Competing interests The authors declare no competing interests.

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