Wetlands of the South American Pacific Coast: A Bibliometric Approach

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Abstract

Wetlands are ecosystems susceptible to anthropogenic impacts; analysis of the scientific publications on these ecosystems can be used as a reference for the adopting of measures to facilitate research and conservation. This bibliometric analysis aimed to evaluate the temporal evolution of scientific publications and trends in research topics related to the wetlands of Ecuador, Peru, and Chile; this region includes an extended desertic region in the southern Pacific. A total of 411 articles published during the period from 2000 to 2019 were reviewed. The most frequent subject areas were 'birds' and 'other types of fauna' (20.7% and 19.2%, respectively); the diversity of publications was similar, but the proportions of the total subject areas for each country varied. The number of papers published per year was found to be increasing. The thematic areas related to these ecosystems that require strengthening in Ecuador, Peru and Chile are identified (e. g. 'hydrology and sediment' in Peru, 'microscopic organisms' in Chile, and 'birds' in Ecuador). Decision-makers should use this information to promote the development of the lines of research identified for each country.

Introduction

Wetlands are highly productive ecosystems, where water is the main controlling factor of the environment and the lives of organisms (Ramsar Convention Secretariat 2013). They provide essential ecosystem services (Ghermandi *et al.* 2010; Soorae *et al.* 2019), making them one of the most important ecosystems in terms of economic value (Davidson *et al.* 2019). However, at the same time, they are environments susceptible to the harmful effects of climate change (Day *et al.* 2008; Lee *et al.* 2015) and other impacts that occur on a local scale due to human activity, such as fires and species introduction (Ramírez *et al.* 2018; Gonzales *et al.* 2019). Wetlands, particularly those located in coastal environments, are frequently impacted by their proximity to urban areas (Aponte and Cano 2013).

One way to better understand the situation of these ecosystems is through bibliometric analysis of scientific publications. Through such analysis, functional aspects for management can be recognized; for example, they allow us to identify research gaps and make correct use of research-oriented budgets and contrast the impact of such studies on society (Ellegaard and Wallin 2015; Song and Zhao 2013; Vanti 2000). At the same time, through this type of study it is possible to identify trends in research on specific fields of knowledge, this being one of the main goals of the bibliometric approach (Romanelli *et al.* 2018; Wang *et al.* 2014). Also, bibliometrics reveals exciting perspectives on an analyzed topic, allowing us to identify any shortcomings (Corrales-Reyes and Dorta-Contreras 2019). All these aspects can generate a new outlook in little-explored fields of science and, in addition, serve as a guide for recently initiated researchers (Ellegaard and Wallin 2015; Zhang *et al.* 2010).

Around the world, most bibliometric analyses in wetlands have focused on the characteristics of trends based on the most frequently cited articles, scientific journals, institutions, and the most productive countries, all without distinguishing the type of wetland (Ma *et al.* 2013; Zhang *et al.* 2010), while others have explored distribution according to thematic and territorial scope (Paracuellos and Ortega 2003;

Wang *et al.* 2012). Bibliometric evaluations that have distinguished the type of wetland have focused on studying artificial wetlands (Zhi and Ji 2012; Colares *et al.* 2020). Studies of this type do not exist within the South American continent. In this region, wetlands form a corridor of diversity that involves an entire desert region between Peru and Chile but continues to a more rainy region in Ecuador. The conducting of a bibliometric evaluation at the South Pacific level gives decision-makers the tools to enable them to identify trends and information gaps related to the coastal wetlands of the region. Therefore, the aim of this study was to evaluate the scientific literature related to the coastal wetlands of the South Pacific in the last 20 years. At the same time, this paper aims to identify the predominant research topics associated with the study of these ecosystems in the region.

Methods

2.2. Literature review and organization

The first step was to compile all the scientific literature on the coastal wetlands of Ecuador, Peru, and Chile (including original articles and scientific notes). For this purpose, the Google Scholar search engine and the Scopus and SciELO databases were used. The keywords employed for this search were 'wetlands,' 'mangroves,' 'marshes,' 'lakes,' 'lagoons,' 'estuaries,' and 'coastal', chosen in accordance with the definition of coastal wetlands established by the Ramsar Convention (2013). These words were used in conjunction with the target country (e.g., coastal lagoons Peru, coastal lakes Ecuador) in both Spanish and English. The search was conducted in duplicate, in order to maximize the efficiency of data compilation.

2.1. Article categorization

The literature was categorized based on three variables: (1) year of publication, (2) country where the study was conducted, and (3) thematic area, such as the discipline within which the work was carried out. The thematic areas were determined according to the variety of wetland research centers in the region (Salazar-Navarro et al. 2020). The articles were categorized according to a) pathology and public health (articles regarding health, pathogens and their interaction with fauna and humans); b) microscopic organisms (studies focused on microorganisms); c) ecology (documents addressing the ecological interactions of two or more different taxa); d) remote sensing (studies using satellite technologies and image-based prediction or modeling programs); e) management and conservation (articles focused on the correct management of wetlands); f) birds (papers on organisms of this taxon); g) other types of fauna (studies that include taxa other than birds); h) flora and vegetation (research focused on the study of the organisms of these taxa); and i) hydrology and sediments (papers on physical-chemical parameters, sediment sampling, hydrogeology, and hydro-seismic relationships).

2.3. Data analysis

The number of articles produced annually by each country was compared; for each country, 20 values were obtained (one for each year between 2000 and 2019). The Kruskal-Wallis test was used to compare these values per country; this test was chosen because the data did not follow a normal distribution in all cases ($p < 0.05$ for Ecuador in the Shapiro-Wilk test).

Linear regression was performed for the total number of publications (without differentiating the country) and year. The slope of the generated line was used as a reference for growth (where positive, it was considered as a tendency to increase over time). The reliability of the model was calculated using the coefficient of determination (R2).

The diversity of thematic area by country was calculated using the Shannon-Wiener index (Harper, 1999):

$$H = - \sum (pi).\ \ln(pi)$$

Where pi is the proportion of studies in a given thematic area, divided by the total number of studies. A diversity T-test (Magurran 1988) was carried out to compare the diversities of thematic area across countries.

A contingency table was prepared to compare whether the proportions of the thematic areas of countries were similar. An X2 test was performed in order to evaluate the association between the proportions of the thematic areas and countries. Cramér's V coefficient was also calculated; this coefficient enables evaluation of the degree of association of qualitative variables (in this case, thematic areas) by category (in this case, countries); this value varies between 0 and 1, where one indicates a strong association (Akoglu 2018).

All the statistical and diversity analyses mentioned in this section were conducted using PAST V 4.03 free software (Hammer *et al.* 2001).

Results

A total of 411 articles were reviewed; 24.8% corresponded to wetlands in Ecuador (102 articles), 37.5% (154) to wetlands in Peru, and 37.7% (155) to wetlands in Chile. The temporal distribution of scientific production for the three countries increased over time, despite some periods of decline (Figure 1). The growth in scientific production is confirmed, displaying a linear trend supported by an R2 = 0.77 with a positive slope (see Figure 2 for the equation's details). Chile was the only country to have produced at least one article per year during the evaluated period. For the three countries, the most significant period for growth in the publication of articles was 2019. Although Ecuador is the country with the fewest number of published articles, its production in 2019 was higher than that of the other countries. The average number of articles produced per year was 5.1, 7.7, and 7.8 for Ecuador, Peru, and Chile, respectively; Kruskal-Wallis analysis indicates that this production is not different between these countries ($p = 0.075$).

'Birds' and 'other types of fauna' were the most frequent thematic areas (with 20.7% and 19.2% of publications, respectively), followed by 'management and conservation', 'flora and vegetation' and 'hydrology and sediment' (with 15.6%, 15.1% and 13.1%, respectively). Finally, those with the lowest percentages were 'ecology', 'remote sensing', 'pathology and public health' (with 4.4% each) and 'microscopic organisms' (3.2%) (Figure 3, Table 1). According to the X2 test, each country displayed a different scientific production in thematic areas ($X^2 = 72.75$ $p < 0.05$ and $V = 0.297$). The largest number of studies in Ecuador is associated with 'management and conservation' and 'other types of fauna' (26.5%). In Peru, the predominant areas of study are 'birds' (25.3%) and 'flora and vegetation' (20.1%). Chile has a higher scientific production in studies related to 'hydrology and sediment' (24.5%) and 'birds' (20%). Finally, Peru is shown as the country with the greatest diversity in terms of thematic scope (H' = 1.969), followed by Chile (H' = 1.903) and Ecuador (H' = 1.856); despite this, no differences between the diversities of the thematic areas by country were identified (p> 0.05 for the diversity T-test, Table 2).

Discussion

The growing interest in coastal wetlands indicated by this study is also a trend seen in other scientific fields, such as those related to forest ecosystems, ecosystem services and renewable energies (Chen *et al.* 2020; Duan *et al.* 2020; Manzano-Agugliaro *et al.* 2013). In the case of coastal wetlands, this trend may be related to the growing worldwide attention arising from their potential ecosystem services, such as flood risk reduction and carbon sequestration (Chen *et al.* 2020; Zedler and Kercher 2005; Mitsch *et al.* 2015). Other causes may be the increased resources devoted to research activities in recent years (Red de Indicadores de Ciencia y Tecnología 2017). The results obtained in this study indicate a linear increase in such publications, a trend that is expected to continue over the coming years; however, further studies will be required in order to confirm whether or not this increase is maintained. It is also essential that studies be developed to evaluate the use of these articles within the scientific community, as well as by decision makers.

The presence of research centers is vital for scientific production on any given subject (Ponomariov and Boardman 2010). In the Andean region, 51% of the organizations focused on the studying of wetlands are located in Ecuador, Peru, and Chile (Salazar-Navarro *et al.* 2020). However, the results of this study indicate that none of these three countries exhibits a marked difference in terms of the number of publications per year, while the three present different preferences in terms of their production. These results are also reflected in the study by Salazar-Navarro *et al.* (2020), where Peru is shown to have presented more studies at conferences in the field of limnology related to 'botany', Chile to 'hydrogeology', and Ecuador to 'conservation'. Ma *et al.* (2013) determined that two of the leading research topics in wetlands are related to organisms and vegetation; this coincides with our results, since fauna and flora studies constitute more than 50% of published articles.

The results obtained in this study indicate the thematic areas that must be reinforced in each country. Efforts should be increased in relation to research associated with 'hydrology and sediment' in the coastal wetlands of Peru; this knowledge is crucial to understand the origin and future of wetlands in this

desertic area. In Chile, studies of 'microscopic organisms' should be expanded, while in Ecuador, it is crucial that greater effort be invested in the publishing of studies on 'birds'. Among the least represented areas for the three countries is 'pathology and public health,' a relevant topic since these desertic areas are constantly affected by epidemics (e.g. Ries *et al.* 1992; Segovia *et al.* 2013; Aspilcueta-Gho 2017).

It cannot be ruled out that many publications may have been made in ways other than those considered in this study (such as books or technical documents); however, we consider it essential that scientific production be empowered in the category of peer-reviewed articles, as well as in the databases used in the present analysis. Currently, initiatives exist which have expressed interest in protecting these ecosystems, such as the Initiative for the Conservation of Coastal Wetlands and Shorebirds on the Arid Coast of the South American Pacific (humedalescosteros.org). It is our hope that this information will serve to promote projects in areas that require special attention, such as those we have identified. We feel certain that the results of this study have the potential to serve to generate policies and recommendations for the continuation of research in these ecosystems which are so important to humanity.

Conclusions

A total of 411 articles concerning the coastal wetlands of Peru, Chile and Ecuador were reviewed. The most frequent subject areas were 'birds' and 'other types of fauna'; the diversity of publications was similar across the different countries, but the proportions of the total subject areas of each country varied. A growing trend is indicated in the number of papers published per year. The thematic areas that require strengthening have been identified, and they must be considered in order to enable decision-makers and researchers to intensify their focus in these specific areas within each country.

Declarations

Acknowledgments

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References

1. Aspilcueta-Gho D (2017). Infección por zika en el Perú: de amenaza a problema de salud. Revista Peruana de Ginecología y Obstetricia. 2017;63(1), 57-64.
2. Aponte H, Cano A (2013) Estudio florístico comparativo de seis humedales de la costa de Lima (Perú): actualización y nuevos retos para su conservación. Revista Latinoamericana de Conservación | Latin American Journal of Conservation, 3(2), 15-27.
3. Akoglu H (2018) User's guide to correlation coefficients. Turkish Journal of Emergency Medicine, 18(3), 91–93. https://doi.org/10.1016/j.tjem.2018.08.001

4. Chen W, Geng Y, Zhong S, Zhuang M, Pan H (2020) A bibliometric analysis of ecosystem services evaluation from 1997 to 2016. Environmental Science and Pollution Research, 27, 23503–23513. https://doi.org/10.1007/s11356-020-08760-x
5. Colares G, Dell'Osbel N, Wiesel P, Oliveira G, Lemos P, da Silva F, Lutterbeck CA, Kist LT, Machado ÊL (2020) Floating treatment wetlands: a review and bibliometric analysis. Science of The Total Environment, 714, 136776. https://doi.org/10.1016/j.scitotenv.2020.136776
6. Corrales-Reyes I, Dorta-Contreras A (2019) Producción científica cubana en estomatología en el período 1995-2016: análisis bibliométrico en Scopus. Revista Cubana de Estomatología, 56 (3), 1–14.
7. Davidson N, van Dam A, Finlayson C, McInnes R (2019) Worth of wetlands: revised global monetary values of coastal and inland wetland ecosystem services. Marine and Freshwater Research, 70 (8), 1189-1194.
8. Day JW, Christian R, Boesch DM, Yáñez-Arancibia A, Morris J, Twilley R, Naylor L, Schaffner L, Stevenson C (2008) Consequences of Climate Change on the Ecogeomorphology of Coastal Wetlands. Estuaries and Coasts, 31, 477–491. https://doi.org/10.1007/s12237-008-9047-6
9. Duan G, Bai Y, Ye D, Lin T, Peng P, Liu M, Bai S (2020) Bibliometric evaluation of the status of Picea research and research hotspots: comparison of China to other countries. Journal of Forestry Research, 31, 1103-1114. https://doi.org/10.1007/s11676-018-0861-9
10. Ellegaard O, Wallin J (2015) The bibliometric analysis of scholarly production: how great is the impact? Scientometrics, 105, 1809–1831. https://doi.org/10.1007/s11192-015-1645-z
11. Ghermandi A, van den Bergh J, Brander L, de Groot H, de Nunes P (2010) Values of Natural and Human-made Wetlands: A meta-analysis. Water Resources Research, 46 (12). https://doi.org/10.1029/2010WR009071
12. Gonzales S, Aponte H, Cano A (2019) Actualización de la flora vascular del humedal Santa Rosa-Chancay (Lima, Perú). Arnaldoa, 26 (3), 867-882. Hammer O, Harper DA, Ryan PD (2001) PAST: Paleontological Statistics Software Package for Education and Data Analysis. Palaeontología electrónica, 4 (1).
13. Harper D (1999) Numerical Palaeobiology: Computer-based modelling and analysis of fossils and their distributions. John Wiley & Sons Inc. Lee SY, Ryan ME, Hamlet AF, Palen WJ, Lawler JJ, Halabisky M (2015) Projecting the Hydrologic Impacts of Climate Change on Montane Wetlands. PLOS ONE, 10, e0136385. https://doi.org/10.1371/journal.pone.0136385
14. Ma J, Fu HZ, Ho YS (2013) The top-cited wetland articles in science citation index expanded: characteristics and hotspots. Environmental Earth Sciences, 70, 1039–1046. https://doi.org/10.1007/s12665-012-2193-y
15. Magurran A (1988) Ecological Diversity and its Measurement. New Jersey: Princeton University Press.
16. Manzano-Agugliaro F, Alcayde A, Montoya FG, Zapata-Sierra A, Gil C (2013) Scientific Production of Renewable Energies Worldwide: An overview. Renewable and Sustainable Energy Reviews, 18, 134–

143. https://doi.org/10.1016/j.rser.2012.10.020

17. Mitsch W, Bernal B, Hernandez M (2015) Ecosystem Services of Wetlands. International Journal of Biodiversity Science, Ecosystem Services and Management, 11(1), 1–4. doi:10.1080/21513732.2015.1006250
18. Paracuellos M, Ortega M (2003) Bibliografía y bibliometría relacionadas con los humedales almerienses (Sudeste Ibérico). En: Paracuellos, M. (ed.). Ecología, manejo y conservación de los humedales. Almería, España: Instituto de Estudios Almerienses, pp. 199-220.
19. Ponomariov B, Boardman P (2010) Influencing scientists' collaboration and productivity patterns through new institutions: university research centers and scientific and technical human capital. Research Policy, Special Section on Government as Entrepreneur, 39 (5), 613–624. https://doi.org/10.1016/j.respol.2010.02.013
20. Ramirez DW, Aponte H, Lertora G, Gil F (2018) Incendios en el humedal Ramsar Los Pantanos de Villa (Lima-Perú): avances en su conocimiento y perspectivas futuras. Revista de Investigaciones Altoandinas, 20 (3), 347–360. https://doi.org/10.18271/ria.2018.398
21. Red de Indicadores de Ciencia y Tecnología (2017) El estado de la ciencia. Principales Indicadores de Ciencia y Tecnología Iberoamericanos / Interamericanos. Buenos Aires, Argentina: Red de Indicadores de Ciencia y Tecnología
22. Ries AA, Vugia DJ, Beingolea L, et al (1992). Cholera in Piura, Peru: A Modern Urban Epidemic, The Journal of Infectious Diseases, 166 (6), 1429–1433. https://doi.org/10.1093/infdis/166.6.1429
23. Romanelli J, Fujimoto JT, Ferreira M, Milanez DH (2018) Assessing ecological restoration as a research topic using bibliometric indicators. Ecological Engineering, 120, 311–320. https://doi.org/10.1016/j.ecoleng.2018.06.015
24. Salazar-Navarro K, Olortigue-Tello AD, Aponte H, Lobato-de-Magalhaes T (2020) Wetland Science in Latin America and the Caribbean Region: Insights into the Andean States. Wetland Science and Practice, 37 (4).
25. Secretaría de la Convención de Ramsar (2013) Manual de la Convención de Ramsar: Guía a la Convención sobre los Humedales (Ramsar, Irán, 1971). Gland, Suiza: Secretaría de la Convención de Ramsar.
26. Segovia H K, Icochea D E, González V R, et al (2013) Presencia del virus de influenza aviar en aves silvestres de los humedales de Puerto Viejo, Lima. Revista de Investigaciones Veterinarias del Perú 24:98–103.
27. Song Y, Zhao T (2013) A bibliometric analysis of global forest ecology research during 2002–2011. Springerplus, 2, 204. https://doi.org/10.1186/2193-1801-2-204
28. Soorae P, Sakkir S, Saji A, Khan S, Zaabi R, Shah J, Ali A, Al Omari K, Al Dhaheri A, Javed S, Tubati S, Ahmed S, Alrashdi Z, Al Dhaheri S (2019) A Review of the Flora and Fauna in the Al Wathba Wetland Reserve in Abu Dhabi, United Arab Emirates. Wetlands Conservation, 40, 1505–1512. https://doi.org/10.1007/s13157-019-01235-x

29. Vanti N (2000) Métodos cuantitativos de evaluación de la ciencia: bibliometría, cienciometría e informetría. Investigación Bibliotecológica: archivonomía, bibliotecología e información, 14 (29). https://doi.org/10.22201/iibi.0187358xp.2000.29.3943
30. Wang B, Pan S, Ke R, Wang K, Wei Y (2014) An overview of climate change vulnerability: a bibliometric analysis based on Web of Science database. Natural Hazards, 74, 1649–1666. https://doi.org/10.1007/s11069-014-1260-y
31. Wang L, Li J, Liu H, Wang W, Liang C, Yang J (2012) Bibliometric analysis of status quo of wetland science in China. Advanced Materials Research, 518-523, 5984-5988. https://doi.org/10.4028/www.scientific.net/AMR.518-523.5984
32. Zedler J, Kercher S (2005) Wetland Resources: Status, trends, ecosystem services, and restorability. Annual Review of Environment and Resources, 30(1), 39–74. doi: 10.1146/annurev.energy.30.050504.144248
33. Zhang L, Wang M, Hu J, Ho Y (2010) A review of published wetland research, 1991–2008: ecological engineering and ecosystem restoration. Ecological Engineering, 36 (8), 973–980. https://doi.org/10.1016/j.ecoleng.2010.04.029
34. Zhi W, Ji G (2012) Constructed wetlands, 1991–2011: a review of research development, current trends, and future directions. Science of The Total Environment, 441, 19–27. https://doi.org/10.1016/j.scitotenv.2012.09.064

Tables

Table 1. Percentage of articles by thematic area for each country.

Thematic area	Ecuador (%)	Peru (%)	Chile (%)
Birds	14.7	25.3	20.0
Other types of fauna	26.5	17.5	16.1
Management and conservation	26.5	10.4	13.5
Flora and vegetation	10.8	20.1	12.9
Hydrology and sediment	8.8	4.5	24.5
Ecology	2.0	5.2	5.2
Remote sensing	5.9	1.9	5.8
Pathology and public health	3.9	7.8	1.3
Microscopic organisms	1.0	7.1	0.6

Table 2. P. values for the diversity T-test, by pairs of countries.

	Peru	Chile
Chile	0.395	
Ecuador	0.227	0.588

Figures

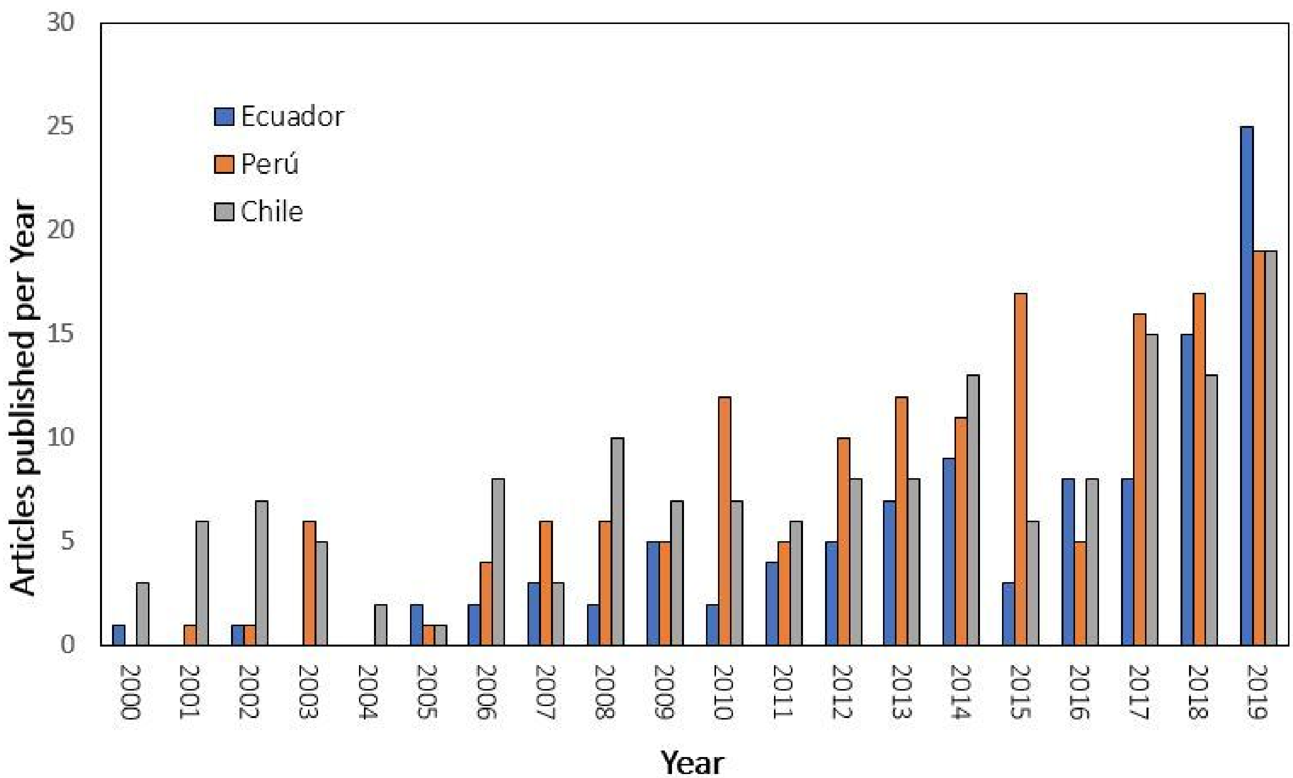

Figure 1

Articles on marine-coastal wetlands of the South American Pacific coast between 2000 and 2019, by country.

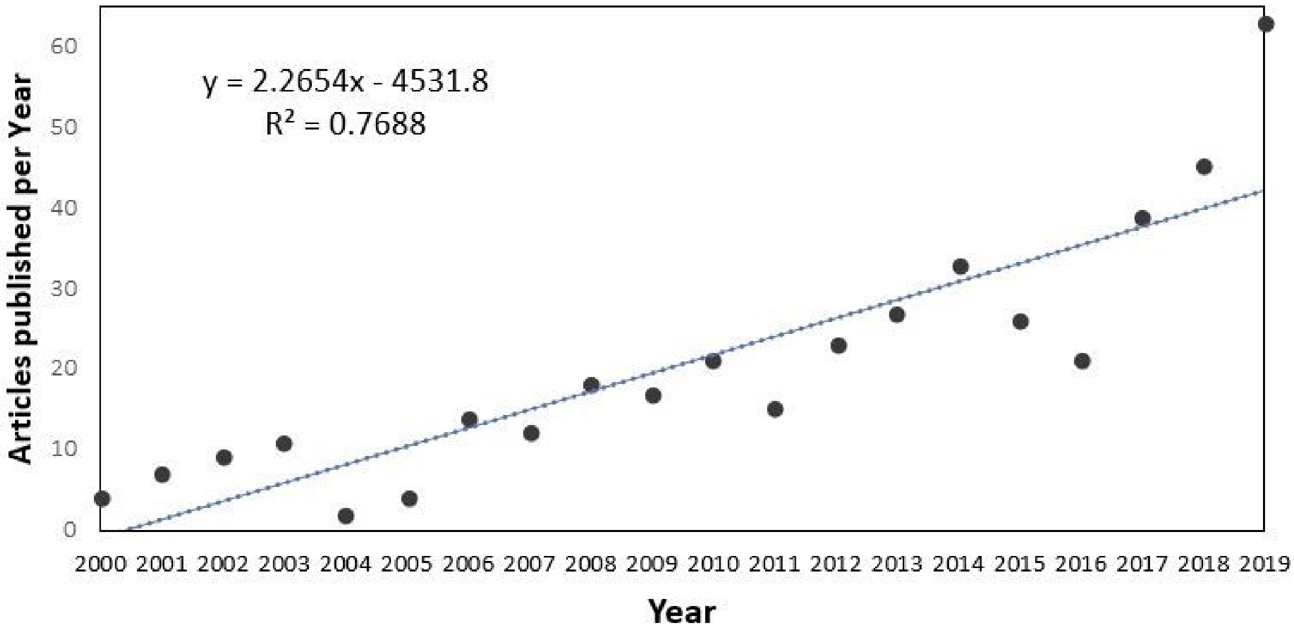

Figure 2

Articles on coastal-marine wetlands of the South American Pacific coast between 2000 and 2019; the equation resulting from the regression is included.

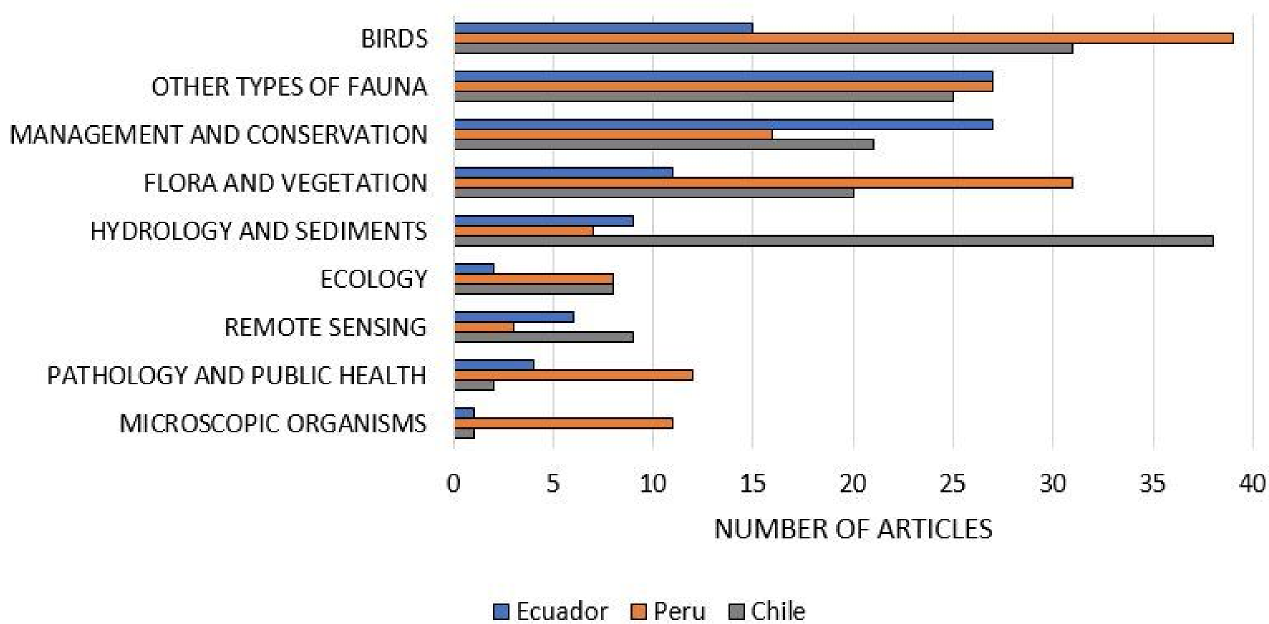

Figure 3

Scientific production in Ecuador, Peru and Chile, according to thematic area.