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Bibliometric Analysis of Global Research Trends on Invertebrate and Conservation Studies from 1990-2022

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Abstract: The current paper presents findings on research studies in line with conservation and invertebrates (1990-2022) using bibliometric techniques in R studio software. Results obtained from the study among others include; key authors, nations' citations and publication numbers, affiliations, journal sources, and important keywords that are often used by authors in the field. A total of 417 pieces of research literature were recovered from the Woos archive with an average citation per doc and co-authors per document ratio of 27.54 and 4.59, respectively. Studies on invertebrates and conservation studies were correlated with the number of years (R^2 = 0.8525 y = 0.9856 x -4.1193) which suggests an increase in the number of articles in the future. The USA was in the top position in relation to article numbers (n = 90) and citations (n = 3118), followed by Australia (n = 48; n = 2315) and the UK (n = 24; n = 462), respectively. Articles from the USA (n = 30), Australia (n = 22), and the UK (n = 11) had strong networks with other countries globally. Top topic priorities in the research field with relation to author keywords include; Conservation (n = 70), Coral reefs (n = 52), Biodiversity (n = 27), and Climate change (n = 16), respectively. Financially stable and scientifically advanced countries have been revealed to have higher research publications than developing nations. It was also observed from the result of thematic evolution and literature classifications that, marine protected areas, conservation management, corals, and the Caribbean are vital to scientists and researchers in this study field, thus signifying the direction of future research.

Keywords: Conservation Research, Bibliometric, Invertebrates, Global Trend

Introduction

Invertebrates form a major and functionally substantial part of terrestrial and freshwater biodiversity and they are priceless indicators of ecological conditions. Invertebrates are also vital in all ecosystems with regard to species richness. It has been estimated that between 80-90% of all species in the ecosystem are invertebrates (Cardoso *et al*., 2011). Meanwhile, not just being abundantly available in the universe, they play a significant role in the ecosystem such as putrefaction, pollination, soil fertility and structure, and plant productivity, as well as assist in the regulation of other species populations in the ecosystem. In addition, invertebrates form a major portion of almost every food chain and play a key role as food sources for several vertebrates (Hamer and Slotow, 2017).

According to Losey and Vaughan (2006), it was reported that the yearly financial worth of invertebrates (insects among others) from four varied ecosystem functions such as ecotourism, pollination, burial of dung, and species control of local herbivores in the United States alone is summed up to $57 billion on a yearly basis. Invertebrates are also known to be key indicators of environmental change (McGeoch *et al*., 2011). In addition to the useful roles that they play, several invertebrate taxa have little spread ranges, that is, they are slim endemics (Harvey, 2002), which makes their conservation very significant in the global ecosystem.

One of the chief reasons for conserving invertebrates is to guarantee the adequate protection of uncommon and endangered species (McGeoch *et al*., 2011). However, the consideration of invertebrates as significant species in the natural ecosystem has not been taken seriously in the area of conservation forecasting and management over the years (Lovell *et al*., 2010). Several reasons have been given for the lack of inclusion of invertebrates in conservation and management schemes. Cardoso *et al*. (2011), enumerated

some of the major constraints that affect invertebrates with respect to conservation activities which include lack of sensitization (among the general public and policy-makers) of the ecological functions that they play, lack of fundamental scientific knowledge, species adaptations to habitat change, a huge amount of undescribed species as well as poor understanding about the spread of recognized species among other reasons. It should be mentioned that the conservation of invertebrates is essential to sustaining healthy ecosystems, enhancing the well-being of humans, as well as protecting the biological diversity of important species for forthcoming generations (McGeoch, 2007).

Although, a lot of literature on invertebrates and their roles in the natural ecosystem has been published (Kepe, 2008; Corona *et al*., 2011; Hamer and Slotow, 2017; Chen, 2021). However, it is scary to find publications that have adopted the use of bibliometrics to describe the trends and distributions in the topics of invertebrates with respect to conservation. Therefore, the current paper aims to reveal the current status of scholarly literature on global research findings and trending topics on invertebrates as linked to conservation.

The research question with respect to the current paper is to first spot the knowledge base of research carried out on invertebrates and conservation. Furthermore, the study aims to project a global social network with regard to invertebrates and conservation findings/ subject trends. This study further hopes to pinpoint the global research range on invertebrates and conservation by presenting the relevant authorities with regard to authors, major nations, article outputs, keywords, global spread in citations, as well as trending topics in this field. Furthermore, we hope to assess the global future progressions in the literature topics from a scholarly perspective by employing various bibliometric indicators.

Suffice it to state that, bibliometric is a unique instrument that involves the permutation of the statistical matrix as well as mathematical indices to describe research findings and how they impact nations, institutions as well as policymakers on the global stage in a specific field (Zou *et al*., 2019). The present study like several other bibliometric research will assist us generate a knowledge portfolio that is capable of projecting future lead-way in this field. The study will further assist in giving the latest global status of what the current hotspots in the field of conservation and invertebrates entail. These details are anticipated to be useful to policymakers, scientists, and all stakeholders in managing and improving this sector.

In summary, the objectives of this study could be captured as follows:

1) To describe the thematic evolution in the field of invertebrates and conservation studies
2) To identify the major/relevant influencers (i.e., countries, institutions, as well as authors) in this field; and
3) To present the indices of how studies in this field (invertebrates and conservation) compare on the global stage such as the number of publications, citations, trends, and country networks

Methodology

Data Retrieval

The present manuscript utilized articles on invertebrates and conservation studies research outputs that were obtained from the Web of Science (WoS) archive due to its known reputable records to generate quality standard academic materials (Zhu and Liu, 2020). Likewise, the WoS database is identified to possess a host of reliable and quality scholarly articles when compared to other databases such as PubMed and Scopus (Qin *et al*., 2020; Mejia *et al*., 2021). In addition, the Web of Science (WoS) data archive was selected for this study because of its high collection of physical sciences, biological sciences, and technology research publications (Balstad and Berg, 2020; Tarragona *et al*., 2020), which was rightly suited for us to use for the present study. While other databases such as PubMed, Scopus, Google Scholar, etc. are good resources for document extractions, the WoS database is usually considered better for bibliometrics because of its advanced citation analysis, comprehensive coverage, high collection of quality data, well-grounded analytical instruments, provision for interdisciplinary investigation, as well as being user-friendly for data extraction (Singh *et al*., 2021; Zhang *et al*., 2023). Web of Science database is known to be one of the most dependable as well as extensive assemblages of bibliometric scholarly literature and it accommodates a group of high-caliber and prominent scientific articles with an estimated 12 million research papers in more than 12,000 journal sources (Wang *et al*., 2023).

Advanced search was adopted in WoS to obtain the required articles in our study because it allows a buildup of long and all-inclusive search questions. Again, the general notion about the use of one database for bibliometric studies is sometimes supported because of the complexities involved in doing bibliometric studies with multiple databases which may result in the loss of several relevant articles about the subject matter (Sweileh, 2020).

Search Stratagem for Data Recovery

A search question that covers the related number of research work with the slightest false-positive outcome by using Wikipedia was employed in the present study after

an exhaustive literature search on the subject matter (especially related studies and systematic reviews) to familiarize with the appropriate keywords connected with the search topic (Fesseha *et al*., 2020). For a broader search, the study adopted the use of the topic search technique for related keywords on "invertebrates" and "conservation" studies to gather all the required data for this study. Since gathering related data of literature from WoS requires a query search, the query research involved both searching for keywords and Boolean functions. Consequently, the present study focused on invertebrates in relation to conservation studies. The operator AND separates these keywords. Each of these has synonymous keywords that authors frequently use in the field. The operator OR is used to separate these keywords within each group.

The keyword includes conservation studies, the invertebrate keyword group ("Coral", "Cnidar", "Octopus", "Squid", "Mollusc", "Velvet worm", "Onychophor", "Nautil", "crab", "Arthropod", "jellyfish", "echinoderm", "sponge", "invertebrate"). However, the Boolean operators AND as well as OR are employed to limit the scope of the resulting subject matter. From our initial search query, we retrieved all article types including review papers, research papers, book chapters, patents, and conference presentations published from 1990-2022 from the Web of Science. Conversely, the present study excluded every other publication, apart from research articles in order to avoid any form of ambiguity that may result from these other publication types (REF). The final article collections comprise the sum of 417 unique research documents.

Search Question for Present Study

Search questions with specific phrases that are closely related to invertebrates as linked to conservation studies were captured in the WoS database, followed by detailed terminologies as a constraint to reduce and take out unwanted research articles that don't contribute to the goal of the present study. After the literature documents were retrieved from WoS, they were cleaned up by removing any articles that did not fit the purpose of the present study before validation. Research literature that appears not to directly address the topic of discourse was excluded. This inclusion and exclusion of data for the study was achieved by an exhaustive literature review search of important keywords related to the subject matter so as to familiarize with frequently used possible keywords linked to the research topic in consideration. Previous authors have also used this type of inclusion and exclusion strategy to screen unwanted documents (King *et al*., 2018; Fesseha *et al*., 2020). Likewise, a literature search was streamlined to remove review articles, technical notes, proceedings other languages aside from English, etc., Fig. (1). For detailed description of the search queries is explained below:

- 418 results from the Web of Science core collection for
- Conservation And (Coral* OR Cnidar* OR Octopus* OR Squid* OR Mollusc* OR 'Velvet worm*' OR Onychophor* OR Nautil* OR crab* OR Arthropod* OR jellyfish* OR echinoderm* OR sponge*) (Title)
- Refined by: Not publication years: 2023. Click to remove this refine from your search. Document Types: Article. Click to remove this refine from your search. Not document types: Early access or data paper or book chapters or proceeding paper
- 417 results from the filter in Rstudio
- Language (English)

Processing and Analysis of Data Used for the Present Study

Research data obtained from WoS were analyzed using the version R version 4.3.0 (2023-04-21 ucrt) RStudio software package with bibliometrix R-package for bibliometric descriptions (Aria and Cuccurullo, 2017). All data were then inputted into R Studio for analysis and visualization of outcomes (Idamokoro, 2023). Bibliometrix R-package was also used (R-project web interface in Biblioshiny) to explain the outcomes of results which include citation analysis, authors' scientific performance nations' performance, author's keywords, and scholarly collaborations by countries and authors. The R studio software package was employed to explain its results (e.g., citation numbers, authors' impact, authors' collaborations, organization networks among others) and bibliometric appraisal of diagrammatic coupling (e.g., keyword co-occurrences and co-citation) of bipartite interactions of the rectangular indexes of research outputs × attributes.

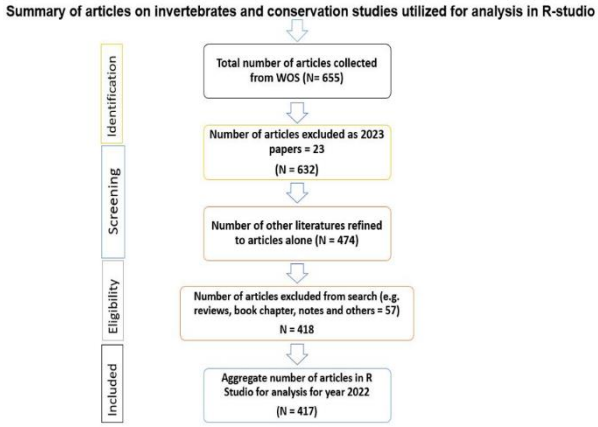

Fig. 1: Diagram showing the criteria for inclusion and exclusion of articles from WoS

For a clearer illustration, the statistical presentation for a classic bibliometric network is presented below:

$$Network\,(N)=O\times T^{P}$$

where, the letter "*O*" depicts a bipartite complex matrix of research articles × attributes (e.g., keywords plus, institution, nations, keywords, countries' influence, and article citations). The letter "*N*" denotes the symmetrical matrix *N* = *TP*.

Additionally, the study employed a model for all networks using a software language called the force-directed Fruchterman technique which was entered into the networkPlot command of the bibliometrix R-package. Furthermore, all the results of networks of countries and keywords were normalized by Salton's cosine coefficient, proximity indexes (collaboration strength), Simpson's coefficient, and Jaccard's similarity indexes in clusters of a network as describe by Aria and Cuccurullo (2017). In addition, the k-means nodes were used for the author's keywords to determine the concepts of keywords often used by authors for invertebrates and conservation studies (Porter, 1980).

Results

A sum of 417 research publications was collected for the study within the year 1990-2022. The summary of the recovered documents is listed in Table (1). From Table (1), the total number of authors that covered the study span was 1619, meanwhile, the number of single authors is 37. There were 4.59% co-authors per document, but 42.21% international co-authorships. The average number of citations per document is 27.54%, the sum total of references is 20901, and the annual growth rate of this research field is 6.85%.

Table 1: Information summary of articles retrieved on the study trend on invertebrates and conservation research from the WoS database

Description	Results
Main information about the data	
Timespan	1990:2022
Sources (Journals, Books, etc.,)	202
Documents	417
Annual growth rate %	6.85
Document average age	9.93
Average citations per doc	27.54
References	20901
Document contents	
Keywords plus (ID)	1713
Author's keywords (DE)	1538
Authors	
Authors	1691
Authors of single-authored docs	35
Authors collaboration	
Single-authored docs	37
Co-authors per doc	4.59
International co-authorships %	42.21
Document types	
Article	417

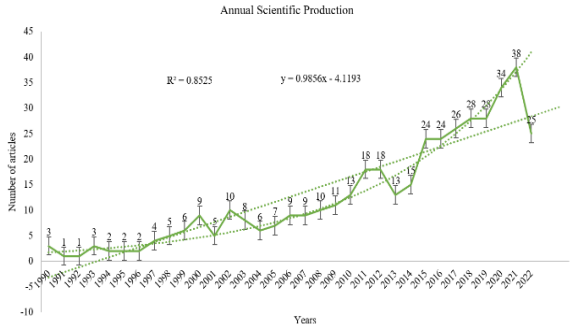

Fig. 2: The annual number of articles on invertebrates and conservation from 1990-2022

Furthermore, Fig. (2) showed results from the data that were analyzed with a polynomial function fitting curve. The polynomial function fitting described by the annual increase rate of study depicts a positive correlation (R^2 = 0.8525; y = 0.9856× -4.1193) between the cumulative numbers of articles as well as years of research articles. From Fig. (2), the result again showed a trend in research outputs with some fluctuations between 1999 and 2016 in the study span, but with a steady rise in article output on invertebrates and conservation studies from 2017-2021, although there was a decrease in the year 2022. The annual increase rate of publication production on invertebrate and conservation research is 6.85%. The highest article number on the subject matter was captured in 2021 (n = 38).

Table (2) shows publication outputs on invertebrates and conservation for the top-ranked 20 most productive countries with regard to the quantity of research outputs. The United States of America (USA) was rated first in the quantity of published research in the field (n = 90% of articles by a nation per total global articles = 21.58). This result was followed by Australia (n = 48% of articles by a nation per total global articles = 11.51), the United Kingdom (n = 24% of articles by a nation per total global articles = 5.75), China (n = 21% of articles by a country per total global articles = 5.03), as well as Spain (n = 15% of articles by a country per total global articles = 3.59), respectively. The frequency of research outputs differs among the 20 top-ranked countries from 0.014-0.216. The peak countries among the 20 globally ranked nations with Multiple Country Publications (MCP), include the USA (n = 30), Australia (n = 22), United Kingdom (n = 11) as well as China (n = 9), respectively. The countries ranked in the top place for Single Country Publications (SCP) of research studies include the USA (n = 60), Australia (n = 26), United Kingdom (n = 13), as well as China (n = 12), respectively (Table 2).

Table 2: 20 most productive nations on invertebrate and conservation research studies based on number of articles from corresponding authors

S/N	Nation	Articles	% of article	TC	AAC	SCP	MCP	Frequency	MCP_Ratio
1	USA	90	21.58	3118	34.60	60	30	0.216	0.333
2	Australia	48	11.51	2315	48.20	26	22	0.115	0.458
3	United Kingdom	24	5.75	462	19.20	13	11	0.058	0.458
4	China	21	5.03	307	14.60	12	9	0.05	0.429
5	Spain	15	3.59	311	20.70	9	6	0.036	0.400
6	France	14	3.35	440	31.40	6	8	0.034	0.571
7	Canada	13	3.11	267	20.50	7	6	0.031	0.462
8	Brazil	12	2.87	117	9.80	8	4	0.029	0.333
9	Italy	12	2.87	166	13.80	5	7	0.029	0.583
10	Germany	11	2.63	297	27.00	4	7	0.026	0.636
11	Portugal	10	2.39	160	16.00	1	9	0.024	0.900
12	New Zealand	9	2.15	319	35.40	3	6	0.022	0.667
13	Costa Rica	8	1.91	76	9.50	2	6	0.019	0.750
14	India	8	1.91	61	7.60	8	0	0.019	0.000
15	Mexico	8	1.91	113	14.10	3	5	0.019	0.625
16	South Africa	8	1.91	165	20.60	7	1	0.019	0.125
17	Indonesia	7	1.67	10	1.40	6	1	0.017	0.143
18	Japan	7	1.67	119	17.00	7	0	0.017	0.000
19	Czech Republic	6	1.43	160	26.70	6	0	0.014	0.000
20	Singapore	6	1.43	111	18.50	4	2	0.014	0.333

SCA: Single Country Articles; MCA: Multiple Country Articles; TC: Total Citations; AAC: Average Article Citations

Table 3:20 most relevant words used by authors in invertebrates and conservation research study

S/N	Authors Keywords (DE)	Occurrences	Keywords plus (ID)	Occurrences
1	Conservation	70	Management	50
2	Coral reef/s	52	Biodiversity	47
3	Biodiversity	27	Diversity	38
4	Climate change	16	Communities	32
5	Marine protected area	16	Marine protected areas	31
6	Marine protected areas	14	Patterns	30
7	Coral	13	Evolution	23
8	Diversity	11	Impacts	23
9	Coral triangle	10	Abundance	21
10	Endangered species	10	Resilience	20
11	Invertebrates	10	Reserves	18
12	Management	10	Great-barrier-reef	17
13	Taxonomy	10	Populations	17
14	Arthropods	9	Connectivity	16
15	Biodiversity conservation	8	Ecology	15
16	Biogeography	8	Species richness	15
17	Marine	8	Fisheries	14
18	Sustainability	8	Decapoda	13
19	Conservation planning	7	Fish	13
20	Corals	7	Growth	13

Equally, the most cited countries in invertebrates and conservation studies indicate that the USA was placed in the first position (n = 3118), while Australia (n = 2315), the UK (n = 462), France (n = 440), and Switzerland (n = 407), were placed at the top position, respectively (Table 2). With regards to the top-ranked 20 relevant keywords (author's keywords) by researchers in the studied field of invertebrates and conservation, it was revealed that Conservation (n = 70) was placed in first position, next was Coral reef/s (n = 52), followed by Marine protected area/s (n = 30), Biodiversity (n = 27), Coral/s (n = 20) and Climate change (n = 16) among other author keywords Table (3).

The output results for the 25 most relevant journal sources with the greatest published articles in the field of invertebrates and conservation are listed in Table (4). The names of this journal include Biological Conservation (n = 22; 5.27%), Frontiers in Marine

(n = 15; 3.59 %), Revista De Biologia Tropical (n = 12; 2.87%), Aquatic Conservation-Marine and Freshwater Ecosystems (n = 10; 2.39%) and Biodiversity and Conservation (n = 10; 2.39%), respectively. In addition, the top-ranked prolific research institutions with more than seven research publications are shown in Table (5). James Cook University in Australia (n = 36) was ranked in the first place position; The University of Queensland in Australia (n = 33) was placed in the second position, while the University of Costa Rica in Costa Rica was ranked in the third position (n = 26) and the National University of Singapore was ranked in the fourth position (n = 23), while the University of British Columbia in Canada was ranked in the fifth position (n = 19), accordingly.

Table 4: The 25 most relevant journal sources in invertebrate and conservation research based on the number of articles published within the studied period

S/N	Sources	Articles	% of articles	Ranking
1	Biological conservation	22	5.27	1st
2	Frontiers in marine science	15	3.59	2nd
3	Revista de biologia tropical	12	2.87	3rd
4	Aquatic conservation-marine and freshwater ecosystems	10	2.39	4th
5	Biodiversity and Conservation	10	2.39	4th
6	Ocean \& coastal management	10	2.39	4th
7	Coral reefs	9	2.15	5th
8	Marine pollution bulletin	9	2.15	5th
9	Plos one	9	2.15	5th
10	Scientific reports	9	2.15	5th
11	Conservation biology	8	1.91	6th
12	Journal of Insect Conservation	8	1.91	6th
13	Diversity and distributions	7	1.67	7th
14	Marine Ecology Progress Series	6	1.43	8th
15	Bulletin of Marine Science	5	1.19	9th
16	Diversity-basel	5	1.19	9th
17	Zootaxa	5	1.19	9th
18	Biological control	4	0.95	10th
19	Marine policy	4	0.95	10th
20	ORYX	4	0.95	10th
21	PEERJ	4	0.95	10th
22	AMBIO	3	0.71	11th
23	Developmental biology	3	0.71	11th
24	Global change biology	3	0.71	11th
25	Global ecology and conservation	3	0.71	11th

Table 5: The 25 topmost global relevant institutions on invertebrate and conservation research studies with over 7 research publications

S/N	Affiliation	Country	Articles	Position
1	James Cook Univ	Australia	36	1st
2	Univ Queensland	Australia	33	2nd
3	Univ Costa Rica	Costa Rica	26	3rd
4	Natl Univ Singapore	Singapore	23	4th
5	Univ British Columbia	Canada	19	5th
6	Univ Hawaii	USA	19	5th
7	Univ Hawaii Manoa	USA	19	5th
8	Univ Montpellier	France	14	6th
9	Univ Stellenbosch	South Africa	13	7th
10	Aix Marseille Univ	France	11	8th
11	Smithsonian Trop Res Inst	Panama	11	8th
12	Beibu Gulf Univ	China	10	9th
13	Inst Rech Dev	France	10	9th
14	Inst Zool	UK	10	9th
15	No Michigan Univ	USA	10	9th

16	Smithsonian Inst	USA	10	9th
17	Univ Nacl Autonoma Mexico	Mexico	10	9th
18	Univ Porto	Portugal	10	9th
19	Natl Inst Environm Studies	Japan	9	10th
20	Univ Puerto Rico	Puerto Rico	9	10th
21	Arizona State Univ	USA	8	11th
22	Australian Inst Marine Sci	Australia	8	11th
23	Inst EntomoL	Czech Republic	8	11th
24	James Cook Univ N Queensland	Australia	8	11th
25	Natl Inst Oceanog	India	8	11th

Table 6: Top 20 most globally cited documents on invertebrates and conservation research

S/N	Author's first name, year of publication, and journal	DOI	Total citations	TC per Year	Normalized TC
1	Byrn MP, 1993, J Am Chem Soc	10.1021/ja00074a013	395	12.74	1.87
2	Ferretti F, 2018, SCI ADV	10.1126/sciadv.aaq0333	388	64.67	12.30
3	Goreau T, 2000, Conserv Biol	10.1046/j.1523-1739.2000.00011.x	300	12.50	4.84
4	Allen GR, 2008, Aquat Conserv-Mar Freshw Ecosyst	10.1002/aqc.880	296	18.50	3.67
5	Hughes TP, 2002, Ecol Lett	10.1046/j.1461-0248.2002.00383.x	282	12.82	4.18
6	Cumberlidge N, 2009, Biol Conserv	10.1016/j.biocon.2009.02.038	236	15.73	4.92
7	Jonsson M, 2008, Biol Control	10.1016/j.biocontrol.2008.01.006	203	12.69	2.52
8	Wilson S, 2004, Biol Conserv	10.1016/j.biocon.2004.03.001	182	9.10	2.72
9	Pfeifer K, 1993, Glycobiology	10.1093/glycob/3.2.179	180	5.81	0.85
10	Wettstein W, 1999, J Appl Ecol	10.1046/j.1365-2664.1999.00404.x	175	7.00	2.69
11	Cinner JE, 2018, Proc Natl Acad Sci U S A	10.1073/pnas.1708001115	144	24.00	4.57
12	Garrabou J, 2002, J Anim Ecol	10.1046/j.1365-2656.2002.00661.x	144	6.55	2.13
13	Cinner JE, 2005, Conserv Biol	10.1111/j.1523-1739.2005.00209.x-i1	113	5.95	2.58
14	Wade MR, 2008, Biol Control	10.1016/j.biocontrol.2007.10.024	110	6.88	1.36
15	Spring J, 2002, Dev Biol	10.1006/dbio.2002.0616	105	4.77	1.56
16	Balzan MV, 2014, J Insect Conserv	10.1007/s10841-014-9680-2	94	9.40	2.76
17	Armstrong RA, 2006, Cont Shelf Res	10.1016/j.csr.2005.10.004	94	5.22	2.05
18	Ferguson EL, 1996, Curr Opin Genet Dev	10.1016/S0959-437X(96)80063-3	92	3.29	1.84
19	magris RA, 2016, Ecography	10.1111/ecog.01507	90	11.25	3.96
20	Richmond RH, 2007, Bioscience	10.1641/B570710	89	5.24	1.92

Table (6) shows 20 top-rated globally cited publications in the field of invertebrate and conservation research based on the Total number of Citations (TC) from 1990-2022. The scholarly publication authored by Byrn (1993) in the Journal of the American Chemical Society was ranked first with a combined total of 395 citations. The publication that was ranked in second place was written in the Journal of Science Advances with a sum aggregate of 388 citations. The third (n = 300) and fourth (n = 296) position for highly cited journals was written by Goreau (2000) and Allen (2008) in Conservation Biology Journal as well as Aquatic Conservation: Marine and Freshwater Ecosystems Journal as authors, accordingly Table (6).

Furthermore, Fig. (3) depicts a collaboration visualization map of nations' cooperation. The single circle/node depicted in Fig. (3) is an individual country

and the diameter of the node gives agreement to the number of articles by the individual country. The strokes in the figure depict the path of networking between different nations and the thickness of the strokes indicates the degree of collaboration between countries. The various different colors (including green, grey, orange, blue, purple, and red) represent the networking alignments of the countries. Networking links ranged from 0-30. The United States of America (USA) had the highest amount of networking (n = 30); followed by Australia (n = 22), the United Kingdom (n = 11), and China (n = 9), respectively.

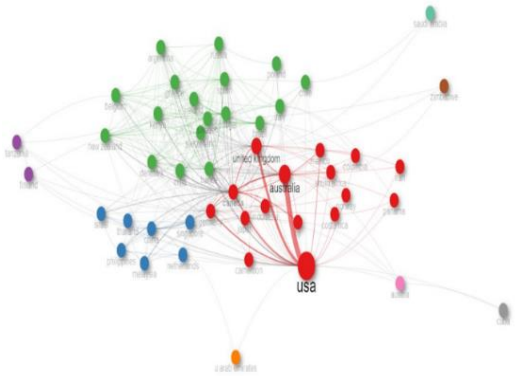

Fig. 3: Collaborative mappings of networks of countries on studies done on invertebrates and conservation. Individual node in the network represents each country and the diameter of the node represents the number of research in the field. The lines represent collaboration between countries and the amount of thickness of the lines represents the degree of collaboration between countries. The different colors represent the networking clusters of the countries

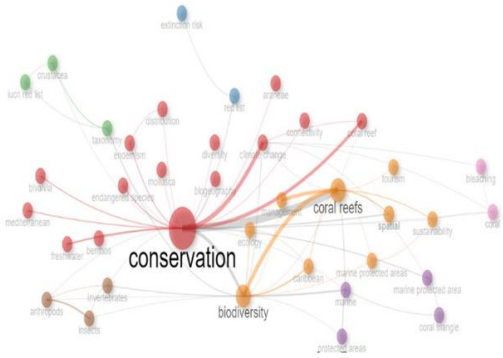

Fig. 4: Collaboration strength of keywords of global research on invertebrates and conservation. An individual node in the network represents each keyword and the diameter of the node corresponds with the keyword strengths. Strokes/lines denote the links of the relationship between keywords, while the various colors represent the collaboration groups of keywords

Figure (4), reveals the co-occurrence network and interrelationship of the topmost terms in invertebrate and conservation research and they are shown in pictures. The individual circle with different colors denotes a group of terms and the networking strokes represent the level of connection in line with keywords. In addition, the closeness of one keyword to the other shows the likelihood of their closeness in the research literature during the study span of 1990-2022. The collaboration visualization in Fig. (4) of the frequently occurring keywords principally depicts the regularly used words in invertebrate and conservation research, which makes it easier to distinguish the focus of the niche field in this study.

Figure (5) reveals the authors' keywords through the thematic evaluation map. This result shows four (4) chief themes based on the authors' keywords networking as well as grouping including the motor theme, the basic theme, the niche theme, and the emerging theme. From these thematic map authors keywords such as "functional diversity", "richness", "climate", "biological control", "Coleoptera", "growth", "invertebrates", "management", "community structure", "marine protected areas", "impacts", "biodiversity", "patterns", "climate change", "communities", "decapoda", "genus", "taxonomy", "evolution", "vegetation", "habitats", "plants", "insights", "gene-expression", "regeneration", "phylogeny", "alignment", "organization", "dna", "pacific", "expression", "gene", "protein", "islands", "marine ecosystems", "coal", "soil", "vulnerable" and "agriculture" were focus in the field of invertebrates and conservation studies among others.

Furthermore, Fig. (6) showed the results of the evaluated thematic evolution and the research group niches and origin, with respect to the occurrence of vital terminologies in invertebrate and conservation research publications. It should be noted that the thematic advancement exemplifies how vital themes evolve over the studied period (1990-2022) in the selected authors' keywords. The result from Fig. (6) indicates that there are steady themes used by authors between the year range (1990-2015)-(2016-2022). The theme, "conservation", has metamorphosed to several other keywords like corals, Caribbean, conservation planning, as well as invertebrates. Conversely, the theme "biodiversity conservation", has metamorphosed into keywords such as conservation. Again, the theme "freshwater" has metamorphosed into the keyword "Mediterranean". The theme "arthropods have metamorphosed to insects, conservation, and taxonomy while the theme "habitat" has metamorphosed to keywords such as corals and carcinoscorpius rotundicauda, accordingly.

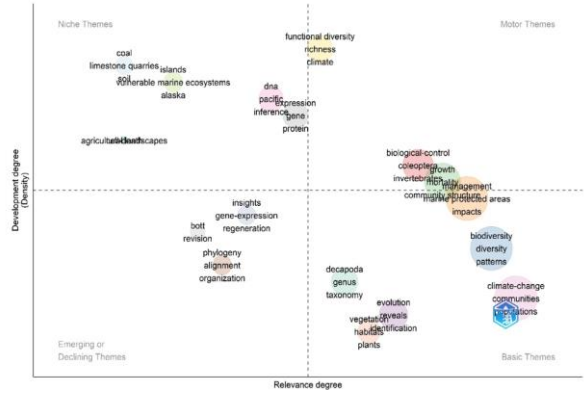

Fig. 5: Thematic map (author-keywords) in the research niche of invertebrates in line with conservation

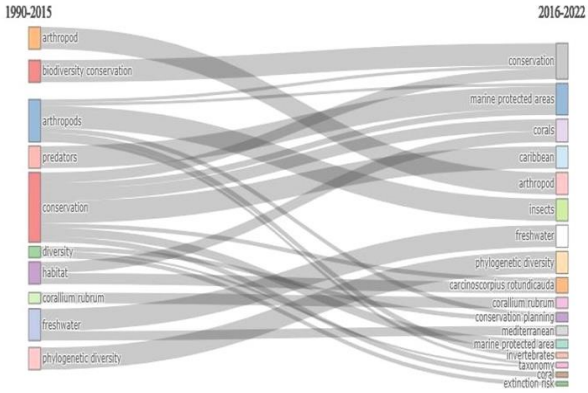

Fig. 6: Thematic evolution of author keywords on invertebrates and conservation from 1990-2022

Discussion

The current paper assessed several publications on invertebrates and conservation studies as well as some significant topic focus and trends in the subject matter between 1990 and 2022 based on retrieved data that were obtained from the WoS archive. The number of research articles on invertebrates and conservation work grew in a non-linear pattern from two (2) articles in 1995-38 articles in 2022. The study experienced fluctuations in the numbers of outputs between the years 1990-2022. Meanwhile, there was a stable rise in outputs from 2013 to 2021, but with a surprising drop in output from 38 articles in 2021 to 25 articles in 2022, which indicates a gradual decline in research outputs on the subject matter. This observation may reflect the sentiment by Lovell *et al*. (2010) in another study who reported a decline in the studies on invertebrates with regards to conservation. The decline in articles made the authors decry the reasons why research on the subject matter is gradually being reduced in conservation forecasting and management over the years (Lovell *et al*., 2010). The fact that invertebrates play a significant role in the ecological food webs and that they form part of the major bioenvironmental engineering functions in the ecosystem should attract more attention in conservation studies (Williams *et al*., 2022). Furthermore, Cock *et al*. (2012), reported that invertebrates significantly influence soil productivity and food security making the subject matter of invertebrate and the conservation of vital essence deserves more attention.

A significant number of research works and articles written in line with the subject matter were mostly from developed countries including the USA, Australia, the UK, China, Spain, France, and Canada among others. In a related conservation study, our findings were similar to the author's report with developed countries such as the USA, UK, China, and Australia among others being the leading nations in this field (Wani *et al*., 2024). Further, our observation was similar to bibliometric studies of other research niche areas (Cañas-Guerrero *et al*., 2013; Ekundayo and Okoh, 2018; Olisah *et al*., 2019). The quest by researchers in more advanced countries to continuously explore innovative ways (in different research fields) for the purpose of mitigating the multiple challenges confronting the global society is the reason for their high involvement in several research endeavors. Interestingly, these scientists from advanced nations are usually heavily funded by their governments and other global collaborative institutions to carry out research in solving human challenges in the scientific space (Peng *et al*., 2015; Idamokoro and Hosu, 2022; Idamokoro, 2023).

South Africa happens to be the only African nation (out of the 20 most relevant Nations-Table (2), that was part of the global countries doing research in line with invertebrates and conservation studies. This observation should be a reflection and wake-up call to other African nations to explore this area of research. Most importantly, more attention is needed in this field of science, more so that this area of research plays a significant role in the global food chain of our ecosystem (Smith *et al*., 2022; Aizen *et al*., 2023). Meanwhile, in a related study on "threat assessment and prioritization of species for conservation at a global level", the authors cited that South Africa and the Benin Republic were the two African countries that prioritize the conservation of species based on their collaborations with developed nations (Wani *et al*., 2024). It is presumed that more African and other developing nations can also tap into the possibility of networking with other advanced nations to improve in this area of research, more so that this aspect of research is a very significant field for conserving the

balance of species diversity in our ecosystem. According to the literature, the biodiversity of various species on a global stage is currently undergoing a very precarious phase due to several various drivers (such as anthropogenic or natural) threatening the survival of species including invertebrates (Ripple *et al*., 2019; Pouteau *et al*., 2022).

The USA, Australia, the UK, France, as well as Switzerland, were placed in the top spots of nations contributing to studies on invertebrates and conservation research with respect to the numbers of articles and citations in Table (2). In line with our findings, the UK, USA, China, Australia, and Germany also top the countries with the highest numbers of citations and article publications (Wani *et al*., 2024). One core reason for any country to be ranked in this category with a high amount of publications and article citations in any particular research field has been credited to the monetary and fund support that they receive from numerous agencies including government parastatals (Peng *et al*., 2015; Idamokoro and Hosu, 2022). In addition, the increased participation by the aforementioned advanced nations in this kind of research study could be credited to a possible high level of their involvement in both regional and international networking with other research institutions (Ekundayo and Okoh, 2020). This is an important booster that enhances research impact, prominence, and frequency of their publication citations (Altarturi *et al*., 2023). However, the comparatively low amount of research on invertebrates with regards to conservation as noticed in the present study (developing nations, as well as African countries) may be connected with the fact that some scientific research work done in these nations is in some cases carried out as self-funded by institutions as well as other internal agencies (Orimoloye and Ololade, 2021; Idamokoro, 2023). Another possible reason could be that publications from these underdeveloped or developing nations are not indexed in globally recognized data sources such as WoS, Scopus, PubMed, etc.

The 20 top-ranked countries having Multiple Collaborations (MCP) on invertebrates and conservation studies indicate their collaborations were among researchers that are based in countries with financially stable economies such as the USA, Australia, the UK as well as China Table (2). This finding is similar to other bibliometric findings that reported nations' networking from among financially stable nations (Smith *et al*., 2022; Idamokoro and Hosu, 2022). Meanwhile, it is commonly observed in bibliometric research studies that networking between financially established and developing countries is scarce (Ekundayo and Okoh, 2018; Orimoloye and Ololade, 2021). Additionally, Yildiz Gülhan and Kurutkan (2021) also reported their findings similar to our result, with nations having a Multiple Country Publications (MCP) rate with over 50% being countries with high global networks in the field. However, in the findings by Wani *et al*. (2024), it was reported that Benin Republic (an African nation) had the highest MCP with a rate of 71.4%, which was closely followed by other developed nations including UK with an MCP of 62.5% and France with an MCP of 37.5%, respectively.

The current study also noticed that India, Japan, and the Czech Republic, had the result of single country publications (SCP; n = 8; n = 7; n = 6), but with zero (0) Multiple Country Publications (MCP), accordingly Table (2). In another related study on "threat assessment and prioritization of species for conservation at a global level", the nation of India was reported to have 4.76 % MCP with other countries on the globe (Wani *et al*., 2024). According to Lloyd *et al*. (2023), networking is important for conservation studies because it allows for the successful implementation of biodiversity conservation programs globally. The lack of international networking by countries may affect citations of research work from such nations on the global stage. Global networking in scholarly research is vital because of the need for the exchange of intellectual ideas and findings from the collaborating countries (Ekundayo and Okoh, 2018). Knowledge sharing in research findings from both intra- and international institutions among nations of the world usually allows for more robust prospects as well as helps in harnessing both human and financial resources for nations to do significant and innovative research in various research areas (Smith *et al*., 2021).

There was a conspicuous switch in position among the top listed countries that are doing research on invertebrate and conservation studies when judged based on Total Citation (TC) per country Table (2). For instance, the nation of China moved from 4th place to 8th place in Table (2). Other bibliometric studies have also reported similar position switches for global nation rankings based on Total Citations (TC) and country collaborations (MCP) (Ekundayo and Okoh, 2018; Idamokoro and Hosu, 2022). The reason for this kind of switch in positions and rankings when considering the number of citations in ranking the relevance of an author or nation's research work merely indicates its undependability as a proper yardstick for research productions. Citation numbers of publications do not justly show the article productivity of authors or countries. This is because, the lesser the number of publications utilized for evaluation, the higher the influence of the few frequently cited publications

(Fricke *et al*., 2013). Several authors engage in self-citations, while others give inaccurate citations of articles. This kind of obvious error by authors of papers encourages false quantitative as well as qualitative indexes of Total Citations (TC) of authors or nations.

Author's keywords in manuscripts are utilized to cover areas of vital subjects of a scientific field, as well as to assist interested scholars of a specific manuscript to comprehend key concepts of the manuscript (Olisah *et al*., 2019; Chen, 2021). Keywords further assist researchers in projecting a cutting hedge summary of a written paper (Synnestvedt *et al*., 2005). Journal outlets often request the list of author's keywords when the author/s are submitting their manuscript prior to the review process of such manuscript. This system of keyword assessment is indicative of its vital role in the use of the author's keywords for a manuscript to be accepted within the scope of a journal (Okaiyeto and Oguntibeju, 2021). The present manuscript used both the singular as well as the plural technique of the author's keywords to portray the most occurring subject trend on invertebrates and conservation research. This approach has been adopted by authors to better understand the research emergence of a studied subject area (Cañas-Guerrero *et al*., 2013). The outcome of our search (WoS) shows both the keywords as well as the keyword plus from the search literature that was used. This is important because author keywords from an article are a collection of terms given by writers to show the main story of the article; whereas keyword-plus indicates phrase/s showing in the references of titles of written papers, aside from the titles of the main articles (Zhang *et al*., 2016).

The most frequently adopted keywords of a given research field normally express the most trending topics and subject matter over a period of time. Between the year 1990 and 2022, a sum of 1713 author keywords as well as 1538 keyword-plus terms were gathered from the database on invertebrates and conservation studies Table (1). Subsequently, these authors' keywords as well as keyword plus including; Conservation, Coral reef/s, Management, Diversity, Marine protected area/s, Biodiversity, Coral/s, and Climate change among others are relevant to the research field related to invertebrates and conservation studies (Table 3). In an earlier study on threat assessment on the prioritization of conservation (Wani *et al*., 2024) the most frequently utilized author keywords were; Conservation (n = 68 in 2015) and Biodiversity (n = 34 in 2014) among others which is quite similar to the result of the present study. Worthy of note is the fact that, even though, invertebrates are likened to ordinary insects with little or no vital contribution to the global food chain and ecosystem (Horvath *et al*., 2013), it is vital to understand that they have been utilized to achieve a lot (e.g., biocontrol, natural enemies, pest control, soil tillage, predators, etc.) in food production (Eisenhauer and Hines, 2021; Aizen *et al*., 2023).

As seen in Table (7), our result shows the profile of the most relevant researchers in the field of research on invertebrates and conservation studies. As observed from the result, Table (7) gave some information on the 25 topmost authors in the field of invertebrate and conservation research, with the authors named M Beger and N Cumberlidge ranked in the first and second positions (n = 7; n = 10), respectively. Judging from their scholarly profile, these authors have a h-index of 7 and 6 (with 411 and 352 citations), accordingly. H-index is often used to evaluate the relevance of articles on the global stage (Huang *et al*., 2019). Conversely, h–index can also be utilized to assess the productivity and relevance of scientists within a given research niche in line with the number of citations in their publications (Hirsch, 2005). Scientists are often ranked through their h-index scores, which often align with the number of publications that they produced and are cited over the years. Furthermore, the h-index is calculated through the h algorithm (of articles) on the minimum amount of h times an article was referenced/cited (Hirsch, 2005). The H-index evaluation of the author's relevance in a field is an essential tool in bibliometric assessment, due to the fact that it accurately reproduces the amount of impact of researchers' scholarly accomplishments toward the knowledge pool in a given field (Guilak and Jacobs, 2011).

The research work of Cumberlidge *et al*. (2009), who is one of the leading authors in invertebrates and conservation studies, reported several crises and challenges that may negatively affect the existence of economically useful invertebrates if they are not rightly conserved. In their study, it was also reported that the conservation status of all recognized species from major countries of the world (including Africa, Americas, Asia, Europe, as well as Australasia) are at high threat levels (Cumberlidge *et al*., 2009). In addition, about one-sixth of all invertebrate (freshwater crab) species are at a very high risk of extinction if they are not properly conserved (Cumberlidge *et al*., 2009). This underlines the need to prioritize and develop conservation measures in order to prevent the decline of invertebrate species to levels from which they cannot recover.

Furthermore, another top-rated researcher in invertebrate and conservation named M Jonsson,

reported in their study how the implementation of a strategic conservation program (of invertebrates) will help to improve ecosystem services as well as enhance economic profits in food production (Jonsson *et al*., 2008). Howbeit, Jonsson, *et al*. (2008), reported that more research is still required to sensitize people to the need to promote invertebrate and conservation studies. The authors also reported how studies in this area will help to improve crop yield by decreasing pest damage in food crops. According to the study by Goreau *et al*. (2000), who specialize in invertebrate conservation studies, it was reported that several factors (especially global bleaching) are responsible for causing invertebrate (coral reefs) mortalities and these factors if not checked/managed may result in the reduction of this economically beneficial invertebrates (Goreau *et al*., 2000). The findings from the studies of these aforementioned authors are a testament to the significance of promoting global investigations and research on invertebrates and conservation.

With regard to the publication sources, they are known to be vital aspects of bibliometric analysis because they are used to describe the potential trends of a specific scientific research field (Leydesdorff and Rafols, 2009). The 25 relevant journal sources in the current topic in Table (4) show that they are credible journal outlets responsible for publishing scholarly findings in line with invertebrates and conservation. These journal sources include the following Biological Conservation, Frontiers in Marine Science, Revista De Biologia Tropical, Aquatic Conservation-Marine and Freshwater Ecosystems, Biodiversity and Conservation, Plos One, Oryx among others. In line with our findings, journals such as Biological Conservation, Biodiversity, and Conservation, Plos One, Conservation Biology, Oryx as well as Diversity and Distribution among others topped the list of sources with the highest number of documents and citations in the field of conservation species (Wani *et al*., 2024). This is a clear pointer that these aforementioned sources are dedicated to research in the conservation of conservation diversity.

Table 7: Top 25 relevant/productive authors on invertebrates and conservation research

S/N	Researchers name	h_index	g_index	m_index	TC	NP	PY_start
1	Beger M	7	7	0.333	411	7	2003
2	Cumberlidge N	6	10	0.375	352	10	2008
3	NG PKL	6	7	0.316	336	7	2005
4	Guevara CA	5	5	0.192	187	5	1998
5	Guzman HM	5	5	0.192	187	5	1998
6	Mcclanahan TR	5	5	0.263	174	5	2005
7	Possingham HP	5	5	0.313	252	5	2008
8	Samways MJ	5	6	0.238	148	6	2003
9	Pressey RL	4	4	0.444	158	4	2015
10	Albrecht C	3	5	0.231	69	5	2011
11	Arias-Gonzalez JE	3	3	0.231	33	3	2011
12	Bond-Buckup G	3	3	0.136	110	3	2002
13	Campbell SJ	3	3	0.250	82	3	2012
14	Darling ES	3	3	0.600	82	3	2019
15	Garrabou J	3	5	0.136	214	5	2002
16	Jupiter SD	3	3	0.250	114	3	2012
17	Klein CJ	3	3	0.214	172	3	2010
18	Kwan KY	3	3	0.600	47	3	2019
19	Ledoux JB	3	3	0.214	67	3	2010
20	Magris RA	3	3	0.333	154	3	2015
21	Mouillot D	3	3	0.500	176	3	2018
22	Muller WEG	3	3	0.097	216	3	1993
23	Naruse T	3	3	0.200	273	3	2009
24	Pryke JS	3	4	0.250	118	4	2012
25	Sebek P	3	3	0.30	87	3	2014

From Table (5), the information for the topmost institutions with more research outputs in invertebrate and conservation indicated that Australia led the chart with institutions doing research in this field even though the United States of America had more institutions featuring in this ranking with more publications. Previous bibliometric studies have also reported similar results indicating that institutions from the USA make significant contributions to the body of knowledge in several other research areas ranging from medicine, technology, microbiology, geography, and agriculture, among others (Ekundayo and Okoh, 2018; Orimoloye and Ololade, 2021; Okaiyeto and Oguntibeju, 2021; Idamokoro, 2023).

Conversely, with regards to global citation of articles as well as their relevance on the global stage, the common world indices to rate how a paper is performing is via the number of citations that paper receives over a space of time as well as how many times the article was downloaded by the global audience. The global citation also relies on the academic influence of the citing article rather than on how many times they are cited. An article that is cited by a journal with a high impact factor draws the attention of more scientists, while the amount of citations that an article attracts to itself shows its level of impact on the global environment. The significance of research publications on the global stage is usually evaluated by how often it was cited (Tahim *et al*., 2016). Conversely, the impact of an article grows in its significance as the citation number increases.

The top 20 globally cited publications that were evaluated on the basis of total citations per year (TC/Year) as well as Total Citations (TCs) on invertebrate and conservation studies from 1990-2022 are given in Table (6). These scholarly papers were published by authors; M.P. Byrn (TC; n = 395), F. Ferretti (TC; n = 388); T. Goreau (TC; n = 300), G.R. Allen (TC; n = 296), T.P. Hughes (TC; n = 282), among others. The outcomes and findings from these aforementioned top-cited publications embrace different topics on the significance of invertebrate conservation and challenges facing the conservation of invertebrates as well as some suggested possible ways of improving the studied subject matter. Meanwhile, it is possible that some scientific publications may be ranked as one of the highly cited articles for a particular subject matter, yet, they may have negative criticisms as a result of the study content as well as the results presented in the paper (Cheek *et al*., 2006).

Talking about global networking in research is a vital benchmark that is utilized in bibliometric assessments because it is used to know how to advance scientific findings of any research field, as it increases partnerships among scientists of related research niches globally. Networking further allows the multi-disciplinary exchange of intellectual ideas from various cadres among scientists with common interests to achieve greater innovative goals in research (WU *et al*., 2019). Research collaboration also enhances the quality of research investigations. Several other vital benefits of research networking include the publication of innovative scientific papers, the exchange of intellectual human potential, funds accessibility as well as state-of-the-art facility sharing, among others (Bozeman *et al*., 2013). The result of the country's networking from this study is presented in Fig. (3) with different colors representing how they are classified in line with their collaboration. In all, nine (9) groups were showcased in the diagram. Furthermore, the node representing a single country as well as the strokes linking the different countries together possesses different magnitudes of thickness. These links are evidence of how important and strong the ties among these countries are. The USA had the most global influence as well as networks with other countries due to its line thickness as well as the node size. This result correlates with those from other authors who reported the USA to have greater influence in terms of networking and collaborations (Zyoud, *et al*., 2017; Orimoloye and Ololade, 2021; Idamokoro, 2023).

Furthermore, the result in Fig. (5) presented the authors' keywords using the thematic evaluation map to describe the relevance of the authors' keywords used over the years. This kind of bibliometric evaluation was previously reported by Cobo *et al*. (2011). The current study showed that the thematic map had four key themes formed on the authors' keywords network clustering Fig. (5). Firstly, the top-right quadrant (the motor theme) demonstrates the high centrality as well as the concentration keywords of invertebrate and conservation studies. From these thematic maps authors' keywords such as "functional diversity", "richness" and "climate" were the keywords that happen to be the most developed in the research area of invertebrate and conservation studies. Secondly, looking at the top-left quadrant (niche theme), it has some themes including "biological control", "Coleoptera", "growth", "invertebrates" and "management". This second theme showcases the "high" centrality as well as how relevant the studied research of invertebrates and conservation is; although, they have not yet been suitably developed.

Conversely, in the bottom-right theme (Basic theme), terminologies such as "community structure", "marine protected areas", "impacts", "biodiversity", "patterns", "climate change", "communities", "decapoda", "genus", "taxonomy", "evolution", "vegetation", "habitats", "plants" appears to have a high focus among researchers, but they are still not developed and centralized. The fourth quadrant, the bottom-left quadrant (emerging or declining theme) comprises challenges-associated author keywords such as "insights", "gene expression", "regeneration", "phylogeny", "alignment", and "organization". This theme portrays the challenge of invertebrate and conservation research

because it is still emerging and not properly developed. However, it has few significant external links with the other keywords. Our findings were quite related to the result from an earlier study on "The impact of land use on stream macroinvertebrates". The authors in this study listed some areas in their thematic map including conservation, invertebrates, species richness, diversity, management, communities, and biodiversity among others as topics of relevance in land use that can have an impact on stream macroinvertebrates (Wang *et al*., 2023). Altarturi *et al*. (2023) also made use of this kind of thematic evolution map to explain the emergence of advanced technology in promoting e-commerce in the field of food production, which appeared to be another emerging and interesting field in science.

Over the past few decades, there seems to be an interest in research on invertebrates and conservation studies, but this trend declined in the year 2022 Fig. (2). This observation, does not signal a good sign for this understudied field of research. The reason is that a reduction in interest in this area of consideration may have a negative impact on the naturally abundant invertebrate species that play a significant role in our ecosystem as they are involved in regulating the strata and principal functions of our ecosystem (Kotze *et al*., 2022). Decrease scientific investigations in this field of study may also reduce the diversity of invertebrates. Previous studies have shown how crucial diversity in invertebrates will assist in the natural food webs as they form part of the ecosystem engineers as well as food production and sustainability (Williams *et al*., 2022).

One of the vital reasons for conserving as well as monitoring invertebrates is to guarantee the adequate protection of scarce and threatened invertebrate species (McGeoch *et al*., 2011). However, invertebrates are also beneficial and often highly effective and they act as informative indexes for other biodiversity, restoration, system health, and associated threats, such as invasive foreign species (McGeoch, 2007).

Our manuscript, to date, appears to be the first bibliometric findings that assessed the research articles of scholarly peer-reviewed publications on invertebrates and conservation studies at a global level. Consequently, we are aware that there might be several limitations to our findings which are not limited to:

a. The chances of overlooking some articles that might not have been included in the assessment of invertebrates and conservation or its related words during the collection of data considering that we used only the Web of Science for our search
b. We may as well be constrained in our study since we did not add articles that were in non-indexed journals, such as some online publications that are written in languages apart from English.
c. The present outcome of our work might also be constrained in its results due to the removal of some publication types such as technical notes, meeting abstracts, conference proceedings as well as note papers, etc.,

Study Possible Limitations

Data from our study has been entirely drawn from the Web of Science (WoS) data bank, thus may not have fully represented the comprehensive article (documents) in the niche area. Although, as earlier mentioned in the methodology section, WoS is an authentic knowledge source as well as a popular data archive among researchers. It is also highly recommended that other possible alternative databases such as Scopus, PubMed, or Google Scholar should be explored in future studies for a comprehensive analysis of the available research literature on this subject matter. In addition, since in the current study, only articles in the English language were used, there is a high chance of omission of other relevant articles written in other languages. Therefore, subsequent authors should reflect on the prospect of adding publications from other languages in the future. This will allow for more intense as well as all-inclusive examination of data. Despite the aforementioned limitations, the present study provides insights into research trends and directions in the field of invertebrate and conservation studies.

Conclusion

Studies on invertebrates and conservation research presently require attention based on the current Annual Scientific Production (ASP) from 1990-2022. This is necessary because of the significance of the subject matter in the global ecosystem. Financially and scientifically advanced nations showed higher research publications on the present topic of discussion in comparison to other underdeveloped and developing nations. It was also observed that from the thematic evolution and literature classifications; marine protected areas, conservation management, corals, Caribbean are vital to scientists carrying out research in conservation studies, thus signifying the direction of future research. In addition, it could be proposed that scientists, government agents, policymakers, and other stakeholders should make a conscious effort to design stratagems and workable policies as well as conservation management that will help save most of the world's threatened invertebrates. Furthermore, since it was noticed that some financially stable and scientifically advanced nations had good interest and resources in doing research in this area, it is imperative that scientists, government agents, policymakers, and other stakeholders from less productive nations especially developing nations should make conscious effort to

network and collaborate with them for effective implementation of conservation of endangered invertebrate species. The need for global conservation of endangered species in most cases greatly supersedes any single institution's capacity and resources (including financial, human capacity, facilities, and expertise), especially among developing countries. Biodiversity conservationists and scientists often prioritize species, resources, and research on a daily basis, but only through a well-organized decision-making approach can strategic decisions be made in an effective manner. This approach will in turn facilitate prospective networking among conservation institutions, policy makers, and other stakeholders in the field. Additionally, we would like to propose a more robust and all-inclusive study piloted by a meta-analysis narrative in the future which should focus on the emerging themes and trends as pathways to chart the course for improvement in invertebrate and conservation studies. This is important because of the likely limitations of using the bibliometric approach alone for this kind of study.

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Authors Contributions

Emrobowansan Monday Idamokoro: Conceptualized the study, contributed to writing the manuscript, and proofread and edited the final draft of the study.

Augustine Suh Niba: Conceptualized the study, and logistics, and approved the final draft of the study.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and that no ethical issues are involved.

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