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Cover: A mesmerising Indian Luna moth *Actias selene* is dancing through the starry night (by Vincent van Gogh) moonlit sky, displaying its ballistic display of feather tail. Digital artwork by Vyshnavee Sneha Jaijar.

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COMMUNICATION

A bibliometric visualization of trends in Philippine sharks studies published in Scopus-indexed journals over the past five decades

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Abstract: Sharks are one of the oldest vertebrates with a lineage over 400 million years, have drastically declined in population due to increased fishing pressure and demand for shark products. Some species of sharks are top hunters essential for maintaining marine biodiversity and ecological balance. The Philippines, a global biodiversity hotspot, hosts approximately 200 shark species, which are ecologically and economically significant, supporting fisheries, and ecotourism. Shark populations in the country have drastically declined partly due to increased fishing pressure and the demand for shark products, such as fins, meat, and oil. Addressing these challenges requires a deeper understanding of research trends and priorities to guide effective conservation, and management strategies. This study utilizes bibliometric methods to analyze trends in Philippine shark research from 1974—2024, using data sourced from Scopus. A total of 93 peer-reviewed documents were analyzed for publication trends, international collaborations, and emerging research themes. The analysis revealed a steady increase in publication output, peaking in 2019, with a subsequent decline during the COVID-19 pandemic, reflecting disruptions in research activities. This study underscores the need for sustained research efforts, enhanced international collaborations, and a focus on underexplored themes such as movement patterns, genetic connectivity, and population structure. By identifying research trends and gaps, this bibliometric analysis provides critical insights to inform evidence-based strategies for shark conservation and sustainable management in the Philippines.

Keywords: Anthropogenic distrurbance, elasmobranch, marine conservation, ocean sustainability, RStudio, sustainable development.

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INTRODUCTION

Sharks are considered as evolutionarily conservative group, comprising approximately more than 1,200 species that have functioned successfully in diverse ecosystems for 400 million years (Abdulla 2004). Sharks play a pivotal role in maintaining the balance of marine ecosystems, occupying different trophic levels that regulate the abundance and behaviour of mesoconsumers, and other marine species (Heithaus et al. 2008). Beyond their ecological significance, sharks are vital natural resources in the Philippines, supporting fisheries, and ecotourism industries. Growing fishing pressure have fueled global population declines in recent decades, threatening both ecosystems, and livelihoods. Shark fisheries in the Philippines started out in small numbers and only for subsistence. The Philippines started supplying the growing international market for shark meat, skin, and fins beginning in the 1960s (Alava et al. 214). These pressures underscore the need for vigorous conservation and management strategies (Oposa & Techera 2023). Additionally, organizations such as the Parties to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) have implemented regulations to control international trade of threatened shark species.

The National Plan of Action for Sharks (NPOA-Sharks) emphasizes the role of shark resources in marine biodiversity conservation and sustainable resource use for future generations. The effectiveness of the strategy is dependent on tight collaboration among implementing agencies and stakeholders. It necessitates the gathering and continuing synthesis of suitable data at the proper resolution, including commercial data, and data resulting in improved species identification, and eventually, abundance indices. One of the overall goals of NPOA sharks is to identify substantial gaps in scientific knowledge, as well as difficulties, challenges, and concerns regarding shark conservation and management (Department of Agriculture, Bureau of Fisheries and Aquatic Resources 2009). This was further supported by International Plan of Action for the Conservation and Management of Sharks (IPOA-Sharks) by expressing the need for improved management of sharks (Lack & Sant 2009).

Globally, shark populations have shown accelerated declines due to overfishing and habitat degradation (Dulvy et al. 2008; Ward-Paige et al. 2010; McCauley et al. 2015), with one quarter of shark and ray species now classified as threatened by the International Union for Conservation of Nature (IUCN) Red List (Dulvy et al. 2014). The IUCN Red List assessments are regarded as reliable tools to determine the conservation status of species because they use a comprehensive and scientifically rigorous approach to estimate extinction risk (Rodrigues et al. 2006). The goal of the assessment is to provide information and analyses on the status, trends, and threats to species in order to inform conservation actions. Current assessments of sharks have been undertaken during regional Red List workshops coordinated by the IUCN Shark Specialist Group (SSG) in the past 5–10 years (Dulvy et al. 2014). Critical gap persists in scientific data on shark fisheries in the Philippines, hindering informed decision-making, and effective management (Muallil & Hapid 2020).

Bibliometrics offers a powerful tool to track and analyze the evolution of research topics over time, enabling the identification of trends, gaps, and opportunities. By examining attributes such as authorship, institutional collaboration, and emerging themes, bibliometric analyses provide critical insights into scientific output, and research dynamics (Small 2003). The Bibliometrix package, through its Biblioshiny interface, has gained prominence as an accessible and comprehensive tool for performing such analyses (Celik et al. 2021). An example of bibliometric study on sharks can be reviewed in demonstrated how their findings draw attention to the disparities in media, and scientific coverage of shark research. Citations are dispersed equally among research groups, but mentions of policies, news, and tweets are more likely to concentrate on particular subjects.

This study used bibliometric analysis to assess trends in Philippine shark research over the past five decades, with the goal of enhancing shark conservation and management. Specifically, this study seeks to identify and analyze: (1) publication and citation, (2) country collaboration, and (3) emerging research theme. By addressing these objectives, the study provides a foundation for informed conservation strategies and highlights research priorities to support sustainable shark management.

METHODS

Scope and Limitation

This study acknowledges various limitations, which may have an impact on its conclusions. First, the search was restricted to peer-reviewed journal articles, book chapters, and reviews (Figure 1). The data source is limited to Scopus-indexed papers, which may exclude

significant research, particularly conference proceedings and publishing in non-indexed journals. Second, while bibliometric methods provide useful insights, they do not fully reflect the intricacies of specific research, such as quality or methodological rigor. Finally, the chosen date range (1974—2024) invariably influences the observed trends, perhaps obscuring earlier or later advancements in the sector.

Data Collection

This study employed a bibliometric approach to analyse trends in Philippine shark studies indexed in Scopus from 1974 to 2024 (Figure 1). The data was collected using the Scopus database on 28 March 2025. We used the following keyword search combination (Philippines OR Indo-pacific OR Luzon OR Visayas OR Mindanao AND "sharks" OR "elasmobranchs") AND ("Philippine Sharks" OR "Sharks in the Philippines"). A total enumeration sampling technique was utilised, ensuring that all relevant articles within the search parameters were included. The retrieved data was exported in a comma separated values (CSV) file format for further analysis.

Data Processing

The exported data underwent rigorous cleaning to ensure accuracy and relevance. Duplicate entries and non-relevant records were removed (Figure 1). The cleaned dataset was structured and organised to facilitate detailed analysis of publication trends, citation, and collaboration networks. Data on authorship, institutional affiliations, and keywords were standardised to ensure consistency and compatibility with analysis tools.

Analytical Tools

The primary tools used for the analysis were: RStudio to run Bibliometrix package and VOSviewer. Bibliometrix provided quantitative and qualitative insights into publication trends, citation metrics, and collaboration patterns. Its Biblioshiny interface enabled interactive visualisations of bibliometric data. VOSviewer was employed for network analysis, creating visual representations of co-authorship networks, keyword co-occurrence patterns, and thematic maps. These tools allowed for an in-depth exploration of research dynamics and thematic evoluation over time.

Metrics Analysed

Several key metrics were evaluated in this study. Annual scientific production was analysed to identify trends in the number of publications over time. Citation analysis provided insights into the academic impact of the research by assessing annual citation rates. International collaboration networks were visualised to map partnerships between the Philippines and other countries, highlighting key collaborators. Trend topic analysis focused on keyword frequency and duration to uncover evolving research priorities. Additionally, thematic mapping was conducted to classify research themes into four categories—motor, niche, basic, and emerging/declining—based on their centrality (relevance) and density (development).

Visualization

A range of visualisation techniques was applied to present the results effectively. Line graphs were generated to depict trends in annual scientific production and citation counts. Bubble plots illustrated the frequency and duration of prominent research topics. Thematic maps provided a comprehensive view of research themes, categorising them based on their development, and relevance. Network diagrams were used to visualise international collaborations and keyword co-occurrence patterns, enabling an understanding of the data.

RESULTS

A total of 267 documents matched the searched keyword; after thoroughly cleaning the dataset, we were able to gather 93 published documents. The remaining documents consisted of journal articles, book chapter, and reviews. There were two single-authored documents, 6.38 co-authors per document, and 58.51 international co-authorship. The documents were published from 1974 to 2024 (Table 1).

Annual Scientific Production

After the fiest publication in 1974, no shark studies were published annually until 2000 (Figure 2). Research output increased steadily from 2010, reaching its peak in 2019 with 16 documents. A decline was recorded in 2022, marking one of the lowest outputs with five documents during 2019–2024, followed by a recovery in 2023 with 11 documents.

Average Citation per Year

The annual citation trends for Philippine shark studies from 1974 to 2024 show variability across the years. Citations peaked in 2007 with average citation per year (ACpY) of 6.4, indicating high academic impact during this period (Figure 3). A decline followed until 2011

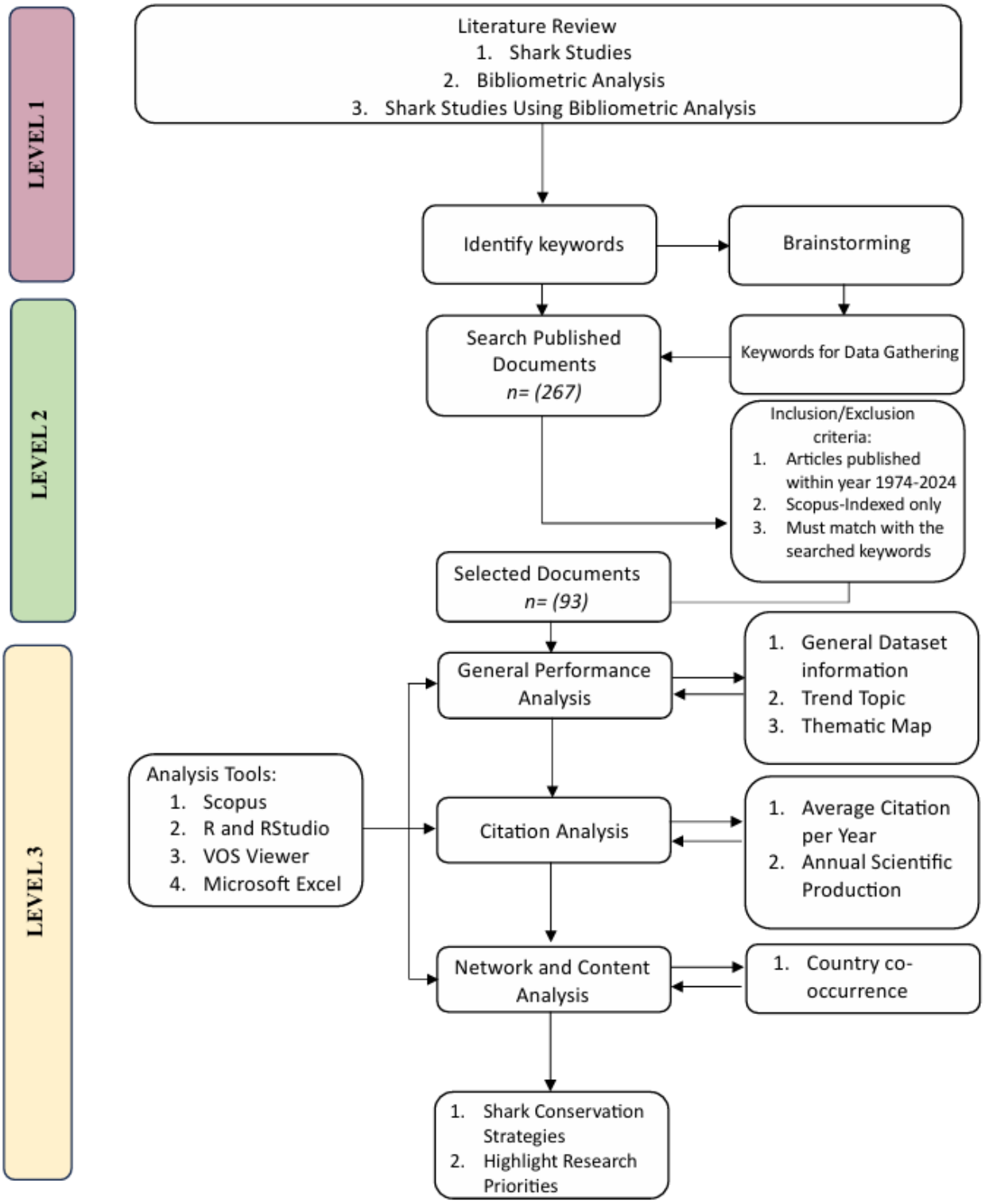

Figure 1. Research procedure of this study adopted from the published article of Hartafan et al. (2024).

with ACpY of 1.5, after which citation rates gradually increased in the following year, reaching another peak in 2012 with 3.7 ACpY. Post-2017, a steady decrease in citations is evident, with minimal citation activity observed by 2024.

Country Partnership

Key collaborators in Philippine shark research included

Table 1. Summary of bibliometric data for Philippine shark studies indexed in Scopus.

Description	Results
Key Information About Data	
Timespan	1974–2024
Sources (Journals, Books, etc.)	56
Documents	93
References	5095
Types of Documents	
Article	90
Book chapter	1
Review	2
Contents of Documents	
Keywords plus (ID)	639
Author's keywords (DE)	326
Authors Collaboration	
Single-authored document	2
Co-authors per document	6.38
International co-authorships	58.51

the United States, Australia, the United Kingdom, Japan, South Africa, France, China, Italy, Canada, and Indonesia (Figure 4). The strongest collaboration was with the United States, reflecting frequent contributions to shark-related research.

Trend Topics

The analysis identified key terms in Philippine shark studies. From 2011 to 2014, terms like "animal behavior", and "Chondrichthyes" were frequent, especially in the year 2013. From 2016 onwards "endangered species", "tourism", and "environmental protection" became prominent. "Species conservation" and "population density" were the most frequent terms in recent years. Larger bubbles in the analysis indicate higher term frequency (Figure 5).

Emerging or Declining Themes

The thematic map (Figure 6) of Philippine Shark studies categorizes research topics into four distinct quadrants based on centrality (relevance) and density (development). The motor themes, located in the top-right quadrant, are highly developed and central to the research, including topics such as "elasmobranchs", "demographic history", and "whale shark". These core themes drive the bulk of research activities and are critical to advancing the field. In the top-left quadrant, niche themes such as "movement patterns", "acoustic telemetry", "pelagic thresher shark", and "genetic connectivity" are well-developed but less central, reflecting specialised research areas with limited broader application.

The bottom-right quadrant contains basic themes, which are central but less dense themes. These include "conservation", "population structure", and "migration",

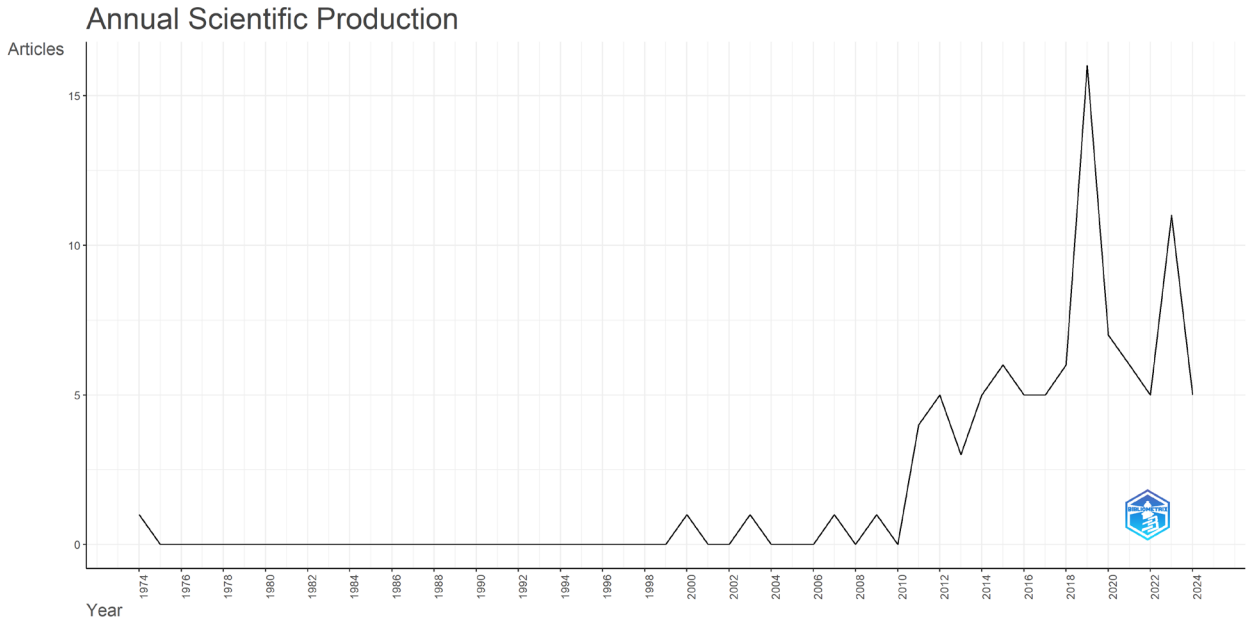

Figure 2. Annual scientific production of research articles on Philippine sharks indexed in Scopus from 1974 to 2024.

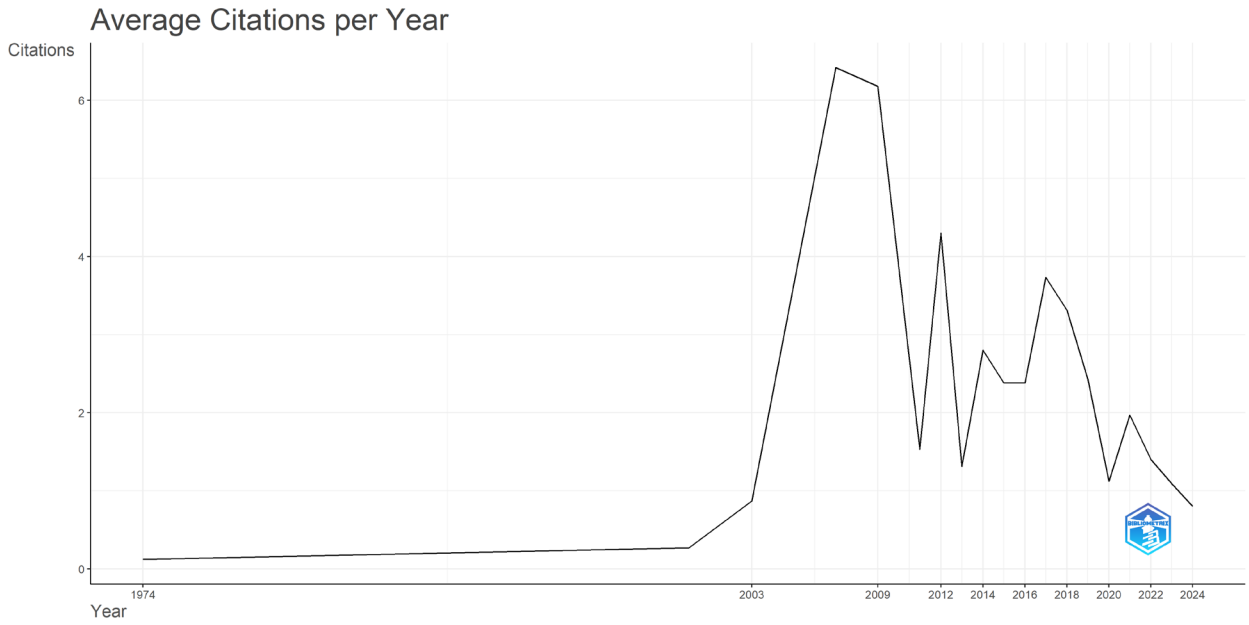

Figure 3. Annual citation trends of Philippine shark studies indexed in Scopus (1974–2024).

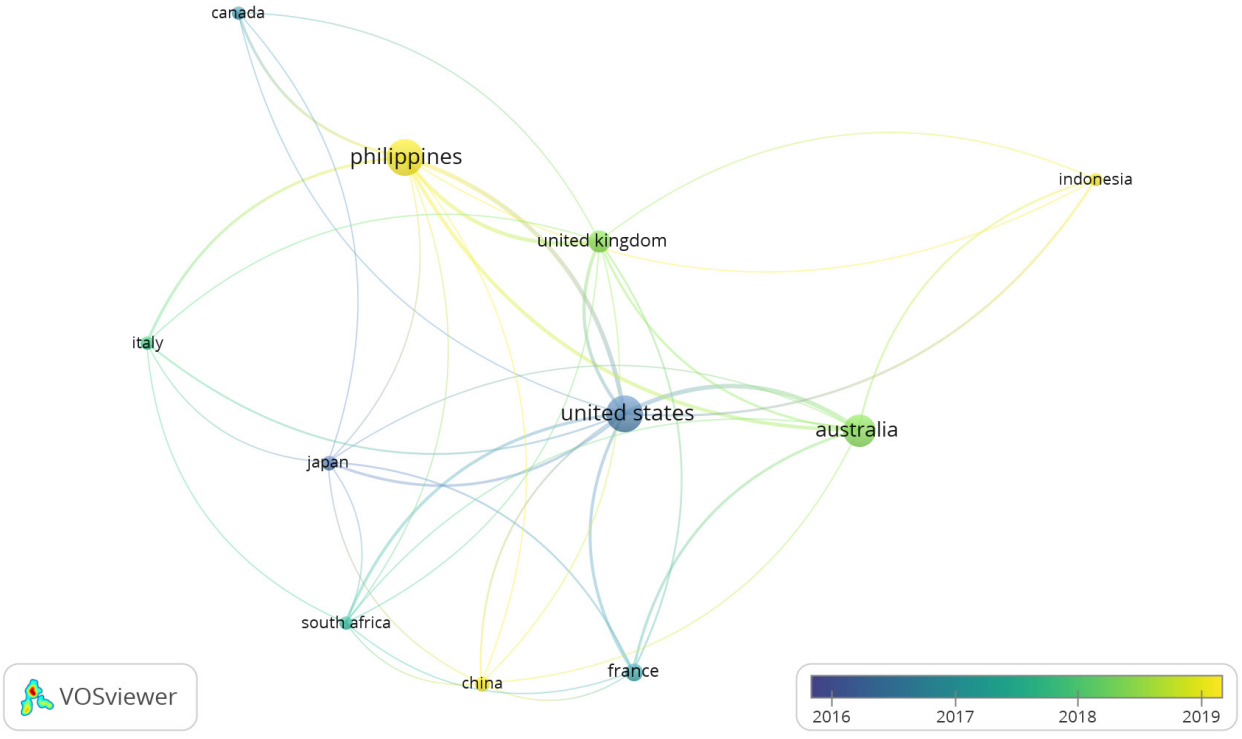

Figure 4. International collaboration network in Philippine shark studies (1974–2024).

which form the foundational topics, are mostly discussed and well-developed. In the bottom-left quadrant, emerging or declining themes such as “new species”, “climate change”, and “endangered species” are identified as less central, and less developed, indicating research areas that are either gaining traction or losing

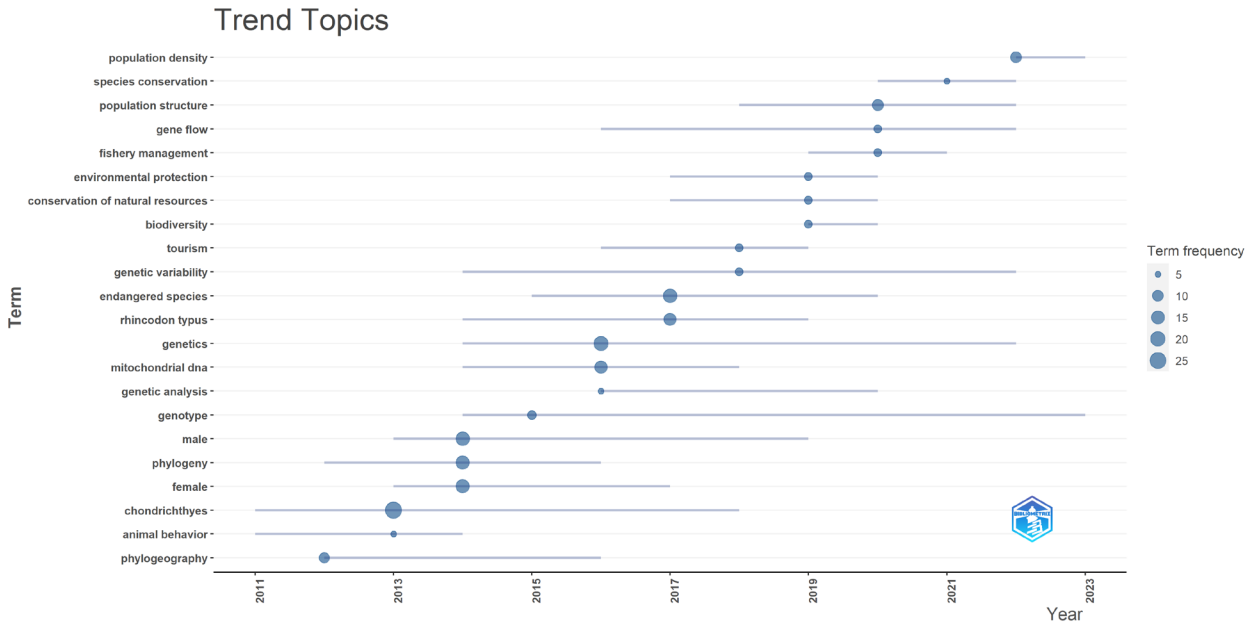

Figure 5. Trend topics in Philippine shark studies, illustrating the evolution of research focus over time from 1974 to 2024. Bubble sizes represent term frequency, with larger bubbles indicating higher occurrences.

relevance. This thematic map provides a comprehensive overview of the multidimensional focus of Philippine shark studies, highlighting well-established themes while identifying opportunities to expand foundational and emerging areas of research.

DISCUSSION

The Philippine shark studies' yearly scientific output from 1974 to 2024 showed a varying pattern: Early research was scarce, with no articles published annually until 2000, and then publications increased 16 documents in 2019, probably due to increased awareness of shark conservation and domestic policies like whale shark protection (Araujo et al. 2018). The COVID-19 pandemic interrupted research in 2020–2022 (Rutz et al. 2020), which caused a steep drop in publications, and a recovery in 2023 indicates a gradual return to pre-pandemic research levels. These high citation rates likely reflect the academic impact of key publications addressing significant topics such as genetics and conservation strategies (Heithaus et al. 2008). The post-2017 decline in citations may indicate a shift in focus or reduced visibility of subsequent studies.

The nodes in the findings may represent individual pieces of publication, journals, researchers, institutions or key words. Edges represent the existence or type of relationship between pairs of nodes (Aria & Cuccurullo 2017). The analysis of international collaboration networks revealed that the Philippines served as a central node in studying Philippine sharks, collaborating extensively with top 10 major countries: the United States, Australia, the United Kingdom, Japan, South Africa, France, China, Italy, Canada, and Indonesia. The strongest partnership was with the United States, reflecting shared interests in marine biodiversity and conservation efforts. Moreover, visualisation of temporal data can color code network nodes to the year of publication allowing the identification of trajectories and trends in a given field (Arruda et. al. 2022). The partnership between countries in studying Philippine sharks are essential for conservation and diversity of these species (Department of Agriculture, Bureau of Fisheries and Aquatic Resources 2009; Oposa & Techera 2023). Collaborations with Australia and the United Kingdom emerged as more recent, somewhere around 2018, while earlier partnerships were established with China and Indonesia alongside with the Philippines. This network underscores the importance of international partnerships in advancing shark research and conservation, particularly for a biodiversity hotspot like the Philippines. The analysis of trend topics highlighted the evolution of research priorities in Philippine shark studies. Early research from 2011 to 2014 focused on foundational topics such as "gene flow", "animal behavior", and "Chondrichthyes" reflecting efforts to establish baseline knowledge about shark species. From

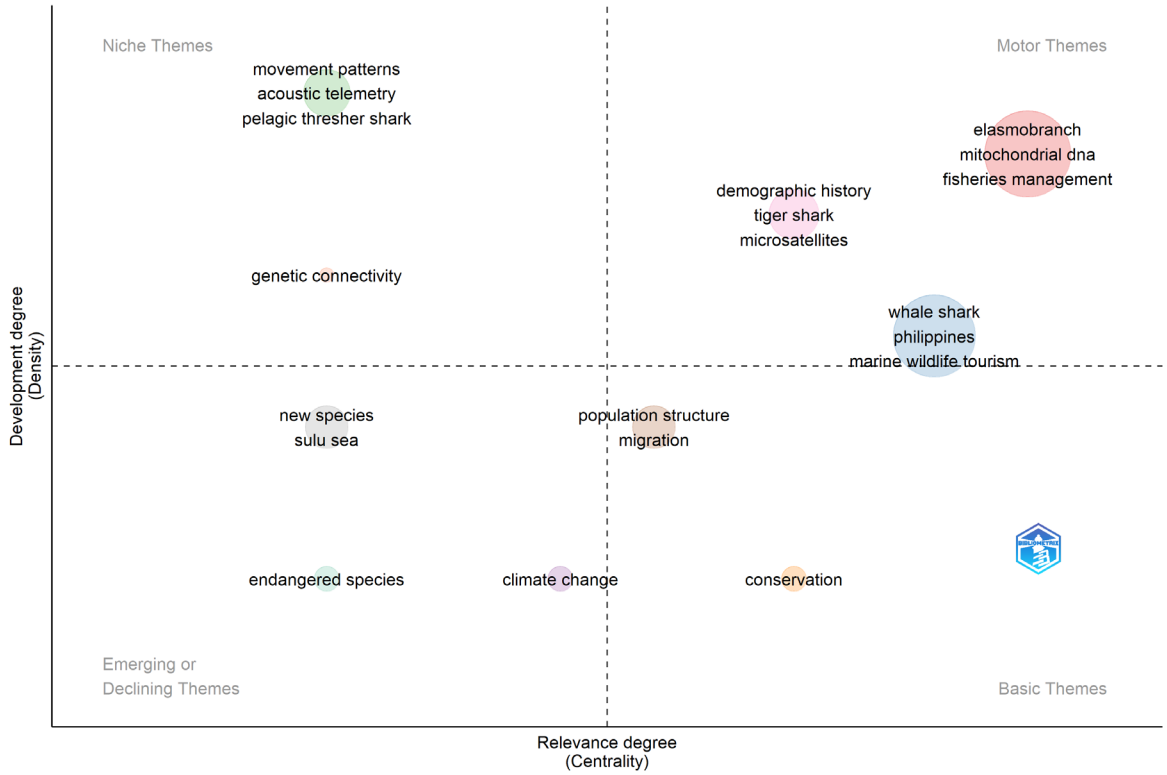

Figure 6. Thematic map of Philippine shark studies, highlighting motor themes, niche themes, basic themes, and emerging or declining themes.

2016 onward, a shift toward conservation-oriented topics such as "endangered species", "tourism", and "environmental protection" became evident. This transition aligns with increasing global concerns about shark population declines and the need for sustainable management practices for both extractive and non-extractive purposes for their meat, oil, skin, and fins, and is a tourism draw for a few coastal sites (Dulvy et al. 2014; Oposa & Techera 2023).

Our findings of this study have significant implications for shark conservation and management in the Philippines. The increasing focus on species conservation and ecosystem-based management highlights the growing recognition of sharks' ecological importance, their impacts on fisheries, ecotourism, and international market (Alava et al. 2014; Oposa & Techera 2023). However, the decline in research output and citations in recent years emphasizes the need for sustained funding and capacity building to maintain momentum in shark research. Sustainable funding is important as it encourages comprehensive, long-term studies that examine the intricate relationships between environmental, social, and economic systems, which is critical for addressing diverse sustainability concerns. Secure financing enables academics to take interdisciplinary approaches and integrate scientific and social disciplines, resulting in more comprehensive solutions (Mobjörk & Linnér 2006). Strengthening international collaborations, particularly with countries that have advanced marine research infrastructure, can further enhance the quality, and impact of Philippine shark studies. Moreover, addressing underdeveloped themes such as population structure, migration, and climate change could provide insights into sustainable resource use and conservation strategies. Expanding research on niche themes like movement patterns and genetic connectivity can also contribute to integrating socio-economic considerations into shark conservation efforts, fostering stakeholders' engagement and support. This study highlights significant trends and gaps in Philippine shark research, offering insights to guide future studies and conservation strategies. By leveraging international collaborations and addressing underdeveloped themes, researchers & policymakers can advance shark conservation & management, ensuring the sustainability of marine resources, and ecosystems in the Philippines.

CONCLUSION AND RECOMMENDATION

This study highlighted the significant growth of Philippine shark research, particularly from 2010, peaking in 2019 due to increased conservation awareness, and supportive policies such as whale shark protection. Collaborative networks, particularly with countries like the United States, Australia, and the United Kingdom, have played a crucial role in advancing shark research, and conservation efforts. The shift in research focus from foundational topics, such as species classification and behavior, to conservation-oriented priorities like species tourism, conservation, and population density reflects the increasing urgency to address shark population declines, and sustainable management practices.

To sustain and enhance Philippine shark research, it is crucial to maintain funding and build capacity to support ongoing efforts. Strengthening international collaborations, especially with countries that have advanced research infrastructure, can further improve research quality and outcomes. Expanding research on niche topics such as movement patterns and genetic connectivity can integrate socio-economic considerations into conservation strategies, fostering greater community engagement, and support. These actions are essential for ensuring the long-term sustainability of shark populations and marine ecosystems in the Philippines.

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