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Citizen Science Contributions in Ornithological Research

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Özet

Vatandaş bilimi, kuşları incelemek için hızla önemli bir yöntem haline geldi. Bu bilim, profesyonel olmayan kuş gözlemcilerinin ve amatörlerin çok çeşitli verilerin toplanmasına yardımcı olmasını sağlar. Bu çalışma, 1999 ile 2024 yılları arasında SCOPUS veri tabanından alınan ve vatandaş bilimi ile ornitolojinin kesişim noktasına odaklanan 179 makalenin kapsamlı bir bibliyometrik analizini sunmaktadır. Sonuçlar, son on yılda bilimsel üretimin önemli ölçüde arttığını göstermektedir. Amerika Birleşik Devletleri, Birleşik Krallık ve Avustralya, araştırma üretkenliği açısından diğer ülkelerle iş birliği yaparak öncülük etmektedir. Çalışma, vatandaş biliminin tür bolluğunu incelemede, biyoçeşitliliği izlemede ve göç, iklim değişikliği ve kentleşme gibi ekolojik süreçleri anlamada çok önemli bir rol oynadığını bulmaktadır. Bulgular, kuşbilimsel yönden vatandaş araştırmasının çeşitli ve işbirlikçi olduğunu ve veri yönetimi, gönüllü desteği ve etik uygulamalarda sürekli iyileştirmeler yapılması gerektiğini vurgulamaktadır. Bu çalışma, vatandaş bilimi'nin sadece ornitolojik araştırmaları geliştirmekle kalmayıp, aynı zamanda biyoçeşitliliğin korunması ve küresel ekolojik izleme için önemli içgörüler sunduğunu ortaya koymaktadır.

Halk Katılımı | Biyoçeşitlik Değerlendirmesi | Ekolojik İzleme | Gönüllü Katılımı | Kuş gözlemcileri

Çalışmanın Önemi

Bu çalışma, vatandaş biliminin ornitoloji alanındaki yükselen rolünü kapsamlı bir bibliyometrik analizle ortaya koymaktadır. Kuş gözlemciliğinde gönüllü katılımı ve veri paylaşımının bilimsel araştırmalara sağladığı katkıları sistematik olarak değerlendiren çalışma, hem veri çeşitliliği ve erişilebilirliği hem de uluslararası işbirliğinin artışını göstermektedir. Çalışma bulguları, vatandaş biliminin biyolojik çeşitliliğin izlenmesi, ekolojik değişimlerin anlaşılması ve koruma stratejilerinin geliştirilmesinde vazgeçilmez bir kaynak olduğunu vurgulayarak, alandaki mevcut bilgi boşluklarına da ışık tutmaktadır.

Abstract

Citizen science has quickly become an important way to study birds. It allows non-professional birdwatchers and amateurs to help collect a wide range of data. This study provides a comprehensive bibliometric analysis of 179 articles published between 1999 and 2024, sourced from the SCOPUS database, focusing on the intersection of citizen science and ornithology. Results show that scholarly production has gone up a lot in the last ten years. The United States, the United Kingdom and Australia are leading the way in terms of research productivity, collaborating with other countries. The study finds that citizen science plays a crucial role in studying species abundance, monitoring biodiversity, and understanding ecological processes such as migration, climate change, and urbanization. The findings suggest that ornithological citizen research is diverse and collaborative, highlighting the need for continuous improvements in data management, volunteer support, and ethical practices. This study finds that citizen science not only enhances ornithological research but also offers substantial insights for biodiversity conservation and global ecological monitoring.

Public Engagement | Biodiversity Assessment | Ecological Monitoring | Volunteer Engagement | Birdwatchers

Significance

This study highlights the growing significance of citizen science in the field of ornithology through a comprehensivebibliometric analysis. By systematically evaluating the contributions of volunteer birdwatchers and data sharing to scientific research, the study demonstrates increased data diversity, accessibility, and international collaboration. The findings underscore citizen science as an indispensable resource for biodiversity monitoring, understanding ecological changes, and informing conservation strategies, while also addressing existing knowledge gaps in the literature.

1. Introduction

Citizen science has become a powerful way to gather information in ecological and bird research, greatly increasing the amount and variety of data collected compared to traditional professional methods (Bonney et al., 2014; Cooper et al., 2014). In recent decades, the involvement of non-professional birdwatchers and volunteers in data collection has had a significant impact on the field of ornithology (Kelling et al., 2015). This involvement has made research cover more areas and times, and it has also made it easier to do large biodiversity assessments that would have been hard to do logistically and financially (Clark et al., 2024; Kerr and Auld, 2024; Neate-Clegg et al., 2020). The widespread adoption of digital technologies and internet-based platforms has accelerated this trend, making it possible to crowdsource bird observations on a global scale through mobile applications and online databases (Sullivan et al., 2014; Kelling et al., 2019; Toivonen et al., 2019). This has the effect of objective data collection and generating enormous datasets across diverse geographic regions and over extended times (Backstrom et al., 2024; Cervantes et al., 2023; Farr et al., 2023; Shen et al., 2023). Large-scale citizen science projects such as eBird have revolutionized access to data on bird occurrence and abundance, facilitating a wide range of ecological and conservation research (Sullivan et al., 2014; Neate-Clegg et al., 2020; Shen et al., 2023).

Volunteers have been instrumental in collecting a substantial amount of valuable information on various aspects of bird populations, species distributions, and behavioural ecology. This is of particular utility in circumstances where professional monitoring is not available (Kittelberger et al., 2023; de Camargo Barbosa et al., 2023). This includes significant data on how human activities, climate change and changes in habitats affect bird diversity (de Camargo Barbosa et al., 2023; Ráos et al., 2024). The utilisation of data derived from citizen science initiatives can present certain challenges, primarily due to the fact that observers possess varying degrees of expertise, the extent of effort expended on data collection varies, and the protocols for data collection are not universally consistent. This phenomenon has the potential to influence our perception of ecology, as evidenced by studies conducted by Passarotto and Costanzo (2024) and Scher and Clark (2023). Many studies have shown that it is important to validate data carefully, compare it to professional surveys, and use statistical models to account for biases related to detectability and the observer (Nabias et al., 2024; Hertzog et al., 2021; Shen et al., 2023).

Recent methodological advances have involved integrating citizen science data with structured survey data. This enhances the precision and reliability of population trend estimates by capitalising on the complementary strengths of both data types (Zhao et al., 2024; Hertzog et al., 2021). Citizen science has effectively been employed to evaluate species richness and distribution, enabling the identification of biodiversity hotspots and guiding conservation priorities (Butler et al., 2021; Backstrom et al., 2024). Also, the participation of local citizens and interest can contribute to conservation efforts in other ways such as ecotourism activities (Büyük and Karakaş, 2022, Atabey and Karakaş, 2024). Furthermore, citizen-generated data has broadened our understanding of intricate ecological phenomena, such as avian migration and urban adaptation, thereby informing conservation and management strategies in an ever-changing environment (de Camargo Barbosa et al., 2023).

Technological innovations have further enhanced the potential of citizen science in ornithology. For example, artificial intelligence (AI) improves the accuracy of species identification and facilitates learning among volunteers, while automated recording devices and smartphone apps enable efficient data collection and real-time monitoring (Pankiv and Kloetzer, 2024; Kerr and Auld, 2024). It is crucial to sustain volunteer engagement for the success of projects, as motivation and specialisation influence the quality of data and project outcomes. Therefore, understanding volunteer behaviour is key to tailoring training and support to maximise scientific contributions and participant satisfaction (Randler, 2022; Jäckel et al., 2023).

Citizen science projects have contributed to a more complete ornithological dataset in terms of geography and taxonomy, particularly with regard to areas and taxa that have not been studied extensively. For example, R packages containing African bird data provide citizen scientists with datasets that supplement previous data (Cervantes et al., 2023). Furthermore, long-term datasets on Caprimulgid birds in southern Brazil demonstrate the value of combining citizen observations and formal literature records (Cavarzere, 2021). Such large-scale spatiotemporal datasets enable long-term studies, which are crucial for understanding how species respond to environmental changes in regions where traditional monitoring is impractical (Kittelberger et al., 2023).

Although citizen science has proven to be invaluable, there are still limitations, such as biases in species detectability, uneven geographic sampling and data heterogeneity, which require ongoing methodological refinement (Scher and Clark, 2023; Ráos et al., 2024). The integration of volunteer and professional datasets, supported by robust statistical techniques, is essential to maximise data utility (Hertzog et al., 2021; Nabias et al., 2024). Furthermore, the sustainability of citizen science projects hinges on sustaining volunteer motivation, ensuring data quality and addressing ethical considerations, such as data privacy and proper usage (Passarotto and Costanzo, 2024; Jäckel et al., 2023). Looking ahead, technological advances, improved data integration methods and community engagement strategies are expected to strengthen the role of citizen science in ornithological research and conservation worldwide further (Pankiv and Kloetzer, 2024; Neate-Clegg et al., 2020).

For this study, a total of 179 documents obtained from the Scopus database, containing keywords related to citizen science and ornithology, published between 1999 and 2024, were analyzed. The bibliometric analysis will examine the most frequently used keywords, the annual growth of publications on the subject, the countries contributing the most research output, the most commonly used terms, author productivity based on thematic topics, and journal productivity.

Bibliometric network analysis was used to answer the following research questions;

Research Questions (RQ);

RQ 1: What are the temporal trends in publication output on citizen science contributions to ornithological research from 1999 to 2024?

RQ 2: Which countries and institutions are leading contributors to the field of citizen science in ornithology?

RQ 3: What are the most frequently used keywords and thematic clusters in citizen science-related ornithological research?

RQ 4: Which journals publish the majority of research on citizen science in ornithology, and what are their thematic focuses?

2. Material and Method

2.1 Dimensionality Reduction in Bibliometric Analysis

Dimensionality reduction techniques are extensively applied in bibliometric analysis because they enable effective handling of complex datasets (Garson, 2022; Çelik and Sarıboğa, 2023). By reducing the number of variables, these methods facilitate the detection of fundamental structures and relationships within the data. Additionally, they aid in uncovering latent patterns and emerging trends in high-dimensional bibliometric information (Garson, 2022). The use of such approaches improves data interpretability by simplifying intricate, multidimensional interactions. In the context of bibliometrics, dimensionality reduction is instrumental in revealing central research themes, mapping author networks, and tracking the evolution of scientific productivity. This simplification also supports more thorough investigations into research dynamics and existing knowledge gaps (Ebidor and Ikhide, 2024). Recent studies suggest that integrating dimensionality reduction with network analysis can further enhance the identification of interdisciplinary connections in scholarly literature, thus broadening insights into the development of scientific domains (Chen, 2020; Waltman and Van Eck, 2013; Kumar, 2025). This method enables more focused investigations into new and developing research areas. In recent years, bibliometric studies have gained significant interest. Based on SCOPUS data, a total of 48,184 publications related to “bibliometrics” have been released from 1969 to 2024 (Access date: 17.07.2025) (Figure 1). The reported figure of 48,184 publications includes studies on “bibliometrics” from 1969 to 2024. Since the year 2025 is not yet complete, publications from this year have been excluded from the SCOPUS database to ensure the accuracy and consistency of the dataset. This approach was adopted to maintain data integrity in the analysis.

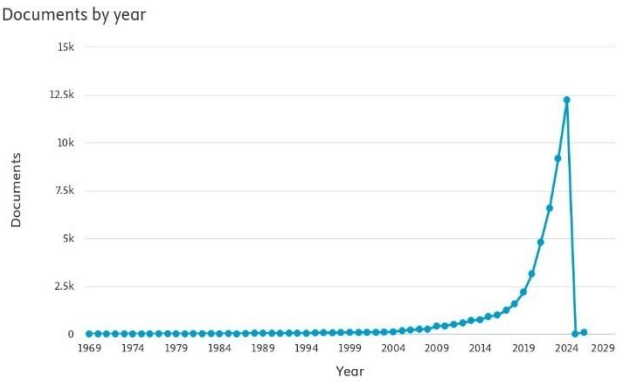

Figure 1. Annual publication growth of bibliometric studies between 1969-2024 (This graph was obtained from Scopus database. Accessed on July 17, 2025).

Bibliometric studies are very useful for understanding how scientific production and scholarly collaboration change over time (Kumar, 2025). Bibliometric studies, on the other hand, examination of large datasets in a systematic and unbiased way (Börner et al., 2003). Qualitative methods are typically used in traditional reviews, but quantitative methods are used in bibliometric research, which provide more full and reliable results (Moed, 2009). Bibliometric analysis may also quickly and easily find important trends and gaps in knowledge in the literature (Hood and Wilson, 2001). We used Bibliometrix (https://www.bibliometrix.org/home/), a free online program based on R-Studio, and VOSviewer version 1.6.17 (Van Eck and Waltman, 2007) to make all the graphs and visualizations from the dataset. For content analysis, SCOPUS records were utilized in both BibTex and CSV formats.

2.2 Data Sources and Coverage in Modern Research

In contemporary research, numerous databases are accessible for information retrieval and bibliographic analysis (Celik et al., 2021; Kulak et al., 2019). Among the most prominent of these are Web of Science (WoS), SCOPUS, Google Scholar, PubMed, and MEDLINE (Falagas et al., 2008). A key objective for researchers is to gather the most extensive collection of documents, making it essential to compare various databases. SCOPUS offers access to a larger number of documents compared to others, owing to its extensive content and inclusion of diverse document types (e.g., conference proceedings, notes, editorial comments) (Falagas et al., 2008; Gusenbauer and Haddaway, 2020). A search using identical keywords showed that SCOPUS contained more documents than the other databases.

The types and numbers of documents obtained were searched in the SCOPUS database using the "TITLE-ABS-KEY" filter: (("citizen science" OR "bird watchers") AND ("ornithology" OR "bird surveys")) AND (EXCLUDE (PUBYEAR,2025)) (Accessed: 28.11.2024). As a result of the search, a total of 179 documents were accessed (Table 1). These documents were stored in CSV format for later analysis. Various visuals, tables, and graphs were generated for visualization and analysis purposes using the Bibliometrix and VOSviewer programs.

Table 1. Types and numbers of documents obtained

Document Types	Number
Article	140
Book	11
Book chapter	2
Conference paper	6
Data paper	1
Editorial	4
Note	2
Review	13

3. Results and Discussion

A total of 179 documents were found in the SCOPUS database examining the relationship between "citizen science" and "ornithology." The first scientific document on the subject was published in 1999 as a research article. In this study, the BTO (British Trust for Ornithology) ringing program is presented as a fundamental scientific tool for ecological research and monitoring bird population dynamics, and the strategic contributions of the data obtained to conservation biology are discussed (Baillie et al., 1999). In these studies, published between 1999 and 2024 on citizen science and ornithofauna, data from 115 different sources were analysed. The average annual growth rate was calculated to be 12% (Figure 2).

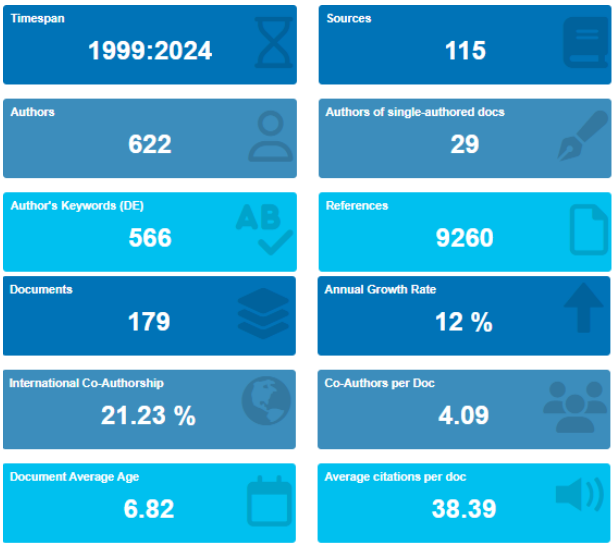

Figure 2. Main information about the documents

In recent years, citizen science, particularly in the context of birdwatching and ornitho-fauna research, has become a subject of increasing academic interest, and this trend is also reflected in annual scientific output data. Upon examining Figure 3, it is evident that publications addressing the topics of "citizen science," "ornithofauna," and "bird watchers" show an increasing trend over the years. While production was limited and fluctuated between 1999 and 2010, a clear upward trend began after 2010. A steady increase in the number of publications, especially since 2017, is noteworthy, reaching its highest level in 2021. However, a certain decline in research activities and publication output was observed due to the COVID-19 pandemic, which emerged in 2019 and had a global impact. This situation led to a short-term disruption of the upward trend in the field during the 2020-2021 period. However, although production in 2022 and 2023 was below previous peak values, the number of publications remained at high levels compared to previous years. Overall, it can be said that scientific interest in these topics has significantly increased in the last decade and has become an increasingly important area for interdisciplinary research.

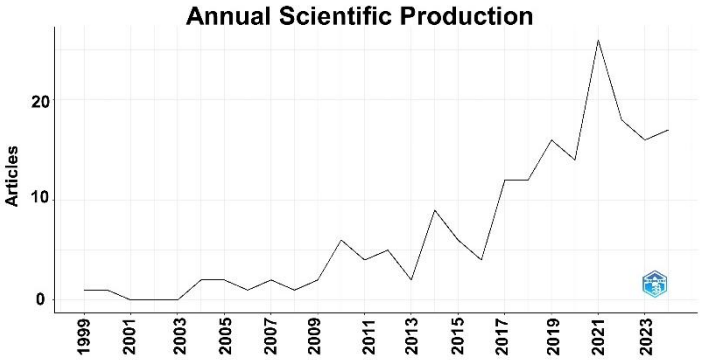

Figure 3. Annual scientific production on the topic between 1999-2024 (Source: Obtained from annual document production analysis of documents from SCOPUS using R-based Bibliometrix software: Accessed May 21, 2025)

3.1 Country Analysis

Scientific knowledge reflects not only the intensity of research activities, but also the scientific infrastructure of countries, regional needs and the effectiveness of environmental policies (Hood and Wilson, 2001). Therefore, there are marked differences in the distribution of scientific publications between different countries (Figure 4). The USA (n=194) stands out as the country with the highest number of studies. The UK (n=84), Australia (n=68), Canada (n=52), Germany (n=35), Brazil (n=30), China (n=26) and France (n=26) also have a remarkable number of studies in this field (Figure 4). The difference in the number of documents between countries is due to differences in research budgets and resources, research infrastructure, scientific collaborations, scientific culture and incentives, and the number of publications and citations. Countries such as the USA, the UK and Australia

are able to produce more and more effective studies thanks to strong institutional structures (e.g., Cornell Lab of Ornithology, British Trust for Ornithology, BirdLife Australia), large-scale citizen science projects (e.g., eBird, Great Backyard Bird Count, Garden BirdWatch, Aussie Bird Count) and international collaborations (Clements et al., 2019) (Figure 5). In addition, scientific studies in these countries are more visible due to high participation rates and long-term data collection, which increases both the number and impact of research. These factors lead to differences in the number of documents and scientific activity between countries.

3.2 Source Analysis

The significance of scientific journals extends beyond the mere dissemination of novel information; they also serve as a conduit for the demonstration of interdisciplinary collaboration among researchers from diverse geographical backgrounds (Bornmann and Leydesdorff, 2014; Waltman, 2016). The identification of prominent academic journals specialising in a particular field facilitates the acquisition of information regarding the evolution of the field and the configuration of its network. This study has found the most productive sources for research on the keywords "citizen science," "bird watchers," and "ornithology" (see Figure 1). Avian Conservation and Ecology is the most important journal in this field (n=8). It is followed by Diversity and Distributions (n=5), Journal of Applied Ecology (n=5), British Journal of Ornithology (n=4), Citizen Science: Theory and Practice (n=4), Journal of Ornithology (n=4), Australian Field Ornithology (n=3), Bird Study (n=3), and Ecological Indicators (n=3) (Figures 6 and 7). There are a lot of articles in these journals, which shows that citizen science and birdwatching are very popular topics, especially in the fields of ecology and ornithology. The fact that these topics are common in many journals shows that this research area is multidisciplinary, bringing together environmental sciences and public engagement. The network analysis also shows that some journals are central nodes in the research landscape, making it easier for researchers and institutions to work together and share information. This shows how "citizen science," "bird watchers," and "ornithology" can bring people together and help scientists work together in different communities.

region	Freq
USA	194
UK	84
AUSTRALIA	68
CANADA	52
GERMANY	35
BRAZIL	30
CHINA	26
FINLAND	26
FRANCE	26
SOUTH AFRICA	18
MEXICO	15
ARGENTINA	14
SWITZERLAND	14
CZECH REPUBLIC	11
SPAIN	11
TURKEY	10
INDIA	9
NEW ZEALAND	9
COLOMBIA	8
MALAYSIA	7
NETHERLANDS	7
POLAND	6
SWEDEN	6

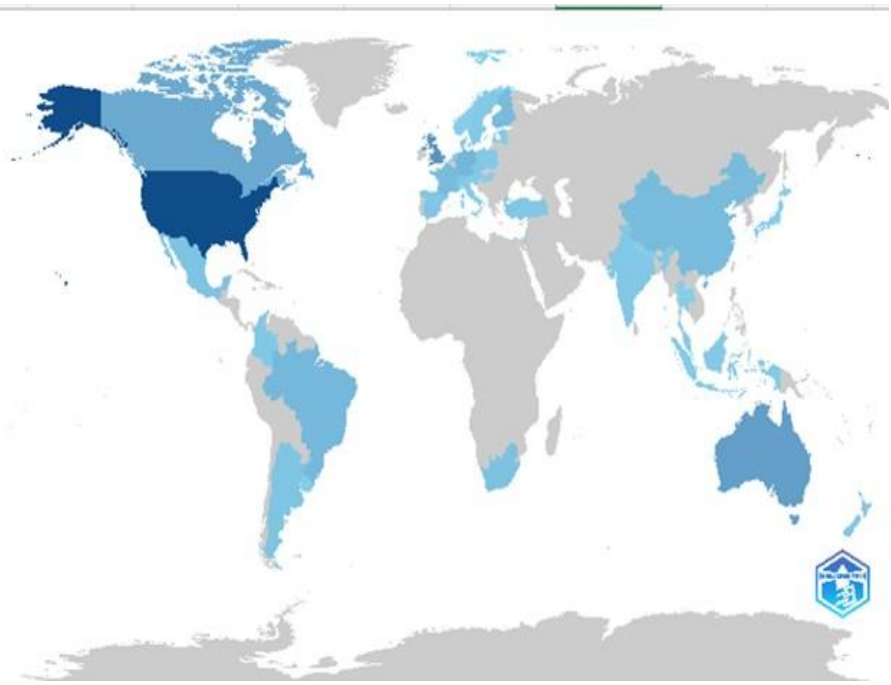

Figure 4. Authorship collaboration between countries (Dark blue= Countries that published the most documents andhad the most collaboration)

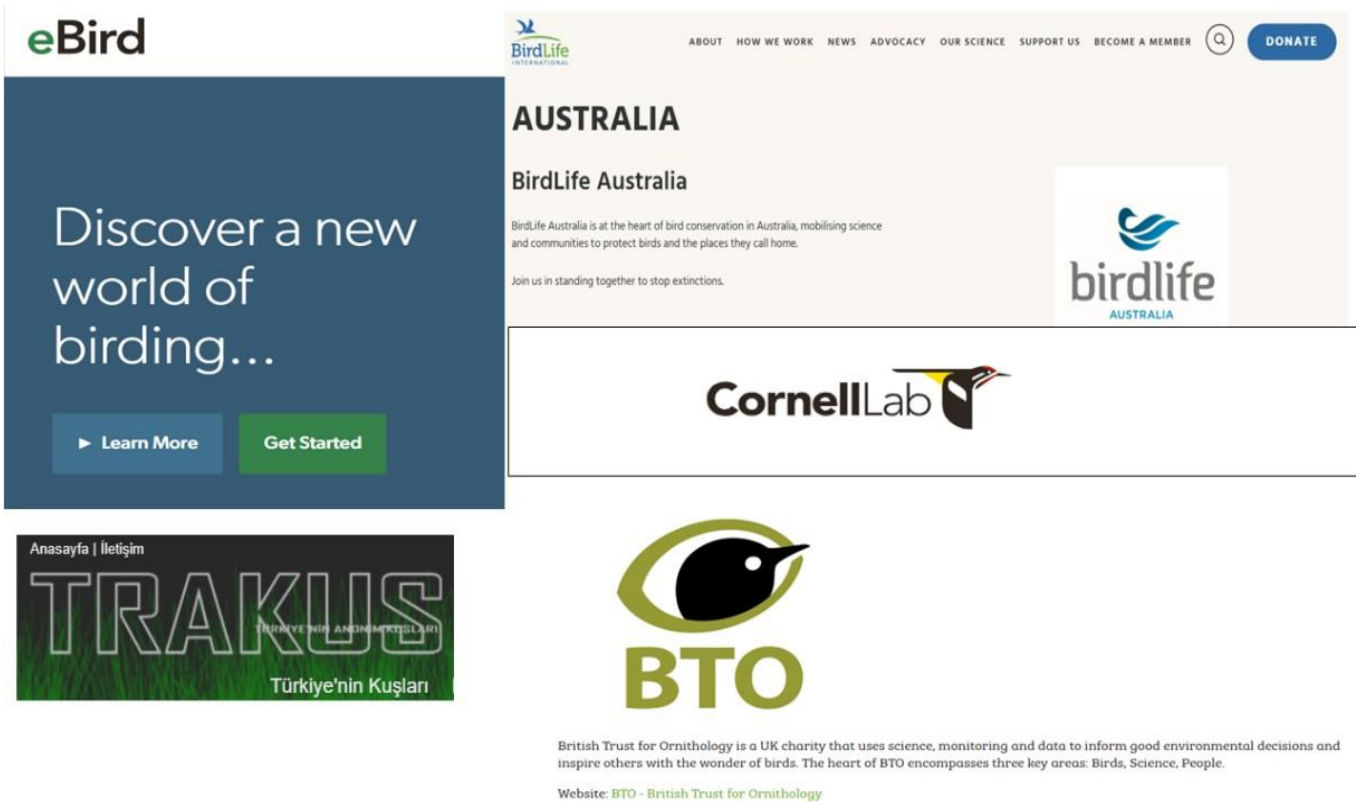

Figure 5. Major citizen science platforms and ornithological organizations

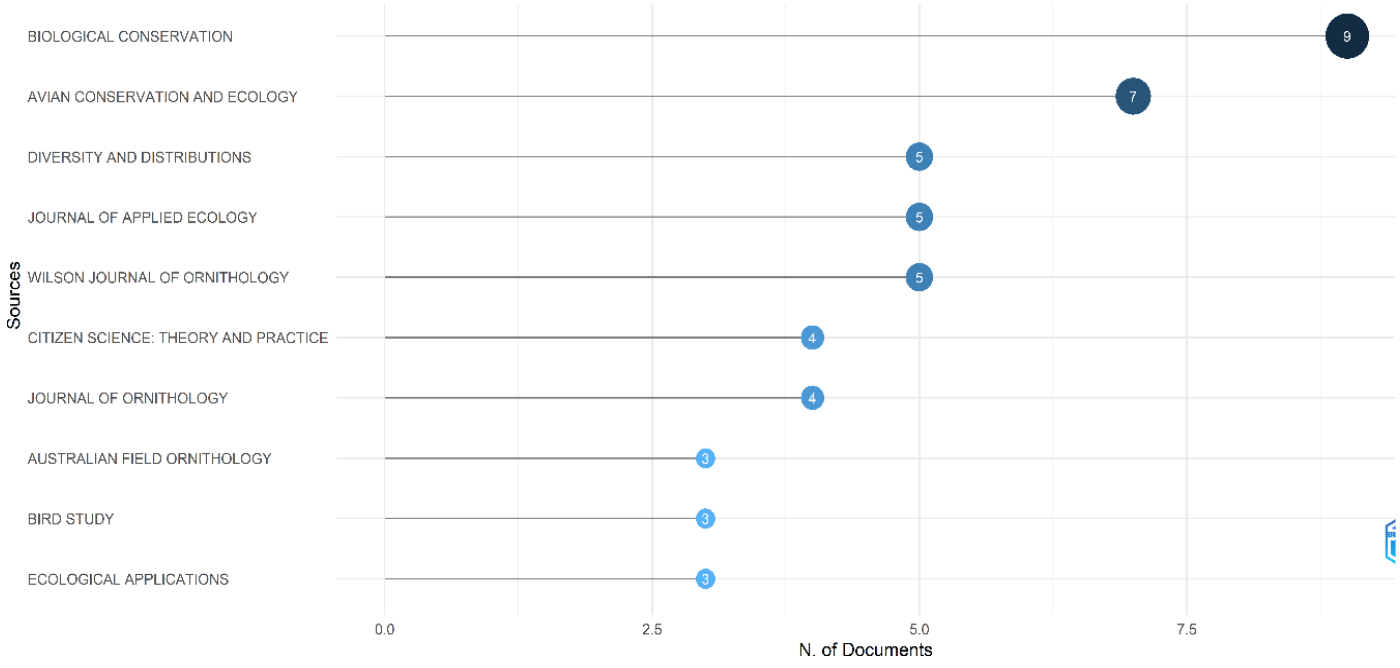

Figure 6. Most relevant sources

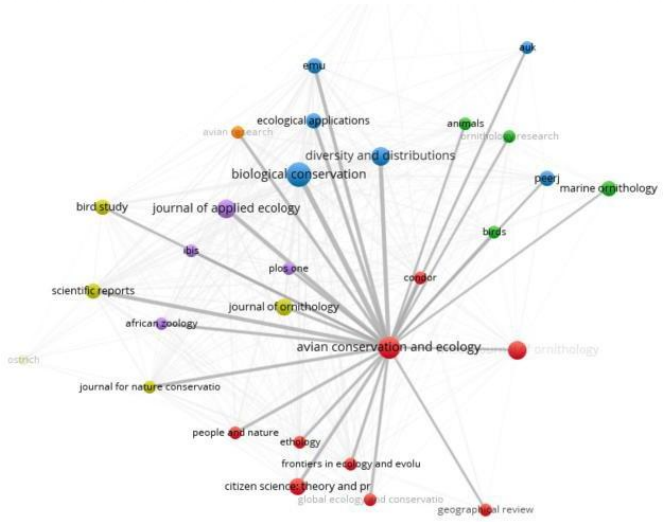

Figure 7. Citation network map between sources

3.3 Contributions by keyword

Keyword analysis is a useful approach for learning about a scientific issue and how it is evolving (Donthu et al., 2021). This study produced a keyword co-occurrence network based on documents containing the terms 'citizen science', 'birdwatchers' and 'ornithology'. The graphic depicts several major clusters and their relationships. It shows how the field is divided into subjects and how these relate to other topics. The phrase 'citizen science' lies at the centre of the network, indicating its dominance. It is closely related to terms such as 'birdwatchers', 'ornithology', 'biodiversity monitoring' and 'species abundance'. This demonstrates that birdwatching, a popular recreational activity, plays a significant role in citizen science within the field of ornithology (Figure 8) (Bonney et al., 2014). The strong correlation between 'citizen science' and 'biodiversity monitoring' highlights the vital contribution of non-professional volunteers to large-scale data collection and environmental monitoring, as evidenced by previous studies (Chandler et al., 2017). The inclusion of terms such as 'population dynamics', 'species richness' and 'protected areas' highlights the complexity of ornithological citizen science programmes, which encompass more than just species identification. They also monitor broad ecological trends and contribute to the development of conservation plans (Tulloch et al., 2013; Kelling et al., 2019). Researchers are now investigating the relationship between 'urban birds' and 'urbanisation' (Chen and Wang, 2017; Sun et al., 2022; Çelik and Çelik, 2024; Celik and Azizoglu, 2025). This involves studying how birds adapt to human-transformed environments. This approach is becoming increasingly useful given the existence of extensive citizen science databases (Tryjanowski et al., 2015).

The usage of terms such as 'data quality', 'protocols' and 'community science' indicates that the literature continues to discuss the reliability of citizen-generated data and the importance of established methods to maintain scientific rigour (Kosmala et al., 2016). This finding is consistent with recent literature emphasising the necessity of rigorous data validation protocols in citizen science projects, particularly ornithological studies (Crall et al., 2013).

The network includes links to the issues of "migration," "climate change," and "breeding." This means that people are using citizen science databases to learn more about global issues, such as how climate change impacts migratory patterns and breeding success (Devictor et al., 2010; Sullivan et al., 2014). The frequency of these studies suggests an increasing citizen science agenda, which has advanced significantly in terms of both scope and scale over time (Cooper et al., 2007; Bonney et al., 2014; Theobald et al., 2015; Irwin, 2018).

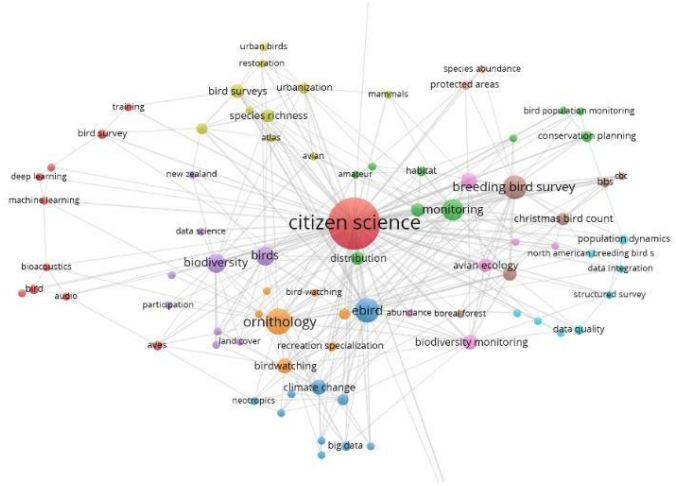

Figure 8. Co-occurrence of keywords

3.3 Thematic Map

Thematic map analysis presents prominent and increasingly developing research themes in citizen science and ornithology literature from a holistic perspective (Figure 9). In the study, key concepts such as "citizen science," "birdwatchers," and "ornithology" formed the foundation of the field, while themes like "biodiversity monitoring," "species abundance," and "protected areas" were found to make significant contributions to biodiversity monitoring and species abundance assessment using data collected thru citizen science (Bonney et al., 2014; Chandler et al., 2017; Tulloch et al., 2013; Backstrom et al., 2024). In addition, more specific themes such as "urban birds" and "urbanization" demonstrate that citizen science data provides a unique resource for research on urbanization processes and the adaptation mechanisms of bird populations in urban environments (Tryjanowski et al., 2015; Sun et al., 2022). Additionally, topics such as "data quality," "community science," and "protocols" indicate that issues like data quality, community participation, and the need for standardized practices remain relevant in the literature on citizen science projects, highlighting the need for further research (Kosmala et al., 2016; Crall et al., 2013). Themes such as "migration," "climate change," and "reproduction" show that data collected thru citizen science is effectively used in tracking global environmental issues like climate

change and migration, and in understanding ecological processes (Devictor et al., 2010; Sullivan et al., 2014). In conclusion, the thematic map reveals that citizen science is guiding the literature in many fundamental and emerging topics within the field of ornithology, and that the research agenda is progressing in a multi-dimensional structure (Donthu et al., 2021) (Figure 9).

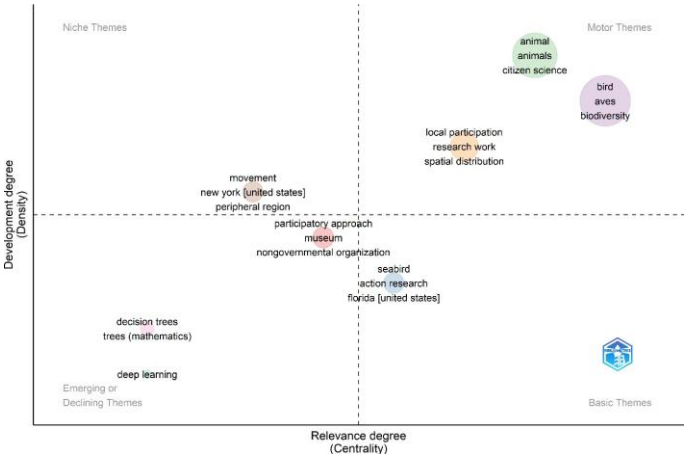

Figure 9. Co-occurrence of keywords

4. Conclusion

This study demonstrates that citizen science has become an invaluable tool in ornithological research, enabling the collection of a far greater quantity and variety of data than traditional professional methods. There has been a steady rise in scientific output in the areas of citizen science and ornithology since 1999, with particularly significant growth in the last ten years. The most productive countries, such as the USA, the UK and Australia, have strong institutional infrastructures and large, active citizen science projects, and collaborate extensively with other countries.

Journals specialising in ecology and ornithology have prominently featured research on this topic, underscoring its multidisciplinary importance. Thematic and keyword network analyses show that citizen science projects contribute to biodiversity monitoring and species distribution studies, as well as addressing broader ecological challenges such as climate change and urbanisation. Nevertheless, issues relating to data quality, protocol standardisation, and volunteer motivation continue to present challenges that require ongoing attention.

4. Future Outlook and the Way Forward

In the future, new technologies such as artificial intelligence, automated recording devices, and mobile applications could make it even easier for people to participate in citizen science initiatives, collect data, and verify data accuracy. To make data more reliable and address issues related to observer bias and data heterogeneity, it will be crucial to combine data obtained from humans with structured surveys and professional datasets. It will also be vital to create comprehensive training and support mechanisms to sustain volunteer participation and ensure they provide good data. Ethical issues, particularly those related to data protection and responsible use, should always be at the forefront of project planning. As techniques advance and collaboration becomes more globalised, citizen science will become increasingly important for ornithological studies and the conservation of biological diversity.

Declaration of Ethical Standards

The author declares that he complies with all ethical standards.

Credit Authorship Contribution Statement

Author-1: Conceptualization, investigation, methodology and software; visualization and writing – original draft; supervision and writing – review and editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability Statement

All data generated or analysed during this study are included in this published article.

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