

Review

Birds-of-paradise (Paradisaeidae) research: analysing research trends from 1862 to 2023

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Summary:

The Birds-of-Paradise (BoPs), celebrated for their exquisite plumage and significant historical allure, have faced threats from deforestation and hunting, necessitating ongoing conservation efforts. This study employs bibliometric analysis to examine the scientific literature on BoPs from 1862 to 2023, focusing on publication trends, influential countries, institutions, authors, and funding sources. By employing the Scopus database and VOSviewer for data visualisation, we have successfully identified a total of 255 publications, which include articles, reviews, and a variety of document types. Overall, the species of the genus *Paradisaea* are the most discussed. From a total of 44 species, only one species of BoPs is highlighted among all the papers examined using VOSviewer: *Lophorina superba* (n=14). This suggests that many other BoPs species have not received sufficient research attention. The analysis reveals a gradual increase in research interest since the 1970s, with the United States, Australia, and the United Kingdom leading in publication output. The study also maps the evolution of research topics, showing shifts from biogeography and species classification to phylogenetics and sexual selection. This comprehensive overview underscores the global research efforts and evolving focus areas, aiming to enhance awareness and guide future studies in BoPs conservation.

Keywords: Birds-of-Paradise; Paradisaeidae; Bibliometry; VOSviewer; Scopus database.

Introduction

The fame of the Birds-of-Paradise (BoPs) was greatly influenced by the writings of the father of biogeography, Alfred R. Wallace, in "The Malay Archipelago: The Land of the Orangutan, and the Bird of Paradise. A Narrative of Travel, with Studies of Man and Nature" (Wallace 1869) who made them a symbol of beauty and fashion. BoPs have faced various threats of extinction due to increased demand and hunting (van Solinge 2008). According to Wallace's travel records, some species of these birds were still very easy to find in the mid-19th century (van Solinge 2008). However, over time, they have become threatened again due to the large-scale deforestation in Indonesia (as one of the habitats for BoPs) that occurred from the 1970s until the end of the 19th century due to export-oriented log production and global demands (Tsuji et al. 2016).

Birds-of-Paradise have long been famous and attract attention due to the unique and extravagantly coloured plumage of the adult males (Diamond 1986). BoPs are birds that can only be found in Australasia (Gill et al. 2021), intended as the geographical area that includes Australia, eastern Indonesia, and nearby islands in the tropical southwestern Pacific (Gibson 2009). According to Tsuji et al. (2016) the areas in Indonesia that are the native habitats of these birds have suffered significant damage. Therefore, studies on population ecology and conservation efforts are needed to foster the preservation of these birds. One way to support conservation activities is by providing clear descriptions of their condition and the extent to which these birds have been explored and studied. With all this, it is hoped that researchers will realise that these birds have not been studied in depth and have been studied quite disproportionately among all bird families, especially for its small number of species.

Bibliometrics (Pritchard 1969) is a discipline that involves methods for analysing and studying the progress and evolution of scientific literature (Hood & Wilson 2001). Bibliometrics is also often used for trend analysis of a topic in a region or around the world, for example, analysis of biodiversity identification through DNA barcoding research in Indonesia (Priyono et al. 2023). Systematic bibliometric reviews about BoPs have been previously realised (e.g. Heads 2001a; Heads 2002) but these are not so

recent. Bibliometric studies related to the class Aves or the field of ornithology span a diverse range of topics and journal types, including those with dedicated 'Reviews' sections (Bautista & Pantoja 2000; Bibby 2003; Hood & Wilson 2001). But these generally focus on birds in relation to environmental or other subjects, such as metals accumulation, breeding, seed distribution, or even tourism (e.g. Çelik 2023; Celik et al. 2021; Mohammadi et al. 2024; Sarà 2023). Much rarer are the documents approaching a specific taxonomical group with a bibliometric approach, such as "Bibliometric Penguins Argentina" by Menéndez-Blázquez (2020). On the other hand, some discuss birds in a very wide perspective, for example with the subject of *Ornithology* by Bautista & Pantoja (2000).

This bibliometric study is focused on evaluating and providing comprehensive data related to BoPs, aiming to identify potential gaps in existing research. This study also aims to provide visual data on developing and mapping researchers' interests worldwide based on the number of documents each year. Additionally, it looks at which characteristics of documents are most frequently cited. The research topics that emerged and were discussed will be highlighted, as well as how the data has developed. The progress of research topics is also expected to be mapped out. Supporting data such as countries, authors, affiliations, and sponsors that focus on this topic will also be highlighted. It is hoped that this will attract the attention and interest of researchers to contribute to the conservation of BoPs.

Materials and Methods

The Scopus database was used to collect documents in terms of BoPs published in 1862-2023, using "Bird-of-Paradise" AND NOT "sterna, strelitzia, steganura, vidua" as keywords on the search column (Article title, Abstract and Keywords). These publications were categorised into ten types: articles, reviews, book chapters, letters, notes, conference papers, short surveys, errata, books and editorials. All of the data and related documents were collected and extracted in June 2024 and then analysed using VosViewer (van Eck & Waltman 2010). Among all extracted terms, 45 meet the

threshold. The top 10 most productive (assessed by the total percentage of documents) and influential countries/affiliations/authors in terms of BoPs research, the highest cited articles, subject area of research, and funding sponsor of documents source will also be displayed. As additional data, we also attempted to compare the number of publications by the most contributing authors on Google Scholar. Bibliometric analysis is a study approach focused on identifying current research topics (Duan et al. 2020) of various disciplines in a specific area (Md Khudzari et al. 2018). The literature from the Scopus database will be analysed mathematically and statistically (Zou et al. 2018), to create and view bibliometric maps based on the following criteria: title, year, country, affiliation, author, keywords, and study area. This visualization can help to understand and summarize the development of a topic that is often discussed in a field of science, thereby encouraging researchers to advance this field of science.

Results

Overall, we collected a total of 255 publications belonging to BoPs and spanning from 1862 to 2023. Most publications are in the form of articles (73.2%), followed by reviews (8.3%) and book chapters and letters (4.7%). Meanwhile, other publication types only contributed less than 4% each to the total publications.

The distribution of documents published annually regarding BoPs throughout the world can be seen in Fig. 1. Overall, the yearly increase of documents started to rise abruptly around the 1970s. The overall publication record was produced by authors belonging to 36 different countries. The top 10 most productive countries can be seen in Supplementary Table 1, which illustrates the proportionate contribution number of total documents on a worldwide scale. Publications share by country ranging from 28.0% to 1.97% of the top 10. The United States led this list with 71 publications and also had the largest number of citations, (n= 1,471).

Research related to BoPs is mostly concentrated in the Americas (United States and Brazil), Oceania (Australia and Papua New Guinea), Europe (United Kingdom, Germany, Netherlands, Sweden, and Denmark), and Asia (Indonesia). The statistical results of the

main source countries for BoPs research also show that 7 out of the top 10 most productive affiliations are from the United States (Cornell University, Harvard University, Cornell Lab of Ornithology, Yale University, American Museum of Natural History, Smithsonian Institution, David Geffen School of Medicine at UCLA). The remaining 3 are from Europe, one of which holds the rank 1 position among the top 10 most productive affiliations, Naturhistoriska riksmuseet (Sweden, with a total of 9 publications).

Scientific publications on BoPs were derived from 159 affiliations in total (in three cases we could not properly assign an affiliation to an author). The 'top 10' research affiliations in terms of the number of produced documents are listed in Supplementary Table 2. This list is led by the Naturhistoriska Riskmuseet from Sweden, which led with nine publications. From the second to the seventh position in this list are all occupied by affiliates originating from the USA. Cornell University, Harvard University, and Cornell Lab of Ornithology are ex-quo in second place with six publications each. On the other hand, the American Museum of Natural History succeeded in becoming the affiliate with the highest total document citations among the 10 other affiliates, with a total of 261 citations.

Between 1862 and 2023, 159 authors contributed to the publications on the BoPs research field. The top 10 most productive and influential authors on BoPs are listed in Table. 1. The author with the most publications publishing documents on BoPs research is "Frith, Clifford Brodie" with 16 publications, followed by "Frith, Dawn Whyatt" and "Irestedt, Martin" both with nine publications and "Beehler, Bruce M." and Scholes, Edwin A." with six publications each. However, the author with the most total citations on his documents was "Cracraft, Joel L.", even though he only had five publications. "Irestedt, Martin" ranked second with 251 total citations. Among these authors, 97 authors (61,0%) published one document, and 51 authors published two or three publications. In total, 11 authors (6,91%) published at least four publications. Overall, 255 documents have been published from 1862-2023, Supplementary Table 3 shows the top 10 highest-cited articles on BoPs-related research. As additional data that is more detailed, we tried to analyse the number of publications published by each author who

contributed the most in different databases. There were 11 files for Frith, Clifford Brodie; three for Frith, Dawn Whyatt, nine for Irestedt, Martin, six for Beehler, Bruce M., nine for Scholes, Edwin A., and five for Cracraft, Joel L.

The published documents are also the result of funding by several sponsors. In the case of these BoPs, the top 10 most funding sponsors are listed in Supplementary Table. 4 Rank 1 is held by the National Science Foundation, a US government agency. Ranks 2 and 3 are held by institutions from Sweden, namely Vetenskapsrådet (a Sweden government agency) and Science for Life Laboratory (a non-governmental; Swedish national centre for large-scale research). Apart from institutions from the United States and Sweden, Australia also contributed to one institution that made it to the top 10. This is the Australian Research Council, a government agency (ranking 6th).

The published documents in the BoPs research field are published in several journals or other publication sources. The document per year by the top 10 main source journals on the BoPs research field from the first document published in 1862 to 2023 is presented in Supplementary Fig. 1. Emu (Australia) is the journal that has published the most documents related to BoPs, followed by Ibis (UK) in rank 2 and Notes And Queries (UK) in rank 3. The ranks 4 to 10, in order, are Nature (UK), International Zoo Yearbook (UK), Proceedings of The Zoological Society of London (UK), Bulletin of The British Ornithologists' Club (UK), Zoo Biology (USA), Zootaxa (New Zealand), and Plos One (USA).

Furthermore, the data in this study also discusses occurrence terms or keywords that are widely used in documents, as well as the coverage of the research area or research subject area. VOSviewer mapping of occurrence terms extracted from titles and abstracts in BoPs research articles by Scopus. A total of 1,139 terms from the 255 documents related to BoPs were analysed. From all the terms extracted, 5 prominent clusters were generated and are presented in 5 representative colors (Fig. 2a). The red cluster is the largest with the highest number of members with 15 items. Common words in this cluster are as follows: evolution, Ptilonorhynchidae, biogeography and biodiversity. The green and blue clusters ranked second with 12 items for both. The

green cluster focused on research related to sexuality, such as sexual selection and sexual behaviour. The blue cluster common keywords used were animals, phylogeny, Passeriformes, genetics, classification and molecular evolution. While the other 2 clusters are small clusters that only have 2 keywords. The yellow cluster focused on BoPs (Laska et al. 1992) in particular and lek (social mating system) (Beehler 1988). The keyword in the other smallest cluster (purple) is *Lophorina superba* (Beehler et al. 2012), a BoP species distributed across various mountainous areas, such as the Vogelkop and Arfak Mountains in West Papua, Indonesia, and areas around Tari in Hela Province, Papua New Guinea (Scholes & Laman 2018); and an animal experiment. Among all the documents analysed with VOSviewer, only one species of BoPs is highlighted, *Lophorina superba*. This indicates that many other species of BoPs have not been thoroughly studied.

An overview of the topics discussed and emerging each year is represented in Figure 2b. Categorization is depicted with a colour gradient from blue to yellow, which represents keywords that emerged in publications from the old to the latest year. The terms discussed at the beginning of the BoPs studies were Paradisaeidae, birds of paradise, Papua New Guinea, biogeography, mitochondrial DNA and species specificity. Meanwhile, the terms discussed in BoPs studies in recent years are about biological evolution, sexual behaviour, phenotype and history. Data analysis shows that the most frequent terms are Papua New Guinea and male with, each appearing 17 times (2.15%).

Discussion

Although the data in this study were solely obtained from the Scopus database, which may limit coverage of literature from other sources such as Web of Science or Google Scholar, the results still provide a comprehensive insight into the development of research in this field, offering a strong representation of research trends and patterns. By using Scopus, this study successfully identifies key trends, author contributions, and the most influential institutions, thus providing an informative and meaningful overview.

Since Wallace, A.R. re-popularized BoPs in his writing "Narrative of Search After Bird of Paradise" in 1862 (Wallace 1862), studies on the BoPs have been carried out for the past 162 years. More than 1.5 centuries is a relatively long period, but research progress related to the BoPs is still not extensive. However, this estimate could have been made longer, because based on Frith & Beehler's 1998 monograph, this bird was already known and popular in the 16th century. The phylogenetics of some BoPs members (as in the superclade *apoda-minor-raggiana*) is still not completely resolved and still requires several studies to prove the actual phylogenetics of the BoPs (Stelbrink et al. 2022).

The development of BoPs studies in terms of the number of documents since it was first discussed in 1862 has not experienced a constant increase until 2023 (Fig. 1). The publication time intervals between documents appear relatively far apart. The number of documents in the first 124 years was recorded at only 76 (from 1862 to 1986), with no more than 4 documents per year. There was indeed an increasing in the number of documents in the following years and 1992 (reaching 6 documents in one year), but the number then experienced a drastic decline until 2005. It was only in 2008 that researcher interest began to rise again (though still not constant), as indicated by the increasing number of documents related to BoPs until 2023. The highest number achieved was in 2021 with 13 publications. The oscillating interest in BoPs research could be attributed to fluctuations in funding priorities for biodiversity studies, advancements in research technologies, or geopolitical challenges affecting accessibility to study sites. Alternatively, it may reflect natural variations in researcher focus or global events influencing conservation awareness during specific periods.

In the history of BoPs research, the evolution of research topics has continuously changed and can be divided into three stages (Fig. 2b). First, from 1862 to 2008, the focus was on BoPs, the newest publication by Sanders (Sanders 2023). Then was about Paradisaeidae (Diamond 1986), Papua New Guinea (Alamgir et al. 2019; Marsden et al. 2006), classification (Anmarkrud & Lifjeld 2017), and species specificity (Skoracki 2005). Second, from 2008 to 2012, the focus was on phylogeny (Cracraft 1992; Irestedt et al. 2017; Nunn & Cracraft 1996; Stelbrink et al. 2022), evolution (Ligon et al. 2018; McNab

2005), DNA sequencing (Peona et al. 2021), and sexual selection (Irestedt et al. 2009) (Wilts et al. 2014), including feather aspects (Burger et al. 1993; Van Den Bergh et al. 2013) and colours (Arnold & Houck 2006). Third, from 2012 to the present, the focus is on Passeriformes (Johansson et al. 2011), genetics (Prost et al. 2019; Xu et al. 2020), sex characteristics (Miles & Fuxjager 2018), biological evolution (Eliason 2018), sexual behaviour (Wang et al. 2013), and history (Chapman 2015).

VosViewer highlights terms or nodes based on their frequency and co-occurrence strength in the dataset being analysed. In this case, the presence of certain species that are the most highlighted suggests that this species is particularly prominent in the literature due to its high citation frequency or its frequent association with key research topics in the field. This may also indicate a disproportionate focus on research on BoPs species.

If classified based on the species recognition of the BoPs in each of the previous three periods, then it could be described as follows: At the beginning of his period of discovery, the introduction of all species in the family BoPs that were known at that time was massively carried out in documents published by the researchers. The species described by Wallace (Wallace 1862) is *Paradisaea apoda*, and it tells a lot about the genus. He also mentioned several other species names of the BoPs: *P. regia*, *papuana*, *magnifica*, *superba*, *rubra*; *Astrapia nigra*; *Epimachus magnus*; *Seleudicis alba*; *Lophorina superba*; *Parotia sexsetacea*; *Paradigalla carunculate*; *Diphylloides wilsoni*; *Cicinnurus regius*, and *Semioptera* genus. He then described *Seleudicis alba* specifically in his second document (Wallace 1870). Some traces of new species growth in the BoPs family like Sclater added *Drepanornis albertisi* to the new species (Sclater 1873). Meyer also added a new species, *Diphylloides guilhelmi* (Meyer 1875).

At this first to second stage (1862-2012), a lot of research was done on the genus *Paradisaea* in general and specifically on the species *P. raggiana*, *P. rubra*, and *P. minor*; species of the genus *Cicinnurus* are also mentioned several times. While the third stage (2012-present) deals with several species, most species discussed also come from the genus *Paradisaea*, as well as some articles dealing with *Lophorina superba* specifically.

Several researchers focus on various topics related to BoPs. For example, studies addressing phylogenetic relationships were conducted by Nunn & Cracraft (1996) and Irestedt et al. (2009). So far, the most comprehensive discussion on phylogeny at the species level has been conducted by Irestedt, M. Discussions on BoPs have also gained attention as these birds are prime examples of sexual selection and geographical speciation (Stelbrink et al. 2022). Some researchers and highly cited publications focusing on this include Ligon et al. (2018), and Irestedt et al. (2009). Additionally, discussions on biogeography, terrane tectonics in New Guinea, and ecology related to BoPs distribution patterns have been extensively conducted by Heads in the *Journal of Biogeography* (Heads 2001a, 2002), *Biogeography of Australasia* (Heads 2011), and the *Journal of Zoology* (Heads 2001b). Quite an interesting discussion regarding the physical basis of structural coloration in this group has also been discussed (see Wilts et al. 2014).

The total number of published documents is also viewed from the geographic origin of the countries. The United States is the country with the most publications, with a total of 71 documents (28.0%). This is followed by Australia with a total of 44 documents (17.3%) and the United Kingdom with a total of 24 documents (9.45%). However, the researchers of these countries also collaborate to research this topic. Among these top three ranked countries, only Australia is home to the BoPs species. Essentially, BoPs are found in three countries: Australia, Indonesia, and Papua New Guinea. Two of these countries are still in the top 10 most productive countries, ranking 7th for Papua New Guinea (3.54%) and 9th for Indonesia (2.36%). BoPs are not taxon with a rich species diversity (Stelbrink et al. 2022); they only have 16 genera with 44 species. Nonetheless, 90% of them are endemic to Papua New Guinea, and the surrounding islands (Frith & Beehler 1998).

The statement that research related to BoPs is mostly concentrated in the Americas can be understood from a historical and research resource distribution perspective. European countries and the United States, as former colonial powers, have large natural history museums with extensive collections of BoPs specimens, obtained during the colonial-era explorations in the Australasian region. These museums, such as the

American Museum of Natural History, have become research hubs because they house critical collections for studies on the morphology, evolution, and diversity of BoPs. Furthermore, the advanced research facilities and funding available in these countries enable researchers to analyze specimens using cutting-edge technologies, even though BoPs are not native to the Americas or Europe. Therefore, while the natural habitat of BoPs is in Australasia, the focus of research often shifts to countries with greater access to scientific resources.

The analysis of the source countries of the top 10 authors who publish the most documents on BoPs research indicates that researchers from Australia have a greater interest in BoPs research. This is likely because Australia is also one of the regions where BoPs originate, giving researchers in this area easier access and more opportunities to study BoPs. Besides, the most cited publication among the top three authors is: "Archbold's bowerbird *Archboldia papuensis* (Ptilonorhynchidae) uses plumes from king of saxon bird of paradise *Pteridophora alberti* (Paradisaeidae) as bower decoration," a collaborative work by "Frith, C.B." and "Frith, D.W." published in the journal *Emu* in 1990 with a total of 17 citations (Frith & Frith 1990). Although this paper does not discuss BoPs directly, this paper has used data from BoPs species which shows that BoPs is also included in the discussion. On the other hand, the paper that discusses BoPs directly by "Irestedt, M." received the highest number of citations for his collaborative article titled "Identifying the causes and consequences of assembly gaps using a multiplatform genome assembly of a bird-of-paradise", with a total of 72 citations (Peona et al. 2021). Additionally, based on data from Scopus, it is known that "Frith, D.W." has always collaborated with "Frith, C.B." in all of their publications (a total of 9 documents from 1981 to 1998).

The number of documents published by researchers, affiliations, and certain countries is certainly influenced to some extent by the availability or absence of sponsors funding research on this topic. This is evidenced by the analysis of the top 10 funding sponsors for BoPs research found that the institutions providing the most funding came from three countries: the United States, Sweden, and Australia. In addition to being ranked

2nd in countries with the most published documents and also being the country of origin for the most productive and influential authors, Australia also has one institution in the top 10, the Australia Research Council. Similarly, Sweden, as the country ranked 1st in most productive affiliations in terms of BoP research, also has 3 out of the 10 most funding sponsors, namely Vetenskapsrådet (ranked 2nd), Science for Life Laboratory (ranked 3rd), and Knut och Alice Wallenbergs Stiftelse. From this statement, it can be concluded that the support of countries and funding from government or non-government institutions greatly influences researchers' interests. Thus, indirectly, countries also play a role in supporting the conservation of BoPs by helping to provide research funding.

The highest coverage area for research subjects on BoPs comes from Agricultural and Biological Sciences. This data is certainly influenced by the subject area of the source type of these documents. Looking at the total documents per year of the top 10 main source journals (Supplementary Fig. 1), ranks 1 and 2 are Emu and Ibis, both of which are journals with subject areas in Agricultural and Biological Sciences. Therefore, it is not surprising that this research subject area is the most indexed by Scopus.

Discussions about BoPs in other subject areas were also found in this analysis. For instance, the discussion on BoPs conservation is addressed by van Solinge (van Solinge 2008) in his writing titled *"The Land of the Orangutan and the Bird of Paradise Under Threat."* He juxtaposes the Orangutan and the Bird of Paradise in the same discussion because both are native species from the same nation. Additionally, mining and oil palm are the two main causes of tropical deforestation that affect them both. In his writing, he narrates the journey of the Bird of Paradise's fame starting from Wallace (Wallace 1862, 1869) until it faced the threat of extinction, and then it can be said to have been saved due to the conservation movement for this bird. However, documents discussing the conservation of this bird are still not widely found. This is certainly not surprising, because more targeted work on ecological surveys of BoPs would be important, because this data alone is still very lacking.

Another equally interesting subject is the evidence we found of the fame and beauty of

BoPs in the field of fashion. Abrego (2012) has written a document from a film festival event in New York, with the theme *“New York with Birds of Paradise: A Major Extravaganza in Costume Spectacle, Dance, and Diabolical Glamour.”* Abrego also states that the BoPs managed to showcase an unusual interconnectedness in filmmaking. Designers use the beauty of this bird as inspiration in creating fashion and costumes in film and television. The fashion world also “seen” BoPs as one of the world's jewels that can create unlimited imagination.

If we analyse further, each of these top 10 publication sources has a different time range or publication year scale. Emu, ranked 1st, started publishing one document in 1901, but Emu began publishing numerous documents in the period from 1975 to the early 2000s. Additionally, Ibis, ranked 2nd, published many journals in 1897 but stopped in 1929. Ibis published one document in 1970 and 1988, and the last document in 2006. Another example is the Proceedings of The Zoological Society of London. Although ranked 6th, this journal has been active and first published a document related to BoPs in the early days of research on these birds in 1862. This journal only published one journal each year, last publishing a document related to BoPs in 1938, and has not been seen again until 2023.

If we explore the last 20 years, the journals or publication sources that started to discuss BoPs are the last four ranks of the top 10. These three journals are Bulletin of the British Ornithologists' Club, Zoo Biology, Zootaxa, and PLOS One. Narrowing it down to the last three years, the most active journals are Zoo Biology and Bulletin of the British Ornithologists' Club, which recently published documents related to BoPs in 2023. From these results, it can be predicted that the journals or publication sources that will actively publish documents related to BoPs in the coming years are these four journals (ranks 6 to 10).

Ultimately, the most popular topics related to BoPs can also be seen in the top 10 most cited articles. The most cited discussions are about the genome, sexual selection, phylogenetics and evolution (Cracraft 1992; Helm-Bychowski & Cracraft 1993; Irestedt et al. 2009; Ligon et al. 2018; Peona et al. 2021); feathers (Stavenga 2014; Stavenga et

al. 2015; Wilts et al. 2014); and their ecology (Pratt & Stiles 1983; Diamond 1986). This article also highlights that many research gaps have not been deeply studied regarding BoPs, including genomic aspects, evolution, and conservation strategies. Research shows that despite attention to BoPs for more than 1.5 centuries, the development of research related to these birds is not very extensive. This indicates that many aspects have not been deeply explored regarding birds-of-paradise.

The study indicates that to date, although quite a lot of work has been done on BoPs genomics over the last 15 years including whole genomes, there is still no available complete genome of this bird group published in documents or Genbank. This shows a gap in the genomic understanding of BoPs, which is an important area for understanding their evolution and genetic diversity. This study also identifies research gaps related to BoPs, specifically concerning distinguishing characteristics from morphological or genomic data that differentiate subspecies of *Paradisaea minor*. Additionally, there is a lack of research on the conservation of this bird species. This article hopes that the understanding and descriptions provided will offer information on knowledge gaps about BoPs and will attract researchers to participate in uncovering these gaps. The goal is to raise awareness and guide future studies in the conservation of BoPs.

We can concentrate on the most crucial strategies or initiatives to protect this species first if we are aware of the current status of its family. For instance, doing equal study on all members of this family and concentrating more on ecological surveys. Furthermore, it is strongly advised to conduct research that aims to provide complete genomes from members of this family. Bibliometric surveys of BoPs literature can produce real action in conservation efforts, including through improving habitat protection policies and data-based conservation management. For example, by understanding critical habitat areas that are often identified in the literature, conservationists can propose the establishment of protected areas or expanding areas that are already protected. In addition, bibliometrics can show the specific types of threats (such as hunting or deforestation) that are most discussed in research, so that governments or NGOs can plan direct actions, such as anti-poaching patrols and

reforestation programs.

On the other hand, the results of this survey can also be used to identify key institutions or research groups that are active in the study of BoPs. With the collaboration between researchers and conservation institutions, it is hoped that sustainable conservation programs can emerge, such as long-term population monitoring programs, training local communities in ecosystem management, and public education campaigns that focus on the ecological value of BoPs. These real actions become more focused and evidence-based, thus strengthening the chances of success of BoPs conservation efforts.

In summary, the discussion of the results of data analysis regarding BoPs sourced from the Scopus database provides an overview of the development of BoPs studies that have been carried out throughout the world. Apart from that, it also provides an understanding of the extent to which this BoPs topic has been discussed. Studies in the fields of biological evolution, history and sexual behaviour will probably be discussed a lot in the future. The hope is that this understanding and description can provide information about the gaps in BoPs knowledge. Apart from that, it is also hoped that it will provide ideas for hot topics to be discussed. Thus, it will attract the interest of researchers to participate in uncovering gaps in BoPs knowledge. In the end, all the knowledge gained will help preserve the BoPs, because all this information will be useful in developing BoPs conservation policies.

Electronic Supplementary Material are available on the website

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Early view

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Figure and table captions

Table 1. The highest cited articles on BoPs research

Figure 1. Annual publications of BoPs research, 1862-2023. A total of 255 documents were retrieved from the Scopus database. The productivity in BOP research has gradually increased since the 1970s and the highest number of documents was published in 2021.

Figure 2. VOSviewer mapping of occurrence terms extracted from titles and abstracts in BoPs-related research articles. **(a)** network visualization, with 5 distinguished clusters: red, green, blue, yellow, and purple; **(b)** overlay visualization. The size of the circle indicates the proportion or frequency of occurrence of the term. the length of the link indicates the degree of relationship between terms and other terms.

Table 1.

Rank	Authors	Title	Article Type	Year	Journal Title	Number of Citations
1	Helm-Bychowski & Cracraft (Helm-Bychowski & Cracraft 1993)	Recovering phylogenetic signal from DNA sequences: Relationships within the corvine assemblage (class aves) as inferred from complete sequences of the mitochondrial DNA cytochrome-b gene	Article	1993	Molecular Biology and Evolution	179
2	Stavenga (Stavenga 2014)	Thin film and multilayer optics cause structural colors of many insects and birds	Conference Paper	2014	Materials Today: Proceedings	120
3	Wilts et al. (Wilts et al. 2014)	Sparkling feather reflections of a bird-of-paradise explained by finite-difference time-domain modeling	Article	2014	Proceedings of the National Academy of Sciences of the United States of America	98
4	Cracraft (Cracraft 1992)	The Species of The Birds-of-Paradise (Paradisaeidae): Applying the Phylogenetic Species Concept to A Complex Pattern of Diversification	Article	1992	Cladistics	90
5	Stavenga et al. (Stavenga et al. 2015)	The high refractive index of melanin in shiny occipital feathers of a bird of paradise	Article	2015	Light: Science and Applications	83

6	Peona et al. (Peona et al. 2021)	Identifying the causes and consequences of assembly gaps using a multiplatform genome assembly of a bird-of-paradise	Article	2021	Molecular Ecology Resources	72
7	Ligon et al. (Ligon et al. 2018)	Evolution of correlated complexity in the radically different courtship signals of birds-of-paradise	Article	2018	PLoS Biology	71
8	Irestedt et al. (Irestedt et al. 2009)	An unexpectedly long history of sexual selection in birds-of-paradise	Article	2009	BMC Evolutionary Biology	66
9	Pratt & Stiles (Pratt & Stiles 1983)	How long fruit-eating birds stay in the plants where they feed: implications for seed dispersal.	Article	1983	American Naturalist	58
10	Diamond (Diamond 1986)	Biology of birds of paradise and bowerbirds	Article	1986	Annual review of ecology and systematics	53

Figure 1.

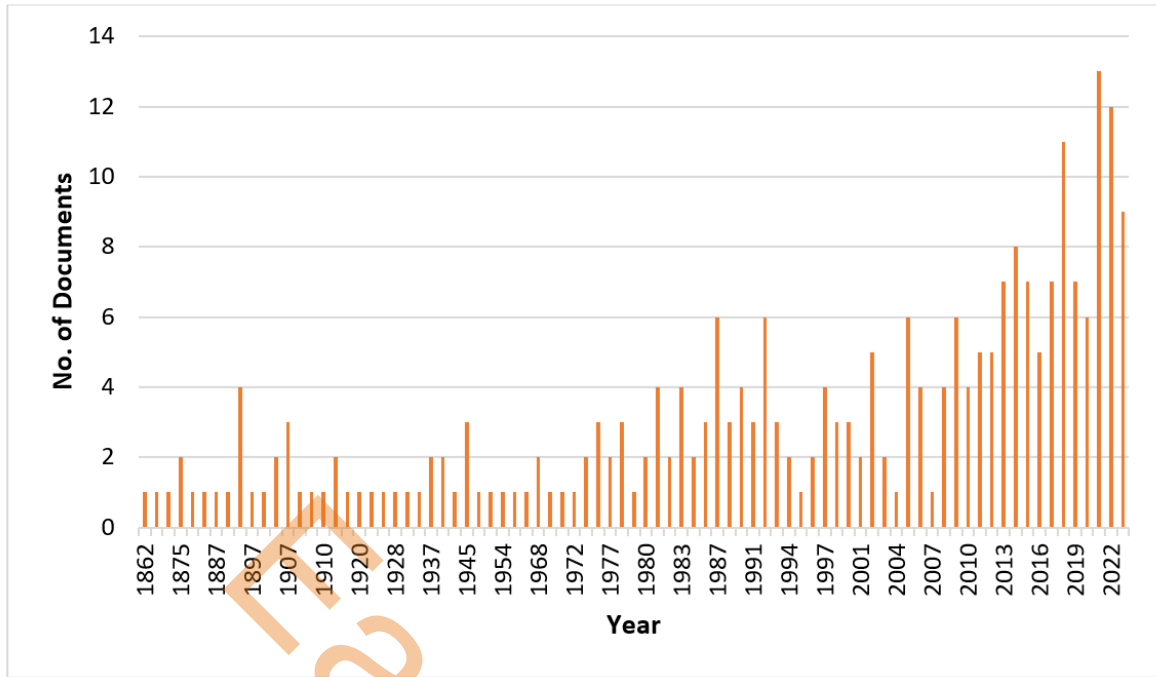
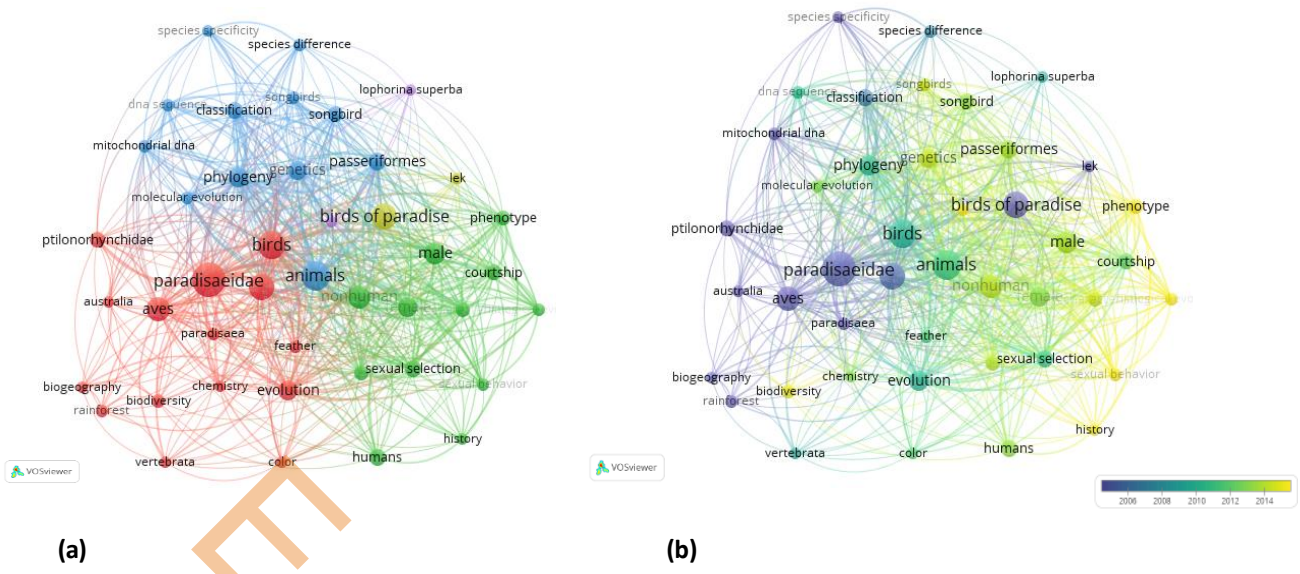


Figure 2.



Early view