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Original Article

Trends in Paragonimiasis Global Research: Bibliometric Analysis of a Neglected Food-Borne Parasite

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Abstract

Background: *Paragonimus* is a genus of parasitic flatworms known as lung flukes that cause the parasitic disease paragonimiasis in humans and other mammals. We aimed to use bibliometric analysis to identify the global characteristics and temporal trends of published literature about paragonimiasis.

Methods: Using the Web of Science database, we identified all original articles on paragonimiasis 1997 to 2022. After collecting the bibliographic and citation data, keywords, citation networks, and co-citations pertaining to paragonimiasis was carried out using the VOSviewer program.

Results: The study identified 563 paragonimiasis articles published in 250 journals. Publications in paragonimiasis research have been cited 6190 times and 2803 times without self-citations. The years with the most publications were 2013, 2016, and 2021. The minimal threshold for analysis was met by 19 of the 52 countries investigated. The study included 19 items, yielding 170 links between countries. The total strength of these links was discovered to be 104772. The journal with the most publications in this category was Parasitology Research (n=31). The most frequently used terms in paragonimiasis study were "paragonimiasis", "*Paragonimus westermanii*", and "lung-fluke."

Conclusion: The study concluded by providing an overview of the paragonimiasis research field, including current trends, development, and researcher collaboration. By addressing gaps in this bibliometric analysis and increasing collaboration, stakeholders could strengthen their strategies to effectively combat paragonimiasis and improve public health outcomes.



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Introduction

Paragonimus is a genus of parasitic flatworms known as lung flukes that cause the parasitic disease paragonimiasis in humans and other mammals (1). The disease is most diagnosed in Southeast Asia, Africa, and South America (2). According to the WHO, *Paragonimus* infection is a neglected tropical disease that affects millions of people worldwide. The infection is acquired through consumption of raw or undercooked crustaceans, such as crayfish and crabs, which act as the intermediate host for the parasite (3). In these intermediate hosts, the parasite's larvae develop and mature before being transmitted to the final host, humans, through consumption of the undercooked or raw crustaceans (4). The larvae burrow into the tissues of the human body and find their way to the lungs, where they mature into adult worms and lay their eggs. The eggs that are discharged in the infected person's sputum or coughed up and ingested leave the body and continue the life cycle in the intermediate host (5). The disease is more prevalent in rural communities, where these intermediate hosts are regularly consumed and access to adequate food handling and cooking processes is limited (4).

The infection may cause a variety of symptoms such as coughing, chest pain, fever, and weight loss, and if untreated, it may lead to serious complications such as lung abscesses, pleural effusion, and fibrosis (6). The disease is considered an important public health issue in many regions and is associated with significant morbidity and economic costs (7). The mortality and morbidity rates of paragonimiasis vary depending on region and access to adequate treatment. In regions with inadequate access to medical care, the condition can cause severe morbidity and mortality (8). Left untreated, *Paragonimus* can cause severe lung damage and other complications, making it an important public health concern in endemic areas. Because of the non-specific symptoms

and low sensitivity of adopted diagnostic procedures, diagnosing paragonimiasis might be challenging (9). Early diagnosis and proper treatment are crucial for preventing long-term consequences of the disease. A comprehensive strategy to disease control is required, including education and awareness campaigns, improved food safety policies, and improved diagnostic and treatment technologies (1).

Using careful methodologies, bibliometric analysis can be utilized to make sense of vast amounts of data. Bibliometric studies that are well-conducted can offer a strong foundation. Scientists can use it to position their intended contributions in the area and obtain an overview from a single source (3). Bibliometric analysis of paragonimiasis can provide a comprehensive overview of the research trends, patterns, and advancements in the field of paragonimiasis.

Materials & Methods

Design of the study

We used a descriptive bibliometric analysis.

Selection of data

A comprehensive global academic database with more than 9000 high-impact research publications is called the Web of Science Core collection® (<https://clarivate.com/products/>). The preliminary database was created by retrieving a selection of publications from the WoS that were relevant to the study's subject. WoS is primarily designed to make it easier for authors to find relevant literature, but it has also been effectively utilized for bibliometric analyses. In fact, it was not designed for direct bibliometric analyses (10).

Title, Author, Institution, Country/Region, Year of Publication, and Keywords are just a few of the capabilities in WoS that can be utilized for bibliometric research (10). On February 2, 2023, we ran a publication search on

WOS. The papers from the database were carefully reviewed to assess the validity of our search method, and then they were stored in TXT format (11). The countries' geographical locations were established as previously mentioned. Only publications from the indexed WoS database that were published between 1997 and 2022 were examined. This study employed an automatic Boolean query refinement technique (12).

Search terms for this study were [MeSH Terms], (*Paragonimus kellecottia*) OR (*Paragonimus*) OR TI= (*Paragonimus westermani*) OR (paragonimiasis) OR (*Paragonimus* Infection) OR (*Paragonimus africanus*) OR (*Paragonimus mexicanus*). The time range was determined as 1992-01-01 to 2022-12-31 (publication date) and the publication type was not selected. The WoS publications saved as TXT files were imported into Microsoft Office Excel 2019 (Los Angeles, California, USA) along with the document categories, publication years, author names, journals, affiliations, keywords, group authors, and citations.

Data exploration and network visualization

Bibliometric maps are a manner to visualize the affiliation, correlation, and connection among extraordinary scientific domain names

or studies subjects, and vosviewer is a software program tool that lets in users to formulate these maps by way of comparing big categories of bibliographic statistics. They are beneficial for understanding the structure of a scientific field, identifying emerging research trends, and identifying potential areas for future research. In this study, bibliometric maps were created with VOSviewer 1.6.18 for Microsoft Windows. VOSviewer, a free computer program we developed to create and view bibliometric maps (1).

Results

Using the strategy specified in the method, 563 publications that had appeared since 1992 were identified because of the database search. All query results were manually verified before excluding duplicates. In this way, all documents (514 SCI-Expanded, 36 ESCI, 26 CPCI-S, 6 BKCI-S, 5 SSCI, 3 A&HC publications) are included in this study as shown in Table 1. The document types were presented in Table 2 and the form of publication is presented in Table 3. English (n=54, 96.27%), Spanish (n=8, 1.42%), Korean (n=7, 1.24%), and French (n=6, 1.06%) were the publishing languages.

Table 1: Documents about *Paragonimus* published from 1992-2022

<i>Web of Science Index</i>	<i>Record Count</i>	<i>% of 563</i>
Science Citation Index Expanded (SCI-EXPANDED)	514	91.2
Emerging Sources Citation Index (ESCI)	36	6.3
Conference Proceedings Citation Index – Science (CPCI-S)	26	4.6
Book Citation Index – Science (BKCI-S)	6	1.0
Social Sciences Citation Index (SSCI)	5	0.8
Arts & Humanities Citation Index (A&HCI)	3	0.5

Table 2: Document type of publications on *Paragonimus*

<i>Document Types</i>	<i>Record Count</i>	<i>% of 563</i>
Article	437	77.6
Meeting Abstract	34	6.03
Review Article	25	4.4
Editorial Material	24	4.2
Letter	17	3.0
Note	12	2.1
Proceeding Paper	10	1.7
Book Chapters	6	1.0
Correction	4	0.7
Correction, Addition	1	0.1
Data Paper	1	0.1
News Item	1	0.1
Retraction	1	0.1

Table 3: Type of publications on *Paragonimus*

<i>Open Access</i>	<i>Record Count</i>	<i>% of 563</i>
All Open Access	211	37.4
Gold	111	19.7
Gold-Hybrid	15	2.6
Free to Read	42	7.4
Green Published	139	24.6
Green Accepted	11	1.9
Green Submitted	51	9.0

*352 record(s) (62.522%) do not contain data in the field being analyzed

Publication distribution by year

Publications in the paragonimiasis research have cited as shown in Fig. 1, with a full H index of 33. 2013 (30 documents), 2016 (28

documents), and 2021 (28 documents) were the three most productive years of publication (Table 4).

Table 4: Distribution of publications about *Paragonimus* by year

<i>Publication Years</i>	<i>Record Count</i>	<i>% of 563</i>
2022	18	3.1
2021	28	4.9
2020	17	3.0
2019	24	4.2
2018	23	4.0
2017	20	3.5
2016	28	4.9
2015	26	4.6

*Publications after 2015 are shown in the table

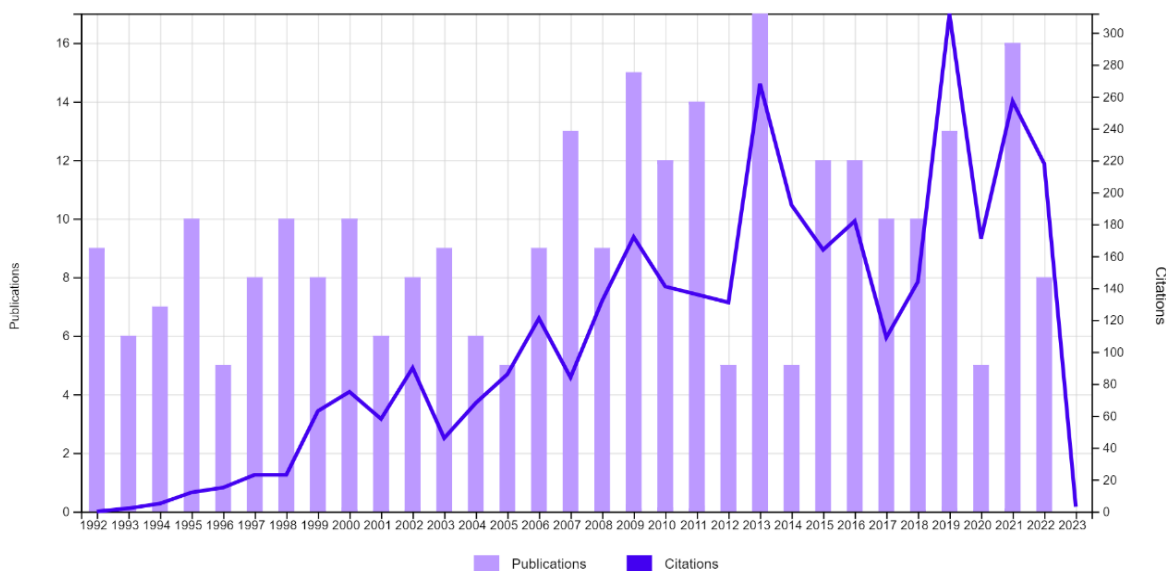


Fig. 1: Number of publications and citations in paragonimiasis research by years

Distribution of publications by country

The number of countries contributing to scientific output on paragonimiasis from 1992-2022 is 45. Overall, 172 (30.5%) of the publications were produced in Japan. The

other high contributors are South Korea (n=111, 19.7%) and China (n=99, 17.5%). Table 5 presents the top ten most productive countries.

Table 5: Countries with at least 5 publications

Countries/Regions	Record Count	% of 563
Japan	172	30.5
South Korea	111	19.7
Peoples R China	99	17.5
USA	81	14.3
Thailand	55	9.7
Australia	35	6.2
India	33	5.8
Vietnam	26	4.6

*Countries with at least 25 publications are shown in the table

Most active research areas

The WoS database has classified the documents obtained from the application of the search algorithms into 52 research areas. The research area of 186 published documents was

parasitology. Eighty-nine of the documents relate to tropical medicine and sixty-seven of them to the research area of public environmental occupational health (Table 6).

Table 6: Most active research areas

<i>Research Areas</i>	<i>Record Count</i>	<i>% of 563</i>
Parasitology	186	33.0
Tropical Medicine	89	15.8
Public Environmental Occupational Health	67	11.9
General Internal Medicine	65	11.5
Infectious Diseases	55	9.7
Respiratory System	40	7.1
Immunology	31	5.5
Radiology Nuclear Medicine Medical Imaging	29	5.1
Zoology	25	4.4
Veterinary Sciences	22	3.9

*Showing 10 out of 52 entries

Most prolific affiliations in the paragonimiasis

Five hundred seventy-seven (577) affiliations published on paragonimiasis between 1992 and 2022. The University of Miyazaki was the most active institution producing published

documents on paragonimiasis research (n=46, 8.1%), followed by Khon Kaen University (n=37, 6.5%) and Kochi University (n=37, 6.5%). Affiliations in the top ten in this field were shown in Table 7.

Table 7: Most prolific affiliations in the paragonimiasis

<i>Affiliations</i>	<i>Record Count</i>	<i>% of 563</i>
University of Miyazaki	46	8.1
Khon Kaen University	37	6.5
Kochi University	37	6.5
James Cook University	31	5.5
Vietnam Academy of Science Technology Vast	26	4.6

*Showing 5 out of 577 entries

14 record(s) (2.487%) do not contain data in the field being analyzed

Most prolific authors in paragonimiasis

Overall, 1890 authors published paragonimiasis between 1992 and 2022. Agatsuma T (n=41) ranked first in the list of top-ten publishing authors, followed by Nawa Y (n=40) and Blair D (n=31).

Most prolific journals in paragonimiasis

The documents were published in 250 different journals. The list of journals that published more than 10 articles on paragonimiasis from 1992-2022 is shown in Table 8.

Table 8: Most prolific funding agencies in paragonimiasis

<i>Publishers</i>	<i>Record Count</i>	<i>% of 563</i>
Elsevier	102	18.1
Springer Nature	60	10.6
Wiley	36	6.3
Amer Soc Trop Med & Hygiene	27	4.7
Korean Soc Parasitology, Seoul Natl Univ Coll Medi	20	3.5
Lippincott Williams & Wilkins	20	3.5
Taylor & Francis	19	3.3
Cambridge Univ Press	18	3.1
Oxford Univ Press	18	3.1
Japan Soc Internal Medicine	14	2.4

*Showing 10 out of 111 entries

Most prolific funding agencies in paragonimiasis

The Ministry of Education Culture Sports Science and Technology was the most active funding agency for paragonimiasis research (4.4%), followed by the Japan Society for the

Promotion of Science (3.9%) and the United States Department of Health and Human Services (2.8%). The list of funding agencies for paragonimiasis from 1992-2022 was shown in Table 9.

Table 9: Most prolific funding agencies in paragonimiasis

<i>Funding Agencies</i>	<i>Record Count</i>	<i>% of 563</i>
Ministry of Education Culture Sports Science and Technology Japan Mext	25	4.4
Japan Society for The Promotion of Science	22	3.9
United States Department of Health Human Services	16	2.8
National Natural Science Foundation of China	15	2.6
National Institutes of Health Nih USA	14	2.4

*Showing 5 out of 185 entries; 423 record(s) (75.133%) do not contain data in the field being analyzed

Using VosViewer for mapping

The size of the bubbles is directly proportional to the number of articles published by that country when seen in relation to the network map of overlay visualization of co-authorship analysis of countries. The diameters of the lines connecting the writers are directly connected to how much collaboration there is between them, and their colors represent the clusters to which the authors have

been assigned. Authors who are grouped together typically work more closely together. The co-authorship analysis used a color transition from red to yellow to represent the authors' collaboration. We select a minimum number of documents of 5 for co-authorship analysis. Of 2213 authors, 56 meet the threshold. There were 33 items, 6 clusters, and 126 links and the total link strength was 407 (Fig. 2).

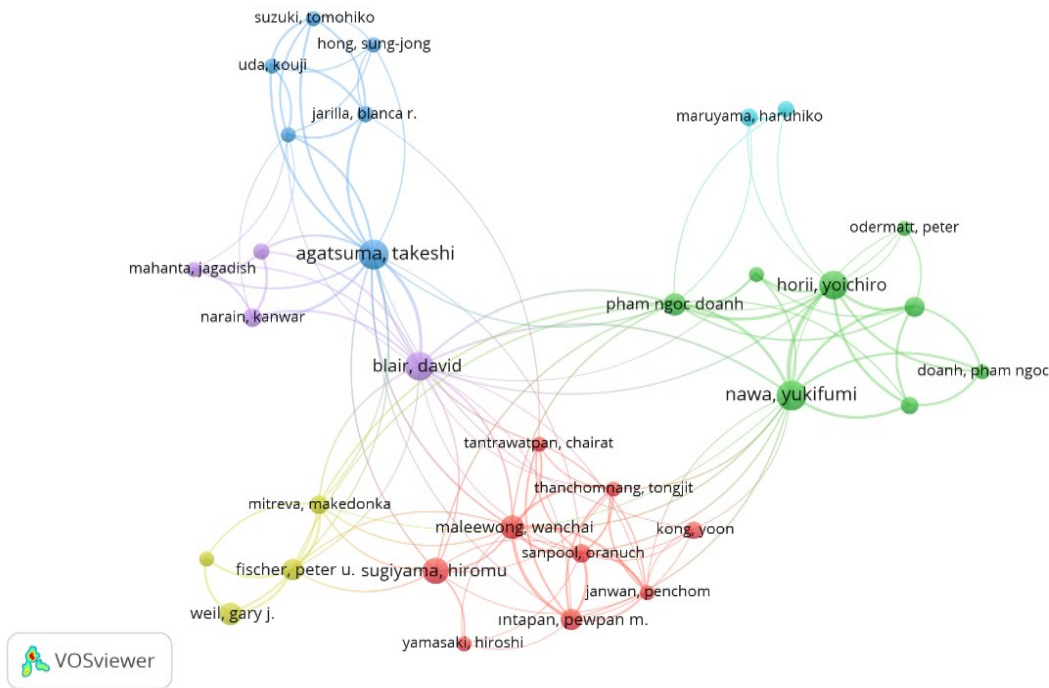


Fig. 2: Authors with at least 10 publications and 100 citations are shown on the map
 **Citations are shown by lines linking authors. Authors with a greater circle size or font size had a higher number of citations

Occurrence of the keyword

Keywords are an important aspect of bibliometric analysis, as they help to identify the main topics and themes related to a particular research area. In the analysis of the visualization of the keywords, colors demonstrate preferred keywords, especially greens and blues show popular keywords like ‘paragonimiasis’ or ‘*Paragonimus westermani*’. The diameters of the lines connecting keywords are directly related to the degree of collaboration between them (Fig. 3).

Comparison of citations by country

In view of the network visualization of citation analysis between countries, the dimension of the bubbles is immediately proportional to the number of citations by that country. The diameters of the line connecting countries are immediately related to the degree

of citation collaboration between countries, and their color shows the cluster to which the country has been allocated. We select a minimum number of documents of a country as 5 for citation analysis between countries. Of the 52 countries, 19 met the threshold. There were 19 items, and 141 links and the total link strength was 5012. Countries were grouped into 5 clusters: the green cluster, with 3 countries, led by Japan in terms of citations and collaborations with other countries; the blue cluster with South Korea, China, and Colombia; the red cluster with 8 countries led by the USA; the yellow cluster, with Thailand, India, and Nepal; the purple cluster with only Vietnam. According to Fig. 4, the strongest collaborative relationship was improved between Japan, South Korea, and China.

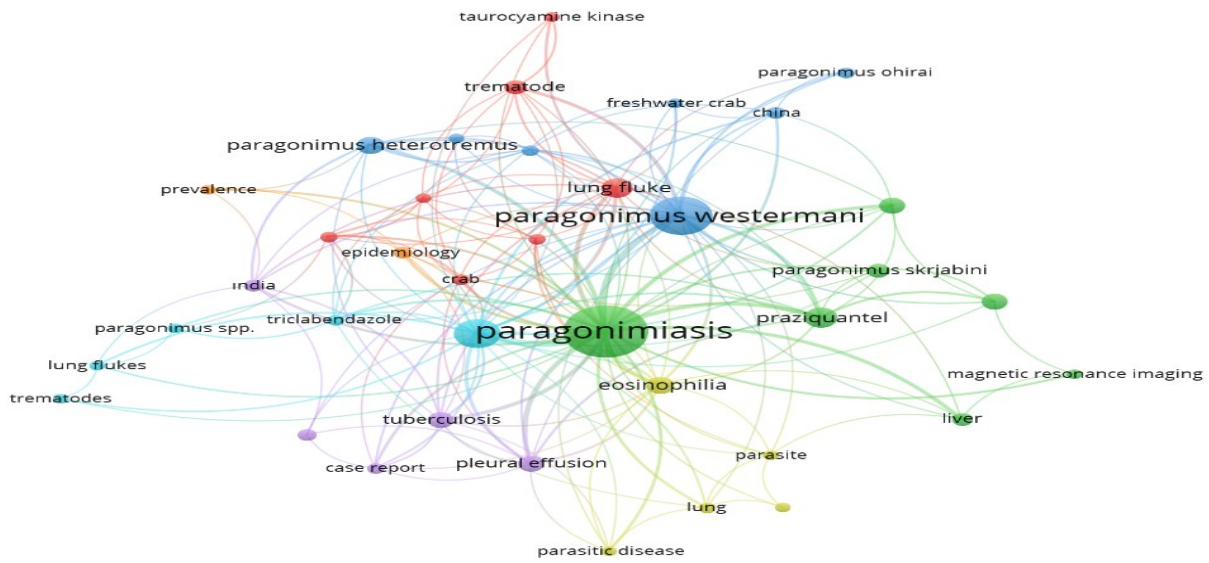


Fig. 3: Keyword visualization map of articles with at least 5 occurrences. Lines connecting are indicative of occurrence relations in the articles. Keywords represented with larger circle size or font size had a relatively higher occurrence in the articles

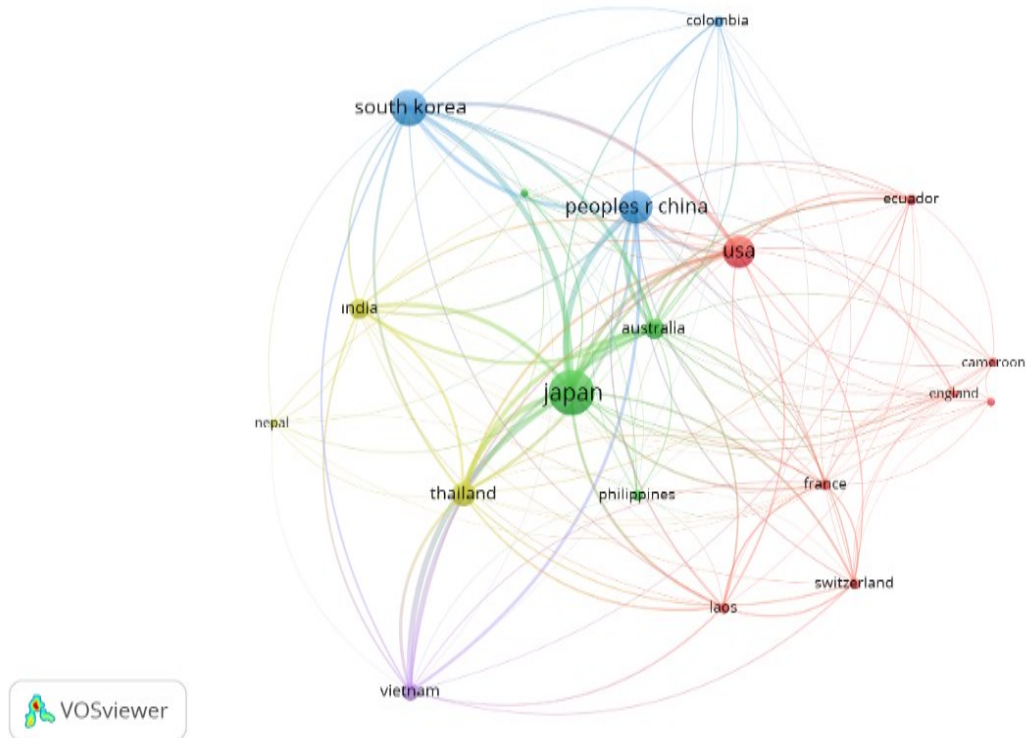


Fig. 4: Citation network visualization map among nations with at least one publication **Collaboration is shown with lines linking nations. Stronger cooperation is indicated by thicker lines. Countries with a bigger circle or text size had a higher level of international cooperation

Bibliographic coupling between countries

The size of the bubbles is directly related to the quantity of research conducted by that country when looking at the network visualization of bibliographic coupling between countries. The widths of the lines linking the countries are directly connected to how closely the countries are coupled, and the color of the lines identifies the cluster to which each country has been assigned. For this research, we use a minimum of 5 and 0 citations each country's documents. We select a minimum

number of documents of a country as 5 and 0 for citations for this analysis. Of the 52 countries, 19 met the threshold. There were 19 items, and 170 links and the total link strength was 104772. Countries were grouped into 4 clusters: the green cluster with 5 countries, led by Japan in terms of collaborations with other countries; the blue cluster with China, Colombia, and Ecuador; the red cluster with 9 countries led by the USA and the yellow cluster led by South Korea (Fig. 5).

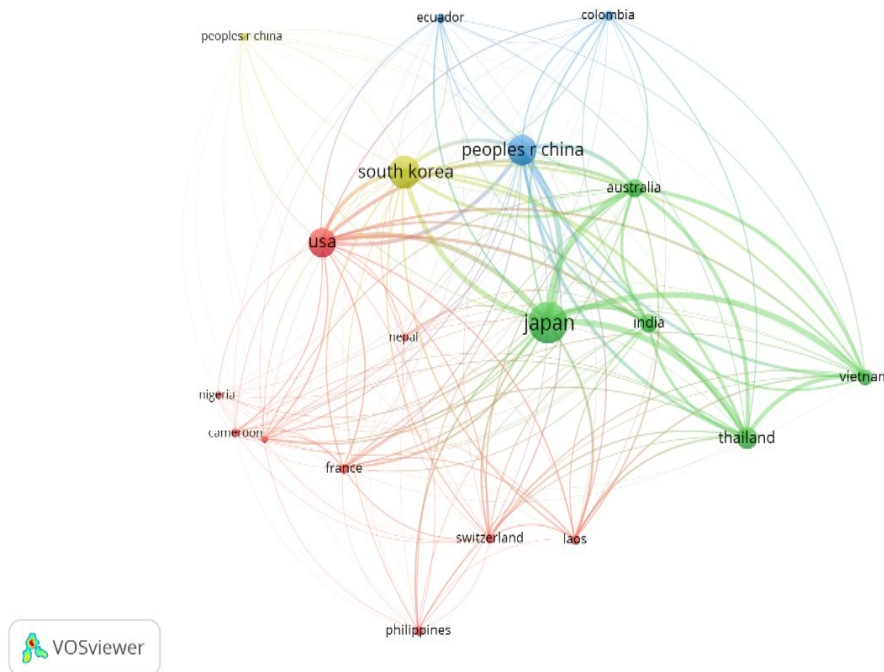


Fig. 5: Bibliographic coupling between countries

Collaboration is shown with lines linking nations. Stronger cooperation is indicated by thicker lines. Countries with a bigger circle or text size had a higher level of international cooperation

Discussion

The WoS database's search engine identified out 563 items, including 437 documents that were published in the field of paragonimiasis between 1992 and 2022. The quantity of publications changes annually. The results demonstrate that paragonimiasis-related challenges in

the context of food safety and public health continue to be significant throughout time because the years 2016 and 2021 have the largest annual number of publications. This would suggest that *Paragonimus* research saw a spike in interest during these years, possibly because of a recent disease epidemic or discovery, developments in diagnosis and treatment, or increased financing for *Paragonimus*

study. However, its challenging to pinpoint the precise reason for this increase in publications in the absence of more information. Additional bibliometric analysis can shed more light on the variables influencing the trend of *Paragonimus* publications.

This bibliometric analysis showed that the top three of the most productive countries in the process were Japan, South Korea and China. Paragonimiasis is a well-known public health concern in Japan and has been documented in several regions, especially rural areas. With thousands of cases reported each year, paragonimiasis is regarded as a significant public health issue in this country (12). The disease is widespread in Japan and is brought on by consuming raw or undercooked freshwater crustaceans, such crayfish, which act as intermediate hosts for the parasite, according to a study published in the Journal of Parasitology (13). In Japan's rural areas, where consumption of raw or undercooked seafood is frequent and access to medical care is constrained, the disease becomes particularly significant (13). Paragonimiasis is a neglected tropical illness that poses a serious threat to public health in Japan, particularly in rural areas where the disease is most prevalent, according to a review article published in the Japanese Journal of Infectious Diseases (14). In South Korea, the disease is known to have significant health effects on the infected population and, for example, paragonimiasis was once a common cause of lung disease, but with the advent of modern medical treatments and improved public health measures, the incidence of the disease has significantly declined (15). Coughing, chest pain, and fever are paragonimiasis symptoms in South Korea, which can result in serious respiratory issues. Paragonimiasis continues to be a major public health issue in South Korea, where thousands of cases are reported annually (16).

In southern and southwestern China, where most of the infected population lives in rural areas and works in farming and fishing, the

disease is extremely prevalent, according to a study (17). The study further reported that there are thought to be over 10 million cases of paragonimiasis in China. The illness was prevalent in the Chinese provinces of Sichuan and Yunnan, with the Liangshan Yi Autonomous Prefecture having the greatest frequency (18). So paragonimiasis continues to be a serious public health issue in China, especially in rural areas where consumers are more likely to eat raw or undercooked freshwater crabs (17, 18).

This bibliometric analyse shows that, the University of Miyazaki's researchers may have contributed significantly to the field of *Paragonimus* study and have been highly effective in distributing their results so they have many publications. Future research initiatives may benefit from using this knowledge, which can also offer insightful information about the priorities and areas of strength of the research community.

The high number of publications on *Paragonimus* in the journal "PARASITOLOGY RESEARCH" suggests that the journal has a strong focus on research in this area and is well-established as a venue for publishing research on *Paragonimus*. Therefore, the journal has an excellent record in the field of parasitology. It is acknowledged as a top venue for communicating highly qualified *Paragonimus* research. Additionally, it might indicate that the journal has a sizable network of professionals in the field of *Paragonimus* who are dedicated to supporting high-quality research on this subject. These professionals include researchers, reviewers, and editors. The *Paragonimus*-related articles that the Elsevier publisher has been actively publishing have significantly advanced the field of study on this subject.

The top two positions in our bibliometric analysis of *Paragonimus* were occupied by two funding organizations, the Ministry of Education, Culture, Sports, Science, and Technology (Japan Mext) and the Japan Society for the Promotion of Science, which may indicate that

Japan assigns a high priority on funding the disease-related research. This might be a symptom of the significant impact of *Paragonimus* on economic growth or public health in Japan, as well as an intense commitment to using scientific research to identify practical answers. This emphasis on supporting *Paragonimus* research may possibly be due to the high level of knowledge and resources available in Japan to treat the condition.

In bibliometric analysis, keywords play an important part in identifying the main topics and concerns pertinent to a given field of study. In the case of *Paragonimus*, relevant keywords may include "paragonimiasis," "lung fluke," "infection," "disease transmission," "epidemiology," "diagnosis," "treatment," "prevention," "drug resistance," and "public health." These keywords can be used to search databases and retrieve relevant articles, which can then be analysed to gain insights into the current state of research on *Paragonimus* (19).

The fact that the most cited article about "Paragonimiasis and the genus *Paragonimus*" suggests that the article is widely recognized and has a significant impact within the scientific community. The article's high number of citations may suggest that it is an important resource in the area and that *Paragonimus* and paragonimiasis-related arguments and studies frequently rely on the results it provides. It is also probable that the article has an important effect on how individuals currently understand the disease and the genus.

We found twelve Asian (South Korea, China, Thailand, Philippines, Japan, Taiwan, Singapore, India, Nepal, Vietnam, Philippines, Laos) and three European (France, England, Switzerland), three American (USA, Colombia, Ecuador), one African (Cameroon), and one Oceanian (Australia) countries when we examined into the co-citation collaborations between countries. It demonstrates that international collaborations are still scarce even though researchers have published excellent studies on paragonimiasis in many African, South American, and Asian nations (based on

the global citation of their publications on this topic). Similarly, to this, local journals published in these countries ought to improve their national research repositories as well as be indexed in international databases like the Scopus database, Science Direct, PubMed, and WoS so that their research results on paragonimiasis can be readily accessible and are based on the actual situation with regard to this parasite burden.

Limitations

There are a few limitations on this bibliometric analysis. Firstly, the area of study of this bibliometric analysis was restricted to publications that were published and indexed in the Wos database. As a result, it is possible that we overlooked reports from other databases. Despite these limitations, the study nonetheless offered information on paragonimiasis trends and information shortages. Second, considering that some authors may have many names or name spellings, the standardization of author names and terms based on the VOSviewer results may not be accurate. For expected authors, this might lead to inaccurate results from studies. This article offers a basic summary of paragonimiasis research despite these disadvantages.

Conclusion

The bibliometric analysis of *Paragonimus* research emphasizes the persistent issues in the context of paragonimiasis connected to food safety and public health. The growing number of publications suggests a rise in interest in the topic, which is likely affected by disease outbreaks, advances in detection, treatment, and greater financing. China, South Korea, and Japan have all contributed significantly to *Paragonimus* research, demonstrating high incidence rates and underlining the importance of effective public health interventions. Despite the excellent quality of studies from diverse nations, international collaborations are lim-

ited, and encouraging partnerships between high-income and middle- or low-income countries could boost worldwide efforts to eradicate paragonimiasis.

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Conflict of interest

All authors declare there was no conflict of interest.

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