

The trend of publication about *Lumbricus rubellus* for periodontitis treatment in the Scopus database: A bibliometric analysis

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ABSTRACT

Periodontitis presents as a sustained deterioration of the periodontium, ultimately resulting in tooth loss. *Lumbricus rubellus*, a taxonomically recognized species commonly called the earthworm, is a significant component of natural constituents. This extraordinary organism exhibits intrinsic characteristics that confer antibacterial and anti-inflammatory capabilities. Nevertheless, it is essential to acknowledge that only a restricted subset of these pharmaceutical compounds has undergone meticulous scrutiny through clinical trials despite the potential effectiveness of *L. rubellus* in the treatment of periodontitis. The present investigation utilizes the Scopus database to conduct a bibliometric examination of the antioxidant characteristics of diverse strains of *L. rubellus*. This evaluation is performed through the utilization of the RStudio and VOSviewer applications. Consequently, 55 papers were encompassed within the ultimate bibliometric dataset. Moscow State University is widely acknowledged as a highly productive academic institution with significant global contributions. Mihara H is extensively acknowledged as the author with the highest level of productivity. The scholarly publication by Mihara *et al.* in 1991 significantly impacted the respective scientific discipline. These results provide insights to stimulate pharmaceutical research collaborations and reveal open issues about *L. rubellus* in the context of periodontitis therapy.

INTRODUCTION

The periodontium represents a multifaceted and intricate functional entity encompassing various anatomical components: the gingiva, alveolar bone, periodontal ligament, and cementum [1]. Periodontal disorders encompass many inflammatory pathologies that inflict deleterious effects upon the intricate framework responsible for supporting the dental structures, namely the gingiva, alveolar bone, and periodontal ligament [2]. Periodontitis, a prevalent and persistent

inflammatory ailment, manifests as an enduring degradation of the periodontium, particularly intrabony defects, culminating in the unfortunate consequence of tooth loss [1,3,4]. Following dental caries, periodontitis emerges as the subsequent prevailing etiological factor contributing to tooth loss in the adult population residing in developed nations [5].

According to Van Dyke and Dave [6], risk factors for periodontitis can be divided into modifiable and nonmodifiable risk factors. Modifiable risk factors typically encompass environmental or behavioral determinants, while nonmodifiable risk factors predominantly pertain to inherent characteristics of the individual, rendering them less amenable to alteration. Nonmodifiable risk factors, commonly referred to as determinants, encompass a set of influential variables that are inherently unalterable and impervious to intervention. Modifiable risk factors include several causes, such as smoking

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[7], diabetes mellitus [8], microorganisms infection [9], and other psychological factors [10–12]. Meanwhile, nonmodifiable risk factors are usually caused by genetics [13], the immune response [14,15], osteoporosis [15], aging [16], and other systemic diseases [17].

Various bacterial species serve as the principal and pivotal pathogens, influencing the initiation and progression of periodontitis [18]. The perpetual occurrence of dental plaque deposition on the dental enamel, particularly in the interproximal spaces and the gingival margin, is undeniable. The accumulation of dental plaque will elicit an immunological reaction within the host organism, instigating a consequential inflammatory response [19]. According to Sun *et al.* [1], the primary objective of periodontal therapy is to effectively mitigate the harmful effects associated with periodontitis, namely the initiation and perpetuation of inflammatory processes, the uncontrolled proliferation of bacterial growth, and the rapid advancement of the disease. Thus, a drug that can work synergistically as an antibacterial and anti-inflammatory is needed to achieve a healthy condition for periodontitis patients.

Lumbricus rubellus represents a noteworthy constituent of natural ingredients. This remarkable organism possesses inherent properties that endow it with antibacterial and anti-inflammatory capabilities [20,21]. Earthworms contain essential amino acids (phenylalanine, valine, methionine, isoleucine, and others) and nonessential amino acids (glycine, alanine, proline, and others) [22]. According to Tasiemski [23], earthworms contain antimicrobial peptides (AMP), namely lumbricin-1. Lumbricin-1 is an AMP of 62 amino acids rich in proline and has antimicrobial action against fungi, Gram-positive and Gram-negative bacteria [20]. *Lumbricus rubellus* contains a polyphenolic compound that mediates anti-inflammatory activity [24].

Even though *L. rubellus* has good antibacterial and anti-inflammatory properties; it is essential to note that not much is known about its pharmacological agents, especially when treating periodontitis. In light of the circumstances above, it is of utmost importance to undertake comprehensive investigations to ascertain methodologies aimed at augmenting the intrinsic periodontitis potency of earthworms. Henceforth, it is imperative to undertake a comprehensive bibliometric analysis that meticulously scrutinizes diverse scientific inquiries, followed by a more profound examination of a selected study. The bibliometric approach, a formidable quantitative data analysis instrument, scrutinizes and evaluates copious quantities of scientific data. This endeavor aims to thoroughly elucidate and meticulously chart the multifaceted expanse of scientific understanding [25–29]. A comprehensive bibliometric analysis of the *L. rubellus* for periodontitis treatment from 2013 to 2023, as documented in the Scopus database, has yet to be conducted. Our review objective was to comprehend *L. rubellus* for periodontitis treatment fully.

MATERIALS AND METHODS

Methodology and information retrieval approach general procedure

The data employed in this investigation were obtained from the Scopus database, a well-regarded repository of

scholarly literature accessible at <https://www.scopus.com/>. The data extraction process was executed on the 25th of July, 2023, encompassing a temporal span of 10 years (2013–2023), explicitly emphasizing publications written in English. The Scopus searches were conducted using the keywords “*Lumbricus rubellus*” AND “periodontitis” OR “antibacterial” OR “anti-inflammatory” OR “gel” OR “formulation.” The dataset was subjected to a rigorous cleansing process and meticulous verification to eliminate duplication, ensuring that the collected publications exclusively examined *L. rubellus*. A thorough investigation was conducted, including examining abstracts and articles, to ascertain the suitably selected article. Following a systematic approach, the data were methodically extracted and subsequently converted into a comprehensive file format known as Excel comma-separated values.

Data analysis

The VOSviewer application, version 1.6.19, developed by the Center for Science and Technology Studies at Leiden University in The Netherlands, performed a keyword co-occurrence analysis. The process of data purification is carried out using the Excel software platform, utilizing the thesaurus functionality. The main aim is to reduce the occurrence of redundant data entries. The data were subsequently analyzed using RStudio 2023.03.0-386, a software platform widely recognized for its statistical prowess. The analysis was undertaken closely with the esteemed Department of Economics and Statistics at the University of Naples Federico II in Italy. The primary objective of the current investigation is to examine the existing trends in academic publishing, involving a comprehensive examination of the institutions, sources, authors, and publications involved.

RESULTS AND DISCUSSION

Data searches

After using the keywords “*Lumbricus rubellus*” AND “periodontitis” OR “antibacterial” OR “anti-inflammatory” OR “gel” OR “formulation” in the Scopus database, 55 articles were found. A bibliometric analysis was conducted utilizing the esteemed Scopus database to investigate the *L. rubellus* for periodontitis treatment. The primary objective of this analysis was to meticulously characterize and visually represent the knowledge concepts associated with the advancement of research in the domains of periodontitis treatment by *Lumbricus rubellus*. According to Dede and Ozdemir [30], bibliometric analysis encompasses two distinct methodologies: performance analysis and science mapping. The performance evaluation process entails meticulously examining the immeasurable contributions of researchers from various nations, esteemed institutions, reputable sources, and esteemed authors. The collaborative endeavors augment the overall efficacy of the academic articles’ output [25].

It is essential to acknowledge that this study was subject to numerous limitations. Initially, our exploration of the literature about *L. rubellus* for periodontitis therapy was significantly constrained due to the limited number of researchers who have investigated the activities of *L. rubellus*

in periodontitis. Therefore, alternative methodologies were employed, specifically focusing on using keywords for bibliometric analysis of periodontitis therapy. Our knowledge of the existing literature influenced the choice of keywords for our analysis, which impacted the quantity and variety of articles included in our study.

Within scientific investigation, the practice of cartography functions as a highly advantageous instrument for illuminating the intricate cognitive structure and progressive trajectory of scholarly pursuits. Moreover, this investigation provides a comprehensive understanding of the complex dynamics and interrelationships among the diverse constituents, emphasizing the strength and adaptability of their integrated connections [30]. Table 1 presents the established criteria for selecting the publication to conduct a bibliometric analysis. The dataset obtained from Scopus consisting of articles, conference papers, and reviews is listed in Table 2.

Descriptive analysis

Table 3 summarizes the bibliographic metadata of Scopus articles related to *L. rubellus*. During 1982–2023, 55 articles were published from 47 different sources, with an average age of 14.7 articles and an average number of citations of 21.58 per article. Out of 55 articles, there was an average of 4.25 authors per article, with four articles per author. Figure 1 shows the number of items produced each year.

Analysis of the contributing countries

The five most influential countries in the *L. rubellus* studies are shown in Table 4. The country with the most articles produced is Indonesia (14 articles), followed by China and Japan (7 articles in each country). Besides the number of articles produced, a country’s contribution can also be determined by the number of citations the articles received. The most cited country is Japan (294 citations), followed by the UK (244 citations) and Austria (134 citations). A document with many citations can impact how other researchers use the knowledge it contains as a basis. Citations are increasingly utilized in search policies and systems as performance measures. Citations often indicate the importance or extent of research [31–33].

Figure 2 shows the article production heat map for each country. The country with a darker blue has published many articles about *L. rubellus*. The countries that started the study of *L. rubellus* were Asia, Australia, and Europe. *Lumbricus rubellus* is native to Europe and is expected in the northern Palearctic region, including Russia’s Far East. It has been introduced to other parts of the world, such as North America, Australia, and New Zealand [34,35]. The orange line represents the cooperation of each country. Transnational cooperation occurs only in the European region.

Analysis of the contributing institution

One of the essential elements of bibliographic analysis is determining which institutions perform best [36]. Table 5 shows the top five institutions that have contributed research on *L. rubellus*. According to the number of articles produced, the four most contributing institutions are Moscow State University (6 articles), Okayama Prefectural University (4

articles), the University of Innsbruck, and Udayana University (3 articles each). Meanwhile, by number of citations, the top 3 contributing institutions are Okayama Provincial University

Table 1. Criteria for the selection of the publications.

Criteria	Value
Data source	Scopus
Search terms	" <i>Lumbricus rubellus</i> " AND "periodontitis" OR "antibacterial" OR "anti-inflammatory" OR "gel" OR "formulation"
Document type	The article, Review, and Conference Paper
Language	English
Number of articles	55

Table 2. Metadata document type.

Type of document	Number of document
Article	49
Conference paper	4
Review	2

Table 3. Summary of bibliometric metadata of Scopus articles.

Description	Results
Timespan	1982:2023
Sources (e.g., Journals, Books, etc.)	47
Articles	55
Article average age	0
Annual growth rate %	14.7
Average citations per doc	21.58
References	1414
Keywords plus	764
Author’s keywords	136
Authors	184
Single authored articles	4
Authors per articles	4.25
International colaboration index	3.636

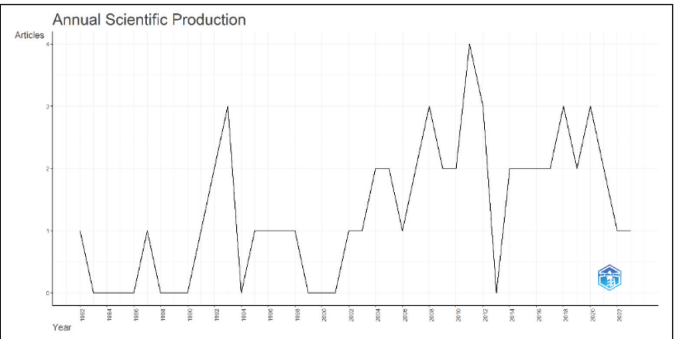
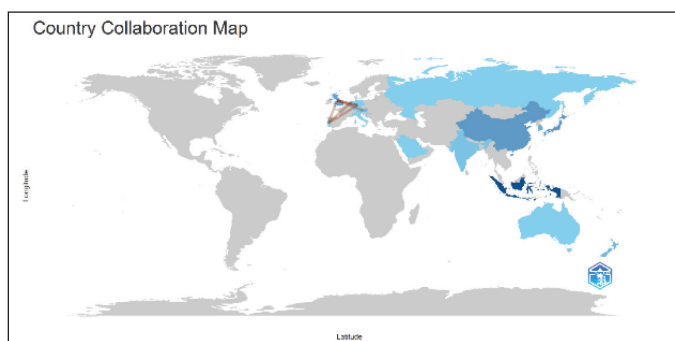


Figure 1. Annual scientific production of articles.

Table 4. The most impactful countries using the RStudio application.

Country	Number of articles	Number of citations	Average citations per articles
Indonesia	14	45	3.75
China	7	121	17.3
Japan	7	294	42
United Kingdom	5	244	48.8
Austria	3	134	44.7

**Figure 2.** Globe heatmap and collaborative connection of countries.

(205 citations), the University of Wales (150 citations), and the University of Innsbruck (134 citations).

The relationship between author organization (AU_UN), source (SO), and keyword (DE) is shown in Figure 3. Gray lines connect the three regions, and the length of the rectangle indicates the number of associated entries in each box. The analysis of entries revealed each writer's publication sources from various institutions, such as Nanjing University and the Biotechnology Letter. Meanwhile, the output analysis shows the views of each writer from other organizations.

Analysis of the contributing sources

According to the metadata, as shown in Table 6. The top three sources contributing to the *L. rubellus* study by number of articles were the Bioinformatics Bulletin, the Journal of Biochemistry, and the IOP Conference Series: Earth and Environmental Science (three articles each). Meanwhile, the top 3 influential sources by number of citations are "Japanese Journal of Physiology" (219 citations), "Biosciences, Biotechnology and Biochemistry" (143 citations), and "FEBS Letter" (123 citations). Figure 4 shows the correlation between author affiliations (AU_UN), source (SO), and author country (AU_CO). The analysis of entries shows that authors from institutions have been accepted to publish their articles in sources, such as manuscripts published by the Biology Bulletin of Moscow State University and the Institute of Ecology. Severtsoy accepted. The analysis of the results shows which countries the author has taken sources from to publish his articles, such as the Journal of Biochemistry and Molecular Biology, which has accepted manuscripts from Indonesian authors.

Source analysis was also performed using Bradford's law. Bradford's law is a general rule widely applied to

Table 5. The most impactful institutions using the RStudio application.

Institution	Country	Number of articles	Number of citations	Average citations per articles
Moscow State University	Rusia	6	10	1.7
Okayama Prefectural University	Japan	4	205	51.25
University of Innsbruck	Austria	3	134	44.7
Udayana University	Indonesia	3	11	3.7
University of Wales	Wales	2	150	75

distributing articles among journals of a particular scientific discipline [37]. Articles are ranked in descending order of productivity of relevant articles for a given topic; three regions can be identified such that each region produces one-third of the total number of relevant articles [38]. Consistent with Table 4, Bradford's Law in Figure 5 shows that the core area includes the Biology Bulletin, the Journal of Biochemistry and Molecular Biology, and the IOP Lecture Series: Earth and Environmental Science.

Analysis of contributing author

Table 7 provides a comprehensive compilation, showcasing authors who have made notable contributions to the literature on *L. rubellus*. These authors have authored numerous publications within this specific field of study. From 1992 to 1993, Mihara H and Sumi H, associated with Miyazaki Medical College, wrote four academic journals. These articles received an average of 102.25 citations per article. The third individual, Nakajima N, has been identified in this study and is affiliated with Okayama Prefectural University. Nakajima N has made notable contributions as an author to four scholarly publications. It is worth noting that these works have garnered an average of 51.25 citations. Mihara, Sumi, and Nakajima have collaborated to generate scholarly articles. Tjandrawinata RR, hailing from the Atma Jaya Catholic University of Indonesia, has successfully disseminated its research findings by publishing four scholarly articles. These articles have garnered an average of 5.25 citations per article, indicating notable recognition within the scientific community. The individual identified as Kodolova OP, hailing from Moscow State Forest University, has been credited as the author of three scholarly articles. These articles have garnered an average of 3.33 citations per article.

Table 6 also presents the H-index of each author, a metric that quantifies the influence of the respective author. The researchers Mihara H, Sumi H, and Nakajima N made notable contributions to the scientific literature concerning *L. rubellus*, as evidenced by their respective H-index of 4. Tjandrawinata RR and Kodolova OP contributed, albeit with a lower H-index of 2 and 1, respectively. The articles authored by Mihara H and Sumi H primarily focus on conducting a thorough investigation into the fibrinolytic and thrombolytic activity of *L. rubellus*. The provided data proves to be of great utility for scientific article

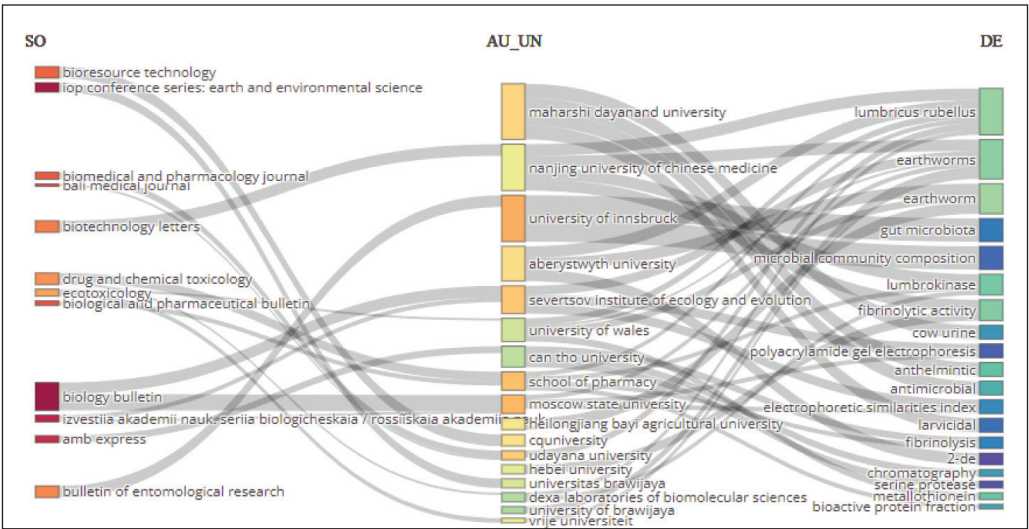


Figure 3. Three-field plot between Source (SO), author affiliations (AU_UN), and keywords (DE) using the Rstudio application.

Table 6. The most impactful sources using the RStudio application.

Sources	Number of articles	Number of citations	Average citations per article
Biology Bulletin	3	8	2.7
Journal of Biochemistry and Molecular Biology	3	88	27.7
IOP Conference Series: Earth and Environmental Science	3	4	1.3
Japanese Journal of Physiology	1	219	219
Bioscience, Biotechnology, and Biochemistry	1	143	143
FEBS Letters	1	123	123

authors, specifically researchers, as it aids in formulating and elucidating research study outcomes and their consequential influence.

According to Lotka’s Law, Figure 6 visually represents the author’s productivity. Lotka’s law of scientific productivity exemplifies bibliometric principles, wherein the logarithmic scale is employed to graphically represent the relationship between the number of authors and their corresponding contributions [39]. Figure 6 elucidates the correlation between the number of scholarly articles disseminated and the number of individuals contributing as authors. The majority of authors have exclusively published a single article about *L. rubellus*. Subsequently, authors who have published a mere two articles, as well as authors who have published three articles, exhibit the lowest frequency in this regard.

Analysis of contributing paper

The number of citations acquired by a scholarly article signifies the degree to which a specific investigation has had a significant and influential impact. The research impact of *L. rubellus* exhibits a positive correlation with the number of

citations garnered by an article. Based on the data obtained from RStudio, the analysis indicates that selecting the top 5 articles resulted from a collaborative effort involving 55 publications.

To date, a limited body of research exists about utilizing *L. rubellus* as a potential therapeutic intervention for the management of periodontitis. To induce the healing process of periodontitis, it is imperative to identify an agent capable of halting the inflammatory response and inhibiting the proliferation of bacteria responsible for the onset of periodontitis. Sun *et al.* [1] observed that the principal aim of periodontal therapy is to efficiently attenuate the deleterious consequences linked to periodontitis, specifically the initiation and perpetuation of inflammatory cascades, the unregulated proliferation of bacterial populations, and the accelerated progression of the ailment.

The article “Antibacterial activity of *L. rubellus* earthworm extract against *Porphyromonas gingivalis* as the bacterial cause of periodontitis” was authored by Dharmawati *et al.* [20]. According to the report, *L. rubellus* exhibited antibacterial properties against *P. gingivalis*, a known etiological agent of periodontitis. When diluted to a concentration of 50%, the earthworm extract showed the most substantial mean inhibitory zone, measuring 21.88 mm. In comparison, the inhibitory zones observed for the 25% and 12.5% concentrations were 17.23 and 15.50 mm, respectively. At a concentration of 6.25%, the extract derived from earthworms did not exhibit any inhibitory effects on the growth of *P. gingivalis* bacteria. The study conducted by Cooper and Hirabayashi [40] elucidated the impact of earthworms on bacterial lysis and its potential implications on various diseases, specifically focusing on the involvement of lysenin and eiseniapore molecules. The interaction between lysenin and sphingomyelin at cellular membranes is a valuable method for studying the role of sphingomyelin in biological membranes and elucidating the bacterial lysis mechanism employed by earthworms. The lysis above pathway elucidates how the earthworm extract fortifies the immune system against bacterial pathogens. Observations

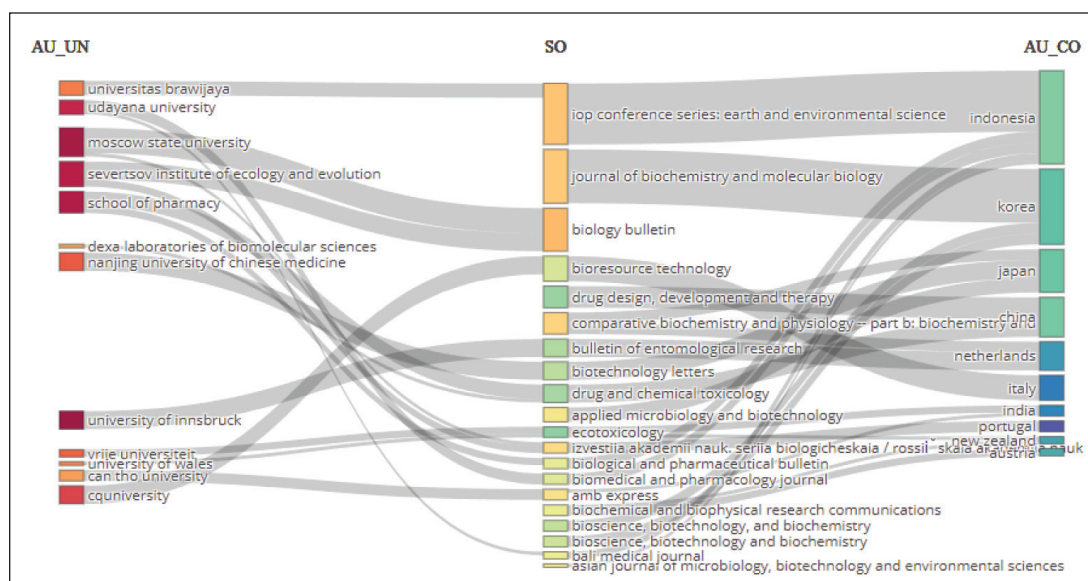


Figure 4. Three-field plot between author affiliations (AU_UN), Source (SO), and author country (AU_CO) using the Rstudio application.

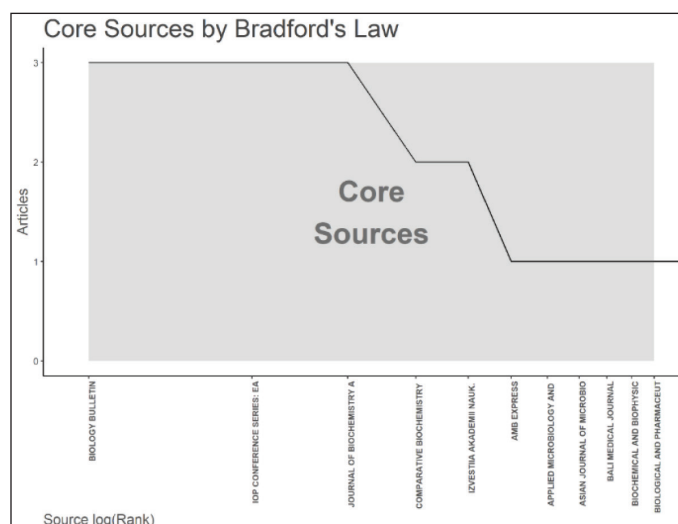


Figure 5. Core sources by Bradford's Law using the RStudio application.

indicate that using earthworm extract exhibits the capacity to elicit antibacterial properties, particularly by impeding the proliferation of bacteria responsible for the onset of periodontitis.

"The *in-vivo* anti-inflammatory effect of red earthworm (*Lumbricus rubellus*) ethanolic extract from organic farmland in Bali, Indonesia" was the article written by Dewi and Mahendra [24]. This investigation assessed the *in vivo* anti-inflammatory activity through oral administration in Wistar rats. According to the investigation's findings, using earthworm extract exhibited a notably enhanced capacity for anti-inflammatory activity compared to the experimental group subjected to negative control [24]. Dewi *et al.* [41] reported that the total amount of phenolics in the ethanolic extract made from the powder of *L.*

rubellus was 1,016.31 mg GAE/100 g DW. Furthermore, this extract's IC₅₀ value of 12.33 mg/ml demonstrated its capacity to scavenge free radicals effectively. The anti-inflammatory activity of *L. rubellus* is mediated by its polyphenolic components [24]. The anti-inflammatory activities of polyphenols involve various molecular mechanisms. These mechanisms include inhibiting enzymes associated with proinflammatory properties, such as COX-2, LOX, and iNOS [42]. An additional study has also exhibited that earthworm powder from different regions exhibits equivalent anti-inflammatory activity to diclofenac sodium [43]. Diclofenac sodium, a commonly employed pharmaceutical agent, is an analgesic agent for pain mitigation and exhibits anti-inflammatory properties [44]. Hence, it is evident that the application of earthworm extracts possesses significant potential, demonstrating characteristics akin to those of anti-inflammatory pharmaceuticals.

Analysis of keyword co-occurrence

The current study employed the VOSviewer software to examine the co-occurrence of keywords throughout all phrases. The current investigation can expedite the discernment and classification of contemporary and forthcoming research subjects about *L. rubellus* for periodontitis therapy by leveraging the substance of the articles above [25]. The frequency of a particular keyword's manifestation is quantified to ascertain the numerical representation of scholarly articles wherein said keyword is present. The investigation employed a comprehensive computational methodology to ascertain the frequency of keyword instances. The presented count exhibits the aggregate frequency of specific keywords throughout published materials. The group referred to as the "All keyword" category encompasses a collection of author keywords, which includes article titles, abstracts, complete texts, and indexed keywords, as stated by Arifah *et al.* [45]. The network representation of the topic, as generated by VOSviewer, is illustrated in Figure 7.

is conceivable to gain a deeper understanding of the progress in utilizing *L. rubellus* to treat periodontitis.

CONCLUSION

According to the findings derived from bibliometric analysis, 55 scholarly articles specifically investigating the antioxidant properties exhibited by *L. rubellus* have been identified. The observed annual growth rate exhibited a substantial increase of 14.7%, whereas the average number of citations per publication displayed a noteworthy value of 21.58. Based on the empirical evidence derived from the performance study, it has been determined that Indonesia has exhibited the highest degree of influence, as indicated by 14 articles about said country. According to the analysis, Moscow State University has been identified as the institution with the highest level of productivity, having successfully produced a cumulative total of six scientific papers. The “Journal of Biochemistry and Molecular Biology” had the most substantial impact, acquiring a single article and garnering 88 citations. A comprehensive scientific mapping analysis shows that individuals named Mihara H, Sumi H, and Nakajima N have significantly and noteworthy impacted the existing corpus of literature about the research on *L. rubellus*. Their remarkable H index value, at the highest level of 4, supports this. The term that exhibits the highest frequency of occurrence is “*L. rubellus*.” The scholarly publication by Mihara *et al.* in 1991 has garnered considerable recognition within the scientific community, evidenced by its notable citation count of 219. The keywords “*Lumbricus rubellus*” exhibited 62 occurrences and a link strength of 427, while “periodontitis” demonstrated a total of 62 occurrences and a link strength of 396, indicating their prominent presence. Through bibliometric science mapping analysis, researchers are empowered to strategically devise, contemplate, and formulate prospective research endeavors that adhere to the requisite pharmaceutical standards for cultivating *L. rubellus* to address periodontitis treatment.

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AUTHOR CONTRIBUTIONS

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work. All the authors are eligible to be an author as per the International Committee of Medical Journal Editors (ICMJE) requirements/guidelines.

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CONFLICTS OF INTEREST

The authors report no financial or any other conflicts of interest in this work.

ETHICAL APPROVALS

This study does not involve experiments on animals or human subjects.

DATA AVAILABILITY

All data generated and analyzed are included in this research article.

PUBLISHER’S NOTE

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USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declares that they have not used artificial intelligence (AI)-tools for writing and editing of the manuscript, and no images were manipulated using AI.

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