Original Article

Bibliometric assessment of *Thelaziosis* research in Europe from 1970-2023

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Abstract
Given the increase in cases of thelaziosis in recent years, especially in Europe, we evaluate the publication patterns of research focusing on *Thelazia*. We also discuss the results of published articles and how more clinical and epidemiological information on *Thelazia* is still needed. All the documents registered in Web of Science with the subject of *Thelazia* between 1970 and 31 March 2023 were analyzed, using the Online Analysis Platform of Literature Metrology and the VOS viewer as tools. Between 1970 and March 2023, there were 336 publications on *Thelazia*. During the same period, these documents were mentioned 5597 times, averaging 16.66 times for each record. *Thelazia*'s first publications appeared in 1970, and 55.95% of all publications were published after 2010. Regarding total publication numbers, the most influential country was Italy (n = 87), followed by the United States (n=57). The most prolific author in this field was "Domenico Otranto" (n = 77), while the journals that drew the most papers were Parasites & Vectors (n = 30) and Veterinary Parasitology (n = 29). The findings of this article will be useful in defining research priorities related to *Thelazia* and diagnosing the importance of scientific production associated with this pathogen.
Keywords: Bibliometric analysis, *Thelazia*, *Thelazia callipaeda*, VOSviewer software

Introduction

Thelazia callipaeda (likewise called the oriental eye worm) is a zoonotic nematode transmitted by a vector (drosophilid flies) that infects the conjunctival sac of domestic and wild animals, rabbits, and humans (Otranto et al., 2013; Mihalca et al., 2016). It belongs to the *Spirurida* order and *Thelaziidae* family (do Vale et al., 2019). *Phortica variegata* (order *Diptera*; family *Drosophilidae*) fruit flies serve as both intermediate hosts and

vectors in the life cycle of *T. callipaeda* (Otranto and Dantas-Torres, 2015). Domestic animals (dogs and cats), wild animals (red foxes, wolves, beech martens, wildcats, and golden jackals), lagomorphs (brown hares and wild European rabbits), and humans are among the infected vertebrate host species (do Vale et al., 2019). The parasite causes ocular thelaziosis (also known as *Thelaziasis*), or this ocular eye disease can affect a vast variety of

domestic and wild mammals, including humans (Otranto et al., 2013; Trenkić et al., 2023).

This parasite was initially identified in Asia in early 1900, but by the beginning of the 21st century, reports of this parasite were also often made in Europe. *Thelazia* infections have been reported in the following European nations: Italy, France, Germany, Switzerland, Spain, Portugal, Belgium, Bosnia and Herzegovina, Croatia, Serbia, Romania, Greece, Bulgaria, Hungary, Slovakia, the United Kingdom, Turkiye, Austria and, Portugal (do Vale et al., 2019; Morgado et al., 2022).

Bibliometrics is a statistical technique used to assess the bibliometric characteristics of a body of literature, assess the progress of a particular area, and predict its future trends (Miao et al., 2022). The importance of bibliometric assessments of emerging and re-emerging diseases has been described previously, as they can contribute to understanding how the global scientific and health communities respond to outbreaks. Here, we aimed to use a bibliometric technique to analyze *Thelazia* research.

Materials and methods

In this study, a bibliometric evaluation focusing on the scientific bibliography of *Thelazia* was conducted. A single database was used for retrieving information: The web of Knowledge online database (https://www.webofscience.com/). *Thelazioideas* (Topic) OR *Thelazia* (Topic), OR *Thelazias* (Topic) were the keyword combinations we utilized for the search process (MeSH, Medical Subject Headings). We included the following types of publications in the category (original articles, review articles, case reports, and editorials). These were further categorized by publication year, name, and institution of the first author at the time of publication. The time period of the publications was chosen as 1970- March 31, 2023.

Data summaries were expressed as numbers and percentiles for quantitative variables (number of publications, publication numbers per country, publications per year or periods, citations), and proportions were presented for qualitative variables.

The search data were converted into plain text and text formats and then imported into the programs VOSviewer (version 1.6.19) and the Online Analysis Platform of Literature Metrology (https://bibliometric.com/app) for additional analysis.

Results

General information
We reached 336 publications on *Thelazia* published between 1970-March, 2023. These publications were cited 5597 times in the same period (16.66 times per document). The first publications on *Thelazia* were published in 1970, and 55.95% of all publications were published in 2010 and later.

The summary of the publication and citation numbers are given in Figure 1. Most documents (93.750%) were published in Science Citation Index Expanded (SCI-EXPANDED) indexed journals. 91.667% of them were published in English, and 39.286% as open access publishing style. The documents were mainly in Parasitology (46.131%), Veterinary Sciences (39.583%), and tropical medicine (14.286%) research areas. The remaining research areas were Infectious Diseases, Ophthalmology, Zoology, Entomology, Immunology, Microbiology, Public Environmental Occupational Health, Agriculture, Biochemistry, Molecular Biology, Biotechnology Applied Microbiology, Cell Biology, General Internal Medicine, Life Sciences, Biomedicine, Other Topics and Science Technology other Topics.

Citation analysis
The top-cited document on *Thelazia* was published by Otranto and Dantas-Torres (Otranto and Dantas-Torres, 2010), and cited 237 times. It is also seen that 'Domenico Otranto' was the author with the highest number of citations in analyzing the most cited articles. The other top-cited ten

documents on *Thelazia* published between 1970-March, 2023 were given in Table 1.

A Leiden-style community algorithm was used to cluster all texts published between 1980 and the present based on how frequently they were

mentioned and which authors cited them. The program incorporates constraints that require clustering and uphold a minimum cluster size; stated relationships to texts from before 1980 are also considered (Traag et al., 2019).
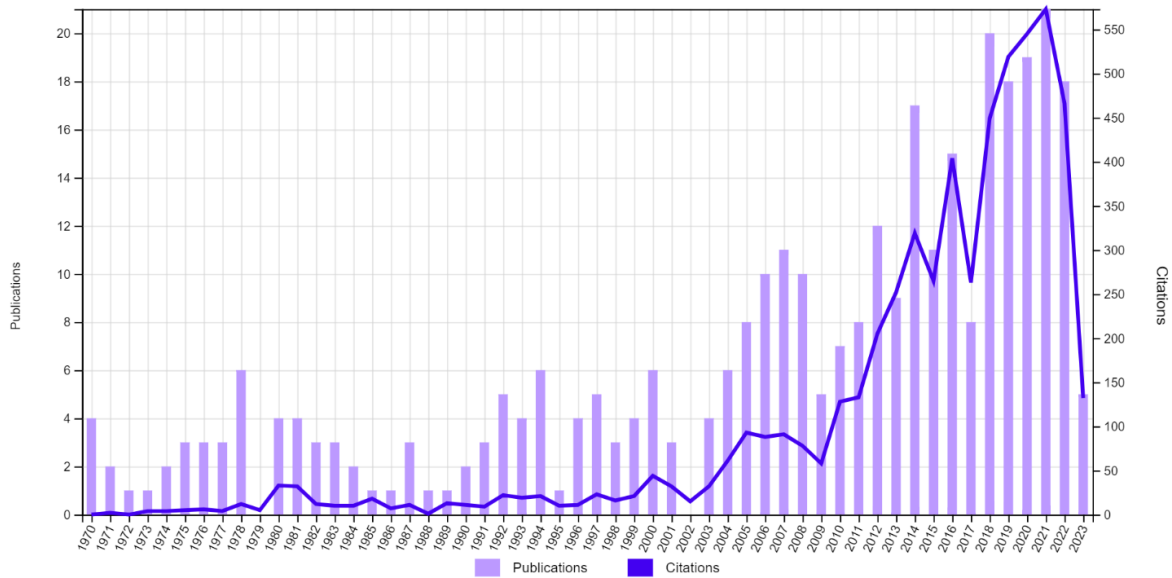
Fig. 1. The summary of the publication and citation numbers.

Table 1. The top cited 10 documents on *Thelazia* published between 1970-March, 2023.

	Authors	Journal abbrevation	Total Citations	Citation numbers Average per Year	DOI
1	Otranto et al., 2010	Parasites Vectors	237	16.93	10.1186/1756-3305-3-2
2	Otranto et al., 2013	Parasites Vectors	222	20.18	10.1186/1756-3305-6-16
3	Casiraghi et al., 2004	Int. J. Parasitol.	188	9.4	10.1016/j.ijpara.2003.10.004
4	Colwell et al., 2011	Vet. Parasitol.	153	11.77	10.1016/j.vetpar.2011.07.012
5	Otranto and Eberhard, 2011	Parasites Vectors	129	9.92	10.1186/1756-3305-4-41
6	Otranto et al, 2015	Vet. Parasitol.	125	13.89	10.1016/j.vetpar.2015.04.020
7	Otranto et al, 2006	Int. J. Parasitol.	105	5.83	10.1016/j.ijpara.2006.06.006
8	Otranto et al, 2003	Vet. Parasitol.	100	4.76	10.1016/j.vetpar.2003.07.022
9	Otranto et al, 2005	Mol. Cell. Probes.	89	4.68	10.1016/j.mcp.2005.05.001
10	Otranto and Traversa, 2005	Trends Parasitol	89	4.68	10.1016/j.pt.2004.10.008

Based on their contents, macro- and, meso-topics are manually labeled. Microtopics were assigned their most important keyword using an algorithm. Citation Topics are named by inference; any term may not be descriptive for every document in the topic since they are based on citation connections rather than the substance or subject matter of the papers that make them up. To distinguish each topic, it is additionally provided with a permanent numeral term (Clarivate InCites help). The Citation

Topics Micro on *Thelazia* publications is given in Table 2.

Top leading affiliations/institutions, countries, and journals

The authors from Italy (87 documents), the United States (57 documents), China (25 documents), Germany (23 documents), England (19 documents), Brazil (18 documents), France (18 documents), Canada (17 documents), and Iran (17 documents) were published most of the documents on *Thelazia*.

Table 2. The Citation Topics Micro on *Thelazia* publications*

Citation Topics Micro	n	% of 336
1.163.1393 Onchocerciasis	182	54.167
1.163.1022 Haemonchus Contortus	92	27.381
1.258.227 Lyme Disease	7	2.083
3.32.1638 Forensic Entomology	7	2.083
1.163.645 Digenea	6	1.786
1.163.1943 Toxocara Canis	5	1.488
1.248.1317 Mycoplasma	4	1.190
3.97.1108 Root-knot Nematode	3	0.893
1.132.2417 Macrophage Migration Inhibitory Factor	2	0.595
3.32.1485 Antifreeze Proteins	2	0.595
3.32.1508 Wssv	2	0.595
1.163.2363 Trichinella Spiralis	1	0.298
1.217.1038 Toxoplasma Gondii	1	0.298
1.246.985 Cryptosporidium	1	0.298
1.261.695 Visceral Leishmaniasis	1	0.298
1.5.894 Nicotine	1	0.298
1.54.1546 Nuclear Envelope	1	0.298
3.232.1120 Animal Oncology	1	0.298
3.275.705 Herbicide Resistance	1	0.298
3.32.750 Apis Mellifera	1	0.298
3.32.827 Bacillus Thuringiensis	1	0.298
3.45.1113 Earthworms	1	0.298
3.64.34 Mitochondrial Genome	1	0.298

*12 records (3.571%) do not contain data, **Web of Science database data

Figure 2 was created with the Online Analysis Platform of Literature Metrology (https://bibliometric.com/app). Figure 2 depicts the number of publications according to years and countries. According to Figure 2, it was observed that while there were publications originating from the United States in the early years, it was observed that Italy, which had the highest number of publications, increased the number of publications, especially after the 2000s, but in 2022, the highest number of publications originating from Iran.
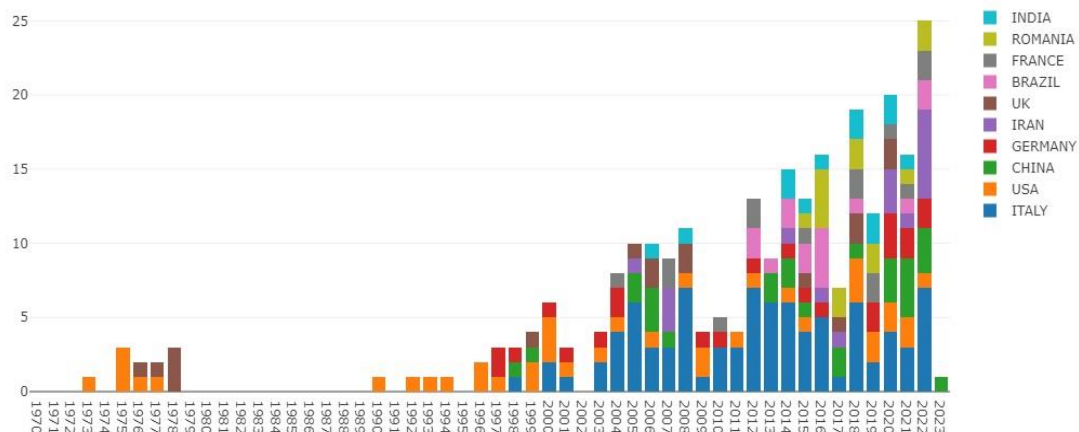
**Fig. 2.** Number of publications according to years and countries.

Figure 3 was created with the Online Analysis Platform of Literature Metrology (https://bibliometric.com/app). Figure 3 depicts the relationship map between countries. According to Figure 3, Italy had the most cross-country cooperation. Italy published the largest publications and had close collaborations with France, Portugal, Iran, Spain, the Czech Republic, Australia, and the United States.

The mostly published affiliations/organizations are listed in Table 3. Authors from the University of Bari Aldo Moro/ Italy published the most documents on *Thelazia* and had the highest number of citations. One thousand and one authors from 55 countries and 455 different affiliations/organizations contributed to the *Thelazia* literature.

Table 3. The top affiliations/organizations contributed the *Thelazia* literature.

Affiliations/organizations and located country	Document number	Number of citations
University of Bari Aldo Moro/ Italy	75	2843
The University of Kentucky/ the United States	19	181
Oswaldo Cruz Foundation/ Brazil	16	71
The University of Teramo/ Italy	15	615
University of Agricultural Sciences and Veterinary Medicine, Cluj-Napoca/ Romania	12	126
The Ministry of Agriculture and Irrigation/ Alberta	11	64
Bu-Ali Sina University/ Iran	10	56
The University of Trás-os-Montes and Alto Douro/ Portuguese	10	64
The University of Zurich/ Switzerland	8	392
Complutense University of Madrid/ Spain	7	51

*Showing top 10 of the 455 affilitions/organisations, **Web of Science database data
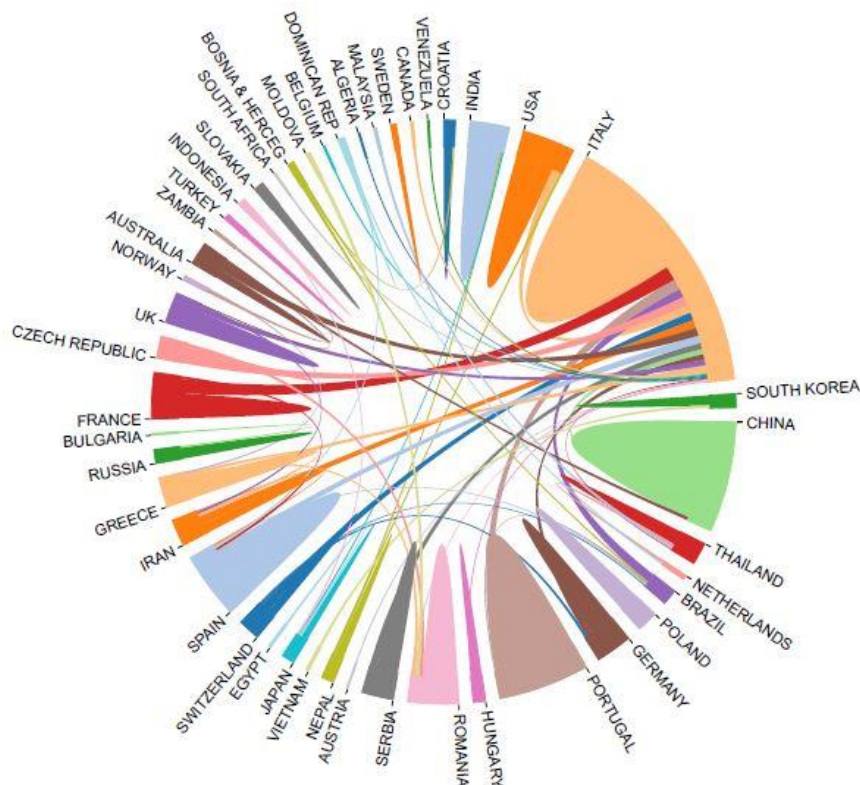
Fig. 3. The relationship between countries.

The documents on *Thelazia* have been published in 131 different journals, mostly in *Parasites & Vectors* (30 documents) and *Veterinary Parasitology* (29 documents) journals. The mostly published journals on *Thelazia* are summarized in Table 4. The Journal Citation Indicator evaluates the typical Category Normalized Citation Impact (CNCI) of citable items (articles and reviews) published by a journal over the previous three years. It is employed to help users in evaluating journals using measures other than the Journal Impact Factor (JIF; https://www.webofscience.com/).

Table 4. The journals published more than 15 documents on *Thelazia*.

Journal	n	Publisher Name	The Journal Citation Indicator Category	Journal Citation Indicator ™ 2021
PARASITES VECTORS	30	BMC	PARASITOLOGY in SCIE edition TROPICAL MEDICINE in SCIE edition	1.13
VETERINARY PARASITOLOGY	29	ELSEVIER	PARASITOLOGY in SCIE edition VETERINARY SCIENCES in SCIE edition	1.02
PARASITOLOGY RESEARCH	19	SPRINGER VERLAG	-	-
JOURNAL OF PARASITOLOGY	18	ALLEN PRESS INC	PARASITOLOGY in SCIE edition	0.38
VETERINARY RECORD	18	WILEY	VETERINARY SCIENCES in SCIE edition	0.86

Keyword co-occurrence network visualization
The keyword analysis was conducted with the VOSviewer application to create a keyword co-occurrence map that reflects the current interest in the *Thelazia* topic. The keywords with a frequency >5 were extracted. The circle's size reflects how frequently the keywords are used, and the link's thickness reflects how strong the connection is.

The analysis's findings are listed below. There were 559 keywords. Forty-two of them were used more than five times. Figure 4 was created with the VOSviewer application. Figure 4 depicts the keyword analysis, and Table 5 summarizes the keywords' occurrence times and total link strengths.
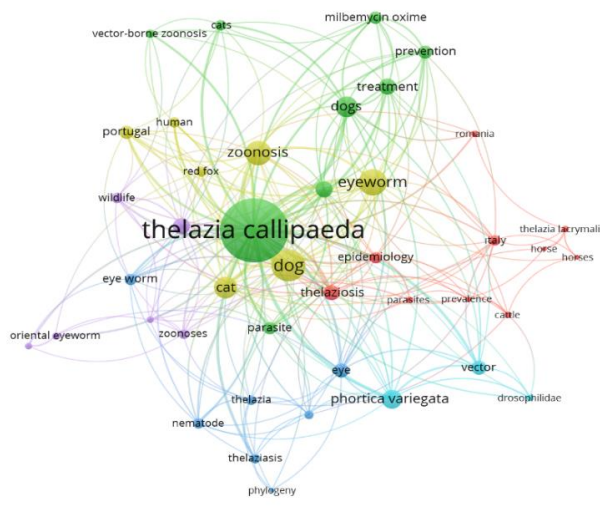
Fig. 4. Keyword analysis

Discussion

As in all fields of science, bibliometric studies in parasitology years (Rodriguez-Morales et al., 2018; Soosaraei et al., 2018; Ahmad et al., 2021; Ekici et al., 2022; Tantengco and Rojo, 2022) and different medicine research areas (Alkan et al., 2022; Akar, 2023; Çelik, et al., 2023) have gained popularity in recent years. Although previous bibliometric studies have been published on different pathogens, this is the first study published in the literature on *Thelazia*, despite the increasing number of human infections, especially in Europe. In this study, all the documents registered in the Web of Science Core Collection (WoSCC) database between 1970 and 31 March 2023 were analyzed, using the Online Analysis Platform of Literature Metrology and the VOS viewer tools. The WoSCC was searched using key phrases that included a broad range of synonyms for the disease (*Thelaziasis*) and its causal agent (*Thelazia*).

In this study, essential participants in *Thelazia* literature were examined in terms of trajectory, bibliometric characteristics, and research foci. Although there has been a decrease in some years, it was determined that the number of publications has increased since 2003, and the number of citations has been increasing since 2009, with the peak number of publications being in 2021. The first publications on *Thelazia* were published in 1970, and 55.95% of all publications were published in 2010 and later. The first publication from Italy (the most publishing country in *Thelazia*) was published in 1998.

Table 5. The most occured keywords on *Thelazia* and their total link strength.

keyword	occurrences	total link strength
cat	13	47
cats	6	17
cattle	7	9
conjunctivitis	5	13
dirofilaria	5	9
dog	27	82
dogs	16	45
drosophilidae	5	9
epidemiology	7	19
Europe	8	29
eye	10	26
eye worm	8	18
eyeworm	22	63
horse	6	6
horses	5	5
human	6	16
human thelaziosis	6	8
Italy	6	16
milbemycin oxime	5	20
moxidectin	8	31
nematode	8	17
oriental eyeworm	6	10
parasite	8	21
parasites	8	9
phortica variegata	12	37
phylogeny	5	5
portugal	7	24
prevalence	5	7
prevention	6	23

red fox	5	17
romania	6	8
Thelazia	14	15
Thelazia callipaeda	103	225
Thelazia lacrymalis	9	8
Thelaziasis	10	14
Thelaziosis	13	28
treatment	8	29
vector	9	26
vector-borne zoonosis	5	12
wildlife	8	17
zoonoses	7	15
zoonosis	20	57

Due to its strong international inter-institutional collaboration and high publication rate, Italy leads the field of *Thelazia* research. In previous studies, Thelaziosis has been reported according to the order of frequency respectively in European countries: Italy, France, Germany, Switzerland, Spain, Portugal, Belgium, Bosnia and Herzegovina, Croatia, Serbia, Romania, Greece, Bulgaria, Hungary, Slovakia, the United Kingdom, Turkey, Austria, and Portugal (do Vale et al., 2019; Morgado et al., 2022). Also, in recent decades, *T. callipaeda* eyeworm disease prevalence in both humans and animals has increased throughout Europe and the United States (Otranto et al., 2021; Schwartz et al., 2021). According to our findings, the documents mostly from Italy (87 documents), the United States (57 documents), China (25 documents), Germany (23 documents), England (19 documents), Brazil (18 documents), France (18 documents), Canada (17 documents), and Iran (17 documents) were published most of the documents on *Thelazia.* Also, the authors from the University of Bari Aldo Moro/ Italy published most of the documents on *Thelazia.* 'Domenico Otranto' (Parasitology Unit, Department of Veterinary Medicine, University of Bari, Valenzano, Italy and Faculty of Veterinary Sciences) is the most active researcher in the field of *Thelazia,* compiling and participating in 77 documents.

According to the results of our study, the number of publications from countries where thelaziosis is common is still very low, or no publications have been published from these countries. However, it should be noted that our study only includes the Web of Science database and does not cover all scientific literature.

Journals are regarded as crucial resources for disseminating research. One of the key factors in drawing pertinent studies from various regions is a journal's area of expertise (Ahmad et al., 2021). Given that Thelaziasis is a parasitic disease and is based on veterinary science, most of the articles have been published in journals that deal with these topics. The journals that drew the most papers were *Parasites & Vectors* (n = 30) and *Veterinary Parasitology* (n = 29).

When researching or looking for a specific document, keywords are essential (Ahmad et al., 2021). In our analysis, the most used keywords were *Thelazia callipaeda* (n = 103), dog (n = 27), eyeworm (n = 22), zoonosis (n = 20), dogs (n = 16), *Thelazia* (n = 14) and cat (n = 13). This suggests that the disease burden is high in cats and dogs. The first keywords refer to the etiology of the disease and the disease it causes, while the others indicate that dogs and cats are the most affected animal species. Most of the studies focused on basic information on prevalence (especially in Europe), disease burden, causes, and epidemiology. Few studies have focused mainly on the disease's diagnosis and treatment, which are crucial for battling the disease.

Limitations

There were some limitations of this study. We selected one database for the study and only used MESH terms to search the data. Due to its well-

known status as the most essential data source for bibliometric investigations, we selected the Web of Science database. It's possible that some studies were omitted as a result. Therefore, bibliometric analysis results may vary based on the database used. The bibliometric community should continue to develop methods and metrics that account for scientific output that isn't accounted for in international databases (Web of Science, Pubmed, Scopus, etc.), including domain-specific and national citation indices.

Additionally, it couldn't conclusively establish the author's affiliation. Additionally, some authors may have very similar names, which may be biased. When using the data with the Vosviewer program, only the country and affiliation of the first author were taken into account. In addition, no further analysis, such as content analysis, was conducted.

Conclusion

As a result, contrary to the results of many other global bibliometric analyses, Italy was the most productive country for *Thelazia* literature. In our study, it was also found that Italy ranked first in international cooperation. The United States ranked second. Iran has made progress, especially in the number of publications published in 2022. Most of the publications came from the field of parasitology. However, due to the increasing number of human cases, the number of human studies should be increased.

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