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RESEARCH

History of research on *Aedes albopictus* (Diptera: Culicidae) in Europe: approaching the world's most invasive mosquito species from a bibliometric perspective

Pedro María Alarcón-Elbal[1] · Carlos Suárez-Balseiro[2] · Cláudia De Souza[2] · Ashley Soriano-López[3] · Giovanna Riggio-Olivares[4]

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Abstract

The Asian tiger mosquito, *Aedes albopictus* (Skuse), is an invasive species native to Southeast Asia. This insect, which is an important vector of arbovirus such as dengue, Zika, and chikungunya, has spread rapidly to several parts of the world over the last few decades. This study employed a bibliometric approach to explore, for the first time, *Ae. albopictus* research activity and output in Europe. We used the Web of Science Core Collection data source to characterize the current scientific research. A total of 903 publications from 1973 to 2022 were retrieved. We also provided a comprehensive analysis by year of publication; distribution by most productive European countries, institutions, and authors; collaboration networks; research topics; most productive journals; and most cited publications. Results showed a notable increase in the number of studies after the chikungunya virus outbreak in Northeast Italy in 2007. More than 60% of these publications across the entire European continent originated from France and Italy. Research output related to 'population and community ecology' topics was significantly high. The most common type of collaboration was national, which occurred between institutions in the same European country. By providing an overview of *Ae. albopictus* research in Europe, this work contributes to upcoming debates, decision-making, planning on research and development, and public health strategies on the continent and worldwide.

Keywords *Aedes albopictus* · Mosquito-borne diseases · Outbreak · Scientific activity · Bibliometric analysis · Europe

Introduction

Aedes albopictus (Skuse 1894) (Diptera: Culicidae), commonly known as the Asian tiger mosquito, is among the top 100 most invasive species on Earth (Lowe et al. 2000). In recent years, this dipteran has been considered the world's most invasive mosquito species (Guglielmi 2019). Indigenous to Southeast Asia, this mosquito has expanded its range considerably in recent decades. Currently, it is found in large areas of all the inhabited continents except Antarctica, residing in both tropical and temperate environments (Kraemer et al. 2015).

The first record of this mosquito appearing outside its indigenous region was registered in Europe, specifically in Albania, in 1979 (Adhami and Reiter 1998). However, there were no accounts in other European countries until 1990, when the mosquito was detected in Italy (Sabatini et al. 1990). The species is mainly spread passively by ground traffic, aircraft, and maritime traffic, reaching regions including France, Spain, Croatia, and others. Over thirty countries have reported the Asian tiger mosquito, with its northernmost population existing in Germany (ECDC 2023a).

The biting of *Ae. albopictus*, particularly if present in large numbers near human populations, can have a negative impact on the quality of life of the population (Curcó et al. 2008). However, the prime concern regarding this species is its potential to transmit mosquito-borne diseases of public health importance (Näslund et al. 2021). This vector establishment in the Euro-Mediterranean countries has led to autochthonous transmission events of arboviruses. For instance, cases of chikungunya, dengue, and Zika were first reported in 2007 in Italy (Rezza et al. 2007), 2010 in France (La Ruche et al. 2010), and 2019 in France, respectively (Giron et al. 2019). Other European countries, such as Croatia (Gjenero-Margan et al. 2011) and, more recently, Spain (MSCBS 2018, 2023), have reported additional cases of arboviruses linked to *Ae. albopictus*.

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The arrival of this mosquito species in Europe has led to various scientific institutions intensifying their research on this vector, focusing on different topics of interest. The introduction of this species has heightened the risk of local transmission of mosquito-borne diseases in the regions where it has become established. As a result, extensive research has been performed to understand the species' ecology, distribution, and potential for disease transmission (Collantes et al. 2015; Gossner et al. 2018). Researchers have also been studying the relationship between climate change and the spread of mosquito populations to predict potential future expansion and assess the risk of disease outbreaks in new areas (Oliveira et al. 2021) and develop novel methods of mosquito control, including genetic, biological, and environment-friendly approaches (Tur et al. 2021). Other key research areas include population genetics and phylogeography (Porretta et al. 2012), pathogen detection and monitoring (Masetti et al. 2008), vector competence and host interactions (Severini et al. 2018), and mosquito resistance to insecticides (Balaska et al. 2020).

Due to the increasing interest in this species from the European scientific community, we conducted a comprehensive bibliometric study to characterize and examine the research activity and output on the subject of *Ae. albopictus* over the last 50 years (1973–2022), coinciding with the first European publications on this species (Enzmann 1973; Otova and Krobova 1974). The results of this analysis made it possible to observe the evolution of European research production on *Ae. albopictus*, which covers the most productive countries, institutions and researchers, scientific collaboration networks, and visibility and impact. This work also enabled the identification of trends concerning different topics and addressed the methodological approaches in studies on the Asian tiger mosquito. Furthermore, it facilitated an analysis of the connection between the spread of this species and the changes in the entomo-epidemiological landscape in the region.

Materials and methods

Based on publication records ranging from 1973 to 2022 that were retrieved from the Web of Science Core Collection™ (WoS), the work discussed in this article used a bibliometric approach to explore the scientific production from European countries on the Asian tiger mosquito. We built our search strategy on author affiliation (by searching for European countries in the addresses field) and topic terms (by searching for the species name in all its variants—*Aedes albopictus*, *Stegomyia albopicta*, and Asian tiger mosquito—in the title, abstract, author keywords, and Keywords Plus® fields). For the analysis of multi-authored publications or with more than one European country involved, the full counting method was applied. There were no restrictions based on language or document type. We conducted extensive work to identify errors in the affiliation data and to normalize the names of authors and institutions.

The scientific production was analysed considering the annual growth of the documents published; the dispersion of the literature; the production distribution by countries, institutions, and thematic areas; and the author productivity index calculated based on the approach of Lotka's Law (1926), according to the frequency distribution of scientific productivity. The productivity index (PI), calculated as the decimal logarithm of the number of publications, allowed us to group authors into small producers (a single publication, $PI = 0$), medium producers (two to nine publications, $1 > PI > 0$), and large producers (10 or more publications, $PI \geq 1$). The transience index (the proportion of authors who publish a single article relative to the total number of authors) has also been calculated (Price and Gürsey 1975). We analysed scientific collaboration according to its type (national, international, intra-regional, or extra-regional) and by identifying the participation of non-European countries. VOSviewer (version 1.6.19) was used to visualize the collaboration networks of authors and countries. The size of the research groups was calculated using the co-authorship index. The impact factor and the quartile classification of the journals served to assess the visibility and impact of the publications. Finally, we identified the most cited publications during the analysed period.

Classification of mosquito studies based on topics can be broad, leading to different possible categories. In this case, we classified the papers according to the main themes or sections used by entomological journals: 'morphology, systematics, evolution'; 'sampling, distribution, dispersal'; 'development, life history'; 'population and community ecology'; 'behaviour, chemical ecology'; 'population biology/genetics'; 'molecular biology/genomics'; 'vector control, pest management, resistance, repellents'; 'arthropod/host interaction, direct injury, immunity'; 'vector/pathogen/host interaction, transmission'; 'vector-borne diseases, surveillance, prevention'; and 'modelling/GIS, risk assessment, economic impact, citizen science'. Considering that a single paper can also delve into different topics, each article was assigned a maximum of three themes.

Results

Scientific production

From the analysed period (1973–2022), we recovered 903 publications. Figure 1 presents the annual evolution of the absolute number of publications. The determination coefficient ($R^2 = 0.6611$) indicates a good linear fit with an increasing trend. It is possible to observe that production

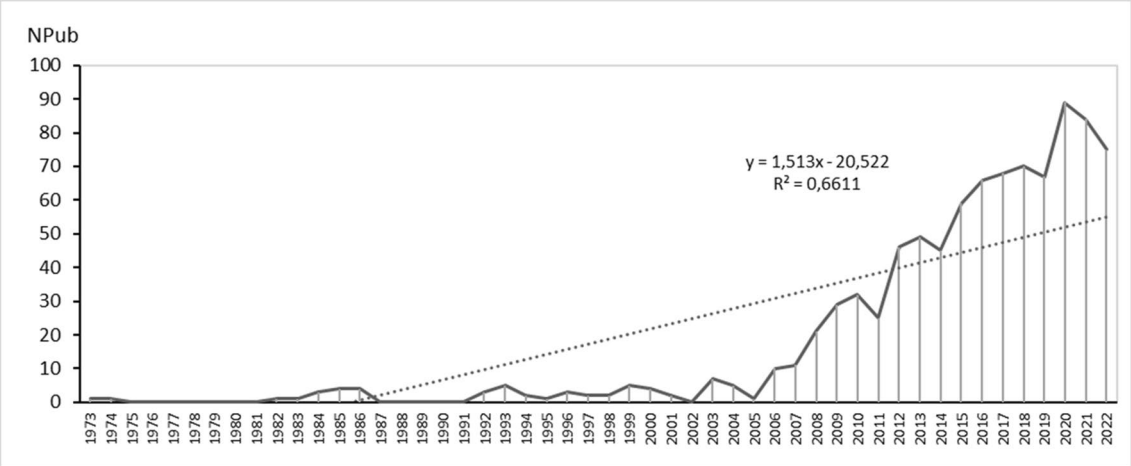

Fig. 1 Annual evolution of scientific production in Europe on *Aedes albopictus*, 1973–2022

has been increasing with some fluctuations, going from a single document in 1973 to 75 documents published in 2022, representing an average inter-annual increase rate of 47.89%. The year with the highest number of publications (89 documents) is 2020.

Countries

Forty-three European countries have scientific production on *Ae. albopictus*, both from the analysed period and registered in the WoS databases (Fig. 2). As shown in Table 1, France has the highest number of publications ($n = 342$; 37.87%). This number includes publications by researchers from institutions located in the French Overseas Territories (La Réunion, 57; Guadeloupe, 8; Martinique, 4; New Caledonia, 3; French Guiana, 4; and French Polynesia, 1) and many of whom co-authored with researchers from institutions in Metropolitan France. Italy is in second place with 32.56% of total production. France and Italy together produced more than 60% of publications. With lower percentages, Spain

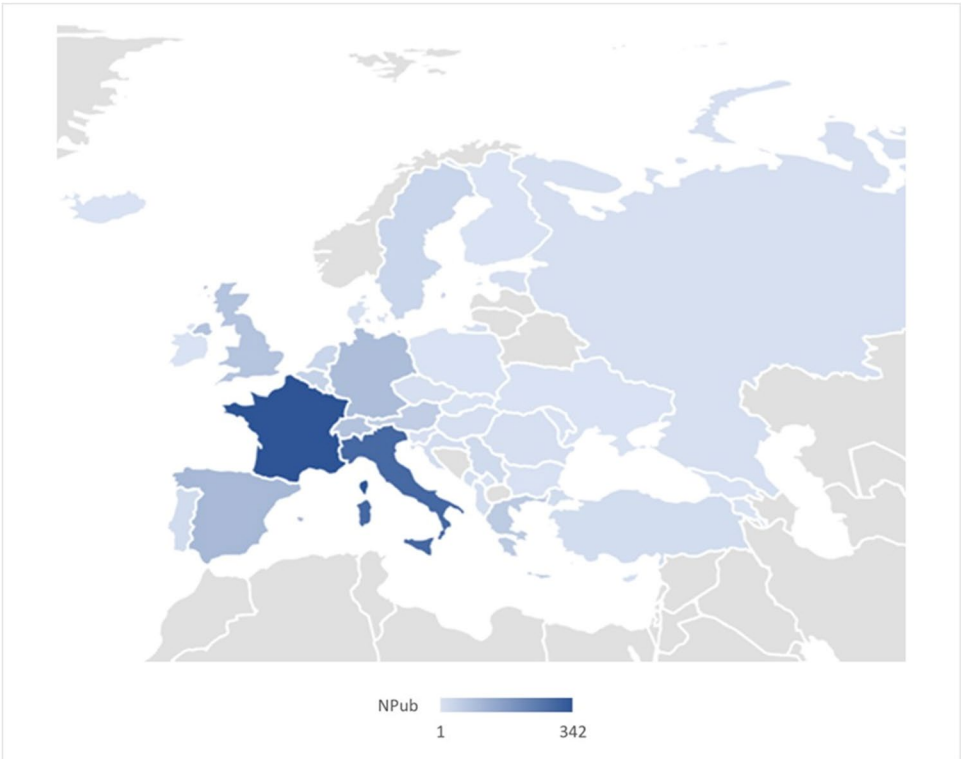

Fig. 2 European countries with scientific production on *Aedes albopictus* registered in the WoS databases, 1973–2022

Table 1 Distribution of scientific production on *Aedes albopictus* in Europe by most productive countries, 1973–2022

Country	NPub-Affil*	%	NPub-Context**	%
France	342	37.87	147	16.28
Italy	294	32.56	324	35.88
Spain	103	11.41	88	9.75
Germany	91	10.08	63	6.98
Switzerland	76	8.42	43	4.76
UK	61	6.76	23	2.55
Greece	59	6.53	64	7.09
Austria	51	5.65	11	1.22
Belgium	40	4.43	17	1.88
The Netherlands	32	3.54	21	2.33
Sweden	32	3.54	3	0.33
Croatia	13	1.44	19	2.10
Albania	11	1.22	22	2.44

*According to the authors' affiliation

**According to the geographical context of the research

(11.41%) and Germany (10.08%) followed France and Italy. The following countries occupy positions 5 to 9: Switzerland (8.42%), UK (6.76%), Greece (6.53%), Austria (5.65%), and Belgium (4.43%). The Netherlands and Sweden together occupy the 10th place in this ranking, with 32 documents published by each country (3.54% of the total).

Twelve European countries have no visible scientific output: Andorra, Azerbaijan, Belarus, Bosnia and Herzegovina, Kazakhstan, Latvia, Liechtenstein, Lithuania, Monaco, Norway, San Marino, and Vatican City.

We carried out a further analysis based on the bibliographical data, including the geographical context (territorial scope—country or region—where the samples were taken, etc.) of the research work described in each of the publications considered in this study. The aim was to identify the European countries where the presence of *Ae. albopictus* has been most studied. Although there are many multi-country or regional studies ($n = 128$; 14.15%), the results of this analysis showed that the presence of the Asian tiger mosquito has been studied the most in Italy (324 publications), France (147 publications), Spain (88 publications), Greece (64 publications), Germany (63 publications), and Switzerland (43 publications); relatively less in the UK (23 publications), Albania (22 publications), the Netherlands (21 publications), Croatia (19 publications), and Belgium (17 publications); and very little in other countries of the European continent. A significant number of papers ($n = 147$; 16.28%) related to the presence of *Ae. albopictus* in the overseas territories of European countries were identified, mainly on the island of Réunion, France. However, for the main body of the study, our focus was directed towards research conducted in continental Europe, thus delimiting the analysis to a more homogeneous geographic context.

Figure 3 shows in 5-year periods the evolution of production according to the geographical context of the research and a timeline indicating the date when the Asian tiger mosquito was first reported in each of these countries.

Organizations

A total of 686 European institutions have scientific publications on *Ae. albopictus* that are registered in the WoS for the period analysed. Italy is the country with the highest percentage (19.97%) of institutions represented. Table 2 shows the top 10 most productive institutions: five are from Italy, three are from France, one is from Austria, and one is from Greece.

The most productive European institution with 75 published documents (8.31% of the publications) is the Institut Pasteur of France, mainly its Département de Virologie, Laboratoire Arbovirus et Insectes Vecteurs. Closely following it are the University of Roma Sapienza and the Centro Agricoltura Ambiente 'Giorgio Nicoli'. Also, from the most productive countries, we identified the institutions with the highest number of publications (these data are not included in this article due to space limitations).

Authors' productivity

Table 3 shows the results of the calculation of the PI and its characterization of the 3280 signatory authors of published papers. The proportion of authors with a single work exceeds 70% of the total number of authors, indicating a high transience indicator.

The most productive authors on *Ae. albopictus* were Romeo Bellini (72 papers) and Marco Carrieri (36 papers), both from the Centro Agricoltura Ambiente 'Giorgio Nicoli', Italy; Beniamino Caputo (39 papers) from Sapienza Università di Roma, Italy; Anna-Bella Failloux (47 papers) from the Department of Virology of the Institut Pasteur of Paris, France; and Francis Schaffner (36 papers) from Francis Schaffner Consultancy, Switzerland.

Figure 4 shows the authors with the highest productivity ($PI \geq 1$) and their collaborative networks. Distinguished by different colours, we have eight large groups of authors. The red cluster has the highest number of collaborators (15), followed by the blue cluster (13) and the green cluster (11).

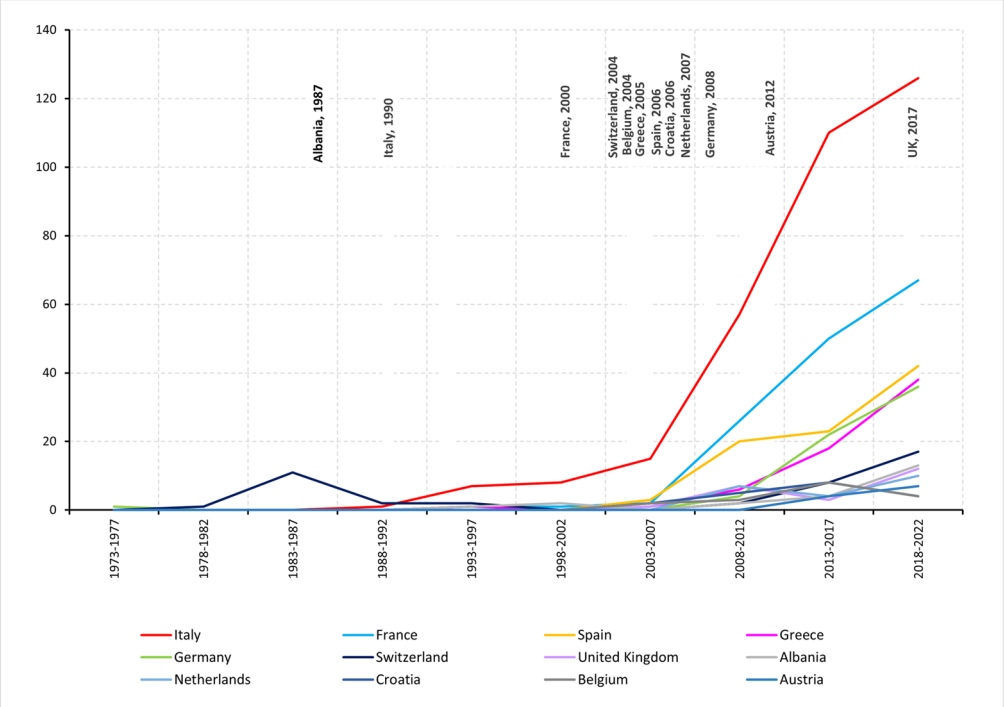

Fig. 3 Evolution of research output on *Aedes albopictus* according to the geographical context of the research

Research topics

An analysis of scientific publications on *Ae. albopictus* in Europe, according to previously defined subject categories, showed that 'population and community ecology' and 'vector/pathogen/host interaction, transmission' were the most frequently addressed topics. Table 4 shows that the combined production on both topics represents about 60% of the identified documents. Multi-classification of the documents into different topics revealed that a quarter of the publications were related to 'vector control, pest management, resistance, repellents'.

Figure 5 shows that the earliest publications on *Ae. albopictus* in Europe focused on 'vector/pathogen/host interaction, transmission'; 'molecular biology/genomics'; and 'behaviour, chemical ecology'. Since 2004, there has been a remarkable increase in the number of works that address the following topics: 'population and community ecology'; 'molecular biology/genomics'; 'vector/pathogen/host interaction, transmission'; 'vector-borne diseases, surveillance, prevention'; and 'modelling/GIS, risk assessment, economic impact, citizen science'. Starting from 2019, a slight decline in research in the aforementioned areas was observed, with

Table 2 The 10 most productive European research institutions on *Aedes albopictus*, 1973–2022

	Institution	Country	NPub	%
1	Institut Pasteur (mainly its Département de Virologie, Laboratoire Arbovirus et Insectes Vecteurs)	France	75	8.31
2	Sapienza Università di Roma	Italy	74	8.19
3	Centro Agricoltura Ambiente 'Giorgio Nicoli'	Italy	71	7.86
4	Centre national de la recherche scientifique (CNRS)—UMR Maladies infectieuses et vecteurs: écologie, génétique, évolution et contrôle (MIVEGEC)—Université de Montpellier	France	65	7.20
5	Fondazione Edmund Mach (FEM)	Italy	45	4.98
6	Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture—Insect Pest Control Laboratory	Austria	40	4.43
7	Istituto Superiore di Sanità (ISS)	Italy	38	4.21
8	Aix-Marseille Université (AMU)	France	34	3.77
9	Università degli Studi di Pavia	Italy	33	3.65
10	Benaki Phytopathological Institute	Greece	30	3.32

Table 3 Productivity index (PI) of authors who published papers on *Aedes albopictus* in Europe, 1973–2022

PI ≥ 1 (10 or more articles)	0 < PI < 1 (two to nine articles)	PI = 0 (one article)
71	778	2431
2.2%	23.7%	74.1%*

*Transience index

an increase seen only in research on 'vector control, pest management, resistance, repellents'.

Regarding the percentage contribution of each country to the total production by topic, we found a high concentration of Italian production on 'Behaviour, chemical ecology' (52%), whereas France is noteworthy for 'Population biology/genetics' (50%).

Scientific collaboration

Most of the publications were performed in collaboration, with only 2.60% of the documents written by a single author. In the total set of documents analysed in this study, the co-authorship index was 6.9.

We found inter-institutional scientific collaboration in 76.52% of the publications. The most common type of collaboration is national, between institutions in the same European country (60.24%). The analysis at the country level also revealed that cross-sectoral collaboration has been frequent. Universities, national research agencies and centres, foundations, and associations have produced much of this work. Nevertheless, intra-regional international collaboration (between institutions from different European countries) is present in 24.70% of publications.

As shown in Fig. 6, France and Italy are the countries that have collaborated the most in research on *Ae. albopictus*. Collaboration between European institutions and those from countries outside Europe (i.e. extra-regional international collaboration) is less frequent (16.50%). The USA is the main country for extra-regional scientific collaboration during the analysed period, having participated in 44.30% of publications in international collaboration between European and non-European countries.

Visibility and impact

We identified the journals that have published the highest number of research papers from European institutions on the subject of *Ae. albopictus* over the analysed period (Table 5). Most of these journals are classified as Q1 and Q2 according to the 2021 Journal Impact Factor (JIF), Journal Citation Reports (JCR) from Clarivate. At the top of this list is the journal *Parasites & Vectors*, with 74 documents. However, the articles published in *Plos One* have achieved a greater impact, accumulating the highest number of citations (2568) between 1973 and 2022. Both journals have a high percentage of publications in Golden Open Access, which, for the

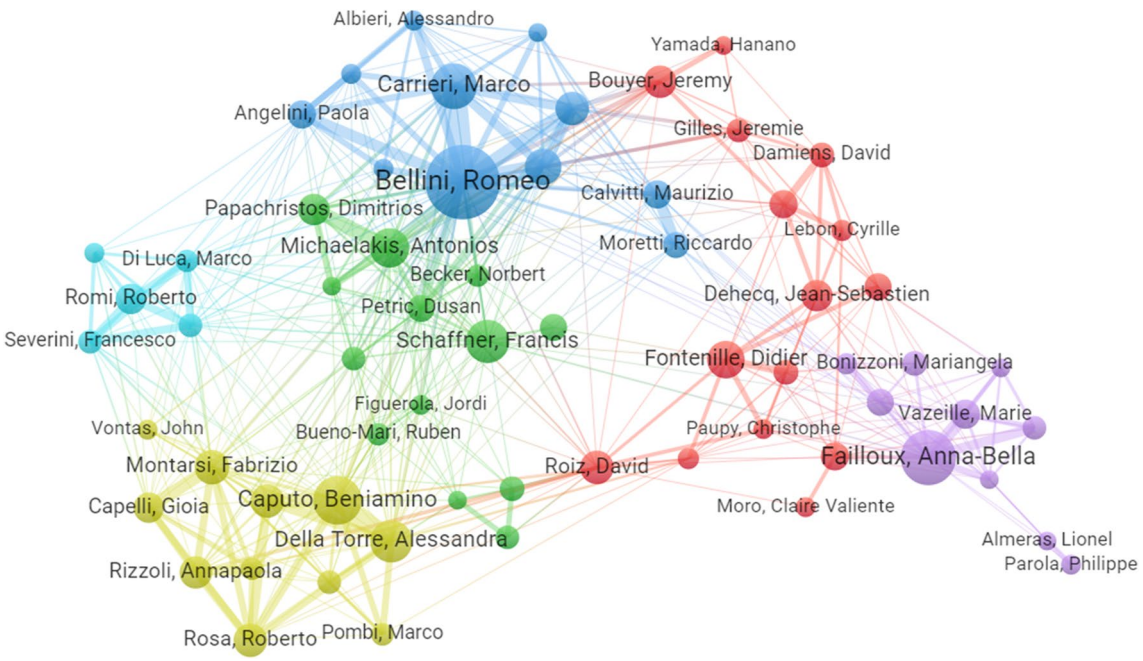

Fig. 4 Most productive authors on *Aedes albopictus* and their collaborative networks, 1973–2022

Table 4 Distribution of publications on *Aedes albopictus* in Europe according to research topics, 1973–2022

Topic	NPub	%
Population and community ecology	275	30.45
Vector/pathogen/host interaction, transmission	263	29.13
Vector control, pest management, resistance, repellents	226	25.03
Sampling, distribution, dispersal	192	21.26
Vector-borne diseases, surveillance, prevention	181	20.04
Molecular biology/genomics	178	19.71
Modelling/GIS, risk assessment, economic impact, citizen science	155	17.17
Behaviour, chemical ecology	71	7.86
Development, life history	70	7.75
Population biology/genetics	44	4.87
Arthropod/host interaction, direct injury, immunity	35	3.88
Morphology, systematics, evolution	32	3.54

reader, means immediate and permanent access to the final article.

Table 6 shows that 10 documents, of which four are articles and the rest reviews, have received more than 500 citations for the period analysed. The document that has received the most citations ($n = 1{,}061$) was published in 2007 by Italian researchers and deals with the outbreak of the chikungunya virus in Italy. The average number of citations per article is 36.5, considering the total number of articles analysed.

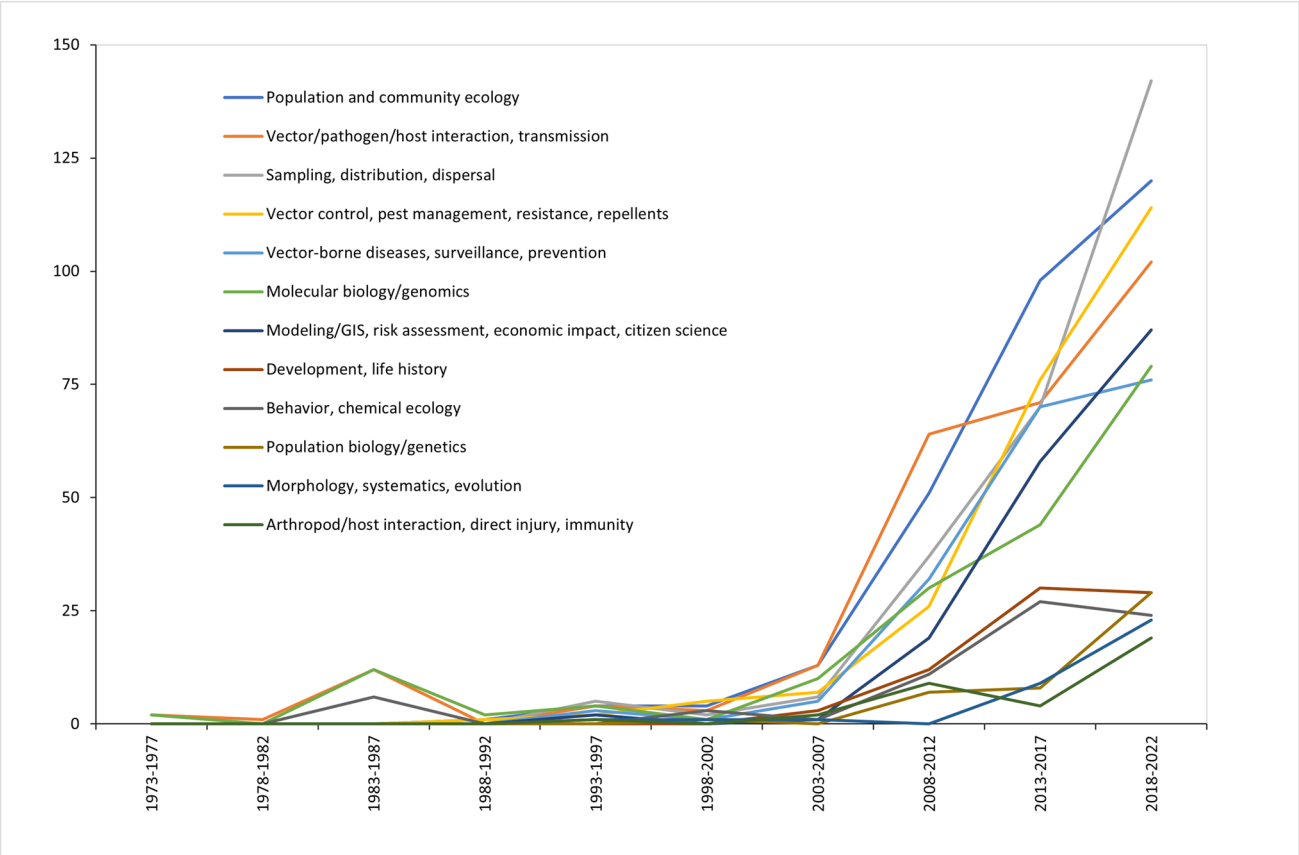

Fig. 5 Evolution of the number of publications on *Aedes albopictus* by research topics in 5-year periods, 1973–2022

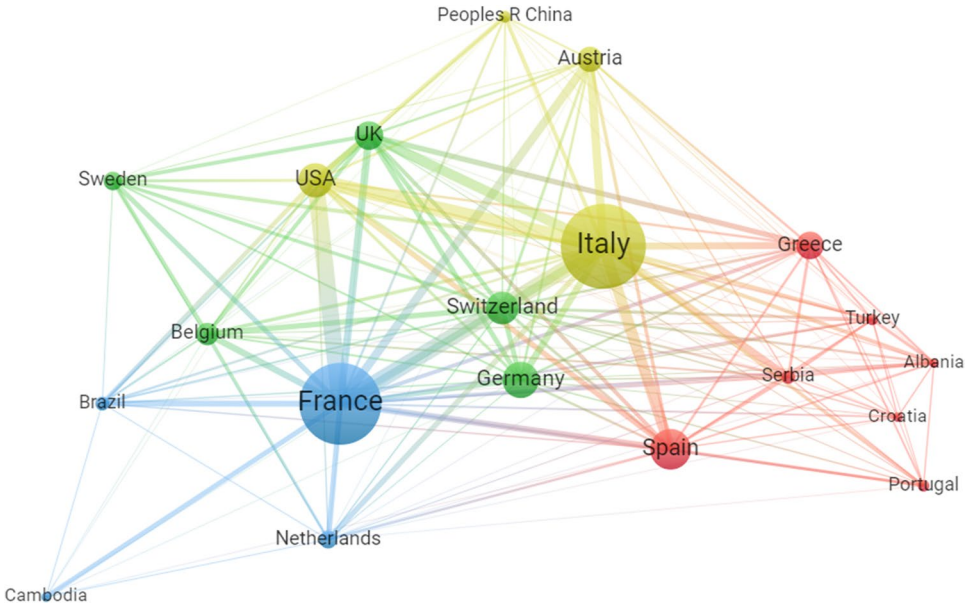

Fig. 6 Collaboration research network between European countries with 10 or more publications on *Aedes albopictus*, 1973–2022

Table 5 Most productive journals (> 10 articles) on *Aedes albopictus* in Europe, 1973–2022

Source	NDoc	Citations	Subject category	2021 Journal Impact Factor	JIF quartile	% OA gold	Immediacy index
Parasites & Vectors	74	1831	Tropical Medicine; Parasitology	4.052	Q1	99.77%	0.689
Plos Neglected Tropical Diseases	46	2447	Parasitology; Tropical Medicine	4.781	Q1	99.67%	0.845
Plos One	43	2568	Multidisciplinary Sciences	3.752	Q2	99.54%	0.801
Journal of Medical Entomology	36	1529	Entomology; Veterinary Sciences	2.435	Q2	14.61%	1.130
Journal of the American Mosquito Control Association	35	1040	Entomology	1.000	Q3	99.35%	0.111
Parasitology Research	34	1566	Parasitology	2.383	Q3	10.20%	0.630
Insects	31	468	Entomology	3.141	Q1	96.84%	0.739
Acta Tropica	24	916	Parasitology; Tropical Medicine	3.222	Q2	11.78%	0.887
Eurosurveillance	24	1440	Infectious Diseases	21.286	Q1	96.72%	7.390
Medical and Veterinary Entomology	24	1530	Entomology; Veterinary Sciences	2.479	Q2	13.57%	0.660
Vector-Borne and Zoonotic Diseases	22	1771	Infectious Diseases; Public, Environmental & Occupational Health	2.523	Q4	10.13%	0.520
Scientific Reports	21	293	Multidisciplinary Sciences	4.997	Q2	99.63%	0.973
International Journal of Environmental Research and Public Health	16	239	Public, Environmental & Occupational Health; Environmental Sciences; Public, Environmental & Occupational Health	4.614	Q2	96.11%	0.903
Viruses-Basel	16	223	Virology	5.818	Q2	95.59%	1.396
Experientia	10	0	Multidisciplinary Sciences	2.072*	Q1	N/A	N/A
Journal of Vector Ecology	10	145	Entomology	1.889	Q2	0.00%	0.269
Pest Management Science	10	112	Agronomy; Entomology	4.463	Q1	8.48%	0.778

*1998 Journal Impact Factor

Table 6 Top 10 most cited publications (> 500 citations) on *Aedes albopictus* in Europe, 1973–2022

Reference	Times cited	Type
Rezza G, et al. (2007) Infection with chikungunya virus in Italy: an outbreak in a temperate region. *Lancet* 370(9602): 1840–1846. https://doi.org/10.1016/S0140-6736(07)61779-6	1061	Article
Kraemer MUG, et al. (2015) The global distribution of the arbovirus vectors *Aedes aegypti* and *Ae. albopictus*. *eLife* 4: e08347. https://doi.org/10.7554/eLife.08347	996	Article
Gratz NG (2004) Critical review of the vector status of *Aedes albopictus*. *Med Vet Entomol* 18(3): 215–227. https://doi.org/10.1111/j.0269-283X.2004.00513.x	865	Review
Pialoux G, et al. (2007) Chikungunya, an epidemic arbovirosis. *Lancet Infect Dis* 7(5): 319–327. https://doi.org/10.1016/S1473-3099(07)70107-X	723	Review
Paupy C, et al. (2009). *Aedes albopictus*, an arbovirus vector: from the darkness to the light. *Microbes Infect* 11(14–15): 1177–1185. https://doi.org/10.1016/j.micinf.2009.05.005	525	Article
Lambrechts L, et al. (2010). Consequences of the expanding global distribution of *Aedes albopictus* for dengue virus transmission. *PLOS Negl Trop Dis* 4(5): e646. https://doi.org/10.1371/journal.pntd.0000646	478	Review
Weaver SC, Lecuit M (2015) Chikungunya virus and the global spread of a mosquito-borne disease. *N Engl J Med* 372(13): 1231–1239. https://doi.org/10.1056/NEJMra1406035	472	Review
Vazeille M, et al. (2007) Two Chikungunya isolates from the outbreak of La Reunion (Indian Ocean) exhibit different patterns of infection in the mosquito, *Aedes albopictus*. *PloS One* 2(11): e1168. https://doi.org/10.1371/journal.pone.0001168	454	Article
Medlock JM, et al. (2012) A review of the invasive mosquitoes in Europe: ecology, public health risks, and control options. *Vector Borne Zoonotic Dis* 12(6): 435–447. https://doi.org/10.1089/vbz.2011.0814	434	Review
Simón F, et al. (2012) Human and animal dirofilariasis: The emergence of a zoonotic mosaic. *Clin Microbiol Rev* 25(3): 507–544. https://doi.org/10.1128/CMR.00012-1212	425	Review

Discussion

In the field of human parasitology, there have been recent bibliometric studies that delve into some of the most dangerous protozoan agents (Soosaraei et al. 2018; Ekici et al. 2022) as well as the medically significant helminths (Ahmad et al. 2021; Tantengco and Rojo 2022). There are also bibliometric works that address the specific topic of diseases transmitted by arthropods (Albuquerque et al. 2017; Ong et al. 2022), while other studies focus more on the vectors themselves (Klingelhöfer et al. 2022) or on the medical entomology in certain areas, such as the Caribbean (Alarcón-Elbal et al. 2023). In the specific case of mosquitoes, bibliometric studies conducted to date have focused on *Aedes aegypti* (Linnaeus 1762) (Vega-Almeida et al. 2018; Piovezan-Borges et al. 2022), the primary vector of arboviruses worldwide. However, with this study, we accomplished for the first time the bibliometric research on *Ae. albopictus*.

The scientific interest in *Ae. albopictus* has significantly increased over the last few decades, which can be explained by several factors: (i) the species' extensive geographic distribution across the continent, (ii) significant importance as a nuisance-producing pest, and (iii) role as a vector of several arboviral diseases and the associated public health implications (Schaffner et al. 2013). Consequently, the number of scientific documents in Europe that are related to this species has likely increased over the last few years, as shown in Fig. 1.

The remarkable surge in studies on *Ae. albopictus* that have been produced since 2007 is particularly noteworthy and can be attributed to several factors. Firstly, the occurrence of the initial autochthonous outbreak of chikungunya in Europe, specifically in the Italian region of Emilia Romagna (Angelini et al. 2007; Rezza et al. 2007), underscored the necessity for a more comprehensive understanding of the mosquito ecology, distribution, and behaviour. Secondly, the ongoing spread of *Ae. albopictus* to new territories in Europe, even in Northern and Central European countries (Scholte et al. 2007; Pluskota et al. 2008), intensified the urgency to conduct research aimed at monitoring the species' expansion. As it continues to extend throughout Europe, this mosquito has prompted the need for scientists to investigate its population dynamics and potential risks to public health. New autochthonous cases of chikungunya and dengue have occurred from 2007 to the present (ECDC 2023b, 2023c), further increasing the interest and, in parallel, the scientific research focused on this species, as previously noted. In October 2019, the first locally acquired cases of mosquito-transmitted Zika virus were reported in Europe (Giron et al. 2019). This outbreak event had implications far beyond the three people affected and represented a new phase in the global Zika threat (Brady and Hay 2019). The event most likely resulted in 2020 becoming the year with the highest scientific production throughout the study period.

After Albania, Italy and France were among the countries most heavily and earliest affected by the invasion of this mosquito (Sabatini et al. 1990; Schaffner and Karch 2000),

prompting them to dedicate significant amounts of effort to research. This fact is firstly reflected in the remarkable number of publications produced by both countries, accounting for more than half of the publications across the entire European continent (Table 1) and, secondly, in the many institutions actively involved in studying the mosquito and its impact. Indeed, of the 10 most productive European institutions, eight of them are Italian and French (Table 2). These research efforts have led to numerous impactful publications, with French and Italian authors being among the most prolific in this field (Fig. 4). Similarly, the countries that have collaborated the most on *Ae. albopictus* research have been France and Italy, although collaborative links, albeit not as robust, also appear between these two countries and others in the region (Fig. 6.).

Still, the European overseas territories, especially those in tropical latitudes, play a crucial role in addressing vector-borne diseases. The territories serve as hotspots for arboviruses such as dengue, Zika, and chikungunya (Josseran et al. 2006; Boyer Chammard et al. 2017), although lesser-known arboviruses, whose importance should not be underestimated, also circulate in these regions (Ali et al. 2023). Given the interconnectedness of the world, controlling vector-borne diseases in the European overseas territories not only helps protect the local populations but also prevents potential outbreaks in mainland Europe. This is particularly important on islands, where attack rates often reach high percentages (Aubry et al. 2017). International cooperation and support for these regions are essential to combat the diseases effectively and safeguard public health on a global scale. Many of the outermost regions are popular tourist destinations, so when outbreaks occur, the likelihood of exporting *Aedes*-borne diseases to other countries increases. In addition, the high number of people travelling from other endemic countries poses the risk of introducing additional arboviruses to the populations (WHO 2019).

The early scientific literature in Europe on *Ae. albopictus* primarily focused on its identification, distribution, and biology. As the mosquito began spreading into new regions, research intensified to understand its ecological impact and potential for disease transmission. The emergence of autochthonous disease outbreaks, such as dengue and chikungunya (ECDC 2023b, 2023c), transmitted by the Asian tiger mosquito prompted a surge in research activity. Outbreaks of these diseases in Europe led to a significant increase in studies investigating the mosquito's vector competence and disease transmission dynamics (Di Luca et al. 2016). The development of advanced molecular techniques, such as DNA sequencing and PCR-based assays, facilitated investigations into the genetics and pathogen detection of *Ae. albopictus* in addition to providing a gold mine resource for the development of several vector control strategies (Gamez et al. 2020). These techniques expanded research capabilities and contributed to the rise in scientific articles.

Climate change impact and increased global travel have likely influenced the spread and establishment of this invasive species in new European regions. Research efforts have focused on understanding the relationship between climate change, globalization, and the expansion of the mosquito range, which has been influenced by the development of various computer tools, such as Geographic Information Systems (Zou et al. 2006). Nonetheless, studies assessing the efficacy of different control methods are likely to have contributed to the scientific literature, among other fields. The works focused on certain topics, such as 'Molecular biology/genomics' or 'Modeling/GIS, risk assessment, economic impact, citizen science', have increased considerably since the beginning of the twenty-first century, as the scientific areas under study are relatively new.

Certain approaches, such as citizen science and the increased use of digital and networked technologies, have provided a new dimension for scientific research in the vector ecology field (Južnič-Zonta et al. 2022). Furthermore, their implementation has become more 'democratized' upon becoming more economically accessible over the years. Although rapid and significant advances have been made in the fields of biology, ecology, genetics, taxonomy, and virology, the field of mosquito control has changed fairly little in recent decades (Faraji and Unlu 2016). This may be one of the reasons why works related to this topic are currently the most abundant, as efforts are still underway to enable the innovation of effective mosquito control strategies.

The utilization of bibliometric methods in examining scientific production within a disciplinary domain stands as a complementary approach for delving into the organization of knowledge within that field. This approach holds potential for facilitating information retrieval (often referred to as bibliometric-enhanced information retrieval) and aiding users in navigating through complex knowledge spaces. Nonetheless, these studies harbour inherent limitations, including biases towards specific disciplines or languages, thus excluding non-dominant languages or less explored fields. Bibliometric studies may overlook non-indexed works, prioritizing metrics over the inherent worth of research, consequently influencing evaluations of its relevance and significance. For instance, noteworthy omissions from this database encompass key discoveries, such as the first confirmed outdoor winter reproductive activity of this mosquito species in Europe (Collantes et al. 2014), which is related to the topics of 'development, life history', and 'population and community ecology'. Another example is the first instance in Europe when the presence of *Ae. albopictus* was detected by citizen-provided data through a smartphone application (Delacour-Estrella et al. 2014), which is related to the main themes of 'sampling, distribution, dispersal', and 'modelling/GIS, risk assessment, economic impact, citizen science'. Despite the importance of these

findings, they do not appear in our study because they were published in a journal not indexed in WoS.

Finally, the study in Europe of *Ae. albopictus* requires a multidisciplinary approach involving entomologists, virologists, epidemiologists, and other specialists. Collaborative research projects have likely increased the number of publications in this field, even in the framework of multi-centre studies. In addition, given the invasive nature of this mosquito, research efforts often require international collaboration and the sharing of data among European countries and other regions affected by this vector (Corbel et al. 2023). This collaboration may have led to joint publications and contributed to a growing body of scientific literature.

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Declarations

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Authors and Affiliations

Pedro María Alarcón-Elbal[1] · Carlos Suárez-Balseiro[2] · Cláudia De Souza[2] · Ashley Soriano-López[3] · Giovanna Riggio-Olivares[4]

✉ Pedro María Alarcón-Elbal
pedro.alarconelbal@uchceu.es

✉ Carlos Suárez-Balseiro
carlos.suarez5@upr.edu

Cláudia De Souza
claudia.souza@upr.edu

Ashley Soriano-López
asoriano@est.unibe.edu.do

Giovanna Riggio-Olivares
g.riggio@unibe.edu.do

[1] Department of Animal Production and Health, Facultad de Veterinaria, Veterinary Public Health and Food Science and Technology (PASAPTA), Universidad Cardenal Herrera-CEU, CEU Universities, Valencia, Spain

[2] College of Communication and Information, University of Puerto Rico, Río Piedras Campus, San Juan, Puerto Rico

[3] School of Medicine, Universidad Iberoamericana (UNIBE), Santo Domingo, Dominican Republic

[4] Learning and Research Resources Centre, Universidad Iberoamericana (UNIBE), Santo Domingo, Dominican Republic