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ORIGINAL RESEARCH ARTICLE

Research on medical and veterinary entomology in the insular Caribbean: a bibliometric analysis

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Abstract

Research on medical and veterinary entomology (MVE) is especially needed in the Caribbean islands, which are threatened by the burden of several arthropod species due to their tropical climate and environment. Identifying relevant MVE-related scientific activity in these countries and examining the characteristics of its outputs can aid in the analysis of trends, knowledge gaps and decision-making in vector-borne disease research management. This study used bibliometric methods to understand how research in this discipline developed in the insular Caribbean countries during the first two decades of this century. Data were extracted from the Web of Science Core Collection™ and SciELO Citation Index™. During the study period, the region's scientific MVE production grew at a steady rate. Most studies focused on the order Diptera and the family Culicidae. Cuba is the largest regional producer. The predominance and growing trend of international scientific collaboration were observed. These scientific results are scattered and mainly published in journals in the United States and European countries. Recent MVE studies in the insular Caribbean have been promising; it is crucial to ensure knowledge transfer across generations of researchers to generate trained human resources that will allow these studies to continue in each country in the future.

Keywords Vector-borne diseases · Caribbean region · Public health · Study of arthropods · Scientific publications · Scientometrics

Introduction

Arthropods can have a variety of negative effects on human and animal health. Most notably, they can be biological vectors for disease-causing organisms. Mosquitoes are unquestionably the most important vector of medical importance, transmitting disease-causing pathogens, including those that cause malaria, lymphatic filariasis, yellow fever, dengue, chikungunya and Zika, among others (Beerntsen et al. 2000). Ticks, on the other hand, are second only to mosquitoes as human disease vectors globally, but they are the most significant vector of disease-causing pathogens of veterinary relevance (Estrada-Peña et al. 2008).

Studies on medical and veterinary entomology (MVE) are particularly needed in tropical regions like the Caribbean islands, which are threatened by the burden of several arthropod species due to their climate and environment. Frequent and intense extreme climatic events, such as heat waves, Saharan dust incursions, hurricanes, floods, and droughts, have a detrimental impact on human health and development in the Caribbean region (Trotman et al. 2018).

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Given these suitable climatic conditions for the proliferation of vectors, as well as the Caribbean's high socioeconomic burden and widespread intra- and extra-regional travel, a better knowledge of these organisms is a major goal for Caribbean small island developing states (WHO 2018). Despite the high incidence of many arthropod-borne diseases in the region, the absence of continuous project funding and the non-availability of qualified personnel are the key underlying challenges affecting vector control program success rates in these countries (Francis et al. 2021). This situation affects the scientific output of these countries in this field.

Researchers in this subject will benefit from identifying important scientific activities in the Caribbean in the field of MVE, which has recently been called "One Health Entomology" (Alarcón-Elbal and Sandiford 2021). Examining the characteristics of the region's scientific output in this field would make it possible to analyze trends and knowledge gaps, and support decision-making in research management on vector-borne diseases (VBDs) in these developing countries.

Bibliometric analysis is a statistical method widely used to describe productivity and trends in a particular research area. Based on the analysis of scientific publications, bibliometric indicators offer quantitative measurements of concepts, such as scientific output, scientific impact, and scientific collaboration (Van Raan 2019). These measurements are often used in research management and research evaluation (Waltman and Noyons 2018).

Despite the importance of entomology research for human and public health, very few scientometric studies analyze the dynamics, advances, and contributions of this discipline, either globally or in the Caribbean region. Some bibliometric studies have indirectly addressed this topic, but they mainly focus on analyzing publications on neglected infectious diseases in the Latin American and Caribbean contexts (Dujardin et al. 2010; Fontecha et al. 2021).

There have been no previous bibliometric analyses of the Caribbean region's scientific production on MVE. The current study used bibliometric methods to examine how research in this discipline has developed in the Caribbean countries over the last two decades, gain insight into characteristics, and trends of scientific activity in this region, and reflect on whether these countries are making the necessary efforts and investments in research and development in this field.

This comprehensive overview will help identify crucial gaps in this area of knowledge. Research in MVE must respond to the dynamic changes of VBDs and other emerging concerns on this topic. Priority setting for MVE research is a matter of context. Considering the regional specificity of VBDs, this bibliometric profile could be beneficial in analyzing the relation between the burden of these diseases and scientific publications in this field of the entomology, and therefore, assessing the social and scientific relevance of Caribbean research production in this field.

We hope that the results of this study will help to promote the advances of MVE research in the region and strengthen current research policies and investments in this reemerging field, leading to more precise and efficient actions for the prevention and control of arthropods and VBDs.

Methodology

Overview of bibliometric analysis

A bibliometric analysis of the scientific production of the insular Caribbean countries in MVE was carried out, encompassing the first two decades of this century (2001–2020) to analyze the region's scientific production in this field. The countries that have published articles on this topic are those that have been considered for the study: Antigua and Barbuda, Barbados, Cuba, Curaçao, Dominica, Dominican Republic, Grenada, Guadeloupe, Haiti, Jamaica, Martinique, Puerto Rico, St. Kitts and Nevis, St. Lucia, and Trinidad and Tobago.

Data sources

The data was extracted from the Web of Science Core Collection™ indices and SciELO Citation Index™, both of which are accessible through the Web of Science (WoS) platform (Clarivate 2022a, b). Records extracted from the WoS enabled the identification of regional publications with high international visibility representing the main contribution of Caribbean researchers to mainstream scientific literature in the field of MVE. SciELO Citation Index was employed considering that previous metric studies have highlighted the importance of using data sources that have better coverage of Latin American and Caribbean scientific publications than WoS, especially when assessing the scientific output of non-English speaking countries of this region (Galbán-Rodríguez et al. 2019). In addition, WoS now includes the Emerging Sources Citation Index (ESCI), which adds to the Core Collection a greater number of journals of significant importance from the Latin American and Caribbean regions (Machin-Mastromatteo et al. 2017). The use of the ESCI and SciELO databases made it possible to cover a larger and more representative volume of scientific results from the Caribbean countries and obtain more precise results from this analysis.

The results of this study necessarily reflect the databases employed in the analysis. The omission of other publications

not covered by the selected databases or other forms of communication (for example, publications in local sources and gray literature), could be a limitation, particularly when assessing the relevance, quality, or social impact of scientific output or when examining links between research activity and implementation of policies and strategies.

Information retrieval and processing

An advanced search strategy was structured delimiting: first, the countries considered in this study, and second, the subject categories (WC = Web of Science Subject Category) relevant to the analysis: Entomology, Biology, Immunology, Infectious Diseases, Microbiology, Parasitology, Public, Environmental & Occupational Health, Tropical Medicine, Veterinary Science, Virology and Zoology. The search strategy included topic terms selected from a carefully compiled list that comprised the common and scientific names (family and genus) of the arthropods that cause or transmit diseases and other harm to human and animal health, together with the names of all known diseases for which they may be vectors. In MVE publications, these subject terms are frequently found in the title, abstract or a list of keywords annotated by the authors. The list of topic terms employed also included the most common variants of the names of the diseases' names (for example, *leishmaniasis* and *leishmaniosis*). Some truncated terms were used to retrieve records of publications that contained various forms of these terms by finding alternate endings (e.g., Filari*, Leishman*, Mansonell*, Onchocer* and Trypanosom*). List of topic terms (TS = Topic terms) used in the search strategy:

TS=(Acari; Acariformes; Acarina; *Aedes*; "African horse sickness"; "African swine fever"; "African trypanosomiasis"; allergy; "American trypanosomiasis"; anaplasmosis; *Anopheles*; ants; Araneae; Argasidae; babesiosis; "bed bugs"; bees; beetles; "biological control"; bites; "Biting midges"; "Black flies"; "black fly"; blackflies; blackfly; *Blatella*; *Blatta*; Blattodea; Blood-sucking; bluetongue; Boutonneuse; "bovine dermatophilosis"; caterpillars; Ceratopogonidae; Chagas; Chikungunya; *Chrysops*; *Cimex*; Cimicidae; cockroaches; Coleoptera; "Colorado tick fever"; Copepods; cowdriosis; crabs; "Crimean-Congo hemorrhagic fever"; *Culex*; Culicidae; *Culicoides*; *Cyclops*; "deer fly"; "delusional parasitosis"; dengue; "dog hearthworm"; Dracunculiasis; *Dracunculus*; "eastern equine encephalitis"; ectoparasites; ectoparasitism; ehrlichiosis; "Ekbom syndrome"; elaeophorosis; entomophobia; "epidemic typhus"; "epizootic hemorrhagic disease"; "equine infectious anemia"; filari*; filariasis; filariosos; Fleas; flies; *Glossina*; Glossinidae; "Guinea worm"; *Haemagogus*; hematophagous; Hippobocidae; "hog cholera"; "Horse flies"; "horse fly"; Hymenoptera; "insecticide resistance"; Ixodidae; "Japanese encephalitis"; Keds; "LaCrosse encephalitis"; latrodectism; *Latrodectus*; leishman*; *Leishmania*; leishmaniasis; leishmaniosis; Lepidoptera; Leucocytozoonosis; Lice; loiasis; "louse flies"; louse-borne; *Loxosceles*; loxoscelism; *Lutzomyia*; Lyme; malaria; mange; Mansonell*; *Mansonella*; Mansonelliasis; mansonellosis; "mechanical vector"; Mites; Mosquitoes; moths; "murine typhus"; "Murray Valley encephalitis"; myiasis; myxomatosis; nagana; nuisance; "O´nyong nyong"; Onchocer*; Onchocerciasis; Oncocercosis; Oropouche; Oroya; pediculosis; *Pediculus*; *Periplaneta*; Phlebotominae; *Phlebotomus*; Phthiraptera; plague; Psychodidae; "pubic lice"; "Q fever"; Reduvidae; repellence; rickettsialpox; "Rift Valley"; "Rocky Mountain Spotted fever"; "Ross River fever"; *Sabethes*; "sand flea disease"; "Sand flies"; "sand fly"; sandflies; scabies; Scorpiones; scorpions; Simuliidae; *Simulium*; Siphonaptera; spiders; spirochetosis; "St. Louis encephalitis"; surra; "swine pox"; Tabanidae; *Tabanus*; theileriosis; "Tick-borne encephalitis"; Ticks; "trench fever"; *Triatoma*; "Triatomine bugs"; Trypanosom*; Trypanosomosis; "Tsetse flies"; "tsutsugamushi fever"; tularemia; tungiasis; "Venezuelan equine encephalitis"; "Veruga Peruana"; "vesicular stomatitis"; wasps; "West Nile"; "western equine encephalitis"; "Yellow Fever"; Zika).

Inclusion and exclusion criteria

Articles published in scientific journals, books, book chapters, reviews, brief-reports, rapid-communications, case-reports, and editorial notes were included in the analysis as these are generally considered to contain substantial scientific material. Meeting abstracts and proceeding papers were excluded. One expert evaluated all articles focusing on titles and abstracts to verify that they were relevant to MVE. If necessary, the expert read the full text and decided whether to include it. If the article was listed in both databases, it was counted only once. There were no restrictions based on language. An extensive work was done to identify errors in the affiliation data and to normalize the names of authors and institutions from the Caribbean countries as extracted from databases records. After excluding repeated or irrelevant documents, 540 records –whose provenance is detailed in Table 1– remained for analysis. These 540 publications represent 80.4% of all the documents relevant to MVE produced by the Caribbean countries up to December 2020 and indexed in the databases consulted for this study. The remaining 19.6% corresponds to publications before 2001.

Data analysis

The analysis employed several different bibliometric approaches:

Table 1 The provenance of the final set of bibliographic records: insular Caribbean scientific publications in the field of MVE, 2001–2020

Data sources	Number of records
Records retrieved by the search strategy	767
Overlapped records between WoS and SciELO	342
Unique records retrieved from WoS	425
Unique records retrieved from SciELO	151*
Total number of unique records	576
Duplicated titles due to regional collaboration	67
Final set of records	**540**

*Note: SciELO only contributed to the study unique records from Cuba and the Dominican Republic

a) *Scientific production*: Several publications were used as a quantitative measure of research activity at different levels: regional, national, and institutional. The average annual growth percentage was calculated. The characteristics of the production were analyzed to identify publication patterns of this scientific community (document formats, languages, dispersion or concentration of publications, among other indicators).
b) *Research collaboration*: The addresses of the publications' authors were used to carry out co-authorship analysis and calculate the rate and degree of scientific collaboration, as well as to explore types and patterns of collaboration: inter-regional (an international collaboration between countries within and outside the insular Caribbean); intra-regional (between countries of the studied region); national (between institutions of the same Caribbean country). It's worth noting that scientific collaboration in Puerto Rico was classified as national, territorial, or international, depending on whether the collaboration was local (between institutions on the island) or territorial (between institutions in continental states).
c) *Bibliometric impact*: Citation analysis aimed to provide an insight into the impact of ongoing MVE research on the Caribbean islands in the context of the mainstream international scientific activity in this field.
d) *Research topics*: Classification of publications into defined subjects of research and the analysis of the keywords gave information about the Caribbean research activity across different topics. This analysis aimed to identify regional specific research trends in the broader field of MVE. The data extracted from the KeyWords Plus® field, which was present in 95.2% of the databases records, were used to analyze the keywords. On the other hand, publications were classified considering the taxonomic categories of the arthropods that are studied in these works. When articles could not be classified into subtopics based solely on metadata, the full text was read to ensure an accurate categorization.

Results and discussion

Scientific production

Scientific production of MVE in the region underwent constant growth during most of the period studied. Figure 1 shows the time series of the annual evolution of scientific production. Even though absolute values fluctuate from one year to another, a growth trend is observed for the entire period. Production peaked in 2016, 2019 (47 documents), and 2020 (54 documents). This growth in production is generally driven by the increase in international scientific collaboration, as will be shown in the section on scientific collaboration indicators in this paper.

This increase in scientific production is linked to the rise in the incidence of problems caused by arthropods. In recent years the Caribbean region has experienced an unprecedented crisis of epidemics due to arboviruses transmitted mainly by *Aedes* mosquitoes. Chikungunya was first reported in the Americas in 2013, on the island of Saint

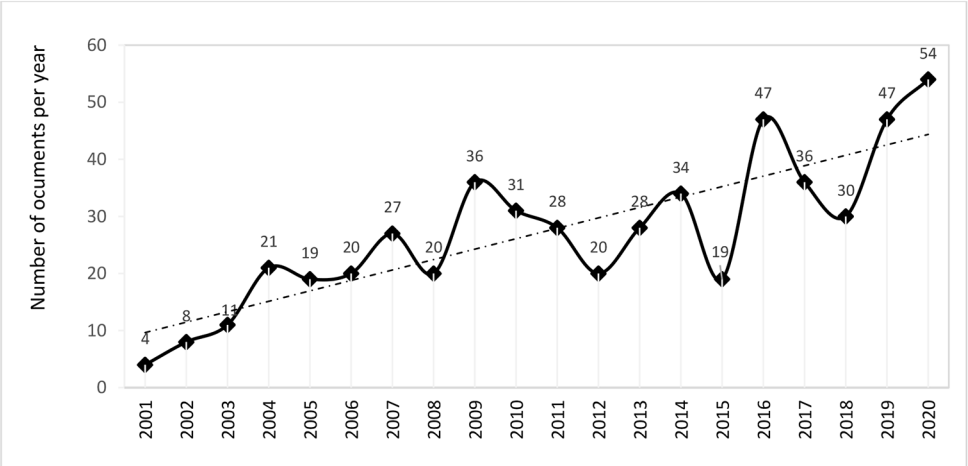


Fig. 1 Annual evolution of insular Caribbean scientific production in the field of MVE, 2001–2020

Table 2 Distribution by country of insular Caribbean scientific production in the field of MVE, 2001–2020

Country	Percentage (%)
Cuba	41.1
Trinidad and Tobago	15.6
Puerto Rico	14.9
Guadeloupe	8.3
St. Kitts and Nevis	5.0
Dominican Republic	3.8
Martinica	3.3
Haiti	2.3
Jamaica	1.6
Granada	1.4
Barbados	1.0
Antigua and Barbuda	0.9
St. Lucia	0.3
Curaçao	0.2
Dominica	0.2
Total	**100.0**

Martin in the northeast Caribbean Sea, leading to more than 2.4 million cases and 440 deaths in the region by December 2016 (PAHO-WHO 2016). Zika reached the insular Caribbean in late 2015 with the confirmation of local transmission in Martinique (European Centre for Disease Prevention and Control [ECDC] 2016). The virus spread rapidly, not only throughout the rest of the Caribbean islands but also threatening to become a huge worldwide pandemic (Troncoso 2016). This epidemiological event led to the declaration of a Public Health Emergency of International Concern (PHEIC) by the World Health Organization (WHO) due to links with neurologic complications in newborns and adults (Lowe et al. 2018). This largely explains the increase in scientific production in 2016.

Regarding dengue, the incidence rates are increasing mainly in tropical and subtropical regions, and in the Americas, a dramatic increase of cases has been reported during the last decades, with the Caribbean being the subregion most affected by several outbreaks (Brathwaite et al. 2012). The most recent dengue outbreaks began in 2019 and persisted into 2020, which explains the peak in production during both years. The re-emergence of other mosquito-borne viruses in the insular Caribbean, such as Mayaro in Haiti (Blohm et al. 2019), will result in increased work on these vectors, which have the aggravating circumstance of inhabiting not only the domestic environment (Diéguez Fernández et al. 2021), but also in other anthropic hotspots, such as dump yards (Borge de Prada et al. 2018), cemeteries (González et al. 2019), and tire repair storage shops (González et al. 2020), among others.

The analysis by countries shows that Cuba was by far the largest regional producer, accounting for 41% of total production, with only Trinidad and Tobago (15.6%) and Puerto Rico (14.9%) contributing between 10% and 16% (see Table 2). Guadeloupe (8.3%), Saint Kitts and Nevis (5%), Dominican Republic (3.8%), Martinique (3.3%), Haiti (2.3%), Jamaica (1.6%), Grenada (1.4%), and Barbados (1.4%) were among the countries that contributed less than 10% of the total. Antigua and Barbuda (0.9%), Saint Lucia (0.3%), Curaçao (0.2%), and Dominica (0.2%) all contributed less than 1%.

Cuba shows the largest production of works in the field of MVE. In fact, this leadership began at the end of the 19th century with Carlos J. Finlay. This Cuban physician is widely considered as the father of medical entomology in the Caribbean. In 1881, he presented persuasive evidence for his theory that yellow fever was transmitted by the mosquito *Aedes aegypti* (Linnaeus, 1762). A century later, the first hemorrhagic dengue epidemic in the Americas was reported in Cuba, strengthening the Cubans' commitment to improving the comprehensive surveillance of mosquito-borne diseases (Guzmán 2012). This country (which is also the largest island in the Caribbean Sea) has provided cooperation and health assistance to different countries in times of meteorological catastrophes, such as hurricanes, floods, and earthquakes. In this assistance, activities related to hygiene and epidemiology stand out, including vector control and research as a key activity in the event of natural disasters and the emergence of epidemics in African, Central American, and even Caribbean countries, such as Haiti and Jamaica (Marquetti et al. 2018). Several studies carried out in these countries have also been signed by scientists with Cuban affiliations.

Types of documents and language of publication

Over the last 20 years, the scientific article (91.5%) has been the vehicle most often used by Caribbean researchers when publishing on MVE. Other types of documents, such as review (3.3%), letter to the editor (1.5%), book chapter. (1.3%), case report (0.9%), editorial material (0.7%), article commentary (0.2%), book-review (0.2%), brief-report (0.2%), and reprint (0.2%) accounted for 8.5% of the total.

English (70.7%) is the dominant language in all of the analyzed scientific production, with Spanish as the second language of publication (29.1%). It is important to highlight that only 14% of the journals that have published these works are from Latin America. In French, which is the official language of Haiti and the French Antilles (Guadeloupe and Martinique), only one paper was published.

The five most productive institutions in MVE in the region were: Instituto de Medicina Tropical Pedro Kourí (IPK), Cuba (19.3% of affiliations), The University of the

Table 3 The most productive insular Caribbean institutions in the field of MVE, 2001–2020

Institution	Number of authored docs	Country	Percentage of region total	Rank
Instituto de Medicina Tropical Pedro Kourí (IPK)	151	Cuba	19.3	1
The University of the West Indies (UWI)	76	Trinidad and Tobago	9.7	2
Centers for Disease Control and Prevention (CDC)	68	Puerto Rico	8.7	3
Ross University School of Veterinary Medicine	28	St Kitts and Nevis	3.6	4
Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD)	23	Guadeloupe	2.9	5
Centros Provinciales de Higiene, Epidemiología y Microbiología (CPHEM)	20	Cuba	2.6	6
Institut Pasteur de la Guadeloupe (IPGp)	20	Guadeloupe	2.6	6
Unidades Provinciales de Vigilancia y Lucha Antivectorial (UPVLA)	19	Cuba	2.4	7
Centro de Ingeniería Genética y Biotecnología (CIGB)	15	Cuba	1.9	8
Centre de Démoustication et de Recherches Entomologiques (CEDRE)	15	Martinique	1.9	8
Unidades Municipales de Higiene, Epidemiología y Microbiología (UMHEM)	13	Cuba	1.7	9
Ministry of Health, Insect Vector Control Division	13	Trinidad and Tobago	1.7	9
Universidad Agroforestal Fernando Arturo de Meriño (UAFAM)	9	Dominican Republic	1.1	10
St. George's University	9	Grenada	1.1	10
Universidad de Puerto Rico	9	Puerto Rico	1.1	10

West Indies (UWI), Trinidad and Tobago (9.7%), Centers for Disease Control and Prevention (CDC), PR USA (8.7%), Ross University School of Veterinary Medicine, St Kitts and Nevis (3.6%), and Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), Guadeloupe (2.9%) (see Table 3). It is noticeable that the only Dominican institution on the list was Universidad Agroforestal Fernando Arturo de Meriño (UAFAM), a university founded in 1996 that contributed significantly more during the study period than other, much more consolidated Dominican institutions, especially considering that it specializes in agroforestry, rather than biology, medicine, or veterinary sciences. The fact that this university invested in a line of research in MVE positioned it as a leader in the country.

IPK, which was founded in 1937 by its namesake, has gained considerable worldwide prestige during the last decades. Formerly engaged in parasitology, it has evolved into one of the top institutions in the Cuban public healthcare system. Today it is a leader in the fields of VBDs and MVE and the most productive institution in the entire insular Caribbean in the latter. During the period 2001–2020, this institution employed 6 of the 10 most productive authors in the insular Caribbean.

Table 4 shows the most productive authors in the region in this research field. Dave Chadee, who has the most documents (62), led research into mosquito-spread diseases, and his work has guided the development of mosquito traps, new disease surveillance systems, and new control strategies in Trinidad and Tobago. Sadly, this great researcher passed away in 2016. In terms of production, he is followed by two outstanding senior researchers, Dr. Barrera of Puerto Rico and Dr. Bisset Lazcano of Cuba. It is important to ensure the transfer of knowledge between different generations of researchers. To retain expertise in MVE, funding agencies will need to strike a balance between field studies on the ecology of vectors and the pathogens they transmit and laboratory research exploring other trends, such as genetics, molecular biology, and computational epidemiology (Reisen 2013).

Scientific collaboration

Table 5 shows the characteristics of scientific collaboration. It should be noted that papers involving more than one type of collaboration (e.g., national and international) have been classified under both headings. The number of papers in collaboration accounted for 77% (415) of total papers. International collaboration was found in 76% (315) of these papers, while national collaboration was found in 43% (180). Intra-regional collaboration was manifested in 6% (31) of the documents with international collaboration, while extra-regional collaboration reached 57% (305). In the total set of documents in the analyzed period, the co-authorship index was 6.5. Figures 2, 3 and 4 show the evolution of collaboration during that period.

Table 4 The most productive authors of insular Caribbean in the field of MVE, 2001–2020

Author	Affiliation	Country	Documents
Chadee, Dave D.	The University of the West Indies (UWI) / Ministry of Health, Insect Vector Control Division	Trinidad and Tobago	62
Barrera, Roberto	Centers for Disease Control and Prevention (CDC)	Puerto Rico	54
Bisset Lazcano, Juan Andrés	Instituto de Medicina Tropical Pedro Kourí (IPK)	Cuba	44
Marquetti Fernández, María del Carmen	Instituto de Medicina Tropical Pedro Kourí (IPK)	Cuba	40
Rodríguez Coto, María Magdalena	Instituto de Medicina Tropical Pedro Kourí (IPK)	Cuba	38
Amador, Manuel	Centers for Disease Control and Prevention (CDC)	Puerto Rico	30
Leyva Silva, Maureen	Instituto de Medicina Tropical Pedro Kourí (IPK)	Cuba	20
Kelly, Patrick John	Ross University, School of Veterinary Medicine	St. Kitts and Nevis	18
Menéndez Díaz, Zulema	Instituto de Medicina Tropical Pedro Kourí (IPK)	Cuba	17
Montada Dorta, Domingo	Instituto de Medicina Tropical Pedro Kourí (IPK)	Cuba	15
Vega-Rua, Anubis	Institut Pasteur de la Guadeloupe (IPGp)	Guadeloupe	15
Yébakima, André	Centre de Démoustication et de Recherches Entomologiques (CEDRE) / VECCOTRA	Martinique	15

Table 5 Indicators of scientific collaboration in the insular Caribbean in the field of MVE, 2001–2020

	Documents	Percentage (%)
Single authorship	28	5.2
Multi-authorship	512	94.8
Total	**540**	
Non-collaboration	125	23
Collaboration	415	77
National	180	43
International	315	76
Intra-regional	31	5.7
Extra-regional	305	56.5
Academic Leadership Index	108	35.4

The number and percentage of documents in international collaboration with the first author is from one of the Caribbean countries is an index of Caribbean researchers' academic leadership in international research groups. Of the total production of the Caribbean in extra-regional international collaboration, the percentage of publications in which the first author was from a Caribbean institution was 35.4%.

The predominance and growing trend of scientific collaboration are observed (Fig. 2). Documents involving collaboration represent on average around 74% of the total number of documents produced in the study period. It is worth noting that, for almost the entire period, the trend of documents with collaboration has been increasing and is higher than that of documents without collaboration, except for the years 2006 and 2008, which coincided with the global financial crisis of 2008. It is also necessary to take into account that the occurrence of regional epidemiological events tends to increase collaboration between researchers.

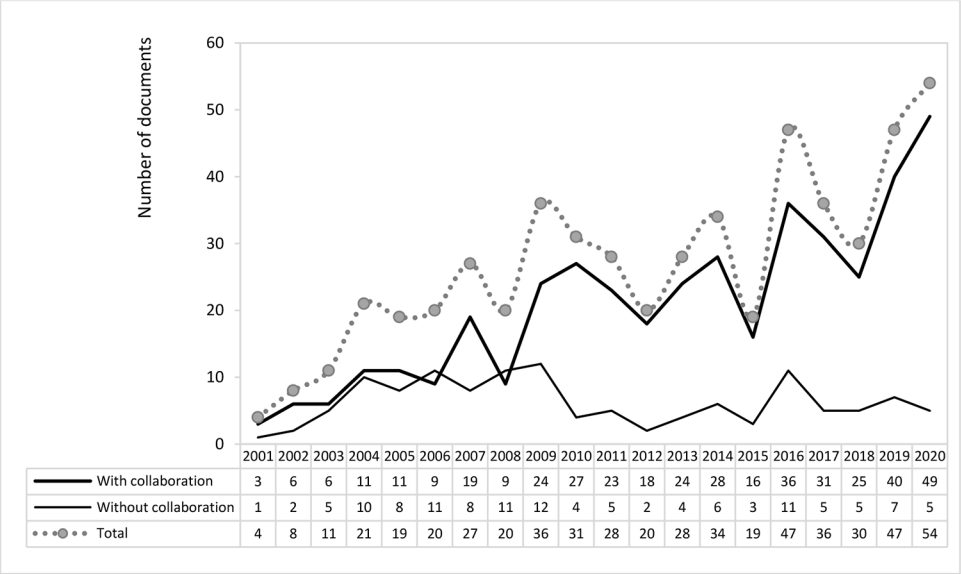
Figure 3 shows the annual evolution of production by type of collaboration. When compared to the national collaboration trend line, the slope of the international collaboration trend was steeper and increasing.

Figure 4 shows the evolution of intra-regional and extra-regional collaboration. Although the number of documents with intra-regional collaboration appears to have increased in recent years, when analyzing the behavior of the series, it is observed that intra-regional collaboration decreased from 2016 to 2018, and grew only slightly in 2019, for which no growth rate can be identified. Extra-regional collaboration showed growth in the last two years.

Visibility, impact and dispersion of scientific production

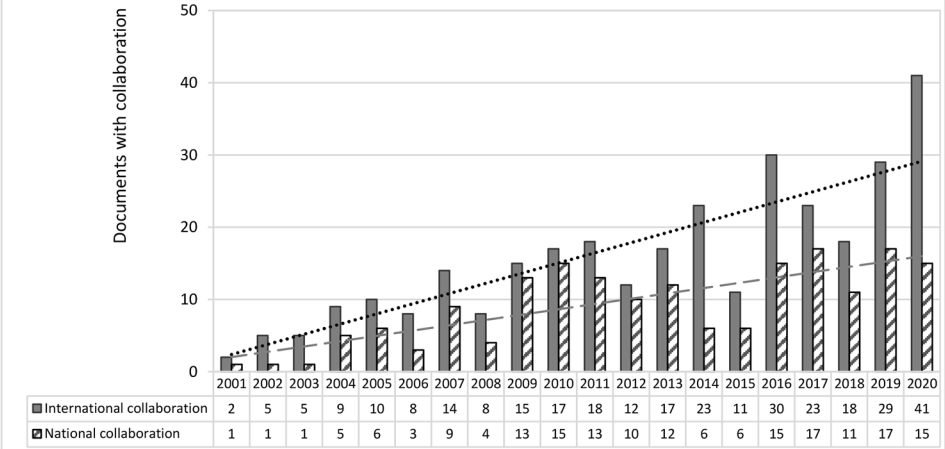
Scientific production on MVE in the region is scattered across 132 sources, mainly published in the USA (34%), England (22%), Switzerland (8%), and the Netherlands (8%). Cuban journals have published the most MVE articles of any country in the Caribbean region (8%). Table 6 highlights the top 10 most productive journals, which collectively published more than half of the region's scientific production in this field (56.3%). In the 2020 edition of the Journal Citation Report (JCR), nine of these journals are indexed.

This paragraph is not a footnote. Please integrate it into the body text of the article, where appropriate.In terms of the journals used for publication, 119 are indexed in the Journal Citation Report (2020), with 31% ranking in the first quartile of their area of research, 28% in the second quartile, 21% and 20% in the third and fourth quartile, respectively. This is an indication that the visibility of research throughout the period was relatively high, reaching almost 60% in the first



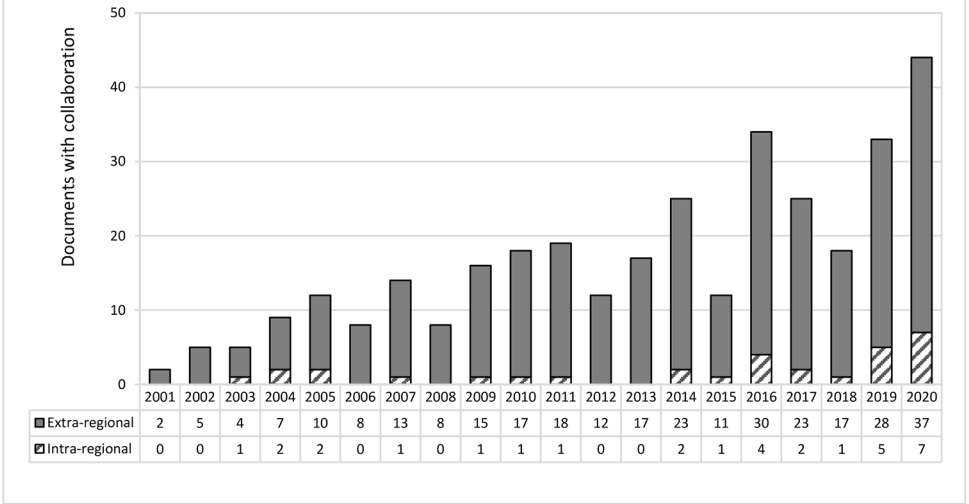
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
With collaboration	3	6	6	11	11	9	19	9	24	27	23	18	24	28	16	36	31	25	40	49
Without collaboration	1	2	5	10	8	11	8	11	12	4	5	2	4	6	3	11	5	5	7	5
Total	4	8	11	21	19	20	27	20	36	31	28	20	28	34	19	47	36	30	47	54

Fig. 2 Annual evolution of scientific collaboration in the insular Caribbean in the field of MVE, 2001–2020: Collaboration vs. Non-collaboration



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
International collaboration	2	5	5	9	10	8	14	8	15	17	18	12	17	23	11	30	23	18	29	41
National collaboration	1	1	1	5	6	3	9	4	13	15	13	10	12	6	6	15	17	11	17	15

Fig. 3 Annual evolution of production by type of collaboration in the insular Caribbean in the field of MVE, 2001–2020: National vs. International



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Extra-regional	2	5	4	7	10	8	13	8	15	17	18	12	17	23	11	30	23	17	28	37
Intra-regional	0	0	1	2	2	0	1	0	1	1	1	0	0	2	1	4	2	1	5	7

Fig. 4 Annual evolution of production by type of collaboration in the insular Caribbean in the field of MVE, 2001–2020: Intra-regional vs. extra-regional

Table 6 Top 10 journals that contributed to insular Caribbean scientific research in the field of MVE, 2000–2021

Journal	Country	Language	JIF*	Q**	Articles	Percentage of total	Cumulative percentage of total
Revista Cubana de Medicina Tropical	Cuba	Spanish, English, Portuguese	-	-	113	20.93%	20.93%
Journal of Medical Entomology	USA	English	2.278	Q1	33	6.11%	27.04%
Journal of The American Mosquito Control Association	USA	English	0.917	Q3	29	5.37%	32.41%
Plos Neglected Tropical Diseases	USA	English	4.411	Q1	25	4.63%	37.04%
Acta Tropica	Netherlands	English	3.112	Q1	24	4.44%	41.48%
Parasites & Vectors	England	English	3.876	Q1	23	4.26%	45.74%
American Journal of Tropical Medicine and Hygiene	USA	English	2.345	Q2	19	3.52%	49.26%
Journal of Vector Ecology	USA	English	1.671	Q2	13	2.41%	51.67%
Tropical Medicine & International Health	USA	English	2.622	Q2	12	2.22%	53.89%
Medical and Veterinary Entomology	USA	English	2.739	Q1	9	1.67%	55.56%

*JIF: Impact Factor (JIF) is the average number of times articles from a journal published in the past two years have been cited in the Journal Citations Report year (Clarivate Analytics)

**Q: Journal Citation Reports (JCR) provide quartile rankings based on rank for the Journal Impact Factor. Quartiles (Q) are defined as the following: Q1 are the highest ranked journals in a category. Q4 are the lowest ranked journals in a category

and second quartiles. A staggering 41% have lower visibility, and the first journal in the top 10 list, *Revista Cubana de Medicina Tropical*, is listed in Scopus and Scielo Citation Index, despite not being in the JCR.

Most cited publications

The most cited publications by insular Caribbean researchers in the field of MVE were identified in WoS (number of citations received ≥ 100). Fifteen articles were cited more than 100 times. Eight of the 10 most cited articles (Table 7), deal directly or indirectly with mosquitoes, one with ticks, and the last one with vector and rodent-borne diseases in general, demonstrating the great impact that these Diptera have in the insular Caribbean and the research efforts that have been made in this particular group.

Research topics analysis

Diptera, Ixodidae, Ceratopogonidae, Muscidae, and Reduviidae were the five taxonomic categories (families) most studied in the field of MVE in the Caribbean. Figure 5 shows the total annual production for each category. Research has primarily focused on Diptera in the last two decades because Culicidae are considered the most relevant family of arthropods in human health worldwide (Becker et al. 2010), as well as in the insular Caribbean (Alarcón-Elbal et al. 2017; Francis et al. 2021). In this geographic context, some synanthropic and widely distributed mosquito species, such as *Ae. aegypti*, *Aedes albopictus* (Skuse, 1894), and *Culex quinquefasciatus* Say, 1823 stand out due to their role in arbovirus transmission (Alarcón-Elbal et al. 2021; Diéguez-Fernández et al. 2021). On the other hand, *Anopheles albimanus* Wiedemann, 1820 is the most important vector of human malaria in the Caribbean Basin, where all the essential transmission conditions still exist on most islands (Rawlins et al. 2008). This is consistent with the results obtained in the analysis of the literature by family, where most of the literature is focused on Culicidae ($n = 396$; 69.0%). The structure of taxonomic topics relations is visualized in a network graph (Fig. 6). Network graphs are typically used to depict relations in data. In this case, Fig. 6 shows a hierarchical structure with nodes representing topics and lines representing relationships between them. The Phylum Arthropoda is first, followed by Classes, Orders, and Families, and finally, the frequency with which it is published in the documents. This graph will give a panoramic vision of the variety of these insects that are studied in the Caribbean region.

The predominance of the order Diptera over the rest is even more evident the data is analyzed at this level ($n = 436$; 76.0%) as studies of other Diptera of interest, such as biting midges (Ceratopogonidae), black flies (Simuliidae) and sand flies (Psychodidae), are also included (Fig. 6). The literature on the family Ixodidae is the second most abundant ($n = 67$; 11.7%), and likewise when we consider the order Ixodida ($n = 68$; 11.8%). The most important ticks transmitting pathogens to cattle in the Caribbean islands, and from which most of the works have been published, are: *Amblyomma variegatum* (Fabricius, 1794), a vector of cowdriosis and associated with acute dermatophilosis, *Amblyomma cajennense* (Fabricius, 1787), a potential vector of cowdriosis, and *Boophilus microplus* (Canestrini, 1887), a vector of babesiosis and anaplasmosis (Basu et al. 2012).

Table 7 Top 10 most cited articles published by insular Caribbean researchers in the field of MVE, 2000–2021

First author	Year	Title	Journal	Times cited
Reiter, P.	2001	Climate change and mosquito-borne disease	*Environmental Health Perspectives*	455
Gubler, D. J. et al.	2001	Climate variability and change in the United States: Potential impacts on vector- and rodent-borne diseases	*Environmental Health Perspectives*	396
Chouin-Carneiro, T. et al.	2016	Differential susceptibilities of *Aedes aegypti* and *Aedes albopictus* from the Americas to Zika Virus	*PLOS Neglected Tropical Diseases*	381
Harrington, L. C. et al.	2005	Dispersal of the dengue vector *Aedes aegypti* within and between rural communities	*American Journal of Tropical Medicine and Hygiene*	381
Brady, O. J. et al.	2013	Modelling adult *Aedes aegypti* and *Aedes albopictus* survival at different temperatures in laboratory and field settings	*Parasites & Vectors*	216
Barrera, R. et al.	2011	Population dynamics of *Aedes aegypti* and dengue as influenced by weather and human behavior in San Juan, Puerto Rico	*PLOS Neglected Tropical Diseases*	145
Marcombe, S. et al.	2009	Exploring the molecular basis of insecticide resistance in the dengue vector *Aedes aegypti*: a case study in Martinique Island (French West Indies)	*BMC Genomics*	134
Lounibos, L. P. et al.	2002	Does temperature affect the outcome of larval competition between *Aedes aegypti* and *Aedes albopictus*?	*Journal of Vector Ecology*	126
Jahfari, S. et al.	2014	Circulation of four *Anaplasma phagocytophilum* ecotypes in Europe	*Parasites & Vectors*	121
Barrera, R. et al.	2006	Ecological factors influencing *Aedes aegypti* (Diptera: Culicidae) productivity in artificial containers in Salinas, Puerto Rico	*Journal of Medical Entomology*	117

These taxonomic data indicate that there is a clear predominance of articles focusing on medical entomology, much more than those focusing on veterinary entomology. This distinction is often not feasible as many of these vectors can transmit zoonotic agents (pathogens that cause diseases in animals and occasionally infect humans), and no further subclassification has been undertaken.

Concluding remarks

In an increasingly globalized society, the study of MVE is a constantly changing field, influenced by the ongoing movements of arthropod vectors and their pathogens (Smith 2020). In this context, the importance of a One Health approach needs to be emphasized, requiring many professionals (e.g., physicians, veterinarians, and biologists, among others) to unify their efforts in the management of VBDs, several of which are zoonoses. There are still many gaps to be filled in this field, even more so in the insular Caribbean, where there are many low- and middle-income countries with vulnerable healthcare systems and economies heavily dependent on tourism.

In recent years, several promising MVE studies have been carried out in different countries of the insular Caribbean. Cuba remains at the forefront of the region when it comes to conducting studies in this field. Other countries, such as Puerto Rico and Trinidad and Tobago have also made considerable research contributions. Other islands, such as Jamaica and Hispaniola, which contributed significantly in the latter half of the 20th century, have not been as prolific in past years. Fortunately, a change has been observed, and important research has recently been reported. Several studies, including the first report of *Ae. albopictus* in Jamaica (Ali et al. 2019), the first findings of *Aedes vittatus* (Bigot, 1861) in the Dominican Republic (Alarcón-Elbal et al. 2020), and some interesting contributions to the mosquito fauna of Haiti (Samson et al. 2015), all point to the islands' resurgence and hopefully sustained contribution to the field of MVE. Also, research on poorly studied groups, such as the black flies and *Culicoides* biting midges, has recently come to light (González et al. 2022a, b). In the Lesser Antilles, such as Grenada and St. Lucia, promising research on mosquito behavior patterns and infectivity with novel insect-specific viruses are also being carried out (Fitzpatrick et al. 2019; Jeffries et al. 2020).

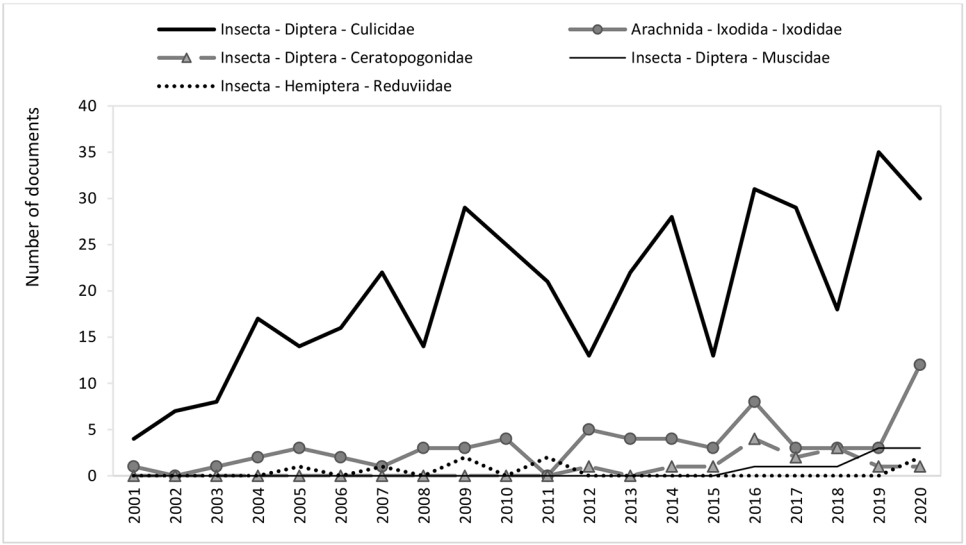


Fig. 5 Annual research output in the insular Caribbean according to top five taxonomic categories of the field of MVE, 2000–2021

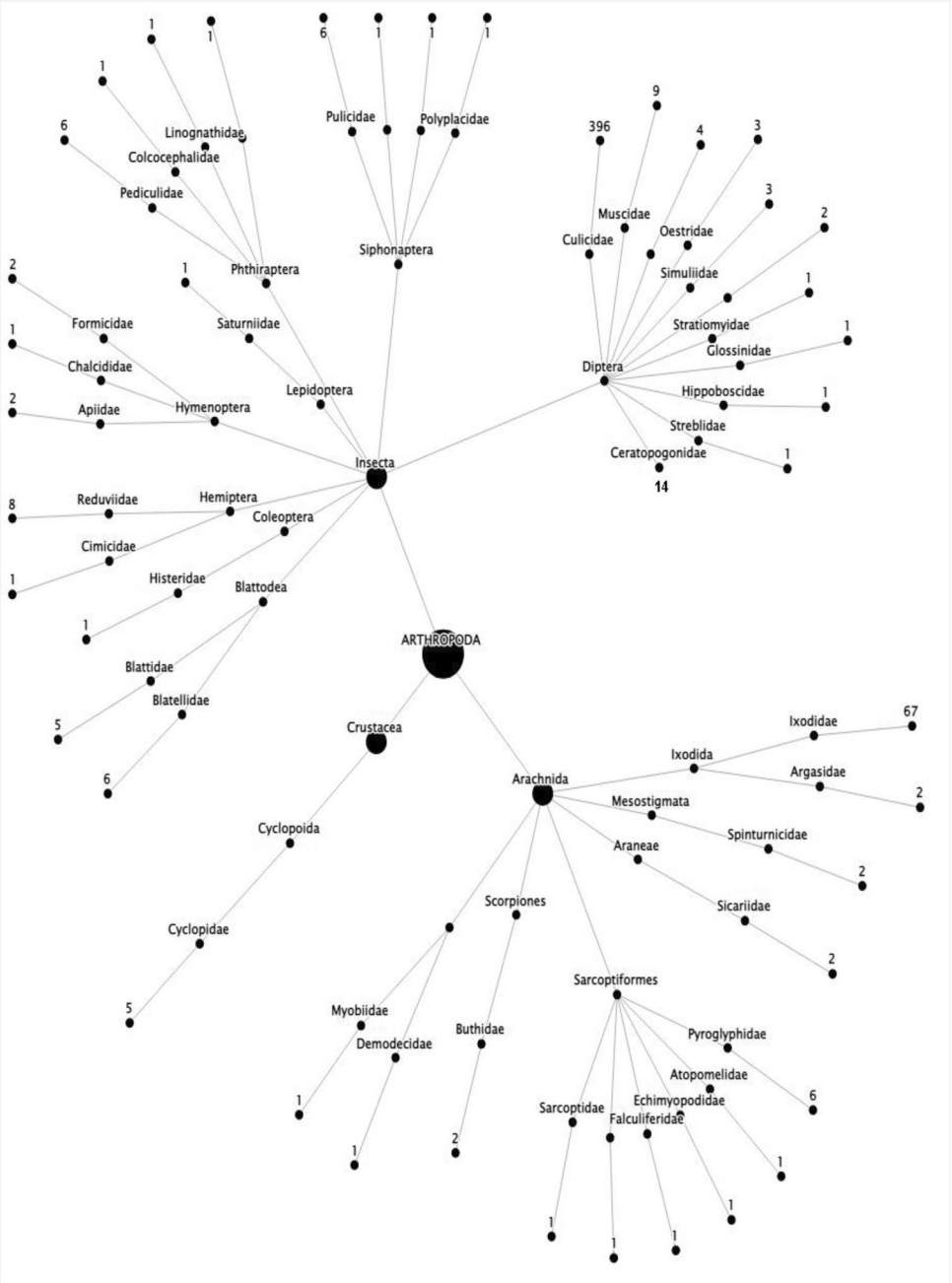


Fig. 6 Graph of taxonomic topics relations of insular Caribbean scientific production in the field of MVE, 2001–2020

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Data availability Not applicable.

Declarations

Ethics approval Not applicable.

Consent to participate Not applicable.

Consent for publication Not applicable.

Conflicts of interest / competing interest The authors have no conflicts of interest to declare that are relevant to the content of this article.

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