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Twenty Years of Research Trends Regarding the Application of Ovitraps in Controlling Aedes sp.; Bibliometric Analysis

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Abstract

Background: One of *Aedes sp.* vector control that is environmentally friendly and relatively cheap in terms of costs is an ovitrap application. Information about research on this matter is still limited.
Objective: The aim of this research focuses on the type of ovitrap, the research methods, the surrounding attractants, and the country chosen for the research described.
Methods: This paper was written as a result of bibliometric analysis of 681 documents from the Scopus, PubMed, and Wiley Online Library databases of 2003-2023. Mapping terms using VOSviewer.
Results: The largest ovitrap type theme was the lethal ovitrap (15.65%), and the smallest was the CDC light trap (2.27%). There are the terms "attractant" and "ovopo attractant" (7.94%) apart from grass and hay infusion at 19.84%. The research method most widely used is intervention research (33.26%), apart from experiments and trials. The research locations that appeared the most were from Southeast Asia (39.06%), Europe (6.86%), the US, Latin America (18.61%), and Australia (6.07%). Research on resistance, first detection, recyclable material, control area, and combination related to the application of ovitrap on *Aedes sp.* has become a trend from 2018 until now.
Conclusion: There are still many themes and challenges in the development of *Aedes sp.* vector control with the ovitrap application.

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Introduction

Insects known as vectors can transfer infectious or infectious illnesses from one person to another (World Health Organization, 2020). One mosquito species that may spread many infectious arbovirus infections (arthropode-borne viruses) that are harmful to the general public's health is *Aedes sp*. (Mundim-Pombo et al., 2021). The main disease transmitted by *Aedes sp* is dengue (Organization, 2009; World Health Organization, 2021). In addition to dengue, other arbovirus-borne illnesses including Zika can also be spread by *Aedes sp*.(Fauci & Morens, 2016; Marcondes & Ximenes, 2016). Infections occurred in people in African nations in 1950 after occurring in monkeys in 1947 (World Health Organization, 2022b). The first case of Chikungunya was reported in Tanzania in 1952 (Erin Staples et al., 2009). As of right moment, Chikungunya has spread to over 110 nations in Asia, Africa, Europe, and America (World Health Organization, 2022a). Severe dengue fever was originally discovered in the Philippines and Thailand at the same time, in 1950 (World Health Organization, 2021). Additionally, reports of Aedes sp. spreading yellow fever exist throughout Africa. (Kamgang et al., 2019).

Currently, controlling the *Aedes sp* vector is a key component of attempts to minimize arbovirus infections. The goal of vector control is to lower the risk of disease transmission by using methods to lessen the availability of habitat for breeding, lower the population of vectors, and decrease human-vector interaction. Chemical, biological, physical, and combined physical, biological, and chemical techniques can all be used to control vectors (World Health Organization, 2021). There are benefits and drawbacks to each of these strategies, so consider these factors before using them. Resistance develops in an environment when pesticides are used repeatedly over an extended length of time. Insecticides of various kinds have been used all over the world to control vectors, such as Aedes sp. The efficiency of this method in managing Aedes mosquitoes must be taken into account, though, given the rising pesticide resistance and the fact that every place is unique. (Demok et al., 2019; Gan et al., 2021; Vontas et al., 2012). A biological vector control technique is the use of natural enemies or biological poisons. Although there are a few issues with using this approach in the field, it has been shown in lab experiments to be both successful and promising. For instance, the duration of exposure, the stage of larval development, the availability of food, the temperature and quality of the water, and the feeding habits of the intended mosquito population are all important aspects that impact the efficacy of employing *Bacillus sp* as a mosquito pathogen in the field (Melanie et al., 2018). The use of *Wolbachia* still depends on the mosquito's resistance to environmental conditions and its sensitivity to insecticides (Ogunlade et al., 2021).

Mosquito traps are an alternate mechanical way of managing the *Aedes sp* vector (Mahmud et al., 2022). A variety of trap types have been created, including non-lethal traps, sticky autocidal traps, sticky lethal traps without insecticides, and lethal traps with insecticides (Komaria, 2021). The ovitrap was initially employed to find *Ae. albopictus* and *Ae. aegypti* mosquitoes in order to establish appropriate management methods. Fay and Eliason created Ovitrap for the first time in 1966 (Kumawat et al., 2014). Then, the Centers for Disease Control and Prevention (CDC) employed the ovitrap approach extensively (Cilek et al., 2017). Modifications to the ovitrap model were made to enhance its function so that its efficacy is better. To do this, either add a substance that acts as a larvicide to the area where mosquitoes deposit their eggs on the apparatus, or supplement it with an attractant solution. Ovitrap is an inexpensive, easy-to-make, and very successful mosquito control instrument for *Aedes sp*. mosquitoes. Its other benefits include being cheap and ecologically benign (Ambiya et al., 2020).

Ovitrap or larvitrap do not appear to be effective in lowering the prevalence of dengue fever, according to a review of research findings on *Aedes* mosquito management in Latin America and the Caribbean (Bardach et al., 2019). In 2011, investigation on the variety of techniques used in dengue fever vector monitoring in endemic and epidemic nations revealed the usage of BG-sentinel traps, autocidal, and sticky ovitraps among other techniques in larval surveys. Ultimately, it is suggested that further research be done on the sensitivity of techniques used to estimate vector population levels and the efficacy of assessing the success of vector control efforts (Azil et al., 2011). The results of a meta-analysis study on dengue fever vector control methods show that the use of mosquito traps can reduce the incidence of dengue fever with an OR value of 1.8 times (Bowman et al., 2016). There is not much information about the development of research results regarding the use of ovitrap in controlling *Aedes sp* mosquitoes, especially in the last twenty years. Therefore, this paper will describe the development of the research results from 2013-2023 related to the type of ovitrap, the research method used by the attractant used to attract mosquitoes, and the region or country where the research was conducted.

Methods

Data source

Currently, with the very rapid development of the use of the internet and digital data, there is a database of research results available that can be accessed globally with very fast access. This study used 3 databases, namely Scopus, PubMed, and Wiley Online Library (WOL), taking into account reputation and the field of biology and health studies. One of the largest comprehensive databases of references to journals, books, and seminar proceedings is Scopus. 240 scientific disciplines are in the Scopus database. Another advantage of Scopus is that each article is indexed 10-15% more than other databases and there are more than 1.8 billion references cited (Elsevier, 2023). Scopus indexes 66.07% more journals than Web of Science and Dimensions, especially in the areas of life sciences, physics, and technology (Singh et al., 2021). The second data source is PubMed, which is a database containing references and research results on natural sciences and biomedical themes. In PubMed, there are more than 35 million citations in biomedical references from Medline which is managed by the National Library of Medicine USA (Medicine, 2022). PubMed is the front door to health science references for millions of researchers, students, doctors, and the general public (pubmed, 2020). The next database used is WOL, this database has the largest collection in the world from multidisciplinary sciences including natural sciences, health, physics, and social humanities. More than 1600 journals, 22,000 ebooks, and more than 250 other types of references (Wiley_VCH, 2023). Bibliography related to research on the use of ovitrap in controlling the *Aedes sp* vector. using the three databases will be carried out in August 2023.

Study design

To find emerging keywords, research theme trends, and the most favorite journals related to publications regarding the application of ovitrap in controlling the *Aedes Sp* vector, bibliometric analysis was used. This analysis is used to show a statistical picture of the development of knowledge and information resulting from studies or research and other information such as journal identity and frequency of keyword similarities (Madani & Weber, 2016). This analysis can also be used to find the number according to highest ranking, indexation quartile category, impact factor, and publishing country of the journal. This refers to the latest related papers. Analysis based on search keywords is used to obtain rankings according to the number of words or phrases based on their frequency, both those that are rare and those that are widely researched. The keywords or phrases searched are related to ovitrap applications, research methods, and research areas. The mapping chart which is the result of the free VOSviewer version 1.6.18 tool is used to present keyword network data based on the research period. Data validation in this bibliometric compilation was carried out through several stages. The first step involved selecting relevant and accurate database sources, followed by a search using a Boolean system. The third stage was identifying and eliminating duplications through double-checking with VOSviewer and Mendeley.

Search strategy

Search for paper theme keywords using "ovitrap" and the MeSH term "Aedes". MeSH (Medical Subject Headings) is the NLM-controlled vocabulary thesaurus used for indexing articles for PubMed (Medicine, 2023). Inclusion criteria for documents included in the data processing include research articles on Aedes control using ovitraps, written in English, and in the form of abstracts or full papers. Excluded articles are review articles and not from scientific journals. In the Scopus and WOL data bases, the same keywords are used, namely "Aedes" AND "ovitrap". The search was limited to 3 data bases covering publication years 2003-2023, keywords obtained from titles and abstracts and documents in the form of journals. Document selection began in 2003, because that was the year the first evaluation of the effectiveness of insecticide-treated ovitraps (lethal ovitraps) in the field began(M J Perich, A Kardec, I A Braga, I F Portal, R Burge, B C Zeichner, W A Brogdon, 2003). Management to eliminate duplication used free software, namely Mendeley online (open source), obtained 681 documents.

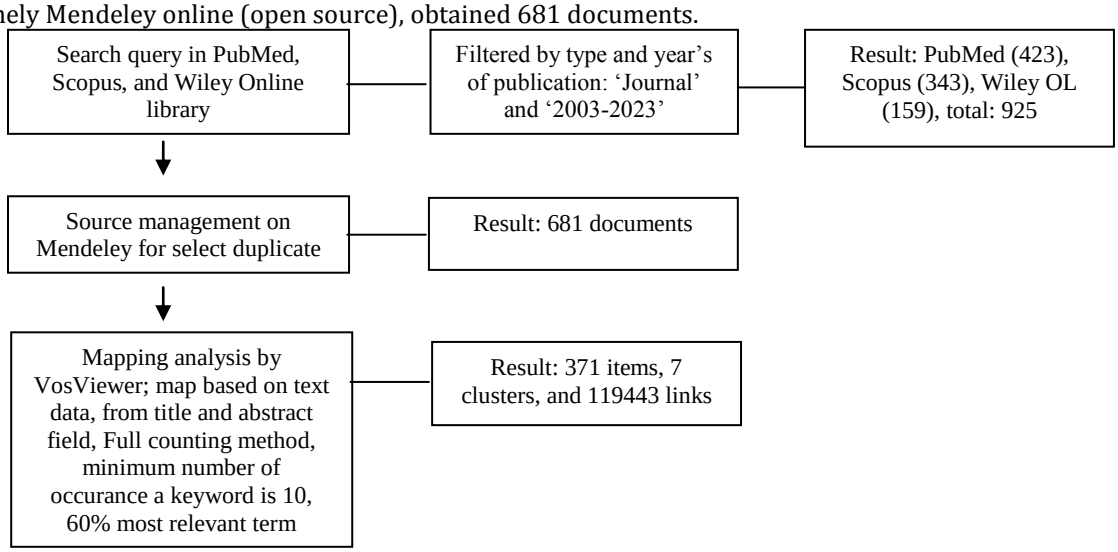

Figure 1. Bibliometric study strategy

Data Analysis

All documents resulting from searching from 3 databases are compiled from Mendeley into RIS formatted files. The file is then processed in VOSviewer to extract words or phrases based on similar occurrences in the title and abstract. VOSviewer is a useful program in bibliometric network analysis. Publication mapping can be based on citations, link networks or keyword mapping can also be made based on co-occurrence networks (Van Eck & Waltman, 2012). This paper will describe the distribution according to ovitrap-type keyword groups, research methods, and research areas. In VosViewer, the full counting method is used and the minimum number of occurrences is 10. The default terms that are relevant to the search keywords are 60% relevant, resulting in 371 items with 7 clusters and 119,443 links. This article does not analyze statistical significance because it focuses on the bibliography of related articles.

Results

Table 1. Top 20 Journals Based on Number of Articles About Ovitrap Application on *Aedes Sp*. Published

No	Journal title	Issue nation	Publication			
			N	%	Quartile Category (Q)	IF
1	Journal of Medical Entomology	USA oxford	56	8.22	1	0.69
2	Journal of Vector Ecology	United States	50	7.34	2	0.46
3	Parasites and Vectors	United Kingdom	44	6.46	1	0.96
4	Journal of the American Mosquito Control Associati	United States	42	6.17	3	0.39
5	Medical and Veterinary Entomology	United Kingdom	42	6.02	1	0.64
6	Tropical Biomedicine	Malaysia	29	4.26	3	0.27
7	Tropical Medicine & International Health	United Kingdom	28	4.11	2	0.79
8	PLoS Neglected Tropical Diseases	United States	20	2.94	1	1.3
9	Pest Management Science	United Kingdom	18	2.64	1	1.02
10	PLoS ONE	United States	16	2.35	1	0.89
11	Acta tropica	Netherland	15	2.20	1	0.75
12	Insects	Switzerland	15	2.20	1	0.79
13	Memorias do Instituto Oswaldo Cruz	Brazil	15	2.20	3	0.55
14	Parasitology Research	Germany	12	1.76	1	0.60
15	Revista da Sociedade Brasileira de Medicina Tropic	Brazil	10	1.47	3	0.42
16	The American journal of tropical medicine and hygiene	US	9	1.32	1	1.04
17	Dengue Bulletin	Switzerland	7	1.03	Discontinue after 2012	
18	Journal of Vector Borne Diseases	India	7	1.03	4	0.23
19	The Southeast Asian journal of tropical medicine and Public Health	Thailand	7	1.03	4	0.13
20	Malaysian Journal of Medicine and Health Sciences	Malaysia	6	0.88	4	0.14
	Total		448	65.79	Mean of IF	0.60

Source: scimagojr.com, August 2023
IF= Impact Factor

Search results from three databases obtained 618 documents in 156 journals. The 20 journals with the highest frequency (65.79% of total documents) published ovitrap and *Aedes sp* research themes were published in America (25.99%), followed by England (19.23%), Malaysia, Brazil, and Switzerland with 10% each. And 50% of these journals are included in quartile 1. The largest number of publications is in the 'Journal of Medical Entomology' with 8.22% of documents. The highest impact factor in 'PLoS Neglected Tropical Diseases' is 1.3 and there is a journal that has been discounted since 2012, namely 'dengue bulletin' from Switzerland. Journals originating from Asia (Malaysia, Thailand, and India) are ranked at the bottom, namely in the 3-4 quartile category. The number of documents published in Malaysia has reached the top six, namely the journal 'Tropical Medicine' with a total of 4.26% of documents. Among the 156 journals, from Indonesia there are the journals 'Kemas', Semarang State University, and 'Kesmas', University of Indonesia, both of which have been indexed in Scopus with one document each.

According to the findings of a bibliographic analysis, the Medicine journal is the one that publishes the most on the Aedes sp vector and related illnesses (Vega-Almeida et al., 2018), this is similar to publications on ovitrap, namely Medical Entomology. publications in veterinary-related journals, where the proportion ranking at rank 5 is likewise not significantly different from the findings of our investigation. In contrast, Rosa Lidia et al, Veterinary journal ranked 6th. The findings of this study are consistent with those of Rasa Lidia's research on journal publishing nations, the biggest of which being Brazil and the United States. India serves as the representative for Asia; it is a productive nation that publishes well on both the ovitrap and the *Aedes sp* vector.

Table 2. Frequency Distribution of Items Associated with "Ovitrap" and "Aedes Sp." Contains Attractant, Field, Research Method, and Ovitrap Type.

Ovitrap	F	%	Research Methode & Attractant	F	%	Field	F	%
Lethal ovitrap	69	15.65	Intervention	142	33.26	Malaysia	185	24.41
Sticky ovitrap	55	12.47	Laboratory	87	20.37	Italy	67	8.84
Ovitrap surveilance	49	11.11	Trial	65	15.22	Europe	52	6.86
Sticky trap	44	9.98	Experiment	60	14.05	Argentina	46	6.07
Autocidal gravid trap	37	8.39	Field trial	34	7.96	Australia	46	6.07
Ovoposition trap	37	8.39	Control methode	26	6.09	Srilanka	40	5.28
Ago trap	36	8.16	Field experiment	13	3.04	Puerto rico	32	4.22
Standart ovitrap	24	5.44				Indonesia	30	3.96
Mosquitrap	23	5.22	BG sentinel trap	39	15.48	Thailand	26	3.43
Autocidal Ovitrap	18	4.08	Attracctand	36	14.29	Florida	25	3.30
Ovitrap collection	15	3.40	Attraction	32	12.70	Austria	22	2.90
Conventional ovitrap	13	2.95	Grass infussion	25	9.92	Spain	20	2.64
Outdoor ovitrap	11	2.49	Hay Infussion	25	9.92	Trinidad	19	2.51
CDC light trap	10	2.27	Attractiveness	22	8.73	USA	19	2.51
			Ovopo attractant	20	7.94	Germany	18	2.37
			BG sentinel	17	6.75	Switzerland	17	2.24
			BG-Lure	15	5.95	Shah Alam	15	1.98
			Piper nigrum I	11	4.37	Africa	14	1.85
			Boric acid	10	3.97	Czech	11	1.45
						pakistan	11	1.45

Of the 371 items, identified according to ovitrap type groups, 14 terms were obtained. The one with the highest frequency of appearance is the lethal ovitrap while the smallest is the CDC light trap. Of the 14 items, there are only 3 types of traps for adult mosquitoes, namely AGO trap, mosquito trap, and CDC light trap, the rest are all egg traps. 3 types of traps indicate that the trap is a dead trap, namely lethal ovitrap, autocidal gravid trap, and autocidal ovitrap. More standard ovitrap (5.44%) appeared than conventional ovitrap (3.40%). 2 terms indicate ovitrap is used in mosquito collection activities, namely ovitrap surveillance and ovitrap collection. Based on the placement application, outdoor ovitrap was found (2.49%). In terms of lethal ovitrap, ovitrap is evolving pretty quickly in terms of both use and research. This technique has been used in Peru and has proven successful in lowering dengue illness incidence by 75% (Paz-Soldan et al., 2016). Studies on the autocidal gravid ovitrap have emerged as a cost-effective and alternative method of reducing *Aedes Sp* density (Barrera et al., 2014).

The research method most often mentioned in research on ovitrap and Aedes sp. is intervention research (33.26%). Meanwhile, the use of the term 'field experiment' method is the smallest, only 3.04% compared to the term 'field trial' which occurs more frequently (7.96%). Meanwhile, the use of the term trial (15.22%) is greater than the experiment which is only 14.05%. Research in 'laboratories' was ranked second in terms of frequency of occurrence, namely (20.37%). Meanwhile, the research method using a control group, namely the 'control method', was only 6.09%.b It is still common practice to use this kind of ovitrap for study, development, and publishing. Interventions in public health are required to lower the burden of disease (Craig et al., 2017). The percentage of "field experiment" type is higher, indicating that this research approach is still highly significant in helping to control the *Aedes sp* vector, which is primarily responsible for the rise in dengue fever. Experimental and interventional methods are the most widely used in ovitrap research for Aedes mosquito control. These methods are used to improve and develop more effective traps, assess their impact on mosquito populations and arbovirus transmission, and optimize surveillance and intervention efforts. Researchers modify ovitraps to increase their efficacy in capturing eggs or adults, using features such as sticky surfaces or attractants, and experimenting with different designs and placements to identify the most efficient methods for detecting and controlling Aedes populations (Fernandes et al., 2025)(Widyanto & Santjaka, 2020).

In the group using attractants in the ovitrap application on *Aedes sp*, the terms 'Attractand', 'Attraction', 'Attractiveness', and 'ovopo attractant' were found whose total frequency of appearance reached 43.66%. Meanwhile, the attractants that come from soaking plants include 'grass infusion' and 'hay infusion', each of which has the same frequency of appearance, namely 9.92%. Also found was the use

of 'BG sentinel trap', BG sentinel', and 'BG-lure', the total frequency of occurrence of which reached 28.18%. A part from that, the use of 'piper nigrum I' (4.37%) and 'boric acid' (3.97%) were also found. Nearly half of the papers on deadly ovitrap on *Aedes sp* employ attractants, according on data recapitulated from documents. It may be possible to lower mosquito density and, in turn, lessen the spread of the dengue virus by employing "attract and kill" strategies with natural substances and combinations with insecticidal compounds (Scott-Fiorenzano et al., 2017). The research topics that are most frequently mentioned include "grass infusion," "hay infusion," "piper nigrum," and "boric acid." More study is still needed to determine the suitability of other natural compounds as attractants.

Most frequently referenced about the use of ovitrap on *Aedes sp,* with 24.41%, followed by 'Shah Alam' at 1.98%. Other Southeast Asian nations that received a lot of mentions were Malaysia (39.06%), Sri Lanka (5.28%), Indonesia (3.96%), and Thailand (3.43%). The paper makes extensive reference to 23.48% of the nations in Europe, with Italy (8.84%), Austria (2.90%), Spain (2.64), Switzerland (2.24), and the European word itself coming in at 6.86%. The United States, Florida, and Latin American nations like Trinidad, Puerto Rico, and Argentina make up no more than one-fifth (18.61%) of the total. Beyond Africa, a small portion of Central Asia (Pakistan), and then the 20 countries with the highest frequency of former Soviet Union (Czech). According to the WHO report of 2023, dengue is present in 80 countries worldwide, with over 80% of cases being recorded from the Americas. Ten of the eleven nations in Southeast Asia alone are endemic regions. Thailand, Sri Lanka, Indonesia, Myanmar, India, and Indonesia are the top 30 nations with the highest dengue endemic rates (World Health Organization, 2023). Since 2008, the number of dengue fever cases in Malaysia has ranked third among countries in the Western Pacific region (Mohd Ngesom et al., 2021). Since 2009, Malaysia has intensified the use of ovitraps for surveillance in its dengue infection control program (Wan-Norafikah et al., 2009). To date, Malaysia has produced the most research reports on ovitraps . This demonstrates the regularity of the amount of ovitrap research conducted in various nations.

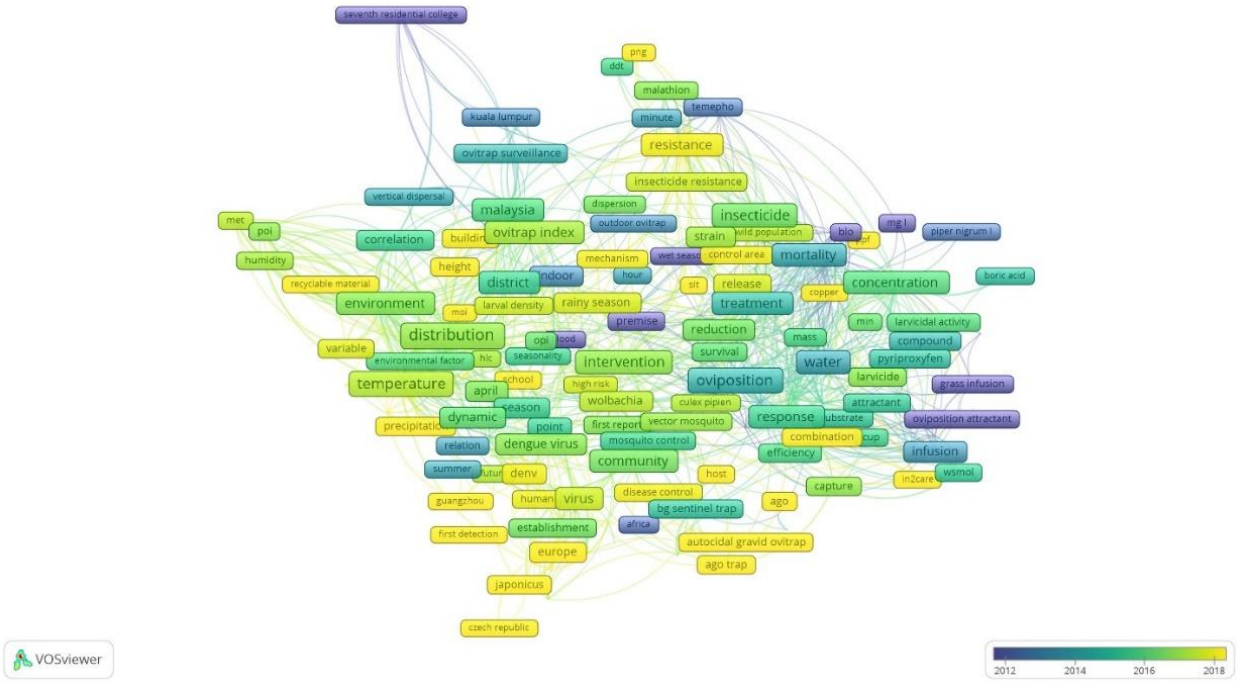

Figure 3. Overlay Visualization of Ovitrap application on *Aedes sp* Vector Control (2003-2023)

There have been many studies about ovitrap surveillance, oviposition, related attractants, larvacidal activity, bg sentinel trap, and insecticide. Around 2016, larvacide still appeared in many publications apart from the ovitrap index, environmental factors such as humidity, temperature, season, rainy season, and studies on reduction. From 2018 until now, the research trend has been about resistance, first detection, recyclable material, agotrap, autocidal gravid ovitrap, control area, and combination related to ovitrap application on Aedes sp. Many studies related to ovitrap in recent years have come from Europe, China, and the Czech Republic, while from Southeast Asia the only ones seen have been Malaysia, many of which were before 2018.

Conclusion

The results showed that the largest ovitrap type theme was lethal ovitrap (15.65%), and the smallest was the CDC light trap (2.27%). For the attractant theme, there are the terms attractant and ovopo attractant (7.94%) apart from grass and hay infusion at 19.84%, then BG sentinel trap (15.48%). The research method most widely used is intervention research (33.26%), apart from experiments and trials. The research locations that appeared the most were from Southeast Asia (39.06%), including Malaysia, Sri Lanka, Indonesia, and Thailand. Apart from that, Europe (6.86%), the US, Latin America (18.61%), and Australia also accounted for 6.07%. Research on resistance, first detection, recyclable material, agotrap, autocidal gravid ovitrap, control area, and combination related to the application of ovitrap on *Aedes sp* has become a trend since 2018 until now. There are still many themes and challenges in the development of *Aedes sp* vector control with the ovitrap application. The combination of lethal ovitrap and light trap is a research opportunity in the future.

Author Contributions

Suharyo contributed to the design and writing of the manuscript; Mursid R, Martini, and Muh. Fauzi supervised and critically revised the final version of the manuscript; All authors have read and agreed to the published version of the manuscript.

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