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Potential Of Organic Infusion As a Preferred Attractant for Mosquito Oviposition: A Literature Review

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Abstract

This study reviews the potential of organic substances (organic infusion) as an attractant for oviposition of gravid mosquito trap in surveillance and control of the mosquito-borne disease based on literature indexed by Scopus and Web of Science (WOS), such as PubMed, ScienceDirect, MDPI, Springer, Wely, SiELO, and Cochrane Database of Systematic Reviews. A total of 1,804 scientific papers were obtained, and only 12 articles met the inclusion criteria. All selected articles were quantitative studies (laboratory, semifield, and field studies). The results showed that the Ae. aegypti, Ae. albopictus and various species of Culex are attracted to organic infusion. The organic infusion is effective in attracting mosquitoes to lay eggs in traps, especially Aedes spp. It can be used as surveillance and the best solution in environmentally friendly disease vector control.

Keywords : Organic, mosquito, trap

Introduction

Vector-borne diseases are still a global health problem (El Amri et al., 2020; Ligsay et al., 2021; Sweileh, 2020). As a result, various vector control measures have been implemented, such as the use of insecticides and larvicides (Lamaningao et al., 2020; Muturi et al., 2020; Raul et al., 2021). However, continuous use of insecticides can lead to vector resistance (Boyer et al., 2018; Li et al., 2021; Moyes et al., 2017; Vontas et al., 2020), undesirable effects on natural enemies and non-target organisms, and environmental damage (Abeyasuriya et al., 2017; Page et al., 2014; Pinkney et al., 2000; Su et al., 2014).

The World Health Organization (WHO) urged vector control programs to find and implement more environmentally friendly and cost-effective strategies through Integrated Vector Management (IVM) (Mutero et al., 2020; Nurlaela & Mardliyah, 2021; Tur et al., 2021; WHO, 2004). One of the measures is the use of mosquito attractants inserted into a trap called an Ovitrap (Marin, Mahiba, et al., 2020; Nascimento et al., 2020). The attractant material can be in chemicals, semi-chemicals, or organic substances (Kim et al., 2021).

On a laboratory scale, adding various insecticides into Ovitrap (Lethal Ovitrap or LO) can increase the mortality by 45 to 100% for larvae and adult mosquitos. The modification of Ovitrap with the addition of attractants has also been developed, such as using 10% hay infusion proved to be more effective at catching mosquito eggs than using tap water (Polson et al., 2002). However, other

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research stated no significant difference between hay infusion and tap water (Alfiantya et al., 2018; Noreen, 2017).

The use of organic materials to attract mosquitoes was developed by Allan and Kline, Díaz-Santiz et al, and Schoelitsz et al. by fermented hay/grass (both dry and fresh) as a base material. The use of organic infusion to attract mosquitoes is environmentally friendly and is considered the best solution for vector disease control. Therefore, this study aims to review the potential of organic infusion as an attractant for the oviposition of various mosquitoes to control disease-transmitting vectors based on available literature.

Methods

The literature review used the PRISMA method, which is a method that identifies, evaluates, and interprets all findings on a particular research topic to answer predetermined questions (Moher et al., 2009). The review was carried out on various articles covering attractants as a preference for oviposition of various mosquito species. Literature was obtained from PubMed, ScienceDirect, MDPI, SciELO, Springer, and Cochrane Database of Systematic Reviews with the keywords "Attractant" and "Preference" and "Mosquito"*.

The bibliographic references of selected articles were manually analyzed to find studies that could be included for review. In addition, documents from gray literature, scientific articles, systematic reviews (SR), meta-analyses, and book chapters that met the inclusion criteria were included as references (Table 1).

Initial selection and screening were carried out by the principal investigator based on the title and abstract. Furthermore, the final selection was made by three reviewer teams consisting of entomologists in Environmental Health and experts in scientific publications of public health. The objectives and roles of each reviewer have been agreed upon in a separate meeting. A table was created to exclude and enter studies as needed. The review focused on the types of organic infusion attractants, both from grass/hay, leaves, flowers, fruits, and other household waste.

Table 1. Inclusion Criteria for Research

Features	Inclusion Criteria
Font Type	articles, book chapters, review articles
Language	English
Period	Unlimited / until 31st December 2020
Design Types	True-Experimental, quasi-experimental

Each article was evaluated based on: Country and year of study, type of study design, intervention evaluation, mosquito species tested, type of organic attractant used, type of traps/Ovitrap and volume of infusion water, and the attractiveness of the organic infusion used.

Results

A total of 1,851 journal results were obtained through the mentioned keywords, and 12 articles were included in this study after screening using the PRISMA method (Figure 1).

The selected articles matched the keywords and met the criteria mentioned in the discussion above (Table 1). The number of articles was reduced to 1720 after the merger of the same articles. After eliminating the publications of books, symposiums, posters, and proceedings, the articles left were 307 scientific articles. Next, the elimination of titles and abstracts resulted in 32 articles. The final selection was based on the discussion of organic infusion attractants in the obtained research, and 12 articles were included as literature for this study (Table 2).

Design

The designs used to test organic infusions are generally quantitative through laboratory bioassays (9,11,12), field studies (2,5,7,10), a combination of laboratory and semifield (8), and a combination

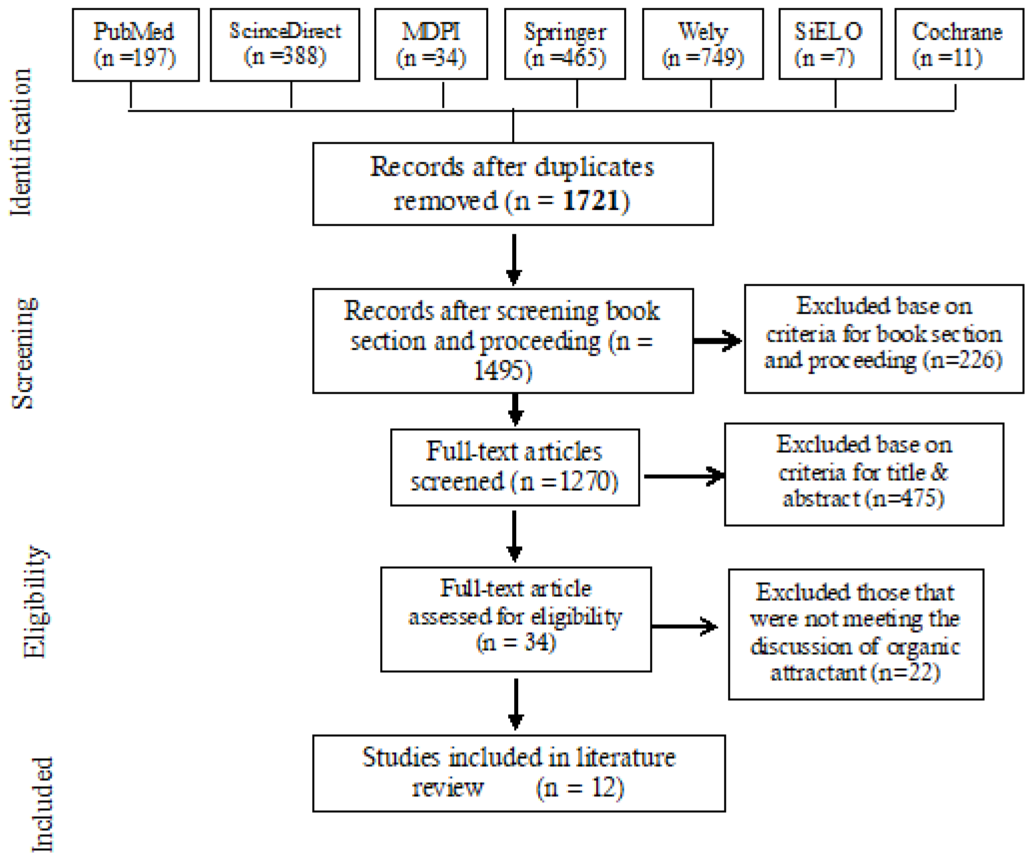

Figure 1. Literature Analysis Process

of laboratory and field bioassays (1,3,4,6,). The duration takes for the study varies, ranging from 24 hours to 1 year for the laboratory scale and 1 to 2 years for the field scale. Meanwhile, the studies were conducted in various countries, such as the US (1,2,3,5,7,8,12), Florida (1,8,12) & Alabama (5,7), Thailand (4), China (6), Brazil (9), Israel (10), Kenya (11).

Tested Mosquito Species

The most common species used in the study were Aedes spp (Ae. aegypti and Ae. albopictus), Culex spp (Cx. quinquefasciatus, Cx. pipiens, Cx. restuans, Cx. tarsalis), Anopheles spp (An. gambiae, An. quadrimaculatus). In addition, laboratory-scale studies in studies 1, 3, 4, 6, 8, 9, 10, and 11 tested the potential for organic infusion to attract certain mosquito species, while the other identified the mosquitoes after the experiment was carried out.

Trap and Atractant

The materials used for infusion were derived from various organic substrates or their combination, such as flowers (6,10), fruits (9), a combination of flowers and fruits (10), vegetables (9), grasses (1,3,5,8,9, and 11), aquatic plants/macrophyte (12), and a combination of leaves and grasses (2,6,7,8). The organic infusion attractant uses fresh leaves and grass then dried (11), and some also use dry leaves (3). The attractant was mixed with water and then fermented and tested with a certain concentration. Besides plants, the rinse water of household waste in the form of leftover side dishes, such as waste of crab shells and shellfish (4), was also used as an infusion material.

Table 2. Various uses of organic infusion as attractants for mosquito oviposition preference

Researcher and year of study	Country	Type of Study	Outcome Measures	Intervention Material (Attractant Infusion)	Traps : Infusion Volume	Treatment Method	Tested Mosquito	Conclusion
(Sandra A. Allan & Kline, 1995)	Florida (US)	Laboratory and Field study	ANOVA	Hay infusion (*10%, 25%, 50%, & 100%),* Larval rearing water, Soil Water (dilution: *5%, 25%, 75%, and 100%)*	*Black plastic glass: 60 ml*	Laboratory Bioassay: Releasing gravid mosquitoes in a cylindrical cage with a trap installed, eggs were counted after 24 hours of treatment. Semi-field Study:Releasing 50 *Aedes* in a 5 x 5 x 5 m cage	*Ae. albopictus,* *Ae. aegypti*	All organic infusions (hay infusion, larva rearing water, and soil water) significantly elicited a strong oviposition response to *Ae. albopictus*, while *Ae. aegypti* have a moderate response to larval rearing water and soil water and low to hay infusion.
2 (Lampman & Novak, 1996)	US	Quantitative design: A field study	Egg raft	Tap water, grass clippings, rabbit chow, alfalfa, oak leaves, maple leaves, bluegrass sod, straw, sod	White plastic bucket: 6 liters	Preference test on four groups in 2 wood gardens with the area of 0.4 Ha for each. The distance between the Ovitrap was 10 m. The culex egg rafts were collected every day.	*Cx. pipiens* *Cx. restuans* *Cx. salinarius*	The number of egg rafts oviposited by *Culex pipiens* and *Culex restuans* in infusion-fed Ovitraps varied according to the type of infusion substrate, age of infusion, method of infusion, and calendar date.
3 (Du & Millar, 1999)	US	Quantitative design: laboratory and Field study	Rakit telur (Eggs-rapts)	Bulrush infusions (100%, 10 %, and 1 %)	Glass = 100 ml a\nd black enamel turkey roasting pans= 5 L	Laboratory bioassays: The glass was placed in the corners of the cage (30x30x45cm), 20 gravid mosquitoes were released, eight repetitions, 15 hours duration. Field: divided into 3 groups, black enamel turkey roasting pans were installed for four nights and then checked	*Cx. quinquefasciatus* *Cx. tarsalis*	Infusion of dried elephant grass has considerable potential as an attractant in the Culex mosquito surveillance and control program.

Researcher and year of study	Country	Type of Study	Outcome Measures	Intervention Material (Attractant Infusion)	Traps : Infusion Volume	Treatment Method	Tested Mosquito	Conclusion
4. (Thavara et al., 2004)	Thailand	Quantitative design: laboratory and field study	ANOVA & Duncan's Multiple Range Test	Rinse water of: Blood cockle (*Anadara granosa*), Carpet shell (*Paphia undulata*) Sea mussel (*Mytilus smaragdinus*) Giant tiger prawn (*Penaeus monodon*).	White plastic cups (height 15 cm, diameter 12 cm) = 300 ml Black flower pots (Height 9 cm, top diameter 10.5 cm) = 300 ml	Labs: 250 gravid *Ae. albopictus* (3-4 days after blood-fed) were released in a screen cage (40x40x40 cm), where five traps were placed for oviposition. Field: 120 pairs of Ovitrap (carpet skin rinse water and rainwater) installed in various habitats	*Ae. albopictus*	Giant tiger prawn and Carpet shell rinses are sources of oviposition attractant for *Ae. albopictus* under both laboratory and field conditions
5. (Burkett-Cadena & Mullen, 2007)	Alabama (US)	Quantitative design: Field study	ANOVA (Tukey Kramer)	Bermuda hay Emergent aquatic on soft rush *(Juncus effuses), Rhynchospora corniculata*; and Bulrush (*Typha latifolia*)	The trap used is not explained; only the fermentation container is explained	The device was placed along 125 m, divided by six blocks; each block consists of 4 types of traps, replicated six times, and collected after 24 hours	*Culex spp.* *Aedes spp*	Bermuda hay infusion was very attractive for *Culex* spp., in particular: *Cx. quinquefasciatus*.
6. (Zhang & Lei, 2008)	China	Laboratory and field study	log(xz1) transformation	Infusion of leave: Fresh Bermuda grass (20,40& 60 days) Camphor tree Box Green bristle grass Lotus magnolia Bamboo	Two types of oviposition cups (sticky & standard) and three of Ovitrap (sticky, standard red, and standard clear): 500 ml	Laboratory Bioassays: 1 Gravid per Cage, 25 cages (30x30x40 cm), 20 days of hay infusion and tap water, repeated 40 & 60 days Field: 16 pairs of sticky Ovitraps (20, 40 & 60 days of infusion each and one tap water), placed between 3–5 m. Simultaneously, a similar test used 16 pairs of standard red Ovitraps mounted at the second site. After a week, mosquitoes trapped in sticky Ovitraps were counted in the microscope	*Ae. albopictus,*	*Ae. albopictus* were more attracted in laying eggs in red traps that had Bermuda grass infusion compared to tap water, both in the insectarium ($P<0.001$) and in the field test ($P<0.001$).

Researcher and year of study	Country	Type of Study	Outcome Measures	Intervention Material (Attractant Infusion)	Traps : Infusion Volume	Treatment Method	Tested Mosquito	Conclusion
7. (Burkett-Cadena & Mullen, 2008)	Alabama (US) (Q3, SJR: 0.42)	Field Study	3-way ANOVA (Turkey Kramer)	Oak leaves, Pine straw, red hardwood mulch (colored), and compost manure.	The type of traps was not shown nor explained. .	Locations were divided into six blocks (CRD), at least 25 m apart. Each block contains 4 Ovitraps arranged in a square. Traps were examined after 24 h for eight weeks of repetition.	*Culex Spp* *Aedes Spp*	Infusions were effective for various mosquito species (*Cx. quinquefasciatus, Cx. restuans, Cx. salinarius, Cx. tarsalis, Cx. nigripalpus, Ae. Albopictus,* and *Ae. triseriatus*).
8. (Obenauer et al., 2010)	Florida (US)	laboratory	ANOVA	WO WO + LP WO + SAG LP SAG Well Water	Black plastic cup: 156 ml	Laboratory Bioassay in aluminum cages (30 x 30 x 30 cm). Each cage consists of 2 traps (one contains infusion and one well water as control). 10% of infusion dilution.	*Ae.albopictus*	The infusion stores more eggs than water alone
		Sem-ifield			Black plastic cup: 200 ml	Field cages, circular (2.13 x 2.74 m high), each cage had four infusion cups (WO, LP, SAG & Well Water), 100 gravid females were released		Mixed infusion (WO + LP) stores significantly more eggs compared to traps containing single infusion
10 (Müller et al., 2011)	Israel	Quantitative design: A field study	T-Test, Attraction index	flowers, fruits, and honeydew	Plastic bottles = 1,5 L	30 traps were placed along the road, 10 m apart, adult mosquitoes trapped were counted every day for eight consecutive days	*Ae. albopictus*	None of the attractants act as a repellent. Very high attractiveness of ornamental flower types: *Tamarix chinensis, Vitex agnus-castus, Polygonum baldchuanicum, Buddleja davidii.*

Researcher and year of study	Country	Type of Study	Outcome Measures	Intervention Material (Attractant Infusion)	Traps : Infusion Volume	Treatment Method	Tested Mosquito	Conclusion
11 (Eneh et al., 2016)	Kenya	Laboratory study	behavioral assays. (linear models)	Fresh Bermuda Grass à dried (diluted 10, 25, 50 & 100%)	Glass cup (Pyrex) = 100 ml	2 pairs of traps (control & test) were placed in the cage (30x30x30 cm). 1 gravid mosquito was released for 24 hours with 3 repetition	*An. gambiae ss*	Anopheles gambiae s.s prefers laying eggs in tap water rather than an infusion of Bermuda hay
12 (Turnipseed et al., 2018)	Florida (US)	Quantitative design: a laboratory study	One-way ANOVA	water hyacinth (*Eichhornia crassipes*), Water lettuce (*Pista stratioles*), 'Parrot's feather (*Myriophyllum aquaticum*), dollarweed (*Hydrocotyle umbellata*)	Clear glass: Pyrex= 295,7 ml & Corning,NY =266 ml (control)	Cage (30x30x30 cm) contained 2 traps, screened after 24 hours, replicated 12 times	*Cx. quinquefasciatus, Ae. aegypti (L.)* *An. quadrimaculatus*	Water hyacinth and water lettuce attracts two out of three mosquitoes species tested

CSO = Combined Sewage Overßows, WO = Water Oak, LP = Longleaf pine, SAG = St. Augustine grass, OAI = Oviposition Activity Indices, CRD= Completely Randomized Design

Discussion

The selection of mosquito oviposition habitat is influenced by a variety of chemical, physical and physiological factors. The female mosquito determines the appropriate place to lay eggs using visual (color, texture, brightness) and olfactory (info chemicals) sensors. Therefore, humans use info chemicals to observe and manipulate mosquito behavior to control diseases and vectors in the future(Schoelitsz et al., 2020). The use of organic infusion as an attractant has a content that can emit chemicals that are volatile and liked by mosquitoes (Soonwera, 2015; Turnipseed et al., 2018).

Based on the literature review results above, all studies inform the potential of organic infusion as a mosquito preference for oviposition. Thus, the use of organic infusion attractants effectively controls disease-transmitting mosquitoes through vectors (Marin, Tennyson, et al., 2020).

Dengue vector, Aedes albopictus, is attractive to an organic infusion from hay (Sandra A. Allan & Kline, 1995), flowers, fruits, and honeydew (Müller et al., 2011), water oak (Obenauer et al., 2010), fresh Bermuda grass (Burkett-Cadena & Mullen, 2007; Zhang & Lei, 2008). Meanwhile. Ae. aegypti is attracted to cashew leaves infusion,(Santos et al., 2010) and water hyacinth (Turnipseed et al., 2018).However, Bermuda hay infusion is not optimal for Anopheles (Eneh et al., 2016).

The infusion of oak leaves, pine straw, fresh Bermuda grass attracted various Culex sp. when applied in the field (Burkett-Cadena & Mullen, 2007, 2008; Zhang & Lei, 2008), while Bulrush infusions can draw Culex spp both in the laboratory and field (Du & Millar, 1999).

However, no studies have been conducted regarding an effective container/trap combined with an effective organic infusion attractant, such as Ovitrap recommended by CDC (Centers for Disease Control) with geosmin attractant (Melo et al., 2020). Therefore, it is necessary to develop further research related to first, comparing each organic infusion (flowers, leaves, grasses) simultaneously to find the most effective one (Acevedo, 2021; Burkett-Cadena & Mullen, 2008; Lampman & Novak, 1996), and the factors affecting its effectiveness (Obenauer et al., 2010; Rajapaksha et al., 2021; Sant'ana et al., 2006). Second, combining the use of effective organic infusion with the various type of trap used. Third, it is necessary to look for a more cost-effective and locally available container in the community.

Finally, this literature review has several limitations. This study may have a bias in publication selection as the initial screening by peers was not carried out. In addition, this study only focuses on the use of organic infusions, does not include the combination of organic infusions with other attractants (chemical and/or biological compounds). Finally, the articles were explored only from six sources. Thus, the findings related to organic infusion were limited and needed to be explored further.

Conclusion

The review study showed that the use of organic infusion from various substrates has the potential as a preferred attractant for oviposition of various Aedes spp., while the type of mosquitoes that were mostly drawn to organic infusion at a field scale was Culex spp. Because of this study based on the literature review, therefore, for further research the effectivity of organic infusion on a field scale is needed as its information is still limited.

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