Jurnal Berkala Epidemiologi
Volume 10 No 1. January 2022. 30 – 39
p-ISSN: 2301-7171; e-ISSN: 2541-092X
DOI: 10.20473/jbe.v10i12022.30–39
https://e-journal.unair.ac.id/JBE/
Email: jbe@fkm.unair.ac.id / jbepid@gmail.com

Jurnal Berkala
EPIDEMIOLOGI
PERIODIC EPIDEMIOLOGY JOURNAL

LITERATURE REVIEW

POTENTIAL BREEDING SITES AND ORGANOPHOSPHATE RESISTANCE STATUS OF *AEDES* SPP. IN YOGYAKARTA

Potensi Tempat Perindukan dan Status Resistensi Aedes* spp. *terhadap Insektisida Organofosfat di Daerah Istimewa Yogyakarta

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ARTICLE INFO

Article History:
Received October, 7th, 2020
Revised form March, 5th, 2021
Accepted December, 31st, 2021
Published online January, 30th, 2022

Keywords:
Aedes spp.;
breeding sites;
density;
organophosphate;
resistant

Kata Kunci:
Aedes spp.*;*
kepadatan;
organofosfat;
resisten;
tempat perindukan

ABSTRACT

Background: The discovery of *Aedes* spp. in the breeding sites is the leading cause of the high incidence of Dengue Hemorrhagic Fever (DHF) in Yogyakarta in 2019. This incidence can be calculated based on the Container Index (CI), House Index (HI), and Breteau Index (BI). Efforts to control the density of *Aedes* spp. The use of organophosphate insecticides in the long term and with the wrong dose will cause resistance. **Purpose:** This research was conducted to determine the potential breeding sites, the density, and the organophosphate resistance status of *Aedes* spp. in Yogyakarta. **Methods:** A literature review with the criteria of referenced journals from 2011-2020, national journals accredited at least Sinta 5 to Sinta 1 and international journals at least Q4 to Q1. **Results:** This study shows that the potential breeding sites for *Aedes* spp. in Yogyakarta, in general, are both indoors or outdoors, stagnant clean water, opened, not exposed to direct sunlight, and the duration of not eradicating the mosquito nests > 1 month. *Aedes* spp. in Yogyakarta has a high population density, so it is at high risk of transmitting dengue cases. The resistance status of *Aedes* spp. in various regions of Yogyakarta are categorized as resistant to organophosphate insecticides. **Conclusion:** Literature review requires field research also, implementation of prevention through the mosquito nests eradication program and 3M (Shutting, Draining, and Burying), and the replacement of insecticides types other than organophosphates.

How to Cite: Qudsiyati, N., Nazara, F. A., Kilima, J. T., & Poerwanto, S. H. (2022). Potential breeding sites and organophosphate resistance status of *Aedes* spp. in Yogyakarta. *Jurnal Berkala Epidemiologi*, *10*(1), 30–39. https://dx.doi.org/10.20473/jbe.v10i12022.30–39

ABSTRAK

Latar Belakang: *Penemuan Aedes* spp. *pada tempat perindukan merupakan penyebab utama tingginya angka kejadian Demam Berdarah Dengue (DBD) di Daerah Istimewa Yogyakarta pada tahun 2019 yang dapat dihitung berdasarkan Container Index (CI), House Index (HI), serta Breteau Index (BI). Upaya pengendalian kepadatan Aedes* spp. *menggunakan insektisida organofosfat selama waktu yang lama dan dosis yang tidak tepat akan mengakibatkan resisten.* ***Tujuan:*** *Penelitian ini dilakukan untuk mengetahui potensi tempat perindukan, kepadatan, dan status resistensi organofosfat Aedes* spp. *di Daerah Istimewa Yogyakarta.* ***Metode:*** *Literature review menggunakan kriteria jurnal referensi tahun 2011-2020, jurnal nasional terakreditasi minimal Sinta 5 sampai Sinta 1 dan jurnal internasional minimal Q4 sampai Q1.* ***Hasil:*** *Studi ini menunjukkan bahwa kontainer yang berpotensi sebagai tempat perindukan nyamuk Aedes* spp. *di Daerah Istimewa Yogyakarta umumnya berada di dalam maupun luar ruang, genangan air bersih yang tidak mengalir, terbuka, tidak terkena sinar matahari langsung, dan durasi tidak melakukan PSN (Pemberantasan Sarang Nyamuk) > 1 bulan. Nyamuk Aedes* spp. *di Daerah Istimewa Yogyakarta memiliki kepadatan populasi yang tinggi, sehingga berisiko tinggi terhadap penularan kasus DBD. Status resistensi nyamuk Aedes* spp. *terhadap insektisida golongan organofosfat dalam penelitian di berbagai wilayah Daerah Istimewa Yogyakarta dikategorikan dalam kriteria resisten terhadap insektisida golongan organofosfat.* ***Kesimpulan:*** *Literature review ini diperlukan penelitian di lapangan juga pelaksanaan pencegahan melalui program pemberantasan sarang nyamuk dan 3M (Menutup, Menguras, dan Mengubur), dan adanya pergantian jenis insektisida selain organofosfat.*

INTRODUCTION

Aedes is a genus in the mosquito cluster (ordo Diptera) that has a vector role in transmitting potentially harmful diseases to humans and animals. *Aedes aegypti* and *Aedes albopictus* are vectors which transmit dengue hemorrhagic fever, Chikungunya, yellow fever, Zika virus, and Rift Valley Fever (Leta et al., 2018).

The case of dengue in DIY in 2019 was reported to have 3.399 cases with seven deaths where Bantul district be the epicentre of dengue cases with 1.424 cases and four deaths; followed by Sleman district with 575 cases and one death; then Kulonprogo district with 478 cases and one death; and last Gunungkidul district with 194 cases (Yogyakarta Health Office, 2020).

The habitat for breeding of *Aedes* spp. generally found in stagnant water, which is located inside things called a container, so there are no standing water located on the ground. Environmental factors such as temperature, precipitation, and moisture can also promote the number of *Aedes* spp. (Ahmed, Hassan, & Elrahman, 2019). Society can also do active preventive participation by identifying potential mosquito breeding sports and ensuring that there are no breeding grounds around the house. The mosquito breeding sites have a significant correlation with the physical aspect of their environment. The physical aspect includes the place/jar of the breeding mosquito, the type of shrink material, the clarity of water or contamination water, water volume, temperature, and humidity (Susanti & Suharyo, 2017).

Increasing population size, the density of dengue vectors, and human movement cause the dengue virus to spread rapidly in Indonesia. Mosquito density as a vector of dengue fever has a high impact on the spread and the transmission of

the DHF disease. The massive effort that society makes to control the breeding of mosquitoes, such as the use of fogging insecticide and household insecticide (Purnamasari, Kadir, & Marhtyni, 2017). Yogyakarta has been using organophosphate insecticides (malathion) and pyrethroid insecticides (cypermethrin) which are replaced the fogging substance in the long term to control dengue fever. Nevertheless, the control effort has not provided a good result, and it shows in the report of dengue cases that still appear annually. Long term use of insecticides did not eliminate *Aedes aegypti* because of resistance, so the importance of designing health policies to insecticide usage (Mulyaningsih, Umniyati, & Hadianto, 2017). It could illustrate that the use of insecticide is less effective in controlling dengue cases in Yogyakarta. Therefore, the resistance of the vector should be detected as soon as possible. It could be checked regularly to know the status of vector resistance in each region, including in Yogyakarta. This research intends to discuss in detail the potential place for breeding *Aedes* spp., the mosquito density, and the resistance status of *Aedes* spp. toward organophosphate insecticide in Yogyakarta (DIY).

METHODS

The method of this literature study was designed to formulate the research question based on the population of interest, intervention, comparison, and outcome (PICO) elements. The information needed for this study was written in the form of a question "do the density of *Aedes* spp. based on entomological parameters and the used organophosphate insecticide affect the dengue haemorrhagic fever cases in Yogyakarta?"

This study was conducted by summarizing a literature review of the journals which are related to the subject of this study, either from national or international journals. The reviewing process used some keywords such as the characteristics of the breeding sites of *Aedes* spp. mosquitoes, the organophosphate resistance status of *Aedes* spp., entomological parameters, resistance mechanisms, and so on. The inclusion criteria-based keyword in topic literature review such as characteristic, binomonic, potential breeding site *Aedes* spp.; CI, HI, BI value; Panggungharjo, Bantul, Gunung Kidul, Sleman, Umbulharjo, Yogyakarta city, detection methods, status resistance, organofosfat. The total of references downloaded were 73 references from Google Scholar, Researchgate, ScienceDirect and saved in google drive. Then, it had done by choosing reference journals with criteria published around 2011-2020. The requirements for the national journal is accredited minimum Sinta 5 to Sinta1, and for the international journal is accredited minimum Q4 to Q1. The literature review flow is shown in Figure 1.

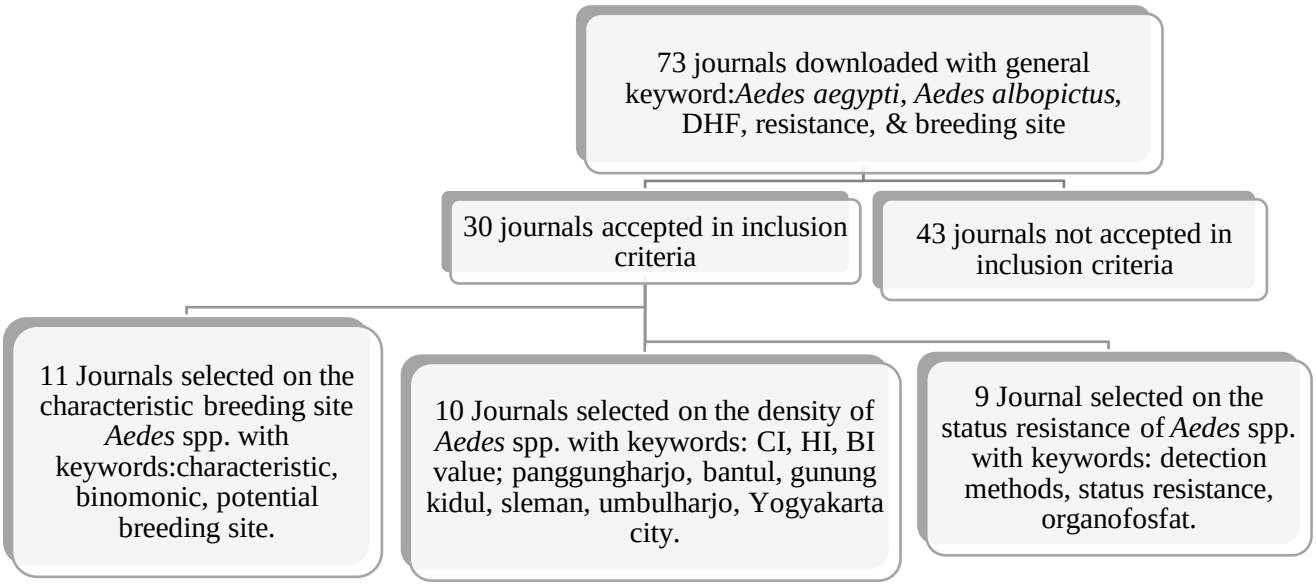


Figure 1. The Literature Review Flow of Potential Breeding Sites and Organophosphate Resistance Status of *Aedes* spp. in Yogyakarta

RESULTS

Potential Breeding Sites of *Aedes* spp.

Based on the container that was examined and to be the breeding sites of *Aedes* spp., the researcher accumulated positive container with *Aedes* spp. larva from many researches which present in Figure 2.

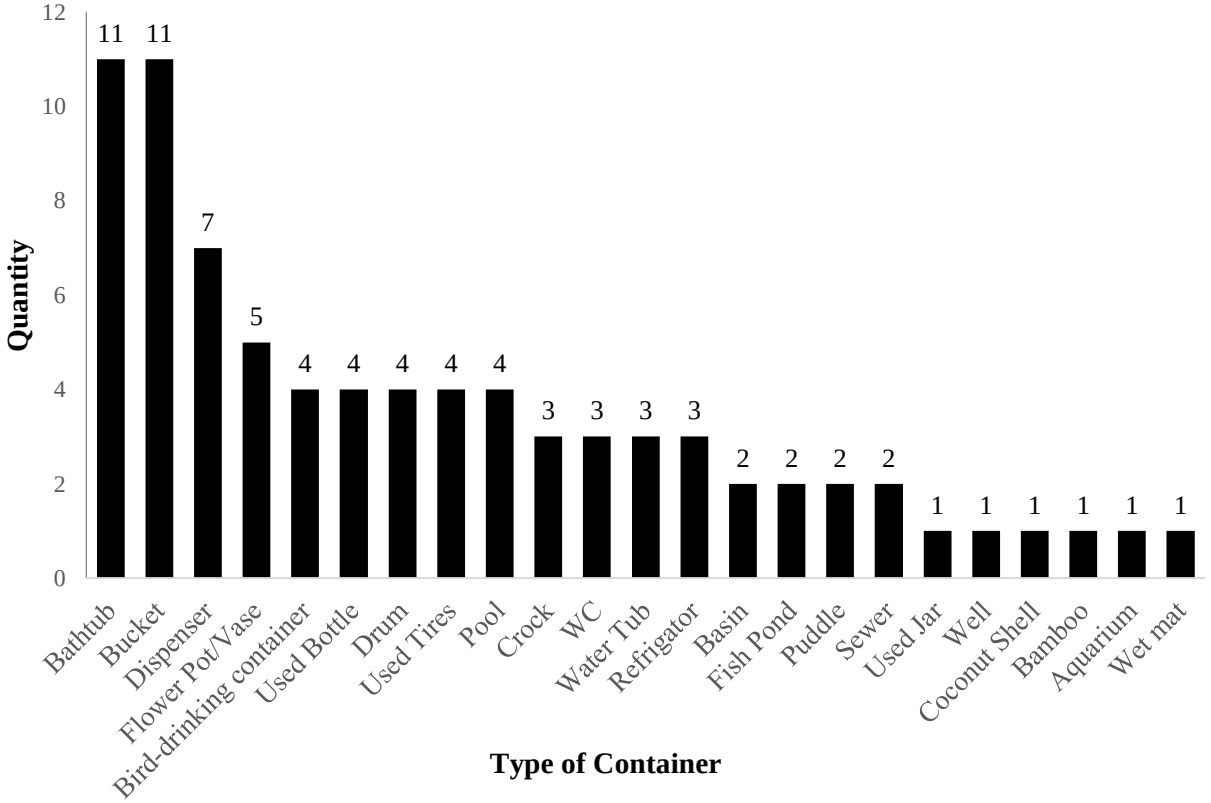
The Density of *Aedes* spp. based on Entomological Parameter

The literature study was based on an entomological parameter in Yogyakarta towards the risk of transmission of dengue hemorrhagic fever. Table 1 regarding the entomology parameter and the risk of transmission of dengue hemorrhagic disease (DHF) in Yogyakarta shows that Yogyakarta has a high-density population of *Aedes* spp., so in general, there is a high infection of DHF cases. The data shows in Table 1.

The literature review was collected from data of density based on parameter entomology (CI, HI, and BI value) in Yogyakarta from journals. The data is presented in Table 2 and the risk category of transmission of dengue fever in Yogyakarta in every reference based on Table 3. The Indicator standard of the high risk in Colombo and Kandy, Srilanka was (HI≥11.90%) and (BI≥ 5.30%). Colombo and Kandy, Sri Lanka, has the same tropical climate as Indonesia with the same climatic conditions so that it can be used as a standard indicator for Yogyakarta, Indonesia (Udayanga et al., 2018).

Organophosphate Insecticide Resistance Status of *Aedes* spp. in Yogyakarta

The literature examined various references of organophosphate insecticides resistance status in villages and sub-districts in Yogyakarta. The resistance status of *Aedes* spp. based on various testing methods in Daerah Istimewa Yogyakarta, most villages and sub-districts in Yogyakarta are categorized as resistant to organophosphate insecticides. The resistance status was stated by each researcher based on the methods and data analysis that they used for their researches. The data is presented in Table 3.



Source: Marza & Shodikin (2016), Pohan, Alvira, Wati, & Nurhadi (2016), Purnamasari, Kadir, & Marhtyni (2017), Budiman & Hamidah (2017), Ramadhani, Nurhayati, & Ismail (2017), Faridah, Hamda, Syafei, & Agrianfanny (2018), Setiyaningsih, Pujiyanti, Hidajat, & Lasmiati (2018), Akhiriyanti & Handoyo (2019), Suhermanto & Ariyani (2019), Washliyah, Tarore, & Salaki (2019), and Windyaraini, Giyantolin, Maulidi, & Marsifah (2019)

Figure 2. Types of positive containers of *Aedes* spp. larvae

Table 1
The Density of *Aedes* Larva based on Entomological Parameter and The Risk Category of Transmission of Dengue Fever in Yogyakarta

Location	CI (%)	HI (%)	BI (%)	Category	Reference
Bantul District					
Panggungharjo Village	5.41	17.00	-	High Risk	Poerwanto, Chusnaifah, Giyantolin, & Windyaraini (2020)
Bangunharjo Village	4.26	13.00	-	High Risk	
Banguntapan Village	33.10	37.00	46.00	High Risk	Widiastuti, Isnani, Sunaryo, & Wijayanti (2018)
Gunungkidul District					
Bejiharjo Village, Karangmojo	36.60	74.00	142.00	High Risk	Widiastuti, Isnani, Sunaryo, & Wijayanti (2018)
Kepek Village, Wonosari	41.90	56.00	78.00	High Risk	
Siraman Village, Wonosari	36.20	58.00	76.00	High Risk	
Sleman District					
Sardonoharjo Village, Ngaglik	47.30	63.00	70.00	High Risk	Widiastuti, Isnani, Sunaryo, & Wijayanti (2018)
Catur tunggal Village, Depok	33.10	50.00	78.00	High Risk	
Sido Agung Village, Godean	20.10	36.00	42.00	High Risk	
Yogyakarta City					
Umbulharjo sub-district	12.95	38.40	123.91	High Risk	Sukesi, Sulistyawati, & Mulasari (2017)
The work area of a local clinic in Umbulharjo I	13.57	36.36	84.00	High Risk	Pohan, Alvira, Wati, & Nurhadi (2016)
Sorosutan Village	21.95	45.00	35.00	High Risk	Windyaraini, Giyantolin, Maulidi, & Marsifah (2019)
Kulonprogo District					
Panjatan Village	14.00	6.31	14.00	Low Risk	Windyaraini, Giyantolin, Maulidi, & Marsifah (2019)

Table 2
Indicator Standard on Entomological Parameter and The Risk Category of Transmission of Dengue Fever

Location	HI (%)	BI (%)	Category	Reference
Colombo, Sri Lanka	$5.50 \leq HI < 8.90$	$2.40 \leq BI < 3.80$	Low Risk	Udayanga et al (2020)
	$8.90 \leq HI < 11.90$	$3.80 \leq BI < 5.00$	Moderate Risk	
	≥ 11.90	≥ 5.00	High Risk	
Kandy, Sri Lanka	$6.90 \leq HI < 9.10$	$2.90 \leq BI < 4.20$	Low Risk	
	$8.90 \geq HI < 11.80$	$4.20 \leq BI < 5.30$	Moderate Risk	
	≥ 11.80	≥ 5.30	High Risk	

DISCUSSIONS

Potential Breeding Sites of *Aedes* spp.

The breeding sites of *Aedes* spp. can be divided into 3 parts, such as water shelter, non-water shelter, and natural water shelter. Water shelter is the daily reservoir for daily needed such as bathtubs, buckets, and jars. Non-water shelter is the place of water, but it is not used for daily needed such as bird drinking, flower vase, and dispenser. Natural water shelter is water reservoirs from nature such as coconut shells, bamboo, leaf sheeting, and so forth (Purnamasari, Kadir, & Marhtyni, 2017).

Table 3
Organophosphate Insecticide Resistance Status of *Aedes* spp. in Yogyakarta

Location	Testing Method	Resistant Status	Reference
Yogyakarta City			
Gondokusuman, Umbulharjo, Tegalrejo	Gondokusuman, Umbulharjo, Tegalrejo	Gondokusuman, Umbulharjo, Tegalrejo	Widiarti et al (2011)
Yogyakarta City	Yogyakarta City	Yogyakarta City	Widiastuti, Isnani, Sunaryo, & Wijayanti (2018)
Sorosutan, Umbulharjo	Sorosutan, Umbulharjo	Sorosutan, Umbulharjo	Windyaraini, Giyantolin, Maulidi, & Marsifah (2019)
Sleman District			
Purwomartani Depok Tamanmartani	Purwomartani Depok Tamanmartani	Purwomartani Depok Tamanmartani	Widiarti et al (2011)
Kabupaten Sleman	Kabupaten Sleman	Kabupaten Sleman	Mulyaningsih et al (2018)
Plosokuning, Minomartani	Plosokuning, Minomartani A biochemical test with esterase enzyme non-specific activity	Plosokuning, Minomartani Moderate Resistance	Mulyaningsih et al (2018)
Malangrejo	Malangrejo A biochemical test with esterase enzym activity	Malangrejo Resistance	Lusiayana, Fitiah, Putri, Rahmi, & Ilham (2019)
Bantul District			
Sewon Kadipiro	Sewon Kadipiro	Sewon Kadipiro	Poerwanto, Chusnaifah, Giyantolin, & Windyaraini (2020)
Bantul District	Bantul District	Bantul District	Poerwanto, Chusnaifah, Giyantolin, & Windyaraini (2020)
Banguntapan	Banguntapan	Banguntapan	Lusiyana (2019)
Panggungharjo Bangunharjo	Panggungharjo Bangunharjo	Panggungharjo Bangunharjo	Poerwanto, Chusnaifah, Giyantolin, & Windyaraini (2020)
Kulonprogo District			
Kulonprogo District	Kulonprogo District	Kulonprogo District	Mulyaningsih, Umniyati, & Hadianto (2017)
Panjatan	Panjatan	Panjatan	Windyaraini, Giyantolin, Maulidi, & Marsifah (2019)

Aedes spp. larva is found generally in the positive container that provides water storage (Akhiriyanti & Handoyo, 2019; Faridah, Hamda, Syafei, & Agrianfanny, 2018; Marza & Shodikin, 2016). *Aedes* spp. larva is generally located inside of the room (Akhiriyanti & Handoyo, 2019; Budiman & Hamidah, 2017; Faridah, Hamda, Syafei, & Agrianfanny, 2018; Marza & Shodikin, 2016; Pohan, Alvira, Wati, & Nurhadi, 2016; Suhermanto & Ariyani, 2019). Nevertheless, it is different from the research conducted by Ramadhani, Nurhayati, & Ismail (2017) dan Setiyaningsih, Pujiyanti, Hidayat, & Lasmiati (2018) showed that the location of the container does not influence the existence of *Aedes* spp. In this case, the location of the positive container does not provide exposure by the sunlight (Akhiriyanti & Handoyo, 2019; Pohan, Alvira, Wati, & Nurhadi, 2016), and it consists of pure stagnant water (Purnamasari, Kadir, & Marhtyni, 2017; Washliyah, Tarore, & Salaki, 2019). Then the positive container had a small volume of water (< 50 litres) (Marza & Shodikin, 2016).

The positive container of *Aedes* spp. larva is generally in open condition (Marza & Shodikin, 2016; Purnamasari, Kadir, & Marhtyni, 2017;

Washliyah, Tarore, & Salaki, 2019). The main material of the positive container is made from ceramic (Budiman & Hamidah, 2017; Pohan, Alvira, Wati, & Nurhadi, 2016). Pohan, Alvira, Wati, & Nurhadi (2016) added that fibre is a high-volume positive container material, while Budiman & Hamidah (2017) and Setiyaningsih, Pujiyanti, Hidajat, & Lasmiati (2018) found that plastic becomes a high quantity of positive container.

The dark or light colour of the container has no significance to the discovery of *Aedes* spp. (Ramadhani, Nurhayati, & Ismail, 2017), this case is quite different from Akhiriyanti & Handoyo (2019), who stated that the dark color has a significant effect on the discovery of the larva. They also claimed that the mosquito nested behavior had not been done for more than one month, which has more potential for *Aedes* spp. Larva, so, it could be concluded that the potential place/ containers of breeding mosquito depend on the location of the container inside or outside of the room, stagnant which do not flow, outside of the room, do not get direct sunlight, and the duration to not to do the mosquito nested behavior more than one month. Then, the different locations of this research obtained a similar result that shows the potential of breeding *Aedes* spp. in Yogyakarta can refer to the research finding of the other place in a tropical country.

The Density of *Aedes* spp. based on Entomology Parameter

Early detection using an index larva vector with a prescribed threshold value can be the effort to control the dengue epidemic. Index larva *Aedes* is House Index (HI), Container Index (CI), Breteau Index (BI) (Udayanga et al., 2020). House Index (the percentage of homes which was found larva/pupa), Container Index (the percentage of the container which found larva/pupa), dan Breteau Index (the percentage of positive container for each home) (Alvarado-Castro et al., 2017).

House Index (HI) $\geq$ 5% indicates that the region has a high number of transmissions of dengue fever. The higher the HI number means, the higher the mosquito density, the higher the population risk of being in contact with mosquitoes and being infected by the dengue virus (Triyanti, Lutpiatina, & Rifqoh, 2019). The Breteau Index (BI) value can be the main idea of controlling vectors by doing chemical fogging in high-risk areas of dengue fever. Then, selecting the high-risk area can initiate and monitor the effectiveness of assessment vector activity control, which can be measured based on entomology parameters (Udayanga et al., 2018).

Each year, the high number of dengue cases continued monitoring of breeding sites of Aedes spp. to determine entomological indicators and the level used of insecticides resistance. Based on the data in Table 1 regarding the entomology parameter and the risk of transmission of dengue hemorrhagic disease in Yogyakarta (DIY) shows that Yogyakarta has a high-density population of *Aedes* spp., so in general, there is a high infection of DHF cases. The high number of *Aedes* mosquito density control the vector with chemical fogging. It is necessary to monitor the breeding sites of *Aedes* spp. and detect to the level used of resistance of insecticides to find an effective way to prevent and control the case. Hence, it is necessary to study mosquito vector resistance status and its possible mechanisms for long-term use of insecticides (Mulyaningsih et al., 2018).

Organophosphate Insecticide Resistance Status of *Aedes* spp. in Yogyakarta

Malathion and temephos from the organophosphate class are often used as insecticides to control *Aedes* spp. (Prasetyowati, Hendri, & Wahono, 2016). The primary mechanism to identified organophosphate resistance in *Aedes* is increased detoxification through esterase enzyme and insensitivity target site acetylcholinesterase (knock-down resistance and kdr). Esterase is a hydrolase enzyme that describes Esther in the organophosphate side chain. Target site acetylcholinesterase (AChE) has a role in the control of the hydrolysis of Acetylcholine (ACh), which means the neurotransmitter produced inside of vesicles in the axon near the synapsis so that when the acetylcholinesterase in the resistant insect has changed it will decrease the sensitivity to decline the enzyme (Karunaratne, De Silva, Weeraratne, & Surendran, 2018).

The method was used in the testing of mosquito resistance toward insecticide such as Bioassay test like WHO Susceptibility Test or CDC Bottle Bioassay Test, Biochemical test detoxification enzyme levels that work for the insecticide(Mulyaningsih et al., 2017), and also can be down by observing gene mutation on target site knock-down resistance (*kdr*) and analysis of PCR quantitative gen P450 (Badolo et al., 2019).

Based on Table 2, it can be concluded that the status of resistance *Aedes* spp. toward organophosphate insecticide in Yogyakarta fulfil the resistant criteria. Based on the study, the

literature showed that the use of organophosphate insecticide as the chemical control could be less effective. There is no innovation in controlling the effort of *Aedes* spp. then the outbreak potential can be grown.

CONCLUSION

Based on the literature study, it can be concluded that the container of potential for *Aedes* spp. generally exist both inside and outside, water stagnant, water without a cover-up, water without sunlight, and the duration to not do the mosquito nested behaviour more than one month and the high density of *Aedes* spp. population in Yogyakarta. Hence, it is generally at high risk of transmitting the case of dengue haemorrhagic fever. The *Aedes* spp. resistance status of the organophosphate insecticides in Yogyakarta can be categorized as resistant to an organophosphate insecticide.

CONFLICT OF INTEREST

There is no conflict of interest.

AUTHORS CONTRIBUTIONS

The author's contribution to this article can be seen in the following details. NQ: Data accuration, data analysis, and editing. FAN: Data accuration, data analysis, and editing. JTK: Visualize, data accuration, and data analysis. SHP: Concept, data accuration, and data analysis.

ACKNOWLEDGMENTS

The author would like thank to the Directorate General of Higher Education - Ministry of Education and Culture Republic of Indonesia that has helped with funding to write this article under program *Program Kreativitas Mahasiswa Bidang Penelitian* (PKM-PE) in 2020 and for PKM Center of Universitas Gadjah Mada who has assisted in the creating of this article.

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