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RESISTANCE OF *Aedes aegypti* TO ORGANOPHOSPHATE INSECTICIDES IN MAGETAN DISTRICT, EAST JAVA, INDONESIA

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ABSTRACT

Dengue haemorrhagic fever (DHF) is one of the infectious diseases transmitted through the mosquito vector *Aedes sp*. Dengue disease management is still aimed at controlling the vector (*Aedes aegypti*) using organophosphate insecticides malation and temefos. In Magetan District, there is no report on the resistance of *Ae. aegypti* to organophosphate insecticides or mapping of *Ae. aegypti* resistance to these insecticides. The results of this research are determine the resistance of *Ae. aegypti* to organophosphate insecticides. The resistance system was established by biochemical test based on the activity of non-specific esterase enzyme against organophosphate insecticides in Magetan District using Arc GIS tool. The results of this study showed that *Ae. aegypti* in four working areas of Candirejo Health Centre from 14 villages 10 villages (71.42%) have been resistant to organophosphate insecticides, while in Taji from 11 villages 7 villages (63.63%) are resistant, in Plaosan 100% are resistant and in Ngujung from 7 villages, 3 villages (42.28%) are resistant. The use of insecticides for a long period of time is not effective in eliminating dengue fever vectors because it can cause resistance. Based on the results of this study, it is necessary to monitor and evaluate the use of insecticides in dengue vector control as a programme at the Magetan District Health Office, so that the right insecticide can be selected for *Ae. aegypti* control.

Keywords: *Ae. aegypti*, Organophosphate Insecticides, Resistance

ABSTRAK

Demam berdarah dengue (DBD) merupakan salah satu penyakit infeksi yang ditularkan melalui vektor nyamuk *Aedes sp*. Penanggulangan penyakit dengue masih ditujukan kepada pengendalian vektornya (*Aedes aegypti*) menggunakan insektisida organofosfat malation dan temefos. Di Kabupaten Magetan belum ada laporan mengenai resistensi *Ae. aegypti* terhadap insektisida organofosfat maupun pemetaan tentang resistensi *Ae. aegypti* terhadap insektisida tersebut. Tujuan penelitian ini adalah untuk mengetahui resistensi *Ae. aegypti* terhadap insektisida organofosfat. Sistem resistensi ditegakkan dengan uji biokemis berdasarkan aktivitas enzim *esterase non specific*

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terhadap insektisida organofosfat di Kabupaten Magetan menggunakan perangkat *Arc GIS.* Hasil penelitian ini menunjukkan *Ae. aegypti* di empat wilayah kerja Puskesmas Candirejo dari 14 desa 10 desa (71,42%) telah resisten terhadap insektisida organofosfat, sedangkan di Taji dari 11 desa 7 desa (63,63%) resisten, di Plaosan 100% resisten dan di Ngujung dari 7 desa, 3 desa (42,28%) resisten. Pemakaian insektisida dalam jangka waktu lama tidak efektif untuk mengeliminasi vektor demam berdarah karena dapat menimbulkan resistensi. Berdasarkan hasil penelitian ini, perlu dilakukan monitoring dan evaluasi penggunaan insektisida dalam pengendalian vektor demam berdarah sebagai program di Dinas Kesehatan Kabupaten Magetan, sehingga bisa dipilih insektisida yang tepat untuk pengendalian *Ae. aegypti*.

Kata Kunci: *Ae. aegypti*, insektisida organofosfat, resistensi

Introduction

Dengue fever (DHF) is a vector-borne disease caused by the dengue virus which belongs to the genus Flavivirus, consisting of four serotypes (Ministry of Health, 2011; Lloyd, 2003; World Health Organization, 1997). DHF is transmitted from person to person through the *Ae. aegypti* vector (Country Office fo India, 2015; Yushananta, 2021; Yushananta, Setiawan, & Tugiyono, 2020).

Data from the Indonesian Ministry of Health's 2021 Profile shows that there were 73,518 cases of DHF or an average incidence rate (IR) of 27 cases/100,000 population and a death rate of 705 people or an Average Case Fatality Rate (CFR) of 0.96% in Indonesia. Magetan District is one of the districts in East Java that is endemic for DHF (Kemenkes RI, 2022). The number of DHF cases in Magetan District in 2021 was 218 cases with a morbidity rate (IR) of 34.3 per 100,000 population and a mortality rate of 1.4%. The highest incidence rate in the Candirejo Health Center work area is 94 per 100,000 residents; the Taji Health Centre working area is also an endemic area while the Plaosan and Ngujung Health Centre working areas are sporadic areas (Profil Kesehatan Magetan, 2021).

The ineffectiveness of vaccines or medication means that insecticide vector control is often used (Sunaryo & Widiastuti, 2018). DHF vector control has been carried out by fogging using malation insecticide and abatement using temefos. Prolonged exposure to insecticides triggers the emergence of resistant insect strains (Pradani *et al.,* 2018) because mosquitoes can adapt to the insecticides used (Francis, 2017). Therefore, there is a need for early detection of the resistance status of Ae. aegypti to organophosphate insecticides in four health centre working areas in Magetan Regency. By knowing the resistance status in a particular area, control strategies can be adjusted by selecting insecticides that are still effective.

Methods

This study is a descriptive observational study with a cross-sectional design. The method used was biochemical test of non-specific esterase enzyme activity against alpha naphthyl acetate. Arc GIS tool was used to map the susceptibility status of *Ae. aegypti* to organophosphate insecticides based on non-specific esterase enzyme activity against alfa-naptyl acetate substrate at larva stage in endemic and sporadic areas. The study was located in four health centre areas of Magetan district in East Java, namely Candirejo, Taji (endemic), Plaosan and Ngujung (sporadic). The study was located in four health centres in Magetan district in East Java, namely Candirejo, Taji, Plaosan

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and Ngujung health centres. Mosquito breeding and susceptibility testing were conducted in the Parasitology Laboratory, Department of Parasitology, Faculty of Medicine UGM. The study was conducted from February to July 2023. Entomological surveys in the form of sampling of *Ae. aegypti* larvae, eggs and adults were conducted in 400 purposively selected houses in four health centre areas namely Candirejo (14 villages), Taji (11 villages), Plaosan (8 villages) and Ngujung (7 villages). 100 houses were taken from each health centre area. Determination of the location of houses was carried out referring to the provisions of FUNASA (Da Silva Soares et al., 2003), and WHO (World Health Organization, 2011) by considering the number of buildings and the House Index (HI). The criteria for houses where the ovitrap was placed included houses reported as DHF case points in the last three years (2020-2022) and houses within a 100 m radius of the case point. Furthermore, eggs, larvae and mosquitoes obtained were maintained in the laboratory to obtain F1 for testing purposes. *Aedes sp*. larvae were reared in the laboratory until they became mosquitoes and laid eggs, and larvae were identified under a microscope and reared until they laid eggs. Filter paper containing mosquito eggs were transferred into plastic trays to hatch along with eggs from ovitraps to become instar I larvae, instar II larvae, instar III larvae, instar IV larvae. Biochemical tests on 3rd instar *Ae. aegypti* larvae were conducted according to the method described by Lee *et al*., (1992). Replications were performed three times. Readings of non-specific esterase enzyme activity against substrate-α naphthyl acetate (AV) were taken by spectophotometer at a wavelength of 450 nanometres. Determination of susceptibility status was based on positive cut off values. Mosquitoes were said to be resistant if AV ≥ cut-off positive and susceptible if AV < cut-off positive. Determination of cut off positive was taken from three larval samples that showed low AV (no colour).

Results and Discussion

The biochemical resistance test of *Ae. aegypti* mosquitoes to organophosphate insecticides for the presence of non-specific esterase enzyme activity against the substrate-α naphthyl acetate was conducted for *Ae. aegypti* mosquitoes from endemic (Candirejo and Taji Puskesmas working areas) and sporadic dengue areas (Plaosan and Ngujung Puskesmas working areas). Examples of the biochemical susceptibility test results can be seen in Figure 1 to 4 and Table 1 to 6 below:

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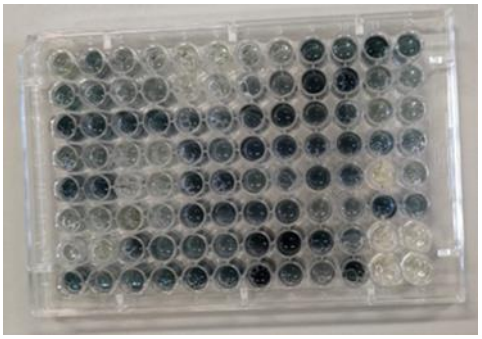

Figure 1. Microplates of biochemical test results on larvae from Candirejo Health Centre working area 1

Biochemical assay describing non-specific esterase enzyme activity against Alfa-naphthyl acetate of *Ae. aegypti* larvae was read using a spectrophotometer at λ = 450 nm. Columns 11-12 rows D-F are laboratory larvae. Column 11-12 rows G - H are blanks. Column 1-2 rows A-F are homogenates of *Ae. aegypti* mosquitoes from Mangkujayan Village. Columns 1-2 rows G-H, columns 3-4 rows A-E are homogenates of *Ae. aegypti* mosquitoes from Bulukerto urban village. Column 3-4 row F-H, column 5-6 row A-C are homogenates of *Ae. aegypti* from Magetan Village, column 5-6 row D-H, column 7-8 row A are homogenates of *Ae. aegypti* from Selosari Village, column 7-8 row B-G are homogenates of *Ae. aegypti* from Tawanganom, column 7-8 row H, column 9-10 row A-E are homogenates of *Ae. aegypti* mosquitoes from Sukowinangun Village. Negative control (susceptible control) was taken from the wells with low AV value and clear colour, i.e. column 3-4 row D, column 5-6 row A-B.

Susceptibility status based on esterase enzyme activity towards Alfa-naphthyl acetate was determined as follows:

Table 1. Determination of the hydrolysis activity of non-specific esterase enzymes against the substrate Alfa-naphthyl acetate using microplate assays related to resistance in *Ae. aegypti* from Candirejo 1 Health Centre wilker, Magetan Regency, East Java.

Location	Mean AV of negative control ± 3SD	Cut off point	Susceptibility status	
			Susceptible %	Resistant %
Mangkujayan	0,1603+ 0,0761	0,236	0	100
Bulukerto	0,1603+ 0,0761	0,236	14,29	85,71
Magetan	0,1603+ 0,0761	0,236	16,67	83,33
Selosari	0,1603+ 0,0761	0,236	0	100
Tawangmangu	0,1603+ 0,0761	0,236	0	100
Kepolorejo	0,1603+ 0,0761	0,236	0	100
Sukowinangun	0,1603+ 0,0761	0,236	0	100

Resistant = AV ≥ Cut-off positive; Susceptible = AV < Cut-off positive.

The distribution and frequency of the measurement results of the mean value of negative control AV + 3SD are presented in Table 5.4. The resistance of *Ae. aegypti* in the Candirejo Health Centre working area, in Bulukerto Village is categorised as 14.29% susceptible and 85.71% resistant while in Magetan Village is categorised as 16.67% susceptible and 83.33% resistant.

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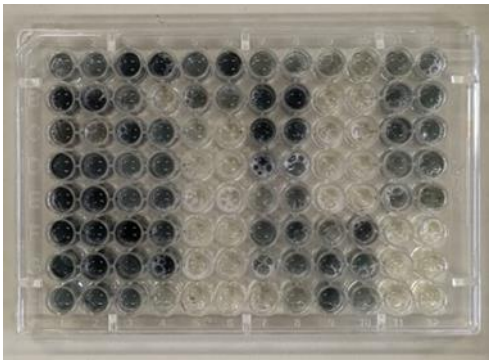

Figure 2. Determination of the hydrolysis activity of non-specific esterase enzymes against the substrate Alfa-naphthyl acetate using microplate assays related to resistance in *Ae. aegypti* from Candirejo 2 Health Centre wilker, Magetan Regency, East Java

Biochemical tests describing non-specific esterase enzyme activity against □-naphthyl acetate of *Ae. aegypti* larvae were read using a spectophotometer at λ = 450 nm. Columns 11-12 rows C-E are laboratory larvae. Column 11-12 rows F-H are blanks. Columns 1-2 rows A-F are homogenates of *Ae. aegypti* larvae from Kebonagung Village. Columns 1-2 rows G-H, columns 3-4 rows A-D are homogenates of *Ae. aegypti* from Tambran Village. Columns 3-4 rows E-H, columns 5-6 rows A-B are homogenates of *Ae. aegypti* from Tambakrejo urban village, columns 5-6 rows C-G are homogenates of *Ae. aegypti* larvae from Ringinagung urban village, columns 7-8 rows A-G are homogenates of *Ae. aegypti* larvae from Candirejo Village, Column 9-10 row H, column 9-10 row A-D are homogenates of Ae. aegypti mosquitoes from Baron, Column 9-10 row E-H are homogenates of *Ae. aegypti* larvae from Purwosari Village. Negative control (susceptible control) was taken from the wells with low AV value and clear colour, i.e. column 5-6 row F, column 5-6 row H, column 9-10 row D.

Susceptibility status based on esterase enzyme activity towards Alfa-naphthyl acetate was determined as follows:

Table 2. Determination of hydrolysis activity of non-specific esterase enzyme against Alfa-naphthyl acetate substrate using microplate assays related to susceptibility status in *Ae. aegypti* from Candirejo 2 health centre, Magetan district, East Java.

Location	Mean AV of negative control ± 3SD	Cut off point	Susceptibility status	
			Susceptible %	Resistant %
Kebonagung	0,116+ 0,0455	0,161	0	100
Tambran	0,116+ 0,0455	0,161	0	100
Tambakrejo	0,116+ 0,0455	0,161	0	100
Ringinagung	0,116+ 0,0455	0,161	83,33	16,67
Candirejo	0,116+ 0,0455	0,161	0	100
Baron	0,116+ 0,0455	0,161	16,67	83,33
Purwosari	0,116+ 0,0455	0,161	0	100

Resistant = AV ≥ Cut-off positive; Susceptible = AV < Cut-off positive

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Figure 3. Microplates of biochemical test results on larvae from the Taji Health Centre working area 1

Biochemical assay describing non-specific esterase enzyme activity against Alfa-naphthyl acetate of *Ae. aegypti* larvae read using a spectrophotometer at λ = 450 nm. Columns 11-12 rows A-D are laboratory larvae. Column 11-12 rows E-H are blanks. Column 1 - 2 row A - H is homogenate of *Ae. aegypti* larvae from Ginuk Village. Column 3-4 row A-H is homogenate of *Ae. aegypti* from Botok Village. Column 5-6 row A-H is homogenate of *Ae. aegypti* from Taji Village, Column 7-8 row A-H is homogenate of *Ae. aegypti* larvae from Kuwon Village. Column 9-10 rows A-H are homogenates of *Ae. aegypti* larvae from Karas village. Negative control (susceptible control) was taken from the wells with low AV value and clear colour, namely column 3-4 row C and H, column 7-8 row D, E, H.

Susceptibility status based on esterase enzyme activity towards Alfa-naphthyl acetate was determined as follows:

Table 3. Determination of hydrolysis activity of non-specific esterase enzyme against Alfa-naphthyl acetate substrate using microplate assays related to susceptibility status in Ae. aegypti from Taji 1 health centre, Magetan district, East Java.

Location	Mean AV of negative control ± 3SD	Cut off point	Susceptibility status	
			Susceptible %	Resisten %
Ginuk	0,0899 + 0,02036	0,1103	0	100
Botok	0,0899 + 0,02036	0,1103	66,67	33,33
Taji	0,0899 + 0,02036	0,1103	0	100
Kuwon	0,0899 + 0,02036	0,1103	50	50
Karas	0,0899 + 0,02036	0,1103	0	100

Resistant = AV ≥ Cut-off positive; Susceptible = AV < Cut-off positive

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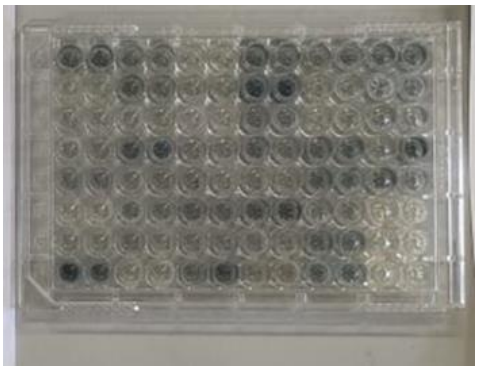

Figure 4. Microplates of biochemical test results on larvae from the Taji Health Centre working area 2

Biochemical assay describing non-specific esterase enzyme activity against Alfa-naphthyl acetate of *Ae. aegypti* larvae read using a spectrophotometer at λ = 450 nm. Columns 11-12 rows C-E are laboratory larvae. Column 11-12 rows F-H are blanks. Columns 1-2 rows A-G are homogenates of *Ae. aegypti* larvae from Temboro village. Column 1-2 row H, column 3-4 row A-F are homogenates of *Ae. aegypti* larvae from Jungke Village. Column 3-4 row H, column 5-6 row A-E are homogenates of Ae. aegypti larvae from Temenggungan village, Column 5-6 row F-H, column 7-8 row A-D are homogenates of *Ae. aegypti* larvae from Gepl. aegypti larvae from Geplak village, column 7-8 rows E-H, column 9-10 rows A-C are homogenates of *Ae. aegypti* larvae from Sobontoro, column 9-10 rows D-H, column 11-12 rows A-B are homogenates of *Ae. aegypti* larvae from Sumursongo village. Negative control (susceptible control) was taken from wells with low AV value and clear colour, namely columns 1-2 row B, and F, columns 5-6 row C.

Susceptibility status based on esterase enzyme activity against Alfa-naphthyl acetate was determined as follows:

Table 4. Determination of non-specific esterase enzyme activity against the substrate Alfa-naphthyl acetate using microplate assays related to susceptibility status in *Ae. aegypti* larvae from the Taji 2 Health Centre wilker, Magetan District, East Java

Location	Mean AV of negative control ± 3SD	Cut off point	Susceptibility status	
			Susceptible %	Resistant %
Temboro	0,1204 + 0,0139	0,134	42,86	57,14
Jungke	0,1204 + 0,0139	0,134	0	100
Temenggungan	0,1204 + 0,0139	0,134	71,43	28,57
Geplak	0,1204 + 0,0139	0,134	0	100
Subontoro	0,1204 + 0,0139	0,134	0	100
Sumursongo	0,1204 + 0,0139	0,134	0	100

Resistant = AV ≥ Cut-off positive; Susceptible = AV < Cut-off positive

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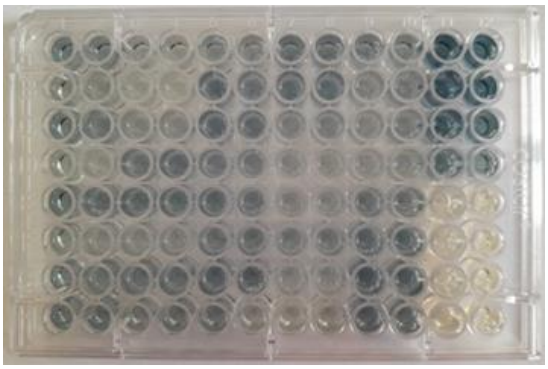

Figure 5. Microplate of biochemical test results on larvae from the working area of Plaosan Public Health Center

Biochemical tests describing non-specific esterase enzyme activity against Alfa-naphthyl acetate of *Ae. aegypti* larvae were read using a spectrophotometer at λ = 450 nm. Columns 11-12 rows A - D are laboratory larvae. Columns 11 - 12 rows E - H are blanks. Columns 1 - 10 rows A - H are homogenates of *Ae. aegypti* larvae from the working area of Puskesmas Plaosan. Negative control (susceptible control) is taken from the wells with low AV value and clear colour, namely column 1-2 row D, column 4-5 row B, column 7-8 row 7-8.

Susceptibility status based on esterase enzyme activity towards Alfa-naphthyl acetate was determined as follows:

Table 5. Determination of esterase enzyme hydrolysis activity towards Alfa-naphthyl acetate substrate using microplate assays related to susceptibility status in *Aedes aegypti* mosquitoes from Plaosan Health Centre wilker, Magetan Regency, East Java.

Location	Mean AV of negative control ± 3SD	Cut off point	Susceptibility status	
			Susceptible %	Resistant %
Plasoan	0,1650+ 0,0263	0,1913	0	100

Resistant = AV ≥ Cut-off positive; Susceptible = AV < Cut-off positive

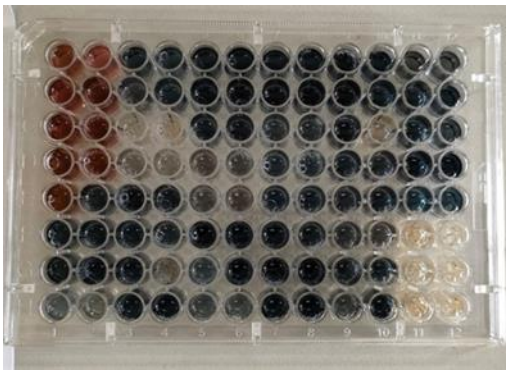

Figure 6. Microplates of biochemical test results on mosquito larvae from Ngujung Health Centre working area.

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Biochemical assay describing non-specific esterase enzyme activity against Alfa-naphthyl acetate of *Ae. aegypti* larvae read using a spectrophotometer at λ = 450 nm. Columns 11-12 rows C-E are laboratory larvae. Column 11-12 rows F-H are blanks. Column 1-2 row F is homogenate of mosquitoes from Gambiran village. Columns 1-2 rows G-H, columns 3-4 rows A-D are homogenates of *Ae. aegypti* from Pandean urban village. Columns 3-4 rows E-H, columns 5-6 rows A-B are homogenates of *Ae. aegypti* from Suratmajan urban village, columns 5 6 rows C-H are homogenates of *Ae. aegypti* mosquitoes from Ronowijayan urban village. Columns 7-8 rows A-F are homogenates of *Ae. aegypti* from Ngujung, Columns 7-8 rows G-H, columns 9-10 rows A-D are homogenates of *Ae. aegypti* mosquitoes from Sumberejo Village. Columns 9-10 rows E-H, columns 11-12 rows A-B are homogenates of *Ae. aegypti* from Pesu Negative control (susceptible control) is taken from wells with low AV value and clear colour, namely columns 1-2 rows H, columns 3-4 rows C-D.

Susceptibility status based on esterase enzyme activity towards Alfa-naphthyl acetate was determined as follows:

Table 6. Determination of hydrolysis activity of non-specific esterase enzyme against Alfa-naphthyl acetate using microplate assays related to susceptibility status in *Ae. aegypti* from Ngujung Health Centre wilker, Magetan District, East Java

Location	Mean AV of negative control ± 3SD	Cut off point	% Resistant	
			Susceptible	Resistant
Gambiran	0,2797 + 0,1902	0,469	33,33	66,67
Pandean	0,2797 + 0,1902	0,469	83,33	16,67
Suratmajan	0,2797 + 0,1902	0,469	66,67	33,33
Renowijayan	0,2797 + 0,1902	0,469	16,67	83,33
Ngujung	0,2797 + 0,1902	0,469	0	100
Sumberejo	0,2797 + 0,1902	0,469	0	100
Pesu	0,2797 + 0,1902	0,469	0	100

Resistant = AV ≥ Cut-off positive; Susceptible = AV < Cut-off positive

The map of non-specific esterase enzyme activity level against alpha naphthyl acetate substrate related to the susceptibility status of *Ae. aegypti* to organophosphate insecticides in endemic (Candirejo Health Centre working area, Taji) and sporadic DHF areas (Plaosan Health Centre working area, Ngujung) of Magetan Regency is shown in Figure 7.

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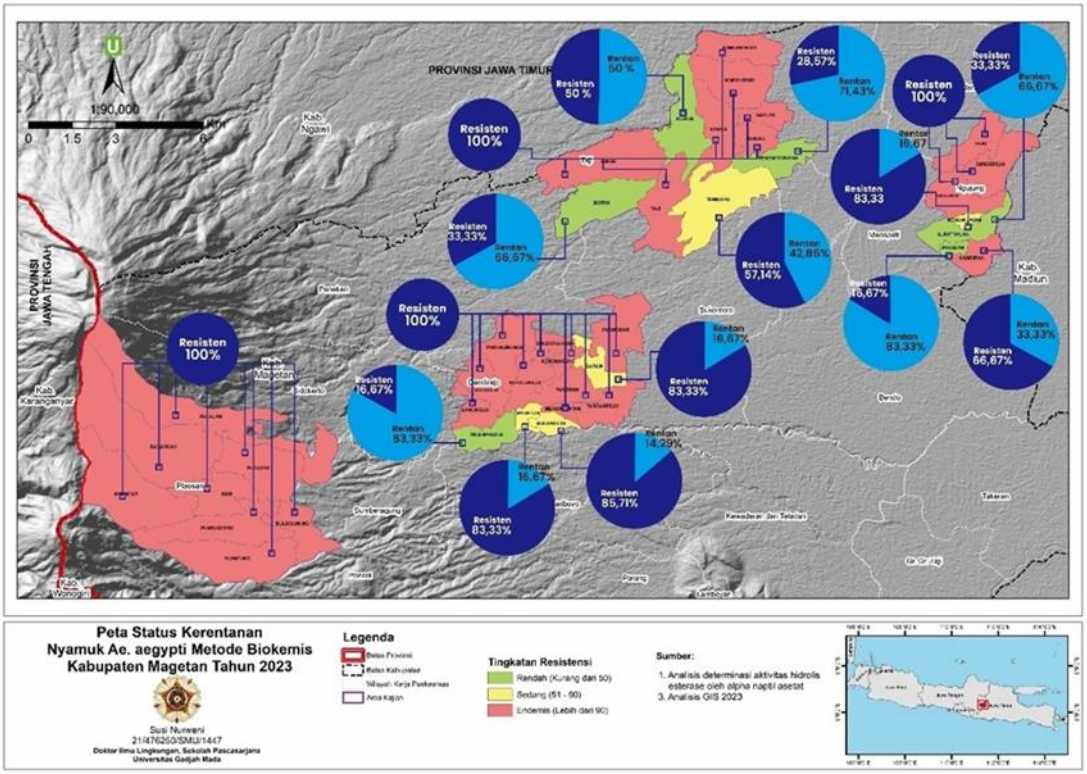

Figure 7. Map of non-specific esterase enzyme activity level against alpha naphthyl acetate substrate related to the susceptibility status of Aedes aegypti mosquitoes to organophosphate insecticides in endemic (Candirejo Health Centre working area, Taji) and sporadic dengue areas (Plaosan Health Centre working area, Ngujung) of Magetan Regency.

Figure 7 shows the brick red, green and yellow coloured areas. Mosquitoes originating from the brick red region show 100% resistance to organophosphates (high resistance) while the yellow coloured region shows moderate resistance (above 50% but below 90% of mosquitoes originating from the region are resistant to organophosphates). The green coloured area indicates low resistance (below 50% of mosquitoes from the area are resistant to organophosphates).

The results showed that *Ae. aegypti* in the Candirejo Health Centre working area of 14 villages, there are 10 villages that are highly resistant namely Mangkujayan Village, Selosari, Tawangmangu, Kepolorejo, Sukowinangun, Kebonagung, Tambran, Tambakrejo, Candirejo and Purwosari while the area that shows moderate resistance there are 3 villages namely Bulukerto Village, Magetan and Baron. As for the area that shows low resistance there is 1 village, namely Ringinagung Village.

Ae. aegypti in the Taji Health Centre working area out of 11 villages, there are 7 villages that are highly resistant, namely Ginuk, Taji, Karas, Jungke, Geplak, Sobontoro, Sumursongo and Purwosari villages while the area that shows moderate resistance is 1 village, namely Temboro village. There are 3 villages that show low resistance, namely Botok, Kuwon, Temenggungan. *Ae. aegypti* in Plaosan Health Centre working area out of 8 villages, all are highly resistant, namely Plaosan, Sarangan, Ngancar, Dadi, Bulugunung, Puntukdoro, Plumpung, Pacalan villages. Ae. aegypti in the working area of Ngujung Health Centre out of 7 villages, there are 3

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villages that are highly resistant, namely Pesu, Sumberejo and Ngujung villages while the areas that show moderate resistance are 2 villages, namely Gambiran and Rejowinangun villages. As for the areas that show low resistance, there are 2 villages, namely Suratmajan and Pandean villages.

The results of this study showed that in some samples of test mosquitoes showed an increase in non-specific esterase enzyme activity. This result proves that most of the mosquito sample population has been resistant, especially to organophosphate insecticides. Esterase is one of the enzymes in the insect body that plays a role in the detoxification process (xenobiotic metabolism) (Tokudome, 2015). Increased activity of the enzyme means that there is a mechanism of resistance to organophosphate insecticides. Research on esterase enzyme activity in field mosquitoes has been widely studied, especially in *Ae. aegypti* mosquitoes (Irawati & Putri, 2021).

The esterase enzyme is one of the enzymes that plays a role in the metabolic mechanism that causes resistance (Sudiharto *et al*., 2020). This is proven by research conducted by Widiastuti and Ikawati (Widiastuti & Ikawati, 2016) which shows that the resistance that occurs in Pekalongan Regency is based on enzymatic mechanisms, especially the esterase enzyme. The esterase enzyme has two caboxylic acid ester groups that have a role in lipid metabolism and xenobiotic metabolism in the mosquito body to hydrolyse malathion (Lima *et al*., 2011). Prolonged exposure to malathion allows the offspring of *Ae. aegypti* to secrete excessive amounts of esterase enzymes so that mosquitoes can bind malathion, slowly detoxify the poison, and prevent malathion from reaching its target acetylcholinesterase and mosquitoes from dying (Sudiharto *et al*., 2020).

Susceptibility test results to organophosphorus insecticides have resulted in resistance to *Ae. aegypti*. This indicates that the study site has a population of *Ae. aegypti* mosquitoes that are resistant to organophosphate insecticides. This resistance condition can be inherited from previous generations (Shetty *et al*., 2015). Bizzet and Rodriguez et al. proved that resistance status can be passed down from one generation to the next. This has been proven in the deltamethrin resistance test study in the *Ae. aegypti* population (Bisset *et al*., 2014). In addition, another study in Malaysia showed that *Ae. aegypti* exposed and selected using malathion until the 45th generation will have a high level of resistance to the insecticide with an increase in resistance of 3.24 times from the 0th generation (Hidayati *et al*., 2011).

Conclusion

The results of this study showed that Ae. aegypti in four working areas of Candirejo Health Centre out of 14 villages there were 10 villages (71.42%) with high resistant status to organophosphate insecticides while in Taji there were 7 villages (63.63%) with high resistant status, in Plaosan 8 villages were 100% high resistant, in Ngujung 3 villages (42.28%) out of 7 villages had high resistant status to organophosphate insecticides. The use of insecticides for a long period of time is not effective in eliminating dengue fever vectors because it can cause resistance. Based on the results of this study, it is necessary to monitor and evaluate the use of insecticides

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in dengue vector control as a programme at the Magetan District Health Office, so that the right insecticide can be selected for *Ae. aegypti* control.

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