Research Paper

Portable Device for *Aedes Sp* Larva Suction with Mechanical Electric Methods: Innovation in Control of DHF Disease

Nur Alvira Pascawati[1]*, Tri Baskoro Tunggul Satoto[2]
[1] Respati University of Yogyakarta, Indonesia
[2] Gadjah Mada University, Indonesia

Received : March 7, 2023	Revised : March 7, 2023	Accepted : March 9, 2023	Online : March 16, 2023

Abstract

Controlling *Aedes Sp* larvae is an essential component in the Integrated Mosquito Management (IMM) program because when mosquitoes are removed before they become adults, there will be no transmission of vector-borne diseases, especially DHF. However, physical, chemical, and biological control is still not optimal because it is considered resistant, less sensitive, effective, and efficient, especially in scarce clean water. The research aims to make and test the effectiveness of the innovative portable *Aedes Sp* larvae sucker using the electric-mechanical method. This type of research is an actual experiment in the laboratory test stage and quasi-experimental in the field test. This innovation is a pump with a suction power of 1400 litres/hour and 1800 litres/hour equipped with an AC electric motor connected to an inverter circuit. On the laboratory scale, it was tested on 1,500 instars III and IV *Aedes aegypti* larvae, and on a field scale, it was tested on 45 containers in Endemic Village, Klaten Regency. Data analysis used the Pearson correlation, independent sample, and Cochran tests. Laboratory test results showed that the time to catch all *Aedes Sp* larvae in containers with a volume of 80 litres and 90 litres using a power of 1400 litres/hour took 60 seconds and 138 seconds, while with a power of 1800 litres/hour, it took 33 seconds and 110 seconds. The speed of the number of *Aedes Sp* larvae caught is affected by the volume of water ≥20 litres with a water level of ≥8 cm. This tool was tested in the community at 43 houses and 45 positive larvae containers. The results show that with a power of 1800 litres/second, the time needed to suck the larvae in a bathtub-type container with a volume of 80-85 litres is 122.14 seconds, while a container with a volume of 86-90 litres is 208.67 seconds. A crock-type container with a volume of 80-85 litres takes 87.80 seconds, while a volume of 86-90 litres takes 98 seconds. This tool can reduce the presence of larvae at home from 61.43% to 3.77% and the density of larvae in containers from 38.14 to 5.56%. This means that this tool is declared effective, efficient, and sensitive in reducing the density of *Aedes Sp* larvae compared to physical methods.

Keywords *Innovation, Larvae, Aedes Sp, Electrical, Mechanical*

INTRODUCTION

Vector-borne diseases are still a problem in Indonesia, especially Dengue Hemorrhagic Fever (DHF). According to WHO data for 2004-2010, the Asia Pacific region bears 75% of the burden of dengue in the world, while Indonesia is reported as the second country with the largest number of dengue cases among 30 countries in endemic areas (Khoiri, 2016; Harapan et al., 2019). In 2019 DHF cases were spread across 472 regencies/cities and 34 provinces with a total of 95,893 cases, 661 deaths, and 73.35% of districts/cities had an Incidence Rate of <49/100,000 population (Widyawati, 2020).

To deal with this problem, surveillance activities are needed to provide an appropriate response, especially from an entomological point of view (Jourdain et al., 2019). Vector surveillance is a tool for collecting and tracking vectors comprehensively based on place and time, including geographical distribution, seasonal variation patterns, behaviour, density, and the influence of abiotic elements on vectors, to detect anomalies in evaluating entomological parameters (Braks et al., 2019). This activity is an important component of any Integrated Mosquito Management (IMM) program because when mosquitoes are removed before they become adults, there will be no

Corresponding author's email: alvirapascawati@gmail.com

transmission of vector-borne diseases, especially DHF (CDC, 2020; Ngadjeu et al., 2020). Larval surveillance is the main activity to determine the appropriate action to be taken, including "No Action", "Physical Control", "Biological Control", or "Chemical Control". However, this control is considered to be still not optimal because the larva-free rate (ABJ), which is often used as an epidemiological measure in this activity for ten years, is still below the target (<95%), namely in the range of 24.1-80.2% (Arisanti & Suryaningtyas, 2021).

One of the main problems in larval surveillance activities carried out by technical personnel in the field is the survey method to estimate the density of larvae in a less sensitive area (Cheah et al., 2006), (Antonio-Nkondjio et al., 2018). Chemical larval control techniques still yield good results but lead to adverse environmental effects and the evolution of insecticide resistance in many targeted mosquito species (Meier et al., 2022). We conducted a preliminary study on several cadres of Larvae Monitors (Jumantik) to find their weaknesses and difficulties when surveying and controlling *Aedes Sp* larvae in containers. This study shows that the survey results provide less sensitive and valid data because many containers, such as containers with large volumes and dark colours, are difficult to reach visually. Inefficient because the survey takes a long time. It is inefficient in areas experiencing water scarcity because many homeowners refuse if Jumantik cadres have to drain the water in the container where the larvae are found.

To help efforts to eradicate DHF in Indonesia by controlling *Aedes Sp* larvae, an innovation was created in the form of a portable *Aedes Sp* larva suction device using an electric-mechanical method. The idea for making it was inspired by the working principle of an aerator pump in an aquarium or fishpond. The working principle of this aerator is an AC electric motor that can rotate the fan in the water so that the water will be sucked in and enters through the filter. The larvae sucked in with the water will be trapped in the filter and can later be destroyed or used according to research needs. The research aimed to test the tool's effectiveness based on the number of *Aedes Sp* larvae that entered the portable suction device using the electric-mechanical method using a laboratory scale and a field scale.

LITERATURE REVIEW

Dengue Hemorrhagic Fever (DHF)

DHF is an infection caused by the dengue virus. Dengue is a viral disease that is transmitted from *Aedes Sp* mosquitoes, the fastest-growing mosquito in the world has caused nearly 390 million people to be infected each year (P2P, 2018). Dengue virus is found in tropical and subtropical areas, especially urban and suburban areas. Indonesia's tropical climate is very suitable for developing various diseases, especially diseases carried by vectors, namely organisms that spread pathogenic agents from host to host, such as mosquitoes which transmit many diseases (Candra, 2010). DHF is a disease caused by *Aedes aegypti* and *Aedes albopictus* species as primary vectors, *Aedes polynesiensis, Aedes scutellaris,* and Ae (Finlaya) niveus as secondary vectors (Pramatama et al., 2020). Usually, there is also trans-sexual transmission from male mosquitoes to female mosquitoes through mating (Felipe Ramírez-Sanchez, Camargo and Avila, 2020) as well as transovarial transmission from the mother mosquito to its offspring (Heath et al., 2020).

Dengue Hemorrhagic Fever Vector

DHF is transmitted by *Ae. aegypti*, the primary vector and *Ae. albopictus* as a companion vector. The two mosquito species are found throughout Indonesia, living optimally at an altitude of no more than 1,000 meters above sea level. Several reports they can be found in areas with altitudes up to 1,500 meters (Irwinsyah et al., 2018); even in India, it is found at an altitude of 2,121 meters, in Colombia at an altitude of 2,200 meters (Santosa, 2020).

RESEARCH METHOD

This type of research is an actual experiment at the laboratory test stage and a quasi-experiment at the field test stage. The research design for laboratory tests was post-test-only, and field tests used a pre-test-posttest. The research location was at the Entomology Laboratory, Faculty of Medicine, Gadjah Mada University, and all houses with positive larvae containers were in Kebondalem Kidul Village, Klaten Regency, Central Java. The criteria for site selection in the field test were: High category DHF endemic villages, the average larva-free rate (ABJ) in 2016-2018 was only 58.6%, still very far from the target of ≥ 95% and experiencing water scarcity, so many homeowners must hold large amounts of water for a long time. (Health Service, 2019). The subject of this study was a potable sucker for *Aedes Sp* larvae using the electric-mechanical method. The design and components of a portable *Aedes Sp* larvae suction device using the electric-mechanical method have several parts, namely:

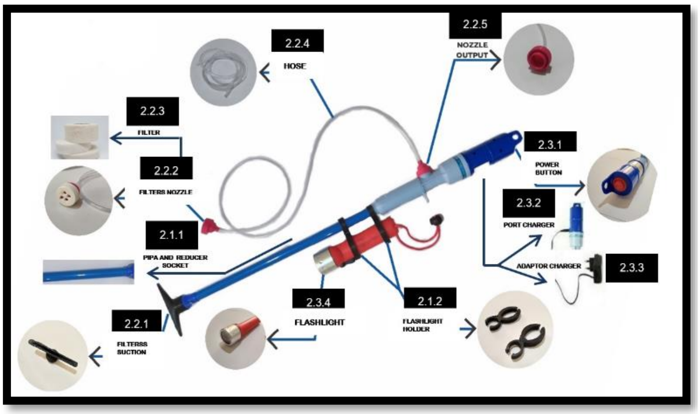

Figure 1. Components of a portable *Aedes Sp* larvae suction device using the electric-mechanical method

The tool component consists of 3 parts:

1) Part one is a suction extension component that is made flexible so that it can reach the depth of containers of various sizes. As present in Figure 1, part one consists of section 2.1.1, a pipe with a length that can be adjusted flexibly; Section 2.1.2 in Figure 1 is a reducer socket and a flashlight holder to place the flashlight.
2) Part two is a filter that functions to catch incoming larvae. Section 2.2.1 in Figure 1 is the suction nozzle, section 2.2.2 in Figure 1 is the filter nozzle, section 2.2.3 in Figure 1 is the filter, section 2.2.4 in Figure 1 is the hose, and section 2.2.5 in Figure 1 is the output nozzle.
3) Part three is an electronic circuit that provides artificial lighting in dark containers and components to suck/catch larvae in containers, and then water is circulated back into the holding tank in a clean condition. Part three consists of section 2.3.1 in figure 1, the power button; section 2.3.2 in figure 1 is a recharger plug, section 2.3.3 in Figure 1 is a charger that functions for charging, and section 2.3.4 in Figure 1 is a flashlight.

This tool underwent two test stages: 1) The laboratory stage was tested on 1,500 third and fourth-instar Aedes aegypti larvae obtained from colonization results with three repetitions. 2) The field stage was tested in 43 houses with 45 containers positive for *Aedes Sp*. In the field test, the type of container that met the requirements was determined according to laboratory test results such as container volume, water level, and power used, while the water volume, container colour, container material, and the number of larvae were by the results of field observations. The independent variables in this study were: *Aedes Sp* larvae sucker potable electric-mechanical method, the dependent variable was: *Aedes Sp* mosquito larvae and the moderator variables were: container volume, water level, water volume, container colour, container shape, container lighting, suction power tools, and power sources. The time needed to capture *Aedes Sp* larvae in each container is seconds or minutes. The container's volume is the container's contents in litres to accommodate the water used in the 80-litre and 90-litre sizes. The volume of water is the amount of water in units of litres provided in containers of 10, 20, 30, 50, and 70 litres. The water level is the height of the water surface from the bottom of the container in centimetres.

The flow of installing a portable *Aedes Sp* larvae suction device using the electric-mechanical method is described in Figure 2.

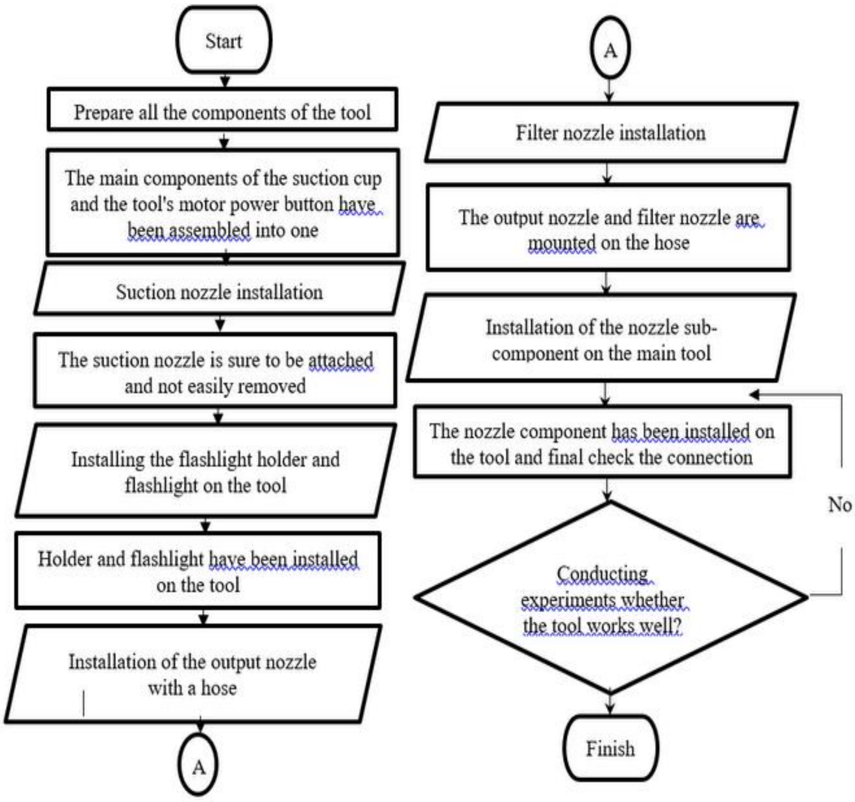

Figure 2. Describes the installation of the tool starting from preparing all the components of the portable

Data analysis in this study used four types of tests, namely descriptive analysis, to determine the mean and standard deviation of the number of sucked *Aedes Sp* larvae based on power, container volume, water volume, water level, and time. The next analysis is the person correlation test with α = 0.05 to determine the factors that influence the effectiveness of the portable *Aedes Sp*. larvae suction device. One-way ANOVA test and independent sample t-test with α = 0.05 to determine the accuracy of applying portable *Aedes Sp* larvae suction devices based on the characteristics of the container. Cohcran test with α = 0.05 to determine differences in indicator container index (CI) before and after applying the portable *Aedes Sp*. larvae suction device. All of these tests were determined based on the results of the data normality test with Shapiro Wilk indicating that the data was declared normally distributed (P-Value = 0.783 > 0.05).

FINDINGS AND DISCUSSION

Laboratory Test

To determine the ability of portable Aedes aegypti larvae suction devices, each test uses the average value obtained from 3 repetitions. The time needed to catch Aedes aegypti larvae using an 80-litre container volume with a power of 1400 litres/hour and 1800 litres/hour can be seen in Table 1.

Table 1. The average length of time to catch Aedes aegypti larvae using a portable electric-mechanical sucker using a container volume of 80 liters with a power of 1400 liters/hour and 1800 liters/hour

Water Volume (Liters)	Water Level Height (cm)	Number of Larva (Tail)	Suction Power 1400 Liters/Hour			Suction Power 1800 Liters/Hour		
			Average Length of Time (Seconds)	Average Larvae Captured	Percentage (%)	Average Length of Time (Seconds)	Average Larvae Captured	Percentage (%)
10	4	50	136	8	16	0	0	0
20	8	50	87	47	95	33	50	100
30	12,5	50	71	49	98	36	50	100
50	20	50	60	50	100	49	50	100
70	29	50	72	50	100	62	50	100

Table 1 shows that the portable Aedes aegypti larvae sucker tested in an 80-litre container with 1400 litres/hour power could suck all the larvae in a 50-litre water volume with a water level of 20 cm in 60 seconds. This time becomes shorter if you use 1800 litres/hour of power, 33 seconds in a smaller volume of water, namely 20 litres with a water level of 8 cm. The second test was carried out on a 90-litre volume container with a maximum power of 1400/hour and 1800/hour, with the results in Table 2.

Table 2. The average length of time to catch Aedes aegypti larvae using a portable mechanical electric sucker using a container volume of 90 litres with a suction power of 1400 litres/hour and 1800 litres/hour

Water Volume (Liters)	Water Level Height (cm)	Number of Larva (Tail)	Suction Power 1400 Liters/Hour			Suction Power 1800 Liters/Hour		
			Average Length of Time (Seconds)	Average Larvae Captured	Percentage (%)	Average Length of Time (Seconds)	Average Larvae Captured	Percentage (%)
10	9	50	85	44	88	79	47	94
20	15	50	99	46	92	99	48	96
30	23	50	90	48	96	70	49	98
50	36	50	138	50	100	76	47	94
70	49	50	140	50	100	110	50	100

Table 2 shows that the portable Aedes aegypti larvae sucker tested in a 90-litre container with 1400 litres/hour power could suck all the larvae in a 50-litre water volume with a water level of 36 cm in 138 seconds. This time becomes longer if you use 1800 litres/hour of power, 140 seconds in 70 litres with a water level of 49 cm.

The results of the different tests to determine the characteristics of the right container for portable equipment so that it can suck a lot of Aedes aegypti larvae in a short time based on water volume, water level, container volume, and container colour can be seen in Table below.

Table 3 shows no difference in container volume and suction power based on the number of Aedes aegypti larvae caught with a portable suction device. However, this tool can catch large amounts of Aedes aegypti larvae when the water volume reaches 20-70 litres. At 80 litres, this tool can catch a large number of larvae when the water level reaches 8 cm, but at a volume of 90 litres, this tool can catch the same number of Aedes aegypti larvae at a water level of 9-49 cm. The difference in container colour also does not affect the number of larvae that can be caught with this tool.

Table 3. Differences in the characteristics of the containers based on the number of Aedes aegypti larvae caught using a portable suction device

Variable	Indicator	Number of *Aedes aegypti* Larvae Caught (tails)		P-Value
		Mean	Standard Deviation	
Volume Container (Liter)	80	40,40	19,21	0,237
	90	47,90	1,97	
Suction Power (Liters/Hour)	1400	44,20	12,88	0,988
	1800	44,10	15,54	
Water Volume (Liters)	10	24,75	24,21	0,021
	20	47,75	1,71	
	30	49,00	0,82	
	50	49,25	1,50	
	70	50,00	0,00	
Water Level Height (cm) with 80-liter Container Volume	4	4,00	5,66	0,000
	8	48,50	2,12	
	12,5	49,50	0,71	
	20	50,00	0,00	
	29	50,00	0,00	
Water Level Height (cm) with 90 Liter Container Volume	9	45,50	2,12	0,732
	15	47,00	1,41	
	23	48,50	0,70	
	36	48,50	2,12	
	49	50,00	0,00	
Container Color	Bright	44,20	12,89	0,988
	Dark	44,10	15,54	

Table 3 shows that there is no difference in the speed of using the portable Aedes aegypti larvae suction tool using the electric-mechanical method based on the characteristics of water volume and water level, but the time to use a portable device to suck Aedes aegypti larvae will be faster in a light-coloured container, 80-litre volume with a power of 1800 litres/hour.

Field Test

Field trials were carried out on the volume of the container and the water level according to the results of laboratory tests, while the volume of water, colour, and material of the container were by the results of field observations. The power used in the field trial was 1,800 litres/hour because, based on laboratory tests, this power resulted in a higher number of caught larvae than a power of 1,400 litres/hour. The containers the community uses to store large amounts of water for a long time are in the form of bathtubs/toilet tubs and water jars/drums. The results of the field test of the mechanical electric portable vacuum cleaner can be seen in Table 4 and Figure 3.

Table 4. The average length of time to catch *Aedes Sp* larvae using a portable electric mechanical sucker with a power of 1800 liters/hour

Type	Volume (Liters)	Water Volume (Liters)	Water Level Height (cm)	Color	Material	Number of Containers	Time of all larvae caught/ Second
Bathtub/WC Tub =25 container	80-85	10	4	Dark	Cement	2	162
				Bright	Ceramics	1	98
		20	8	Dark	Cement	2	192
				Bright	Ceramics	1	96
		30	12,5	Dark	Cement	1	127
		50	20	Dark	Cement	4	98
		70	29	Dark	Cement	3	82
		Average Time					122,14
	86-90	30	23	Dark	Cement	6	223
		50	36	Dark	Cement	3	219
		70	49	Dark	Cement	2	184
		Average Time					208,67
Crock/Water Drums= 20 container	80-85	10	4	Bright	Plastic	1	97
				Dark	Clay	3	110
		20	8	Bright	Plastic	4	87
		50	20	Bright	Plastic	5	76
		70	29	Bright	Plastic	1	69
		Average Time					87,80
	86-90	50	36	Bright	Plastic	4	112
		70	49	Bright	Plastic	3	98
		Average Time					105,00

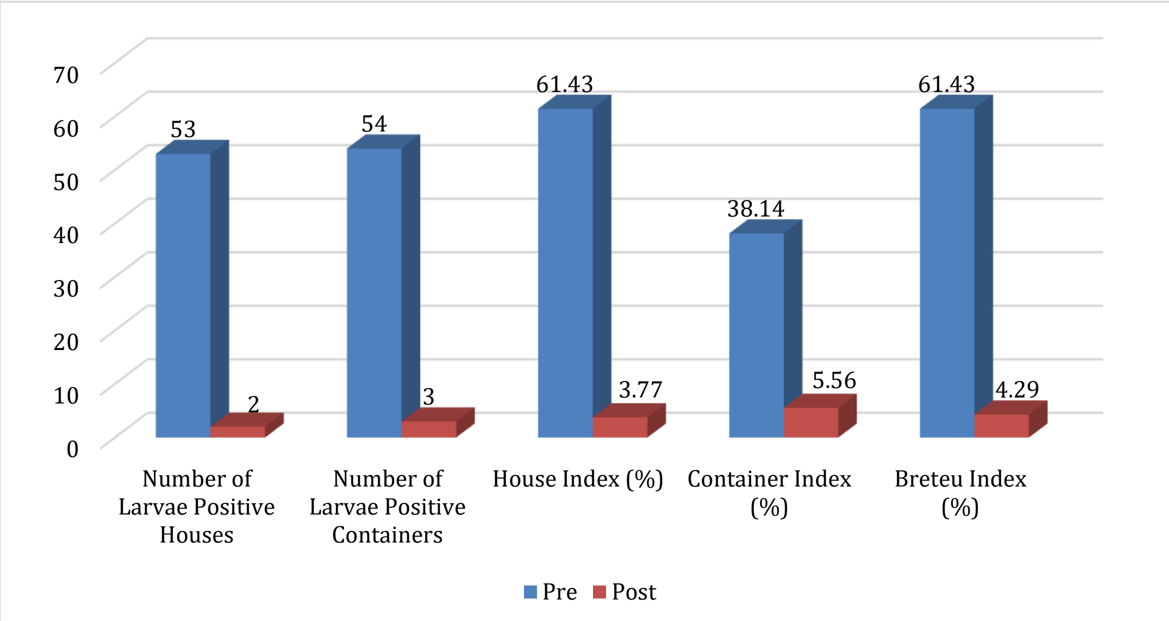

Figure 3. Graph of the results of the evaluation of larva density before (pretest) and after (posttest) the application of the portable *Aedes Sp* larvae sucker using the electric-mechanical method

Table 4 shows that containers in the field with dark-coloured cement baths/WC tubs tend to take longer to catch all the larvae than light-coloured ceramic containers. The average time needed to suck all the larvae in a bathtub-type with a volume of 80-85 litres was 112.14 seconds, while in a container with a volume of 86-90 litres, it was 208.67 seconds. Another type of container is a water jar/drum made of plastic and clay. The results for the container show that a volume of 80-85 litres made of clay and dark colours tends to take longer than light-coloured materials. A container volume of 86-90 with a volume of 70 litres of water and a water level of 69 cm requires faster time than a volume of 50 litres with a water level of 36 cm. The average time needed to suck all the larvae in water crock/drum containers with a volume of 80-85 litres was 87.80 seconds, while containers with 86-90 litres were 105.00 seconds.

The results of evaluating the reduction in larval density based on the House Index (HI), Container Index (CI), and Bretau Index (BI) indicators after the application of the portable *Aedes Sp* larvae sucker using the electric-mechanical method with a power of 1800 litres/hour can be seen in Figure 3.

Figure 3 shows a decrease in the HI value from 61,43% to 3,77%, the CI value from 38,14% to 5,56%, and the BI value from 61,43% to 4,26%. The larvae in several containers cannot be caught with this tool because they are disposable sites/garbage, which have a very small container volume with a small amount of water, such as cans/jars/glasses and used tires. The decrease in HI, CI, and BI values showed a significant decrease with a P-Value of 0.000 <0.05, meaning that the portable suction device for *Aedes Sp* larvae can be a mechanical electric method to control the presence of larvae in containers used to hold water for a long time.

The main component of this tool uses an electric motor, which is an electromagnetic device that converts electrical energy into mechanical energy. This mechanical energy rotates pump impellers, fans or blowers, drives compressors, and lifts other materials (Nave, 2005). The aerator pump modified into a model/prototype of an electric-mechanical suction device has proven effective for catching Aedes aegypti larvae in laboratory and field tests. This tool is designed in a portable form so that it is easy to carry and move when in a container with flexible pipe lengths to catch and reach target larvae. This is also so that the tool can produce better energy because the mechanical energy produced can be associated with the motion and position of an object. The principle of mechanical energy states that when only a conservative force isolates a system, the magnitude of the mechanical energy remains constant. If an object moves in the opposite direction from a conservative force, the potential energy increases, and if the object's velocity (not speed) changes, it is kinetic energy also changes (Resnick et al., 1966).

The aerator pump can rotate the fan so that when the tool is inserted into the water holding tank, the Ae. aegypti is sucked into the filter. The mechanical filter on the tool is defined as a component that can physically separate solid materials from water (based on their size) by capturing or filtering these materials so that no floating objects are found in the water. This tool is very beneficial for areas experiencing water shortages because it can reduce the density of larvae and dirt in the water without wasting water so that you do not need to drain the tub/jar to clean it. This tool can also be an alternative to reduce the use of larvacide, which can cause resistance to *Aedes Sp*. Larvae.

Exposure time affects the number of larvae caught in the 80-litre container. The 80-litre container with a power of 1400 litres/hour can suck up all the larvae in just 60 seconds, faster than the number of larvae that are sucked in for a longer time due to the large volume of water and the high water level. When the suction power of the tool is increased to 1,800 litres/hour, the time needed becomes faster, namely 33 seconds. This means that the higher the power, the faster the time needed to catch all Aedes aegypti larvae in the filter. Suppose the volume of the container is enlarged to 90 litres. In that case, the volume of water will be greater, and the water level will be higher so that with a power of 1,400 litres/hour, the time needed to catch all the Aedes aegypti larvae will be longer, namely 138 seconds. If the power is increased to 1,800 litres/second, the time will be faster, namely 110 seconds, but for a higher water level. This is because the blower or fan of the tool has a higher position than the water level, so water in contact with the fan takes longer and affects the sucked larvae.

The portable Aedes aegypti larvae suction device using the electric-mechanical method is more effective for containers with a water volume of ≥ 20 litres with a water level of ≥ 8 cm. in containers. The speed of the tool when sucking Aedes aegypti larvae is strongly influenced by the characteristics of the container, namely the volume of 80 litres, the suction power of 1,800 litres/hour, and the bright colour of the container. Light-coloured containers with high power make it easier and faster for surveyors to aim the tool at target larvae than dark-coloured containers with low power. To simplify the monitoring process for dark-colored containers, this tool is equipped with a flashlight placed in the middle of the pipe and can be removed if not needed.

Light and dark-coloured containers were used in this trial because several studies have shown that dark colours can provide a sense of security and calm for Aedes mosquitoes when laying eggs, so more eggs are placed in containers (Sari, 2021; Pramatama et al., 2020; Satoto et al., 2017). In terms of colour, the containers that are the most common breeding habitat for Aedes aegypti are black and blue. Research in Semarang shows a relationship between container colour and the presence of Aedes aegypti larvae used by people in endemic and non-endemic areas of DHF (Wirayoga, 2013). However, other studies have also shown that brightly coloured containers can potentially become breeding grounds for *Aedes Sp* larvae if they are never cleaned or tightly closed (Pascawati et al., 2020; Satoto et al., 2020; Satoto et al., 2019).

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The test results of the portable *Aedes Sp* larvae sucker using the electric-mechanical method in the field using a power of 1,800 litres/hour at a container volume of 80-85 litres and 86-90 litres gave very varied results and required a longer time to catch all the larvae in containers compared to the test results laboratory. Variations strongly influence this condition in colour, material, room lighting, and the number of larvae in each container examined. Even so, this tool can facilitate survey activities with a faster time of 112.14 seconds - 208.67 seconds compared to visual observations. The results of the evaluation of the work of the tool in reducing the level of larval density (HI, CI, and BI) in the environment based on the size of the density figure gave significant results, namely the HI high category (scale 8) fell to the moderate category (scale 2), the CI value from the high category (scale 8) is in the moderate category (scale 3), the BI value is in the high category (scale 6) is in a low category (scale 1) (Pascawati et al., 2021; Miller et al., 1992).

CONCLUSIONS

This tool can reduce the presence of larvae at home from 61.43% to 3.77% and the density of larvae in containers from 38.14 to 5.56%. This means that this tool effectively reduces the level of larval density from high risk to low risk and can help the success of vector control programs in areas experiencing a scarcity of clean water. This tool cannot be used to control *Aedes Sp* larvae breeding grounds in Disposable Sites (DS) type containers, so activities such as burying or recycling used items that can hold water must still be carried out. For the next stage, the tool will continue to be refined to be suitable for use in all types of containers.

REFERENCES

Antonio-Nkondjio, C., Sandjo, N. N., Awono-Ambene, P., & Wondji, C. S. (2018). Implementing a larviciding efficacy or effectiveness control intervention against malaria vectors: Key parameters for success. *Parasites and Vectors*, *11*, 57. https://doi.org/10.1186/s13071-018-2627-9.

Arisanti, M. & Suryaningtyas, N. H. (2021). Kejadian Demam Berdarah Dengue (DBD) Di Indonesia Tahun 2010-2019. *Spirakel*, *13*(1), 34–41. https://doi.org/10.22435/spirakel.v13i1.5439.

Braks, M., Giglio, G., Tomassone, L., Sprong, H., & Leslie, T. (2019). Making Vector-Borne Disease Surveillance Work: New Opportunities From the SDG Perspectives. *Frontiers in veterinary science, 6*, 232. https://doi.org/10.3389/fvets.2019.00232

Candra, A. (2010). Demam Berdarah Dengue : Epidemiologi , Patogenesis , dan Faktor Risiko Penularan. *Demam Berdarah Dengue: Epidemiologi, Patogenesis, dan Faktor Risiko Penularan*, *2*(2), 110–119.

CDC (2020) *Integrated Mosquito Management , Centers for Disease Control and Prevention*. Retrieved at February 11, 2023 from https://www.cdc.gov/mosquitoes/mosquito-control/professionals/integrated-mosquito-management.html

Cheah, W. L., Chang, M. S., & Wang, Y. C. (2006). Spatial, environmental and entomological risk factors analysis on a rural dengue outbreak in Lundu District in Sarawak, Malaysia. *Tropical biomedicine, 23*(1), 85–96.

Felipe Ramírez-Sanchez, L., Camargo, C., & Avila, F. W. (2020). Male sexual history influences female fertility and re-mating incidence in the mosquito vector Aedes aegypti (Diptera: Culicidae). *Journal of Insect Physiology*, 121, 104019. https://doi.org/10.1016/j.jinsphys.2020.104019.

Harapan, H., Michie, A., Mudatsir, M., Sasmono, R. T., & Imrie, A. (2019). Epidemiology of dengue hemorrhagic fever in Indonesia: analysis of five decades data from the National Disease Surveillance. *BMC research notes, 12*(1), 350. https://doi.org/10.1186/s13104-019-4379-9

Heath, C. J., Grossi-Soyster, E. N., Ndenga, B. A., ...LaBeaud, D. (2020). Evidence of transovarial transmission of chikungunya and dengue viruses in fieldcaught mosquitoes in Kenya. *PLoS Neglected Tropical Diseases*, *14*(6). https://doi.org/10.1371/journal.pntd.0008362.

Irwinsyah, F., Dalilah, & Triwani (2018). The Influence Of Chlorine To The Egg Hatchability Of Aedes Aegypti. *Majalah Kedokteran Sriwijaya*, *4*(oktober), 192–199.

Jourdain, F., Samy, A. M., Hamidi, A., Bouattour, A., Alten, B., Faraj, C., Roiz, D., Petrić, D., Pérez-Ramírez, E., Velo, E., Günay, F., Bosevska, G., Salem, I., Pajovic, I., Marić, J., Kanani, K., Paronyan, L., Dente, M. G., Picard, M., Zgomba, M., ... Robert, V. (2019). Towards harmonisation of entomological surveillance in the Mediterranean area. *PLoS neglected tropical diseases, 13*(6), e0007314. https://doi.org/10.1371/journal.pntd.0007314

Khoiri. (2016) *Indonesia Peringkat Dua Negara Endemis Demam Berdarah*. Indoensia. https://www.cnnindonesia.com/gaya-hidup/20160616170332-255-138672/indonesia-peringkat-dua-negara-endemis-demam-berdarah (Accessed: 6 December 2019).

Meier, C. J., Rouhier, M. F., & Hillyer, J. F. (2022). Chemical Control of Mosquitoes and the Pesticide Treadmill: A Case for Photosensitive Insecticides as Larvicides. *Insects*, *13*(12). https://doi.org/10.3390/insects13121093.

Miller, J., Martinez-Balanzar, A., &Gazga-Salinas, D. (1992). Where Aedes aegypti live in Guerrero; using the maya index to measure breeding risk, in *Dengue: A worldwide problem, a common strategy*. In: Halste. Mexico: Ministry of Health Mexico, pp. 311–317.

Nave, C. (2005) *How does anelectric motor work?In: Hyperphysics, Electricity and Magnetism*. Departemen. Georgia: Georgia State University. http://hyperphysics.phyastr.gsu.edu/hbase/hframe.html.

Ngadjeu, C.S., Doumbe-Belisse, P., Talipouo, A. et al. (2020). Influence of house characteristics on mosquito distribution and malaria transmission in the city of Yaoundé, Cameroon. *Malaria Journal, 19*, 53 (2020). https://doi.org/10.1186/s12936-020-3133-z

Ohm, J. R., Baldini, F., Barreaux, P., Lefevre, T., Lynch, P. A., Suh, E., Whitehead, S. A., & Thomas, M. B. (2018). Rethinking the extrinsic incubation period of malaria parasites. *Parasites and Vectors*, *11,* 178. https://doi.org/10.1186/s13071-018-2761-4.

P2P, D. (2018). InfoDatin-Situasi-Demam-Berdarah-Dengue-2. *Kemenkes RI*, April, pp. 1–7.

Pascawati, N. A. (2015). Survei entomologi dan penentuan Maya Index di Daerah Endemis DBD Dusun Krapyak Kulon, Desa Paggungharjo, Kecamatan Sewon, Kabupaten Klaten. *Medika Respati*, *10*(3), 76–86.

Pascawati, N. A., Songjanan, E. P., Tunggul Satoto, T. B., & Deta, E. (2018). Improvement to Early Warning System Of DHF Transmission Through Controlling Vector Breeding Places Of *Aedes Sp*. In Klaten District, Central Java. J*ournal of Public Health for Tropical and Coastal Region, 1*(1), 20-26. https://doi.org/10.14710/jphtcr.v1i1.3245

Pascawati, N. A., Satoto, T. B. T., Wibawa, T., Frutos, R., Maguin, S., Kadek, I., & Wardana, A. (2020) Knowledge, Attitudes and Practices on Community with Dengue Haemorrhagic Fever in Mataram, West Nusa Tenggara. *BALABA: Jurnal Litbang Pengendalian Penyakit Bersumber Binatang Banjarnegara*, *16*(2), 149–158. https://doi.org/10.22435/blb.v16i2.3165.

Pascawati, N. A., Saputri, E. S., Asmarani, F. L., Erwanto, R., & Vidayanti, V. (2021). Vector control *Aedes Sp*. During pandemic COVID-19. *International Journal of Public Health Science*, *10*(4), 713–723. https://doi.org/10.11591/ijphs.v10i4.20924.

Pramatama, S. P. M., Octaviana, D., & Nurlaela, S. (2020). Identification of Primary Container of Aedes Mosquitoes Breeding Site in Urban Region of Dengue Endemic Area, Purwokerto Indonesia. *BALABA*, *16*(2), 181–188. https://doi.org/10.22435/blb.v16i2.2491.

Resnick, R. & Halliday, D. (1966). *Physics***.** Wiley: New York

Ritchie, S. A. (2014). Dengue Vectors Bionomics : Why Aedes aegypti Such a Good Vector, in D.J.Gubler, E. E. O. and J. F. S. V. (ed.) *Dengue and Dengue Hemorrhagic Fever*. 2nd edn. Boston, USA: CAB International, 455–480.

Santosa, B. J. (2020). Challenges in Against DHF in the Tropical Area. *Health Notions*, *4*(6), 187–191. https://doi.org/10.33846/hn40605.

Sari, K. R. Y. (2021). Determinant Factors To the Existence of Aedes Aegypti Mosquito in the Working Area of Ubud I Health Center Gianyar Regency, Bali. *The Indonesian Journal of Public Health*, 16(1), 101. https://doi.org/10.20473/ijph.v16i1.2021.101-111.

Satoto, T. B. T., Dwiputro, A. H., Risdwiyanto, R. N., Hakim, A. U. F., Pascawati, N. A., & Diptyanusa, A. (2019). Prediction model of dengue hemorrhagic fever transmission to enhance early warning system in Gergunung Village, Klaten District, Central Java. Journal of thee Medical Sciences (Berkala Ilmu Kedokteran). Journal of the Medical Sciences (Berkala Ilmu Kedokteran), 51(03), pp. 258–269. doi: 10.19106/jmedsci005103201909.

Satoto, T. B. T., Alvira, N., Wibawa, T., & Diptyanusa, A. (2017). Improvement to Early Warning System the Transmission of Dengue Fever through Controlling Potential Factor in Public Elementary School At Yogyakarta. *Kesmas: National Public Health Journal*, *11*(4), 178. https://doi.org/10.21109/kesmas.v11i4.1248.

Satoto, T. B. T., Pascawati, N. A., Wibawa, T., Frutos, R., Maguin, S., Mulyawan, I. K., & Wardana, I. (2020). Entomological Index and Home Environment Contribution- -to Dengue Hemorrhagic Fever in Mataram City, Indonesia. *Kesmas: National Public Health Journal*, *15*(1), 32. https://doi.org/10.21109/kesmas.v15i1.3294.

Slavov, S. N., Cilião-Alves, D. C., Gonzaga, F. A. C., Moura, D. R., de Moura, A. C. A. M., de Noronha, L.

A. G., Cassemiro, É. M., Pimentel, B. M. S., Costa, F. J. Q., da Silva, G. A., Ramos, D. D. A. R., de Araújo, W. N., Kashima, S., & Haddad, R. (2019). Dengue seroprevalence among asymptomatic blood donors during an epidemic outbreak in Central-West Brazil. *PloS one, 14*(3), e0213793. https://doi.org/10.1371/journal.pone.0213793

Sunardi, P., Kusnanto, H., Satoto, T. B. T., & Lazuardi, L. (2018). Prevalence of Dengue Virus Transovarial Transmission and DHF Incidence Rate in Grogol Sub-district of Sukoharjo District. *Jurnal Medicoeticolegal dan Manajemen Rumah Sakit*, *7*(2), 102–107. https://doi.org/10.18196/jmmr.7262.

WHO (2022) *Dengue and severe dengue*, *World Health Organization*. Geneva. Retrieved April 9, 2022

Widyawati (2020). *Data Kasus Terbaru DBD di Indonesia*, *Ministry of Health*. Retrieved at February 4, 2021 from https://sehatnegeriku.kemkes.go.id/baca/umum/20201203/2335899/data-kasus-terbaru-dbd-indonesia/.

Wirayoga, M. A. (2013). Hubungan Kejadian Demam Berdarah Dengue Dengan Iklim Di Kota Semarang Tahun 2006- 2011. *Unnes Journal of Public Health*, 2(4), 1–9.