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Community perception of biocontrol agent using *Betta splendens* (*Ikan Cupang*) against *Aedes aegypti* larvae: a community study in Bali

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Abstract

Purpose: This study attempted to analyze the predation ability of *Betta splendens* as a biocontrol of *Aedes aegypti* larvae with a case study in Kartika Neighborhood, Dauh Puri, Denpasar City. **Methods:** This study employed a quasi-experimental approach and a qualitative investigation to ascertain public perceptions of using *Betta splendens* as a biocontrol agent for *Aedes aegypti* larvae. The trial lasted one month. *Betta splendens* were added to the respondent's bath (n=30), and larval mortality was determined at 2, 4, 6, 8, and 10 hours. Analysis of data using the paired t-test. **Results:** The results showed that the characteristics of respondents were dominated by being 18–45 years old (73.30%), being male (56.70%), having a dominant education level of high school (66.60%), and using a cement bathtub (53.30%). The comparative test results obtained a p-value of 0.0001 ($p<0.05$), indicating a very significant change in the number of Aedes aegypti larvae during bathing before and after adding Betta fish, with an average predation ability of 85.87%. Community perception regarding using Betta fish as a biocontrol agent is very positive, and the acceptance rate and sustainability of Betta fish use reached 96.67%. There is no change in water conditions due to aroma, color, and taste. **Conclusion:** The predation power of *Betta splendens* as a natural biocontrol is excellent and effectively utilized in minimizing the presence of *Aedes aegypti* larvae in the bath (container).

Keywords: *Aedes aegypti*; bath; biocontrol; predation ability; ikan cupang

INTRODUCTION

Dengue virus infection (IVD) is transmitted through mosquito bites *Aedes* spp., *Aedes aegypti* and *Aedes albopictus*, resulting in dengue fever (DD), dengue hemorrhagic fever (DBD) and *dengue shock syndrome* (DSS) [1]. During COVID-19 pandemic, the incidence of *dengue* has increased in several regions, including the province of Bali [2,3]. Data on dengue hemorrhagic fever cases in Bali in 2020 reached 12,173 points, increasing 2.5 times from the previous year [4,5]. Furthermore, Denpasar City has become an endemic area that reports the incidence of dengue every year. The Denpasar health officials said that in 2020, there were 1,501 cases of dengue with the highest incidence rate in the West Denpasar area (IR = 131.36 / 100,000); the figure is still far above the national target of <49/100,000 people [6,7].

The increase in dengue cases in the Denpasar City area is caused by various factors, including eradicating mosquito nets that are still low [8,9], The 4M plus program (Draining, Burying, Closing and Monitoring). The occurrence of resistance due to excessive use of insecticides and larvacide has implications for the explosion of the *Aedes aegypti* mosquito population [10]. The dense population

supports this factor in endemic areas, excellent environment and high mobility resulting in faster *dengue* virus transmission [11,12]. Efforts can be made to control and break the chain of breeding and breeding mosquito vectors by using a biocontrol system naturally by utilizing *species betta splendens* [13–15]. Due to its distinctive color and shape, the community frequently cultivates *Betta splendens* as an ornamental fish. This type of betta slayer is excellent for the community because it has strong predation powers. This fish is the result of a cross between a Halfmoon and a Serit Betta, with the characteristics of having a small body shape and a broad tail. *Betta splendens'* ability as a natural biocontrol agent against mosquito larvae has been widely studied. Still, application at the household level has not been widely practiced, and the effectiveness of use within a certain period has yet to be reported. Previous research has revealed that *Betta splendens* include carnivorous animals that like protein-containing (larvivorous) foods, such as mosquito larvae. Their use as biocontrol agents is relatively effective [16].

Research Sari and Novela [14] Betta fish have a more substantial predation power in *Aedes aegypti* mosquitoes with p = 0.000 than lead head fish and larvavorn fish. Furthermore, Jabal [18] stated that people who at home keep betta fish found the presence of a lower flick than those who do not maintain it. Rahmi (16) revealed that variations in the size of betta fish affect predation's ability against the *Aedes aegypti* mosquito. The study found that the size of L in betta fish (>5.5 cm) has a higher predation ability with an average of 48.78 tails within 15 minutes, so it can effectively be applied to control dengue hemorrhagic fever vectors.

Reviewing the potential and utilization of *Betta splendens* to control dengue disease vectors. This study sought to analyze the predation power of *Betta splendens* as biocontrol of *Aedes aegypti* larvae (in Denpasar City). The West Denpasar region was chosen, considering the number of cases and the low participation of the community in controlling the *Aedes aegypti* vector. The study is expected to help cut the life cycle of vectors in the larval stage and contribute to lowering the incidence of IVD in Denpasar City and Bali Province.

METHODS

Larvae

This study *uses a quasi-experimental* design with the *post-test only control group design* (20). The study sought to find out, describe and interpret the number of larvae of *the Aedes aegypti* mosquito before and after the administration of *Betta splendens* within 2, 4, 6, 8 and 10 hours. Testing the predation power of *Betta splendens* is done by inserting fish into a bathtub (container) filled with larvae, then larvae before and after recording on the observation sheet by the predetermined time. The treatment is repeated for three consecutive days. After treatment, continued with interviews with each homeowner to obtain data on public perception of the use of *Betta splendens* as a natural biocontrol agent against *Aedes aegypti* larvae. The research was conducted in Kartika Neighborhood, Dauh Puri Village, West Denpasar District, Denpasar City. Materials and instruments used include water, glass bottles, stationery, filterers, labels, observation sheets, interview guidelines, flashlights and tally counters, and fish species *Betta splendens* as many as 36 tails measuring 4-8 cm (Figure 1).

Figure 1. Species *Betta splendens – Cupang slayer*

The population of this study is the larvae of the *Aedes aegypti* mosquito found in the bathtub for experiments. In contrast, the people for qualitative studies are the entire head of the family (KK) domiciled in Kartika Neighborhood, Dauh Puri, West Denpasar, numbered 260 KK. This study's test samples are all the *Aedes aegypti* mosquitoes' larvae contained in the bathtub (container) of the Kartika Neighborhood community, Dauh Puri, West Denpasar, Denpasar City. Qualitative studies on people's perceptions use 30 respondents (n = 30) who meet the criteria [21]. Inclusion criteria in this study include: subjects domiciled and registered as residents in Kartika neighborhood, willing bathtub (container) given treatment, larvae of *Aedes aegypti* mosquitoes in the bath; not using larvicides, do not drain the bathtub, and bathtub volume 100-400 L. Exclusion criteria among others: Subjects were not willing to follow the study,

subjects resigned, no larvae were found in the bathtub, and matters did not have bathtubs.

The procedures and workings of this research are as follows: 1) In the pre-research stage, acclimatization of *Betta splendens* species as many as 36 tails obtained directly from breeders in Denpasar Satria Market. The *Betta splendens* species of plaque varieties with a body length of 4–7 cm are placed in the aquarium for three days. The fish was satisfied before being put in the respondent's bathtub one day before the treatment. Furthermore, identify respondents willing to bathtub (container) given the treatment of *Betta splendens* at a predetermined time. 2) The stage of research implementation begins by calculating the number of larvae of the *Aedes aegypti* mosquito using a tally counter and recording them on an observation sheet. Furthermore, the treatment is carried out by inserting species of *Betta splendens i*nto the bath, and the number of larvae remaining is calculated every 2, 4, 6, 8 and 10 hours on the observation sheet. All treatments are repeated for three consecutive days. The data that has been obtained is tabulated and further analyzed statistically. 3) Post-research stage, at this stage, all respondents who have been determined (n = 30) conducted structured interviews using guidelines that have been prepared and recorded data on the observation sheet. The information that has been obtained is tabulated and analyzed descriptively in relation to community perception of the use of betta fish as a biocontrol agent for *Aedes aegypti* larvae.

Community response study

Aedes aegypti mosquito larva research data before and after the corrected treatment was statistically analyzed using SPSS Inc. version 23 software with a comparative test (Paired T-Test). The confidence level is set at 95% with a probability value ($p < 0.05$). Furthermore, community perception data is analyzed descriptively by percentage (%). The answers people gave about how they felt about using Betta fish were analyzed based on the level of acceptance, advantages, and benefits of keeping Betta fish as a biocontrol agent for *Aedes aegypti* mosquito larvae, as well as how people felt about how long it would be possible to keep and use Betta fish in each household.

RESULTS

Kartika Neighborhood is located in Dauh Puri Village, West Denpasar Subdistrict, Denpasar City. Data monographs of the West Denpasar subdistrict in December 2019 are known Kartika Neighborhood has a permanent population of 998 people identified into 228 family heads (KK). The total number of family heads, it is reclassified into three alleys (neighborhoods). The Kartika Neighborhood used as a location in this study is Gang 01 and 02. Administratively, Dauh Puri Village has a “larvae monitorer” (Jumantik) in charge of monitoring the presence of mosquito larvae every week. The results of information obtained by the community in the Kartika Neighborhood show that they utilize artesian wells that are turned on with the help of electricity; in addition, the district has a habit of filling the bathtub to hold water and not draining periodically, so that it becomes a risk factor for the presence of larvae in the bathtub. In addition, JUMANTIK officers do not occasionally observe every house, resulting in a growing mosquito larvae population.

Table 1. Individual and household respondent characteristics

Variable	Frequency (n)	Percentage (%)
Age		
≤ 17 years	0	0
18 – 45 years	22	73.30
> 45 years	8	26.70
Gender		
Male	17	56,7
Female	13	26,7
Level of education		
Primary school	0	0
Junior high school	2	6,70
Senior High School	20	66,60
College	8	26.70
Type of bathtub		
Plastic	4	13,30
Ceramics	10	33,40
Cement	16	53,30
Other	0	0

Table 1 displays respondent characteristics. Thirty people (n = 30) participated in the study because they fulfilled the inclusion and exclusion criteria. The majority of respondents were between the ages of 18 and 45 (73.30%), the majority were men (56.70%), the majority had completed at least some high school education (66.60%), and the majority used cement bathtubs (53.30%) in the Kartika Neighborhood.

Larvae of *Aedes aegypti* mosquito before and after intervention

Table 2 displays data collected on *Aedes aegypti* mosquito larvae before and after the introduction of *Betta splendens*. *Aedes aegypti* mosquito larvae were significantly lower after *Betta splendens* treatment than pre-treatment. After administering *Betta splendens* for 2, 4, 6, 8, and 10 hours, the surviving larvae had an average of 0.87 tails and 26.

Table 2. Observation of larval *Aedes aegypti* mosquitoes before and after intervention

Respondent data	Observation time (Hours)					Larvae before intervention (n)	Larvae after intervention (n)
	2	4	6	8	10		
R1	10	0	0	0	0	25	0
R2	73	32	0	0	0	133	0
R3	63	22	0	0	0	113	0
R4	27	0	0	0	0	91	0
R5	34	6	0	0	0	82	0
R6	39	11	0	0	0	78	0
R7	123	90	79	41	11	142	11
R8	36	8	0	0	0	159	0
R9	46	6	0	0	0	97	0
R10	0	0	0	0	0	47	0
R11	18	0	0	0	0	53	0
R12	39	7	0	0	0	75	0
R13	27	0	0	0	0	108	0
R14	43	16	0	0	0	87	0
R15	18	7	0	0	0	51	0
R16	13	0	0	0	0	49	0
R17	14	0	0	0	0	39	0
R18	84	41	19	0	0	110	0
R19	18	0	0	0	0	52	0
R20	56	11	0	0	0	124	0
R21	84	74	52	39	15	132	15
R22	20	0	0	0	0	56	0
R23	52	7	0	0	0	121	0
R24	29	0	0	0	0	63	0
R25	42	0	0	0	0	95	0
R26	52	14	0	0	0	125	0
R27	0	0	0	0	0	69	0
R28	13	0	0	0	0	65	0
R29	37	0	0	0	0	77	0
R30	55	28	11	0	0	84	0
Total	**1165**	**380**	**161**	**80**	**26**	**2602**	**26**
Mean	**38,8**	**12,7**	**5,4**	**2,7**	**0,87**	**86.7**	**0.87**
SD						**34.097**	**3.34**
Min.						**25**	**0**
Max.						**159**	**15**

Abbreviation: SD = Standard Deviation; Min = Minimum Value; Max = Maximum Value

This compares to a pre-intervention count of 2,602 tails and 86.7 seats. *Aedes aegypti* mosquito larvae dropped by 99%, from 2,576 before treatment to 0 after. Table 3 displays the results of statistical testing of the predation ability of *Aedes aegypti* mosquito larvae by *Betta splendens* before and after treatment.

The number of *Aedes aegypti* mosquito larvae in a test room decreased after adding *Betta splendens* to the water, with a probability of 0.0001 0.05, indicating a statistically significant decrease. As a result, *betta splendens* fish are well-suited for controlling and preventing mosquito vectors that spread the dengue virus. They are particularly effective against the larvae of the *Aedes aegypti* mosquito. Within 2-10 hours, *Betta splendens* can generate a predatio2–10wer of 85.86% against *Aedes aegypti* mosquitoes.

Community perception of the use of *Betta splendens* as a biocontrol agent of *Aedes aegypti* larvae

Table 4 provides a synopsis of the general public's opinion on *Betta splendens*' efficacy as a biocontrol agent against *Aedes aegypti* mosquito larvae. The general public is on board with using *Betta splendens* to control *Aedes aegypti* mosquito larvae. Almost everyone (96.7% of respondents) didn't notice any differences in the water's appearance, smell, or flavor after using the biocontrol agent to clean latrines. All survey participants also agreed that the fish did a good job preventing mosquito larvae from developing in bathtubs. Almost all respondents (96.7%) were interested in participating in the home maintenance program.

Table 3. Paired t-tests on the number of larvae before and after intervention

Inter-vention	Mean ± SD	Difference/ %	*p-value*	n
Before	86.73 ± 34.097	85,86 / 99	0.0001	30
After	0.87 ± 3.34			

Table 4. Community perception of Betta fish as larval biocontrol

Variable	Yes (%)	No (%)
Water physical change		
Color	2 (6.67)	28 (93,33)
Taste	1 (3.33)	29 (96,67)
Aroma	4 (13,33)	26 (86,67)
Benefits of use		
Useful	30 (100)	0 (0)
Sustainability of maintenance		
Continue the program	29 (96,67)	1 (3,33)

The results of direct interviews with thirty respondents stated that using *Betta splendens* as a biocontrol agent for *Aedes aegypti* mosquitoes is very beneficial, especially in decreasing the number of mosquito larvae in each household. Fish care is very easy to make people prefer fish assistance to eradicate larvae rather than larvicide, which tends to cause resistance in larvae. Interviews conducted with respondents regarding the use of Betta fish to minimize mosquito larvae stated:

> "*Putting betta fish in the bathtub and keeping it in the bathroom, room, or living room is very useful because it can be used for decoration as well as natural feed for larvae, allowing mosquitoes that lay eggs and breed in the tub to be eradicated (R13, R18, R29).*"

Other opinions about whether or not physical changes happened in the water after putting *Betta splendens* fish in the bathtub were:

> *"If I, even after adding the Betta fish, the water is still clean, let alone after releasing the fish in a short period, so the water can still be used in baths and latrines (R 10)." Another opinion is that "the water smells the same as the water that fish do not make, and for me, it is okay to add fish for a while, let alone mosquito larvae as Betta fish food, so the water is made clean and free of larvae" (R4)".*

Regarding the continued use of *Betta splendens* for the control and eradication of *Aedes aegypti* mosquitoes, several respondents stated:

> *"Like or not, Harrus still uses Betta fish because it can be used to decorate the house and eradicate mosquitoes. Betta fish are inexpensive, so you can buy them for joint planting (R9). The same opinion expressed by R12 states, "If I personally, Betta fish are easy to find and care for, it is easy for sure, and obviously I use this fish because it is beautiful, and I just found out that it can minimize larvae, so I am very enthusiastic to use Betta fish for mosquito repellent and so that DHF quickly drops (R21)."*

Interviews with people in the Kartika Neighborhood show that using *Betta splendens* as a biocontrol agent to stop larvae from breeding is a very promising way to reduce the number of cases of dengue hemorrhagic fever [5]. The community has agreed and promised that dengue control programs, such as educating people on how to raise betta fish and utilize them to destroy mosquito eggs, larvae, and adults, will cut down on dengue cases, especially in the Kartika Neighborhood. *Betta splendens* is easy to get, does not cost much, and works well, especially for speeding up the decline of larvae in every home [22–24]. Hence, the use of *Betta splendens* as a biocontrol agent for *Aedes aegypti* mosquito larvae has a perfect chance of success, and a positive role in the community means that this effort can be used sustainably. In-depth socialization is needed regarding the efficacy of Betta fish as a biocontrol agent.

DISCUSSION

The *Aedes aegypti* mosquito is one insect species that transmit the virus through bites that result in *dengue virus* infection [25,26]. The presence of these mosquitoes can be associated with poor sanitary conditions, fair weather, and climate and environmental conditions in their natural habitat [27,28]. Research conducted in Kartika Neighborhood, Dauh Puri, Denpasar City, still found a place of miss that triggers the presence of *Aedes aegypti* mosquito vectors, such as used cans and places that contain puddles, including furniture and flower vases. In addition, 16 out of 30 community bathtubs (*containers*) still use cement, so the dark grayish structure with a smooth surface and ability to absorb water make mosquitoes like the place as a habitat for their longing. This is in line with the discovery of 2,602 larvae of *the Aedes aegypti* mosquito in thirty identified bathtubs. The presence of *Aedes aegypti* mosquito vectors indicates the community's subordinate role in controlling *dengue virus* infection [29]. Furthermore, the community is always encouraged to pay attention, maintain and participate in improving the quality of sanitation so that the presence of vectors, mainly *Aedes*

aegypti mosquitoes, is lower. The results align with Krishnakumar [30] that *Aedes* mosquitoes like areas with clear water, quiet light reflection, and low temperatures, making it easier for vectors to breed.

Betta splendens is a natural method for controlling the *Aedes aegypti* mosquito vector that is useful in all communities, but especially in the Kartika Neighborhood of Dauh Puri Village in the West Denpasar District of Denpasar City. By interrupting the vector life cycle at the larval stage, *Betta splendens*-based vector control allows for rapid and efficient management [18,31]. Research shows that within 2-10 hours, *Betta splendens'* predation ability against *Aedes aegypti* mosquito larvae reaches 85.86%, significantly reducing dengue virus transmission vector populations. These findings are consistent with those of Campos [32], who found that betta fish (*Betta splendens*) have a high capacity for predatory killing. Pangesti [33] added that, as aggressive predatory fish, *Betta splendens* could quickly eradicate larvae, making them a useful tool in the fight against dengue vectors.

Betta splendens is a formidable predator. The presence of *Aedes aegypti* mosquito larvae, perceived as a nuisance or hazard, indicates this. *Betta splendens* protect themselves by preying on mosquito larvae. *Betta splendens* exhibit monophagous feeding behavior and remain active as long as food is present [16,34 35]. These traits result in a significant reduction in the number of larvae found in the bathtub. Alim [36] and Dion [14] found that *Betta splendens* is an effective biocontrol agent for reducing the population of the flick. This species is carnivorous and has a preference for protein-rich food, with a specific feeding periodicity. The duration is 24 hours without interruption. *Betta splendens* actively forage for food throughout the day to aid in the control of mosquito larvae and prevent breeding. According to studies [15,35,37], the size of *Betta splendens* has a significant impact on its capacity for feeding and predation. The study found that *Betta splendens*, also known as Siamese fighting fish, attain a size of 4-7 cm (L-sized) and exhibit strong predatory behavior towards larvae. Consistent with Rahmi's findings [19], the study demonstrated that betta fish measuring over 5.5 cm in length (L) possess a greater predation capacity, averaging 48.78 tails in 15 minutes. This suggests their potential effectiveness in controlling the vector of dengue hemorrhagic fever.

Based on the results of the public perception assessment through structured interviews obtained, 100% of marks (30 respondents) revealed that the use of *Betta splendens* as a biocontrol agent *of Aedes aegypti* mosquito larvae is very effectively applied, mainly in Kartika Neighborhood, Dauh Puri, Denpasar City. *Betta splendens* in water give quick results and don't change the water's color, taste, or smell. Respondents stated that they would continue the maintenance and utilization program of *Betta splendens* as a biocontrol agent of *Aedes aegypti* mosquito larvae to lower the larval population of their *bathtubs*. These results indicate that biocontrol agents are quite in demand by the public, are easy to obtain, and that their practical use is a benchmark for sustainable use. The community anticipates that the assessment of water quality following the addition of *Betta splendens* to the bathtub or water body will be expanded to ensure the safety, cleanliness, and quality of the water used, particularly for bathing and washing latrines. In addition to utilizing biological agents, the community is expected to participate in the prevention and control of *dengue virus* infection disease by routinely implementing the 4M Plus program (draining, closing, burying, and monitoring), minimizing mosquito breeding sites, and promoting the return of mosquito nest eradication programs on a household, environment, and village/ local scale.

CONCLUSION

The predation power of *Betta splendens* as a biocontrol agent against *Aedes aegypti* mosquito larvae *reaches* 85.86% after 2-10 hours of treatment. The study found a significant difference between the number of larvae of *the Aedes aegypti* mosquito before and after being given Betta fish in the bath. There is a significant decline in larvae, reaching 99% after treatment. Community members in the study have a positive view of using betta fish to control *Aedes aegypti* larvae as a biocontrol agent. The community thinks betta fish, as fun as ornamental fish, can also be used as a biocontrol agent to lower the number of larvae in homes. The absence of water, color, and aroma changes makes its sustainable use very prospective, especially in Kartika Neighborhood, Dauh Puri, and Denpasar City. Future research needs to be done on how long-term use of Betta fish in bodies of water affects them and how well they work as biocontrol.

REFERENCES

1. Nath H, Mallick A, Roy S, Sukla S, Biswas S. Computational modelling supports that dengue virus envelope antibodies can bind to SARS-CoV-2 receptor binding sites: Is pre-exposure to dengue virus protective against COVID-19 severity?

Computational Structural Biotechnology Journal. 2021;19:459–66.
2. Masyeni S, Santoso MS, Widyaningsih PD, Asmara DW, Nainu F, Harapan H, et al. Serological cross-reaction and coinfection of dengue and COVID-19 in Asia: Experience from Indonesia. International Journal of Infectious Diseases. 2021;102(2021):152–4.
3. Mertha Adnyana IMD, Azhari FSS, Sudaryati NLG. Prevalence of dengue hemorrhagic fever in Bali from 2015 to 2020 and during the COVID-19 pandemic. Jurnal Berkala Epidemiologi. 2022 May 30;10(2):169–78.
4. Bali Health Department. Bali Province Health Profile in 2020. Denpasar: Bali Provincial Health Office; 2021 p. 243. Available from: [Website]
5. Mertha Adnyana IMD, Surya A. Strategy to control and eradicate dengue hemorrhagic fever vectors in Bali. International Journal of Public Health Science. 2023;12(1):196–202.
6. Ministry of Health. Dengue update: observing the journey of dengue in West Java. 1st ed. Jawa Barat: Indonesian Institute of Sciences (LIPI) Press; 2019. 1–262 p.
7. Mertha Adnyana IMD, Sumarya IM, Sudaryati NLG. Efficacy and toxicity of Parasayu incense ash as a larvicide for the eradication of Aedes aegypti (Diptera: Culicidae) Mosquito Larvae. Journal of Research in Pharmacy. 2022;26(6):1805–13.
8. Widjajanti W, Ayuningtyas RTD, Adnyana NWD. Entomological index of dengue hemorrhagic fever vectors in three districts in Bali Province. Vektora: Jurnal Vektor dan Reservoir Penyakit. 2019;11(1):11–20.
9. Tawatsin A. Development of a novel ultrasonic sound-generated device: the physical tool for controlling immature stages of mosquitoes transmitting dengue haemorrhagic fever (Aedes aegypti) and filariasis (Culex quinquefasciatus). Biomedical Journal of Scienctific and Technical Research. 2019;19(3):14308–14.
10. Mertha Adnyana IMD, Sudaryati NLG, Sitepu I. Toxicity of Legiayu incense as insecticide and larvicide against Aedes aegypti mosquitoes mortality. Indonesian Journal of Pharmacy. 2021;32(4):514–21.
11. Adarsh MB, Abraham A, Kavitha P, Nandakumar MM, Vaman RS. Severe thrombocytopenia in covid-19: A conundrum in dengue-endemic areas. Indian Journal of Critical Care Medicine. 2021;25(4):465–6.
12. Mertha Adnyana IMD, Sudaryati NLG, Suardana AAK. Blood smear profile of patients with dengue hemorrhagic fever in Bali Royal Hospital. Journal of Vocational Health Studies. 2021;5(1):39–46.
13. Harsono S. Betta fish (Betta Splendens) biocontrol method as a vector control of dengue fever in Kartasura, Sukoharjo Regency. Jurnal Manajemen Informasi dan Administrasi Kesehatan. 2019;2(2):38–43.
14. Dion A, Christina Prayogo M, Mufti Yuana H, Adrianto H. Kajian predassi catfishterhadap larva nyamuk Aedes aegypti sebagai upaya pencegahan penyebaran demam berdarah dengue. Hang Tuah Medical Journal. 2021;19(1):41–53.
15. Andriani NDA, Adrianto H, Darmanto AG. Daya predasi Ikan Lemon (Labidochromis caeruleus) dan Ikan Kapiat (Barbonymus schwanenfeldii) terhadap larva nyamuk Aedes aegypti. ASPIRATOR: Journal of Vector-borne Disease Studies. 2021;13(1):37–46.
16. Miraldo MC, Pecora IL. Efficiency of brazilian native ornamental fishes as mosquito larvae predators. Boletim do Instituto de Pesca. 2017 Dec 27;43:93–8.
17. Sari M, Novela V. Pengendalian biologi dengan daya predasi berbagai jenis ikan terhadap larva Aedes aegepty di rilayah kerja Puskesmas Tigo Baleh. Jurnal Sehat Mandiri. 2020;15(1):79–85.
18. Jabal AR, Balyas AB, Augustina I, Ratnasari A. Pengendalian nyamuk sebagai vektor penyakit di Kelurahan Menteng Kota Palangkaraya. Indonesian Journal of Community Services. 2021;1(1):74–80.
19. Rahmi, Amir R, Usman. Biokontrol ikan pemangsa jentik dalam pemberantasan vektor nyamuk penyebab demam berdarah dengue (DHF) di Kota Parepare. Jurnal Ilmiah Manusia dan Kesehatan. 2018;1(3):265–71.
20. Darwin M, Mamondol MR, Sormin SA, Nurhayati Y, Tambunan H, Sylvia D, et al. Quantitative approach research method. 1st ed. Tambunan TS, editor. Bandung: CV Media Sains Indonesia; 2021. 192 p.
21. Adnyana IMDM. Populasi dan Sampel. In: Metode Penelitian Pendekatan Kuantitatif. 1st ed. Bandung: CV Media Sains Indonesia; 2021. p. 103–16.
22. Datta A, Sen R, Banerjee R, Banerjee PK. Larvicidal efficacy of ornamental fishes to control Aedes aegypti in West Bengal. Internationa Journal of Mosque Research. 2022 Jul 1;9(4):39–46.
23. Thongprajukaew K, Pettawee S, Muangthong S, Saekhow S, Phromkunthong W. Freeze‐dried forms of mosquito larvae for feeding of Siamese

fighting fish (Betta splendens Regan, 1910). Aquaculture Research. 2019 Jan 18;50(1):296–303.
24. Azevedo-Santos VM, Vitule JRS, Pelicice FM, García-Berthou E, Simberloff D. Nonnative fish to control Aedes mosquitoes: a controversial, harmful tool. Bioscience. 2017 Jan 1;67(1):84–90.
25. Kesetyaningsih TWulandari, Andarini Sri, Sudarto., Pramoedyo Henny. Determination of environmental factors affecting dengue incidence in Sleman District, Yogyakarta, Indonesia. African Jounal of Infections Disease. 2018;12(5):13–25.
26. Faridah L, Ekawardhani S, Wiraswati HL, Fauziah N, Rinawan FR, Mayasari W, et al. Underdiagnosis does not account for the decrease in dengue cases in Bandung, Indonesia. Systematic Reviews in Pharmacy. 2021;12(1):1340–2.
27. Kurniawati I, Susilawaty A, Habibi H. Dengue fever case management in Maros Regency, Indonesia. Disease Preventive of Research Integrity. 2020;1(1):8–14.
28. Mutmainah S, Prasetyo E, Sugiarti L. Daya predasi Ikan Cupang (Betta splendens) dan Ikan Guppy (Poecilia reticulate) terhadap larva instar III nyamuk Aedes aegypti sebagai upaya pengendalian cektor penyakit demam berdarah dengue (DHF). Jurnal Sains Natural. 2017;4(2):98.
29. Rathnayaka RMGS, Jayatunga DPW, Ganehiarachchi GASM. The effect of chemical exudates of three larvivorous fish species on oviposition preference of Aedes aegypti and Aedes albopictus (Diptera: Culicidae). Medical and Veterany Entomology. 2021;35(3):495–500.
30. Krishnakumar A, Patrick Anton ES, Jayawardena UA. Water hardness influenced variations in reproductive potential of two freshwater fish species; Poecilia reticulata and Betta splendens. BMC Research Notes. 2020;13(1):1–6.
31. Mejia-Mejia M, Arce E, García-Rodríguez J, Burciaga LM. Effect of feeding mosquito larvae on the coloration of siamese fighting fish (Betta splendens) during grow-out. International Aquatic Research. 2021;13(1):71–9.
32. De Campos Júnior EO, Silva CF, da Silva CR, Pereira BB, Caixeta ES, Cardoso de Paula MB, et al. Validation of the species Xiphophorus maculatus for biological control of Aedes aegypti by comparing its larvae-eating potential with Poecilia reticulata. Biological Control. 2018;117:30–4.
33. Pangesti M Della, Wahyudi Y, Susila WDC. Efektivitas pemeberian Ikan Cupang (Betta splendens) dalam menurunkan jumlah jentik sebagai upaya pencegahan DBD di Desa Talok Kecamatan Turen. Health Care Media. 2021;5(2):77–87.
34. Hamed AMR, S.El-Sherbini M, Abdeltawab MSA. Eco-Friendly Mosquito-Control strategies: advantages and disadvantages. Egyptian Academic Journal of Biological Sciences. 2022;14 (1): 1–5.
35. Lukas JL, Adrianto H, Darmanto AG. Kemampuan predasi Ikan Kepala Timah Aplocheilus panchax jantan dan betia terhadap larva nyamuk Aedes aegypti. Jurnal Kesehatan Andalas. 2021;9(4):387.
36. Alim F, W, Sari E. Predation power of betta fish (Betta splendens) and sword plati fish (Xyphophorus helleri) against Aedes aegypti mosquito larvae. Gema Lingkungan Kesehatan. 2020;18(1):12–5.
37. Hustedt JC, Doum D, Keo V, Ly S, Sam BL, Chan V, et al. Field efficacy of larvivorous fish and pyriproxyfen combined with community engagement on dengue vectors in cambodia: A randomized controlled trial. American Journal of Tropical Medicine and Hygiene. 2021; 105(5): 1265–76.