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Comparative Predation Efficiency of Betta Fish (*Betta splendens*) and Golden Cichlid (*Melanochromis auratus*) Against *Aedes aegypti* Larvae

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ABSTRACT

Introduction: Vector-borne diseases such as dengue, malaria, chikungunya, and filariasis remain major public health problems. In Indonesia, the Larva Free Index (LFI) in 2019 was 79.2%, below the national target (>95%), with 138,127 dengue cases reported. Biological control using natural predators is a potential strategy to reduce mosquito larvae populations. This study aimed to compare the predation ability of betta fish (*Betta splendens*) and golden cichlid (*Melanochromis auratus*) against *Aedes aegypti* larvae. **Methods:** This quasi-experimental study used a completely randomized design (CRD). Observations were conducted with 18 replications. Data were analyzed using an Independent t-test with a 95% confidence level (α = 0.05). **Result:** Betta fish consumed an average of 20 larvae per hour, with a total predation rate of 96.4%. Golden cichlid consumed an average of 18 larvae per hour, with a total predation rate of 80.6%. Statistical analysis showed a significant difference between the two groups ($p < 0.05$), indicating higher predation efficiency in Betta fish. **Conclusion:** Betta fish demonstrated significantly greater effectiveness as a biological control agent against *Aedes aegypti* larvae compared to golden cichlid. This species has strong potential for application in community-based mosquito control programs.

Keywords: Betta fish; Golden cichlid; *Aedes aegypti*; biological control; mosquito larvae

1. INTRODUCTION

Infectious diseases can be caused by vectors; such as, dengue hemorrhagic fever, malaria, chikungunya and filariasis. It is still become a problem both in Indonesia and in the world.(1) The number of DHF sufferers in Indonesia is expanding along with the increasing population density and increasing community mobility.(2) The larva-free rate is an indicator which is used to measure efforts to control DHF.

Based on data from the Indonesian Health Profile, the larva-free rate (ABJ) in 2019 was 79.2%, which still has not reached the target of the ABJ program, which is > 95%. It means that efforts to control DHF have not yet reached the target and there are still high dengue cases in Indonesia.(3) Moreover, cases of dengue hemorrhagic fever have increased from the previous year. The number of dengue fever cases in 2019 was 138,127 cases.

Containers are water reservoirs (TPA) or vessels which can act as a breeding ground for Aedes sp mosquitoes. Furthermore, in urban areas, 90% of the Aedes sp mosquito habitat is in man-made containers.(4) The existence of this container plays a very important role in the existence of the Aedes sp mosquito vector, the more containers there will be more breeding places and the higher the density of mosquitoes. Tubs are generally the most preferred container for

mosquitoes to lay eggs.[5]

In preventing the transmission of diseases caused by vectors, it is necessary to control them. Chemical vector control or spraying of organophosphate insecticides is currently commonly used in vector control in Indonesia in order to reduce mosquito density.[6] Seventy percent of Indonesian people often use aerosol type insecticides in controlling mosquitoes.[7] The use of insecticides in the long term triggers the emergence of resistance in vector mosquitoes and environmental damage.[8]

Not only chemical control which can be used, but also there are other controls which are safe and do not cause health problems and environmental damage that is biological control. It is the control of mosquito larvae by utilizing predators or natural enemies of mosquitoes.[9] This control method is considered better since it can eradicate mosquitoes; besides, it is easy to do in conditions of mosquito larvae stage and it does not cause damage to the surrounding environment.

Types of predators which can be used as vector control are larvae eating fish; such as, betta, gold molly panda fish and Betta sp.[10] Furthermore, betta fish have a high/strong immune system and take food continuously for 24 hours.[11] In addition,it can live in water with low oxygen levels. Another advantage of this betta fish is that it can easily adapt to the environment and it has ability to eat voraciously.[10] Not only betta fish, but also there are several types of fish which have ability to adapt easily. One of them is the golden cichlid. It has the ability to adapt quickly and eat voraciously. In addition, it can live in places with clean water or in cloudy water conditions.

Research on controlling mosquito larvae using betta fish has many previous studies which have used and have effective results. Therefore, this study will focus on comparing betta fish and golden cichlid as mosquito larvae controllers. Considering that golden cichlid have almost the same characteristics as betta fish. The aim of this study is that to determine the differences in the ability of betta fish and golden cichlid to control *Aedes aegypti* mosquito larvae.

2. METHODS

2.1 Study Design

This study employed a quasi-experimental design using a Completely Randomized Design (CRD). The aim was to compare the effectiveness of two fish species in consuming *Aedes aegypti* mosquito larvae. The dependent variable was the number of larvae consumed, while the independent variable was the type of fish, namely betta fish (*Betta splendens*) and golden cichlid (*Melanochromis auratus*).

2.2 Study Population and Sample

The study population consisted of third instar *Aedes aegypti* larvae obtained from the Entomology Laboratory of the Surabaya Provincial Health Office. A total of 360 larvae were used in this study. The fish samples included 18 individuals, consisting of 9 betta fish and 9 golden cichlids. All fish were selected based on uniform inclusion criteria: body length of 2–3 cm and an approximate age of 4 months. This standardization was applied to minimize variability in predation ability due to size and age differences.

2.3 Acclimatization Procedure

Prior to the experiment, all fish underwent an acclimatization process to reduce stress and ensure normal feeding behavior. Each fish, still inside its original plastic bag, was floated in a glass jar containing 2 liters of clean water for 15–30 minutes. This allowed gradual adjustment to environmental conditions such as water temperature and quality.

2.4 Experimental Procedure

A total of 360 third instar mosquito larvae were prepared and distributed evenly into 18 plastic cups, with 20 larvae in each cup using a pipette to ensure consistency. Each fish was placed individually into a separate jar containing 2 liters of water. Subsequently, 20 mosquito larvae were introduced into each jar. The experiment was conducted simultaneously for both fish species under controlled environmental conditions, including similar temperature, light exposure, and water volume. The feeding activity was observed for one hour. At the end of the observation period, the remaining larvae were counted to determine the number of larvae consumed by each fish.

2.5 Data Analysis

Data analysis was performed in two stages. Univariate analysis was used to describe the distribution of larvae consumption, presented in the form of tables and diagrams. Bivariate analysis was conducted using an independent t-test to compare the mean number of larvae consumed between betta fish and golden cichlids. A significance level of 95% (α = 0.05) was applied to determine statistical differences between the two groups.

3. RESULTS

3.1 The Distribution of the Number of Mosquito Larvae Eaten by Betta Fish

Based on Table 1, it shows the results of the distribution of the number of mosquito larvae eaten by betta fish. The results shows that most of the betta fish can eat 20 mosquito larvae in the 15th minute with a total number of mosquito larvae eaten that are 174 mosquito larvae (96.4%) and leaving 6 *Aedes aegypti* mosquito larvae with an average of 19.3. In addition, betta fish eat at least 17 *Aedes aegypti* mosquito larvae in 30 minutes.

Table 1. Distribution of the number of mosquito larvae eaten by betta fish

Replication	Time to eat larvae				Total	Remainder	Percentage (%)
	15 minutes	30 minutes	45 minutes	60 minutes			
1	20	-	-	-	20	0	11.1
2	17	2	-	-	19	1	10.5
3	20	-	-	-	20	0	11.1
4	20	-	-	-	20	0	11.1
5	20	-	-	-	20	0	11.1
6	19	-	-	-	19	1	10.5
7	20	-	-	-	20	0	11.1
8	14	3	-	-	17	3	9.4
9	17	2	-	-	19	1	10.5
Total	167	7	-	-	174	6	96.4
Average					19.3		

3.2 The Distribution of the Number of Mosquito Larvae Eaten by Golden Cichlid

Based on Table 2, it shows the distribution results of the number of mosquito larvae eaten by golden cichlid. It shows that most of the golden cichlid eat mosquito larvae in the 15th minute with the total number of mosquito larvae eaten were 146 *Aedes aegypti* mosquito larvae (80.6%) and leaving 34 *Aedes aegypti* mosquito larvae with an average of 16.2. In addition, golden cichlid eats at least 14 *Aedes aegypti* mosquito larvae in 45 minutes.

Table 2. Distribution of the number of mosquito larvae eaten by niasa fish

Replication	Time to eat larvae				Total	Remainder	Percentage (%)
	15 minutes	30 minutes	45 minutes	60 minutes			
1	12	3	-	1	16	4	8.8
2	11	4	-	-	15	5	8.3
3	10	5	1	1	17	3	9.4
4	12	3	1	-	16	4	8.8
5	13	3	1	-	17	3	9.4
6	11	4	2	1	18	2	10
7	12	2	3	-	17	3	9.4
8	13	2	1	-	16	4	8.8
9	11	2	1	-	14	6	7.7
Total	105	28	10	3	146	34	80.6
Average					16.2		

3.3 The Analysis of the Difference in the Ability of Betta Fish and Golden Cichlid

Based on Table 3, it shows the results of differences in the ability of betta fish and golden cichlid. It shows that betta fish has higher predation ability than golden cichlid with an average *Aedes aegypti* larvae preyed on 19.3. Based on the results of the T-test that has been conducted with α= 0.05, the result obtained is $p < \alpha$ that is $0.000 < 0.05$.
in 45 minutes.

Table 3. Analysis of the differences in the abilities of betta fish and niasa fish

Variable	N	Average	T	SD	T-test	*p*–value
Betta fish	9	19.3	5.970	1.0	2.120	0.000
Niasa betta fish	9	16.2	5.970	1.2		

4. DISCUSSION

The distribution of the number of mosquito larvae consumed by betta fish shows their potential as effective biological control agents. Betta fish are ornamental species that can be utilized to feed on mosquito larvae.[12]. hey exhibit a variety of tail shapes and patterns, including crown, round, crescent, and slayer types. Male betta fish generally display more vibrant colors and more attractive fins compared to females.[13] In terms of morphology, males tend to have a slender and elongated body, while females typically have a larger body with a more rounded abdomen. They have an active nature and can easily adapt to the environment.[14] They are inhabitants of fresh water; such as, rivers, lakes, rice fields, ditches and swamps with temperatures ranging from 26-32 degrees Celsius and pH 7.0-8.5.[15] The high adaptability may be related to the presence of a breathing apparatus (labyrinth) which allows absorption of oxygen (O_2) directly from the air.[16] Based on the results of study which has been conducted, it shows that 5 betta fish can eat 20 mosquito larvae in 1 hour with a percentage of 55.5%. It proves that betta fish can be better natural predators of mosquito larvae than golden cichlid. Similar studies have found that betta fish are better at being predators of mosquito larvae and can consume as many as 20 mosquito larvae in 1 day.[17] In addition, another study stated that betta fish (Betta sp) are aggressive fish and are able to become effective natural predators of *Aedes aegypti* mosquito larvae.[18]

The distribution of the number of mosquito larvae consumed by golden cichlids highlights their role as effective natural predators. Golden cichlids are ornamental fish that can be utilized as biological control agents for mosquito larvae. Adult males and females can reach maximum lengths of approximately 9.5 cm and 7.5 cm, respectively, and have a lifespan of up to six years.[19] Golden cichlids exhibit distinct sexual dimorphism. Males typically display darker coloration, such as brownish-black or dark blue, along with larger heads and longer fins. In contrast, females tend to have brighter coloration, such as yellow, with shorter bodies, shorter fins, and smaller heads.[20] In terms of behavior, golden cichlids are active and aggressive swimmers, capable of moving quickly in the water. They are voracious omnivores; in their natural habitat, they feed on a wide variety of food sources, including worms, spirulina, and mosquito larvae. Optimal environmental conditions for their survival typically range between 22°C and 28°C, with a pH of 7.0–8.5.[21] Based on the study which has been conducted, it shows that golden cichlid can eat 14-18 mosquito larvae in one hour. Although golden cichlid cannot eat 20 mosquito larvae in one hour, they can be said to be a fish which can be used as a mosquito larvae predator. Furthermore, the results of the study using lemon chiclid (Labidochromis caeruleus) which is still a family with golden cichlid namely the silkid fish family (Family: Chichidae) shows that lemon chiclid has better predation power than tinfoil barb in eating mosquito larvae. A similar study using tilapia which is also a silkid family golden cichlid shows that tilapia is able to eat 100 mosquito larvae within 24 hours and can be a natural predator of Anopheles sp mosquito larvae.[22] It proves that fish from the silkid family can also be predators of mosquito larvae.

The analysis indicates a significant difference in the ability of betta fish and golden cichlids to consume *Aedes aegypti* mosquito larvae. Betta fish are shown to be more effective as mosquito larvae predators compared to golden cichlids. Betta fish are freshwater species commonly found in rivers, lakes, rice fields, ditches, and swamps. They are highly adaptable and tend to thrive in environments rich in aquatic vegetation.[23] This adaptability is closely associated with the presence of a specialized respiratory organ, known as the labyrinth organ, which enables them to absorb oxygen directly from the air (16). Betta fish are also known for their active and aggressive behavior, particularly in males, which contributes to their efficiency as predators.[14] In their natural habitat, they typically consume live food such as mosquito larvae, silk worms, and water fleas, as these provide suitable nutritional content and match their feeding mechanisms and digestive systems.[12] Golden cichlids, scientifically known as *Melanochromis auratus*, are ornamental freshwater fish native to Lake Malawi in Africa. They are capable of adapting to various

environments and generally prefer habitats with rocky substrates that provide shelter.[24] Similar to betta fish, golden cichlids are omnivorous and exhibit a strong feeding response. In the wild, they consume a wide range of food sources, including worms, spirulina, and mosquito larvae. However, despite their voracious feeding behavior, their effectiveness in consuming mosquito larvae is lower compared to betta fish.

This study is in line with other studies which observed betta fish (*Betta splendens*) and guppies (Poecilia reticulate) against the larvae of Ae. Aegypti which obtained statistical test results with p value = 0.000 which proves that there is a significant difference between the eating power of betta fish (*Betta* sp.) and guppies (Poecilia reticulata).[22] The results of a similar study also obtained a test result of p value = 0.0005 which means that there is a significant difference in ability between betta fish and guppies, goldfish, tilapia, tin heads, larvivorous fish, and beunteur fish as predators of *Aedes aegypti* mosquito larvae.[11] In addition, betta fish can be a predator of the third instar larvae of the *Aedes aegypti* mosquito with the most effective level of predation. In addition, other studies have also shown that betta fish are better at being predators of mosquito larvae than manvis fish.

The ability of fish to eat mosquito larvae can be influenced by several factors; such as, gender and age. Another study showed that female A. panchax fish are more effective at eating mosquito larvae than male A. panchax fish. In addition, age can also affect the ability to eat in fish where betta fish and golden cichlid at the age of 2 weeks are still in the form of fry (fish fry) which can only eat egg yolks and water fleas. Golden cichlid and betta fish at the age of 3-4 months can eat a variety of foods ranging from water fleas, silk worms, frozen worms, and adult mosquito larvae. Betta fish at the age of 2-3 months are ready to be harvested since at that age the betta fish already appear to show beautiful and active colors.[25] In addition, in golden cichlid where the pigmentation of the pattern on the fish fins is already visible which indicates that the fish has entered the adult phase.[26] Water quality; such as, water temperature can also affect the ability to eat fish. Based on the results of water quality measurements, it shows that the water temperature in this study ranged from 25-26 degrees Celsius. This temperature condition is still supportive for the survival of the two fish. In addition, temperatures which exceed the survival limit of fish >35 degrees Celsius can cause fish stress and loss of appetite in fish and if allowed to continue can cause fish death.[27]

5. CONCLUSION

The findings demonstrated a statistically significant difference in larval predation between the two species ($p < 0.001$), indicating that the type of fish influences larval control capacity. Betta fish were found to be more effective in consuming mosquito larvae compared to golden cichlids, highlighting their greater potential as biological control agents. Based on these results, betta fish are recommended for use in mosquito control programs, particularly in freshwater environments where *Aedes aegypti* breeding occurs. Further studies are suggested to evaluate their long-term effectiveness and applicability in natural field conditions.

Ethical Approval

Not required.

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Competing Interests

All the authors declare that there are no conflicts of interest.

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Underlying Data

Derived data supporting the findings of this study are available from the corresponding author on request.

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