UNIVERSITI PUTRA MALAYSIA

COMPARATIVE ASSESSMENT OF MOSQUITO BIOCONTROL EFFICIENCY BETWEEN ANABANTOIDEI NATIVE FISH: CLIMBING PERCH (ANABAS TESTUDINEUS) AND THREE-SPOT GOURAMI (TRICHOGASTER TRICHOPTERUS)

LIM CHIA HUI

COMPARATIVE ASSESSMENT OF MOSQUITO BIOCONTROL EFFICIENCY BETWEEN ANABANTOIDEI NATIVE FISH: CLIMBING PERCH (*Anabas testudineus*) AND THREE-SPOT GOURAMI (*Trichogaster trichopterus*)

LIM CHIA HUI

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It is hereby certified that we have read this project paper entitled "COMPARATIVE ASSESSMENT OF MOSQUITO BIOCONTROL EFFICIENCY BETWEEN ANABANTOIDEI NATIVE FISH: CLIMBING PERCH (Anabas testudineus) AND THREE-SPOT GOURAMI (Trichogaster trichopterus)" by Lim Chia Hui and in our opinion it is satisfactory in terms of scope, quality, and presentation as partial fulfillment of the requirement for the course VPD 4999 – Project

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LIST OF ABBREVIATIONS

CP	Climbing perch
CP.D	Climbing perch in drain water
CP.L	Climbing perch in lake water
CP.C	Climbing perch in non-chlorinated water
GR	Gourami
Ppt	part per trillion
^{o}C	degree Celsius
UPM	Universiti Putra Malaysia

ABSTRACT

An abstract of the project paper presented to the Faculty of Veterinary Medicine in partial fulfillment of the Course VPD 4999 – Project

COMPARATIVE ASSESSMENT OF MOSQUITO BIOCONTROL EFFICIENCY BETWEEN ANABANTOIDEI NATIVE FISH: CLIMBING PERCH (Anabas testudineus) AND THREE-SPOT GOURAMI (Trichogaster trichopterus)

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Over one million people die from mosquito-borne diseases every year urging the need to control mosquito population effectively. A study was carried out for comparison of mosquito biocontrol efficiency between two species of native Anabantoids, which were climbing perch (Anabas testudineus) and three-spot gourami (Trichogaster trichopterus). For each species, three fish were used to observe their feeding on mosquito larvae for three continuous days to determine the maximum daily intake of mosquito larvae. The mosquito larvae varying in length from 5 to 6mm were placed in each tank containing either A. testudineus or T. trichopterus. The mean maximum daily intake of mosquito larvae for a 3-day period was shown to be higher in A. testudineus as compared to the T. trichopterus. Amount of mosquito larvae fed was determined by enumerating the total number of larvae ate by the fish for each day. There was significant difference ($p<0.05$) in mean maximum daily intake of mosquito larvae between A. testudineus(71.1±4.37) and T. trichopterus(39.2±1.57). A. testudineus which was determined with higher predatory capacity was then further tested on the mean maximum daily intake of mosquito larvae when conditioned in tanks filled with three water sources: lake water, drain water and non-chlorinated water. It was found that the maximum daily intake of A. testudineus on mosquito larvae remained consistent regardless of the different water sources introduced. There was no significant difference ($p>0.05$) in the mean maximum daily intake of A. testudineus conditioned in three different water sources.

Keywords: Anabantoids, climbing perch (Anabas testudineus), three-spot gourami (Trichogaster trichopterus), mean maximum daily intake, mosquito larvae

ABSTRAK

Abstrak daripada kertas projek yang dikemukakan kepada Fakulti Perubatan Veterinar untuk memenuhi sebahagian daripada keperluan kursus VPD 4999 – Projek Ilmiah Tahun Akhir

PENILAIAN PERBANDINGAN ATAS KECEKAPAN KAWALAN BIOLOGI NYAMUK ANTARA IKAN ANABANTOIDEI TEMPATAN: IKAN PUYU (Anabas testudineus) DAN IKAN SEPAT (Trichogaster trichopterus) Oleh

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2015

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Lebih daripada satu juta orang mati dijangkiti penyakit bawaan nyamuk, menggesakan keperluan untuk mengawal populasi nyamuk secara berkesan. Satu kajian telah dijalankan untuk membandingkan kecekapan kawalan biologi nyamuk ke atas jejentik nyamuk diantara dua jenis ikan Anabantoids tempatan, iaitu ikan puyu (*Anabas testudineus*) dan ikan sepat (*Trichogaster trichopterus*). Bagi setiap spesis ikan, tiga ikan telah digunakan untuk menelitikan pemakanan mereka ke atas jejentik nyamuk selama tiga hari bagi menentukan min pemakanan maksimum harian ke atas jejentik nyamuk bagi setiap jenis ikan. *A. testudineus* yang telah ditentukan dengan tahap pemakanan maksimum harian yang tinggi kemudian diuji lagi dengan meletakkan ikan dalam tiga jenis air berlainan iaitu air kolam, air longkang dan air tanpa klorin untuk menentukan min pemakanan harian ikan ke atas jejentik nyamuk. Min panjang jejentik nyamuk yang digunakan untuk diberi makan kepada *A. testudineus* ataupun *T. trichopterus*. adalah diantara 5 hingga 6mm. Jumlah jejentik nyamuk yang dibagi makan ditentukan berdasarkan jumlah keseluruhan jejentik nyamuk yang dimakan oleh ikan setiap hari. Tahap min pemakanan maksimum harian ke atas jejentik nyamuk di antara *A. testudineus* dan *A. testudineus*(71.1±4.37) and *T. trichopterus*(39.2±1.57) mempunyai signifikasi yang berbeza($p<0.05$). Min pemakanan maksimum harian ke atas jejentik nyamuk oleh *A. testudineus* yang diletakkan dalam tiga jenis air tidak mempunyai signifikasi yang bebeza ($p>0.05$).

Kata Kunci: Anabantoids, ikan puyu (*Anabas testudineus*), ikan sepat (*Trichogaster trichopterus*), tahap pemakanan maksimum, jejentik nyamuk

1.0 INTRODUCTION

Mosquitoes

Mosquitoes belong to the family Culicidae and are distributed worldwide. They comprise of approximately 3400 species belonging to 34 genera. Among the common genera are *Aedes, Anopheles, Culex* and Psorophora. Mosquitoes are two-winged flying insects, with a long slender bodies and needle-shaped, piercing mouthparts. (Manguin and Boëte ,2011)

Mosquitoes are one of the most common insect vectors that transmit diseases, affecting the health of both humans and animals worldwide. They cause a variety of health problems, acting as a vector by transmitting disease-causing pathogens. Female mosquitoes require blood meals for egg production. During feeding on the host, either humans or animals, the pathogenic agents are transmitted to the host. The disease transmitted varies from one species of the Culicidae to another. The *Anopheles* acts as a vector transmitting diseases such as, malaria, and lymphatic filariasis. The *Culex* transmits Japanese encephalitis disease. The well-known *Aedes* mosquito could transmit several diseases namely, yellow fever, dengue, and other viral diseases. (Manguin and Boëte, 2011)

Mosquitoes require water to complete their life cycle. There are four distinct stages in their cycle: egg, larva, pupa and adult. Female mosquitoes usually mate only once, produce and lay eggs at certain time intervals throughout their life. Females require blood-meals from humans and animals to attain protein mainly for egg production. Males on the other hand do not suck blood but feed only on plant juices. In females, a period of 2 to 3 days is required from the starting of blood meal intake, followed by blood meal digestion, until they reach the stage for development of eggs. The gravid females will then lay eggs at suitable places with availability of water resources. Another blood meal will be taken to produce and lay the next batch of eggs. The process is repeated until the mosquito dies. Different species of mosquitoes lay eggs in different forms, either singly as seen in the eggs of *Culex* species, whereas the eggs of *Anopheles* are seen to be wedged together in raft. In the tropical region, the eggs usually hatch within 2 to 3 days due to the higher climatic temperature compared to the temperate region.

The larvae formed develop into four different stages. The first instar measures about 1.5 mm in length, and increase to approximately 8 to 10 mm at the fourth instar. At each instar, the larvae molt and shed their skin for growth and body development. The mosquito larvae are most commonly observed hanging and wiggling on the surface of the water. There is a siphon tube attached at the tip of the slender abdomen of the larvae for breathing. Once in a while, they can be seen diving to the bottom for the purpose of feeding or escaping from danger. The larval period lasts for about 4 to 7 days. The larval period can be extended when there is a shortage of food.

Fully grown larvae develop into comma-shaped pupae. The pupal stage is a resting and non-feeding stage. This stage normally takes for about 2 days before a fully developed adult mosquito emerges. The newly emerged adult rests on water surface for a short time to dry its body and wings before takeoff. The entire cycle from development of egg to adult takes about 7 to 13 days under circumstances of suitable environmental conditions.

Native Fishes- Climbing Perch (*Anabas Testudineus*) and Three-Spot Gourami (*Trichogaster trichopterus*)

Climbing Perch (*Anabas Testudineus*)

The climbing perch, *Anabas Testudineus,* belongs to the family of Anabantidae and order of Perciformes. It is a native fish species that is common in our country, Malaysia. This species is naturally distributed in other southern Asia countries as well as Thailand, India, Sri Lanka, Phillipines and Southern China. It is found mainly in low lying water bodies such as swamps, lakes, ponds, paddy fields, small pits and estuaries. They are very hardy fish and able to survive and strive through areas with depleted dissolved oxygen, by possessing a special accessory air breathing organs, which facilitate the utilization of atmospheric air for respiration. As such, they are well known for the ability to migrate between ponds over land. They are omnivorous feeders and feed mainly on insects, invertebrates and plants. Additionally, this species has been reported as one of the successful biological control organisms in controlling mosquitoes, for example *Aedes sp.*, *Culex sp.* and *Anopheles sp.* in sewage water. (Chandra et al., 2008)

Three-Spot Gourami (*Trichogaster trichopterus*)

The three-spot gourami, *Trichogaster trichopterus,* also known as the blue gourami belongs to the family of Osphronemidae and order of Perciformes. It is an air-breathing fresh water fish, indigenous to Africa and South East Asia (Nelson, 2006) . It can be found in most water bodies such as the paddy fields, river, and stream. This species of fish is omnivorous, feeds mainly on zooplankton, macroinvertebrates such as insects and larvae, as well as detritus and terrestrial macrophytes. Besides, they do eat insect larvae and algae which are harmful to man especially when being integrated in paddy field. As such, this fish species has been recommended to be used as biological control for mosquito.

Both fish species are well known to be used as biocontrol of mosquito. Being native, accompanied with their active, resilient behavior as well as their compatible nature make them to be suitable candidates for the control of mosquitoes. Since both fish species possess similar ability, it is interesting to know whether there are differences in their efficacy on mosquito control.

Thus the objectives for this study were:

1. To determine whether water inhabited by the climbing perch (*Anabas testudineus*) or three-spot gourami (*Trichogaster trichopterus*) can control mosquito breeding.

2. To compare the mean maximum daily intake on mosquito larvae between the climbing perch (*Anabas testudineus*) and the three-spot gourami (*Trichogaster trichopterus*).

3. To determine the effects of variable water conditions of the fish species with higher predatory capacity (based on objectives No.2) on the maximum daily intake of mosquito larvae.

2.0 LITERATURE REVIEW

2.1 Biological Control of Mosquito Larvae Using Larvivorous Fish: Climbing Perch and Three-Spot Gourami

Dengue continues to be a major health threat to Malaysia a century after its first reported outbreak in 1902. The disease is fast becoming a menace worldwide with new dengue-afflicted areas appearing on the dengue map every year. This is despite all the modem technologies available and the ways on controlling the potential mosquito vectors, as well as the much taunted progress in molecular biology and biotechnology which was thought to hold promise for eradication of dengue in the last century (Abubakar and Shafee, 2002).

A previous study had shown that there was development of resistance in the mosquitoes to chemicals due to the extensive usage of these synthetic insecticides (Milam et al., 2000). Use of synthetic insecticides acting as adulticides is not a prudent strategy in eradication of mosquitoes as it only targets mosquitoes which are in adult stage, and many times these mosquitoes can easily escape from the remedial measures (Service, 1992). As such, this has prompted the effort in exploring alternative, simple, sustainable methods of biological control of mosquitoes.

Biological control of mosquito larvae has been proven effective and successful in many studies and researches. The biological control agents used such as bacteria (Becker and Ascher,1998), protozoa (Chapman 1974; Legner 1995) and nematodes (Kaya and Gaugler, 1993) have all shown promising results as a means for controlling mosquito populations. Predatory activity of indigenous Mesocyclops and Microcyclops as biological control agents for Aedes larvae was evaluated and was found that the Mesocyclops was more aggressive and effiecint in attacking the Aedes larvae (Ong, 2006). The use of predatory fish as a biological control agent has also been reviewed extensively by Kumar and Hwang. (2005).

The most widely recognized and widely used biocontrol agents of mosquito populations are the western mosquito fish, *Gambusia affini*s and the eastern mosquito fish, *G. holbrooki*. However, the effect of these fishes on native faunal composition and their inability to survive in small spaces such as small containers, tree holes make them inefficient for mosquito control. (Kumar and Hwang, 2006). The practice of using *Gambusia* fish as a biological control agent against mosquito has since been discouraged due to the high variability on the efficacy of this fish and the negative impacts on native fauna due to its voracious and aggressive behavior. The introduction of *Gambusia* has eventually led to elimination of native fish from certain habitats (Rupp, 1995).

Native indigenous fishes have been prompted to be used as biological control for mosquito. This is because there are risks to an existing community which can result from the introduction of non-indigenous organism (Becker, 2010). According to Becker (2010), in China, the grass carp, Ctenopharygodon idella, and the common carp, *Cyprinus carpio*, are used in rice fields as young fish for the control of mosquito breeding as well as to feed on rice pests, such as grasshoppers. In Malaysia, a study was conducted by Abdullah (2006) with the use of two species of indigenous Anabantoids, *Betta pugnax* and *Betta anabatoides* in determining their predatory capacity on the mosquito larvae. Both species of fish had shown promising result and was proven suitable to be used as biological control agent on mosquito. *Betta pugnax* had a higher predatory capacity compared to *Betta anabatoide.*

Fish has been proven effective in controlling malaria vectors associated in rice fields (Lacey and Lacey, 1990). In Asia, introduction of larvivorous fish for biological control on mosquitoes has been effective and such integrated pisciculture provide additional economic, agricultural and nutritional benefits (Victor et al., 1994). In China, according to Wu et al. (1991), stocking rice paddies integrated with rearing of edible fish, improved rice yield, supported significant fish production as well as greatly reduced malaria cases. Examples of suitable integrated fish species in concurrent rice-fish culture can be *Clarius macrocephalus* (air-breathing fish), *Ophicephalus striatus* (snakehead catfish), climbing perch (*Anabas testudineus*) and snakeskin gouramis (*Trichogaster pectoralis*).

Three species of subtropical cichlids, *Tilapia zillii*, *Oreochromis mossambica and Oreochromis hornorum* were introduced in the irrigation system of Southeastern California. This had become established and the mosquito populations were successfully controlled by a combination of direct predation by these omnivorous fishes (Legner & Medved, 1973; Legner, 1978; 1983; Legner & Fisher, 1980; Legner & Murray, 1981; Legner & Pelsue, 1983).

There is a great variety of man-made containers on backyards or patios that collect rain water or that are filled with water by people where dengue vectors thrive. While conducting *Aedes aergypti* surverys in Malaysia during the mid-1960s, Garcia observed that *Poecilia reticulata* were utilized by town residents for the control of mosquitoes in bath and drinking water storage containers.

2.2 Larvivorous Fish - Anabantidae – Climbing Perch *(A. testudineus)* – Ikan Puyu

The climbing perch, *Anabas tesdunineus*, a native air breathing, fresh water food fish species which belongs to the family of Anabantidae and order *Perciformes*. *A. tesdunineus* is well known to be a visual feeder, predator and insectivore. Wijeyaratne and Perera (2001) investigated and determined that the main diet of this fish species is meat-based, such as insects and arthropods. This fish species has been reported as one of the successful biological control organism in controlling mosquito like *Aedes sp*., *Culex sp*., and *Anopheles sp.* in sewage water (Chandra et al., 2008)

2.3 Larvivorous Fish - Osphronemidae – Three-Spot Gourami (*Trichogaster trichopterus*)- Ikan Sepat

The three-spot gourami, *Trichogaster trichopterus*, is another native fresh water fish species belonging to the family of Osphronemidae. It is omnivorous, feeds mainly on zooplankton, macroinvertebrates such as insects and larvae, as well as detritus and terrestrial macrophytes. Besides, they do eat insect larvae and algae which are harmful to man especially when being integrated in paddy field. This fish species is commonly used in biological control for mosquito (Bindu et al., 2014).

3.0 MATERIALS AND METHODS

3.1 Fish species and acclimatization process

A total of eleven fish was used in the experiment. There were seven climbing perch (*Anabas testudineus*) and four three-spot gourami (*Trichogaster trichopterus*), acquired from Hasya Aquarium Shop, Selangor. Each fish was placed in an individual tank, measuring 8cm in height, 15cm in length, and 8cm wide. An acclimatization period of 1 week was set to allow the fish to adapt to the changes of the environment. During that 1 week period, the fish was fed mainly with mosquito larvae using a pipette.

3.2 Natural incubation and collection of mosquito larvae

Ten plastic pails half-filled with tap water were placed around shady areas at the jungle fowl farm located at Dengkil, Sepang. The pails were left for a period of 6 to 10 days. The matured larvae observed were obtained using a sieve to filter out all the water contained in the pails. Larvae of suitable length which was between 5 to 6mm were selected to be fed to the fish.

3.3 Predatory capacity of the climbing perch and three-spot gourami in respective aquarium tanks exposed to natural breeding environment of mosquito

Three tanks were prepared and were filled with an equal volume of water. The first tank consist a climbing perch, the second tank consist a three-spot gourami, whereas the third tank consist of plain water, acting as the control. The tanks were accessed after a week by the prevalence of mosquito larvae in the water.

3.4 Mean maximum daily intake of mosquito larvae between climbing perch and three-spot gourami

Six tanks were prepared. The first three tanks were occupied with a three-spot gourami, one in each tank; while the other three tanks were occupied with a climbing perch, one in each tank. All tanks were filled with an equal volume of water. Larvae were introduced into each tank continuously until to a point when the fish refused and stopped eating the larvae. The number of larvae consumed by each fish per day was recorded. This procedure was repeated for 3 continuous days.

3.5 Effects of different water sources on the selected fish species (based on result from objective 2: climbing perch) on the maximum daily intake of mosquito

Different types of water namely treated tap water, drainage water and lake water were filled into 3 separate tanks. The water quality of each type of water was analyzed via water analysis YSI 556 MPS instrument, measuring the water temperature, pH level, and dissolved oxygen level of the water. The ammonia level was measured using ammonia test kit. Three tanks were prepared for this experiment. The tanks were filled with non-chlorinated water, drainage water and lake water respectively. Each tank consisted of one fish, which was the climbing perch which had higher predatory capacity compared to the three-spot gourami as tested in experiment 2. The fish was fed with larvae for 3 continuous days to obtain the maximum daily intake of larvae.

3.6 Statistical Analysis

For the experiment to test on the mean maximum daily intake of mosquito larvae between climbing perch and three-spot gourami, the statiscal analysis was done via SPSS, the data is normally distributed, as such the data from this experiment were subjected to statistical analysis using Independent T- test, with $P<0.05$ as the acceptable level of significance.

The data from the experiment to test on the effects of different water sources on the selected fish species (based on result from objective 2: climbing perch) on the maximum daily intake of mosquito were subjected to statistical analysis using One-Way Anova, with $P<0.05$ as the acceptable level of significance.

4.0 RESULTS

4.1 Predatory capacity of the climbing perch and three-spot gourami in respective aquarium tanks exposed to natural breeding environment of mosquito

There was complete absence of mosquito larvae in the two tanks accommodated by predatory fish of climbing perch (*Anabas testudineus*) and three-spot gourami (*Trichogaster trichopterus*) respectively. The control tank without fish showed the presence of numerous mosquito larvae.

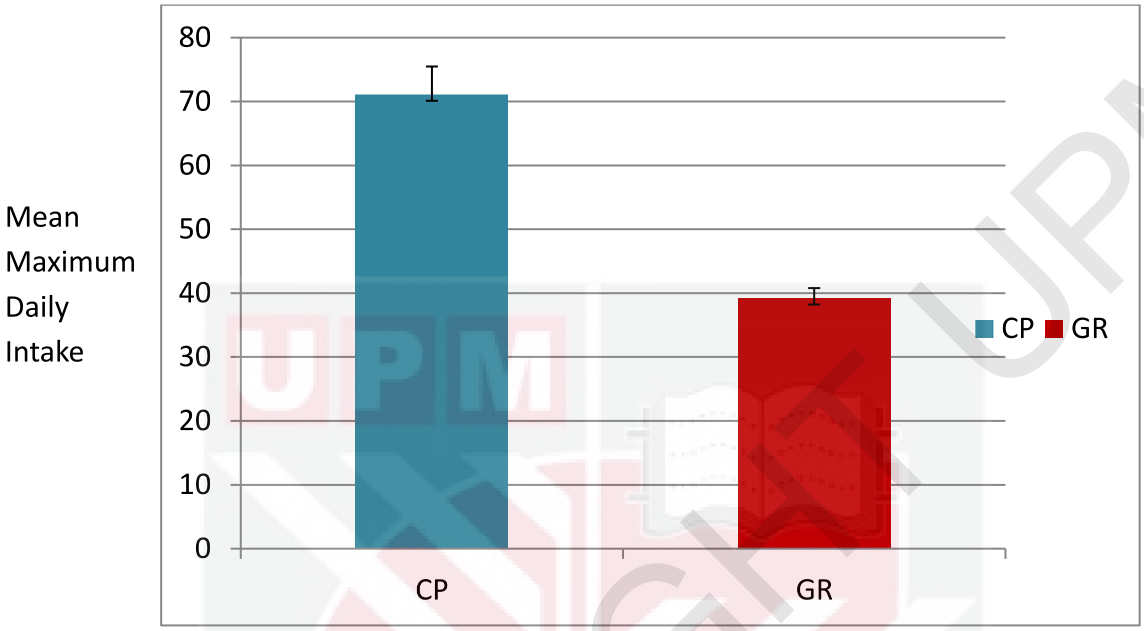
4.2 Mean maximum daily intake of mosquito larvae between climbing perch and three-spot gourami

The mean maximum daily intake during the 3-day period for climbing perch (*Anabas testudineus*) was 72 larvae, while on the other hand the maximum daily mean intake during the 3-day period for three-spot gouramis (*Trichogaster trichopterus*) was 34 larvae. There was significant difference in the mean maximum daily intake of mosquito larvae between these two different species of fish. ($P<0.014$) From the interpretation of the results obtained, the climbing perch (*Anabas testudineus*) has a higher predatory capacity, more than double than the three-spot gourami (*Trichogaster trichopterus*) as the larvae intake for this fish species is consistently higher.

Table I. Mean Maximum Daily Intake of Mosquito Larvae for 3 days for all 3 Climbing Perch and 3 Three-Spot Gourami determined with the use of independent T-Test

Fish Species	Mean Intake
Climbing Perch (Anabas testudineus)	71.11 ± 4.37^{a}
Three-Spot Gourami (*Trichogaster trichopterus*)	39.22 ± 1.57^{b}

Figure 1. Mean Maximum Daily Intake of the Mosquitoes Larvae for 3 days for all 3 Climbing Perch and 3 Three-Spot Gourami



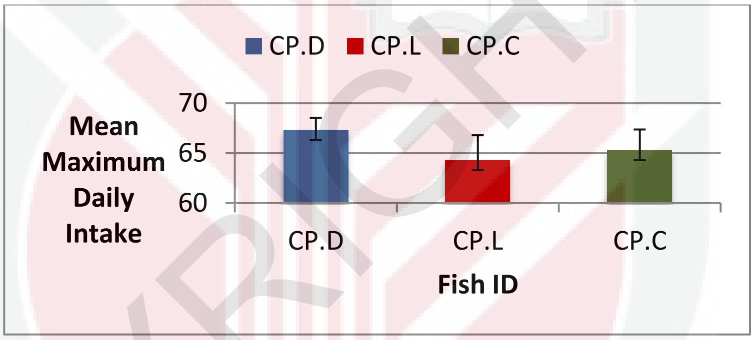
4.3 Effects of different water sources on the selected fish species (based on result from objective 2: climbing perch) on the maximum daily intake of mosquito

The water analysis result obtained from three different water sources, which were the non-chlorinated water, lake water, and drainage water showed that all the water sources were within the optimal water condition. Table II shows that the mean maximum daily intake on mosquito larvae by the each respective climbing perch placed in three different water sources ranged between 65 to 70. From the interpretation of the results obtained, the mean maximum daily intake on mosquito larvae by climbing perch (*Anabas testudineus*) placed in different water sources remained consistent, with no significant difference($p<0.825$) regardless of the different water sources introduced.

Table II. Mean Maximum Daily Intake of the Mosquito Larvae by Climbing Perch determined using One-Way Anova

Fish ID	Mean Maximum Daily Intake of Climbing Perch
CP.D	67.33± 1.202
CP.L	64.00 ± 2.457
Cp.C	65.33 ± 2.028

Figure 2. Mean Maximum Daily Intake of Mosquitoes Larvae for every 24 hours by Climbing Perch in Three Different Water Condition



5.0 Discussion

The first experiment of determining the predatory capacity of the climbing perch and three-spot gourami in aquarium tanks exposed to natural breeding environment of mosquitoes, showed that there was complete absence of mosquito larvae in the respective tanks accommodated with the climbing perch and the three-spot gourami. There were numerous larvae present in the tank without fish. These results proved that the presence of the aquatic predators bears high potential as biological agents in regulating the mosquito population in the habitat (Kumar and Hwang, 2006).

The mean maximum daily intake of mosquito larvae for a 3-day period was shown to be higher in climbing perch (*Anabas testudineus*) as compared to the three-spot gourami (*Trichogaster trichopterus*). The high maximum daily intake of the climbing perch may most probably due to the larger storage capacity of the rounded abdomen of climbing perch (*Anabas testudineus*) compared to the storage capacity of the laterally flattened stomach of the three-spot gourami (*Trichogaster trichopterus*). However, study of the anatomical comparison for both fish species has not yet been established. Moreover, from the data recorded on the weight and length of each experimented fish, it was found that the climbing perch had a heavier body weight even though total body length was shorter. The climbing perch thus had a bigger appetite associating with its heavier body weight. The three spot-gourami had a lighter weight even though with a longer total body length.

Throughout the 3-day period of observation, climbing perch (*Anabas testudineus*) was observed to be more ferocious in its predating behavior on mosquito larvae compared to the three-spot gourami (*Trichogaster trichopterus*) by moving aggressively to-and-fro to hunt its prey, and was see to be very sensitive of every slight movement of the mosquito larvae introduced into the tank. This observed behavior was in agreement with Wijeyaratne and Perera (2001), who considered the climbing perch (*Anabas testudineus*) as a visual feeder, predator and insectivore.

By determining that the climbing perch (*Anabas testudineus*) had a better predatory potential compared to the three-spot gourami (*Trichogaster trichopterus*), the climbing perch (*Anabas testudineus*) was then further tested for its tolerancy against variable water sources. It was found that the maximum daily intake of climbing perch (*Anabas testudineus*) on mosquito larvae remained consistent regardless of the different water sources introduced. The climbing perch (*Anabas testudineus*) is well known for its hardiness as it can tolerate desiccation and low dissolved oxygen condition (Khanna and Singh, 2003). This fish can withstand muddy condition and migrate between pools. (Daniel, 2000) Furthermore, based on the measured water quality parameters of the three different water sources introduced in the experiments, they were all at the optimal water condition. As according to Boyd (1990), the optimal water condition, taking consideration of the water temperature, dissolved oxygen concentration and pH for most warm water fish species are about 25-32 ^{o}C, >3 mg/l, and 6.5-8.5pH, respectively. As the different water sources obtained were all at the optimal water condition, with no distinctive fluctuation of the water quality parameters, the resilient climbing perch were not affected even though being introduced intro different water sources. As such, the mean maximum daily intake on mosquito larvae by climbing perch had no significant difference despite of being introduced intro the three different water sources.

From the experiment, it is concluded that both native fish: the climbing perch (*Anabas testudineus*) and the three-spot gourami (*Trichogaster trichopterus*) are suitable to be used as biological control agent in controlling the mosquito population. Climbing perch (*Anabas testudineus*) has a better predatory potential with a higher count of maximum daily intake of mosquito larva. It is no doubt hardy and can be utilized as biological control agent to combat mosquito larvaes.

6.0 Conclusion and Recommendation

Both native fish: the climbing perch (*Anabas testudineus*) and the three-spot gourami (*Trichogaster trichopterus*) are suitable to be used as biological control agent for controlling mosquito population. Climbing perch (*Anabas testudineus*) shows a higher predatory potential with a higher count of mean maximum daily intake of mosquito larvae compare to three-spot gourami (*Trichogaster trichopterus*). It was also found to be hardy and suitable to be utilized as biological control agent to combat mosquito larvaes.

Biological control of mosquito using predatory fish could be carried out commercially, by integrating the predatory fish in commercialized areas such as housing areas, paddy fields, irrigation canals, pools and lakes. At housing areas, specialized tanks inhabited with these predatory fish could be integrated in every house environment as an effort in controlling the mosquito population. The eggs lay in the tank and the larvae formed will be eatem by fish before they managed to develop into the adult stage. With this, the mosquito population could be effectively controlled. Further study of efficacy on biological control of mosquito between male and female climbing perch can be carried out. This study can be optimized by having a larger set of sample size of predatory fish to test on the efficacy of biological control of mosquito.

For future research, it is suggested the species of the mosquito larvae obtained is to be determined so as to see whether the different species of mosquito larvae fed to the fish could affect their predatory potential on mosquito larvae.

Different species of mosquito larvae can have different behavior and characteristic mainly in their preference of hideout places.

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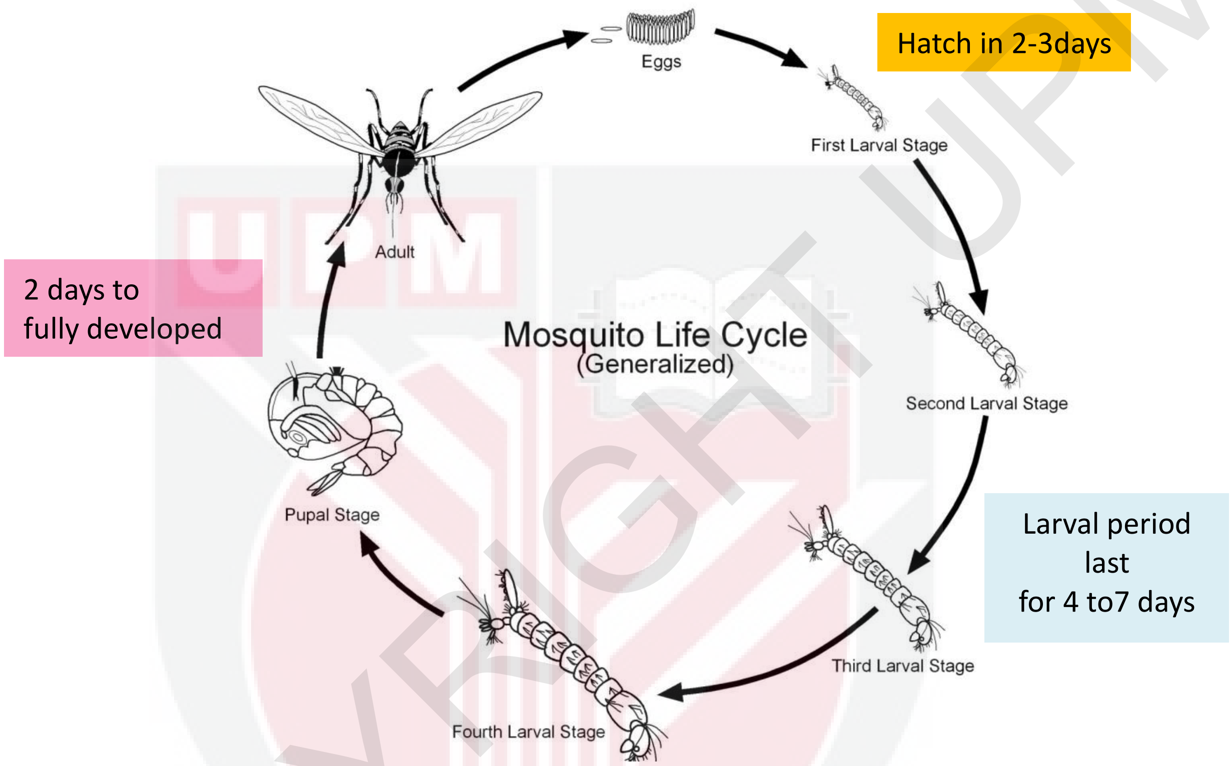
APPENDICES



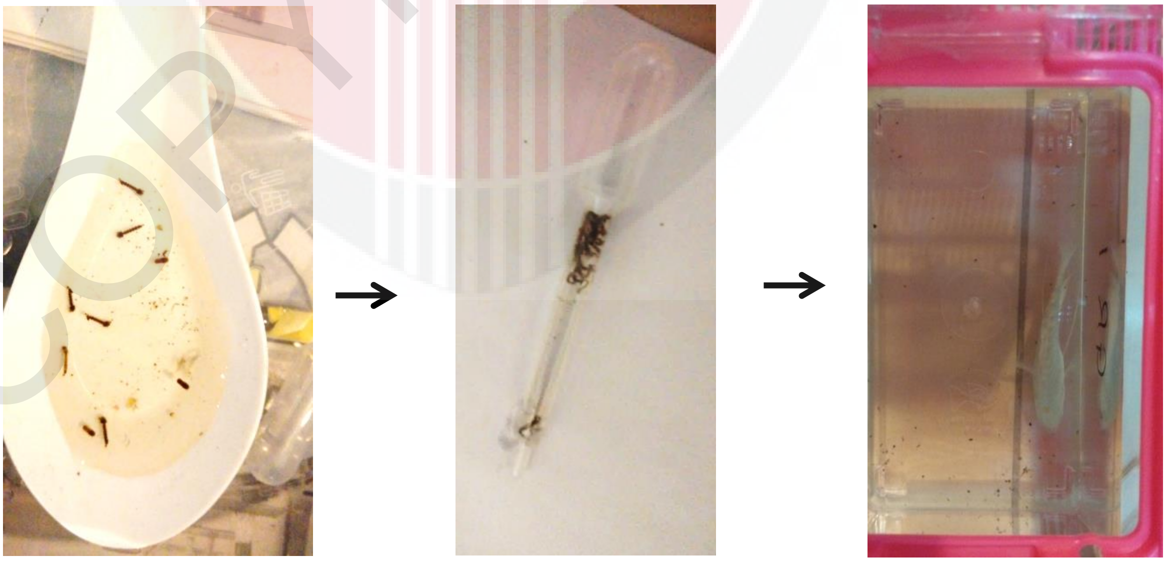
An illustration diagram on the mosquito life cycle.

The aquarium tanks measured at 8cm in height, 15cm in length, and 8cm wide. Fishes were allowed to acclimatized firstly before carrying out the experiment.

Matured mosquito larvae were seen after the pail was placed for a 9 to 10 days period. Mosquito larvae collection was carried out by using a sieved.

The three tanks placed to test for the predatory capacity of the climbing perch and three-spot gourami in respective aquarium tanks exposed to natural breeding environment of mosquito in Experiment 1.

Picture on Left: It was found that the tank with fish: the climbing perch and three-spot gourami had complete absence of mosquito larvae. ***Right***: Numerous mosquito larvae were found in the tank with no fish.



Mosquito larvae which are of suitable length(~5-6mm) was selected to be fed to the fish.

Different water sources of water were obtained: drainage water(left) and lake water(right) to test whether fish conditioned in different water sources will affect its predatory capacity.

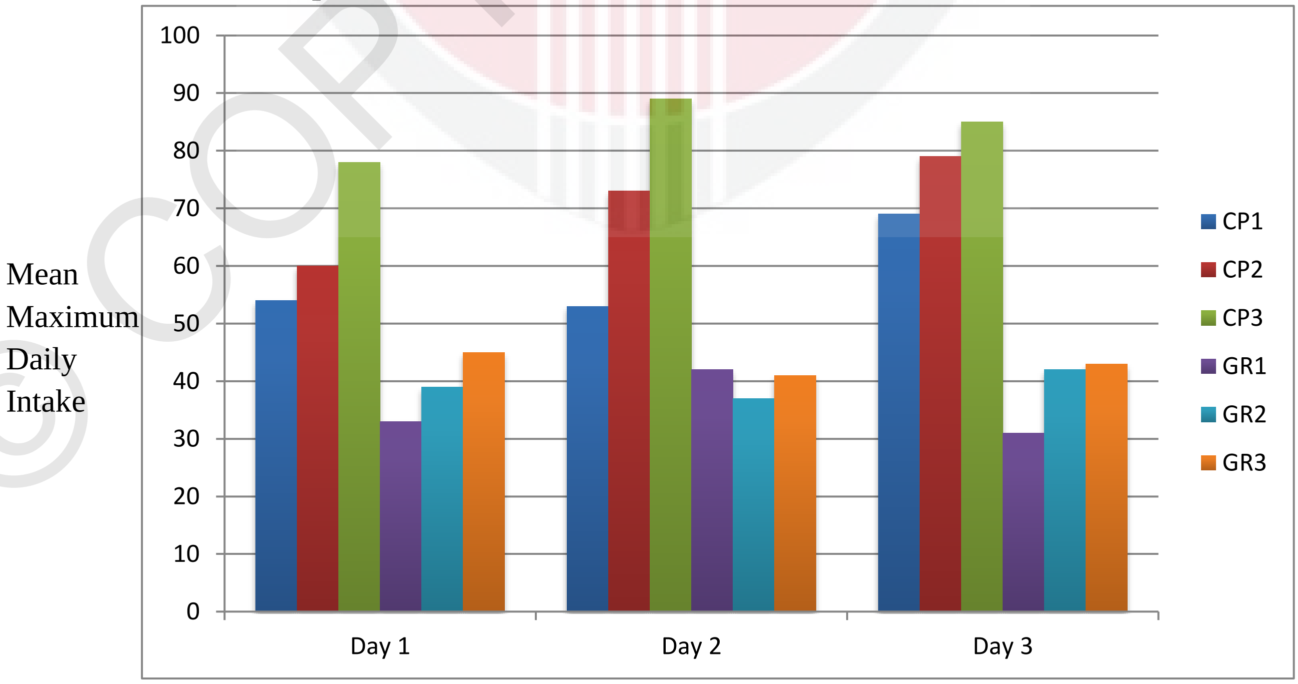
Table I. Maximum Daily Intake of Mosquito Larvae by Climbing Perch

FISH ID	Day 1	Day 2	Day 3	Total	Standard Weight (g)	Standard Length(cm)
CP1	54	53	69	176	10	6.0
CP2	60	73	79	212	11	6.5
CP3	78	89	85	252	13	7.0

Table II. Maximum Daily Intake of Mosquito Larvae by Three-Spot Gourami

FISH ID	Day1	Day2	Day3	Total	Standard Weight (g)	Standard Length(cm)
GR1	33	42	31	106	8	7.0
GR2	39	37	42	118	9	7.5
GR3	45	41	43	129	10	8

Figure 1. Maximum Daily Intake of the Mosquitoes Larvae For Climbing Perch and Three-Spot Gourami

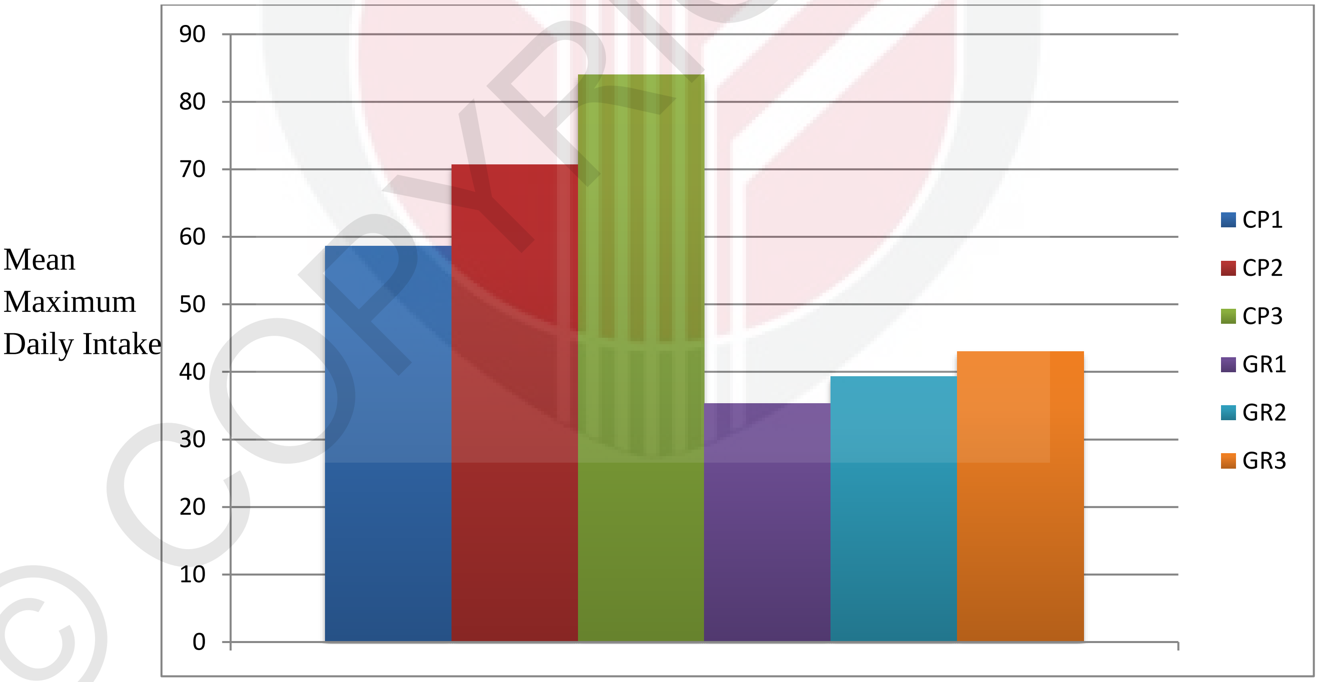


FISH ID: Cp= Climbing Perch; GR= Three-Spot Gourami

Table III. Mean of Maximum Daily Intake of the Mosquito Larvae by Climbing Perch and Three-Spot Gourami

ID	Mean Maximum Daily Intake of Climbing Perch	Mean Maximum Daily Intake of Three-Spot Gourami
1	58.67	35.33
2	70.67	39.33
3	84.00	43.00

Figure 2. Mean of Maximum Daily Intake of the Mosquitoes Larvae for every 24 hours by Climbing Perch and Three-Spot Gourami



FISH ID: CP = Climbing Perch; GR= Three-Spot Gourami

Table IV. Water Analysis Result on Three Types of Water Source

Indicators	Drain Water	Lake Water	Non- Chlorinated Water
Temperature (ºC)	26.22	28. 3	26.47
pH	6.32	6.57	6.8
Dissolved Oxygen Level (%)	4.1	4.6	4.5
Salinity (ppt)	0.57	0.68	1.01
Ammonia Level (mg/l)	< 0.05	< 0.05	< 0.05

Table VI. Maximum Daily Intake of Mosquito Larvae by Climbing Perch in Different Water Condition

FISH ID in Different Water Condition	Day 1	Day 2	Day 3	Total	Standard Weight (kg)	Standard Length(cm)
CP.D in Drainage Water	68	65	69	202	10	6.0
CP.L in Lake Water	57	61	75	192	10	6.5
Cp.C in Non-Chlorinated Tape water	62	69	65	196	9	6.0

Figure 4. Maximum Daily Intake of the Mosquitoes Larvae For for every 24 hours by Climbing Perch (Anabas testudineus) in Three Different Water Condition