Journal of Biological Engineering Research and Review, 2018; 5(1): 01-08
ISSN: 2349-3232 Online
Available online at www.biologicalengineering.in/Archive

Research Article

Biological control of *Aedes* larvae using indigenous fish (*Rasbora daniconius* (Nga Dawn Zin) and *Colisa fasciata* (Nga Thit Kyauk) from Pakokku Township, Magwe Region

Nyunt Nyunt Oo[1], Myo Thandar Thone[1], May Mi Mi Ko[1], Maung Maung Mya[2*]

[1]*Zoology Department, Pakokku University, Myanmar*

[2]*Medical Entomology Research Division, Department of Medical Research, Ministry of Health and Sports, Myanmar*

dr.mgmgmya@gmail.com

ARTICLE INFO:

Article History:
Received: 12/06/2017
Revised: 14/03/2018
Accepted: 28/03/2018
Available Online: 21/05/2018

Keywords:
indigenous fish, Colisa fasciata , Rasbora daniconius, Aedes larvae, consuming rate

Citation: Oo NN, Thone MT, Mya MM. Biological control of Aedes larvae using indigenous fish (*Rasbora daniconius* (Nga Dawn Zin) and *Colisa fasciata* (Nga Thit Kyauk) from Pakokku Township, Magwe Region. Journal of Biological Engineering Research and Review. 2018, 5(1), 01-08.

Abstract: The species *Aedes aegypti* is considered as the major vector of dengue fever, dengue hemorrhagic fever. Field and the laboratory-based descriptive study were performed with laboratory-reared 3rd and 4th instar *Aedes* larvae against native larvivorous fishes as *Rasbora daniconius* (Nga Dawn Zin) Pakokku and *Colisa fasciata* (Nga Thit Kaught) Pakokku from Pauk Inn in Se village, Pakokku Township Magway Region from July 2014 to December 2016. A series of laboratory experiments compared larva consuming rates of both fishes in different water volumes, to determine their potential as mosquito control agent in water storage containers. Laboratory results found that native larvivorous fishes *Rasbora daniconius* and *Colisa fasciata* consumed on significant numbers of *Aedes* larvae. Mean larva consuming rate of one individual, two together and three together *Colisa fasciata* fishes in three different water volumes found higher than *Rasbora daniconius* although when compare larvae/day/g weight, one-gram weight of *Colisa fasciata* consumed highest 439.29 larvae within 24 hours, it was 1.27-fold higher consuming rate than the one gram of *Rasbora daniconius* against *Aedes aegypti* larvae in laboratory. Larva consuming rates of both fishes were significantly higher in daytime than in night time in all water volumes. Of the two native fish species, *Colisa fasciata* showed the greater potential, although both *Colisa fasciata* and *Rasbora daniconius* was potentially larva consuming in the laboratory. Therefore, these two native larvivorous fishes can be used as a mosquito control agent against Aedes larvae in water storage containers in Pakakku Township, Magway Region.

INTRODUCTION

The species *Aedes aegypti* is considered as the principal vector of dengue fever, dengue hemorrhagic fever and dengue shock syndrome (DF, DHF, DSS) in many subtropical and tropical countries throughout the World. In Myanmar, the highest numbers of DHF cases were reported from Irrawaddy, Kachin, Magway, Mandalay, Mon, Rakkine, Sagaing, Tanintharyi and Yangon regions [1]. A severe outbreak of DHF occurred for the first time in Yangon in 1970 [2]. The spread of DHF from Yangon to other States and Regions started at the beginning of 1975 [3]. The urban areas within the Yangon City limits were more affected than the suburban Townships of Yangon Division. This epidemic had an affected mostly school going are groups. Prevention of DHF outbreaks in endemic areas is based on long-term anti-mosquito control measures mainly household and environmental sanitation with emphasis on larval source reduction. Only vector control promises permanency and a cost-effective solution [4].

One of the multiple possibilities of applying ecological theories for human welfare is the use of our knowledge about the effects and mechanisms of predation and competition within various kinds of permanent and temporary aquatic habitats. One of the most widely distributed visually feeding fish is the western mosquito larvivorous fish, *Gambusia affinis*, and the eastern mosquito larvivorous fish, *G. holbrooki* (Giarard). During the 20th century, several fish species were introduced outside their natural habitats. Both the western and eastern mosquito fish were introduced worldwide because of their reputation as mosquito control agents [5, 6].

Biotic interactions such as competition and predation have been reported to be capable of regulating the number of mosquito populations by reducing the number of larvae [7]. The selection of biological control agent should be based on its self-replicating capacity, preference for the target pest population with indigenous organisms. To achieve an acceptable range of control, a sound knowledge of various attributes of interactions between a pest population and the predator to be introduced is desirable. Different predators of mosquito larvae include amphibian tadpoles, fish, dragonfly larvae, aquatic bugs, mites, malacostracans, anostracans, cyclopoid copepods, and helminthes. Comparative research on introduced and indigenous larvivorous fish feeding is particularly scarce, although it is crucial to determine the impacts of their introduction to ecosystems [8].

Small fish such as *Claris fuscus*, *Tilapia nilotica*, and *Macropodus sp*, have been used in many regions to eliminate larvae in domestic water containers with considerable success. The use of catfish appears to be particularly useful [9]. These larvivorous fishes have been widely used as biological control agents of mosquito larvae, but they have their one limitations, for instance, such fish are expensive to rear and do not survive for long in small places (like containers, etc.). For several decades, different species of fish have been used in biological control of mosquito larvae, especially in natural breeding sites [10, 11]. Fish bred in artificial containers, such as large domestic tanks [12,13] and rainwater vessels, have already been used as an alternative to biological control in various parts of the world, including Nicaragua and Mexico [14,15].

Little is known about the ecology of larvivorous fish [16]. Food consumption rate of fish was observed that it could consume 83% of the fish's weight per day [17]. Few studies have analyzed the dietary patterns of mosquito larvivorous fish [18, 19]. Larvivorous fish was introduced in 1922 into southern California subsequently reduced populations of native fish throughout the state due to competitions, predation, and hybridization. It has now become a threat to native fishes that share similar habitats, especially cyprinodonts because of its ecological advantages related to fast growth, early maturity, viviparity [20]. *Aedes aegypti* and *Aedes albopictus* are found throughout Myanmar. *Ae. aegypti* is the primary vector and *Ae. albopictus* has only a secondary role. Many populations of mosquito vectors have developed resistance to synthetic organic insecticides, used mostly during the last half of 20th century [21] and there is growing concern about the potential health and environmental risks caused by these insecticides [22]. It is urgently needed a control method which are more effective than routine method. Thus, prevention of mosquito bite by personal protection and control of vectors are the only methods available to prevent Dengue fever (DF) and dengue hemorrhagic fever (DHF). Larvivorous fishes are excellent predators of mosquito's larvae [23]. Therefore, the present laboratory study attempted to investigate the larva consuming rate of native larvivorous fish *Rasbora daniconius* (Nga Dawn Zin) and *Colisa fasciata* (Nga Thit Kaught) from Pakokku Township to control the mosquito population.

Table 1. Mean larva consuming rate of one-gram weight of one *Rasbora daniconius* and one *Colisa fasciata* against *Aedes* larvae (larvae consumed per weight in 24hour)

Water volumes	*Rasbora daniconius*		*Colisa fasciata*	
	12hr larva/g	24hr larva/g	12hr larva/g	24hr larva/g
1Liter	129.37±13.05	218.25±10.26	113.66±9.71	165.37±11.14
3Liters	147.85±17.01	253.04±31.32	247.06±34.60	361.99±17.93
5Liters	179.07±12.53	299.22±38.55	232.97±3.21	318.69±4.7

(Room temperature 27-28º C and RH 86-90%, pH 7)

Table 2. Mean larva consuming rate of one gram of two *Rasbora daniconius* and two *Colisa fasciata* against *Aedes* larvae (larvae consumed per 24 hours by weight)

Water volumes	*Rasbora daniconius*		*Colisa fasciata*	
	12hr larva/g	24hr larva/g	12hr larva/g	24hr larva/g
1Liter	366.78±55.07	590.81±40.20	309.71±10.11	443.43±1.53
3Liter	372.63±20.82	575.42±45.62	418.13±47.3	666.29±93.20
5Liter	472.98±11.72	710.18±33.47	333.69±3.61	541.18±18.15

(Room temperature 27-28º C and RH 86-90%, pH 7)

MATERIALS AND METHODS

Study design

Field and laboratory-based descriptive study design were done with laboratory-reared *Aedes* larvae against native larvivorous fishes from Pakakku Township.

Study period

The study period was February 2016 to January 2017 (One-year study).

Study areas

Pakokku Township is situated in Magway Region. The population of Pakokku Township is about (301051 persons) and is divided into (264) villages (Census, 2015). Periurban areas of Sin Lan village 95° 2′ 4.11′′ east longitude and 21° 19′ 38.14′′ north latitude and Anout Taw village 94° 48′ 25.34′′ east longitude and 21° 19′ 4.08′′ north latitude of Pakokku Township, Magway Region with high DHF prevalence within the last five years were chosen as study sites. In each village nursery and day care centers, pre and primary schools were available. The inspected sites were randomly selected in each cluster.

Sample collection

Larvae collection

The study was conducted using non-intervention descriptive field investigation method. All potential breeding sites in suspected high-risk areas were examined to carry out the systematic research. Aedes larvae were collected from positive containers of different container categories as the major, minor and miscellaneous sources. Metal drums concrete tank, concrete jar, Bago jars, glazed or unglazed earthen pots (up to a size 30L), were considered as primary sources. Other sources such as flower vases, small glazed earthen jars and ant-guards were regarded as minor sources. Miscellaneous container categories contain discarded utensils (discarded earthen pots and jars, old cans discarded car tires, etc.), tree holes and hollow bamboo poles.

Native larvivorous fishes' collection

Native larvivorous fishes as *Rasbora daniconius* (Nga Dawn Zin) and *Colisa fasciata* (Nga Thit Kaught) were collected from Pauk Inn Lake in Se village, Pakokku Township Magwe Region. Field collected Aedes larvae, and larvivorous fishes were put into plastic bags separately and gave oxygen by oxygen pump till to the laboratory. Larvae and fishes were reared in the laboratory for further study. *Aedes* larvae were reared in the white tray (1x1.5ft) in the laboratory to get good enough quantities of larvae. Fishes were rated in concrete tanks (2.5x3x3fit) separately. DMR larva food was used as larval food, and mosquito larvae were used as fish food.

Laboratory experiment for the predatory rate of larvivorous fishes in three different water volumes

Twenty-four hours predatory rate of two larvivorous fishes as *Rasbora daniconius* and *Colisa fasciata* were tested against laboratory reared *Aedes* larvae. Larvae consuming rate, and day and night predatory rate were measured in three different water volumes. Before testing, fish's weight was measured by HP 300digital balance and length was measured by a ruler in centimeter.

Larva predatory rate of *Rasbora daniconius* and *Colisa fasciata*

Minimum and maximum larva consuming rate of each one, together two and three fishes were measured in different water volumes of one, three and five liters in the laboratory. One *Rasbora daniconius* each was put into three aquariums (size 7x7x10 inch) with 1 liter (water height 4 cm); 3 liters (12 cm) and 5 liters (20 cm) of tap water volumes. According to preliminary larva consuming test, one fish can consume 250-270 laboratory-reared larvae per day. Therefore at-least four hundred third and fourth instars of *Aedes aegypti* larvae (immature stages) were good enough for one fish for one day trial. Therefore, four hundred third and fourth instars of *Aedes aegypti* larvae (immature stages) were put into each aquarium at 06:00 hours and consuming rate were recorded 12 hourly at 18:00hrs for 12 hours and next day morning 06:00hrs for 24hours. The larva consuming rate for together two and three fishes, 800 *Aedes* larvae were used for two fishes, and 1200 *Aedes* larvae were used for three fishes in each different water volumes, and consuming rate was recorded as above procedure. Room temperature, Relative Humidity, and pH of water were recorded. Larva consuming rate of *Colisa fasciata* was recorded as above same procedure.

Data analysis

Larva consuming rate, day and night predatory rate, larva/day/gram were calculated by Microsoft Excel software.

RESULTS

Larvivorus effect

The highest mean larva consuming rate of one gram of one *Rasbora daniconius* against *Aedes* larvae within 24 hours was found 299.22±38.55 larvae in 5 liters water followed by 253.04±31.32 larvae in 3 liters volumes of water. Lowest consuming rate was found 218.25±10.26 in the 1-liter volume of water. The highest larva consuming rate of one gram of one *Colisa fasciata* was found 361.99 ±17.93larvae in 3liters water volumes followed by 318.69±4.7 larvae in 5 liters, and lowest consuming rate was found 165.37±11.14 larvae in 1-liter water volume. Feeding habit of one *Rasbora daniconius* and one *Colisa fasciata* found more larvae consumed in daytime than in night time in all water volumes (Table 1).

Table 3. Larva consuming rate of one gram of three *Rasbora daniconius* and *Colisa fasciata* against *Aedes* larvae (larvae consumed per day by weight)

Water volumes	*Rasbora daniconius*		*Colisa fasciata*	
	12hr larva/g	24hr larva/g	12hr larva/g	24hr larva/g
1Liter	382.88±61.33	596.50±76.97	490.65±10.44	707.01±36.46
3Liter	440.94±57.30	718.79±54.44	479.59±126.73	846.53±127.02
5Liter	507.43±10.02	801.35±28.10	527.57±91.66	953.25±64.02

(Room temperature 27-28º C and RH 86-90%, pH 7)

The highest mean larva consuming rate of two *Rasbora daniconius* against *Aedes* larvae within 24 hours was found 710.18±33.47 larvae in 5-liter water volumes followed by 590.81±40.20 larvae in a 1-liter volume of water. Lowest consuming rate was found 575.42 ±45.62 larvae in 3 liters water volume. And the highest mean larva consuming rate of one gram of two *Colisa fasciata* on *Aedes* larva within 24 hours was found 666.29 larvae in three liters water volume followed by 541.18 larvae in five liters water volume. Lowest consuming rate was found 443.43 larvae in one-liter water volume (Table 2).

The highest mean larva consuming rate of three *Rasbora daniconius* in 5 liters water volume against *Aedes* larvae within 24 hours was found 801.35±28.10 larvae followed by 718.79±54.44 larvae in the 3-liter volume of water. Lowest consuming rate was found 596.50±76.97 larvae in 1-liter volume of water. Mean larva consuming rate of one gram of three *Colisa fasciata against* 3rd and 4th instar *Aedes* larva within 24 hours in different water volumes were found that highest consuming rate 953.25±64.02 larvae in five liters water followed by 846.53±127.02 larvae in three-liter water volumes and lowest 707.01±36.46 larvae in one-liter water volume (Table 3). Table 4 showed that in the comparison of minimum and maximum amounts of larvae consumed per day by one-gram weight of *Colisa fasciata found* maximum consuming rate 439.29 in three-liter than *Rasbora daniconius* 345.83 larvae/day/ gram in five-liter water volume. Although the minimum consuming rate of *Colisa fasciata* was found 116.09 larvae in one liter was lower than the *Rasbora daniconius* 176 .60 larvae/day/grams in one-liter water volume.

Minimum and maximum consuming rate of *Rasbora daniconius* in three different water volumes by length were found to be 19.76 larvae/day/cm length in one-liter water and 39.52 larvae/day/cm lengths in five-liter water volumes. The maximum amount of *Aedes* larvae consumed by the one-centimeter length of *Colisa fasciata fish* in different water volumes was found highest 72.63 larvae/day /cm length in three-liter water volume, and minimum consuming rate (the lowest consuming rate) was observed 20.61 larvae/day/cm length in one-liter water volume. When compared with consuming rate of both fish in length, the minimum consuming rate in length were not significantly difference (19.76 and 20.61 larvae/day /cm) in one-liter water volume of both fishes although significantly difference was found in maximum consuming rate between in five liters and three-liter water volume of *Rasbora daniconius* and *Colisa fasciata* fish (39.52 and 72.63 larvae/day/cm, $P< 0.05$). *Colisa fasciata* was higher consuming rate than *Rasbora daniconius* in length.

Daytime larva consuming rate of both fishes were found higher than the nighttime larva consuming rate in all water volumes. Feeding habit of three *Colisa fasciata found* more larvae consumed in daytime than *Rasbora daniconius* in all water volumes (Fig. 1).

Table 4. Comparison of minimum and maximum amounts of larvae consumed per day by weight of fish (Larvae/day/gram weighted) and larvae consumed per day by length of fish (Larvae/day/cm length) for indigenous fishes *Rasbora daniconius* and *Colisa fasciata* from Pakakku Township

Water volume	*Rasbora daniconius*		*Colisa fasciata*		*Rasbora daniconius*		*Colisa fasciata*	
	Minimum (gm)	Maximum (gm)	Minimum (gm)	Maximum (gm)	Minimum (cm)	Maximum (cm)	Minimum (cm)	Maximum (cm)
1-liter	176.6	264.1	116.09	212.07	19.76	27.84	20.61	38.44
3-liter	205.41	316.67	286.6	439.29	22.16	35	59.15	72.63
5-liter	228.21	345.83	285.51	342.11	24.05	39.52	51.84	52.7

DISCUSSION

Mosquito-borne diseases have been a major problem in almost all tropical and subtropical countries. And currently, there are no successful vaccines against most such diseases. Many synthetic insecticides are widely used for controlling adult and larval mosquito population. However, the harmful effects of chemicals on non-target populations and development of resistance to these chemicals in mosquitoes along with the recent resurgence of different mosquito-borne diseases [24]. Biotic interactions such as competition and predation have been reported to be capable of regulating the number of mosquito populations by reducing the number of larvae that survive through larval development and by increasing the larval and pupal duration times [7]. Program to decimate mosquito populations by trying to kill the adult stage frequently fail because the adults reside alongside human populations in their households and hiding places can often not be detected as refuges for mosquitoes, thereby allowing them to escape remedial measures. Even larval mosquitoes live in areas where they are difficult to find and kill: for instance, in old tires, trash, water tanks, and any container that holds water [25]. Additionally, mosquitoes have developed resistance to frequently used pesticides making it even more challenging to control adult populations. Essentially, larval mosquito populations should be the first target of all control measures [26, 27].

Aedes aegypti is the most efficient mosquito vector in transmitting the dengue virus. The female mosquito bites man during the daytime. After biting a person whose blood contains the virus, the female *Aedes aegypti* can transmit dengue immediately by a change of host. During the incubation period of 8-10 days, the virus multiplies in its salivary glands and can be transmitted to another person. Dengue outbreaks can be occurred by *Aedes albopictus*, *Aedes polynesiensis* and several species of the *Aedes scutellaris* complex. Each of these species has its particular geographical distribution, and they are in general less efficient vectors than *Aedes aegypti*. Man is the primary reservoir of the virus. *Aedes aegypti* is considered as the principal vector of dengue/dengue hemorrhagic fever (DHF)/ dengue shock syndrome (DSS) and Dengue fever (DF) in many subtropical and tropical nations throughout the world.

The effective mosquito control strategies in temporary water storage containers in the community urgently need to reduce DF and DHF via to mosquito larvae reduction without harmful to environment, ecosystems, and community. The present study was conducted in Pakakku Township, Magwe Region to determine the larvivorous effect of small native fishes as *Rasbora daniconius* and *Colisa fasciata* on 3rd and 4th instar *Aedes* larvae in the laboratory.

Larvivorus effect of indigenous fishes

When compared with one-gram weight of one, two and three together, *Rasbora daniconius* in one, three and five-liter water volumes, the highest consuming rates 801.35 and 710.18 larvae were found in five liters water volume with three and two fishes against 3rd and 4th instar *Aedes* larvae within 24 hours although one *Rasbora daniconius* found 299.22 larvae was highest consuming rate in one-liter water volume against *Aedes* larvae in 24 hours. Molloy [14] found that the *Poecilia sphenops* kills up to 200 larvae in 24 hours or up to 405 larvae/g. Same larva consuming habit of two *Aplocheilus panchex* found highest in five-liter water and followed in one-liter volume [28,29]. One-gram weight of one, two and three together *Colisa fasciata* in one, three and five-liter water volumes, the highest consuming rates were found 953.25 larvae and 666.29 larvae in five and three liters water volume with three and two fishes against 3th and 4th instar *Aedes* larvae within 24 hours although two *Colisa fasciata found* 361.99 larvae was highest in one-liter water volume within 24 hours. Although Nan than than Kyi [28] reported that the highest larvae consuming rates of one-gram weight of *Trichogaster trichopterus* fishes were found in five liters water volume with three and two fishes within 24 hours. Although other researchers mentioned that the highest mean consuming rate of individual one, together two and three each *Applochilus panchax* in one, three and five-liter water volumes against 3rd and 4th instar *Aedes* larvae found highest in three-liter water volumes within 24 hours [29]. Pe Than Htun et al., [30] revealed that *Aplochilus panchax* consumed over hundred *Anopheles* larvae within 24 hours in laboratory condition. Courtenay and Meffe [5] concluded that *Gambusia* is an active predator of mosquitoes and had the positive impact on controlling mosquitoes in many countries for mosquito control and other purposes. Mostly *Colisa fasciata* are habited in a large amount of water in lakes and rivers, and larva consuming rate is high as well as it can be consuming over 300 larvae within one hour [30]. Ritchie and Laidlaw-Bell [31] found that ovipositing *Aedes taeniorhynchus* strongly avoided sites with high densities of *Gambusia holbrooki* and shifted to adjoining habitats with few or no predatory fish.

When compared with the minimum consuming rate against the weight of *Rasbora daniconius* was higher (176.00 larvae/day/g) than *Colisa fasciata* (116.09 larvae/day/g) in one-liter water volume. Although when compared the minimum larvae consuming rate with the length there was not significantly difference (i.e. 19.76 and 20.61larvae/ day/cm) and maximum amounts of larvae consumed per day by weight and length of *Colisa fasciata* fish was higher (439.29 larvae/g, 72.63 larvae/cm) than Rasbora *daniconius* (345.83 larvae/day/g, 39.52 larvae/day/cm) within 24 hours. The consuming rate of *Colisa fasciata* fish was found 1.27 and 1.83 folds higher than the consuming rate of *Rasbora daniconius.* Maximum and minimum consuming rate of *Aplochilus panchax* and *Trichogaster trichopterus* in three different water volumes by weight and length found that higher number of larvae 463.04 larvae/day/g and 122.86 larvae/day/g weights were consumed in three-liter water volume [29]. The study recommended that the measurement of larva consuming rate of larvivorous fishes against weight is the better testing method than the length of the fishes.

Feeding habit of individual one and together two and three *Rasbora daniconius* and *Colisa fasciata* found more larvae consumed in daytime than in night time in all water volumes. Guppies have been credited for their high larvivorous potential against mosquito vectors in daytime [32]. Same larvae consuming pattern were found in *Aplochilus panchax* and *Trichogaster trichopterus* against *Aedes* larvae [29]. *Psuedomugil signifer* showed the highest potential as a mosquito control agent, having consumption rates comparable to *Gambusia holbrooki*, and was the only species that did not show a significant reduction in larval consumption in the night experiments [33].

The larvivorous potential of indigenous fishes collected from natural habitats of Pakakku Township in Magwe Region was studied under laboratory. Among two native fishes namely *Rasbora daniconius* and *Colisa fasciata were* tested against 3rd and 4th instars, *Aedes aegypti* larvae both fishes were found to be suitable species regarding predatory rates were 176.00 to 345.83 larvae/g/day for *Rasbora daniconius* and 116.09 to 439.29 larvae/g/day for *Colisa fasciata.* Although *Colisa fasciata* found slightly higher in maximum larva consuming rate, it was found 1: 1.27fold higher than *Rasbora daniconius*. An Indian researcher group mentioned that the consumption rate of mosquito larvae by four different indigenous fish species of ornamental value under laboratory condition revealed that, among the four species, mean consumption of the *Rasbora daniconius* is highly significant ($P<0.01$) followed by *Colisa lalia* and *Amblypharyngodon mola* ($P<0.05$) [34]. Other researcher reported that one gm of *Aplocheilus panchax* consumed 463.04 larvae within 24 hours, it was 3.727-fold higher consuming rate than *Trichopodus trichopterus* against *Aedes aegypti* larvae in the laboratory [29]. Other study mentioned that the number of larvae removed varied from 188 larvae/g/day by *Trichopodus trichopterus* to 523 larvae/g/day by male *Poecilia sphenops* and female *Betta splendens* [35]. Jayasree &Panicker [36] reported that the *Trichopodus trichopterus* is capable of consuming up to 47 *Culex quinquefasciatus* larvae/g/day. Work by Gene et al., [37] showed that the *Astyanax bimaculatus* has a very high consumption capacity, managing to consume between 342 and thousand larvae in 24 hours (at an average of 655 larvae).

These indigenous fishes are abundant in rivers, lakes, ponds and creek water; high feeding habit of mosquito larvae; hardness and size are very suitable larvivorous fishes to use as the bio-control agent in water storage containers in Pakakku areas. Although Lucino et al., [35] revealed that the *Trichogaster trichopterus* was the only species in which both sexes ate 100% of the available larvae. The *Betta splendens* failed to eat only 15 larvae. The male *Poecilia reticulate* showed a substantial capacity for larvae feeding, compared with the female of the same species. Regarding weight and size, the *Betta splendens* proved capable of eating 523 larvae per gram of weight. Martinez et al., [15] suggested that ten *Poecilia shenops* or *Astyanax fasciatus* specimen be used in each container for effective control in artificial domestic containers of *Aedes* larvae, or of *Culicidae* in general. However, an analysis of the number of larvae that a container can host suggests that only one specimen of the fish is capable of removing, in a short space of time, the *Aedes* larvae that can exist in domestic containers.

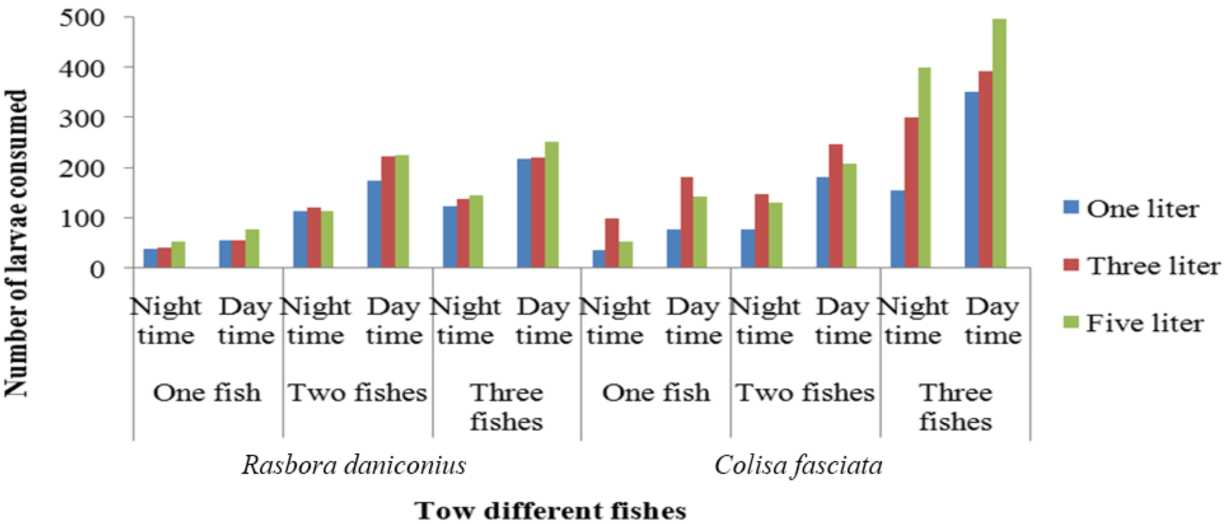

Fig. 1. Night and day time larva consuming rate of different number of two species of fishes in different water volumes

Study of breeding sites and breeding times are essential to know about breeding habit and habitat of local larvivorous fishes and known about which good predators of Aedes are, *Culex,* and *Anopheles* mosquito larvae. Laval predatory rate of *Colisa fasciata was* found highest against *Aedes* larvae but it was not significantly difference consuming rate between other *Aedes, Anopheles* and *Culex* mosquito larvae in laboratory [11,30,38] but Singh and associated revealed that dragonfly nymphs are consumed maximum number of *Anopheles* larvae (121±12) followed by *Aedes* and *Culex* [39]. A study of Chandra in India mentioned that adult dragonflies are found in greater number during summer and monsoons seasons [40]. Guppies have been credited for their high larvivorous potential against mosquito vectors [32]. The limitation of *G. affinis* and *Poecillia reticulate* at controlling mosquito populations have been further proven in a comparative study conducted by Wang [41], who revealed that the Taiwan native larvivorous fish, *Macropodus opercularis*, was better adapted to the breeding habit and could control larval populations eight times more efficiently than could *G. affinis*. The present study emphasizes the biology of the *Aedes aegypti* immature. Based on the knowledge, effective control strategies should emphasize on larval source reduction which will be an important achievement for long-term vector control. The development, survival condition and other attributes of *Aedes aegypti* from different container categories, and types were studied since these breeding sites were focal points which were targeted in control activities. Native larvivorus fish as *Colisa fasciata* and *Rasbora daniconius* was found useful biological control agent for controlling the larval density of vector mosquitoes and it can be used as an effective biological control agent in different water storage containers to reduce the adult mosquito population in urban, peri-urban and rural areas.

CONCLUSION

Aedes, Culex and *Anopheles* are important vectors of diseases, especially in the tropic regions. Resistance to chemical insecticides is a growing problem, and increasing attention is being paid to alternative control methods. Among the weapons available for use against mosquito larvae, biological control may be advantageous. An alternative biological control method of larvivorus was found to be effective in suppression of *Aedes* mosquito larvae and adults population in control of DHF occurrence in the community. The method was regarded acceptable to the public and feasible. This control tool was locally available and harmless to man and environment and ecology. Because of its relatively long life (approximately one or more years in tropical climates) and its recorded daily feeding rate, one gm of *Colisa fasciata* consumed 439.29 larvae was 1.27-fold higher than *Rasbora daniconius.* Although both fishes can be used effectively as a strong bio-control agent for control of mosquito-borne diseases, as well as for control of mosquitoes that are or that may become resistant to pesticides. Therefore, application of both *Colisa fasciata* and *Rasbora daniconius* fishes should be considered in control of DHF when conventional methods fail.

REFERENCES

1. Tun Tun Aung, Soe Win and Soe Aung.. Status report on epidemiology of dengue haemorrhagic fever in Myanmar, 1995. Dengue Bulletin, 1996; 20:41-45.
2. Ohn Khin. Epidemiological situation of Dengue Haemorrhagic Fever in Rangoon Burma. Dengue News WHO SEARO and Western Pacific Region, 1985.
3. Vector Borne Diseases Control, Dengue Haemorrhagic Fever in Myanmar 1970-89. Department of Health, Yangon, Myanmar 1990.
4. Halstead, S.N. *Aedes aegypti*: Why can't we control it? Bulletin of Vector Ecology, 1988; 13: 304-311.
5. Courtenay W.R. and Meffe G.K. Small fishes in strange places: a review of introduced poeciliids. In GK Meffe, FF Snelson, eds. Ecology and evolution of live bearing fishes (Poeciliidae). New York, Prentice Hall, 1989; 319-331.
6. Hammer A. J., Lane S. J., Mahony M. J. The role of introduced mosquito fish (*Gambusia holbrooki*) in excluding the native green and golden bell frog (*Litoria auria*) from original habitats in south eastern Australia. Oecologia, 2002; 132:445-452.
7. Knight, T. M., Chase J.M., Goss G.M., Knight J.J. Effects of interspecific competition, predation, and their interaction on survival and development time of immature *Anopheles quadrimaculatus*. J. Vector Ecol. 2004; 29: 277-284.
8. Hoddle M.S. Restoring balance: using exotic species to control invasive exotic species. Consery. Biol. 200418: 38-49.
9. Neng W., Shusen W., Guangxin, H., Rongman X., Guangkun T., Chen Q. Control of *Aedes aegypti* larvae in house holds water containers by Chinese cat fish. Bull. WHO, 1987; 65: 503-506.
10. Koldenkova I., Famthingoc D., Israel G. G. Alimentaccion de los alevinos de pez larvivoro *Poecilia reticulata* (Cyprinodontiformes: Poecilidae) em un criadero natural de *Culex quinquefasciatus* (Say, 1823). Rev. Cubana Med Trop.1989; 41(1): 140-148.
11. Lardeux F., Sechan Y., Loncke S., Deparis X., Cheffort J., Faaruia M., et al. Integrated control of peridomestic larval habitats of *Aedes* and *Culex* mosquitoes (Diptera: Culicidae) in atoll villages of French Polynesia. J. Med. Entomology.2002; 39(3): 493-498.
12. Wu N., Wang S., Han G., Xu R., Tang G. and Quian C. Control of *Aedes aegypti* larvae in household water containers by catfish. Bulletin of the World Health Organization, 1987; 65:503-506.
13. Sharma S. N., Kaul S.M., Lal S. Use of *Gambusia affinis* in different habitats as a mosquito control agent. J. Commun Dis.1997; 29(4): 371-373.
14. Molloy D.M. Some personal experiences with fish as antimosquito agencies in the tropics. Amer. J. Trop. Med. 1924; 4: 175-194.
15. Martinez-Ibara J.A., Guilen Y.G., Arredondo-Jimenes J.I. Rodriguez-Lopes M. H. Indigenous fish species for the control of *Aedes aegypti* in water storage tanks in Southern Mexico*.* Bio Control. 2002; 47(4): 481-486.
16. Meffe G. K., Snelson FF. An ecological overview of poeciliid fishes. In Meffe G.K., FF. Snelson, eds. Ecology and evaluation of live bearing fishes (Poeciliidse), New York: Prentice Hall, 1989; 13-31.
17. Wurtsbaugh W. and Cech J. Growth and activity of *Gambusia affinis fry:* temperature and ration effects. Trans. Am. Fish. Soc. 1983; 112: 653-660.
18. Crivelli A.J. and Boy V. The diet of mosquito fish, *Gambusia affinis (*Braird and Girard*) (Poeciliidae)* in Mediterranean France. Rev.d'Ecol.1987; 42: 421-435.
19. Specziar A. Life history pattern and feeding ecology of the introduced eastern mosquito fish, *Gambusia holbrooki* in a thermal spa under temperate climate of lake Heviz Hungary, Hydrobiologia. 2004; 522:249-260.
20. Vargas M.J., and Sostoa de A. Life history of *Gambusia holbrooki* (Pisces: Poeciliidae) in the Ebro Delta (NE Iberian Peninsula). Hydrobiologia, 1996; 341: 215-224.
21. Rathbun C.B. Jr. Adulticides in the '90s: the changing picture. In: Wing Beats, 1990; 1: 12-13.
22. Seabastian A., Thu MM, Kyaw M & Sein M. The use of dragonfly nymphs in the control of *Aedes aegypti*. Southeast Asian Journal of Tropical Medicine and Public Health, 1980; 11(1): 104-107.
23. Ghosh, A., Bhattacharjee I. and Chandra G. Bio-control efficacy of *Oreochromis nilotica nilotica* against larval mosquitoes. Journal of Apply Bulletin of Entomology and Research, 2006; 17(1):114-116.
24. Milam C.D., Farris J.L., Wilhide J. D. Evaluating mosquito control pesticides for effect on target and non-target organisms. Arch. Environ. Con. Tox, 2000; 39: 324-328.
25. Service M.W. Biological control of mosquitoes-has it a future? Mosq. News, 1983; 43: 113.
26. Service M.W. Importance of ecology in Aedes aegypti control. SE Asian J. Trop. Med. Publ. Hlth., 1992; 23: 681-688.
27. Briegel H. Physiological Bases of mosquito ecology. J. Vector. Ecology, 2003; 28: 1-11.
28. Nan Than Than Kyi. Feeding rate of two larvivorous fishes on *Aedes aegypti* in two villages in Hpa-an, Kayin State. MRes. 2015; Thesis.
29. Maung Maung Mya, Nun Nyunt Oo, Nan Than Than Kyi, et al. Larvivorous effect of *Aplocheilus panchax* and *Trichogaster tricopterus* native fish of Hpa-an Township, Kayin State. Myanmar Health Sciences Research Journal, 2016; 28(2):121-127.
30. Pe Than Htun, Marcus Winn, W Tun Lin and Maung Maung Mya.. Evaluation of the larvivorus potential of indigenous fishes for malaria control in Mon State, *Myanmar Health Research Congress* 1994. Myanmar. Malaria Research Findings Reference Book 1999-2000, 1994; p 49.
31. Ritchie SA, C Laidlaw-Bell. Do fish repel oviposition by *Aedes taeniorhychus*. J. Am. Mosquito Contr, (1994); 10: 380-384.
32. Meisch M.V. In chapman HC, editor ed. *Gambusia affinis affinis* chap.2. Biological control of Mosquitoes. Fresno, CA American Mosquito control Association Bull, 1985; 6:3-17.
33. Griffin L. Laboratory evaluation of predation on mosquito larvae by Australian mangrove fish. Journal of Vector Ecology, (2014); 39 (1): 197-203.

34. Rao BUS, Krishnamoorthy K, Reddy CBS, Panicker KN. Feasibility of mosquito larval control in casuarina pits using *Gambusia affinis*. Indian J Med Res., 1982; 76: 684-8.
35. Luciano P. de G. C., Ricardo J.S.P., Ana C.F.R., Francisco J. de P.J., Rodrigo L. F., Emanuel P.S., Fabio F.D.F. Jose W. de O.L. Efficacy of fish as predators of *Aedes aegypti* larvae, under laboratory condition. Rev. Saude Publica, 2007; 41(4):1-6.
36. Jayasree M. and Panicker K.N. Larvivorus potential of some indigenous fishes of Sherthallai region with special reference to their efficacy in control of mandonioides. Indian J. Med. Res., 1992; 95:195-199.
37. Gene C. M. Rosa J. R., Rea M. J. F. Borda C. E. Control biologico de mosquitos-I Ensayos Preliminares con peces outcomes. In: Communications cientificasy technological del Centro National de Parasitology Entermidsades Tropicales, 1999.
38. Mandal SK. Ghosh A., Bhattacharjee I. Chandra G. Biocontrol efficiency of Odonate nymphs against larvae of the mosquito, *Culex quinquefasciatus Say*, 1823. Acta Trop., 2008; 106(2): 109-114.
39. Singh R.K., Dhiman R.C. and Singh S.P. Laboratory studies on the predatory potential of dragon fly nymphs on mosquito larvae. Communicable Diseases, 2003; 35:96-101.
40. Chandra G., Mandal S.K., Ghosh A.K., Das D., Banerjee S.S. and Chakraborty S. Biocontrol of larval mosquitoes. Journal of American Mosquito Control Association, 2007; 23:65-92.
41. Wang CH. Laboratory comparative evaluation of larvivorous fishes as dengue fever vector control agents. Chin. J. Publ. Hlth. (Taipei), 1998; 17: 458-467.

About Authors

Dr. Nyunt Nyunt Oo is serving as an Associate Professor in Pakakku University, Magwe Region Myanmar, for 24 years. She has been awarded Ph.D in Zoology from Yangon University in 2006. Her research works has been appreciated in Myanmar Health Research Conferences and he also received best poster award 2014. He has published more 5 national and 3 international journals. Also, she has produced 5 M. Res. and 7 M.Sc. One MRES and one M.Sc. students were under progress.

Dr. Maung Maung Mya is serving as a Research Scientist in Department of Medical Research, Yangon Myanmar, for 25 years. He has done B.Sc., B.Sc. (Hons) in Zoology from Yangon University (1984). Later obtained M.Sc. in Zoology (Special in Parasitology) from the same University in 1988. He has been awarded Ph.D. in Biomedical Engineering at Indian Institute of Technology, Delhi in 2003. He has received several honors and awards such as Young Scientist Award 1998, Dorga Award 2003, FITT Award 2003, Jawaharlal Nehru memorial prize 2005, Good Public Staff Award 2007 and 50 years Golden Jubilee Award for Research 2013. His research works has been appreciated in Myanmar Health Research Conferences and he also received best paper/poster awards. He has published several research/review papers in 43 national and 21 international journals.