



Influence of certain eco-physiological factors on predation efficiency of *Gambusia affinis* (Baird and Girard) on Culicine mosquito larvae

Sawsan A. K. El-Hadeeti^{1,2}, A. I. Farghal¹, T. M. Abo-Elmaged^{1*}, Y. A. Darwish¹, M. A. K. Nasser¹

¹Plant Protection Department, Faculty of Agriculture, Assiut University, 71526 Assiut, Egypt

² Faculty of Agriculture, Baghdad University, Baghdad, Iraq

Abstract

The effect of light, water temperature and pH on the predation efficiency of *Gambusia affinis* (Baird and Girard) on *Culex pipiens* L. (Diptera: Culicidae) mosquito larvae was studied under laboratory conditions. Significant predation rate was recorded in light than in darkness for both male and females, despite fish size. The temperature 30°C showed the most favorable degree for predation compared with 25 and 35°C. Also, the predatory efficiency of *G. affinis* on mosquito larvae was significant at pH 9 than on 7 and 12. The present results should be taken in consideration in biological control of mosquito larvae.

Keywords: Mosquito Culicine, *Gambusia affinis*, Temperature, pH, Light.

* **Corresponding author:** T.M. Abo-Elmaged,
E-mail: tarek.aboelmaged@agr.au.edu.eg

Introduction

It's known that mosquitoes are responsible for the transmission of many serious diseases of human and animals. Alternative ways and strategies to reduce mosquitoes are required in order to avoid the use of pesticides that have harmful effects on the environment and on human at the same time (Hurst et al., 2007; Carlson et al., 1999; Bartlet, 1964). Biological control using fish is necessary part of a complete mosquito control. Biological control mechanism using fishes specifically target mosquito larvae. *G. affinis* have been used for more than 100 years and introduced to more than 60 countries in the last century, and remains as preferred larvivorous fishes on mosquitoes (Walton, 2007; Gerberichand & Laird, 1985). Mosquito fish is easy to culture and capable of rapidly producing large populations in laboratory colony or field aquatic habitats. The mosquito fish was used to evaluate non-target impact for mosuqitocides (Tietze et al., 1994). In this regard, the potential role of *G. affinis* Culicine mosquito predator it is important to elucidate how the environmental factors (temperature, pH and light) affect the predation processes through series of laboratory feeding trails. The objective of the study herein is to evaluate the effect of some eco-physiological factors (light, temperature and pH) on the predation efficiency of *G. affinis* on *C. pipiens* larvae under laboratory conditions.

Materials and methods

Collection of mosquito Culicine and culture rearing: Culicine immature stages were collected from two places of Assiut Governorate (Arab El-Madabigh and El-Ghorieb) during 2016 and 2017, and then transported to the laboratory in

plastic containers. In the laboratory, the immature mosquitoes were transferred to enamel larval trays until adult emergence. After emergence, the adult mosquitoes were identified and species confirmed before rearing. Cyclic generations of *C. pipiens* were maintained separately in two feet mosquito cages in an insectary. Mean room temperature of $25\pm 2^{\circ}\text{C}$ and 70-80% relative humidity were recorded in the laboratory. The adult mosquitoes were fed on glucose solution (10%), while, the adult female mosquitoes were fed on the laboratory rearing dove, and placed inside the cages for eggs laying. The eggs laid were transferred to enamel larval trays maintained in the larval rearing chamber. The larvae were fed with rusk and yeast in 3:1 ratio.

Sampling of *G. affinis*: *G. affinis* were collected from an area near Cid medicine factory in Assiut Governorate, using a network then kept in a plastic drum. The lake water was used for transportation. Fishes were translocated quickly to the laboratory. The fishes were acclimatized in tap water and the experiments were conducted for 120 hours in three replicates. Individual experimental and control tanks were used in the laboratory. The *G. affinis* were measured before experiment.

Effect of light, temperature and pH on the predatory efficiency of *G. affinis*:

To study the effect of light, temperature and pH on the predatory efficiency of *G. affinis* on Culicine mosquito larvae about 20 second and fourth instar larvae of mosquito and one fish were placed in a plastic pot filled will 200 ml of water with three replicates were served. The 3

fish sizes were 1.5, 2.5 and 3.5 cm length were used. Larval consumption was counted after 24h for five successive days. To study the effect of light, the consumption of larvae was recorded on sunrise and on sunset. The tested temperatures were 25, 30 and 35°C, and the pots were put in incubators adjusted for each temperature degree. The pHs used were 7, 9 and 12. In all experiments fishes were starved for 24h before test.

Statistical analysis: Data obtained were statistically analyzed by using General Linear Model (F-test) of MSTAT-C (1983) statistical package software (Michigan State University, USA). Means were compared by least significant difference (LSD) with 5% probability (Steel & Torrie, 1984).

Results and Discussion

Data in Table (1) represented the effect of the light on the predatory activity of *G. affinis* against 2nd instar larvae of *C. pipiens* mosquito. For male, consumption of mosquito larvae was significantly higher during light (day time) than during on darkness (night time) regardless of fish size. The average consumption was 53.3 larvae/fish during day compared with 46.3 larvae/fish during night. However, at day and night the consumption increased as the size of fish increased. The female of *G. affinis* consumed nearly the same number of mosquito larvae during day and night (47.99 and 47.67 larvae/ fish) regardless of fish size. The predatory activity of fish females was relatively high at lower size

than at higher size for both day and night. In general, *G. affinis* predate much mosquito larvae during day as compared with night despite, the fish size and sex. The predation of *G. affinis* males was significantly higher during day than night against 4th instar larvae of *C. pipiens* regardless the fish size (40.66 and 31.34 larvae/ fish) (Table 2). Also, the consumption from 4th instar larvae increase as the male fish size increases. The consumption of fish females from 4th instar larvae of *C. pipiens* was higher than males for all size and during day and night. Results in Table (3) showed the predation activity of *G. affinis* against 4th instar larvae of *C. pipiens* under 3 constant temperatures (25, 30 and 35°C). For fish male, the rate of predation was significantly higher at 30°C (8.33, 8.66 and 10.33 larvae/ fish) as compared with 25 (4.33, 4.33 and 2.67 larvae/fish) and 35°C (3.00, 5.00 and 2.33 larvae/fish) at all fish size 1.5, 2.5 and 3.5 cm respectively. The same trend was noticed with fish females. However, the predation rate of females was significantly higher than males. The influence of pH on the predation efficiency of *G. affinis* against 4th instar larvae of *C. pipiens* (Table 4) show that the predation rate was significantly higher at pH 9 than that at 7 and 12, for all fish sizes and also for both males and females. The average number of mosquito larvae consumed by fish male at pH 9 was 8.00, 8.33 and 12.67 larvae/fish for fish size 1.5, 2.5 and 3.5 cm, respectively. The corresponding numbers for females were 15.00, 10.00 and 17.67, respectively.

Table 1: Effect of light and darkness on the predation efficiency of *G. affinis* on 2nd instar larvae of *C. pipiens*.

<i>G. affinis</i> sex	Fish size	1.5 cm		2.5 cm		3.5 cm		T	Mean ± SD
		T*	Mean ± SD	T	Mean ± SD	T	Mean ± SD		
Male	Light	49	16.33±2.08d	55	18.33±2.08b	56	18.67±1.15c	160	53.33±4.72b
	Darkness	45	15.00±2.00d	45	15.00±2.14c	49	16.33±1.15d	139	46.33±4.72c
	T	94	31.33±4.04b	100	33.33±4.04a	105	35.00±2.00a	299	99.66±9.00a
Female	Light	58	19.33±1.15c	46	13.67±0.57c	40	13.33±4.07e	144	47.99±5.56c
	Darkness	57	19.00±1.73c	54	18.00±2.64b	32	10.67±1.15ef	143	47.67±3.51c
	T	115	38.33±1.52a	100	31.67±1.52a	72	24.00±5.00b	287	95.66±4.61a

Means, in the same column, followed by the same letter are insignificantly different at 0.05% level of probability. * Total mosquito larvae consumed (three replicates) fish.

Table 2: Effect of light and darkness on the predation efficiency of *G. affinis* on 4th instar larvae of *C. pipiens*.

<i>G. affinis</i> sex	Fish size	1.5 cm		2.5 cm		3.5 cm		T	Mean ± SD
		T*	Mean ± SD	T	Mean ± SD	T	Mean ± SD		
Male	Light	31	10.33±0.57d	40	13.33±1.15d	51	17.00±1.73c	122	40.66±2.08d
	Darkness	32	10.67±2.51d	26	8.67±1.15e	36	12.00±2.00d	94	31.34±2.08e
	T	63	21.00±3.00b	66	22.00±2.00b	87	29.00±3.60b	216	72.00±3.00b
Female	Light	43	14.33±1.52c	46	15.33±0.57c	56	18.67±1.52c	145	48.33±3.78c
	Darkness	34	11.33±2.30d	38	12.67±2.51d	49	16.33±3.51cd	121	40.33±8.50d
	T	77	25.66±8.38a	84	28.00±2.04a	105	35.00±5.00a	266	88.66±12.05a

Means, in the same column, followed by the same letter are insignificantly different at 0.05% level of probability. * Total mosquito larvae consumed (three replicates) fish.

Generally, the results showed that, the light, temperature and pH significantly affected the predation efficiency of *Gambusia* fish against mosquito larvae. The predation rate was markedly high at light, temperature (30°C) and pH 9 despite fish size or sex. The present findings agreed with the results obtained by Brett (1971) who found that, *G. affinis* consumed 17.4 larvae in light compared with 15.8 larvae in darkness. Also, Rajan (2014) found that, the predatory efficiency of the fish *Aplocheilus panchax* was higher under conditions of light (95 larvae) than that under conditions of darkness (80 larvae).

Fishes are active visual feeders, the feeding activities and prey predator relations are known to be markedly influenced by the illuminations (Protosov, 1970; Girsu, 1961; Jones, 1956). The fish, *G. affinis* has been extensively used as active visual feeders (Aditya et al., 2012; Ravichandra, 1975; Reddy, 1973; Bay, 1972). Illumination might be the reason for high consumption of mosquito larvae, the fish consumed more numbers of larvae during the day time feeding when compared to night, where the feeding rate was less (Griffin, 2014; Jayapriya & Shoba, 2014). The effect of temperature

on the predatory efficiency of *G. affinis* was studied by Brett (1971) who found that fish consumed in average 12.6 at 20°C, 16.1 at 25°C and 20.5 larvae at 30°C. Also, Clements (1963) and Maglio & Rosen (1969) observed that, the feeding behavior of *G. affinis* was a direct response to water temperature. They found that the feeding rate was decreased at 20°C, whereas at 30°C the

fish consumed more larvae. Rajan (2014) found that the rate of predation of the fish *A. panchax* was 30.5 larvae at 22.5°C, increased to 45.3 at 27.5°C and 60.2 at 32°C. The amount of mosquito larvae consumed by fish increased with the rising in water temperature till an optimum is reached (Brahman & Chandra, 2016; Gerald, 1976; Brett, 1971).

Table 3: Effect of temperature on the predation efficiency of *G. affinis* on 4th instar larvae of *C. pipiens*.

<i>G. affinis</i> sex	Fish size Temp.	1.5 cm		2.5 cm		3.5 cm		T	Mean ± SD
		T*	Mean ± SD	T	Mean ± SD	T	Mean ± SD		
Male	25°C	13	4.33±0.57d	13	4.33±0.57c	8	2.67±1.15e	34	11.33±1.52d
	30°C	25	8.33±2.51b	26	8.66±1.15b	31	10.33±2.51b	82	27.32±5.77b
	35°C	9	3.00±1.00d	15	5.00±1.00c	7	2.33±0.57e	31	10.33±2.30d
Female	25°C	18	6.00±2.00c	23	7.66±1.52bc	14	4.67±1.15de	55	18.33±1.52c
	30°C	34	11.33±1.52a	49	16.33±1.52a	26	15.33±1.15a	109	42.99±3.46a
	35°C	30	10.00±1.73a	21	7.00±2.64b	23	7.67±2.08c	74	24.67±7.23b

Means, in the same column, followed by the same letter are insignificantly different at 0.05% level of probability. * Total mosquito larvae consumed (three replicates) fish.

Table 4: Effect of pH on the predation efficiency of *G. affinis* on 4th instar larvae of *C. pipiens*.

<i>G. affinis</i> sex	Fish size pH	1.5 cm		2.5 cm		3.5 cm		T	Mean ± SD
		T*	Mean ± SD	T	Mean ± SD	T	Mean ± SD		
Male	7	17	5.67±1.52c	31	10.33±1.52b	25	8.33±2.08c	73	24.33±3.21d
	9	24	8.00±2.54cb	25	8.33±1.15c	38	12.67±1.52b	87	29.00±2.08c
	12	28	9.33±1.15b	15	5.00±1.00d	23	7.67±0.57dc	66	22.00±3.66d
Female	7	31	10.33±1.15b	43	14.33±1.15a	34	11.33±2.52b	108	35.99±4.58b
	9	45	15.00±3.66a	30	10.00±2.64b	53	17.67±3.21a	128	42.67±2.52a
	12	20	6.67±0.57c	14	4.67±0.57d	19	6.33±1.15d	53	17.67±3.66e

Means, in the same column, followed by the same letter are insignificantly different at 0.05% level of probability. * Total mosquito larvae consumed (three replicates) fish.

Results of pH showed that no regular alternation in predation efficiency is discernible in *G. affinis*, the predation rate at of pH 9 was the highest (29 larvae for male and 42.67 for female). However,

Rajan (2014) found that the maximum predation rate of *A. panchax* was noticed at pH 7.5 which is mainly due to the fact that the pH of water is 7.1 in which the fishes were acclimatized. Also, Banerjee

(1967) found that, the largest fish crops were found in waters on the alkaline sides of neutrality between pH 7 and 8. Many species of Culicin mosquitoes preferred breeding site with an almost neutral pH of 7.5-8 (Karlekar & Androw, 2016). In conclusion, the predation efficiency of *G. affinis* is dependent on many measurable variables of the prey predator system including temperature, light, fish size and hydrogen ion concentration. Thus this study on *G. affinis* proved the efficiency of the fish holds a good promise as effective biological agents to control the population of mosquito larvae.

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