Bio-Control Efficiency of Water Bug Diplonychus Rusticus (Hemiptera: Belostomatidae) on Culexmosquito Larvae

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H.R. Abhilash
Department of Zoology, Yuvaraja's College (Autonomous)
University of Mysore, Mysuru, Karnataka, India

K.R. Shashank
Department of Zoology, Yuvaraja's College (Autonomous)
University of Mysore, Mysuru, Karnataka, India

M. Mahadevaswamy
Department of Zoology, Yuvaraja's College (Autonomous)
University of Mysore, Mysuru, Karnataka, India

S.V. Sathish
Associate Professor of Zoology, Department of Zoology
Sri Mahadeshwara Government First Grade College
Kollegal, Chamarajanagara (Dist.), Karnataka, India

Abstract

Mosquito-borne diseases continue to pose a significant public health risk, especially in tropical regions, due to the widespread occurrence of malaria, dengue, chikungunya, and other arboviruses. The extensive use of chemical insecticides has led to resistance in mosquito populations and has been proven to be harmful to a host of non-target organisms. As an environmentally friendly alternative, biological control using natural predators has gained attention. This study evaluates the bio-control efficiency of the water bug Diplonychus rusticus (Hemiptera: Belostomatidae) against Culex mosquito larvae, a known vector of many diseases. Specimens of D. rusticus were collected from Dalvoy Lake, Mysore, and tested in controlled laboratory conditions for their predatory impact (PI) and clearance rate (CR) on fourth instar Culex larvae. The results showed that D. rusticus effectively preys on Culex larvae, with a predatory impact of 3.13 larvae per hour and a clearance rate of 2.167 larvae per liter/day. The findings suggest that D. rusticus holds potential as a bio-control agent, offering a promising alternative to chemical interventions in vector control programs. Further research into the application of this predator in natural aquatic habitats could aid in managing mosquito populations and mitigating the widespread dissemination of mosquito-borne diseases.

Keywords: Mosquito-Borne Diseases, Diplonychus Rusticus, Culex Larvae, Clearancerate

Introduction

Mosquito-borne diseases like dengue, chikungunya, lymphatic filariasis, yellow fever, Japanese encephalitis, malaria,and a range of other arboviruses remain serious public health concerns in many tropical nations(Eba et al.).There has been increased fear about the growing prevalence and geographical expansion of mosquito-borne diseases worldwide, with new places witnessing the onset of these diseases (Franklinos et al.). The use of chemicals to control mosquito populations has negative consequences for non-target species as well as creating chemically resistant variants (WHO). This has led to a greater emphasis on sustainable alternative methods of managing vector populations by biological means, for instance, making use of natural predators of mosquito immatures (Karunaratne and Hemingway; Mandal et al.). A wide range of living organisms have been identified as possible mosquito control agents, including bacteria, protozoa, fungus, nematodes, other invertebrate and vertebrate predators (Aditya et al.; Chandra et al.; Gautam et al.; Lundkvist et al.; Stav et al.; Venkatesh and Tyagi).

Of the various predators mentioned above, predatory aquatic insects hold great potential as biological control agents, especially the members of the order Hemiptera, Odonata, Coleoptera, and Diptera (Lutziatigripes), which are cosmopolitans and locally available (Saha et al.; Shaalan and Canyon).The water bugs in the family Belostomatidae (Heteroptera) are well recognized predators of aquatic snails and insects, including several immature stages of mosquitoes (Brahma et al.; Ohba and Nakasuji). Several workers believe that their predatory nature makes them suitable for biological control of mosquito larvae(Ghosh and Chandra; Kumar and Hwang; Weterings et al.).Thus, the purpose of this study was to evaluate the predatory efficiency of hemipteran bug Diplonychus rusticus using the larvae of Culexmosquito as prey. D. rusticus, generally referred to as a water bug, is a common inhabitant and a major predator in the aquatic ecosystems of Mysore and its surrounding areas (Abhilash et al.).The findings will serve as the basis for evaluating these predators as biological resources against Culex sp. and other mosquito vectors.

Materials and Methods

The adult morphs of D. rusticus were collected from Dalvoy Lake of Mysore district, Karnataka, India, by dragging a circular pond net (500-µm mesh size) through the vegetation of the littoral zone. We brought the water bugs to the laboratory, transferred them to plastic trays containing 2 L of lake water, and fed them ad libitum mosquito larvae (Culex sp.) as food. They were kept in the laboratory setup for 5 days for acclimatization before starting the experiment. Mosquito larvae were collected from the sewage drains near Dalvoy Lake for feeding the water bugs during the acclimation period. Further, the egg rafts of Culex mosquito were collected from the same site and were placed within an enamel tray of 30 x 25 cm capacity containing tap water. Upon hatching, the larvae were given a powdered mixture of yeast granules and fish food. The following experiments were conducted to evaluate the rate of predation of the water bug on Culex sp. larvae.

Determination of Predatory Impact (PI)

In this experiment,the predatory impact was determined by following the method adopted by Jacob et al., where a single predatory insect was supplied with 25 Culex larvae in a 500ml beaker (in the ratio 1:25) containing 400 ml of water. The experiment included three replicates along with a control group containing only Culex larvae. Observations were made over a total period of 8 hours. At the conclusion of each hour, the number of preys consumed and those killed in the control group was documented. After each hour, new mosquito larvae were introduced to replace those that had been eaten or killed. The predatory impact was calculated by following the method adopted bySaha et al., using the formula:

$$PI = \frac{\sum PE}{T}$$

Where, PI is the Predatory impact (No. of prey consumed/hours); PE = No. of prey eaten or killed; T=Time (here, T = 8 hours).

Determination of Clearance Rate (CR)

In this experiment the clearance rate (CR) was determined by offering 2 predators with 100 IV instars Culexlarvae within a circular plastic tub containing 1litre pond water. The count of larvae killed or consumed was recorded, and the prey density was reset every 24 hours for three consecutive days, using the same group of predators. Three replicates plus a control group with only Culexlarvae were set for the experiment. The data collected from the experiment were used to calculate clearance rate (CR) using the method established by Gilbert & Burns, as adopted by Aditya & Saha.

"CR= " "V (lnP)" /"TN"

Where, CR = Clearance rate of predators (Nos. of prey killed/liters/day/predator); V is the Volume of water (lltr); T is the Time (in day), N is the Number of predators, and P is the Nos. of prey killed.

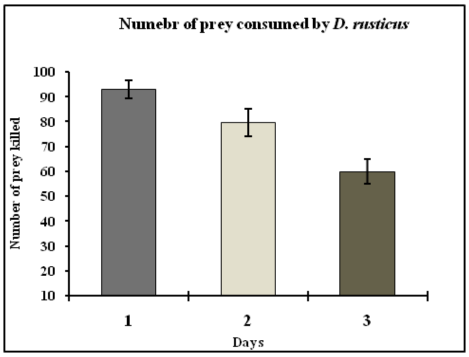

Figure 1 Mean Number (Mean ± SE) of IV Instar Larvae Killed per day by Two AdultD Rusticus (for three consecutive days)

Table 1 Number of Larvae Killed/Hour by D. Rusticus

Time (hour)	No. of larva Killed/Eaten (Mean of 3 replicates)
1	5.33
2	2.67
3	0.67
4	4.67
5	6.00
6	2.67
7	0.67
8	2.33
Total	25.00
PI	25/8 = 3.13

Table 2 Clearence Rate of D. Rusticus on IV Instar Culex Larva

	Vol (l)	No. Killed/day	ln	TN	CR
Day 1	1	93	4.53	2	2.266
Day 2	1	79.67	4.38	2	2.189
Day 3	1	60	4.09	2	2.047
				Mean	2.167

*Where, CR = Clearance rate of predators (Nos. of prey killed /liters/day/predator);
V is the Volume of water (lltr); T is Time in days (1 day), N is Number of predators (2),
ln = natural logarithm; P = Nos. of prey killed.

Result and Discussion

In the present experiment, the predatory efficiency of the water bug, D. rusticus, was assessed using Culex mosquito larvae. It was observed that the water bug vigorously seized the mosquito larva with its pro- and mesothoracic legs, immobilized it by piercing with its sharp rostrum, and then consumed its internal body fluids. It was noted that a large number of preyswere simply killed without sucking the body fluids. A previous study also reported similar findings, indicating that D. rusticus killed more mosquito larvae than it actually fed (Saha et al.). The predatory impact demonstrates the predator's killing efficiency over a specific time period. In the present experiment PI values for D. rusticus for 4th instar Culex larvae was found to be 3.13 larvae/ hour at prey density of 25 larvae (Table 1).The rate of prey consumption is influenced by the size and density of prey species, with many arthropodan predators exhibiting a preference for larger prey, specifically fourth and fifth instar larvae, over smaller alternatives(Gurumoorthy et al.; Prabakaran).The clearance rate indicates the combined effects of the predator's search efficiency, predation, and consumption, along with the evasive strategies of the prey, within a defined time and area(Gautamet al.).Collectively two adults of D. rusticusconsumed between 60 to 93 fourth-instar Culex larvae per day (Fig .1). The clearance rate (CR)was found to be 2.167prey larvae litres/day/ predator (Table 2). The number of prey consumed varied drastically across the days, indicating a decrease in the predation rate after reaching maximum satiation, which is a typical predation pattern for D. rusticus(Pramanik and Raut).

The results of this study on the predatory efficacy of D. rusticus against Culex mosquito larvae have significance for developing bio-control methods as part of an integrated vector control program in India. Given the challenges in controlling adult mosquitoes due to extensive insecticide resistance, using potential aquatic insect predators may serve as an alternate or complementary strategy for controlling the adult mosquito population by targeting the immature stages of Culex mosquitoes. The outcome of the current laboratory experiment suggests a comparable potential for utilizing these hemipteran bugs as predators of mosquito larvae in various aquatic habitats in Mysore and its surrounding regions.

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