*Alwin Rajan D. / International Journal of Phytopharmacology.* **7(1), 2016, 29-33.**

e- ISSN 0975 – 9328
Print ISSN 2229 – 7472

**International Journal of Phytopharmacology**

Journal homepage: www.onlineijp.com

**IJP**

# PREY SHIFT AND PREDATORY PERFORMANCE IN *DIPLONYCHUS RUSTICUS* (FABRICIUS, 1871) AGAINST TWO DIFFERENT PREYS

**Alwin Rajan D.***

Department of Advanced Zoology and Biotechnology, Guru Nanak College, Velachery, Chennai-42, Tamilnadu, India.

**ABSTRACT**

In food web of fresh water communities the aquatic and semiaquatic bugs plays a vital role in effectively controlling the larval forms of certain disease spreading insect vectors by feeding them voraciously. Since *Diplonychus rusticus* is polyphagous and carnivorous predator, the present study was undertaken to observe the effect of prey shift and experience on predation in *Diplonychus rusticus* exposing them to *Culex* and *Chironomous* larvae for 10 day duration alternatively. Adult male water bugs, prestarved for 10 days, were exposed to individual prey item at prey density of 200 for one day in a container filled with 1 litre of dechlorinated tap water and the number of prey killed was recorded after 1 hour and 24 hours. This experiment was carried out for 10 days. The prey shift mechanism was assessed by following the same procedure, exposing the adult male bugs to *Chironomous* larvae from the 11$^{th}$ day after feeding them with *Culex* larvae for 10 days. The number of prey killed by the predator after 1 hour and 24 hours were counted and recorded. Ten trials were carried out to draw the mean and standard deviation for both the prey items. The number of *Culex* larvae killed by the predator was initially high and on the 10$^{th}$ day it declined in 24 hours. The predatory performance was initially declined on 11$^{th}$ day and gradually increased on 20$^{th}$ day when subjected to *Chironomous* larvae in 24 hours. Statistical analysis was determined using Roger's equation (1972) of under non-linear square technique. As far as the prey preference is concerned, the result reveals that *Diplonychus rusticus* preferred *Culex* larvae than that of *Chironomous* larvae for 10 day duration.

**Key words:** Prey shift, Belostomatid bug, *Culex* larvae, *Chironomous* larvae, *Diplonychus rusticus*.

## INTRODUCTION

Insects that live in or on water form an unusual assorted assemblage. They occupy various ecological niches ranging from the shore up to the bottom. Many group of insects such as Plecopterans are aquatic only during their immature stages (Merrit *et.al.*, 1978).Water bugs belonging to family Nepidae, Belostomatidae, Corixidae, Notonectidae that belong to order Hemiptera are truly aquatic, leaving the water only during migratory dispersal flights (Menke, 1979). Water bugs of both Nepomorpha and Gerromorpha feed on mosquito and Chironomidaelarvae. Most of the insects with aquatic life stages are predatory in nature. Hemipterans and Odonates are predominantly predaceous found in both running and standing freshwater clinging to vegetation, burrowing to the substratum or slithering on the water surface (Allan, 1983).Water bugs especially Belostomatids feed on freshwater snails that serve as an intermittent host of the blood fluke that causes schistosomiasis in human (Roy *et.al.*, 1994). Predation by adult aquatic insects exhibit distinct variations. Theses aquatic insects cease feeding just before emergence, just before moulting eats fewer prey and consumes maximum just after a moult (Fox *et.al.*, 1978). Since predation is governed by many factors, some of the factors such as prey type, vegetation, prey shift and period of exposure were considered for carrying out the investigation in laboratory condition. The type of prey is one of the environmental factors that have direct impact on the dynamics of predator population. The

Corresponding Author

**Alwin Rajan, D**
Email: eugene_abner@yahoo.co.in

behavior of the prey makes the aquatic insect to fall under different style of feeding in Odonates (Johnson *et.al.,* 1980). Several investigations have independently been concluded on the life style/ behavior of the bugs. One of the life styles is fast in which the predator actively search for its prey and leading to more consumption results in the fast growth of the organism (Thompson, 1978 and Corbet, 1980).The second one is the slow life style i.e., hiding under vegetation, resulting in ambush foraging in slow feeding and growth (Peckarsky, 1984).Predator shifts their search modes based on the changes in the prey population, prey type and ecological factors (Giller *et.al.,* 1981). It has been known that the prey shift property of predation which generally means that the predatory rate diminishes at low population density of prey which has a stabilizing effect for the predator-prey systems. The idea of prey shift requires that in a system with 2 prey species, the more abundant species is attacked disproportionately in comparison with the less abundant species. In this way, no population is drastically reduced nor allowed to become very abundant (Mudroch, 1969). In a model of two prey and one predator system, the introduction of shifting mechanism of the predator stabilizes their co-existing state; otherwise one of the prey species will be led to extinction (Tansky, 1978). The predation rate is reduced by existence of individuals of other prey species, and can be interpreted by considering a possibility that the predator searches for more abundant prey species, because the predator must spend more energy to search for smaller prey population and may have no interest in that species when enough of another prey is available. By this reason the total amount of prey captured by a predator is unexpectedly reduced when two prey species are coexisting (El Teramota *et.al.,* 1979). It was noted that *Diplonychus rusticus* inhabits in both running and standing freshwater clinging to vegetation and they are found in abundant. Since these water bugs are polyphagous and carnivorous predators, the present study was undertaken to observe the effect of prey shift and experience on predation in *Diplonychus rusticus* exposing them to *Culex* and *Chironomous* larvae for 10 day duration alternatively and also to analyze the attack rate and handling time of the predator against the prey item.

## MATERIALS AND METHOD

### Collection of *Diplonychus rusticus, Culex* and *Chironomous* Larvae

The adult *Diplonychus rusticus* were collected at Coovum river, near Koyambedu, Chennai and the male and female bugs were segregated and transferred to a large transparent glass trough containing dechlorinated tap water with few twigs of *Hydrilla* to avoid cannibalistic action. The larvae of *Culex* mosquitoes and *Chironomous* larvae were used as the prey items which were collected on daily basis from the stagnant and sewage water bodies respectively at Coovum river near Nungambakkam, Chennai.

### Experimental set up for the effect of prey preference and prey shift

Prey preference of *Diplonychus rusticus* was tested by feeding them with large sized *Culex* (0.7 Cm) and *Chironomous*(1.5 Cm) larvae. Adult male water bugs, prestarved for 10 days, were exposed to individual prey item at prey item at a density of 200 for one day in a container filled with 1 litre of dechlorinated tap water and *Hydrilla* vegetation which provided perch sites for the bugs, the prey killed by the predator were counted and recorded after 1 hour and 24 hours. Ten trials were carried out to draw the mean, standard deviation. The experiment was continued for 10 days.

The prey shift mechanism was assessed by exposing the adult male bugs to *Chironomous* larvae from the 11$^{th}$day after feeding them with *Culex* larvae for 10 days. The number of prey killed by the predator after 1 hour and 24 hours were counted and recorded. Ten trials were carried out to draw the mean and standard deviation. In each treatment, the prey density was 200. This experiment was carried out for 10 days.

### Determination of statistical constants

The number of prey killed by the predator was subjected to the procedure of modified random predator equation (Roger equation), under non-linear square technique. $Na = \{N (1-\exp [-a (PT-Na \underline{Th})])\}$ was used to estimate the two statistical constants (attack rate and handling time) which is short term behavioral response by an individual predator and its attack called as type II functional response (Rogers, 1972).

## RESULT AND DISCUSSION

### Effect of prey shifting performance of *Diplonychus rusticus* exposed to *Culex* larvae and *Chironomous* larvae for 10 day duration

In the context of prey shifting mechanism, the predator performance of the adult male of *Diplonychus rusticus* was assessed by exposing them to *Culex* larvae at prey density of 200 for 10 day duration. After one hour duration the predatory performance of the bugs were recorded on the first day to be 22.4 ± 1.42, on the second day as 17.3 ± 1.48 and a gradual decrease was noted. After the time duration of 24 hours the predation rate was noted on the first day as 182.1 ± 1.57 consequently the predation rate decreased on the following days (Table - 1).

The prey shifting mechanism was assessed by exposing the adult male bugs of *Diplonychus rusticus* on the 11$^{th}$ day to *Chironomous* larvae after feeding them with *Culex* larvae for 10 days. After one hour duration the predatory performance of the bugs were recorded on the

first day to be 3.3 ± 1.1, on the second day as 3.9 ± 1.44 and a gradual increase was noted. After the time duration of 24 hours the predation rate was noted on the first day as 21.1 ± 1.37 consequently the predation rate was increased on the following days (Table - 2).

**Attack rate and handling time of *Diplonychus rusticus* in prey shifting performance**

To study the prey shifting mechanism the starved male *Diplonychus rusticus* were exposed to large sized *Culex* larvae at prey density 200 in water volume of 1 litre for 10 day duration. The attack rate and handling time of the bugs was recorded after 1 hour and 24 hours separately. Even though there was only marginal difference, the attack rate was highest on the first day and gradually it declined on 10$^{th}$ day at the end of 1 hour and 24 hours. On the other hand the handling time was low initially and gradually increased. On the 11$^{th}$ day the experimental bugs were exposed to *Chironomous* larvae, in which the attack rate showed a marginal difference, in which the attack rate was initially low on the eleventh day and gradually increased on 20$^{th}$ day and the handling time was initially high and decline gradually on 20$^{th}$ day after 1 hour and 24 hours (Table 3). An opportunistic predator selects a prey that can be approached and captured with less expenditure of energy but continued exposure of the predator to such environmental condition may not maintain an increased level of predation on less profitable prey (Krebs, 1978). Predation by adult aquatic insect are governed by many limiting factors in which prey preference is one of the factors. Prey shift property of predation generally means that the predatory rate diminishes at low population density of a highly preferred prey resulting in a stabilizing effect for the predator-prey system. In an ecosystem with two or more prey specie, the species which is more abundant and also highly preferred by the predator is attacked disproportionately in comparison with the less abundant prey species. In the present study the result of prey shift from *Culex* larvae to C*hironomous* larvae in *Diplonychus rusticus* reveals that the predation rate that was high at the 1$^{st}$ day gradually declined at 10$^{th}$ day when exposed to *Culex* larvae. Due to low population of *Culex* larvae on the 11$^{th}$ day the bugs were exposed to C*hironomous* larvae with which the predation rate was low initially but gradually increased on the 20$^{th}$ day.

**Table 1. Effect of prey shift on the performance of *Diplonychus rusticus* exposed to the first prey *Culex* larvae for 10 day duration**

| Day | *Culex* larvae | |
|---|---|---|
| | No. of Prey Killed in 1h. | No. of Prey Killed in 24 h. |
| 1 | 22.4±1.42 | 182.1±1.57 |
| 2 | 17.3±1.48 | 89.5±0.88 |
| 3 | 15.8±0.97 | 76.9±1.27 |
| 4 | 12.8±0.52 | 73.5±0.31 |
| 5 | 10.6±0.37 | 53.7±0.56 |
| 6 | 10.4±0.35 | 52.5±0.57 |
| 7 | 9.7±0.40 | 52.4±0.85 |
| 8 | 9.6±0.28 | 51.1±0.43 |
| 9 | 9.3±0.28 | 50.8±0.66 |
| 10 | 8.5±0.32 | 48.2±0.54 |

**Table 2. Effect of prey shift on the performance of *Diplonychus rusticus* exposed to the second consecutive prey *Chironomous* larvae for 10 day duration**

| Day | *Chironomous* larvae | |
|---|---|---|
| | No. of Prey Killed in 1h. | No. of Prey Killed in 24 h. |
| 1 | 2.5±0.32 | 21.1±1.37 |
| 2 | 3.3±0.34 | 28.8±0.54 |
| 3 | 3.4±0.28 | 29.1±0.43 |
| 4 | 3.8±0.45 | 31.1±0.43 |
| 5 | 3.9±0.45 | 31.8±0.50 |
| 6 | 4.6±0.49 | 31.9±0.68 |
| 7 | 4.7±0.49 | 32.6±0.66 |
| 8 | 6.6±0.32 | 34±0.69 |
| 9 | 7.4±0.32 | 35.7±0.67 |
| 10 | 8.7±0.49 | 37.6±0.81 |

**Table 3. Attack rate (a) and handling time (Th) of *Diplonychus rusticus* in prey shifting performance exposed to the *Culex* and *Chironomous* larvae for 10 day duration**

| Day | *Culex* larvae | | | | *Chironomous* Larvae | | | |
|---|---|---|---|---|---|---|---|---|
| | Attack Rate (a) | | Handling Time (Th) | | Attack Rate (a) | | Handling Time (Th) | |
| | 1h. | 24 h. | 1h. | 24 h. | 1h. | 24 h. | 1h. | 24 h. |
| **1** | -0.925 | -0.897 | 0.005 | 0.003 | -1.014 | -1.362 | 0.013 | 0.015 |
| **2** | -0.952 | -0.923 | 0.010 | 0.008 | -1.006 | -1.080 | 0.013 | 0.013 |
| **3** | -0.958 | -0.933 | 0.011 | 0.011 | -1.003 | -1.054 | 0.012 | 0.013 |
| **4** | -0.959 | -0.944 | 0.011 | 0.011 | -1.001 | -1.043 | 0.012 | 0.012 |
| **5** | -0.963 | -0.954 | 0.012 | 0.015 | -1.000 | -1.020 | 0.012 | 0.012 |
| **6** | -0.979 | -0.962 | 0.015 | 0.019 | -0.999 | -0.988 | 0.011 | 0.011 |
| **7** | -0.987 | -0.981 | 0.022 | 0.029 | -0.999 | -0.976 | 0.011 | 0.010 |
| **8** | -0.989 | -0.992 | 0.023 | 0.037 | -0.997 | -0.872 | 0.011 | 0.008 |
| **9** | -0.998 | -0.998 | 0.032 | 0.042 | -0.997 | -0.870 | 0.010 | 0.008 |
| **10** | -0.999 | -1.362 | 0.045 | 0.049 | -0.971 | -0.762 | 0.009 | 0.004 |

## DISCUSSION AND CONCLUSION

It has been reported that in a model of two preys and one predator system shows that the introduction of shifting mechanism of the predator stabilizes their co-existing state; otherwise one of the prey species will be led to extinction (El Teramota *et.al.*, 1979). Based on the abundance of the prey species prey shift occurs from one species to another (Cloarec, 1989). The predatory rate of the water bug exposed to *Chironomous* was low initially; this may be probably due to prey mobility, prey size and also the foraging strategies of the predator. As far as the prey preference is concerned, *Diplonychus rusticus* preferred *Culex* larvae than that of *Chironomous* larvae for 10 day duration. This may be due to the tendency of the prey *Culex* larvae to remain at the water surface at 45º angle which provides more area for its attack. More attack rate and handling time were exhibited by the predator towards *Culex* larvae than *Chironomous* larvae. A similar work was reported that reactivity and success rate of prey capture increases with specific prey size groups (Venkatesan *et.al*, 1990 and Alwin Rajan, 2015). Increasing attack rate could be due to the palatability of the prey species that supports the present study (Venkatesan *et.al*, 1984).The results of this investigation reflect the importance of prey shift strategy in a potential predator – *Diplonychus rusticus*.

In context to Integrated pest management (mosquitoes control), the bugs can be introduced initially in the mosquito breeding sites to bring down the larval population of *Culex* mosquito and then an appropriate harmless biopesticide (a bacterial product – like SPIC-BIO) can be sprayed for eradication.

**ACKNOWLEDGEMENT**: None

**CONFLICT OF INTEREST**:

The authors declare that they have no conflict of interest.

## REFERENCES

Allan JD. Predator-prey relationship in streams. In. J.R. Barnes and G.W. Minshall, eds. Stream Ecology: Application and Testing of General Ecological Theory. Plenum, New York, 1983, 191-229.

Alwin Rajan D. Predatory efficiency of *Diplonychus rusticus* (Fabricius, 1871) against *Culex* larvae. *European Journal of Molecular Biology and Biochemistry*, 2(4), 2015, 138-143.

Cloarec A. Variation of foraging tatics in a water bug, *Diplonychus indicus*. *J. Ethol*, 7, 1989, 27-34.

Corbet PS. Biology of Odonata. *Annu Rev Entomol*, 25, 1980, 189-218.

El Teramota, Kohkichi, Karvasaki, Nanako Shigesada. Switching effect of predation on competitive species. *J. Theo. Biol*, 79, 1979, 303-315.

Fox LR and WW Murdoch. Effects of feeding history on short term and long term functional responses in *Notonecta hoffmanni*. *J. Anim. Ecol*, 47, 1978, 945-960.

Giller PS and S McNeill. Predation strategies, resource partitioning and habitat selection in *Notonecta* (Hemiptera: Heteroptera). *J. Anim. Ecol*, 50, 1981, 789-808.

Johnson DM and PH Crowley. Odonate "hide and seek": Habitat – specific rules? In W.C. Kerfoot, ed. Evolution and ecology of Zooplankton communities. University press of New England, Hanover, NH, 1980, 569-579.

Krebs JR. Optimal foraging: Decisions rules for predators. Behavioural Ecology: An evolutionary approach (eds. by J.R. Krebs and N.B. Davies) pp. 23-63. Sinauer Associates, Mass, USA, 1978.

Menke AS. The semiaquatic and aquatic Hemiptera of California (Heteroptera: Hemiptera). *Bull. California Insect survey*, 21, 1979, 1-66.

Merrit, R.W. and H.W. Cummins (eds.). An introduction to the aquatic insects of North America. Kendall / Hunt Publishing Co. Dubuque, IA, 1978, 441.

Mudroch WW. Switching in general predators: Experiments on predator specificity and stability of prey population. *Ecological Monographs*, 39(4), 1969, 335-342.

Peckarsky BL. Predator-prey interaction among aquatic insects. In V.H. Resh and D.M. Rosenberg, eds. Ecology of aquatic insects, Praeger, New York, 1984, 196-254.

Rogers DJ. Random search and insect population models. *Journal of Animal Ecology*, 41, 1972, 369–383.

Roy JK and SK Raut.Factor influencing predation of the water bugs *Sphaerodema annulatumi*(Fab.) and *Sphaerodema rusticum* (Fab.) on the disease transmitting snail *Lymnaea* (Radix) *luteola* (Lamark). Mem. Inst. Oswaldo. Cruz, Rio de Janerio, 89(1), 199411-20.

Tansky M. Switching effect in prey-predator systems. *J Theor. Biol*, 70, 1978, 263-271.

Thompson DJ. Towards a realistic predator-prey model: The effect of temperature on the functional response and life history of larvae of damselfly, *Ishnuraelegans. J. Anim. Ecol*, 47, 1978, 757-767.

Venkatesan P and S Sivaraman. Changes in the functional response of instars of *Diplonychus indicus* Venk. And Rao. (Hemiptera: Belostomatidae) in its predation of two species of mosquito larvae of varied size. *Entomol*, 9, 1984, 191-196.

Venkatesan P and Tena D Sylva. Influence of prey size on choice by the water bug *Diplonychus rusticus* (Fabr.)(=indicus Venk. and Rao.) (Hemiptera: Belostomatidae). Ph.D. Thesis, University of Madras, 1990, 1-57.