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Research Article

Influence of Abiotic and Biotic Factors on the Population Dynamics of *Diplonychus indicus* Venk. & Rao (Hemiptera: Belostomatidae) a Potent Biocontrol Agent for Mosquito Larva

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Abstract

Study of aquatic insect population has assumed importance in the context of pollution to water bodies and the potentialities of many aquatic bugs in controlling vector population especially *Culex* mosquitoes. The population dynamics of *Diplonychus indicus* was studied in a perennial pond in Kanyakumari district, Tamil Nadu, Southern India for a period of eleven months from February 2018 to December 2018. The study yielded eleven aquatic species, *viz*., *Agriocnemis* species, *Anisops bouvieri*, *Culex* species, *Diplonychus indicus*, *Dytiscus marginalis*, *Gerris spinolae*, *Laccotrephes griseus*, *Lethocerus indicus*, *Limnogonus nitidus*, *Mesogomphus lineatus* and *Ranatra filiformis*. Abiotic factors like dissolved oxygen, pH, air and water temperature, relative humidity and rainfall were recorded. Correlation between the abiotic factors and *Diplonychus indicus* nymphs and adults showed positive correlation except for temperature. Correlation between the nymphal population and adults of *Diplonychus indicus* and all the coexisting insects exhibited a perfect positive correlation and between *Culex* larvae and *Diplonychus indicus* it was +0.6797. Further, field value ratios of *Diplonychus indicus* and biotic factors especially with *Culex* during the south west monsoon indicated the fact that *Culex* larval population was under control.

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Introduction

The study of aquatic insect population has assumed importance in the context of pollution to water bodies and the potentialities of many aquatic bugs in controlling the vector population especially *Culex* mosquitoes. The ecology and distribution of aquatic insects are highly governed by the type of habitat they inhabit. One of the most fascinating characteristics of the aquatic insect population is their diverse pattern of distribution coupled with their adaptability. Some naucorid bugs inhabit lakes and prefer streams [1], while belostomatid bugs remain in clusters clinging to the rootlets of floating vegetation such as *Eichhornia* [2]. The aquatic insects are sufficiently flexible to withstand often severe and sometimes unpredictable environments. Hence, the co-existence of nymphal stages and adults of aquatic insects with reference to dispersal pattern as well as spatial temporal changes in their abundance are very essential to assess the effect of comparable parameters on species growth and development. The rate of development of a species in a habitat is dependent on various environmental factors. Some aquatic insects spend their immature life in water bodies. One of the vital factors that govern the population dynamics of aquatic insects is the substratum upon which the drama of their ecology is acted out. The population dynamics of *Diplonychus indicus* is governed in time by the rate of association to substratum, development of immature stages, and the prevalence of cannibalistic behavior among the immature stages and the impact of hydrological and climatic factors [3]. The present work was undertaken to study the influence of abiotic and biotic factors on the population dynamics of *Diplonychus indicus*, a biocontrol agent for the management of mosquitoes which is of great importance and the need of the hour as they transmit vector-borne diseases to man especially *Culex* since these larvae forms the food for this bug.

Materials and Methods

A permanent pond situated 25km away from Kanyakumari district, Tamil Nadu, India was selected as the study area. The pond was rectangular with an area of 1.5 hectares and an average depth of 0.9 meters. It had only one inlet and depends on rain water besides the inlet from the river Pazhayar. The pond has rich vegetation of floating and submerged plants on the northern side and devoid of vegetation on the southern side, where there is a bathing ghat. Habitat sampling of insects were made during the early hours of the day since many aquatic insects migrate to deeper waters during late hours of the day. Weekly collections of aquatic insects were carried for 11months (February 2018-December 2018). The insects were collected by filtering 40 litres of water with the help of a pond net and were identified with taxonomic keys. Vegetation during the collection were quantified, and the immature and adult stages of aquatic insects were collected, categorized, recorded and released back into the pond. Insects clinging to the filtered vegetation were also carefully collected. The environmental parameters of the pond, *viz*., dissolved oxygen (mg/L), pH, air temperature (˚C), water temperature (˚C), relative humidity (%) and

wind speed (km/h) were also recorded simultaneously on a weekly basis. Rainfall (mm) was chosen as the vital meteorological factor in the region of the study area. A correlation and regression analysis was established between *Diplonychus indicus* and the biotic factors in the pond.

Results

The study of the population dynamics of the perennial pond yielded eleven aquatic species,*viz*., *Agriocnemis* species, *Anisops bouvieri*, *Culex* species, *Diplonychus indicus*, *Dytiscus marginalis*, *Gerris spinolae*, *Laccotrephes griseus*, *Lethocerus indicus*, *Limnogonus nitidus*, *Mesogomphus lineatus* and *Ranatra filiformis*. The environmental parameters of the study area are shown in figure1. Dissolved oxygen, pH, air temperature, water temperature, relative humidity and wind speed values ranged from 7.8 to 8.4mg/L, 7.5 to 8.2, 29.8 to 32.1˚C, 25.3 to 26.0˚C, 63.0 to 79.0% and 12.0 to 19.5km/h respectively. Rainfall was maximum during September (10.7mm) when the study area experienced heavy south west monsoon. The relationship between abiotic factors and the nymphs as well as adults of *Diplonychus indicus* are shown in figures 2 & 3. With regard to the biotic factors, there existed a correlation with the nymphal population and adults of *Diplonychus indicus* and all the coexisting species, and it was found that there was a perfect positive correlation between *Diplonychus indicus* and its prey *Culex* larvae (+0.6797) (Figure 4).The field value ratios of *Diplonychus indicus* nymphs and biotic factors are presented in figure 5 and for adults in figure 6. The results also revealed a relative abundance of *Diplonychus indicus* adults and *Culex* (Figure 7) and the regression analysis between *Diplonychus indicus* and *Culex* exhibited a positive relationship (Figure 8).

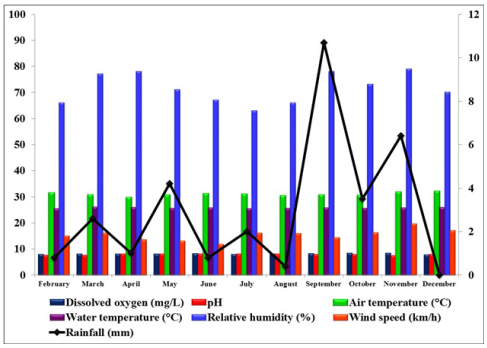

Figure 1: Environmental parameters recorded in the study area.

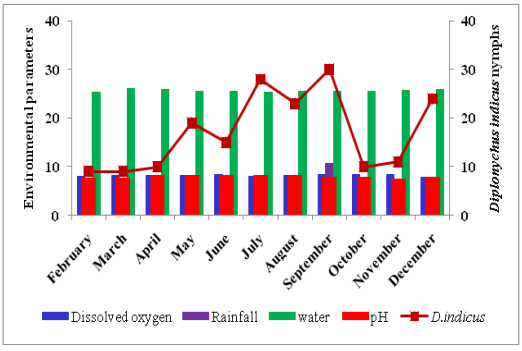

Figure 2: Relationship between abiotic factors and *Diplonychus indicus* nymphs.

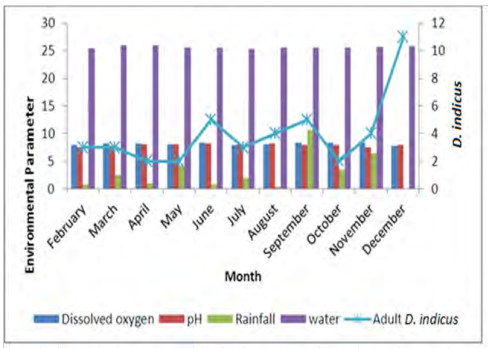

Figure 3: Relationship between abiotic factors and *Diplonychus indicus* adults.

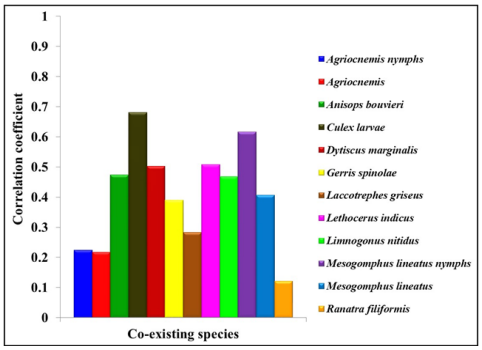

Figure 4: Correlation between biotic factors and *Diplonychus indicus*.

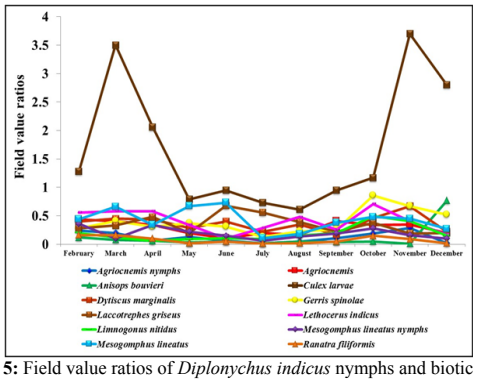

Figure 5: Field value ratios of *Diplonychus indicus* nymphs and biotic factors.

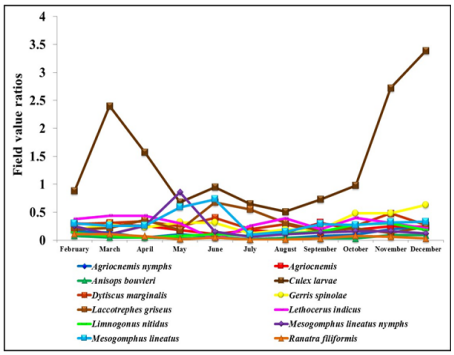

Figure 6: Field value ratios of *Diplonychus indicus* adults and biotic factors.

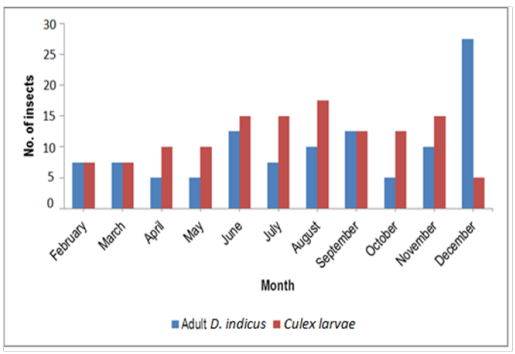

Figure 7: Relative abundance of *Diplonychus indicus* and *Culex*.

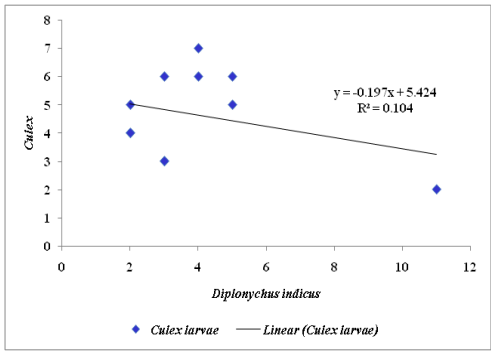

Figure 8: Regression analysis between *Diplonychus indicus* and *Culex*.

Discussion

The results of the present study revealed that the population dynamics of aquatic insects especially *Diplonychus indicus* were regulated and governed by abiotic as well as biotic factors. Environmental parameters governs the population level of aquatic insects in the pond. From the high population density of *Diplonychus indicus* during June 2018 to September 2018 it was apparent that the hydrological parameters governed the population levels and this might be due to south west monsoon. According to Rao in nepids, the abiotic factors such as rainfall and temperature together with abundance of food have an augmentative effect on their population [4]. Further, Nebeker and Lemke have observed in stone fly *Pteronarcys dorsata* that emergence occurs in January in permanent waters probably due to higher water levels due to heavy rainfall [5]. Such an influence was also noticed in *Nysius visitor* by Kehat and Wnydham and the present work showed that increase or decrease in rainfall promotes or suppresses the growth rate of *Diplonychus indicus* [6].

Nebekar and Lemke reported that artificial increase in stream temperature would cause *Ephermerella subvariae* to develop more rapidly and to emerge earlier [5]. It was interesting to note that in the present work there was a negative correlation between the nymphs of *Diplonychus indicus* and temperature. Tonapi and Julka have observed based on their studies on five families of aquatic bugs including notonectids that temperature and rainfall are the governing factors that regulate the population of aquatic insects [7,8]. Okada and Nakasuji compared the population density and nymphal development of *Diplonychus japonicus* and *Diplonychus major* and found that water temperature had a profound influence on the population density and nymphal development [9]. In the present study, pH of water did not show much seasonal fluctuation in the pond. Further, *Diplonychus indicus* may be more adaptable to variations in salinity with the possession of hydrophilic cuticle as reported in *Nepa cinerea* by Staddon [10]. However, *Diplonychus indicus* generally maintained a good population even at higher pH. Dissolved oxygen too had a positive correlation with *Diplonychus indicus.* Interestingly, Thirumalai and Raghunathan found that dissolved oxygen apparently had no effect on the population of *Diplonychus indicus* [11]. Popham and Lansbury has indicated that deficiency in oxygen was a strong stimulus for the migration of corixids [12]. The capacity of aquatic bugs to migrate appears to be yet another important factor causing fluctuation in their population [8,13,14]. However, Stout found that the two species of predacious aquatic creeping water bugs of the family Naucordiae were not affected by reductions in dissolved oxygen as they are plastron breathing insects [15].

With regard to the biotic factors, there was a positive correlation between *Diplonychus indicus* and all the other co-existing insects. *Culex* larval population also showed a positive correlation with the nymphal and adult population of *Diplonychus indicus*. It is important to correlate predator and prey seasonality and habitats if mosquito control is to be considered for a particular predator that has proven to be effective in experimental conditions [16]. During the south west monsoon seasons there was an increase in *Culex* larval population followed by increase in *Diplonychus indicus* population in the present study. The availability of prey was due to high breeding of mosquitoes during the rainy season. Jeyanthi and Venkatesan in their study on the population dynamics of *Diplonychus indicus* in Cooum river, Chennai, Tamil Nadu, India found that among the post embryonic stages, the fourth and fifth nymphal stages occurred throughout the year [17]. But the first and second nymphal stages were poorly represented and they attributed this to the vulnerability of early nymphal stages to predators. However in the present study, all the nymphal stages of *Diplonychus indicus* were well represented in the pond. The uniform population density of all the nymphal stages might be due to the rich vegetation which provides refuge to the nymphal instars to escape from the predators. The presence of vegetation significantly influenced predation activity in both nymph and adult *Diplonychus indicus*. The influence was highly significant and more pronounced due to *Culex* immature having an affinity for vegetation in larval habitats [16].

Laboratory research into aquatic insect predation is fairly common and studies of aquatic bugs have shown that they are quite effective predators of mosquito larvae [16]. Aquatic bugs are voracious feeders on dipteran larvae and their habitats are devoid of mosquitoes which indicates their potential in biological control [18]. The prey availability increased due to high breeding of mosquitoes during the monsoon season which enhanced the density of these insects. Among them *Diplonychus indicus* is found to be very effective in view of its life span, unique behavior of encumbrance and its predatory nature. The species *indicus* is one of the most common species of *Diplonychus* present in the southernmost part of our country and it belongs to the subfamily Belostomatidae and order Hemiptera. It is a predacious water bug even in its nymphal stages and is widely distributed in lentic as well as lotic habitats of Kanyakumari district. They are usually found clinging to the aquatic plants like *Eichhornia* and *Hydrilla* in large masses and exhibit varied behavioral patterns in the fresh water

medium to fulfil their food requirements, respiration and other metabolic activities. These water bugs emerge continually throughout the year in permanent fresh water system in tropics and are adaptable to difference in salinity and temperature conditions [19]. This water bug is a highly versatile predator that forages both actively and from ambush and grasps prey items with their fore legs and consume them by sucking. It expends more energy for prey capture and prey utilization and the predation is governed by many attributes such as prey density, prey type, prey distribution, predatory periodicity, prey choice, and vegetation [20-25]. The present findings on the population dynamics of aquatic insects in the study area established the fact that there was seasonal fluctuation in the population of aquatic bugs. The biotic factors especially *Culex* larvae that formed the main prey had a positive correlation with *Diplonychus indicus* which indicated the fact that *Culex* larval population was under control.

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