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DIVERSITY AND DISTRIBUTION OF AQUATIC INSECTS IN A TROPICAL SMALL STREAM OF SOUTH INDIA BETWEEN 1996-1997 AND 2006-2007: IS IT THE CONSEQUENCE OF ANTHROPOGENIC IMPACT OR CLIMATE CHANGE OR BOTH?

S. DINAKARAN AND S. ANBALAGAN
CENTRE FOR RESEARCH IN AQUATIC ENTOMOLOGY
THE MADURA COLLEGE, MADURAI-625 011, INDIA
(e-mail : dinkarji@gmail.com)

Deforestation, construction of dams for agro-electric projects, urbanization, and industrialization are the different factors of globalization and are lead to modify the natural structures, in developing countries. Aquatic insects are indicators of habitat and climate change in streams. Therefore, we examined the diversity and distribution of aquatic insects in a small stream of Sirumalai hills, south India between 1996-1997 and 2006-2007. In the sampling period of 2006-2007, air and water temperature had slightly higher than that of 1996-1997. The maximum number of taxa was obtained during the month of October in 1996-1997 and November in 2006-2007. The percentage of shredders and scrapers were increased and collector-filterers, collector-gatherers and predators were decreased during 2006-2007. BMWP and ASPT scores were higher in the sampling period of 1996-1997 than 2006-2007. Both global climate change and anthropogenic impact influence the community structure of aquatic insects.

Key words: climate change, anthropogenic impact, aquatic insects.

INTRODUCTION

Freshwater as a commodity generates an exhaustible resource and has been exploited over the years due to its degradation. With a phenomenal development of water resources since independence, India has successfully met water requirements for different usages. Preserving the quality and availability of freshwater resources however, is becoming the most pressing of many environmental challenges on national horizon (MoWR, 2001). In order to evaluate the consequences of anthropogenic impact and global warming on freshwater resources, assessment of current status or prospects for conservation of freshwater fauna is required. Freshwater fauna are exposed to a range of natural disturbances varying in strength, frequency, predictability, duration, and spatial scale. Such disturbances can deplete the fauna, disrupt ecological processes, and redistribute resources (Giller, 1996; Lake, 2000). Aquatic insects are indicators of climate change effects in streams which, provides valuable information owing to their narrow thermal ranges (Polatera & Beisel, 2002). Although tropical streams support many aquatic fauna rather than temperate streams (Dudgeon, 1999), habitat alteration by human being and seasonal fluctuation are subject to faunal changes or the extinction of species in south Indian tropical streams (Dinakaran & Anbalagan, 2007 & 2008). Using changes in species composition, diversity and functional organization of aquatic insects, many techniques, protocols and indices have been developed recently. These changes are valuable in demonstrating the effects of anthropogenic disturbances. Few studies have been concerned with climate change on aquatic insect communities. The objectives of this study were to examine whether the degree of aquatic insects diversity and their distribution have been modified anthropogenically or global warming (naturally) during this period in a tropical stream of south India.

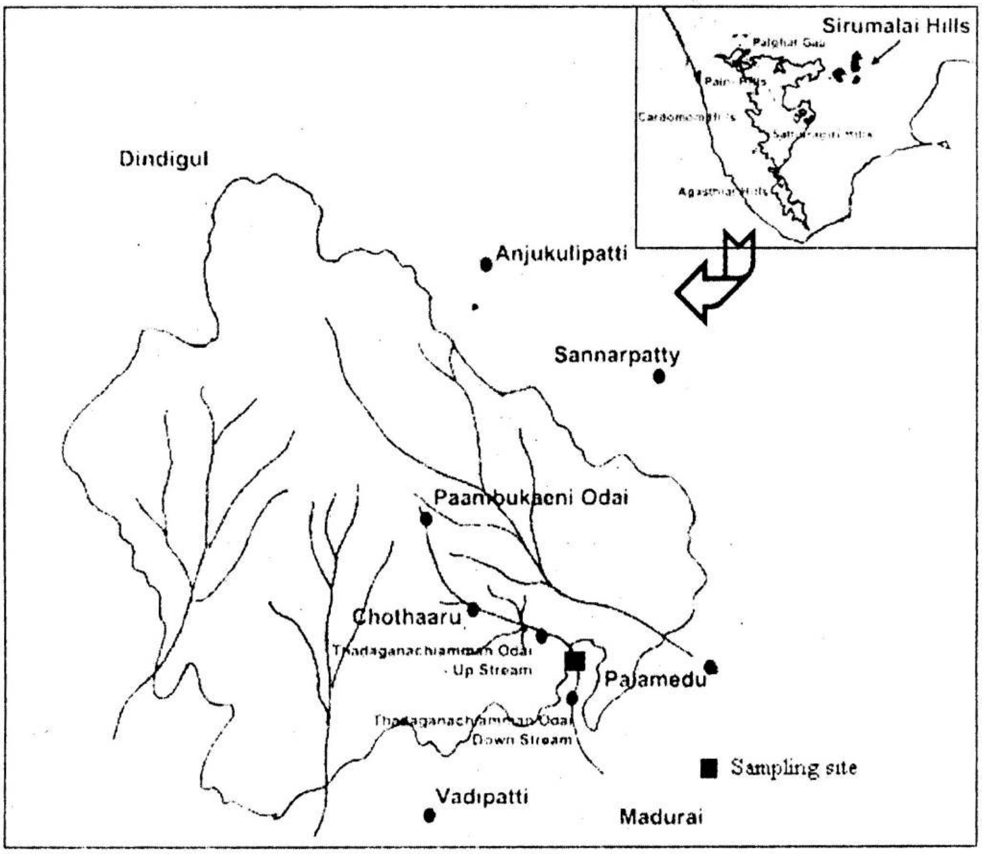

Fig. 1: Map of sampling site in Sirumalai hills, south India

MATERIALS AND METHODS

Study area : The Sirumalai hills belong to Sholavandhan range of Tamil Nadu forest department, which has nine reserve forests extending over an area of 4,4769,74 acres. The main stream is Sathiar, which originates from Pidariammanmalai at Manakattur, Thadganachiamman stream and other small streams.

Sathiar stream, which ultimately join with river Vaigai (Fig. 1). During the monsoon, rains torrential and rainfalls generally range from 156-195cms per year. Rainfall is not evenly distributed throughout the year. Along the banks of the stream are thick stands of trees and shrubs whose leaves are the stream's principal source of organic detritus. Dominant riparian tree species are *Pongamia pinnata, Syzygium cuminii* and *Erythrozylum* sp. Prominent herbs on the banks of the stream are *Cyperus bulbosus, Cyperus dubius, Fimbristlis schoenoides, Cyanoris cristata* and *Commelina clarata.* As Sirumalai hills are considered as dry deciduous and shrub forests and high anthropogenic impact occurring due to sacred bathing and washing cloths, we carried out our study in this hill's stream (Thadaganachiamman stream).

Sampling methods : Physico-chemical and biological samplings were taken in Thadaganachiamman stream of Sirumalai hills for two inter-year periods such as one sampling between June 1996 and May 1997 and other between June 2006 and May 2007. Streams were visited month wise as per the above periods mentioned. Water temperature was recorded in the field using thermometer, dissolved oxygen was estimated using Winkler's method (APHA, 1995), pH and conductivity were determined by pH and conductivity meters (Elico, India). Altitude, latitude, longitude and basin location were taken from GPS (Global Positioning System). Substrates were classified according to the following criteria: <0.5 mm mud/silt, 0.5-2 mm sand, 2-64 mm gravel, 65-256 mm cobbles, and >256 mm boulders (Jowett *et al.*, 1991). The average stream depth was calculated from three measurements from one transversal profile across the channel with a calibrated stick. Surface water current was obtained by flow meter. Dominant species of riparian vegetation were recorded for each sampling sites. For each study site and sampling occasion, three benthic samples were taken at random 1m^2 area from riffle and pool habitat. In riffle samples, aquatic insects were collected using 180 μm mesh kick-net and 500 μm mesh dip net were used for pool samples. Aquatic insects were preserved in

Table 1: Physico-chemical parameters (Mean ± SD) for Thadaga-nachiamman streams of Sirumalai hills for June 1996 to May 1997 and June 2006 to May 2007.

Physical parameters	**1996-1997**		**2006-2007**	
	Riffle	Pool	Riffle	Pool
Location with temperatures				
Latitude (N)	9° 28'			
Longitude (E)	77° 22'			
Altidude (m)	375			
Air temperature (°C)	28.6 ±1.5	28.6 ±1.5	29 ± 1.9	29 ± 1.9
Water temperature (°C)	23.5 ± 2.8	23.5 ± 2.8	23.9 ± 2.4	23.9 ± 2.4
Chemical parameters				
Dissolved Oxygen (mgL^{-1})	16.3 ± 0.4	16.3 ± 0.4	14.01 ±1.56	14.01 ±1.56
pH	6.8 ± 0.2	6.8 ± 0.2	6.78 ±0.19	6.78 ±0.19
Conductivity (μmhos/cm)	0.2 ± 0.1	0.2 ± 0.1	0.2 ±0.06	0.2 ±0.06
Stream habitat				
Wet width (m)	0.9 ± 0.3	4.0 ± 0.9	0.9 ± 0.3	3.8 ± 0.6
Depth (cm)	14.8 ±3.4	48.8 ± 10.3	13.8 ± 3.1	46.5 ± 7.8
Surface water current (sec/cm)	0.4 ± 0.1	0.6 ± 0.1	0.4 ± 0.1	0.6 ± 0.1
Bed rock (%)	30.0 ± 0.0	-	30.0 ± 0.0	-
Boulders (%)	24.0 ± 4.3	-	23.7 ± 4.3	-
Pebbles (%)	28.8 ± 2.3	-	27.1 ± 3.9	-
Gravels (%)	10.0 ± 0.0	-	10.0 ± 4.3	-
Sand (%)	3.8 ± 1.4	-	4.0 ± 1.3	-
Silt (%)	2.5 ± 0.9	-	3.3 ± 1.4	-
Canopy cover (%)	60.0 ± 0.0	60.0 ± 0.0	60 ± 0.0	60 ± 0.0
Riparian cover (%)	80.0 ± 0.0	80.0 ± 0.0	80 ± 0.0	80 ± 0.0
Biotic indices				
BMWP	102	57	61	57
ASPT	277.2	176.4	120.7	102.9

Table II : Diversity indices of aquatic insects in Thadaganachiamman stream of Sirumalai hills for June 1996 to May 1997 and June 2006 to May 2007.

	Riffle					Pool				
	No. of taxa	No. of. individuals	Shannon	Evenness	Margalef	No. of taxa	No. of. individuals	Shannon	Evenness	Margalef
1996-1997										
June	7	61	1.6	0.7	1.5	7	75	1.7	0.8	1.4
July	10	119	1.9	0.7	1.9	8	128	1.7	0.7	1.4
August	11	165	2.0	0.7	2.0	8	124	1.5	0.6	1.5
September	12	199	2.0	0.6	2.1	8	139	1.4	0.5	1.4
October	13	276	2.0	0.6	2.1	9	234	1.2	0.4	1.5
November	12	298	2.0	0.6	1.9	9	186	1.3	0.4	1.5
December	11	325	1.9	0.6	1.7	9	239	1.0	0.3	1.5
January	10	276	1.8	0.6	1.6	8	143	1.4	0.5	1.4
February	10	245	1.4	0.4	1.6	9	146	1.6	0.6	1.6
March	9	279	1.2	0.4	1.4	8	146	1.7	0.7	1.4
April	9	227	1.3	0.4	1.5	8	135	1.8	0.8	1.4
May	8	179	1.1	0.4	1.3	8	164	1.6	0.6	1.4
2006-2007										
June	5	27	1.4	0.8	1.2	5	52	1.3	0.7	1
July	6	53	1.5	0.7	1.3	6	70	1.4	0.7	1.2
August	7	112	1.5	0.6	1.3	8	117	1.9	0.8	1.5
September	6	123	1.4	0.6	1	10	68	2	0.7	2.1
October	11	217	1.7	0.5	1.9	10	195	1.4	0.4	1.7
November	13	290	1.8	0.5	2.1	9	318	1	0.3	1.4
December	12	223	1.6	0.4	2	8	224	1	0.4	1.3
January	11	217	1.8	0.5	1.9	9	106	1.8	0.6	1.7
February	7	194	1.2	0.5	1.1	7	92	1.7	0.8	1.3
March	7	240	1.0	0.4	1.1	7	89	1.4	0.6	1.3
April	7	232	1.0	0.4	1.1	7	82	1.5	0.7	1.4
May	7	162	1.3	0.5	1.2	8	147	1.6	0.6	1.4

Table III : Relative composition (%) of the total aquatic insects in riffle and pool habitat of Thadaganachiamman stream in 1996-1997 and 2006-2007.

Taxa	Riffle		Pool	
	1996-1997	2006-2007	1996-1997	2006-2007
Ephemeroptera				
Choroterpes	10.9	6.12	1.29	0.45
Thalerosphyrus	6.38	1.91	0	0
Baetis	8.49	8.23	47.7	36.6
Odonata				
Gomphus	0.64	1	2.21	3.27
Plecoptera				
Neoperla	5.06	2.44	0	0
Hemiptera				
Ambrysus	0.08	0.43	5.86	10.8
Tenogogonus	0.38	1.05	6.4	8.53
Coleoptera				
Gyrinus	0.49	1	2.69	1.92
Stenelmis	4.42	11	10.8	12.2
Trichoptera				
Hydropsyche	14.3	12.2	0	0
Stenopsyche	1.06	0.33	0	0
Lepidostoma	43.9	52	17.4	16.5
Wormaldia	3.4	0	0	0
Ansiocentropus	0	0	4.52	7.88
Diptera				
Tipula sp.	0.15	1.91	1.13	1.86
Megaloptera				
Corydalus	0.38	0.48	0	0

Table IV : Relative composition (%) of functional feeding group at riffle and pool habitat of Thadaganachiamman stream in 1996-1997 and 2006-2007.

Functional feeding groups	Riffle		Pool	
	1996-1997	2006-2007	1996-1997	2006-2007
Shredders	44.05	53.87	23.09	26.22
Scrapers	12.91	19.19	58.47	48.78
Collectors-filterers	18.76	12.49	0.00	0.00
Collectors-gatherers	17.25	8.04	1.29	0.45
Predators	7.02	6.41	17.15	24.55

the field using 70% ethanol. All aquatic insects were brought to the laboratory and identified to the lowest possible taxonomic level.

Data analysis : In each sampling station three diversity indices were estimated. Alpha diversity indices of Shannon-Wiener diversity index, species richness of Margalef index and evenness of Pielou index, were calculated according to Ludwig & Reynolds (1988). Principal component analysis (PCA) was calculated for measuring relationship between eleven environmental variables and taxa richness of aquatic insects for two sampling periods (Harper, 1999). Biological Monitoring Working Party index (BMWP) and Average Score Per Taxon (ASPT) were used to evaluate the biotic integrity of communities. BMWP and ASPT analyses were based on Armitage *et al.* (1983).

RESULTS

Physico-chemical parameters

The physico-chemical parameters are given in Table I. During monsoonal periods (south-west monsoon : July-September; north-east monsoon : October-November) water temperature was low whereas water current was high during the sampling periods. In the sampling period of 2006-2007, air and water temperature had slightly higher than 1996-1997. Chemical parameters of Dissolved oxygen, pH and conductivity and stream habitats of mean wet width and depth were faintly inferior in 2006-2007 periods than 1996-1997.

Diversity and distribution

16 aquatic insect taxa were collected during the periods 1996-1997 and 2006-2007 (Table II). The higher diversity value and species richness of taxa were found in riffle than pool in both periods. Shannon & Margalef values were higher in the period of 1996-1997 than 2006-2007. Shannon & Margalef indices showed that the diversity value increased from June to November and decreased from December to May during 1996-1997 whereas jagged pattern of diversity value occurred during 2006-2007. The maximum number of taxa was obtained during in the month of October in 1996-1997 and November in 2006-2007. Evenness index value was higher from June to August in 1996-1997 and from June to July in the period of 2006-2007 (Table II).

The order Trichoptera had higher taxa (5) than other insect orders. The number of taxa of other insect orders was 3 taxa for Ephemeroptera, 2 taxa for Hemiptera, Coleoptera and 1taxa for Odonata, Plecoptera, Diptera and Megaloptera. *Lepidostoma* occupied the greatest numbers at riffle whereas at pool, *Baetis* had the highest in both sampling periods (1996-1997 and 2006-2007) (Table III). Ephemeroptera, Trichoptera and Plecoptera were greater numbers in the period of 1996-1997 than 2006-2007. Higher numbers of Odonata and Diptera were observed at pool whereas Coleoptera and Diptera found high at riffle during 2006-2007. There was no change observed in Megaloptera between the two sampling periods (Fig. 2).

In riffle, the percentage of shredders and scrapers were increased and collector-filterers, collector-gatherers and predators were decreased during 2006-2007. The percentage of shredders and predators were higher than the other functional groups in pool during 2006-2007 (Table 4).

BMWP and ASPT score of riffle were higher in the sampling period of 1996-1997 than 2006-2007. In pool, there was no change of BMWP score between 1996-1997 and 2006-2007 sampling periods but ASPT was changed and their score was high in 1996-1997 (Table I).

Effect of environmental variables

Results of Principal Component Analysis (PCA) explained that the eigen values for F1 and F2 axes were 742.6 and 53.0 and cumulative variance was 93.34% for F1 axis and 6.66% for F2 axis. PCA analysis exposed that among eleven environmental variables, the

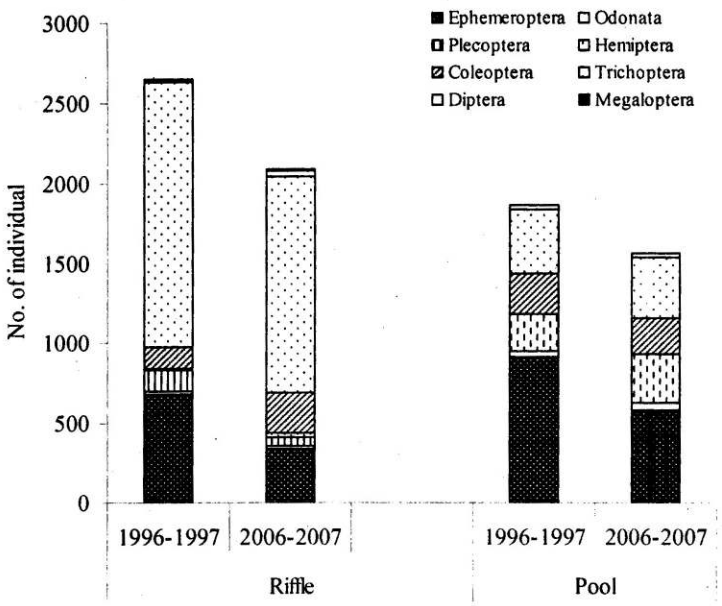

Fig. 2 : No. of individuals of aquatic insect orders at riffle and pool habitat of Thadaganachiamman stream in 1996-1997 and 2006-2007.

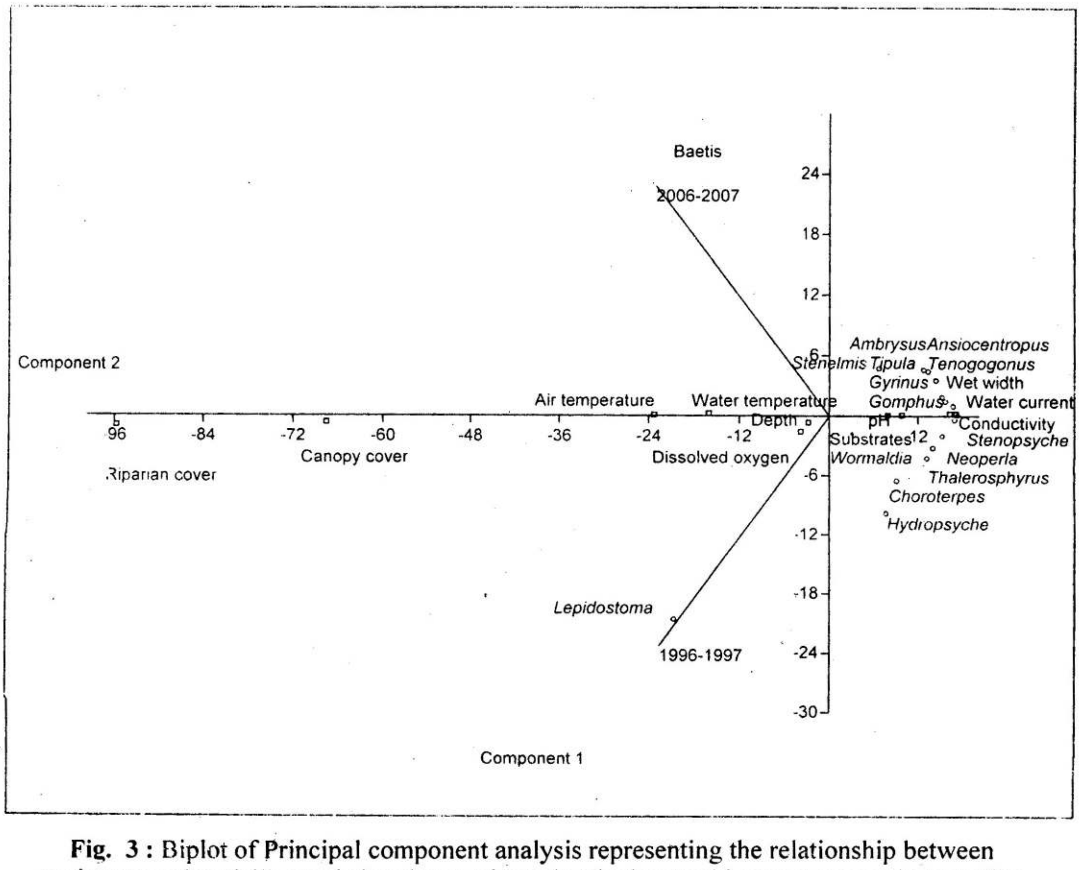

Fig. 3 : Biplot of Principal component analysis representing the relationship between environmental variables and abundance of taxa in Thadaganachiamman stream in sampling periods of 1996-1997 and 2006-2007.

factors of dissolved oxygen and water depth are associated with 1996-1997 plot. The only one taxa of *Lepdiostoma* is associated with 1996-1997 plot whereas for another plot of 2006-2007, *Baetis* is linked (Fig. 3).

DISCUSSION

With the increasing levels of greenhouse gases in the atmosphere, it has been projected that there will be a steady and significant rise in surface temperatures, both on land and in water. Global warming also expresses in freshwater ecosystem which resulted changes in River hydrology and shifts in stream flow (Arnell *et al.*, 1996; Lodge, 2000; Poff *et al.*, 2000). The present study supports the prediction and changes in climate, streams flow and thermal regime of the chosen water shed had a consequent difference between 2006 and 2007 than 1996-1997. Assemblage and constellation of aquatic insects also differ between the span of 10 years. Also, diversity and seasonality of aquatic insects were also changed due to climate change. The shredders and scrapers percentage were increased during 2006-2007 than 1996-1997, it reflect that the global climate change thus supports algae and detritus, algal consumers (mollusks, ephemeropterans, chironomids), detritus consumers (trichopterans, dipeterans) and small predators (odonates, young fishes). BMWP and ASPT score were lower during 2006-2007; it may be due to anthropogenic impact. Therefore, decreasing stream flow regime due to global climate change increase the numbers of shredder's species *Lepidostoma* and algal richness due to habitat alteration, support the abundance of *Baetis* (algal consumers).

All forms of human disturbance producing global climate change has indirectly affect the stream biota whereas anthropogenic impact directly affect stream community. In conclusion, both global climate change and anthropogenic impact influence the community structure of aquatic insects.

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