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RESEARCH ARTICLE

HABITAT PREFERENCE OF CORIXIDAE AND COEXISTING FAMILIES OF HETEROPTERA

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ABSTRACT

Aquatic insects have been extensively studied to know their ecological relationship with other freshwater communities. One stable and one temporary pond- representing a wide hydroperiod gradient were selected from each district *viz.* Chennai (Chetpet and Koyambedu) and Kancheepuram (Chengalpet), India. Members of each genus of water bugs occupy a distinct habitat and exhibit diagnostic behaviour patterns. *Micronecta s cutellaris* prefers limnetic shallow water. *Diplonychus rusticus* inhabits water column as well as near the shores. *Anisops bouvieri* colonizes limnetic water column. *Tenagogonus fluviorum* occupies open water surface, preferentially under shade.

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INTRODUCTION

Freshwater ecosystems have well defined boundaries and differ distinctly in surface area, depth, type of vegetation and existence of prey items than the terrestrial environment. Insects that dwell in water bodies occupy various ecological niches to the extent of shores as well as bottom. Among them, aquatic bugs under the sub-order Heteroptera are of great importance since they decide the potency of freshwater ecosystem (Newbury, 1984). Habitat plays a vital role in deciding the activities of organisms. Substratum is the stage upon which the drama of aquatic insect ecology is acted out. It is the medium upon which aquatic insects move, rest, find shelter and seek food.Aquatic insect communities may be totally aquatic or partially aquatic in their mode of life (Brown, 1987). Members of each family are highly unique in possessing certain diagnostic features that are of high adaptive value for their existence and survival in selective microhabitats of freshwater environment. Each genus of water bug occupies a distinct habitat and exhibits distinctive behaviour patterns and shows an affinity with the type of substratum. Structure of substratum is inseparably linked to variations inspatial colonizations of insects (Minshall, 1984). Autecology is the study of the environmental relations of the individuals of single species whereas synecology is the way in which individuals of different species mutually interact. At the present time, most ecological study is synecological, basically devoted to the study of the paradox of a continual struggle for existence leading to the evolution of highly efficient competitors which, as far as possible avoid competition. This enables elaborate and stable communities to be built up on the basis of what initially seems to be destructive process (Hutchinson. 1982). An unsuspected variety of synecological relationships may depend on the simplest kind of autecological difference. Almost endless variety of physiological and structural modifications in the members of the class Insecta speak for their dominance when compared with all other groups of organism. Aquatic and semi-aquatic bugs are the most important predators in the food chain of aquatic ecosystem, since most of them are polyphagous and carnivorous. Their contribution to the food web and energy flow of freshwater systems is substantial (Runck and Blinn, 1990). Heteropterans capture a variety of prey including zooplankton and larval *Chironomus* (Osborne *et al.,* 2000), Odonate larvae (De Marco *et al.,* 1999), mosquito larvae (Ambrose et al., 1993; Blausteinet *al.,* 1995), frog tadpoles (Petranka and Kennedy, 1999) and even small fishes (Nishi, 1990; Nazoa, 1992; Gilbert and Burns, 1999). Review of literature on occurrence, prevalence, distribution and spatial colonization of water bugs reveal that they are under the influence of definitive abiotic and biotic factors including the habitat structure. Records on occurrence and distribution of *Micronecta scutellaris* (Stål) in Indiaare scanty. This may partly be due to the fact that these water bugs are small enough to remain

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unnoticed or to pass through the ordinary nets used for collecting aquatic insects. Hence, it is pertinent to investigate occurrence, prevalence, and distribution of corixidae and co-existing families of heteroptera in permanent and temporary ponds.

MATERIALS AND METHODS

Selection of key species of heteropterans

Selective heteropterans *viz. Micronecta scutellaris, Tenagogonus fluviorum, Anisops bouvieri* and *Diplonychus rusticus* from varied microhabitats were surveyed to identify the preferable zone and their presence or absence in the habitat was recorded to investigate for their colonization dynamics in permanent and temporary habitats during the study period from August 1998 to July 2000.

Study Area

One stable and one temporary pond- representing a wide hydroperiod gradient were selected from each district *viz.*Chennai (Chetpet and Koyambedu) and Kancheepuram (Chengalpet), India.Hydrological parameters, plankton and probable prey species, and co-existing representative aquatic Hemipterans were investigated.

Pond Ecosystem in the District of Chennai

Koyembedu pond is a temporary (13.3°N, 80.7°E) pond and is 15 Km away from the research laboratory, Loyola College, Chennai. It is near the shore of Bay of Bengal (13.3° N and 80.7° E) and 6.6m above sea level. It is usually dry during most of the year. Depth ranges from 1.1 to 1.3 m. Surface area is 108-121m^2. Principle source of water is rainfall and seepage. Chetpet pond is a tropical and permanent pond (13°N, 80°E), situated 2 km away from the research laboratory, Loyola College, Chennai. It is near the shore of Bay of Bengal (13°N, 80°E) and 6.5m above sea level. The shape of the permanent pond is roughly rectangular with total area of 24000 m^2. Depth of the pond is 0.5 m around the shore region 2.5 m near the centre. Bottom of the pond is sandy in texture. Pebbles and medium size stones are found around shore region with clayey soil. Water temperature ranges between 25°C (December) and 37-39°C (June).

Pond Ecosystem in the District of Kancheepuram

Temporary pond at Chengalpet (12°N, 79°E) in Kancheepuram district is 55 km away from the research laboratory. This small temporary pond is rectangular in shape with well defined margin by stones with a total area of 748m^2. It has 6 inlets for the flow of rain water during monsoon months. Bottom of the pond is gravel in nature and the soil is sandy in texture. Depth of the pond measured 2m at the centre and 0.5m at the shore. Permanent pond selected is also situated at Chengalpet (12°N, 79°E) in Kancheepuram district 57 km away from the research laboratory. It is nearly hexagonal in shape with well defined margin in a total area of 2160m^2. Bottom of the pond is sandy with silt. Margin of the pond showed the presence of fine, medium and coarse pebbles and stones. Depth of the pond measured 2.4m at the centre and 0.5m at the shore.

Sampling Techniques

All ponds were sampled once in each month during the study period.Samples were preserved in 70 per cent alcohol**.** Traditional unrestricted sampling method was adopted and sampling was done following Crisp (1962) and Pajunen (1972). According to Menke (1979), aquatic bugs were collected differently depending on their behaviour or habitat. Two different pond nets with 30 and 16cm in dimeter were used.*D. rusticus* were collected adopting the technique of Venkatesan (1981). *A. bouvieri* and *T. fluviorum* were collected using a net having 30 cm diameter. Since *M. scutellaris* are too small to be caught with ordinary aquatic nets, a net of denser material was preferred (Jansson, 1976). Nymph and adult *M. scutellaris* were netted with a small hand net made of dense terylene gauze and 16cm in diameter. A fixed netting route was selected, normally through the deepest part of the pool. When the water level changed, the route was changed accordingly. Before the start of netting, water was agitated vigorously to cause a standard distribution of animals, and the net was then moved along the bottom of pond at constant speed. Before each net sweep, the water was again agitated and netting was carried out in the standard sampling route. For the sake of convenience, the first three nettings of a series were taken at intervals of 10 minutes. Nine sweeps were used.

Contents of the net were transferred to polypropylene containers and *M. scutellaris* were removed with the aid of wide mouthed glass pipette. Different larval stages were identified visually and the identification was later confirmed in the laboratory. Faunal assemblage of the collection was identified. Areas, where sampling gave negative result, were confidently assumed to be outside the distributional range of these bugs. Plankton were collected using 120µm and 5µm plankton nets in two containers separately. Samples were preserved in 4 per cent formalin for further analysis and identification using the standard key (Edmondson, 1959; Battish, 1992; Anand, 1998). Enumeration of plankton samples were done by Sedgewick Rafter Cell Counter. Values were expressed as cells / m^3 for phytoplankton and individual/m^3 for zooplankton (Santhanam*et al.,* 1989). Hydrophytes available in the sampling sites were visually identified, collected and confirmed in the laboratory.

RESULTS

Investigation on the preference of habitats by the families of aquatic Heteroptera distinguished three different zones of occurrence in the aquatic ecosystem. Corixidae are good swimmers and dwell preferentially in the bottom of the shores. Corixids frequent shallows of lakes and ponds and remain submerged for long time. *Micronecta scutellaris* has higher preference and affinity for the bottom regions of the habitat and represents the bottom community. They were abundant in rocky and sandy shore region with or without the hydrophyte, *Hydrilla* sp. Notonectidae and Belostomatidae occupied water column. Notonectids were observed to be primarily swimmers and good climbers whereas belostomatids were primarily climbers and good swimmers as well. *T. fluviorum* were completely absent in other strata hence they are supra-aquatic. *A. bouvieri* were abundant in water column without vegetation.

They are not averse to water column with sparsely occurring hydrophytes (Table 1&2). *D. rusticus* were more numerous near the rootlets of floating hydrophytes, beneath small stones at the regions. Enumeration of macrohydrophyte species diversity in the freshwater habitats revealed the presence of free floating *Pistia stratioites, Lemna minor* and *Zichhornia crassipes,* floating *Nelambo speciosum, Aponogeton* sp and *Nymphae stellata* submerged *Ceratophyllum sp* and *Hydrilla* sp, and marginal *Marsilia quadrifolia* in the perennial pond. Floating hydrophytes were absent in temporary ponds. But free floating *Lemna minor* and *wolffia pauplifaera,* submerged *Chara*sp, *Hydrilla* sp, *Jussiaea* sp, and marginal hydrophytes such as *Ipomoea aquatica* and *Marsilia quadrifolia* were present (Table 3).

Table 1. Habitat preference of Corixidae and co-existing families of Hemiptera from selective freshwater bodies in the districts of Chennai and Kancheepuram

SI.No	Family	Habitat	Habit
1.	Gerridae	Generally lentic Water surface	Skaters
2.	Notonectidae	Lentic Depositional column	Swimmers Climbers
3.	Belostomatidae	Lentic Littoral column	Climbers Swimmers
4.	Corixidae	Generally lentic Bottom	Swimmers Climbers

Table 2. Relative incidence and distribution of *M. scutellaris, T. fluviorum, A. bouvieri* and *D. rusticus* in different strata of selective freshwater bodies

S.No.	Species (Family)	Habitats	Strata of the water body								
			Water surface			Water column			Bottom		
			ows	wfv	wss	wsv	wwv	wfv	ss	rb	rs
1	*T. fluviorum* (Gerridae)	Permanent	+++	+	++	-	-	+	-	-	-
		Temporary	++	-	+++	-	-	-	-	-	-
2	*A. bouvieri*(Notonectidae)	Permanent	-	-	-	++	+++	-	-	-	-
		Temporary	-	-	-	++	+++	-	-	-	-
3	*D. rusticus* (Belostomatidae)	Permanent	-	-	-	-	-	+++	-	-	++
		Temporary	-	-	-	+++	-	-	-	-	++
4	*M.scutellaris* (Corixidae)	Permanent	-	-	-	-	-	-	+++	-	++
		Temporary	-	-	-	+	-	-	++	+++	-

+++ Abundant ++ Average + Scarce - Absent **ows**-open water surface **wfv**- water with floating vegetation **wss**- water shaded by shrubs **wsv**- water with submerged vegetation **wwv**- water without vegetation **ss**-sandy shore **rb**- rocky bottom **rs**- rocky shore

Table 3. Check list of hydrophytes in pond ecosystem in the districts of Chennai and Kancheepuram

Hydrophytes	Permanent pond	Temporary pond
Free floating	*Pistia stratioites* *Lemna minor* *Eichhornia crassipes*	*Lemna minor* *Wolffia pauplifera*
Floating	*Nelumbo speciosum* *Aponogeton* sp. *Nymphae stellata*	----------
Submerged	*Ceratophyllum* sp. *Hydrilla* sp.	*Chara* sp. *Hydrilla* sp. *Jussiaea* sp.
Marginal	*Marsilea quadrifolia*	*Ipomoea aquatica* *Marsilea quadrifolia*

Table 4. Abundance (%) of plankton in selective freshwater bodies of the districts of Chennai and Kancheepuram

Plankton (%)		Permanent ponds		Temporary ponds	
		Chetpet pond	Chengalpet pond	Koyambedu pond	Chengalpet pond
Phytoplankton	Bacillariophyceae	17.0129	21.9012	18.3214	12.1077
	Chlorophyceae	49.1231	20.6826	10.5233	48.6593
	Cynophyceae	9.1926	10.7253	51.0212	26.1298
	Dinophyceae	24.6714	46.6909	20.1341	13.1032
Zooplankton	Cyclopoid	16.01413	15.76318	17.08441	15.64685
	Clanoid	0.294377	0	0.01843	0
	Rotifer	67.02973	68.49863	61.59233	59.50612
	Ostracod	10.65646	7.069698	9.749355	13.81119
	Cladoceran	6.005299	8.668499	11.55547	11.03584

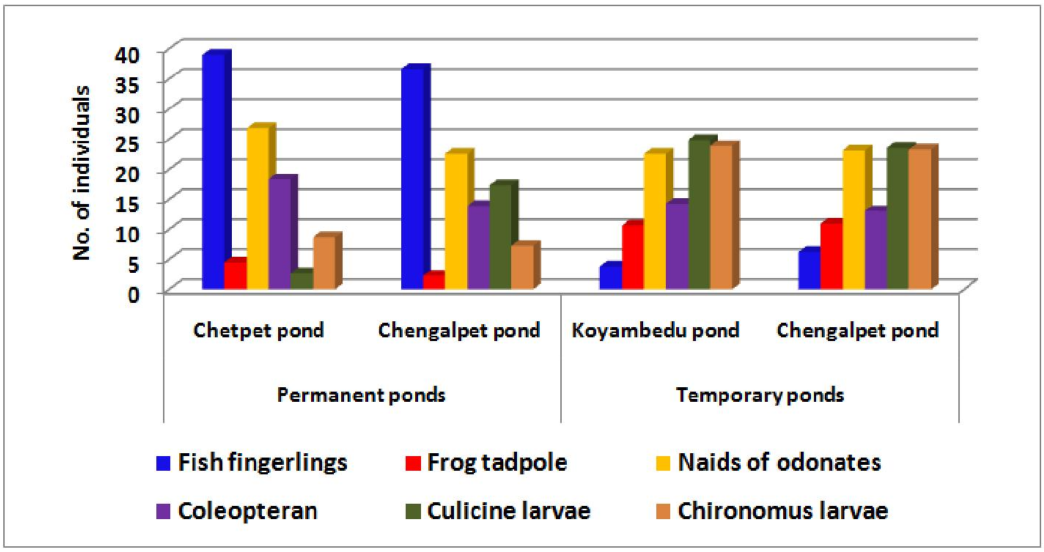

Figure 1. Distribution of probable prey (%) in the study sites

Table 5. Check list of plankton in pond ecosystem in the districts of Chennai and Kancheepuram

S.No.		Plankton category	Ponds	
			Permanent	Temporary
1	PHYTOPLANKTON	Bacillariophyceae	*Cyclotella, Cymbella cymbiformis* *Neidium iridis*	*Cyclotella*
2		Chlorophyceae	*Cylindrocapsa geminella, Gleotilpsis planktonica* *Spirotaenia condensate, Hormidium flaccidum* *Ankistrodesmus convolutes, Micractinium pusillium* *Crucigenia tetrapedia, Pachycladon umbrinus* *Scenedesmus obliuus, Scenedesmus guadricauda* *Trebauriatria ppendiculata, Spirogyra*	*Spirogyra* *Hormidium flaccidum* *Ankistrodesmus convolutes* *Pachycladon umbrinus* *Scenedesmus obliuus* *Scenedesmus guadricauda*
3		Cyanophyceae	*Aphanocapsa banaresensis, Chroococcus* *Microcystis aeruginosa, Microcystis flos - aquae* *Merismopedia glauca, Gloeocapsa nigrescens* *Gomphosphaeria aponina, Oscillatoria amphiba* *Oscillatoria subbrevis, Spirulina meneghiniana* *Phormidium subfuscum*	*Aphanocapsa banaresensis* *Microcystis flos-aquae* *Merismopedia glauca,* *Oscillatoria amphiba* *Oscillatoria subbrevis,* *Spirulina meneghiniana* *Phormidium subfuscum*
4		Dinophyceae	*Navicula cuspidate, Navicula rhyncocephala*	*Navicula cuspidate* *Navicula rhyncocephala*
5	ZOOPLANKTON	Cyclopoid	*Cyclops strenuus*	*Cyclops strenuus*
6		Calanoid	*Calanoid* sp.	-
7		Rotifera	*Keratella himalis* *Keratella vulga* *Keratella quadricauda* *Branchionous* sp.	*Keratella vulga* *Branchionous* sp.
8		Ostracoda	*Cypris*	Cypris
9		Cladocera	*Ceriodaphina cornuta, Daphnia* sp.	*Daphnia* sp.

Abundance of plankton and macro-prey organisms in permanent and temporary ponds are given in Table 4 and Figure 1. Chlorophyceae (49.12%) and rotifer (67.0. %) were the dominant planktonic organism in Chetpet permanent pond, Dinophyceae (46.69 %) and rotifera (68.50 %) in Chengalpet permanent pond, Cynophyceae (51.02 %) and rotifera (61.59 %) in Koyambedu temporary pond and Chlorophyceae (48.66 %) and rotifera (59.517 %) in Chengalpet temporary pond. Fish fingerlings dominate the macro-prey species in the ponds at Chengalpet. Culicine larvae dominate the ponds at Chennai. Frog tadpoles, naids of odonates, coleopteran and larval *Culex* and *Chironomus* have their share in all the four ponds.

Qualitative analysis of plankton showed the dominance of Chlorophyceae and Cyanophyceae. Members of Bacillariophyceae, Dinophyceae, Cyclopoidia, Calanoidia, Rotifera and Ostracoda and Cladocera are also observed in permanent and temporary ponds. *Spirogyra* was the dominant member of Chlorophyceae (Table 5).

DISCUSSION

Spatial colonization of aquatic heteropterans and their diversity are related to specific zones of the habitat (Kurzatkowska, 1999). Zones of colonization are water surface, water column and bottom region in selective freshwater bodies in the districts of Chennai and Kancheepuram, Tamil Nadu, India. Spatial colonization and diversity of *Micronecta scutellaris* and selective representative water bugs in the present study were more or less similar in all the habitats studied. Surface dweller *T. fluviorum* rapidly colonize open water surface of lakes and permanent and temporary ponds. According to Anderson (1996), types of vegetation determine ecological separation of *Gerris*sp. and *T. fluvivorum.* Among column dwellers, *A. bouvieri* was found to colonize the zones free from submerged hydrophytes. *D. rusticus* has greater affinity for zones with submerged hydrophytes. In permanent ponds, they also colonize between the rootlets of floating hydrophytes. Free floating hydrophytes were scarce and floating hydrophytes were absent in temporary habitats. Marginal hydrophytes *Ipomoea aquatic* and *Marsilya quadrifolia* on the shores of temporary ponds serve as shelter for the surface dwellers. Presence of submerged vegetation serving as oviposition sites and shelter for encumbered males may enhance the rate of colonization of *D. rusticus* (Venkatesan, 1981). Richness of a species is governed by the impact of climatic and hydrological factors (Kumar *et al.,* 1991; Savage, 1996; 2000). In general water level plays significant role for nymph population. Water level in habitats is directly related to total rainfall of the area (Lahr *et al.,* 1999). Fish fingerlings were the dominant prey species in permanent ponds throughout study period. Culicine larvae were abundant in temporary ponds. Aquatic insects were reported to be abundant where larval mosquito were also abundant (Lee, 1998). Colonization of aquatic heteropterans is strongly related to the quality and quantity of prey species available in the habitat (Sweeny, 1984). Jansson (1977) has observed *M. minutissima* feeding on dead or dying chironomid larvae. According to Pajunen and Ukkonen (1987) cannibalism is potentially an important mechanism of population limitation in rock pool corixids. Further Corixides were found to prey upon free swimming mosquito larvae (Sailer and Lienk, 1954).

Abundance of plankton as a source of food for aquatic macro-invertebrates in both types of aquatic habitats, conforms with earlier investigators (Blinn*et al.,* 1993; Herwig and Schindler, 1996; Gilbert and Burns, 1999). *Spirogyra* was recorded in permanent as well as temporary ponds throughout the study period. Algal filaments were found to be highly preferred food for the bottom dweller *Micronecta scutellaris.* Corixids are reported to puncture cells of the larger filaments of *Spirogyra* and suck out the chlorophyll (Hungerford, 1948; Papaj and Prokopy, 1989). Corixids preferentially feed on detritus rather than algal filaments and least on free swimming animals (Pajunen, 1972). Presence, abundance and types of food and absence of food source is one of the major biological factors influencing the colonization dynamics of aquatic insects both spatially and temporally. Aquatic insects occupy diversity of niches (Mackay and Wiggins, 1979). Ecologically *M. scutellaris* cause intra and inter-specific interactions at various levels in freshwater bodies. Diversity of trophic structure has a greater impact on distribution and abundance of aquatic insect population. This causes varied dwelling areas of bugs such as the upper and lower water surfaces, water column, aquatic vegetation, prevalence of sandy, silty and clayey nature of the soil substratum (Merrit *et al.,* 1984). Such a relation between population density and habitat reflects the insects' response to supply of food and living space in terms of habitat units actually utilized.

Conclusion

M. scutellaris prefers limnetic shallow water of ponds with or without submerged hydrophyte *Hydrilla* and planktonic *Spirogyra*. *D.rusticus* inhabited water column as well as near the shores, clinging in clusters to the rootlets of floating hydrophytes such as *Eichhornia. A.bouvieri* spatially colonized limnetic water column with or without vegetation. *T. fluviorum* colonized open water surface, preferentially under shade.

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REFERENCES

Ambrose, T., Mani, T., Vincent, S., Cyril Arunkumar, L., and Thresia Mathews, K. 1993. Biocontrol efficacy of *Gerris* (A) *spinolae*, *Laccotrephes griseus* and *Gambusia affinis* on larval mosquitoes, *Indian J. Malariol* , 30: 187-192.

Anand, N. 1998.*Handbook of Blue green algae*, BSMPS, Delhi.

Andersen, N.M. 1996.Ecological phylogenetics of mating systems and sexual dimorphism in water striders (Heteroptera: Gerridae). *Vie et Milieu,* 46(2): 103-114.

Battish, S. K. 1992.*Freshwater zooplankton of India*, IBH/P.U.K, New Delhi.

Blaustein, L., Kotler, B.P. and Ward, D. 1995. Direct and indirect effects of a predatory backswimmer *(Notonecta maculata)* on community structure of desert temporary pools. *Ecol. Entomol.,* 20 : 311-318.

Blinn, D.W., Runck, C. and Davies, R.W. 1993. The impact of prey behaviour and prey density on the foraging ecology of *Ranatra montezuma* (Heteroptera): A serological examination. *Can. J. Zool.,* 71 : 387-391.

Brown, A.L. 1987. Fresh water ecology.Heinemann Educational Books Ltd., pp.11-102.

Crisp, D.J. 1962.The planktonic stages of the cirripedia *Balanus balanoides* (L.) and *Balanus balanus* (L.) from north temperate waters. *Crustaceana,* 3:207-221.

De Marco, P. Jr., Latini, A.O. and Reis, A.P. 1999. Environmental determination of dragonfly assemblage in aquaculture ponds. *Aquaculture Research,* 30(5) : 357-64.

Edmondson, W.T. 1959. *Freshwater Biology*, John wiely and Sons, N.Y.

Gilbert, J.J. and Burns, C.W. 1999. Some observations on the diet of the back-swimmer, *Anisops wakefieldi* (Hemiptera: Notonectidae). *Hydrobiologia,* 412: 111-118.

Herwig, B.R. and Schindler, D.E. 1996. Effect of aquatic insect predators on Zooplankon in fishless ponds. *Hydrobiologia,* 324(2) : 141 - 147.

Hungerford, H.B. 1948 The Corixidae of the Western hemisphere. *Univ. Kans. Sci. Bull.,* 32:1-827.

Hutchinson, G.E., 1982. Life in air and water.*Discovery* 16(1):3-9.

Jansson, A. 1976. Audiospectrographic analysis of stridulatory signals of some North American Corixidae (Hemiptera). *Ann. Zool. Fennici*.,13: 48-62.

Jansson, A. 1977. *Micronecta*as indicators of water quality in two lakes in Southern Finland.*Ann. Zool. Fennici.,* 14 : 118-214.

Kumar, K.V., Paul, P. and Kadedebaru, G. 1991. Physio-chemical features of Atticola pond during pre-monsoon period. *Environ. Ecol.,* 9 : 393 - 395.

Kurzatkowska, A. 1999.Water bugs (Heteroptera) of high bogs and transitional moors of Masurianlake district. *Polskie Pismo Entomologiczue,* 68(4) : 349-369.

Lahr, J., Diallo, A.G., Ndour, K.B., Badji, A. and Diouf, P.S. 1999. Phenology of invertebrates living in a Sahelian temporary pond. *Hydrobiologia,* 405 : 189-205.

Lee, D.K 1998.Effect of two rice culture methods on the seasonal occurrence of mosquito larvae and other aquatic animals in rice fields of southwestern Korea.*J. Vector Ecol.,* 23(2) : 161-170.

Mackay, R.J. and Wiggins, G.B. 1979. Ecological diversity in Trichoptera.*Ann. Rev. Entomol.,* 24: 185-208.

Menke, A.S. 1979. The semi-Aquatic Hemiptera of California (Heteroptera: hemiptera) Bull.California Insect Survey 21: 1-166.

Merrit, R.W., Cummins, K.W., Burton, T.M. 1984. The role of aquatic insects in the processing and cycling of nutrients. In: (Eds) Resh, V.H., Rosenberg, D.M. The Ecology of aquatic insects.Praeger, New York. pp134-163.

Minshall, G.W. 1984. Aquatic insect-substratum relationships.Ecology of Aquatic insects.Praeger.Press, N.Y. pp358.

Newbury, R. W. 1984. Hydrologic determinants ofaquatic insect habitats. In the ecology of aquatic insects (ed) Resh, V. H and Resenberg d. M. Praeger, N. Y. pp. 323-357.

Nishi, R., 1990. Evaluation of the predatory potential of the notonectid bug – *Anisops bouvieri* Kirkaldy (Insecta: Hemiptera). *Ph.D. Thesis, Univ. Madras,* pp. 1-117.

Osborne, S., Hurrell, S., Simkiss, K. and Leidi, K. 2000. Factors influencing the distribution and feeding of the larvae of *Chironomus riparis. Entomologia Experimentalis et applicata,* 94(1) : 67-73.

Pajunen, V.I. 1972. Evaluation of a removal method for estimating the members of the rock pool corixids (Hemiptera: Corixidae). *Ann. Zool. Fennici.,* 9 : 152-155.

Pajunen, V.I. and Ukkonen M. 1987.Intra and interspecific predation in rock-pool corixids (Hemiptera:Corixidae). *Ann. Zool. Fennici.,* 24: 295-304.

Papaj, D. and R.J. Prokopy, 1989. Ecological and Evolutionary aspects oflearning in phytophagous insects.*Ann. Rev. Entomol.,* 43 : 315-350.

Petranka, J.W., Kennedy, C.A. 1999. Pond tadpoles with generalized morphology: is it time to reconsider their functional roles in aquatic communities?. Oecologia120: 621-631.

Runck, C. and D.W. Blinn. 1990. Population dynamics and secondary production by *Ranatra montezuma* (Heteroptera :Nepidae). *J. N. Am. Benthol. Soc.,* 9 : 262-270.

Sailer, R.I. and Lienk, S. 1954. Insect predators of mosquito larvae and pupae in Alaska, *Mosquito News*, 14:14-16.

Santhanam, R., Velayutham, P. and Jegathesan, G. 1989.A manual of freshwater ecology.Daya publishing house, New Delhi, pp125.

Savage, A.A. 1996. Density dependent and density independent relationships during a twenty-seven year study of the population dynamics of the benthic macroinvertebrate community of a chemically unstable lake. *Hydrobiologia,* 335(2) : 115-131.

Savage, A.A. 2000. Community structure during a 27 - year study of the macroinvertebrate fauna of a chemically unstable lake. *Hydrobiologia,* 421(1) : 115-127.

Sweeney, B.W. 1984. Factors influencing life history patterns of aquatic insects. In: (Eds) V.H. Resh and D.M. Resonberg. The ecology of aquatic insects.Praeger Publishers, New York, pp. 625.

Venkatesan, P. 1981. Influence of temperature and salinity variations on an aquatic bug population in a tropical pond. *Hydrobiol.,*79 : 33-50.

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