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Diversity and Community Structure of Aquatic Arthropods in an Irrigated Rice Ecosystem of Tamil Nadu, India

M. Kandibane, S. Raguraman and N.R. Mahadevan
Department of Agricultural Entomology, Tamil Nadu Agricultural University,
Coimbatore-641 003, Tamil Nadu, India

Abstract: Inventory, diversity and community structure of aquatic arthropods between weeded and partially weeded rice ecosystems were studied in a field experiment under irrigated condition during Rabi, 2000. The research revealed that a total of 12, 2, 6 and 3 species of Odonata, Ephemeroptera, Hemiptera and Coleoptera aquatic insects were recorded, respectively. *Agriocnemis femina femina* Brauer of damselfly, *Pantala flavescens* (Fabricius), *Crocothemis servilia* (Drury) and *Diplocodes trivialis* (Rambur) of dragonflies were the dominant species in both the ecosystems, but were significantly more dominant in partially weeded rice ecosystem. *Trithemis* sp., *Rhyothemis variegata* (Linnaeus), *Anax guttatus* (Burmeister) of dragonfly and *Lethocerus indicus* (Lepeletiller + Serville) (Giant water bug) were absent in weeded rice ecosystem and rest of the species occurred in both the ecosystems. Aquatic beetles, water strider and water scorpion evinced perfect similarity through out the season. But, damselfly, backswimmer and mayfly expressed more than 0.80 similarity and perfect similarity (1.00) during early and maturity stages of crop and showed less stability during the 2nd, 3rd and 4th week. The guild of aquatic arthropods revealed the dominance of predatory groups in partially weeded rice ecosystem through out the season. Same group of aquatic arthropods had not dominated in all the weeks of crop growth, but the group of aquatic arthropods changed during various stages of crop. A total of 18 weed species were recorded in partially weeded plots.

Key words: Aquatic Hemiptera, Odonata, Coleoptera, Ephemeroptera, community structure, rice ecosystem, weed plants

INTRODUCTION

There are numerous taxa of aquatic insects like naiads of dragonflies and damselflies, water scorpion, water measurer, giant water bug, back swimmer, water strider, broad shoulder bug, water beetle, whirligig beetle and diving beetle communities recorded in irrigated rice ecosystem. These insects prefer diversified ecosystem for their occurrence and multiplication (Poorani, 1990). Odonata is the largest insect order, which is entirely predaceous in rice ecosystem. Both naiads and adults are the voracious predators on other insects (Krishnasamy *et al*., 1983). Tyagi (1997) checklisted 491 species of Odonata in India. Gunathilagaraj *et al.* (1999) recorded 16 species of Odonata in rice fields of Tamil Nadu, India. Barrion and Litsinger (1994) listed 14 species of odonata in rice fields of Asia and Africa.

Barrion and Litsinger (1982) recorded the four species of water strider *viz*., *Limnogonus nitidus*, *Limnogonus* sp. 1, *Limnogonus* sp. 2 and *Rheumatogonus* sp. (Hemiptera: Gerridae) during the survey of the rice field aquatic ecosystem on the IRRI farm. Almazan and Heong (1992) recorded *Limnogonus fossarum* (Fabricius) species of water strider in rice ecosystem of the philippines. They stated that the water strider is a common predator of brown planthopper (*Nilaparvata lugens*, (Stal.)) in wetland rice fields. Mohanraj *et al.* (1995) recorded *Limnogonus* sp. of water strider in rice ecosystem of Andaman and Nicobar Islands, India. Also, Sridharan *et al.* (2000) noticed the water strider *Gerris* sp., as an aquatic hemipteran predator in rice ecosystem of Tamil Nadu, India. Otake (1966) recorded the broad shoulder bug *Microvelia douglasi* Scott., which is an effective predator of the brown planthopper, *N. lugens*.

In the philippines, Barrion (1979) recorded the two species of giant water bug *viz*., *Diplonychus rusticus* (Fabricius) and *Lethocerus indicus* (Lepeletiller + Serville) (Hemiptera: Belostomatidae), the species of water measurer, *Hydrometra lineata* Eschsch (Hemiptera: Hydrometridae) and the two species of back swimmer *viz*., *Anisops kurawai* Matsumura and *Anisops* sp., (Hemiptera: Notonectidae) in wetland rice conditions.

Corresponding Author: M. Kandibane, Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore-641 003, Tamil Nadu, India

Sridharan *et al.* (2000) recorded *Anisops sardea* species of backswimmer and *H. vittata* species of water measurer in irrigated rice ecosystem of Tamil Nadu, India.

A guild (community structure) is defined as a group of species that exploit the same class of environmental resources in a similar way (Root, 1967). Root used the term as way to group together species without regard to taxonomic position that overlap significantly in their niche requirements. The guild focuses attention on all sympatric species involved in a competitive relationship. It guilds represent the basic building blocks of ecosystem; communities should share similarities that transcend species composition (Hawkins and Mac mohan, 1989).

The guilds are group of functionally similar species and also lead to the idea that ecosystems contain many functionally redundant species all capable of performing the same ecosystem function (Odum, 1971; O' Neil *et al.*, 1986). Guild structure may be more predictable and stable than either the abundance of individual species or species composition (O'Neil *et al.*, 1986). In Tamil Nadu, the diversity and faunal list of aquatic arthropods present in rice ecosystem had not been documented earlier. Hence, the present research to study the inventory, abundance, similarity and community structure (guild) of aquatic arthropods was taken up in an irrigated rice ecosystem of Madurai, Tamil Nadu, India.

MATERIALS AND METHODS

A field trial was conducted in an irrigated condition at the Wetlands of Agricultural College and Research Institute, Madurai, during Rabi, 2000 at an altitude of 147 m amsl with temperature ranging between 24 and 38°C. The study area received water from the Vaigai dam and the annual rainfall was 893 mm in the year, mostly from the northeast monsoon between July and November. The size of the experimental plots was 3.5 x 3.5 m during the season. In this season four ruling rice varieties *viz*., ASD 18, ADT 43, MDU 5, ADT 36 were grown and each variety was subdivided into weeded (all the weed plants removed) and partially weed plot (10 weed plants per square meter allowed with rice plants) to study the diversity of aquatic arthropod fauna. A spacing of 30 cm was allowed between treatments. Twenty five day old rice seedling was transplanted at the rate of 2-seedlings per hill in a regular spacing of 15×20 cm with fertilizer applied at four stages of rice crop growth, basal, after first weeding, maximum tillering and panicle initiation at the rate of 120 kg N (through urea) ha^{-1}. The transplanting was synchronized with the surrounding area of cultivation. Hand weedings were carried out at fortnightly intervals in both weeded and partially weeded plots. In partially weeded plot, the number of weed plants allowed per square meter was based on the definition of critical threshold density of weeds, which describe the density of weeds above which weeds would compete with crop adversely affecting its growth and yield. The structure of the treatments adopted in this research is given below:

T_1	ASD18	-	Weeded
T_2	ASD18	-	Partially weeded
T_3	ADT 43	-	Weeded
T_4	ADT 43	-	Partially weeded
T_5	MDU 5	-	Weeded
T_6	MDU 5	-	Partially weeded
T_7	ADT 36	-	Weeded
T_8	ADT 36	-	Partially weeded

Sampling for aquatic arthropods was carried out in floodwater of rice ecosystem. Twenty five sweeps were made diagonally across each plot with dip net and the collected materials flushed into coded vials containing 70% ethyl alcohol and examined in the Laboratory. The collected arthropods were recorded to calculate the co efficient index of similarity. The collection of aquatic arthropods was done at weekly intervals from 30 days after transplanting. The naiads of dragonflies and damselflies collected were reared separately in cages with potted rice plants at insectary to identify the species present in floodwater of rice ecosystem.

Species were sorted into guilds based on field observations of feeding behaviour, mouthparts morphology and literature sources dealing with close relatives (Merrit and Cummins, 1984; Heong *et al.*, 1992) as detritivores (feeders on suspended particles, submerged rice straw, sediments); herbivores (feeders of rice, aquatic plants, plankton); natural enemies (predators).

In the current investigation, Jaccard (C_j) coefficient index of similarity (Jaccard, 1908; Magurran, 1988) was used to work out the similarity statistics of taxa for flood water insects between weeded and partially weeded rice ecosystems.

$$C_j = j/(a+b-j)$$

Where,

j = No. of taxa occurring in both samples A and B
a = No. of taxa in sample A and
b = No. of taxa in sample B.

Weather data related to light intensity and relative humidity at the top of rice canopy, middle height of rice plants and surface of the water were recorded daily with lux meter and hygrometer, respectively. The collected data on weather factors and population of aquatic insects were used to work out correlation coefficient (r).

RESULTS AND DISCUSSION

The present study revealed the inventory of 12, 2, 6 and 3 species of Odonata, Ephemeroptera, Hemiptera and Coleoptera aquatic insects, respectively, in floodwater of rice ecosystem (Table 1). Odonata, including 9 species of dragonflies and 3 species of damselflies were recorded in rice ecosystem. Among the dragonflies, *Pantala flavescens*, *Crocothemis servilia*, *Diplocodes trivialis*, *Orthetrum sabina* and *Neurothemis tullia* species occurred in weeded and partially weeded rice ecosystems but were more abundant in partially weeded rice condition. This is supported with the fact that naiads of dragonflies and damselflies preferred partially weeded rice condition since it has cool water during daytime.

Table 1: Fauna and abundance of aquatic arthropods in an irrigated rice ecosystem during Rabi, 2000

	Weeded		Partially weeded	
Insect fauna	---		---	
Odonata: Zygoptera: Damselfly	*#	**	*#	***
Fam: Coenagrionidae				
Agriocnemis femina femina Brauer	4.00	3	7.40	1
A. pygmaea Rambur	0.80	6	1.30	7
Ishnura sp.	0.40	9	1.00	9
Anisoptera: Dragonfly				
Fam: Libellulidae				
Pantala flavescens (Fab.)	1.00	5	1.60	6
Crocothemis servilia (Drury)	0.80	6	1.00	9
Diplacodes trivialis (Rambur)	0.40	9	0.60	10
Orthetrum Sabina (Drury)	0.10	10	0.20	13
Trithemis sp.	0.00	11	0.10	14
Rhyothemis variegata (Linnaeus)	0.00	11	0.20	13
Neurothemis tullia (Drury)	0.10	10	0.30	12
Fam: Ashnidae				
Anax guttatus (Burmeister)	0.00	11	0.10	14
Traemea limbata (Desjardin)	0.10	10	0.20	13
Ephemeroptera: Mayfly				
Procloeon harveyii	1.60	4	0.60	10
Beatus sp.	0.40	9	0.20	13
Hemiptera				
Nepidae: Water scorpion				
Laccotrephes ruber (Linnaeus)	0.60	8	0.40	11
Hydromatridae: Water measurer				
Hydrometra freeni Kirkadly	0.40	9	0.20	13
Belostomatidae: Giant water bug				
Lethocerus indicus (Lepeletiller + Serville)	0.00	11	0.42	8
Notonectidae: Back swimmer				
Anisops bouveri Kirkadly	1.00	5	2.10	5
A. cavifrons Brooks	0.60	8	1.20	8
Gerridae: Water strider				
Limnogonus fossarum (Fab.)	5.20	1	3.20	3
Coleoptera				
Dytiscidae: Diving beetle				
Dytiscus sp.	0.60	8	2.20	4
Hydrophilidae: Water beetle				
Hydrophilus sp.	0.63	7	1.20	8
Gyrinidae: Whirligig beetle				
Dineutus sp.	4.20	2	6.20	2
Total number of species	19		23	

*Relative abundance; **Rank abundance values; # Values in the columns are average of 20 sweeps

Therefore, they had more abundance in partially weeded condition compared to weeded condition. These statements are in agreement with the finding of Pearson and Franklin (1968). The three species of damselflies *viz.*, *Agriocnemis femina femina*, *A. pygmaea* and *Ishneura* sp., were present in both the rice ecosystems. However, they had more abundance in partially weeded condition. Among the Odonata, *Agriocnemis femina femina*, *Pantala flavescens*, *Crocothemis servilia* and *Diplocodes trivalis* were the dominant species and others were the rare species. The present statement is in support with the view of Shelton and Edwards (1983) that dominant species of insects with more number of individuals always preferred stable ecosystem and had ability to survive in existing minimum and maximum environmental conditions in the cropping area through out the season, where as rare species had less number of individuals and their occurrence is based on choice. But, Hurd *et al.* (1971) stated that the abundance of one species is to have little effect on the other species in a stable ecosystem. The two species of mayflies naiads *viz.*, *Procloeon harveyii* and *Beatus* sp., were recorded in both the ecosystems. Of these species *P. harveyii* had more abundance in weeded rice ecosystem and was the dominant species of mayfly naiad in rice ecosystem. The reason for the abundance of *P. harveyii* in weeded rice ecosystem is due to the availability of food resources like phytoplankton and detritus, since naiads of mayflies are coming under the group of scavenger. This statement is in conformity with the previous finding of Kumar and Khanna (1983) that presence of phytoplankton and detritus an aquatic ecosystem could support the abundance of scavengers which ultimately enhance the abundance as well as diversity of dragonfly and damselfy because both the scavengers and the predators are present in a trophic cascade of rice ecosystem. *Dytiscus* sp., *Hydrophilus* sp. and *Dineutus* sp. of coleopteran aquatic insects were noticed in weeded as well as partially weeded conditions, but they evinced more dominance in partially weeded rice ecosystem. The greater abundance of aquatic coleopteran insects in partially weeded plots was due to the availability of different species of weed flora, which prevent penetration of light and provide conducive environmental conditions for their abundance. This finding is in corroborative with the statement of Capinera and Sechrist (1982).

Aquatic Hemiptera recorded six species in irrigated rice ecosystem. All the six species were present in partially weeded rice ecosystem, where as in weeded rice ecosystem, the five species of aquatic Hemiptera *viz.*, *Laccotrephes ruber*, *Hydrometra freeni*, *Anisops bouveri*, *A. cavifrons* and *Limnogonus fossarum* were noticed.

Among the aquatic Hemiptera *L. fossarum* was the dominant species in both the ecosystems but was more dominant in weeded rice ecosystem than in partially weeded condition. This statement is supported by Almazan and Heong (1992) with the previous findings that the abundance of *L. fossarum* was more in weed free condition of rice, since the population of its prey (Brown planthopper) was found to be more in such ecosystem. When the individuals of brown planthopper (*N. lugens* Stal.) fell on the water, both nymphs and adults of *L. fossarum* ate them. Another possible reason for the abundance of *L. fossarum* is due to the availability of space between hills, which promoted penetration of light and free movement of air. This statement is in contradiction with the statement of Odum (1971) that the population of water strider would be more in any aquatic system with few numbers of plants or free from plants. The gist of aquatic arthropod abundance evinced that *A. femina femina* was the dominant species of insect in partially weeded rice ecosystem, while the water strider, *L. fossarum* exhibited greater abundance in weeded rice ecosystem.

The similarity statistics revealed that damselfly registered the similarity value ranged from 0.82-0.87 in the 1st week and perfect similarity in the last week (5 week) (Table 2). Schoenly *et al.* (1998) reported that during planting and maturity stages of rice crop aquatic arthropods expressed more stability due to the presence of single species of an insect in weeded and partially weeded rice ecosystems. Also, Lawton (1983) stated that common species of insects were present at initial and maturity stages of crop growth and no diversity was noticed in this observation. The lowest similarity of damselfly recorded was 0.48 in the 4th week sampling and in the 2nd, 3rd and 4th week the similarity indices ranged between 0.74-77, 0.60-0.66 and 0.48-0.60, respectively. The reason for more diversity and abundance during tillering (2nd, 3rd week) and flowering (4th and 5th week) stages of rice crop is that the canopy of rice and weed plants covered the entire surface area of water, prevented penetration of sunlight and temperature into littoral zone and enhanced chillness of flood water of rice ecosystem. This finding is in online with the previous findings of Smith (1976). Earlier, Risch (1981) explained that the diversity of herbivores was significantly more in all weedy soybean habitats than in weed fee soybean habitat. In the 1st week sampling, naiads of dragonfly showed less stability (0.50-0.60), where as naiads of damselfly evinced more stability. Risch (1981) stated that stability is usually defined so that it represents low fluctuations in population overtime. But, Mac Arthor (1965) elucidated that low stability of arthropods is due to the presence of different species in an ecosystem over a particular period of time. Naiads of dragonfly were absent since the 2nd week to the end of the crop growth. The reason for absence could not be ascertained.

Water strider, water scorpion, diving beetle, water beetle and whirligig beetle registered perfect similarity through out the season, because each of the insects has a single species, which is present in weeded and partially weeded rice ecosystems. The present result is in conformity of the finding given by Stroyan (1977). Mayflies registered the similarity values from 0.89-0.99;

Table 2: Diversity of aquatic arthropods in an irrigated rice ecosystem during Rabi, 2000

	1st week				2nd week				3rd week				4th week				5th week			
Aquatic arthropods	ASD 18	ADT 43	MDU 5	ADT 36	ASD 18	ADT 43	MDU 5	ADT 36	ASD 18	ADT 43	MDU 5	ADT 36	ASD 18	ADT 43	MDU 5	ADT 36	ASD 18	ADT 43	MDU 5	ADT 36
Damselfly	0.87	0.86	0.82	0.84	0.77	0.75	0.76	0.74	0.62	0.66	0.60	0.64	0.50	0.60	0.50	0.48	1.00	1.00	1.00	1.00
Dragonfly	0.50	0.55	0.50	0.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Water scorpion	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00
Water measurer	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Back swimmer	0.94	0.89	0.99	0.91	0.84	0.81	0.86	0.83	0.66	0.63	0.60	0.61	0.48	0.50	0.66	0.66	0.60	1.00	1.00	1.00
Water strider	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Giant water bug	0.00	1.00	1.00	0.00	0.00	1.00	0.00	1.00	-	-	-	-	-	-	-	-	-	-	-	-
Mayfly	0.98	0.97	0.89	0.99	0.86	0.85	0.80	0.83	0.60	0.66	0.00	0.66	0.43	0.66	0.42	0.60	0.00	0.00	1.00	0.00
Diving beetle	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00
Water beetle	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-
Whirligig beetle	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Values in the column are indices; Cj : Iindices varying between 0 = No similarity and 1 = Perfect similarity

0.80-0.86; 0.60-0.66 in the 1st, 2nd and 3rd week, respectively and perfect similarity in MDU 5 treatment during maturity stage of crop. However, the lowest similarity values of 0.43 and 0.42 were recorded in 3rd and 4th week, respectively. Odum (1971) stated that abundance of detritus and alternate food materials in aquatic ecosystem determines the abundance and diversity of scavengers (mayflies, mosquitoes). It is true in our observation. The giant water bug, *Lethocerus indicus* exhibited perfect similarity in the 1st and 2nd week and was absent in rest of the weeks. The reason for absence of this insect might be due to the availability of unsuitable weather factors in the experimental arena. Backswimmer expressed the lowest similarity value of 0.48 in the 4th week sampling and showed more than 0.60 similarity indices in other week sampling. Subrahmanyam and Sambamurthy (2000) supported that a more complex ecosystem had high species diversity. But, species of arthropods increased during the early stages of community development (Odum, 1971). Also, Margralef (1963) postulated that diversity of insects may be peaked during early or middle stages of crop growth and then declined at the end. Clay bottom was more favourable for dragonfly, damselfly and mayfly naiads than sand (Odum, 1971). The reason could be attributed to the diversity of Odonata and Ephemeroptera in rice ecosystem in this present study. There was no greater variation of diversity of aquatic arthropods noticed between the varieties.

Guild of aquatic arthropods revealed that predators, scavengers and herbivores occupied the aquatic ecosystem of rice. Odonata, Hemiptera, Coleoptera and invertebrates were the predatory group (Table 3). Scavengers constituted Ephemeroptera, Coleoptera and Diptera. Predatory arthropod guilds had higher percentage of contribution and played a major role only in partially weeded rice ecosystem. But, weeded rice ecosystem had less percentage of contribution of predatory arthropods. The present results are in consonance with the statement of Kumar and Khanna (1983) naiads of dragonfly (predatory arthropods) fed on the primary consumers *viz*., tad poles of frog and toads and larvae of mosquito and mayfly, where tad poles of frog and toads fed on algae and other plant materials, while larvae of mosquito and mayfly are scavengers. It is observed in the study that in weeded plots the littoral zone is not protected by canopy cover, which might increase the water temperature and in turn lowers the percentage contribution of aquatic arthropods. In partially weeded rice ecosystem, naiads of Odonata dominated in the 2nd, 3rd and 4th week sampling and Hemiptera, Coleoptera and invertebrates had less percentage of contribution. However, invertebrates dominated (50.00%) in the fifth week sampling. Myster and Pickett (1994) elucidated that same group of arthropods is not present through out the season but the group of arthropods changed in each week or different stages of crop growth. The group of newly occupying insects had ability to adopt the present environmental conditions. In weeded rice ecosystem, aquatic Hemiptera showed domination in the 2nd, 3rd and 4th weeks and naiads of Odonata and invertebrates dominated in the first and the last week, respectively. The occurrence of these insects may be due to the nekton to the littoral zone as stated by Odum (1971) Among the scavengers, dipteran insects dominated in both the ecosystems but their dominance were more in weeded rice ecosystem compared to partially weeded ecosystem. The aquatic dipteran insects preferred permanent and intermittent stream in a stable rice ecosystem for their development and survival as stated by Vinson and Hawkins (1998).

The influence of weather parameters like light intensity and relative humidity at the top of the crop canopy, middle of the plant height and bottom (just above the water surface) on the population of different groups of aquatic arthropods was studied between weeded and partially weeded rice ecosystems. The correlation study showed that in partially weeded rice ecosystem *N. tullia* showed highly negative correlation at 5% level against light intensity on the surface of the water (Bottom) (Table 4). The population of *P. harveyi* expressed highly

Table 3: Community structure of aquatic arthropods between weeded and partially weeded rice ecosystem during Rabi, 2000

	1st week		2nd week		3rd week		4th week		5th week	
Guilds	Weeded	P. weeded	Weeded	P. weeded	Weeded	P. weeded	Weeded	P. weeded	Weeded	P. weeded
Predators	19.14±2.35	45.45±6.34	22.50±4.08	54.90±9.18	35.29±5.72	41.86±5.72	28.57 1.79	41.66±3.10	20.00±1.67	42.29±2.30
Odonata	44.44	36.00	22.22	46.42	16.66	44.44	12.50	33.33	25.00	33.33
Hemiptera	33.33	32.00	55.55	14.28	27.77	27.77	62.50	33.33	25.00	16.66
Coleoptera	0.00	12.00	0.00	14.28	11.11	11.11	12.50	13.33	0.00	-
Invertebrate	22.22	20.00	22.22	25.00	44.44	16.60	12.50	20.00	50.00	50.00
Scavengers	40.42±5.31	38.18±1.77	32.5±8.86	25.49±5.31	23.52	37.20±3.50	28.57	33.33	50.00±10.63	47.94±1.77
Ephemeroptera	8.29	11.32	12.12	9.31	9.11	12.11	11.68	10.91	13.68	8.15
Coleoptera	21.42	52.38	24.76	54.33	24.22	37.75	38.32	39.09	20.00	36.29
Diptera	70.28	36.28	63.12	36.35±19.60	66.66	50.14	50.00	50.00	66.32	55.55
Invertebrates	40.42±5.31	16.36±5.31	45.00±3.54	19.60	41.17±19.60	20.93±1.77	42.85±7.09	25.00±1.77	30.00±3.50	9.77

Values in the columns are mean percentage of 20 sweeps in four treatments

Table 4: Correlation between aquatic arthropods and weather factors in partially weeded rice ecosystem during Rabi, 2000

	Correlation coefficient (r)					
	Light intensity			Relative humidity		
Insects	Top	Middle	Bottom	Top	Middle	Bottom
A. femina femina	0.62	-0.31	-0.16	0.06	-0.38	-0.39
A. pygmaea	0.75	-0.02	0.03	-0.10	-0.54	-0.58
Ishnura sp.	0.36	-0.29	0.09	0.46	0.06	0.01
Pantala flavescens	0.05	-0.17	0.37	0.73	0.47	0.38
Crocothemis servilia	-0.05	-0.39	0.22	0.58	0.72	0.77
Orthetrum sabina	0.20	-0.22	0.36	0.59	0.46	0.44
Trithemis sp.	0.59	-0.15	0.29	0.22	0.07	0.08
Rhyothemis variegata	-0.07	-0.24	0.36	0.77	0.67	0.63
Neurothemis tullia	-0.29	-0.84	-0.92*	-0.09	0.07	0.23
Anax guttatus	0.58	-0.15	0.29	0.22	0.07	0.08
Traemea limbata	-0.07	-0.24	0.37	0.76	0.67	0.63
Procloeon harveyii	-0.34	-0.25	0.35	0.89*	0.83	0.76
Beatus sp.	-0.07	-0.24	0.36	0.77	0.67	0.63
Laccotrephes ruber	0.34	-0.03	0.27	0.44	-0.04	-0.16
Hydrometra freeni	0.34	0.16	0.12	0.19	-0.39	-0.55
Lethocerus indicus	0.12	-0.19	0.37	0.68	0.47	0.41
Anisops bouveri	0.18	-0.17	0.29	0.64	0.29	0.20
A. cavifrons	0.54	-0.34	-0.03	0.25	-0.12	-0.14
Limnogonus fossarum	0.31	-0.40	0.16	0.31	0.42	0.52
Dytiscus sp.	0.55	-0.33	0.15	0.20	0.14	0.21
Hydrophilus sp.	-0.25	-0.431	0.18	0.83	0.78	0.76
Dineutus sp.	0.58	-0.08	0.27	0.25	-0.08	-0.13

*Correlation is significant at 5% level

positive correlation at 5% level with relative humidity at the top of the crop canopy. All the species of aquatic arthropods except *C. servilia*, *R. variegata*, *N. tulia*, *T. limbata*, *P. harveyi*, *Baetus* sp. and *Hydrophilus* sp. showed positive correlation with light intensity at the top of the crop canopy. For all the species of aquatic arthropods, there was a negative correlation observed with light intensity on the middle of the plant height. A positive correlation was shown by all the aquatic arthropods except *A. femina femina*, *N. tulia* and *A. cavifrons* with light intensity at the surface of the water.

Regarding relative humidity, except few species of aquatic arthropods, the remaining species showed positive correlation at top and middle portions, where as a highly positive correlation was recorded on the surface of the water.

In weeded rice ecosystem, *Baetus* sp. and *Ishnura* sp. registered highly positively significant correlation at 5% level with light intensity at top and middle, respectively (Table 5). *Ishnura* sp. of damselfly showed highly positively significant correlation at 1% level with light intensity on the top of the crop canopy. Similarly, *L. fossarum* showed highly positively significant correlation at 1% level with relative humidity on the top of the crop canopy. *H. freeni* expressed highly positively significant correlation at 5% level with relative humidity on the top of the crop canopy. The population of the five species *viz*., *R. variegata*, *N. tulia*, *A. guttatus*, *T. limbata* and *L. indicus* was absent, so there was no correlation. The remaining species of aquatic arthropods showed positive correlation with different levels of light intensity. For various levels of relative humidity, there was a positive correlation showed by the aquatic insects on the top of the crop canopy, where as in middle and bottom portions the aquatic insects showed mostly negative correlation.

The study of correlation indicated that the aquatic insects recorded in rice ecosystem showed negative correlation with light intensity at middle in partially weeded rice ecosystem. But, in weeded plots positive correlation was recorded. The population of aquatic arthropods was found to be more when relative humidity was high on the surface of the water in partially weeded plots.

In partially weeded rice ecosystem a total of 17 species of weed flora were identified. Among them, *Echinochloa colonum*, *Cyperus rotundus*, *C. iria*, *C. diformis*, *Panicum repens* and *Bracharia mutica* were dominant.

The present study is concluded that *A. femina femina* was the dominant species in partially weeded rice ecosystem, followed by *L. fossarum* and *Dytiscus* sp., where as *L. fossarum* was the dominant species in weeded rice ecosystem, followed by *Dineutus* sp., *A. femina femina* and *P. harveyii* and *Trithemis* sp., *R. variegata*, *A. guttatus* and *L. indicus* were absent in weeded rice ecosystem. All the species of damselfy and

Table 5: Correlation between aquatic arthropods and weather factors in weeded rice ecosystem during Rabi, 2000

	Correlation coefficient (r)					
	Light intensity			Relative humidity		
Insects	Top	Middle	Bottom	Top	Middle	Bottom
A. femina femina	0.87	0.74	-0.01	0.51	-0.27	-0.39
A. pygmaea	0.29	0.20	0.29	0.64	0.55	0.52
Ishnura sp.	0.96**	0.89*	0.22	0.16	-0.65	-0.72
Pantala flavescens	0.81	0.83	0.28	0.70	-0.15	-0.27
Crocothemis servilia	0.76	0.73	0.30	0.79	0.06	-0.04
Orthetrum Sabina	0.68	0.68	0.39	0.81	0.17	0.08
Trithemis sp.	0.01	-0.13	0.18	0.34	0.63	0.64
Rhyothemis variegata	0.0	0.0	0.0	0.0	0.0	0.0
Neurothemis tullia	0.0	0.0	0.0	0.0	0.0	0.0
Anax guttatus	0.0	0.0	0.0	0.0	0.0	0.0
Traemea limbata	0.0	0.0	0.0	0.0	0.0	0.0
Procloeon harveyii	0.71	0.75	0.34	0.81	0.03	-0.08
Beatus sp.	0.93*	0.87	0.31	0.55	-0.27	-0.37
Laccotrephes ruber	0.41	0.24	0.04	0.74	0.52	0.43
Hydrometra freeni	0.36	0.38	0.24	0.95(*)	0.51	0.422
Lethocerus indicus	0.0	0.0	0.0	0.0	0.0	0.0
Anisops bouveri	0.71	0.73	0.28	0.82	0.05	-0.06
A. cavifrons	0.39	0.29	0.18	0.78	0.53	0.46
Limnogonus fossarum	0.24	0.282	-0.02	0.98**	0.49	0.39
Dytiscus sp.	0.65	0.68	0.35	0.85	0.18	0.076
Hydrophilus sp.	0.92*	0.84	0.28	0.56	-0.22	-0.32
Dineutus sp.	0.59	0.64	0.08	0.82	0.03	-0.09

*Correlation is significant at 5% level; ** Correlation is significant at 1% level

dragonfly documented in irrigated rice ecosystem of Madurai were already recorded by many authors in other parts of Tamil Nadu. However, a total of six species of aquatic hemipterans were invented 1st time in rice ecosystem of Madurai. Dragonflies that occurred in the first week were absent in rest of the week of crop growth. All the groups of aquatic arthropods had not preferred partially weeded rice ecosystem and few groups preferred weeded rice ecosystem, since they had different ecological behaviour.

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