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# Diversity and community turnover of floodwater arthropods in irrigated rice

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## ABSTRACT

*The diversity and community turn over of floodwater ASD 18, ADT 43, IR 50 and ADT 36arthropods in weeded and partially weeded conditon were studied in a rice field planted with four rice varieties at Madurai, Tamil Nadu. The study indicated that 23 species containing 12, 2, 6 and 3 species of Odonata, Ephemeroptera, Hemiptera and Coleoptera were recorded, respectively. Among them, Agriocnemis femina femina Brauer (damselfly), Dineutus sp., Crocothemis servilia (Drury), Pantala flavescens (Fabricius) and Diplocodes trivialis (Rambur) (dragonfly) were the dominant species under both the conditions but were significantly dominant in partially weeded rice plot. The other species viz., Agriocnemis pygmaea Rambur, Ishnura sp of damselflies, Neurothemis tullia (Drury), Traemea limbata (Desjardin) (dragonflies), Beatis sp. of mayfly, Laccotrephes ruber (Linnaeus) (water scorpion), Hydrometra freeni Kirkaldy (water measurer), Anisops cavifrons Brooks (back swimmer), Dytiscus sp. (diving beetle) and Hydrophilus sp. (water beetle) were less prevalent and observed under both the conditions. The dragonflies viz., Trithemis sp, Rhyothemis variegata (Linnaeus), Anax guttatus (Burmeister) and the giant water bug, Lethocerus indicus (Lepeletiller and Serville) were absent in weeded rice ecosystem and were present only in partially weeded rice ecosystem. The diversity of floodwater arthropods indicated that diving beetle, whirligig beetle, water beetle, water measurer, water scorpion and water strider expressed perfect similarity (1.00) throughout the season. The community turnover indicated that turn of taxa generally increased during tillering stage of rice crop. The succession rate of taxa in floodwater fauna was higher in partially weeded rice than in weeded rice plots. Partially weeded plots had the highest turnover of 70.96, 70.58, 72.22 and 71.05 per cent at 58days after transplanting (DAT), respectively. The turnover of flood water arthropods had a declining trend in weeded plots and the increasing trend in partially weeded plots through out the season.*

***Key words:*** *rice, irrigated, floodwater, weed, arthropod, diversity*

There are numerous species of aquatic arthropods residing in floodwater of irrigated rice. Barrion and Litsinger (1982) recorded four species of water strider *viz., Limnogonus nitidus, Limnogonus* sp.1, *Limnogonus* sp.2 and *Rheumatogonus* sp. (Hemiptera: Gerridae) during the survey of rice field aquatic ecosystem in the International Rice Research Institute (IRRI) farm. Almazan and Heong (1992) recorded *Limnogonus fossarum* (Fabricius) a 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. Sridharan *et al.* (2000) also noticed the water strider *Gerris* sp., as aquatic hemipteran predator in rice ecosystem of Tamil Nadu, India.

In the Philippines, Barrion (1979) recorded two species of giant water bug viz., *Diplonychus rusticus* (Fabricius) and *Lethocerus indicus* (Lepeletiller and Serville) one species of water measurer, *Hydrometra lineata* Eschsch and the two species of back swimmer *viz., Anisops kurawai* Matsumura and *Anisops* sp. in wetland rice conditions. Sridharan *et al*. (2000) recorded *Anisops sardea* and *H. vittata* in irrigated

rice ecosystem of Tamil Nadu, India. Diversity and community turnover of floodwater arthropods in Tamil Nadu, had not been studied earlier. Hence, the present investigation was taken up in an irrigated rice ecosystem of Tamil Nadu.

## MATERIALS AND METHODS

A field trial was conducted under irrigated condition at the wetlands of Agricultural College and Research Institute, Madurai, during wet season of 2001 at an altitude of 147 m msl with temperature ranging between 24 and 38° C. The study area received water from the Vaigai dam and the annual rainfall was 928.00 mm. The size of the experimental plots was 5 x 5 m and four ruling rice varieties *viz.*, ASD 18, ADT 43, IR 50, ADT 36 were grown. Under each variety a weeded, (all the weed plants removed) and another partially weeded plot (10 weed plants square meter$^{-1}$ along with rice plants) were maintained. Twenty five day old rice seedlings were transplanted with 2 seedlings hill$^{-1}$ in regular spacing of 15 x 20 cm. Fertilizer was applied at four stages of crop growth, basal, after first weeding, maximum tillering and panicle initiation at the rate of 120 kg N (through urea) per hectare. The transplanting was synchronized with the surrounding area of cultivation. Hand weeding was carried out at fortnightly intervals in both weeded and partially weeded plots.

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 (DAT). The naiads of dragonflies and damselflies collected were reared separately in cages with potted rice plants in the greenhouse to identify the species present in floodwater of rice ecosystem. Jaccard index ($C_j$ )of similarity (Magurran, 1988) was used to calculate the similarity of flood water arthropods in weeded and partially weeded plots.

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

Where, j is the number of taxa occurring in both samples A (weeded) and B (Partially weeded)

a is the number of taxa in sample A and
b is the number of taxa in sample B. The values for $C_j$ range from 0 (no similarity) to 1 (perfect similarity); data were plotted as percentage of similarity.

Community turnover of taxa (Diamond, 1969) or per cent turn over taxa was calculated using the following formula.

$$\% \text{ To } (t) = 100. [(a+b) / (c+d-e)].$$

Where, a is the number of taxa in the 1$^{st}$ sample but not in sample t
b is the number of taxa in sample t but not in the 1$^{st}$ sample
c is the number of taxa present in the 1$^{st}$ sample
d is the number of taxa present in sample t and
e is the number of joint taxa occurring in both samples

## RESULTS AND DISCUSSION

Inventory of floodwater arthropods indicated 12, 2, 6, and 3 species of insects belonging to Odonata, Ephemeroptera, Hemiptera, and Coleoptera, respectively, (Table 1). Among the 9 species of dragonflies, *Pantala flavescens*, *Crocothemis servilia*, *Diplocodes trivialis* and *Orthetrum sabina* expressed dominance in both weeded and partially weeded plots, but were comparatively more abundant in partially weeded condition. The naiads of dragonflies and damselflies preferred partially weeded rice condition since it had cool water during daytime. This is in agreement with the findings of Pearson and Franklin (1968). The three species of damselflies *viz.*, *Agriocnemis femina femina*, *A. pygmaea* and *Ishneura* sp., were present in both weeded and partially weeded plots but more abundant in the latter. Among the odonates, *A. femina femina*, *P. flavescens*, *C. servilia* and *D. trivalis* were the dominant species, and others were the rare species. This is in support with the view of Sheltan and Edwards (1980) 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. The two species of mayfly naiads *viz.*, *Procloeon harveyii* and *Beatis* sp., were recorded under both the conditions of weed growth. *P. harveyii* had more abundant in weed free plots and was the dominant species of mayfly naiad in the irrigated rice ecosystem. The reason for the abundance of *P. harveyii* in weeded rice ecosystem is

**Table 1. Abundance of aquatic arthropods in irrigated rice ecosystem, wet season 2001**

| Insect fauna | Weed free | | Partially weeded | |
|---|---|---|---|---|
| Odonata: Zygoptera: Damselfly | *# | ** | *# | *** |
| Fam: Coenagrionidae | | | | |
| *Agriocnemis femina femina* Brauer | 3.20 | 3 | 5.30 | 1 |
| *A. pygmaea* Rambur | 1.00 | 8 | 1.30 | 8 |
| *Ishnura* sp. | 0.50 | 12 | 1.00 | 10 |
| Anisoptera : Dragonfly | | | | |
| Fam: Libellulidae | | | | |
| *Pantala flavescens* (Fab.) | 2.00 | 4 | 2.35 | 4 |
| *Crocothemis servilia* (Drury) | 1.20 | 6 | 1.60 | 7 |
| *Diplacodes trivialis* (Rambur) | 0.80 | 9 | 1.20 | 9 |
| *Orthetrum Sabina* (Drury) | 0.50 | 12 | 0.90 | 11 |
| *Trithemis* sp | 0.10 | 17 | 0.20 | 18 |
| *Rhyothemis variegata* (Linnaeus) | 0.20 | 16 | 0.40 | 15 |
| *Neurothemis tullia* (Drury) | 0.20 | 16 | 0.50 | 14 |
| Fam: Ashnidae | | | | |
| *Anax guttatus* (Burmeister) | 0.10 | 17 | 0.10 | 19 |
| *Traemea limbata* (Desjardin) | 0.10 | 17 | 0.20 | 18 |
| Ephemeroptera: Mayfly | | | | |
| Procloeon harveyii | ***1.90*** | ***5*** | ***0.80*** | ***12*** |
| *Beatus* sp | 0.30 | 15 | 0.10 | 19 |
| HemipteraNepidae : water scorpion | | | | |
| *Laccotrephes ruber* (Linnaeus) | 0.50 | 12 | 0.30 | 16 |
| Hydromatridae **:** water measurer | | | | |
| *Hydrometra freeni* Kirkadly | 0.45 | 13 | 0.25 | 17 |
| Belostomatidae : Giant water bug | | | | |
| *Lethocerus indicus* (Lep. & Serv.) | 0.00 | 18 | 0.20 | 18 |
| Notonectidae: Back swimmer | | | | |
| *Anisops bouveri* Kirkadly | 1.10 | 7 | 1.90 | 5 |
| *A. cavifrons* Brooks | 0.40 | 14 | 0.70 | 13 |
| Gerridae : Water strider | | | | |
| *Limnogonus fossarum* (Fab.) | 6.10 | 1 | 3.90 | 3 |
| Coleoptera Dytiscidae : Diving beetle | | | | |
| *Dytiscus* sp. | 0.70 | 10 | 1.80 | 6 |
| Hydrophilidae : Water beetle | | | | |
| *Hydrophilus* sp. | 0.54 | 11 | 1.00 | 10 |
| Gyrinidae : Whirligig beetle | | | | |
| *Dineutus* sp. | 3.80 | 2 | 5.10 | 2 |
| Total number of species | 22 | | 23 | |

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

due to the availability of food resources like phytoplankton and detritus, since the naiads of mayflies are scavengers. Present observation is in conformity with the findings of Kumar and Khanna (1983). *Dytiscus* sp, *Hydrophilus* sp. and *Dineutus* sp. were the dominant species in partially weeded rice plots. 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 favourable environmental conditions for their abundance. This finding corroborates with the statement of Capinera and Sechrist (1982). Eighteen species of weed were recorded in partially weeded rice plots. Among them,

*Cyperus iria, C. rotundus, C. diformis, Ehinochloa colonum, E. crus-galli, Panicum repens, Brachiaria mutica* and *Eclipta alba* were dominant.

Six species of aquatic hemiptera were recorded in the irrigated rice ecosystem. All the six species were present in partially weeded rice plots, whereas in weed free plots five species were observed. Among the aquatic hemiptera, *Limnogonus fossarum* was the dominant species in both the ecosystems but was more dominant in weeded rice plots than in partially weeded plots. Almazan and Heong (1992) repoted 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 under such condition.

Taxonomic similarity of floodwater arthropods between weeded and partially weeded plots indicated that damselfly exhibited the similarity values between 0.82 and 0.88 in the first week sampling at 37 DAT (Table 2). Dragonfly evinced the similarity values from 0.72 to 0.76, but mayfly expressed more than 0.90 similarity values. Water strider, water scorpion, water measurer, dytiscid, gyrinid and hydrophilus beetles exhibited perfect similarity. Schoenly *et al*. (1998) reported that during planting and maturity stages of rice crop aquatic arthropods expressed more stability. The giant water bug was recorded only at 58 DAT of sampling.

In the second sampling at 44 DAT both damselflies and dragonflies registered similarity values of 0.66 – 0.76. Mayfly and backswimmer showed above 0.80 (80%) similarity indexes. Water strider, water scorpion, water measurer, dytiscid beetle, gyrinid beetle and hydrophilus beetles expressed perfect similarity (100 % stability) throughout the season, because each of the insects were represented by single species, which was present in weeded and partially weeded rice. The present result is in conformity of the findings by Stroyan (1977). At 51 DAT, damselfly showed 0.68, 0.60, 0.55 and 0.62 similarity values in ASD 18, ADT 43, IR 50 and ADT 36, respectively. Dragonfly expressed the higher similarity values of 0.78, 0.82, 0.80 and 0.83 in all the four rice varieties. Mayfly and backswimmer registered 0.60 – 0.66 and 0.70 – 0.75 similarity values, respectively.

In the fourth sampling at 58 DAT, damselfly registered the lowest similarity values of 0.49, 0.46, 0.48 and 0.43 in all the four varieties, while dragonfly showed 0.65, 0.60, 0.66 and 0.64 similarity index values. Similarly, backswimmer expressed the lowest similarity value of 0.58 in this week. The reason for more diversity during late tillering ( 51 DAT to 58 DAT) stage of rice crop indicates that the canopy of rice and weed plants covered the entire surface area of water, prevented penetration of sunlight into littoral zone and enhanced coolness of flood water of rice ecosystem. This finding is in accordance with the findings of Smith (1976). In the fifth week sampling at 65 DAT, damselfly recorded almost perfect stability, where as dragonfly showed 0.74-similarity index value. Mayfly, giant water bug and water scorpion, water measurer, gyrinid beetle and hydrophilus beetles were absent. At 72 DAT, all the floodwater arthropods were absent. There was no greater variation of similarity values between rice varieties.

Community turn over of taxa for floodwater arthropods in irrigated rice indicated that the turnover rates were comparatively more in partially weeded plots than in weeded plots (Table 3). This could be due to presence of more plants, which reduced the temperature of floodwater. In the first week, the turn over rates of 41.17, 40.00, 40.00 and 44.44 per cent were recorded on ASD 18, ADT 43, IR 50 and ADT 36, respectively in weed free plots. In partially weeded plots the turnover rates were 53.84, 55.17, 53.33 and 48.38 per cent on ASD 18, ADT 43, IR 50 and ADT 36, respectively. In the weed free plots there was a decline in community turn over of arthropods, whereas increased trend of turnover was recorded from the first to the last week in partially weeded plots. Percent turnover is denoted by the presence of the original species captured in later samples in comparison to early sample, which may increase after a period of decline due to newly colonizing species (Myster and Rickett, 1994). Moreover, species turnover increases with time in both the partially weeded and weeded plots with the former increasing faster than the latter on most sampling dates (Schoenly *et al*, 1998).

The turn over rates of flood water arthropods at 37 DAT was lower in weeded plots than in partially weeded plots. The highest turn over rates of 70.96, 70.58, 72.22 and 71.05 per cent were recorded in partially weeded plots of ASD 18, ADT 43, IR 50 and ADT 36 in the last week of sampling. The gap of

**Table 2. Diversity of floodwater arthropods in irrigated rice ecosystem during wet season, 2001**

| | I Week (37 DAT) | | | | II Week (44 DAT) | | | | III Week (51 DAT) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ASD 18 | ADT43 | IR 50 | ADT 36 | ASD 18 | ADT43 | IR 50 | ADT 36 | ASD 18 | ADT43 | IR 50 | ADT 36 |
| Damselfly | 0.82 | 0.80 | 0.85 | 0.88 | 0.69 | 0.66 | 0.70 | 0.71 | 0.68 | 0.60 | 0.55 | 0.62 |
| Dragonfly | 0.73 | 0.74 | 0.76 | 0.72 | 0.75 | 0.76 | 0.73 | 0.75 | 0.78 | 0.82 | 0.80 | 0.83 |
| Mayfly | 0.92 | 0.91 | 0.89 | 0.94 | 0.85 | 0.84 | 0.80 | 0.78 | 0.66 | 0.60 | 0.66 | 0.66 |
| 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 |
| Back swimmer | 0.97 | 0.99 | 1.00 | 1.00 | 1.00 | 0.85 | 0.86 | 0.85 | 0.75 | 0.70 | 0.73 | 0.75 |
| Giant water bug | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Water scorpion | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Water measurer | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Dytiscid 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 |
| Gyrinid 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 |
| Hydrophilids | 1.00 | 1.00 | 0.00 | 0.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| | IV Week (58 DAT) | | | | V Week (65 DAT) | | | | VI Week (72 DAT) | | | |
| Damselfly | 0.49 | 0.46 | 0.48 | 0.43 | 1.00 | 0.91 | 0.89 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dragonfly | 0.65 | 0.60 | 0.66 | 0.64 | 0.74 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 |
| Mayfly | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Water strider | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Back swimmer | 0.58 | 0.64 | 0.66 | 0.60 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Giant water bug | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Water scorpion | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Water measurer | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dytiscid beetle | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Gyrinid beetle | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Hydrophilids | 1.00 | 1.00 | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

*Values in the columns are indices

'Cj' indices varying between 0 = no similarity and 1 = perfect similarity

**Table 3. Community turnover of taxa in irrigated rice ecosystem during wet season, 2001**

| Samplingdates | ASD 18 | | ADT 43 | | IR 50 | | ADT 36 | |
|---|---|---|---|---|---|---|---|---|
| | Weed free | Partially weeded | Weed free | Partially weeded | Weed free | Partially weeded | Weed free | Partially weeded |
| I (37 DAT) | 41.17 | 53.84 | 40.00 | 55.17 | 40.00 | 53.33 | 44.44 | 48.38 |
| II (44 DAT) | 52.94 | 60.00 | 46.15 | 60.60 | 47.05 | 56.25 | 46.66 | 58.33 |
| III (51 DAT) | 31.25 | 64.70 | 41.17 | 68.57 | 43.75 | 64.86 | 35.29 | 67.74 |
| IV (58 DAT) | 46.66 | 70.96 | 57.14 | 70.58 | 50.00 | 72.22 | 56.25 | 71.05 |

Values in the columns are Sorensen's indices

turnover was more between weeks in case of weeded plots than in partially weeded plots. However, the difference in turnover rates between the first and the last weeks was more in partially weeded plots (> 15 %) than in weeded plots (<10%). The present study indicated that the abundance and community turnover of floodwater arthropods were more in partially weeded rice fields than in weed free rice fields.

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