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Research article

# Seasonal variations in zooplankton diversity and physico-chemical characteristics of the Nagavathi reservoir, Dharmapuri District, Tamil Nadu, India

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## Abstract

Zooplankton is an important biotic component of aquatic ecosystems. They play a supportive role on economically important fin-fishes and shell-fishes. In the present study, the seasonal variations in freshwater zooplankton biodiversity in the Nagavathi reservoir Dharmapuri District Tamil Nadu, India were studied during January-2011 to December-2011 and correlated with physico-chemical parameters, as utilized for aquaculture of fishes, such as *Catla*, *Rogu* and *Mirigal*. A total of 29 species belongs to four orders of zooplankton such as rotifera (11 species), cladocera (7 species), copepoda (7 species) and ostracoda (4 species) were recorded during the study period. The overall population of zooplankton was found to be higher during summer season (April and May), intermediate during post-monsoon season (December-February) and lower during monsoon season (September-November). The zooplankton species percentage composition were found to be in the following order: rotifera (32%) > copepoda (31%) > cladocera (25%) > ostracoda (12%). The physico-chemical characteristics of reservoir water were positively correlated with zooplankton population. Among the zooplankton, particularly rotifera was the dominant group throughout the study period and the highest count was recorded in the summer season while the lowest incidence was observed in monsoon season.

**Key words:** Cladocera, Copepoda, Nagavathi reservoir, Ostracoda, Rotifera,

## Introduction

Zooplankton (microscopic drifting or wandering animals) feed on phytoplankton. The zooplankton occupies a vital role in the tropic structure of an aquatic ecosystem and plays a key role in the energy transfer. The inadequate knowledge of plankton and their dynamics is a major handicap for the better understanding of the life process of fresh water bodies. Aquatic ecosystems are affected by several health stressors that significantly deplete biodiversity. In the future, the loss of biodiversity and its effects are predicted to be greater for aquatic ecosystems than for terrestrial ecosystems (Sala et al. 2000; Manickam et al. 2015a,b; Manickam 2015). Zooplankton is the central trophic link between primary producers and higher trophic levels. Freshwater zooplankton plays an important role in ponds, lakes and reservoirs ecosystem as well as food chain in the aquatic ecosystem (Manickam et al. 2014). Zooplankton forms a major link in the energy transfer at secondary level in aquatic food

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webs between autotrophs and heterotrophs (Deivanai et al. 2004). The physico-chemical parameters and nutrient status of water body play an important role in governing the production of plankton which is the natural food of many species of fishes, especially zooplankton constitute important food source of many omnivorous and carnivorous fishes and also support the necessary amount of protein for the rapid growth of larval carps (Rahman and Hussain, 2008). They respond quickly to aquatic environmental changes (e.g., water quality, such as pH, colour, odour and taste, etc.) for their short life cycle, and are therefore used as indicators of overall health or condition of their habitats (Thorpe and Covich 1991; Carriack and Schelske 1997). Zooplankton communities have been investigated in numerous reservoirs, lakes and shallow waterbodies (Abbasi et al. 1996; Manickam et al. 2014, 2015a,b; Manickam 2015). The dominance of zooplankton in shallow water bodies by Rotifers, Cladocera or Copepods varies according to the degree of organic pollution (Moitra and Bhowmik, 1968). Hence, zooplankton can speak to condition of water body and can be used to assess over all lake health. The qualitative and quantitative abundance of zooplankton in a lake are of great importance for successful aquaculture management, as they vary from one geographical location to another and lake to lake within the same geographical location even within similar ecological conditions (Boyd 1982). Literature on ecology of zooplankton population from different parts of India is available from the investigation of Sreenivasan (1967), Mathivanan et al. (2007), Manickam et al. (2012b, 2014, 2015a), Bhavan et al. (2015), Manickam (2015), etc. In the present study, an attempt was made to report the freshwater zooplankton biodiversity in the Nagavathi reservoir, Dharmapuri District, Tamil Nadu, India.

## Materials and Methods

### Study Area

Sampling was carried out in the Nagavathi reservoir (Latitude, 12°3'42"N and Longitude 78°1'45"E), during January-2011 to December-2011 (Fig. 1). The reservoir an Nagavathi river, which is seasonal and a tributery of the Cauvery river.

### Analysis of physico-chemical parameters

The water and plankton samples were collected during the early morning between 5.00 A.M to 7.00 A.M every month first week. Air and water temperature, pH, salinity, dissolved oxygen (DO), total dissolved solids (TDS) and electrical conductivity (EC) were estimated by using "µP Based Water & Soil Analysis Kit Model-1160" (Manufactured by Environmental and Scientific Instruments Co., Panchkula, Haryana, India).

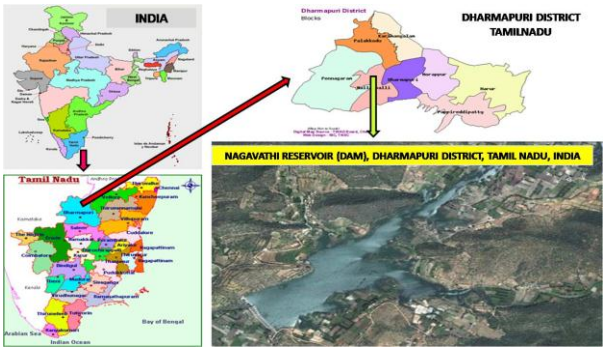


Fig. 1. Satellite view of Nagavathi reservoir, Dharmapuri District, Tamil Nadu, India

### Qualitative and quantitative analysis of zooplankton

For quantitative analysis, 100 liters of water was filtered through Henson's standard plankton net made up of bolting silk (No: 10, mesh size: 150 µm) using a 10 liter capacity plastic container. The collected plankton samples were transferred to polyethylene bottles (90 ml) and preserved with 5% of formalin (10 ml) (aqueous solution of formaldehyde). The plankton samples varied both qualitative (by towing) as well as quantitative (by filtering) analysis throughout the study period.

### Biological analysis and identification of plankton

The four groups of zooplankton (rotifera, cladocera, copepoda and ostracoda) were segregated and separated under a binocular stereo zoom dissection microscope using a fine needle and brush. Individual species of plankton was mounted on microscopic slides with a drop of 20% glycerin after staining with eosin and rose bengal. The zooplankton identification was made referring the standard manuals, text books and monographs (Edmondson 1959; Battish 1992; Murugan et al. 1998; Altaff 2004). Plankton counting was made by drop method. Quantitative analysis was made using a plankton-counting chamber (Sedgwick Rafter's). Photomicrographs were taken for the "Inverted Biological Microscope, Model Number INVERSO 3000 (TC-100) CETI attached with the camera (Modal-IS 300).

The zooplankton sample (1 ml) was taken with a wide mouthed pipette and poured into the counting cell of the Sedgwick Rafter. After allowing for settle some time they were counted. At least 5 such counting was made for each group. The average values were taken. Total number of plankton present in 1 liter of water sample was calculated (Santhanam et al. 1989) using the following formula: $N = n \times v / V$; Where, N = Total number of plankton per liter of water filtered; n = Average number of plankton in 1 ml of plankton sample; v = Volume of plankton concentrated (ml) and V = Volume of total water filtered (litre).

**Statistical analysis and diversity indices**

The population of each group of zooplankton was expressed in average, number of individuals per litre (ind./l or ind./$m^3$). The statistical analysis were done using software programmed for total zooplankton numbers of individual species, diversity indices namely; Shannon's diversity index (H'), species evenness and species richness were calculated using PAST software package (PAST; version = 2.02).

**Results and discussion**

**Physico-chemical parameters**

In the present investigation, all the mean data of selected water quality parameters (i.e., temperature, pH, salinity, electrical conductivity, total dissolved solid and dissolve oxygen) obtained monthly basis during January, 2011 to December, 2011 is depicted in Table 1. Surface water temperature is an important factor in any aquatic environments affecting biological processes, in this study surface water temperature varied from 21.50 °C to 24.5 °C and atmospheric temperature 23.00 °C to 26.00 °C at Nagavathi reservoir. The maximum temperature was observed during May-2011 and minimum were recorded during December-2011. The pH values ranged from 7.10 to 8.50 and maximum (8.50) was recorded during May-2011 and minimum (7.10) during November-2011. This should be discussed in discussion section. Salinity was variable throughout the study period and the values were ranges from 0.63 (ppt) to 0.96 (ppt). A maximum salinity of 0.96 (ppt) were observed in May-2011 and minimum salinity of 0.63 (ppt) was observed in November-2011.

The values of dissolved oxygen varied from 5.40 to 8.50 (mg/l). DO values found maximum in May-2011 and minimum was observed during December-2011. EC values were observed in the range of 0.75 to 0.94 (mg/l). EC were maximum in May-2011 and minimum during November-2011. The total dissolved solid were ranged from 0.57 to 0.54 (mg/l). The maximum of TDS was notice in May-2011 and minimum of 0.51 (mg/l) during November -2011.

**Zooplankton diversity indices**

A total of 29 species of zooplankton were recorded and they were belonging to four orders, namely rotifera (11 species), cladocera (7 species), copepoda (7 species) and ostracoda (4 species). Zooplankton production was maximum during May-2011 and minimum during November-2011 (Table 2). In the present observation, rotifera holds the top rank in percentage composition in Nagavathi reservoir. The rotifera were found to be predominant with 32% followed by copepoda with 31%, cladocera with 25%, and ostracoda with 12% in the lake (Fig. 2).

**Rotifera**

The rotifers are microscopic soft bodies fresh water invertebrates. Their distribution and ecology have interesting evolutionary implications (Krishnamoorthy and Sakhivel, 2007; Manickam 2015).

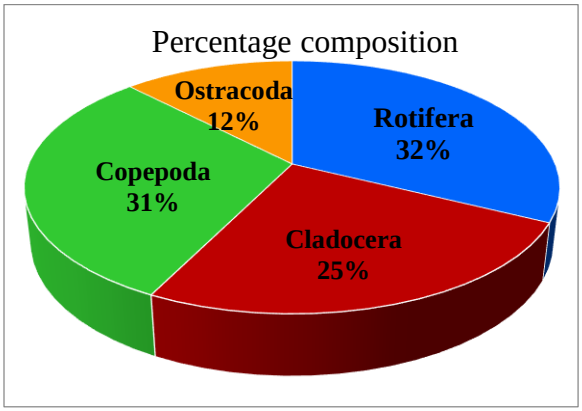


Fig. 2. Percentage composition of zooplankton species in Nagavathi reservoir during January- 2011 to December-2011.

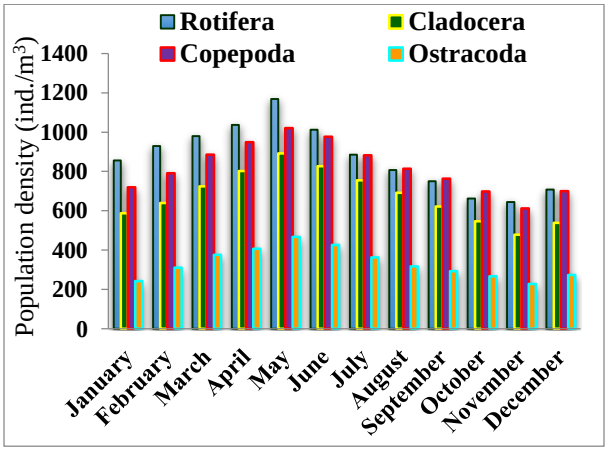


Fig.3. Zooplankton population density (ind./$m^3$) monthly wise for during January- 2011 to December-2011

Rotifera have often been used to indicate trophic status of a water body. Rotifera were occur in almost universally in a freshwater habitat and is an important group of zooplankton community. During the present study of total 11 species of rotifera were recorded belonging to 3 family and 5 genera (Table 2). In the study population density observed were in the range of 644 to 1169 (ind./$m^3$) from January - 2011 to December - 2011 and range from overall during 10440 (ind./$m^3$) to 52200 (ind./$m^3$) respectively. (Fig. 3 & 4 ). A maximum number of individual rotifera - 1169 (ind./$m^3$) during May – 2011 and minimum - 644 ( ind./$m^3$) during November - 2011. The species dominance were high (0.13) in November - 2011 and low (0.11) in May - 2011 (Table 3). Shannon-Wiener rotifera diversity index (H) was found to be maximum (2.32) in May - 2011 and minimum (2.19) in November - 2011. Simpson's diversity index was

maximum (0.89) in May and minimum (0.87) in November - 2011. Species evenness were with (0.92) in May - 2011 and low (0.81) in November - 2011. The species richness of Margalef index (R1) was maximum (1.55) in November - 2011 and minimum were (1.42). The Menhinick index (R2) values were fluctuated throughout the study period, maximum (R2) was recorded during November - 2011 (0.43) and minimum were recorded (0.32) during May - 2011. Similar findings were observed by Jeelani et al. 2005 in Dal lake Kashmir (India). This pattern is common in tropical and subtropical fresh water bodies, such as lakes, ponds, reservoirs, rivers or streams (Neves et al. 2003). Rotifera abundance is related to suitable conditions for their survival (Dhanapati 2000). The species *B. calyciflorus* is considered to be a good indicator of eutrophication (Sampaio et al. 2002). Earlier several researchers were studied the diversity of rotifers in different lakes, 13 species of rotifera were recorded in perennial freshwater lake Haledharmapuri Lake in Dharmapuri Town and the diversity was found maximum during May-2011 and minimum during November-2011 (Manickam et al. 2012b), similarly 19 species of rotifera were recorded in Thoppaiyar reservoir, Dharmapuri District (Manickam et al. 2014), 10 species of rotifera were recorded in Sulur lake, Coimbatore District (Bhavan et al. 2015), 18 species of rotifera in Barur lake, Krishnagiri District (Manickam et al. 2015a); 11 species of rotifera in Sulur and 10 species of rotifera in Ukkadam lake, Coimbatore District, (Manickam 2015), Tamil Nadu, India). In this study rotifera population was ranked first in order of dominance during the study period in Nagavathi reservoir at Dharmapuri District, Tamil Nadu, India.

**Cladocera**

The cladocera are called as water fleas are common occurrence in almost all the fresh water habitats. They represent an important link in the aquatic food chain and form the favorable food for both young, adult fishes and prawns. These groups were represented by 7 genera (Table 2). The recorded monthly population density was ranged from 479 to 892 (ind./$m^3$) and overall population ranged from density 8107 (ind./$m^3$) to 40535 (ind./$m^3$) (Fig. 3 & 4). The maximum density of cladocera was 892 (ind./$m^3$) during May - 2011 and minimum recorded of 479 ( ind./$m^3$) were observed during November - 2011. Species dominance were found higher (0.20) during November - 2011 and observed less (0.16) during May - 2011 (Table 3). The Shannon - Wiener diversity index (H) was found to be maximum (1.88) during May - 2011 and minimum (1.76) during November - 2011. Simpson's diversity indexes showed the maximum value (0.83) during - May - 2011 and minimum (0.80) during November - 2011. Species evenness was high (0.93) in May - 2011 and lower (0.83) during November - 2011. The Margalef species richness index (R1) was found maximum (0.97) during November - 2011 and minimum (0.88) in May – 2011. The Menhinick index (R2) values were fluctuated throughout the study period, maximum was recorded in November - 2011 (0.32) and minimum were recorded (0.23) during May - 2011. About 600 species of fresh water cladocera have been reported so far (Korovchinsky 1996), in India 110 species have been recorded (Patil and Goudar, 1989). The previous workers was identified 7 species of cladocera in Haledharmapuri Lake, Dharmapuri Town (Manickam et al. 2012b); 13 species of cladocera in Thoppaiyar reservoir, Dharmapuri District (Manickam et al. 2014); 10 species of cladocera in Sulur lake, Coimbatore District (Bhavan et al. 2015); 11 species of cladocera in Barur lake, Krishnagiri District (Manickam et al. 2015a); 10 species of cladocera in Sulur and 8 species of cladocera in Ukkadam lake, Coimbatore District, (Manickam 2015), Tamil Nadu, India). The maximum population of cladocera was noticed in summer may be due to the favorable temperature and availability of food in the form of bacteria, nanoplankton and suspended detritus while in monsoon the factors like water temperature, dissolved oxygen, turbidity and transparency play an important role in controlling the diversity and density of cladocera (Edmondson 1965; Baker 1979). The cladocera population was ranked third in order of dominance during the study period in Nagavathi reservoir at Dharmapuri District, Tamil Nadu, India.

**Copepoda**

The copepods constitute an essential link in the aquatic food chain. They are in intermediate trophic level among bacteria, algae and protozoa on one hand and small and large plankton predators on the other. This group was represented by 7 genera (Table-2). The monthly population density of copepoda was ranged from 612 to 1021 (ind./$m^3$) and over all density was 9813 (ind./$m^3$) to 49065 (ind./$m^3$) (Fig. 3 & 4).

A maximum copepod density was 1169 (ind./$m^3$) noticed during May- 2011 and minimum of 644 (ind./$m^3$) during November - 2011 (Table 3). The Shannon-Wiener diversity index (H) was found to be maximum (1.90) during May-2011 and minimum (1.87) during November -2011. Simpson's diversity index was found to be maximum (0.84) during May-2011 and minimum (0.83) during November-2011. Species evenness was found higher (0.96) during May-2011 and recorded lower (0.93) during November-2011. The species richness of Margalef index (R1) was found maximum (0.94) during November-2011 and minimum (0.87) during May-2011. The Menhinick index (R2) values were fluctuated throughout the study period, maximum (R2) was recorded during November - 2011 (0.28) and minimum were recorded (0.22) during May-2011. About 120 species of fresh water free-living copepods are known from India. Patil and Goudar (1989) reported 7 species of copepods in Dharwad District, Karnataka, India.

Table 1. Physico-chemical parameters of Nagavathy reservoir during January-2011 to December-2011.

| Parameter | Post Monsoon | | Summer | | | Pre-Monsoon | | | Monsoon | | | Post Monsoon | Range |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan-11 | Feb-11 | Mar-11 | Apr-11 | May-11 | Jun-11 | Jul-11 | Aug-11 | Sep-11 | Oct-11 | Nov-11 | Dec-11 | |
| A.T. (°C) | 23.5 | 24.0 | 24.0 | 24.5 | 26.0 | 25.5 | 25.0 | 24.5 | 24.0 | 24.0 | 23.0 | 23.0 | 23.0– 26.0 |
| S.W.T. (°C) | 23.0 | 22.5 | 23.0 | 23.5 | 24.0 | 24.5 | 24.0 | 23.5 | 23.0 | 23.0 | 22.0 | 21.5 | 21.5 - 24.5 |
| pH | 7.40 | 7.50 | 7.70 | 8.10 | 8.50 | 8.20 | 7.80 | 7.50 | 7.40 | 7.40 | 7.10 | 7.30 | 7.10 - 8.50 |
| Salinity (mg/l) | 0.70 | 0.74 | 0.83 | 0.88 | 0.96 | 0.91 | 0.86 | 0.78 | 0.73 | 0.66 | 0.63 | 0.65 | 0.63 - 0.95 |
| DO (mg/l) | 5.60 | 5.80 | 6.40 | 7.50 | 8.50 | 8.20 | 7.90 | 7.50 | 7.00 | 6.50 | 6.00 | 5.40 | 5.40 - 8.50 |
| EC (mg/l) | 0.79 | 0.83 | 0.90 | 0.93 | 0.94 | 0.91 | 0.88 | 0.86 | 0.82 | 0.80 | 0.75 | 0.77 | 0.75 0.94 |
| TDS (mg/l) | 0.57 | 0.59 | 0.61 | 0.69 | 0.77 | 0.74 | 0.67 | 0.65 | 0.61 | 0.54 | 0.51 | 0.54 | 0.51 - 0.77 |

A.T. - Atmospheric Temperature; S.W.T. – Surface Water Temperature; DO - Dissolved Oxygen; TDS - Total Dissolved Solids; EC - Electrical Conductivity

Table 2**.** List of freshwater zooplankton species recorded in Nagavathy reservoir at Dharmapuri District, Tamil Nadu, India.

| Group | Family | Genus | Species |
|---|---|---|---|
| Rotifera (11) | Brachionidae (Ehrenberg, 1838) | *Brachionus* Pallas, 1776 | *Brachionus budapestinesis* Hempel 1896 |
| | | | *Brachionus caudatus personatus* Ahlstrom, 1940 |
| | | | *Brachionus diversicornis* Daday, 1883 |
| | | | *Brachionus calyciflorus* Pallas, 1776 |
| | | | *Brachionus falcatus* Zacharias, 1898 |
| | | | *Brachionus quadridentatus* Hermann, 1783 |
| | | | *Brachionus rubens* Ehrenberg, 1838 |
| | | *Notholca* Gosse, 1886 | *Notholca lebis* Gosse, 1887 |
| | | *Keratella* Bory de St. Vincent, 1822 | *Keratella cochlearis* Gosse, 1851 |
| | Asplanchnidae (Harring & Myers, 1933) | *Asplanchna* Gosse, 1850 | *Asplanchna intermedia* Hudson, 1886 |
| | Filinidae (Bartos, 1959) | *Filinia* Bory and Vincent, 1824 | *Filinia longiseta* Ehrenberg, 1834 |
| Cladocera (7) | Sididae (Baird, 1850) | *Diaphanasoma* Fischer, 1850 | *Diaphanosoma sarsi* Richard, 1894 |
| | | | *Diaphanosoma excisum* Sars, 1885 |
| | | *Daphnia* Muller, 1785 | *Daphnia carinata* King, 1853 |
| | | | *Daphnia magna* Straus, 1820 |
| | Daphnidae (Straus, 1850) | *Ceriodaphnia* Dana, 1853 | *Ceriodaphnia cornuta* Sars, 1885 |
| | Moinidae (Goulden, 1968) | *Moina* Baird, 1850 | *Moina brachiata* Jurine, 1820 |
| | | | *Moina micrura* Kurz, 1875 |
| Copepoda (7) | Diaptomidae (Baird, 1850) | *Heliodiaptomus* Kiefer, 1932 | *Heliodiaptomus viduus* Gurney, 1916 |
| | | *Sinediaptomus* Kiefer, 1937 | *Sinodiaptomus indicus* Kiefer, 1934 |
| | Cyclopoidae (Dana, 1853) | *Eucyclops* Claus, 1893 | *Eucyclops serrulatus* (Fischer, 1851) |
| | | | *Eucyclops speratus* Lilljeborg, 1901 |
| | | *Mesocyclops* Claus, 1893 | *Mesocyclops hyalinus* Rehberg, 1880 |
| | | | *Mesocyclops leuckarti* Claus, 1857 |
| | | *Thermocyclops* Kiefer, 1927 | *Thermocyclops hyalinus* Rehberg, 1880 |
| Ostracoda (4) | Cyprididae (Baird, 1845) | *Cypris* Muller, 1776 | *Cypris protubera* Victor and Fernando, 1978a |
| | | *Strandesia* Stuhlmann, 1888 | *Strandesia elongate* Stuhlmann, 1888 |
| | | *Candonocypris* Vavra, 1891 | *Candonocypris dentatus* Victor and Michael, 1975 |
| | | *Cypretta* Vavra, 1895 | *Cypretta fontinalis* Hartmann, 1964 |

7 species of copepoda were recorded in freshwater Haledharmapuri Lake, Dharmapuri Town (Manickam et al. 2012b); 15 species of copepoda in Thoppaiyar reservoir, Dharmapuri District (Manickam et al. 2014), 7 species of copepoda in Sulur lake, Coimbatore District (Bhavan et al. 2015), 11 species of copepoda in Barur lake, Krishnagiri District (Manickam et al. 2015a), 7 species of copepoda in Sulur and 6 species of copepoda in Ukkadam lake, Coimbatore District, (Manickam, 2015). In this study copepoda population was found ranked in Second order of dominance during the study period in Nagavathi reservoir at Dharmapuri District, Tamil Nadu, India.

Table 3. The diversity of zooplankton species in Nagavathy reservoir at Dharmapuri District, Tamil Nadu, India.

| Diversity Indices | | Zooplankton diversity indices | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Post Monsoon | | Summer | | | Pre Monsoon | | | Monsoon | | | Post Monsoon |
| | | Jan-11 | Feb-11 | Mar-11 | Apr-11 | May-11 | Jun-11 | Jul-11 | Aug-11 | Sep-11 | Oct-11 | Nov-11 | Dec-11 |
| Rotifera (11) | Dominance_D | 0.12 | 0.12 | 0.11 | 0.11 | 0.11 | 0.11 | 0.12 | 0.12 | 0.13 | 0.13 | 0.13 | 0.12 |
| | Shannon_H | 2.27 | 2.28 | 2.31 | 2.31 | 2.32 | 2.30 | 2.27 | 2.25 | 2.22 | 2.20 | 2.19 | 2.21 |
| | Simpson_1-D | 0.88 | 0.88 | 0.89 | 0.89 | 0.89 | 0.89 | 0.88 | 0.88 | 0.87 | 0.87 | 0.87 | 0.88 |
| | Evenness_e^H/S | 0.88 | 0.89 | 0.92 | 0.92 | 0.92 | 0.91 | 0.88 | 0.87 | 0.83 | 0.82 | 0.81 | 0.83 |
| | Menhinick (R2) | 0.38 | 0.36 | 0.35 | 0.34 | 0.32 | 0.35 | 0.37 | 0.39 | 0.40 | 0.43 | 0.43 | 0.41 |
| | Margalef (R1) | 1.48 | 1.46 | 1.45 | 1.44 | 1.42 | 1.45 | 1.47 | 1.49 | 1.51 | 1.54 | 1.55 | 1.52 |
| Cladocera (7) | Dominance_D | 0.18 | 0.17 | 0.17 | 0.17 | 0.16 | 0.17 | 0.17 | 0.17 | 0.19 | 0.19 | 0.20 | 0.19 |
| | Shannon_H | 1.83 | 1.85 | 1.86 | 1.86 | 1.88 | 1.86 | 1.86 | 1.84 | 1.81 | 1.79 | 1.76 | 1.79 |
| | Simpson_1-D | 0.82 | 0.83 | 0.83 | 0.83 | 0.84 | 0.83 | 0.83 | 0.83 | 0.82 | 0.81 | 0.80 | 0.81 |
| | Evenness_e^H/S | 0.89 | 0.90 | 0.92 | 0.92 | 0.93 | 0.92 | 0.91 | 0.90 | 0.87 | 0.86 | 0.83 | 0.86 |
| | Menhinick (R2) | 0.29 | 0.28 | 0.26 | 0.25 | 0.23 | 0.24 | 0.25 | 0.27 | 0.28 | 0.30 | 0.32 | 0.30 |
| | Margalef (R1) | 0.94 | 0.93 | 0.91 | 0.90 | 0.88 | 0.89 | 0.91 | 0.92 | 0.93 | 0.95 | 0.97 | 0.95 |
| Copepoda (7) | Dominance_D | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 |
| | Shannon_H | 1.89 | 1.89 | 1.89 | 1.89 | 1.90 | 1.89 | 1.89 | 1.89 | 1.89 | 1.89 | 1.87 | 1.88 |
| | Simpson_1-D | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 |
| | Evenness_e^H/S | 0.95 | 0.94 | 0.94 | 0.95 | 0.96 | 0.95 | 0.94 | 0.95 | 0.95 | 0.95 | 0.93 | 0.94 |
| | Menhinick (R2) | 0.26 | 0.25 | 0.24 | 0.23 | 0.22 | 0.22 | 0.24 | 0.25 | 0.25 | 0.26 | 0.28 | 0.26 |
| | Margalef (R1) | 0.91 | 0.90 | 0.88 | 0.88 | 0.87 | 0.87 | 0.88 | 0.90 | 0.90 | 0.92 | 0.94 | 0.92 |
| Ostracoda (4) | Dominance_D | 0.29 | 0.27 | 0.27 | 0.26 | 0.26 | 0.26 | 0.26 | 0.27 | 0.27 | 0.28 | 0.31 | 0.27 |
| | Shannon_H | 1.31 | 1.35 | 1.35 | 1.36 | 1.36 | 1.36 | 1.36 | 1.35 | 1.34 | 1.32 | 1.28 | 1.34 |
| | Simpson_1-D | 0.71 | 0.73 | 0.73 | 0.74 | 0.74 | 0.74 | 0.74 | 0.73 | 0.73 | 0.72 | 0.69 | 0.73 |
| | Evenness_e^H/S | 0.93 | 0.97 | 0.96 | 0.97 | 0.98 | 0.97 | 0.97 | 0.97 | 0.96 | 0.94 | 0.90 | 0.96 |
| | Menhinick (R2) | 0.26 | 0.23 | 0.21 | 0.20 | 0.18 | 0.19 | 0.21 | 0.22 | 0.23 | 0.24 | 0.26 | 0.24 |
| | Margalef (R1) | 0.55 | 0.52 | 0.51 | 0.50 | 0.49 | 0.50 | 0.51 | 0.52 | 0.53 | 0.54 | 0.55 | 0.53 |

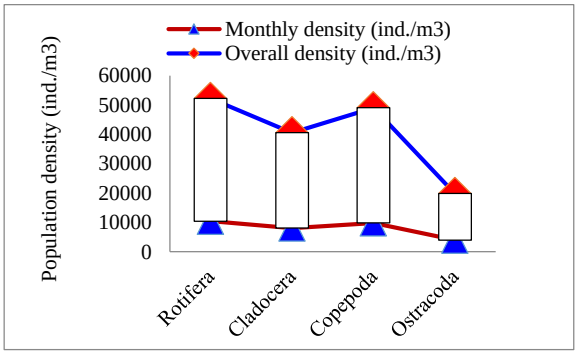


Fig. 4. Zooplankton population density (ind./$m^3$) for annually, during January- 2011 to December-2011.

**Ostracoda**

Ostracoda were commonly known as 'mussel shrimp' or 'seed shirmps' are small crustacean. The freshwater ostracoda are usually smaller than a millimeter. Ostracoda is a free-swimming and occurs in freshwater stagnant pond, lake and reservoirs. Freshwater ostracoda in general tend to have smooth, thin, weakly calcified simple bean-shaped carapaces. During the study period, a total of 4 species of ostracoda were recorded from January-2011 to December-2011, in the monthly 228 to 468 (ind./$m^3$) and range from over all during 3974 (ind./$m^3$) to 19870 (ind./$m^3$)

respectively (Fig. 3 & 4).

A maximum during 274 (ind./$m^3$) was observed during May - 2011 and minimum of 243 (ind./$m^3$) was observed during November. Species dominance was found higher level (0.31) during November - 2011 and lower level (0.26) during May (Table 3).

The Shannon-Wiener diversity index (H) was found to be maximum (1.36) during May - 2011 and minimum (1.28) was observed during November-2011. Simpson's dominance indexes were found maximum (0.74) during May -2011 and minimum (0.69) during November - 2011. Species evenness were high (0.98) during May - 2011 and lower (0.90) during November - 2011. The Margalef species richness index (R1) was found maximum (0.55) during November - 2011 and minimum (0.49) during May and June -2011, respectively. The Menhinick index (R2) values showed fluctuation throughout the study period, maximum was recorded during November - 2011 (0.26) and minimum was recorded (0.18) during May - 2011. Patil and Goudar, (1989) reported seven species of ostracoda in Dharwad District, Karnataka, India. Manickam et al. (2012b) reported 5 species of ostracoda in Haledharmapuri lake in Dharmapuri Town. Similarly 15 species of ostracoda were reported in Thoppaiyar reservoir, Dharmapuri District (Manickam et al. 2014), 6 species of ostracoda in Sulur lake, Coimbatore District (Bhavan et al. 2015), 7 species of ostracoda in Barur lake, Krishnagiri District (Manickam et al. 2015a), 6 species of ostracoda in Sulur and 4 species of ostracoda in Ukkadam lake, Coimbatore District, (Manickam, 2015), Tamil Nadu, India. In this study ostracoda population was found fourth in rank in the order of dominance during the study period in Nagavathi reservoir at Dharmapuri District, Tamil Nadu, India.

The importance of the zooplankton is well recognized; they have been a vital part in food chain and play a key role in cycling of organic matter in an aquatic ecosystem. The distribution and population of density of zooplankton species depending upon the prevailing physico-chemical parameters of the environment, the rotifers were the indicators of eutrophication and measures must be taken to minimize the water pollution by regulating human activities in watershed areas (Manickam et al. 2012b, 2014, 2015a,b; Manickam 2015). In the present study, zooplankton were recorded with high mean value of Shannon-Wiener index ($H^1$) was recorded in the species is as follows rotifera > copepoda > cladocera > ostracoda. Dash (1996) reported that higher value of Shannon's index (H') the greater is the planktonic diversity.

## Conclusion

Present study revealed that the distribution and population density of zooplankton species depend upon the Nagavathi reservoir environment, rotifera diversity was higher than that of copepoda, cladocera and ostracoda. The population dynamics of zooplanktons was found to be higher during summer and lower during monsoon season. Therefore, the Nagavathi reservoir, Dharmapuri District, Tamil Nadu, India was suitable for fishes and prawn cultures.

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## Reference

1. Abbassi, SA., Arya, DS., Hameed, AS. and Abbassi, N. (1996). Water quality of a typical river of Punnurpuzha, Kerala. Pollut. Res. 15: 163–166.
2. Altaff, K. (2004). A manual of zooplankton. p. 1-155. University Grants Commission, New Delhi.
3. Battish, SK. (1992). Freshwater Zooplankton of India. Oxford and IBH Publication Co. New Delhi.
4. Bhavan, PS., Selvi, A., Manickam, N., Srinivasan, V., Santhanam, P, and Vijayan, P. (2015a). Diversity of Zooplankton in a pe-rennial Lake at Sulur, Coimbatore, India. Int. J. Ext. Res. 5: 31-44.
5. Boyd, CE. (1982). Water quality management of Lake fish culture. Elsvier sci. Pub. Co. Amstardam – Oxford, New York. 318.
6. Carriack, JH, and Schelske, LC. (1997). Have we overlooked the importance of small phytoplankton in productive waters. Limn. Ocean. 42: 1612-1613.
7. Dash, MC. (1996).Fundamentals of ecology. Tata McGraw Hill Publishing Company Limited, New Delhi.
8. Deivanai, K., Arunprasath, S., Rajan, MK, and Baskaran, S. (2004). Biodiversity of phyto and zooplankton in relation to water quality parameters in a sewage polluted pond at Ellayirampannai, Virudhunagar District. In: The proceedings of National Symposium on biodiversity resources management and sustainable use, organized by the center for biodiversity and Forest studies, Madurai Kamaraj University. Madurai.
9. Dhanapati, MV. (2000). Taxonomic notes on the rotifers form India, I.A.A.B. Hyderabad. 1-78.
10. Edmondson, WT. (1959). Freshwater Biology,2nd Edition John Wiley & Sons, Inc, New York. 1248.
11. Jeelani, M., Kaur, H, and Sarwar, S.G. (2005). Population dynamics of rotifers in the Anchar lake Kashmir (India). In Ecology of Plankton, Arvind Kumar (ed.), Daya Puplishing House Delhi. 55-60.
12. Krishnamoorthy, G., Rajalakshmi, S, and Sakthivel, D. (2007). Diversity of Zooplankton in mangrove Areas of Puducherry. India. J. Aqua. Bio. 22: 1. 45-48.

13. Mathivanan, V., Vijayan, P. Sabhanayakm, S, and Jeyachitra, O. (2007). An assessment of plankton population of Cauvery river with reference to pollution. J. Env. Biol. 28: 523-527.
14. Moitra, SK, and Bhowmik, ML. (1968).The seasonal cycles of rotifers in a freshwater fish pond in Kalyani, W. Bengal. p. 359-367. In R. Misra and B. Gopal (eds), Proceedings Symposium on Recent Advances in Tropical Ecology. Int. Soc. Trop. Ecol. Banaras Hindu Univ. Varanasi.
15. Manickam, N., Bhavan, PS., Vijayan, P, and Sumathi, G. (2012a). Phytoplankton species diversity in the Parambikulam-Aliyar irrigational canals (Tamil Nadu, India). Int. J. Phar. Bio Sci. 3(3): 289-300.
16. Manickam, N., Bhavan, PS., Santhanam, P., Chitrarasu, P, and Ali, AJ. (2012b). Zooplankton diversity in a perennial freshwater lake. p. 25-37. Diversity and Physiological Processes: Ed. Desai PV, Roy, R. Goa University, India.
17. Manickam, N., Bhavan, PS., Santhanam, P., Muralisankar, T., Srinivasan, V., Radhakrishnan, S., Vijayadevan, K., Chitrarasu, P, and Ali, AJ. (2014). Seasonal variations of zooplankton diversity in a perennial reservoir at Thoppaiyar, Dharmapuri District, South India. Austin. J. Aquac. Mar. Biol.1: 1-7.
18. Manickam, N. (2015). Biodiversity of plankton in two perennial lakes of coimbatore, India and suitability of wild mixed zooplankton as live feed for rearing of the giant freshwater prawn *Macrobrachium rosenbergii* early post larvae. Ph.D., Thesis, Bharathiar University, Tamil Nadu, India. 1 - 145.
19. Manickam, N., Bhavan, PS., Santhanam, P., Muralisankar, T., Srinivasan, V., Radhakrishnan, S., Vijayadevan, K, and Bhuvaneswari, R. (2015a). Biodiversity of freshwater zooplankton and physico-chemical parameters of Barur Lake, Krishnagiri District, Tamil Nadu, India. Malaya J. Biosci. 2: 1-12.
20. Manickam, N., Bhavan, PS, and Santhanam, P. (2015b). Physico-chemical characteristics of lake ecosystem. p. 1-80. Lap Lambert Academic Publishing.
21. Murugan, N., Murugavel, P, and Kodarkar, MS. (1998). Cladocera. Indian Association of Aquatic Biologist. Hyderabad. 5: 1-55
22. Neves, IF., Rocha, O., Rocha, KF., Roche, KF, and Pinto, AA. (2003). Zooplankton community structure of two marginal lakes of the River Cuiaba (Mato Grasso, Brazil) with analysis of rotifera cladocera diversity. Braz. J. Bio. 62: 329-345.
23. Nogueira, MG. (2001). Zooplankton composition dommace and abundance as indicators of environmental compartmentalization in Jaramirim Reservoir (Paranapanema River), Sao Paulo, Brazil. Hydrobiologia. 455: 1-18.
24. Patil, CS, and Gouder, BYM. (1989). Freshwater invertebrates of Dharwad, Prasaranga, Karnataka University, Dharwad.
25. Rahman, S, and Hussain, AF. (2008). A study on the abundance of zooplankton of a culture and non-culture pond of the Rajshahi University campus. Univ. J. Zool. Rajshahi. Univ. 27: 35-41.
26. Sala OE., Chapin, FS., Armesto, JJ., Berlow, E., Bloomfield, J., Dirzo, R., Huber-Sanwald, E., Huenneke, ELF., Jackson, RB., Kinzig, A., Leemans, R., Lodge, DM., Mooney, HA., Oesterheld, M., Poff, NL., Sykes, MT., Walker, BH., Walker, M, and Wall, DH. (2000). Global biodiversity scenarios for the year 2100. Science. 287: 1770-1774.
27. Sampaio, EV., Rocha, O., Matsumura, T., Tundisi, T., and Tundisi, JG. (2002). Composition and abundance of zooplankton in the limnetic zone of seven reservoirs of the Paranapanema River, Brazil. Brazil J. Biol. 62:525-545.
28. Sreenivasan, A. (1967). The limnology of fish production in two lakes in Chinglipat (Madras). Hydrobiologia. 32: 131-144.
29. Thorpe, H.J, and Covich, P.A. (1991). Ecology and classification of North American Invertebrates. Academic Press, Inc.