



E-ISSN: 2320-7078

P-ISSN: 2349-6800

www.entomoljournal.com

JEZS 2020; 8(4): 826-832

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Received: 04-05-2020

Accepted: 07-06-2020

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Composition, diversity and seasonal distribution of zooplankton in the nearshore waters of Gulf of Mannar, Tamil Nadu

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Abstract

The present investigation deals with the assessment of diversity, composition and seasonal distribution of zooplankton in the nearshore waters of Gulf of Mannar. The present study consists of 35 species at three different sampling stations. In this investigation, maximum zooplankton species were recorded at station 1 and 3, i.e., Mandapam and Punnakayal. Decapods and Calanoids were the most dominant groups. The species diversity of zooplankton was comparatively more at station 1 as compared to station 2 and 3 whereas the density of zooplankton was found to be lower at station 1 (542 to 33, 519 nos. m⁻³) compared to station 2 (821 to 41, 624 nos. m⁻³) and station 3 (761 to 39, 648 nos. m⁻³). The maximum and minimum density were recorded during summer 2018 and post-monsoon 2018 respectively at all sampling stations. The species diversity index ('H') was highest at station 1 (1.55) and lowest at station 3 (1.10). The current investigation exhibited that the rich zooplankton diversity in the nearshore waters of the Gulf of Mannar.

Keywords: diversity, distribution, abundance, zooplankton, gulf of mannar

Introduction

Zooplankton are microscopic aquatic organisms having little resistance to currents and are therefore free-floating or suspended in open or pelagic waters (Thorp and Covich, 2009) [25]. While some forms of zooplankton move by vertical migration, their horizontal position is mostly determined by current movements of the body of water they inhabit (Balcer *et al.*, 1984) [3]. Zooplankton forms a major connection in the energy transformation in the aquatic environment and their ecology is of considerable interest in assessing the production potential of the ocean (Jeyaraj *et al.*, 2014) [9]. Zooplanktons also have enormous ecological value as they are primary consumers of phytoplankton, and also recycle the nutrients (Panwar and Malik, 2015) [15]. The Marine ecosystem of the estuaries and lagoon are among the most productive and zooplankton rich in the world (Robertson and Blabber, 1992) [22]. The fishery exhibits marked fluctuation from season to season and from year to year. Fisheries production is influenced mainly by the abundance and distribution pattern of phytoplankton and zooplankton (Jeyaraj *et al.*, 2014) [9]. The species diversity and abundance of the zooplankton are essential to assess the potential fishery resources of a place (Varadharajan *et al.*, 2009) [26]. Diversity indices have been used as an important tool by ecologists to understand community structure in terms of richness, evenness, or a total number of existing individuals (Wilhm and Dorris, 1968 and Allan, 1975) [29, 1]. Many works have been extensively conducted the distribution of zooplankton along Tamil Nadu coast (Chacko, 1949 [4]; Raghu, 1954 [20]; Santhakumari and Saraswathy, 1981 [23]; Varadharajan and Soundarapandian, 2013 [27]; Jeyaraj *et al.*, 2014 [9]; Velmurugan *et al.*, 2014 [28] and Pitchaikani and Lipton, 2015 [17]). However, the information on seasonal abundance and diversity of zooplankton from the waters of the Gulf of Mannar is still scanty. Hence, the present study was carried out to study the seasonal distribution and diversity of zooplankton at three selected stations in the nearshore waters of the Gulf of Mannar.

Materials and Methods

Sample collection

The samples of zooplankton were investigated at three stations. The three stations were

Station-1 (Mandapam), Station-2 (Thoothukudi) and Station-3 (Punnakayal) in the coastal waters of the Gulf of Mannar (Fig. 1). Zooplankton samples were collected seasonally (summer, pre-monsoon, monsoon and post-monsoon) from the surface waters of the study area during the study period (September 2017 to May 2019). Samples were collected by horizontal

towing of the plankton net for 45 minutes at all three sampling stations. Ring diameter of Plankton net was 45 cm and mesh size 158 μ m. Samples were preserved in 5% formalin (Parsons *et al.*, 1984) [16] and used for qualitative analysis.

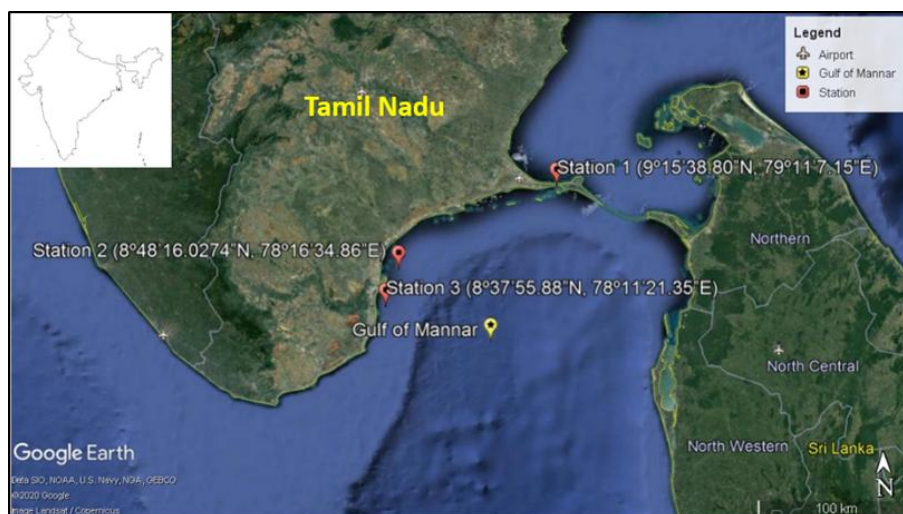


Fig 1: Map showing the sampling stations (Station 1, Station 2 and Station 3) in the nearshore waters of Gulf of Mannar.

Morphological characterization

Quantitative estimation of zooplankton was done using the Sedgwick rafter cell counting method. The samples analysis and pictures were captured with a digital camera under a binocular microscope at a magnification of about four times (4X) and zooplankton were identified using the keys of the standard publications of Kasturirangan (1963) [11] and Santhanam and Srinivasan (1994) [24].

Statistical analysis

The species evenness, richness, diversity index were calculated by using PRIMER V6.1.9 statistical package developed by Plymouth Marine Laboratory, United Kingdom (Clarke and Gorley, 2006) [5].

Results and Discussion

In the present study, 35 species of zooplankton representing 8 phyla, 10 classes, 13 orders, 20 families and 32 genera were recorded from all the three stations from September 2017 to May 2019. A total of, 12 species of Decapoda, 8 species of Calanoida, 3 species of Pteropoda, 2 species of Cyclopoida and Harpacticoida, 1 species of Poecilostomatoida, Siphonostomatoida, Ctenopoda, Onychopoda, Aphragmophora, Copelata, Lingulida and Rhizostomeae (Table1). Among these, 31, 29 and 31 species were identified from stations 1, 2 and 3 respectively and Decapods and Calanoids were found to be the dominant species. Similar observations were made by Pitchaikani and Lipton (2015) [17] in the Gulf of Mannar region. Rakesh *et al.* (2006) [21], Prasath *et al.* (2011) [19] and Mahesh *et al.* (2015) [13] have documented 112, 21 and 110 species of zooplankton respectively from the east coast of India. Anandakumar and Tajuddin (2013) [2], Pitchaikani and Lipton (2015) [17] and Jeyaraj *et al.* (2016) [10] have reported 72, 49 and 114 species of zooplankton respectively in Gulf of Mannar region. The maximum numbers of zooplankton were recorded from station 1 and station 3 followed by station 2. The reason behind this may be because of the enrichment of the nutrients

along with favourable temperature, as optimal temperature favours the growth of plankton in Gulf of Mannar. Santhakumari and Saraswathy (1981) [23] reported the maximum number of zooplankton in the coastal waters of Thoothukudi, Tamil Nadu.

Tables 2, 3 and 4 summarise the seasonal distribution of zooplankton species recorded from the three stations. At station 1, 2 and 3, the number of species distributed during different seasons ranged from 9 to 26, 14 to 25 and 14 to 28. Maximum numbers of species were observed during summer 2018 at all three stations and minimum number of species were observed during pre-monsoon 2017 at all stations. In the current investigation, it was observed that there are similar trends in the seasonal distribution of zooplankton species between all three stations.

In the current investigation, zooplankton density was in the range from 542 to 33, 519 nos. m^{-3} at station 1, 821 to 41, 624 nos. m^{-3} at station 2 and 761 to 39, 648 nos. m^{-3} at station 3 (Fig. 2). In the waters of the Gulf of Mannar, Maheswari *et al.* (2011) [14] recorded zooplankton density in the range of 10,306 to 15,245 nos. L^{-1} , Velmurugan *et al.* (2014) [28] reported the density ranged from 9,800 to 2, 07,000 nos. m^{-3} and Jeyaraj *et al.* (2016) [10] observed the maximum density of 11,733 nos. m^{-3} . In the present investigation, maximum and minimum density was recorded during summer 2018 and post-monsoon 2018 at all three stations (Fig. 2). Similar observations were made by Prabhakar *et al.* (2011) [18] from Cuddalore coastal zone, Tamil Nadu and Velmurugan *et al.* (2014) [28] from the waters of Thoothukudi, Tamil Nadu.

Zooplankton diversity comprises of species richness (number of species in a defined area) and species abundance (relative number of species) (Gorman and Karr, 1978) [8]. The study of species diversity or species richness gives ecologists insights into the stability of communities (Magurran, 2004) [12]. The species richness and diversity of zooplankton at three sampling stations were determined using Pielous evenness which was highest at station 1 (0.60) and lowest at station 3 (0.42). An almost a similar value of Pielous evenness index

(0.9278-0.8741) was observed by Varadharajan and Soundarapandian (2013)^[27] in the coastal waters of Tamil Nadu. Margalef's species richness was highest at station 1 and 3 (0.42) and lowest at station 2 (0.41). The observed range of Margalef's species richness (d) index by Dutta (2005)^[7] and Deepika (2017)^[6] in the Gulf of Mannar region was 1.12 to 3.11 and 2.97 to 7.13, which were higher than the present

study. Shannon-Wiener species diversity was highest at station 1 (1.55) and lowest at station 3 (1.10) (Table 5). An almost similar observation of H' value ranged from 0 to 2.88 reported by Prasath *et al.* (2011)^[19] along the east coast of India, 1.64 to 2.28 by Velmurugan *et al.* (2014)^[28] from the waters of Thoothukudi, Tamil Nadu and 0.88 to 1.58 by Deepika (2017)^[6] from Mandapam in Gulf of Mannar.

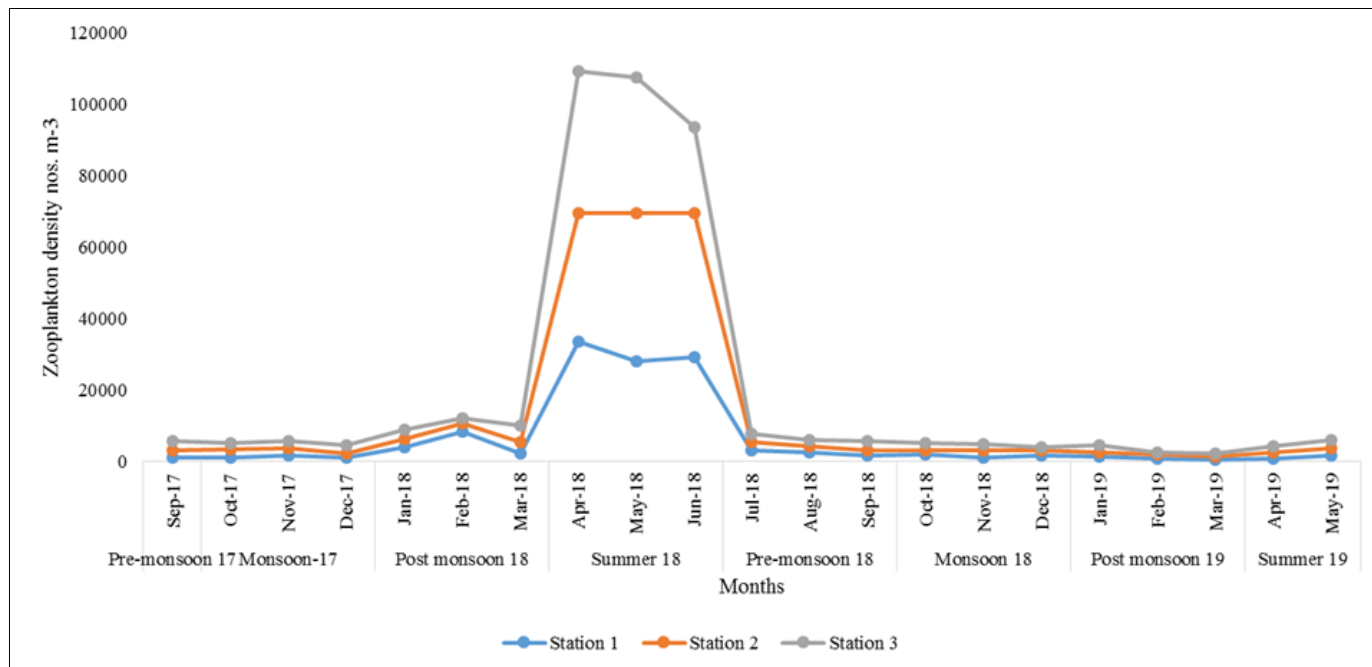


Fig 2: Seasonal variations in zooplankton density at station 1, 2 and 3.

Table 1: Zooplankton species composition of studied stations

Zooplankton species	Station 1	Station 2	Station 3
Kingdom: Animalia			
Phylum: Arthropoda			
Class: Hexannauplia			
Subclass: Copepoda			
Order: Calanoida			
Family: Acartiidae			
1. <i>Acartia dane</i>	+	+	+
2. <i>Acartia erythraea</i>	+	+	+
Family: Paraclanidae			
3. <i>Acrocalanus gracilis</i>	+	+	+
4. <i>Paracalanus parvus parvus</i>	+	+	+
Family: Pontellidae			
5. <i>Calanopia minor</i>	+	+	+
6. <i>Pontella sp.</i>	+	+	+
Family: Centropagidae			
7. <i>Centropages furcatus</i>	+	+	+
Family: Temoridae			
8. <i>Temora turbinata</i>	+	+	+
Order: Cyclopoida			
Family: Corycaeidae			
9. <i>Corycaeus crassiusculus</i>	+	+	+
Family: Oithonidae			
10. <i>Dioithona rigida</i>	+	+	+
Order: Poecilostomatoida			
Family: Oncaeidae			
11. <i>Oncaea venusta</i>	+	+	+
Order: Harpacticoida			
Family: Tachidiidae			
12. <i>Euterpina acutifrons</i>	+	+	+
Family: Ectinosomatidae			
13. <i>Microsetella norvegica</i>	+	+	+

Order: Siphonostomatoidea			
Family: Tachidiidae			
14. <i>Caligus</i> sp.	+	-	+
Class: Branchiopoda			
Superorder: Cladocera			
Order: Ctenopoda			
Family: Sididae			
15. <i>Penilia avirostris</i>	-	+	+
Order: Onychopoda			
Family: Podonidae			
16. <i>Pseudevadne tergestina</i>	+	+	+
Phylum: Chaetognatha			
Class: Sagittoidae			
Order: Aphragmophora			
Family: Sagittidae			
17. <i>Sagitta</i> sp.	+	+	+
Phylum: Chordata			
Class: Appendicularia			
Order: Copelata			
Family: Oikopleuridae			
18. <i>Oikopleura dioica</i>	+	+	+
Phylum: Arthropoda			
Class: Malacostraca			
Order: Decapoda			
Family: Porcellanidae			
19. Porcelain crab zoea	+	-	-
Family: Luciferidae			
20. <i>Belzebub hanseni</i>	+	+	+
Meroplankton			
Phylum: Arthropoda			
21. Barnacle Nauplius	+	-	+
22. Crustacean Nauplius	+	+	+
23. Copepod Nauplius	+	+	+
24. Crab zoea	+	+	+
25. Prawn mysis	+	+	+
Family: Squillidae			
26. <i>Squilla</i> larvae	+	-	-
Phylum: Mollusca			
Class: Bivalvia			
27. Bivalve veliger	+	+	+
Class: Cephalopoda			
28. Cephalopod larva	+	+	-
Class: Gastropoda			
29. Gastropod veliger	+	+	+
30. Snail larvae	+	+	+
Order: Pteropoda			
Family: Creseidae			
31. <i>Cresis acicula</i>	-	+	+
Phylum: Nematoda			
32. Nematode worm	-	-	+
Phylum: Annelida			
33. Polychaete larvae	+	+	+
Phylum: Brachiopoda			
Class: Lingulata			
Order: Lingulida			
Family: Lingulidae			
34. <i>Lingula reevii</i>	+	-	-
Phylum: Cnidaria			
Class: Scyphozoa			
Order: Rhizostomeae			
Family: Mastigiidae			
35. <i>Mastigias papua</i>	-	+	+
Total no. of species	31	29	31

Table 2: Seasonal distribution of different zooplankton species at station 1

S. No.	Zooplankton species	Pre-monsoon 17	Monsoon 17	Post monsoon 18	Summer 18	Pre-monsoon 18	Monsoon 18	Post monsoon 19	Summer 19
1.	<i>Acartia dane</i>	+	+	+	+	+	+	+	+
2.	<i>Acartia erythraea</i>	-	+	+	+	+	+	+	+
3.	<i>Acrocalanus gracilis</i>	-	+	+	+	+	+	+	+
4.	<i>Paracalanus parvus parvus</i>	+	+	+	+	+	+	+	-
5.	<i>Calanopia minor</i>	-	-	+	+	+	+	-	+
6.	<i>Pontella sp.</i>	-	-	+	+	+	-	-	+
7.	<i>Centropages furcatus</i>	-	-	+	+	+	+	-	-
8.	<i>Temora turbinata</i>	-	-	+	+	+	+	-	-
9.	<i>Corycaeus crassiusculus</i>	-	+	+	+	+	+	+	-
10.	<i>Dioithona rigida</i>	+	+	+	+	+	+	+	+
11.	<i>Oncaea venusta</i>	-	+	+	+	+	+	-	-
12.	<i>Euterpina acutifrons</i>	-	+	+	+	+	+	+	+
13.	<i>Microsetella norvegica</i>	+	+	+	+	+	+	+	+
14.	<i>Caligus sp.</i>	-	-	-	-	+	-	-	-
15.	<i>Pseudevadne tergestina</i>	-	-	+	+	+	+	-	-
16.	<i>Sagitta sp.</i>	-	-	-	+	+	+	+	-
17.	<i>Oikopleura dioica</i>	-	+	-	+	+	-	-	-
18.	Porcelain crab zoea	-	-	+	-	+	-	-	-
19.	<i>Belzebub hansenii</i>	+	+	+	+	+	+	+	+
20.	Barnacle Nauplius	-	+	+	+	-	+	+	+
21.	Crustacean Nauplius	-	+	-	+	+	+	+	-
22.	Copepod Nauplius	+	+	-	-	-	+	-	-
23.	Crab zoea	-	+	+	+	+	-	+	-
24.	Prawn mysis	+	+	+	+	+	+	+	+
25.	<i>Squilla</i> larvae	-	-	-	-	-	+	-	-
26.	Bivalve veliger	+	+	+	+	+	+	+	+
27.	Cephalopod larva	-	-	-	+	-	-	-	-
28.	Gastropod veliger	+	+	+	+	+	+	-	+
29.	Snail larvae	-	-	-	+	-	-	-	-
30.	Polychaete larvae	-	-	-	+	+	+	-	-
31.	<i>Lingula reevii</i>	-	-	-	-	-	+	-	-
	Total no. of species	9	18	21	26	25	24	15	13

Table 3: Seasonal distribution of different zooplankton species at station 2

S. No.	Zooplankton species	Pre-monsoon 17	Monsoon 17	Post monsoon 18	Summer 18	Pre-monsoon 18	Monsoon 18	Post monsoon 19	Summer 19
1.	<i>Acartia dane</i>	+	+	+	+	+	+	+	+
2.	<i>Acartia erythraea</i>	+	+	+	+	+	+	+	+
3.	<i>Acrocalanus gracilis</i>	-	+	+	+	+	+	+	+
4.	<i>Paracalanus parvus parvus</i>	+	+	+	+	+	+	+	+
5.	<i>Calanopia minor</i>	-	-	-	+	+	-	-	+
6.	<i>Pontella sp.</i>	-	-	+	+	+	+	-	+
7.	<i>Centropages furcatus</i>	-	+	+	+	-	+	-	-
8.	<i>Temora turbinata</i>	+	+	-	+	+	+	-	-
9.	<i>Corycaeus crassiusculus</i>	-	+	+	-	-	-	+	-
10.	<i>Dioithona rigida</i>	+	+	+	+	+	+	+	-
11.	<i>Oncaea venusta</i>	-	+	+	+	+	+	-	-
12.	<i>Euterpina acutifrons</i>	+	+	+	+	+	+	+	+
13.	<i>Microsetella norvegica</i>	+	+	+	+	+	+	+	+
14.	<i>Penilia avirostris</i>	+	+	+	+	+	+	+	-
15.	<i>Pseudevadne tergestina</i>	+	+	+	+	+	+	+	-
16.	<i>Sagitta sp.</i>	+	+	+	+	+	+	+	+
17.	<i>Oikopleura dioica</i>	-	+	+	+	+	-	+	-
18.	<i>Belzebub hansenii</i>	+	+	+	+	+	+	+	+
19.	Crustacean Nauplius	-	+	-	+	+	-	-	+
20.	Copepod Nauplius	+	+	-	-	-	-	-	-
21.	Crab zoea	-	+	+	+	-	-	+	-
22.	Prawn mysis	+	+	+	+	-	+	+	+
23.	Bivalve veliger	+	+	+	+	+	+	+	+
24.	Cephalopod larva	-	-	-	-	-	-	-	+
25.	Gastropod veliger	-	+	+	+	+	+	+	+
26.	Snail larvae	-	+	+	+	-	+	-	+
27.	<i>Cresis acicula</i>	-	+	-	+	+	-	-	-
28.	Polychaete larvae	-	-	+	+	-	+	-	-
29.	<i>Mastigias papua</i>	-	-	+	-	-	-	-	-
	Total no. of species	14	24	23	25	21	20	18	15

Table 4: Seasonal distribution of different zooplankton species at station 3

S. No.	Zooplankton species	Pre-monsoon 17	Monsoon 17	Post monsoon 18	Summer 18	Pre-monsoon 18	Monsoon 18	Post monsoon 19	Summer 19
1.	<i>Acartia dane</i>	+	+	+	+	+	+	+	+
2.	<i>Acartia erythraea</i>	+	+	+	+	+	+	+	+
3.	<i>Acrocalanus gracilis</i>	+	+	+	+	+	+	+	+
4.	<i>Paracalanus parvus parvus</i>	+	+	+	+	+	+	+	+
5.	<i>Calanopia minor</i>	-	-	+	+	+	+	+	+
6.	<i>Pontella sp.</i>	-	+	+	+	+	+	-	-
7.	<i>Centropages furcatus</i>	-	+	+	+	+	+	-	-
8.	<i>Temora turbinata</i>	+	+	+	+	+	+	-	-
9.	<i>Corycaeus crassiusculus</i>	-	+	+	+	+	+	+	-
10.	<i>Dioithona rigida</i>	+	+	+	+	+	+	+	-
11.	<i>Oncaea venusta</i>	+	+	+	+	+	+	-	-
12.	<i>Euterpina acutifrons</i>	+	+	+	+	+	+	+	+
13.	<i>Microsetella norvegica</i>	+	+	+	+	+	+	+	+
14.	<i>Caligus sp.</i>	-	-	-	-	-	+	-	-
15.	<i>Penilia avirostris</i>	+	+	+	+	+	+	-	-
16.	<i>Pseudevadne tergestina</i>	+	+	+	+	+	+	+	-
17.	<i>Sagitta sp.</i>	+	+	+	+	+	+	+	+
18.	<i>Oikopleura dioica</i>	-	+	+	+	+	-	+	-
19.	<i>Belzebug hansenii</i>	+	+	+	+	+	+	+	+
20.	Barnacle Nauplius	-	+	+	+	+	-	+	+
21.	Crustacean Nauplius	-	+	+	+	-	-	+	+
22.	Copepod Nauplius	-	+	+	-	-	+	-	-
23.	Crab zoea	-	+	+	+	+	+	+	+
24.	Prawn mysis	+	+	+	+	+	+	+	+
25.	Bivalve veliger	-	+	+	+	+	+	+	+
26.	Gastropod veliger	-	+	-	+	-	+	+	-
27.	Snail larvae	-	-	-	+	+	+	-	+
28.	<i>Cresis acicula</i>	-	+	+	+	+	-	-	+
29.	Nematode worm	-	-	-	+	-	-	-	-
30.	Polychaete larvae	-	-	-	+	-	-	-	-
31.	<i>Mastigias papua</i>	-	-	+	-	-	-	-	-
	Total no. of species	14	25	26	28	24	23	19	15

Table 5: Zooplankton evenness, diversity, richness and index of three selected stations in the waters of Gulf of Mannar

Stations	Indices	Ranges	Overall
Station 1 (Mandapam)	d	0.43-0.71	0.42
	J'	0.36-0.76	0.60
	H'(log ₂)	0.95-1.96	1.55
Station 2 (Thoothukudi)	d	0.42-0.65	0.41
	J'	0.42-0.72	0.53
	H'(log ₂)	1.1-1.87	1.38
Station 3 (Punnakayal)	d	0.43-0.63	0.42
	J'	0.28-0.86	0.42
	H'(log ₂)	0.73-2.24	1.10

Conclusion

The composition of zooplankton comprised of 35 species representing 20 families and 32 genera. Decapods and Calanoids were the most abundant groups. The highest density of zooplankton was recorded in summer 2018 at all sampling stations however; minimum density was recorded in post-monsoon 2018 at all sampling stations. Growth of zooplankton was maximum in summer 2018 and minimum in post-monsoon 2018, the reason may be because of enrichment of the nutrients along with the favourable temperature. The results of the current investigation indicated that the rich zooplankton diversity in the nearshore waters of the Gulf of Mannar.

Acknowledgments

The first author thanks Tamil Nadu Dr. J. Jayalalitha Fisheries University, Tamil Nadu for providing facilities and encouragement to carry out the work. This manuscript is part

of the Ph.D. research work of the first author approved by the Tamil Nadu Dr. J. Jayalalitha Fisheries University, Tamil Nadu.

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