Pelagic Fish Eggs Diversity in the Nearshore Waters of Gulf of Mannar, South East Coast of India

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10.18805/ijar.B-3889

ABSTRACT

Background: A study of the diversity, distribution and development of fish eggs and larvae as an integral part of a fishery research programme serves as a valuable aid in the proper management of fisheries. The study is also an essential prerequisite in understanding the spawning biomass of forecasting and trends of production. Information available on diversity of fish eggs from Indian waters is inadequate. The present study was conducted to understand the diversity and distribution of pelagic fish eggs in the nearshore waters of Gulf of Mannar.

Methods: The present study conducted at three stations-Mandapam, Thoothukudi and Punnakayal in the waters of Gulf of Mannar, during 2017-2019. A total of 684 ichthyoplankton samples were collected. In the laboratory, the samples were sorted and identified. The diversity was calculated by Shannon-Weiner, Margalef richness index and Pielou's evenness indices. All the diversity indices were done by using the PRIMER-E software.

Result: Our investigation was taken up with objective to assess the status of pelagic fish eggs diversity in the nearshore waters of Gulf of Mannar and found to be more productive. From the diversity study, it is evident that the Punnakayal waters are habitat for a rich diversity of fish species and also a spawning and nursery ground for fishes. Fish eggs diversity is significant for management of fishery resources.

Key words: Biodiversity, Diversity, Eggs, Gulf of mannar.

INTRODUCTION

A study of the diversity, distribution and development of fish eggs and larvae as an integral part of a fishery research programme serves as a valuable aid in the proper management of fisheries (Bapat, 1955). The study is also an essential prerequisite in understanding the spawning biomass of forecasting and trends of production (Ahlstrom, 1976). Information on abundance and distribution of eggs are important in understanding the life history of any species and will help in locating shoals of fish and their breeding grounds of the ecosystem (Manickasundaram *et al.,* 1987). Most of the marine fishes spawn in the open sea and produce pelagic eggs and larvae (Rengarajan and David, 1984 and Young *et al.,* 1986).

Information available on diversity of fish eggs from Indian waters is inadequate. Earlier, Rajasegar *et al.* (2005), Selvam *et al.* (2013) and Srilatha *et al.* (2013) described the distribution of fish eggs and larvae from Arasalar estuary, Muthupettai and Point Calimere whereas Balakrishnan *et al.* (2015) described seasonal abundance and distribution of ichthyoplankton diversity in the Coleroon estuarine, South east coast of India. These authors mainly focused on qualitative studies of eggs and larvae. Though few works available on the diversity and distribution of fish eggs in Indian waters. However, such studies are not attempted in the waters of Gulf of Mannar. Hence, the present study was conducted to understand the diversity and distribution of pelagic fish eggs in the nearshore waters of Gulf of Mannar.

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How to cite this article: Saroj, J., Jawahar, P., Srinivasan, A., Neethiselvan, N. and Jayakumar, N. (2020). Pelagic Fish Eggs Diversity in the Nearshore Waters of Gulf of Mannar, South East Coast of India. Indian Journal of Animal Research. 54(10): 1296-1303.

Submitted: 25-07-2019 **Accepted:** 25-04-2020 **Published:** 28-07-2020

MATERIALS AND METHODS

The present study was conducted at three stations-Mandapam (Station I) (Lat., 9.28°N, Long., 79.12°E), Thoothukudi fishing Harbor (Station II) (Lat., 8°47′N, Long., 78°9′ E) and Punnakayal (Station III) (Lat., 8°38′ N, Long., 78°7′ E) in the nearshore waters of Gulf of Mannar, south east coast of India during the period from September 2017 to May 2019 (Fig 1). Sampling was done at monthly intervals corresponding to four seasons: Summer, Pre-monsoon, Monsoon and Post-monsoon. A total of 684 ichthyoplankton samples were collected during the study period in the early hours of the day with a 158 μm mesh conical-cylindrical bongo net using surface horizontal hauls lasting 15 minutes each. Samples collected from all the stations were preserved in 5% buffered formalin-seawater and sorted in the laboratory (Day, 1875-1878). In the laboratory, the samples were sorted under the microscope (Nikon SMZ-2T-Nikon Corporation, Japan and Nikon Eclipse E200MV R-Nikon Corporation, Japan) to separate eggs from other organisms.

Eggs identification was performed in accordance with Delsman (1922-1935); Bal and Pradhan (1951), Nair (1952), Bapat (1955), Vijayaraghavan (1958), Venkataramanujam (1975), Ahlstrom and Moser (1976), Russel (1976), Thangaraja (1982), Bensam (1987), Manickasundaram *et al.* (1987), Lalithambika Devi (1993) and Jeyaseelan (1998).

Fish eggs were sorted out from the entire sample and their abundance was expressed as number of eggs/100 m³. The diversity was calculated by Shannon-Weiner, Margalef richness index and Pielou's evenness indices. K- Dominance plot was drawn by ranking the species in decreasing order of abundance (Warwick, 1986). The similarity in species composition based on the abundance was studied by calculating the Bray-Curtis coefficient (Cluster analysis) (Bray and Curtis, 1957). All the diversity indices were done by using the PRIMER-E (Version 6.1.6) analytical package developed by Plymouth Marine Laboratory, U.K. (Clarke and Warwick, 2001; Clarke and Gorley, 2006).

RESULTS AND DISCUSSION

Station wises species composition

The fish eggs in the present study comprises of different species with high abundance. Sampling during early hours of high tide showed high numbers of eggs but during low tide eggs were recorded less. The present study of fish eggs in the nearshore waters of Gulf of Mannar showed that most of the fish eggs species were widely distributed at station III. A total 16 species of fish eggs belonging to 15 genera, 10 families and 7 orders were recorded from station I, 20 species of fish eggs belonging to 16 genera, 11 families and 8 orders from station II and 28 species of fish eggs belonging to 22 genera, 13 families and 9 orders from station III. Eggs of *Cynoglossus semifasciatus* were most numerous and prevalent at all Stations and showed the highest density (3476.75 eggs/100 m³) at Station III (Table 1). Srilatha *et al.* (2013) have reported 18 species of eggs from Point Calimere and 24 species of eggs from Muthupettai. Almost similar results of fish eggs were recorded during the present study.

Familywise composition

Percentage composition of eggs varied from all the three stations. Among these, Clupidae was the predominant family at station I (Fig 2) and Cynoglossidae was the predominant family at station II and III (Fig 3, 4). Selvam *et al.* (2013) have reported major families of fish eggs were Clupeidae from Muthupettai and Balakrishnan *et al.* (2015) have observed major families of eggs were Engraulidae (11.39%) in the Coleroon estuarine, southeast coast of India.

Diversity indices

Shannon-Wiener Species Diversity Index [H'($\log_2$)]

In the present study, the diversity indices were used to characterize species abundance in the community. At station I, the value of seasonal variation in H'($\log_2$) calculated for overall study period was 3.503 (Table 5). The seasonal variation in H'($\log_2$) varied from 0.9903 to 1.952. While the minimum (0.9903) was during pre-monsoon 2017 and maximum (1.952) was during summer 2019 (Table 2). At station II, the value of seasonal variation in H'($\log_2$) calculated for overall study period was 4.267 (Table 5). The diversity index value was ranged from 0.9597 to 3.094. The minimum (0.9597) was in pre-monsoon 2017 and maximum (3.094) was during post monsoon 2018 (Table 3). At station III, the value of seasonal variation in H' ($\log_2$) calculated for

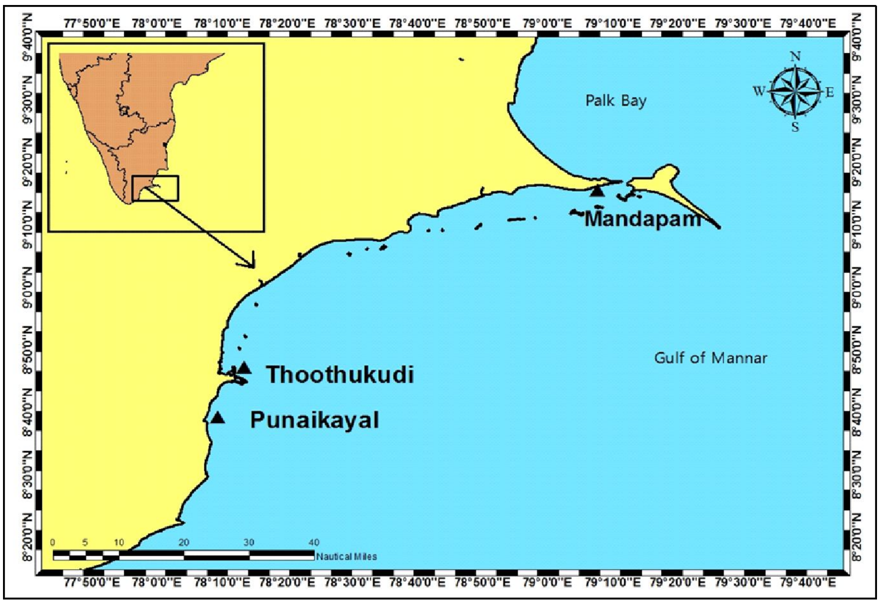

Fig 1: Map showing sampling stations in the nearshore waters of Gulf of Mannar.

Table 1: Distribution of fish eggs (number per 100m³) in different areas in Gulf of Mannar.

Taxa	Species	Station I Egg/100m³	Station II Egg/100m³	Station III Egg/100m³
Anguilliformes				
Ophichthidae	*Ophicthus* spp.	-	562.62	306.06
	Ophisurus macrorhynchos	-	-	2.52
Atheriniformes				
Atherinidae	*Atherinomorus lacunosus*	-	44.94	260.10
Aulopiformes				
Synodontidae	*Saurida gracilis*	-	-	2.52
	Saurus sp.	0.50	-	0.50
	Synodontid egg	0.50	-	1.01
	Synodus indicus	-	1.51	-
Beloniformes				
Exocoetidae	*Hirundichthys coromandelensis*	0.50	-	-
Hemiramphidae	*Hemiramphus* spp.	163.13	-	-
Callionymiformes				
Callionymidae	*Callionymus*	-	6.06	19.69
Clupeiformes				
Clupeidae	*Amblygaster leiogaster*	383.83	-	-
	Dussumieria elopsoides	39.39	-	-
	Escualosa thoracata	16.16	17.17	223.73
	Opisthopterus tardoore	73.23	-	99.49
	Sardinella gibbosa	22.72	30.30	3.03
	Sardinella longiceps	61.11	43.93	-
	Sardinella jussieu	-	12.62	-
Chirocentridae	*Chirocentrus dorab*	27.27	-	263.63
Engraulidae	*Encrasicholina heteroloba*	-	32.32	110.10
	Encrasicholina punctifer	-	-	31.81
	Setipinna taty	-	-	1.01
	Stolephorus baganensis	-	2.52	17.17
	Stolephorus tri	-	4.04	38.38
	Thryssa dussumieri	-	-	2.02
	Thryssa hamiltonii	-	-	11.11
	Thryssa mystax	-	4.54	23.73
Mugiliformes				
Mugilidae	*Liza macrolepis*	-	12.62	11.61
	Mugil cephalus	38.38	197.47	475.25
Perciformes				
Carangidae	*Carangoides malabaricus*	-	121.21	-
	Caranx sp.	98.98	31.31	419.69
	Decapterus russelli	-	-	121.21
Terapontidae	*Terapon jarbua*	75.75	-	-
Pleuronectiformes				
Cynoglossidae	*Cynoglossus arel*	-	112.62	985.8586
	Cynoglossus semifasciatus	148.48	776.76	2551.51
Soleidae				
Paralichthyidae	*Aesopia cornuta*	-	-	0.50
	Pseudorhombus javanicus	-	263.63	157.07
Scombriformes				
Scombridae	*Scomberomorous commerson*	18.68	-	-
Tetraodontiformes				
Tetraodontidae	*Arothron* spp.	-	-	193.9394
Total		1168.68	2278.28	6333.83

- = absent

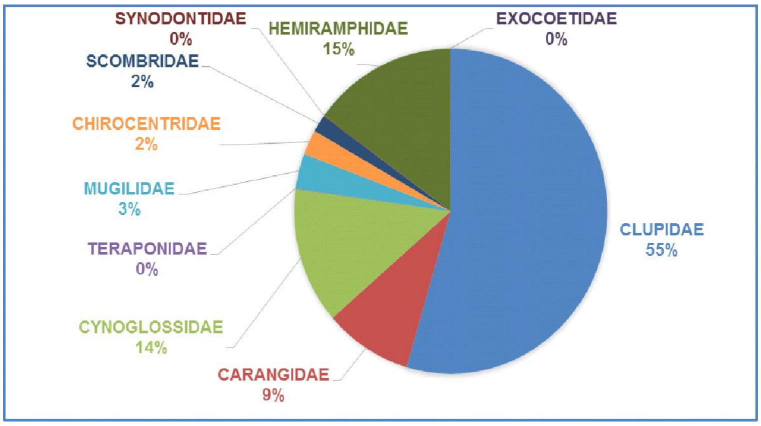

Fig 2: Family wise % composition fish eggs at station I in the nearshore waters of Gulf of Mannar.

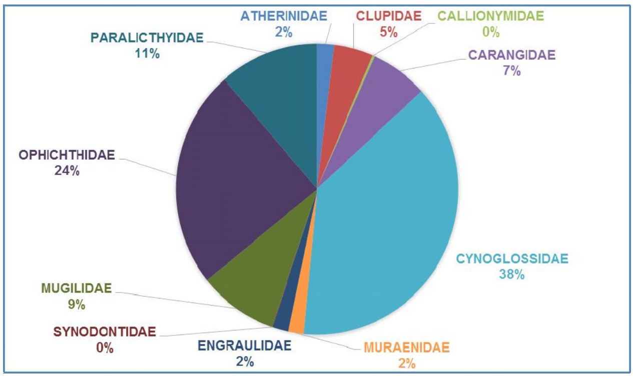

Fig 3: Family wise % composition fish eggs at station II in the nearshore waters of Gulf of Mannar.

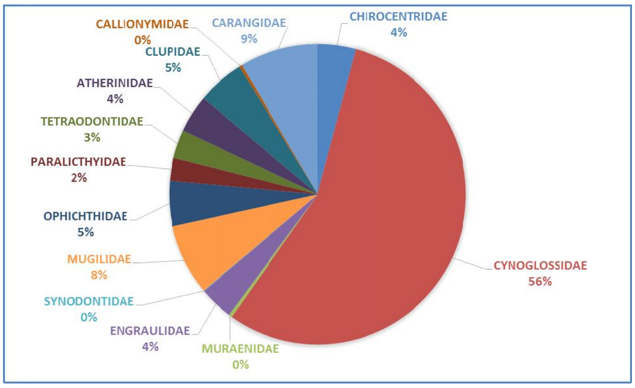

Fig 4: Family wise % composition fish eggs at station III in the nearshore waters of Gulf of Mannar.

overall study period was 4.52 (Table 5). The diversity index value was ranged from 0.5044 to 3.461. The minimum (0.5044) was in pre-monsoon 2017 and maximum (3.461) was during pre-monsoon 2018 (Table 4). The Shannon Wiener species diversity index values of eggs at station III were found to be on the higher side. The Shannon-Wiener species diversity index values for eggs reported from other regions along South east coast of Tamil Nadu were: at Point Calimere (3.25 to3.87) and at Muthupettai 3.83 to 4.48 (Srilatha *et al.,* 2013). However, the diversity values of eggs in present study were lower than the above values indicated lower fish eggs diversity at studied stations.

Margalef's species richness (d)

Margalef index measures species richness and it is greatly sensitive to sample size although it tries to compensate for sampling effects (Magurran, 2004). The individual species dominance affects the species richness. At station I, calculated value of Margalef richness index (d) for overall study period was 3.016 (Table 5). The seasonal variation in eggs richness values varied from 0.2433 to 0.6311. The minimum (0.2433) was recorded during monsoon 2017 and the maximum 0.6311 was observed during summer 2019 (Table 2). The calculated value of species richness for overall study period was 4.813 at station II (Table 5). The eggs richness values ranged from 0.3954 to 2.119 at station II. The minimum (0.3954) was observed during pre-monsoon 2017 and the maximum (2.119) was recorded monsoon 2018 (Table 3). At station III, calculated value of Margalef richness index (d) for overall study period was 5.584 (Table 5). The eggs species richness values varied from 0.3937 to 3.308. Maximum (3.308) was recorded in pre-monsoon 2018 and minimum (0.3937) was recorded in pre-monsoon 2017 (Table 4). The observed range of species richness (d) index by Srilatha *et al.* (2013) at Point Calimere and Muthupettai was 0.90 to 0.95 lower than the present study.

Pielou's Evenness Index (J')

Pielou's evenness index expresses how evenly the individuals are distributed among the different species. Pielou's evenness index is strongly affected by species richness (Peet, 1974). Generally, species evenness increases when the species richness and species diversity decreases (Clarke and Warwick, 2001). During the present study, the observed value of Pielou's evenness index (J') was 0.977 at station I (Table 5). However, J' varied between the seasons and stations. At station I, eggs evenness index (J') varied from 0.6248 to 0.9983. Maximum (0.9983) was recorded in monsoon 2017 and minimum (0.6248) was recorded in pre monsoon 2017 (Table 2). At station II, observed value of evenness index was 0.9715 (Table 5). The eggs evenness values fluctuated from 0.8965 to 0.9597.

Minimum (0.8965) was observed during post monsoon 2019 and maximum (0.9597) was recorded during pre-monsoon 2017 (Table 3). The observed value of evenness index was 0.9616 at station III (Table 5). The evenness index ranged from 0.5044 to 0.9666. Maximum (0.9666) was recorded in summer 2019 and minimum (0.6248) was in pre-monsoon 2017 (Table 4). The calculated values of evenness index of eggs by Srilatha *et al.* (2013) in Point Calimere and Muthupettai, south east coast of India were relatively lower compared to present study.

Average taxonomic distinctness index (Δ+)

The average taxonomic distinctness index showed great variation between seasons and stations during present study. The average taxonomic distinctness index (Δ+) calculated for 21 months was 88.26 at station I, 92.38 at station II and 92.92 at station III (Table 5). Seasonal variation in Δ+ was in

Table 2: Seasonal variation in fish eggs diversity indices at Mandapam.

Sample	S	N	d	J'	H'(log_2)	Delta+	sPhi+
Pre-monsoon 17	3	66	0.4774	0.6248	0.9903	100	300
Monsoon 17	2	61	0.2433	0.9983	0.9983	100	200
Post monsoon 18	0	0	****	****	0	0	0
Summer 18	1	26	0	****	0	0	100
Pre-monsoon 18	3	71	0.4692	0.882	1.398	100	300
Monsoon 18	1	112	0	****	0	0	100
Post monsoon 19	5	1180	0.5655	0.7405	1.719	95	450
Summer 19	5	566	0.6311	0.8406	1.952	85	400

* = sample no. 0

Table 3: Seasonal variation in fish eggs diversity indices at Thoothukudi.

Sample	S	N	d	J'	H'(log_2)	Delta+	sPhi+
Pre-monsoon 17	2	13	0.3954	0.9597	0.9597	100	200
Monsoon 17	5	35	1.128	0.9104	2.114	92.5	425
Post monsoon 18	10	98	1.962	0.9313	3.094	92.78	775
Summer 18	7	83	1.357	0.9081	2.549	96.43	625
Pre-monsoon 18	6	49	1.285	0.943	2.438	100	600
Monsoon 18	9	44	2.119	0.9421	2.986	91.67	700
Post monsoon 19	3	39	0.5476	0.8965	1.421	100	300
Summer 19	3	15	0.735	0.9263	1.468	100	300

Table 4: Seasonal variation in fish eggs diversity indices at Punnakayal.

Sample	S	N	d	J'	H'(log_2)	Delta+	sPhi+
Pre-monsoon 17	2	13	0.3937	0.5044	0.5044	100	200
Monsoon 17	1	13	0	****	0	0	100
Post monsoon 18	7	86	1.346	0.8676	2.436	98.81	675
Summer 18	6	164	0.9801	0.9571	2.474	95	525
Pre-monsoon 18	17	126	3.308	0.8466	3.461	90.63	1200
Monsoon 18	12	77	2.536	0.9025	3.235	92.8	875
Post monsoon 19	4	35	0.8428	0.911	1.822	100	400
Summer 19	3	60	0.4883	0.9666	1.532	100	300

* = sample no. 0.

Table 5: Comparative account on the fish eggs diversity indices of three selected stations.

Indices	Mandapam (station I)			Thoothukudi (station II)			Punnakayal (station III)		
	Min.	Max.	Overall	Min.	Max.	Overall	Min.	Max.	Overall
S	1	5	12	3	10	21	1	17	26
N	26	1180	38	13	98	64	13	164	88
d	0.243	0.631	3.016	0.395	2.119	4.813	0.39	3.308	5.584
J'	0.624	0.998	0.977	0.896	0.959	0.9715	0.50	0.966	0.9616
H'(log_2)	0.990	1.952	3.503	0.959	3.094	4.267	0.50	3.461	4.52
$Delta^+$	85	100	88.26	91.67	100	92.38	90.6	100	92.92
$sPhi^+$	100	450	925	200	775	1425	100	1200	1800

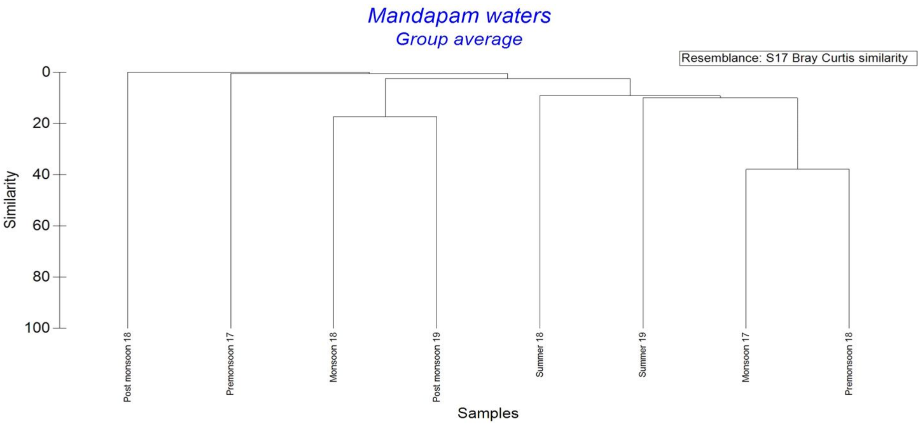

Fig 5: Dendrogram of hierarchial clustering for fish eggs collected from station I during various season.

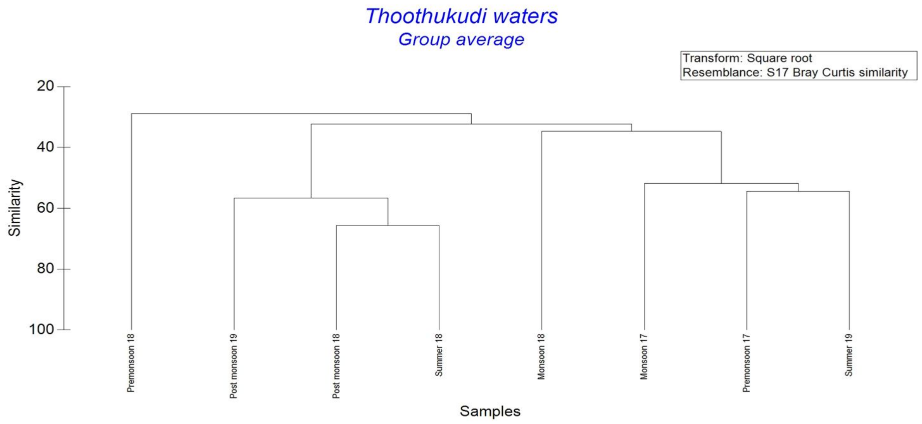

Fig 6: Dendrogram of hierarchial clustering for fish eggs collected from station II during various season.

the range of 85 to 100 at station I (Table2), 91.67 to 100 at station II (Table 3) and 90.63 to 100 at station III (Table 4).

Total phylogenetic diversity index (sPhi+)

The total phylogenetic diversity index (sPhi+) vouches for the taxonomic breadth of the biota (Clarke and Warwick, 1999). In a healthy environment, due to rich faunal assemblages, (taxonomic breadth) the total phylogenetic diversity and average phylogenetic diversity were always higher (Khan *et al.,* 2005). The calculated value of total phylogenetic index during the study period was 925 (Table 5) at station I, 1425 at station II and 1800 at station III (Table 5). The sPhi+ calculated during the seasons varied widely and was in the range of 100 to 450 at station I (Table 2), 200 to 775 at station II (Table 3) and 100 to 1200 at station III (Table 4). The higher seasonal variation in total phylogenetic diversity at Punnakayal station indicated rich egg abundance than other two stations.

Cluster analysis

In the present study, hierarchical cluster analysis technique was used to see the similarity in species composition and abundance during the study period. The cluster analysis was performed between the seasons to organize the individuals into classes or groups using Bray-Curtis similarity based on counts during each season. At station I, the group in the dendrogram was formed by monsoon 2017 and pre-monsoon 2018 seasons at 37.87% similarity (Fig 5). At station II, 65.62% similarity was observed between post monsoon 2018 and summer 2018 (Fig 6) and at station III, 86.10% similarity was recorded between premonsoon 2017 and monsoon 2017 at (Fig 7). Similarity in seasons may be due to similarity in hydrographical parameters of the environment, particularly the fluctuation of salinity and temperature suggested by Lalithambika Devi (1993). Balakrishnan *et al.* (2015) was observed maximum similarity 97.96% between summer and monsoon season in the Coleroon estuarine complex, South east coast of India.

The cluster analysis was performed between the station I (Mandapam), station II (Thoothukudi) and station III (Punnakayal) to organize the individuals into classes or groups using Bray-Curtis similarity based on counts in each stations. The group in the dendrogram was formed by Thoothukudi and Punnakayal stations at 67.87% similarity (Fig 8).

K-Dominance curve

The K-dominance curve was plotted station wise. The result from K-dominance curve was obtained by plotting percentage cumulative abundance against species rank K on a logarithmic scale. Cumulative curve (K-dominance curve) or Abundance Biomass Curve (ABC) expressed as

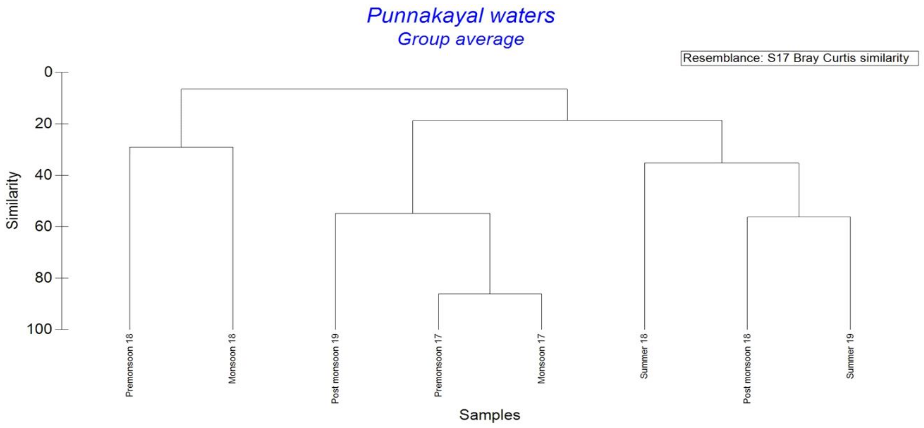

Fig 7: Dendrogram of hierarchial clustering for fish eggs collected from station III during various seasons.

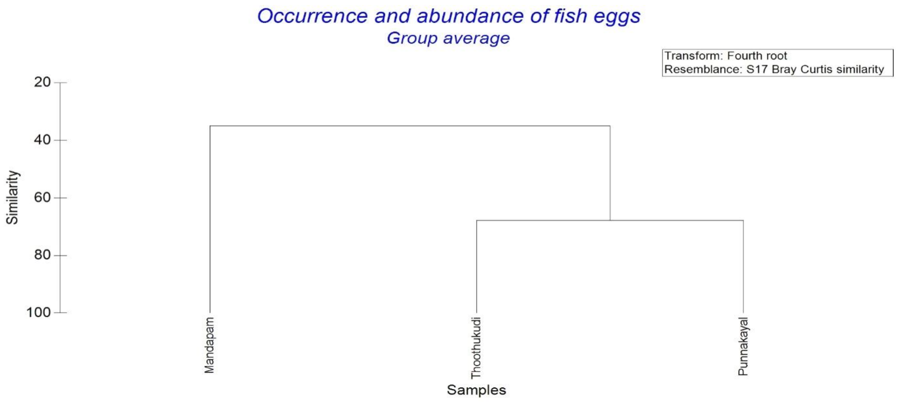

Fig 8: Dendrogram of hierarchial clustering for fish eggs collected from all the three stations**.**

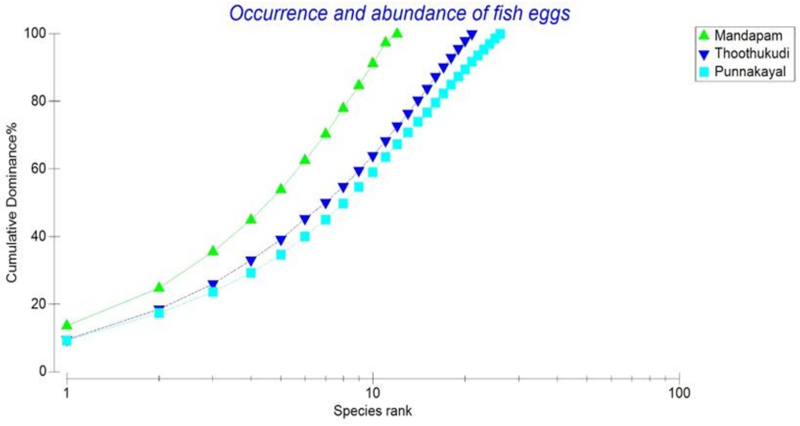

Fig 9: K-dominance curve for species biomass of fish eggs during the study period (Station wise).

the percentage of abundance in the sample, referred to as dominance plot shows that curve for station III (Punnakayal), which lie on the lower side, extended further and rise slowly due to high density of species. This plot shows that density of fish eggs species is high at station III (Punnakayal) and proved the number of species (richness) more at station III compared to other stations (Fig 9).

CONCLUSION

The present investigation was taken up with objective to assess the status of pelagic fish eggs diversity in the nearshore waters of Gulf of Mannar and found to be more productive. From the diversity study it is evident that the Punnakayal waters are habitat for a rich diversity of fish species and also a spawning and nursery ground for fishes. Fish eggs diversity is significant for management of fishery resources. It is also significant for assessing the richness of family and species. Moreover, this present study is very much helpful for the assessment of fishery resource and management in future.

REFERENCES

Ahlstrom, E.H. (1976). Eggs and larvae of fishes and their role in systematic investigations and in fisheries. Revue des Travaux de institute Scientifique et Technique des Peches Maritimes. 40: 379-398.

Ahlstrom, E.H. and Moser, H.G. (1976). Eggs and larvae of fishes and their role in systematic investigations and in fisheries. Revue des Travaux de institute Scientifique et Technique des Peches Maritimes. 40: 379-398.

Bal, D.V. and Pradhan, L.B. (1951). Occurrence of fish larvae and post larvae in Bombay waters during 1944-47. 20 B. University of Bombay New Series, Bombay, p. 15.

Balakrishnan, T., Sundaramanickam, A., Shekhar, S., Muthukumaravel, K., Balasubramanian, T. (2015). Seasonal abundance and distribution of ichthyoplankton diversity in the Coleroon estuarine complex, southeast coast of India. Biocatalysis and Agricultural Biotechnology. 4: 784-794.

Bapat, S.V. (1955). A preliminary study of the pelagic fish eggs and larvae of the Gulf of Mannar and the Palk Bay. Indian Journal of Fisheries. 2: 231-255.

Bensam, P. (1987). Early developmental stages of some marine fishes from India. 2. Ilisha melastoma, I. megaloptera, Thryssa dussumieri, T. mystax and Chanos chanos. La mer. 24: 43-52.

Bray, J.R. and Curtis, J.T. (1957). An ordination of the upland forest communities of southern Wisconsin. Ecological Monographs. 27: 325-349.

Clarke, K.R. and Gorley, R.N. (2006). PRIMER v6: user manual/ tutorial, Primer E: Plymouth. Plymouth Marine Laboratory, Plymouth, UK.

Clarke, K.R. and Warwick, R.M. (1999). The taxonomic distinctness measure of biodiversity: weighting of step lengths between hierarchical levels. Marine Ecology Progress Series. 184: 21-29.

Clarke, K.R. and Warwick, R.M. (2001). A further biodiversity index applicable to species lists: variation in taxonomic distinctness. Marine Ecology Progress Series. 216: 265-278.

Day, F. (1875). 1875-1878. The Fishes of India; being a natural history of the fishes known to inhabit the seas and fresh waters of India, Burma and Ceylon. London: Quaritsch, London. 1-168.

Delsman, H.C. (1922-35). Fish eggs and larvae from the Java Sea. Reprint 1972. Linnaeus press. Amsterdam Holland, Treubia. 225 p.

Jeyaseelan, M.P., Ramanathan, N.,Vannuci, M. (1998). Manual of fish eggs and larvae from Asian mangrove waters. Unesco Pub.

Khan, S.A., Raffi, S.M., Lyla, P.S. (2005). Brachyuran crab diversity in natural (Pitchavaram) and artificially developed mangroves (Vellar estuary). Current Science. 88: 1316-1324.

Lalithambikadevi, C.B. (1993). Seasonal fluctuation in the distribution of eggs and larvae of flat fishes (Pleuronectiformes-Pisces) in the Cochin backwater. Journal of the Indian Fisheries Association. 23: 21-34.

Magurran, A. (2004). Measuring biological diversity–Blackwell Publishing. Malden, MA.

Manickasundaram, M., Sivakumaran, K.P., Ramaiyan, V. (1987). Studies on the abundance of fish eggs and larvae in Coleroon estuary, South east coast of India. Journal of the Marine Biological Association of India. 29: 354-357.

Nair, R.V. (1952). Studies on some post-larval fishes of the Madras plankton. Proceedings: Plant Sciences. 35: 225-244.

Peet, R.K. (1974). The measurement of species diversity. Annual Review of Ecology and Systematics. 5: 285-307.

Rajasegar, M., Bragadeeswaran, S., Kumar, R.S. (2005). Distribution and abundance of fish eggs and larvae in Arasalar estuary, Karaikkal, south-east coast of India. Journal of Environ--mental Biology. 26: 273-276.

Rengarajan, K. and David Raj, I. (1978). On Ichthyoplankton of the Cochin Backwaters during spring tides. Journal of the Marine Biological Association of India. 21: 111-118.

Russell, F.S. (1976). The eggs and planktonic stages of British marine fishes. Academic Press, London, 542.

Selvam, J., Varadharajan, D., Babu, A., Balasubramanian, T. (2013). Distribution and abundance of finfish eggs from Muthupettai, south east coast of India. Fisheries and Aquaculture Journal. 1-20.

Srilatha, G., Mayavu, P., Varadharajan, D., Chamundeeswari, K. (2013). Distribution of fin-fish eggs and larvae from Point Calimere and Muthupettai, South east Coast of India. Journal of Aquaculture Research and Development. 4: 1-8. DOI: 10.4172/2155-9546.1000178.

Thangaraja, M. (1982). Studies on development, distribution and abundance of fish eggs and larvae in the Vellar estuary, Portonovo (South India) (Doctoral dissertation, Ph. D Thesis, Annamalai University, India).

Venkataramanujam, K. (1975). Studies in fish eggs and larvae of Porto-Novo coastal waters. Ph. D. thesis, Annamalai University.

Vijayaraghavan, P. (1958). Studies on fish-eggs and larvae of Madras coast (Doctoral dissertation, University of Madras).

Warwick, R. (1986). A new method for detecting pollution effects on marine macrobenthic communities. Marine Biology. 92: 557-562.

Young, P.C., Leis, J.M., Hausfeld, H.F. (1986). Seasonal and spatial distribution of fish larvae in waters over the North West Continental Shelf of Western Australia. Marine Ecology Progress Series. 209-222.