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Morphological identification and occurrence of engraulid eggs off Gulf of Mannar, South east coast of India

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Sampling of eggs of species of family Engraulidae was investigated at three stations in the nearshore waters of Gulf of Mannar, for the period of January 2018 to December 2018. During sampling, the quantities and distributions of eggs of engraulids were determined. Horizontal tow was conducted from the surface (0-5 m), a plankton net of 45 cm in diameter and 150 µm mesh. The eggs of engraulids sampled in plankton tows were found to be 542.92 ind./100 m^3. A total of 1,075 eggs belonging to 8 species were identified during the sampling period. Eggs of *Encrasicholina heteroloba*, *E. punctifer*, *Setipinna taty*, *Stolephorus baganensis*, *S. tri*, *Thryssa hamiltonii*, *T. dussumieri* and *T. mystax* were identified. Engraulid eggs were found throughout the year in the nearshore waters of Punnakayal and Thoothukudi, but they were much abundant during the summer season. A significant positive correlation was found between environmental factors and the occurrence of eggs at Thoothukudi and Punnakayal stations. Thus Punnakayal region of Gulf of Mannar is identified as the spawning ground for the engraulid fishes.

[**Keywords**: Abundance, Eggs, Engraulidae, Gulf of Mannar, Taxonomy]

Introduction

Engraulids are plentiful along the Indian coast. The species of family Engraulidae (Clupeiformes: Teleostei), popularly called as Anchovies or Engraulid. Engraulids are small or moderate-sized fishes in order Clupeiformes, having a common prominent snout overhanging the mouth. A total of 16 genera and 139 species of engraulids have been recognized throughout the world[1]. Engraulid fishes are extensively distributed from 60° N to 50° S. Engraulids are one of the most important pelagic finfish resources exploited along the coastal waters of India, contributing to almost 8 % in the whole landings[2]. Engraulids are commercially important because of the nourishment value and industrial uses for oil, fertilizers and canning. They are ecologically important also because they play a major role in marine food chains and the connecting links between the planktonic organisms and the predators including carnivorous fishes and oceanic mammals[3]. Though some species are reported to penetrate into brackish water, most of them inhabit in seawater permanently[4]. The species of Engraulidae are oviparous, laying pelagic eggs that differ in shape from almost round to elliptical[5].

In Indian seas, investigations on the eggs of Engraulids started in early 1931. Delsman[6]; Vijayaraghavan[7] and Sudarsan & Rajapandian[8] have been described eggs of the family Engraulidae from Indian seas. Menon & George[9] identified planktonic eggs of *Stolephorus* spp. from the southwest coast of India. Girijavallabhan & Gnanamuttu[10] and Arockiamary[11] reported the occurrence of engraulid eggs from the Coromandal coast. Available information indicates that limited studies have been conducted on the taxonomy and occurrence of eggs of engraulids at the Gulf of Mannar. Since the information on the occurrence of eggs of particular species indicates its spawning ground, it becomes a compulsion for the planners to protect and conserve the area and species where the taxonomy of identification of the species becomes essential. Hence, the current investigation was carried out to learn about the morphological identification and occurrence of eggs of family Engraulidae along southeast coast of India.

Materials and Methods

Study area

The current investigation was conducted at three different stations in the coastal waters of the Gulf of Mannar. The latitude and longitude of the sampling area were recorded with the help of GPS. Station I:

Mandapam- The coastal area with seagrass and seaweed ecosystem, located at 9º15'38.80" N, 79º11'7.15" E, 9º15'00.92" N, 79º10'17.56" E. Station II: Thoothukudi- The coastal area with seaweed ecosystems, located at 8º48'16.0274" N, 78º16'34.86" E, 8º47'14.02" N, 78º16'09.41" E. Station III: Punnakayal- The coastal area surrounded with seaweeds and mangroves ecosystem located at 8º37'55.88" N, 78º11'21.35" E, 8º37'47.88" N, 78º10'51.34" E (Fig. 1).

Collection of samples

Samplings were conducted monthly from January 2018 to December 2018, around 7 to 7-30 a.m. at each stations using Bongo net (mouth diameter of 45 cm, mesh size, 150 µm) during monsoon season (October to December), post-monsoon season (January to March), summer season (April to June) and pre-monsoon season (July to September)[12]. A total of 50 samplings consisting of 108 samples of Ichthyoplankton were collected at all three stations. Horizontal tow was conducted from the surface (0-5 m) at a speed of 0.5 miles/h for 10-15 minutes at each station[13,14]. At each sampling station, sea surface temperature was measured with a mercury thermometer and surface salinity was measured using a refractometer. Samples were preserved in 5 % buffered formalin in seawater. Fish eggs were sorted out in the laboratory and identified under a microscope (Nikon Eclipse E200). The identification of eggs were based on characters described by Delsman[6], John[15], Vijayaraghavan[7], Thangaraja[16], Manickasundaram[17] and Jeyaseelan[18]. The densities were indicated as the number of eggs/100 m^3.

For calculation of abundance, the number of eggs under one m^3 was computed. This was done by multiplying the original numbers for each station and dividing by the volume of water filtered following George[19].

$$\text{Abundance} = \frac{N \times D}{V}$$

The volume of water filtered was calculated based on the length of the tow and the area of the mouth (πr^2 h).

Data analysis

Pearson correlation matrix (r) was worked out at 1 % and 5 % significance level to study the relationship between egg abundance and environmental factors[20]. All statistical analysis was carried out by using SPSS (Ver. 25).

Results

Temperature and salinity

The temperature of surface water was found to vary from 23 to 31 °C, 25 to 34 °C and 25 to 35 °C at stations I, II and III, respectively. The maximum values of temperature of surface water were recorded in summer season at station II and III, the minimum values were recorded in monsoon season at the station I (Table 1). Engraulid eggs were found over the recorded temperature range (26 – 35 °C), but the

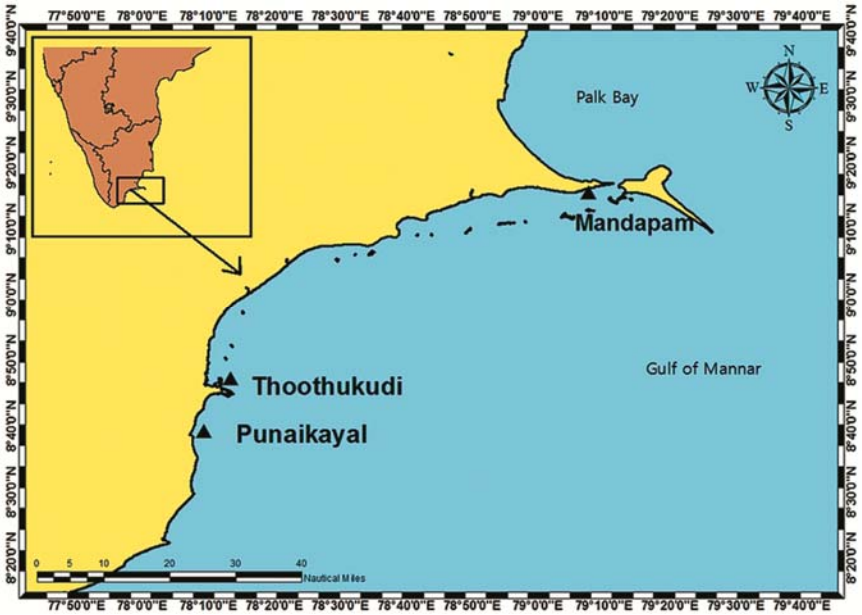

Fig. 1 — Map showing sampling stations in the nearshore waters of Gulf of Mannar

Table 1 — Water temperature and salinity at studied station in the waters of Gulf of Mannar

Month-Year	Mandapam (I)		Thoothukudi (II)		Punnakayal (III)	
	Water temperature (ºC)	Salinity (‰)	Water temperature (ºC)	Salinity (‰)	Water temperature (ºC)	Salinity (‰)
Jan-18	24	34	26	32	26	33
Feb-18	26	33	26	33	27	34
Mar-18	26	34	27	35	28	37
Apr-18	27	32	33	38	32	40
May-18	31	37	34	40	35	41
Jun-18	27	36	30	38	32	39
Jul-18	28	32	29	36	27	40
Aug-18	28	33	27	35	26	39
Sep-18	27	34	26	38	27	39
Oct-18	24	33	27	33	27	32
Nov-18	23	30	26	34	25	33
Dec-18	23	30	25	33	26	33

Table 2 — Pearson correlation matrix between eggs, water temperature and salinity at station II

	Eggs/100 m^3	Water temperature	Salinity
Eggs/100 m^3	1		
Water temperature	.588*	1	
Salinity	.780**	.797**	1

Table 3 — Pearson correlation matrix between eggs, water temperature and salinity at station III

	Eggs/100 m^3	Water temperature	Salinity
Eggs/100 m^3	1		
Water temperature	.683*	1	
Salinity	.667*	.634*	1

highest concentrations occurred between 28 °C and 35 °C. There was a significant positive correlate on between surface water temperature and eggs (r = 0.588*) at station II and (r = 0.683*) at station III (Table 2 & 3).

The salinity values during the study period varied from 30 to 37 ‰ at the station I, 32 to 40 ‰ at station II and 32‰ to 41 ‰ at station III. At each station, the maximum salinity was observed during the summer season and the minimum was during monsoon and post-monsoon season (Table 1). There was a significant positive correlation between salinity and eggs (r = 0.780**) at station II and (r = 0.667*) at station III (Table 2 & 3).

Description of eggs

During the study period, a total of 1,075 eggs belonging to 8 species were sampled from horizontal tows. Eggs of Engraulidae were easy to sort in an ichthyoplankton sample because of their elliptical shape, segmented yolk and generally, the absence of oil globules but few eggs were spherical in shape. Eggs of *Stolephorus baganensizs*, *S. tri*, *Encrasicholina heteroloba* and *E. punctifer* were transparent and elliptical in shape while eggs of *Thryssa hamiltonii*, *T. dussumieri*, *T. mystax* and *Setipinna taty* were spherical in shape (Fig. 2 & Table 4).

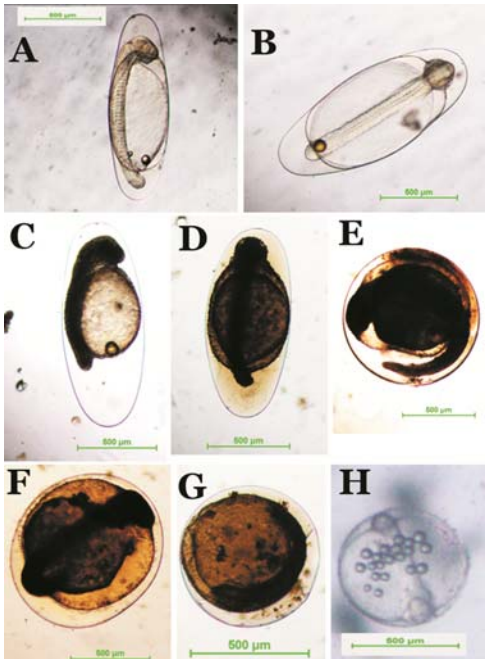

Fig. 2 — Eggs of Engraulidae family: A. *Stolephorus baganensis*, B. *Stolephorus tri*, C. *Encrasicholina heteroloba*, D. *Encrasicholina punctifer*, E. *Thryssa hamiltonii*, F. *Thryssa dussumieri*, G. *Thryssa mystax*, and H. *Setipinna taty*

Station wise and seasonal occurrence of engraulid eggs

During sampling, 542.92 eggs/100 m^3 (a total of 1,075 eggs) were collected between January 2018 and December 2018. Engraulid eggs were obtained only

Table 4 — Morphological identification features of the engraulid eggs

Species	Shape and size range (length × breadth) (mm), shape	Oil globule diameter range (mm) and colour	Yolk diameter (mm) range	Embryo diameter range (mm)	Perivitelline space
A. *Stolephorus baganensis*	Elliptical, 1.15-1.41 × 0.53-0.63	0.07-0.12, Single yellowish oil globule, small vacuole-like structure is present above the oil globule	0.88-0.90, segmented yolk occupies the entire length of the egg	1.14-1.21, eyes and few myotomes of the embryo slightly visible	narrow
B. *Stolephorus tri*	Oval, 1.39-1.73 × 0.51-0.57 probably the largest among the Indo-Pacific species of the *Stolephorus* genus	0.07-0.10, Single, light brownish or yellowish oil globule, situated at the posterior end of the yolk	0.89-0.96 fragmented and occupies the entire volume of the egg	1.10-1.17, eyes and few myotomes slightly visible	very narrow
C. *Encrasicholina heteroloba*	Elliptical, 0.85-1.43 × 0.34-0.56	Single, yellowish oil globule, 0.06-0.08, situated at the posterior end of the yolk	transparent, occupies about two thirds of the length of the egg, 0.57-0.81	0.39-0.50, Embryo occupies nearly the entire length of the yolk.	narrow
D. *Encrasicholina punctifer*	Elliptical, 0.84-1.2 × 0.38-0.52	Oil globule absent	Fragmented, colourless, occupies two thirds the length of the egg 0.47-0.50	0.68-0.70, Embryo occupies nearly the entire length of the yolk.	narrow
E. *Thryssa hamiltonii*	Spherical 1.01-1.27	Oil globule absent	0.49-0.50 yolk is sub-divided	-	narrow
F. *Thryssa dussumieri*	Spherical, 0.80-0.99	Oil globule absent	Spherical, colourless, transparent, 0.63-0.89	0.90-0.10	narrow
G. *Thryssa mystax*	Imperfectly spherical, 0.70-0.85	Oil globule absent	Spherical, segmented, 0.57- 0.71	0.64-0.81	narrow
H. *Setipinna taty*	Spherical, colourless, transparent, 0.80-1.50	10 to 20 uneven sized oil globules, 0.039-0.076, aggregated at the centre of the yolk mass	Spherical, segmented transparent, colourless; 0.60-0.90	0.51-0.66, transparent and colourless	narrow

from station II and III and no eggs were observed from station I. Engraulid eggs were found in all the seasons, the maximum numbers of eggs (216 no.) were encountered from station III followed by station II (175 no.) during summer. The largest number of eggs were found in the month of May at station II and III (49.49 ind./100 m^3 and 60.60 ind./100 m^3). Station III showed a peak of engraulid eggs abundance during summer. The abundance of engraulid eggs was low in monsoon season at station II and III (Fig. 3).

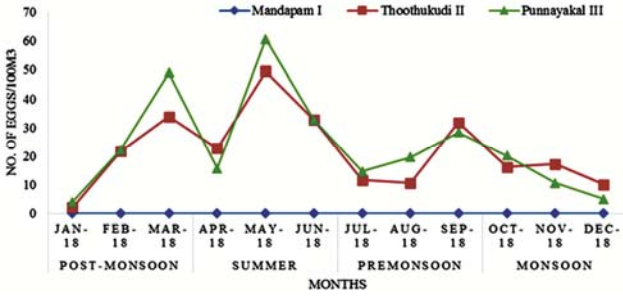

Fig. 3 — Station wise seasonal occurrence of engraulid eggs

Percentage composition of engraulid eggs

Among 8 species, eggs of *E. heteroloba* were the dominant contributor (45.39 %) followed by *S. tri* (25.39 %), *T. dussumieri* (10.79 %), *T. mystax* (8.18 %), *S. baganensis* (4.18 %), *T. hamiltonii* (3.44 %), *E. punctifer* (2.41 %) and *S. taty* (0.18 %; Fig. 4).

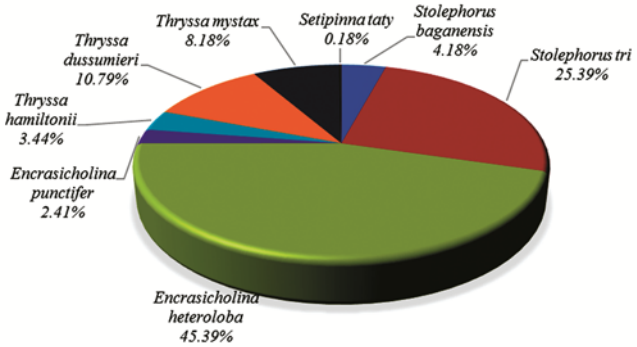

Fig. 4 — Percentage composition of engraulid eggs observed during study period

Discussion

The temperature affects the distribution and abundance of flora and fauna[21]. The surface water temperature showed an irregular mode of distribution. During the present study minimum temperature (23 °C) was observed in monsoon (station-I) and maximum temperature (35 °C) was recorded during summer (station-III). There was a significant correlation between temperature and engraulid eggs ($p < 0.05$) from station II and station III. During the low temperature and salinity condition, the number of eggs was less but during high temperature and salinity condition, the eggs were abundant. Probably higher temperature and salinity environments may stimulate spawning activity in some coastal water fishes as observed presently. This result is also in agreement with the earlier works of Manickasundaram[17], Siraimeetan & Marichamy[22], Venkataramanujam[23], Koteswarma[24], Flores-Coto[25] & Selvam[26]. Salinity is one of the major factors, which influence distribution and abundance[21]. The higher salinity was noted in the summer season at station II and III due to seawater intrusion, low rainfall and high surface water evaporation. Salinity coefficient values indicated a positive correlation with the occurrence of eggs at 1 % level ($p < 0.01$) at station II and at 5 % level ($p < 0.05$). During monsoon season, low salinity was observed due to the influx of monsoon floodwater. Similar trends, in salinity values, were observed from Arasalar estuary[27] and Palk bay[28].

Arockiamary[11] also recorded 8 species of engraulid eggs from Parangipettai waters during their survey period of January 2010 to December 2010. In the last decade (1931-1998), eggs and larvae of *Stolephorus* spp.[6], *S. baganensis*[16], *S. baganensis*, *S. tri*, *E. heteroloba*, *E. punctifer*, *T. mystax* and *Coilia dussumieri* (Manickasundaram[17]) and *Coilia* spp., *S. taty*, *E. punctifer*, *E. heteroloba*, *S. baganensis*, *S. tri*, *T. hamiltoni* and *T. mystax*[18], *S. waitei*[10] were found from southeast coast of India. During the present observation, eggs of *S. waitei* and *Coilia dussumeiri* were not available in nearshore waters which may be due to the shift of their spawning ground to deeper areas.

The eggs of *S. baganensis* were measured between 1.15 and 1.41 mm in length and 0.53 and 0.63 mm in breadth. Delsman[6] described the most significant characteristics of the egg of *S. baganensis* are the somewhat elongate shape (1.00-1.17 mm length and 0.72-0.81 mm, width) and the light brownish or clear yellow oil globule 0.10 mm diameter. The eggs of *S. baganensis* described in the present study confirm with the earlier report of Delsman[6] from the east coast of Sumatra, Jeyaseelan[18] from Asian mangrove waters and Arockiamary[11] from Parangipettai waters. Thangaraja[16] also described the eggs and larval stages of *S. baganensis* from Vellar estuary. These reports confirm the breeding ground of *S. baganensis* along southeast coast of India. Eggs of *S. tri* were oval in shape with a diameter of about 1.39-1.73 mm in length and 0.51-0.57 mm in breadth, possessing a single oil globule (0.07-0.10 mm). Delsman[6] have observed eggs of *S. tri* were 1.30-1.47 mm in length and 0.53-0.57 mm in breadth and oil globule 0.08 mm in diameter. Vijayaraghavan[7] and Manickasundaram[17] have also reported eggs of *S. tri* from the southeast coast of India.

The diameter of eggs of *E. heteroloba* was 0.85-1.43 mm in length and 0.34-0.56 mm in breadth. Delsman[6], Manickasundaram[17] and Jeyaseelan[18] have described similar characters of eggs. The identification of eggs of *E. punctifer* was based on the characters described by Jeyaseelan[18]. Similar eggs were observed by John[15] and Vijayaraghavan[7] from the Madras coast. John[15] and Vijayaraghavan[7] described that the eggs of *E. punctifer* have an elongated shape and without oil globules, while eggs of *T. hamiltonii*, *T. dussumieri*, *T. mystax* and *S. taty* were spherical in shape. These types of eggs were also described by Delsman[6], Jeyaseelan[18] and Manickasundaram[17].

The present investigation showed that engraulid eggs were dominant at Station III in summer season followed by pre-monsoon, monsoon and post-monsoon. It may be due to the fishing holiday in the summer season and spawning was coupled with optimum temperature. The fishing ban was declared along the east coast during the summer season to avoid the catching of brooders and reduce disturbances

during breeding. This must have influenced positively reason for the high occurrence of engraulid eggs during summer which is also reported by Arockiamary[11] from Parangipettai waters. In general, the occurrence of engraulid eggs at the Station III indicates that this area is the spawning ground for fishes of family Engraulidae where *E. heteroloba* eggs were dominant in the waters of Punnakayal.

Conclusion

The present communication deals with the study on the occurrence and distribution of engraulid fish eggs in the Gulf of Mannar. The engraulid fishes were found to spawn during the summer season in the waters where the surface salinity and temperature were high. The study also deals with relevant taxonomic information on engraulid eggs of the Gulf of Mannar region. Thus, the Punnakayal region can be considered as a favourable spawning and nursery area for engraulids.

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Conflict of Interest

The authors have no conflicts of interest.

Author Contributions

JS: wrote the manuscript; PJ and NN: helped during sampling and analysis of samples; and AS and NJ corrected the manuscript.

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