

## Bothid larvae (Pleuronectiformes-Pisces) of the Indian Ocean

C B Lalithambika Devi

National Institute of Oceanography, Regional Centre, P.B. No. 1913, Cochin 682 018, India  
[E-mail: niopc@giasmd01.vsnl.net.in]

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The larvae of bothids were found to be sparsely distributed in the Indian Ocean, being only 7.6% in IIOE collections (1960-65) and 13.5% in *FORV Sagar Sampada* (1986-90) samples. They were confined mostly to the coastal waters. Their density was high in Bay of Bengal, with maximum number in Malacca Strait. Bay of Bengal may be considered as the cradle for larval bothids holding 45.9% while only 38.4% occurred in the Arabian Sea. They were more during northeast monsoon period. There is no direct relationship between abundance of zooplankton biomass and the number of bothid larvae. The present report includes 23 species belonging to 9 genera from the Indian Ocean, their regional, seasonal as well as diurnal variations. *Engyprosopon grandisquamis* dominated contributing to 23.2% of the total larvae. Numerically the incidence of bothid larvae suggested a uniform pattern of distribution during the two monsoons. Yet certain species in the Arabian Sea like *Arnoglossus tapeinosoma*, *Engyprosopon multisquama*, *E. latifrons*, *E. grandisquamis* and *A. aspilos* showed a preference to north east monsoon while *E. coccosensis*, *Bothus myriaster*, *B. pantherinus*, *Arnoglossus intermedius* and *Crossorhombus valde-rostratus* showed preference to south west monsoon. In Bay of Bengal *Engyprosopon grandisquamis* was dominant during both the seasons with a preference for S.W. monsoon and larvae of *Engyprosopon coccosensis*, *E. latifrons*, *Arnoglossus tapeinosoma* and *Bothus pantherinus* dominated during N.E. monsoon. In the Arabian Sea, eleven species were dominant in the night samples whereas in the Bay of Bengal only nine species showed affinity towards darkness. The study has enabled delineation of the spawning grounds, incidence and relative abundance thus providing data for the stock assessment and management of the economically important bothid fishery resources of the Indian Ocean.

Generally the abundance of a species in an ecosystem is an indication of its success to adapt, thrive and propagate within the community. In the marine ecosystem fishes are comparatively less than other taxa, which is also reflected in their larval population forming only a small percentage both in number and volume among zooplankton biomass. However, fish being the most demanded food item from the sea, they have become important group in the marine resources of a region. Flat fishes though form only a relatively small percentage of the total fish population still occupy a significant position in the list of highly preferred food fishes. According to Norman<sup>1</sup>, they reach as far as 2 to 2.4 m in length weighing 136 to 181 kg (*Hippoglossinae*-Halibut) and much larger examples have been recorded. Some flat fishes are regarded as lean fishes at all seasons and some contain lecithin and related compound which make them as a biomedically viable prospective group which remains to be explored in detail.

Most of the flat fish larvae have a comparatively short larval life except in bothids where it exceeds six months or more in some species. Studies on larval flat fishes are fragmentary, and some time quite confusing, particularly so in the materials from the

Indian Ocean. Many<sup>2-20</sup> have reported some species but most of the descriptions are based on solitary stages from isolated regions without proper connecting links.

The material of the present study was collected during the International Indian Ocean Expedition which was a multinational endeavour to generate information for the exploration and exploitation of its vast resources as a new frontier for food and wealth. The material thus collected forms a rich source of information, hitherto unavailable.

### Materials and Methods

Fish larvae from IIOE (International Indian Ocean Expedition 1960-65) collections formed the basic data in this presentation. The *FORV Sagar Sampada* (1986-90) fish larval collections, taken after 20 years, have become valuable to check the distribution at least in Andaman Nicobar region. The sampling gear used in IIOE was IOSN (mesh size 0.33 mm). The stratum sampled<sup>21</sup> being the upper 200 m in deep water and the entire water column where sounding was less than 200 m. In *FORV Sagar Sampada* cruises, oblique hauls were taken from 150 m using Bongo-60 net with (mesh size of 0.33 mm) flow

meter. The number in both cases was estimated from 1000 m<sup>3</sup> of water filtered. Bothid fish larvae were sorted out from zooplankton samples and identified. While preparing the data for general distribution and abundance and also for seasonal as well as day and night variations, the number of larvae per 1000 m<sup>3</sup> of water filtered was tabulated, compared and represented graphically by using selected notation to denote grades of density such as 1-5, 6-10, 11-20, 21-40, 41-80 and above 80.

In order to understand the monsoonal influence the samples taken during north east monsoon (October 16 to April 15) and south west monsoon (April 16 to October 15) were pooled together and presented in charts. Similarly to assess the day and night differences samples taken during 0600 to 1800 hrs were pooled for the day and the other half for night.

## Results

### Total population

The larvae of bothids were sparsely distributed in the Indian Ocean (Fig. 1) occurring only in 146 out of

1927 (7.6%) IOOE stations (1960-65), when compared with other taxa. The numerical abundance varied from 0-320 per collection. Out of 146 stations, 85 contained larvae up to 5/1000 m<sup>3</sup>, 32 stations 6 to 10 and 17 stations from 11 to 20, above 100 were found in 3 stations and above 300 only at one station.

They were confined to stations close to the shore and were conspicuously absent in the plankton samples taken from stations situated between 52° and 100°E long. and 10° and 45°S lat. In some places they were also found a few hundred miles away from the shore, as in the case of stations near west coast of Australia, west coast of Malaya, Burma, east and west coasts of India including Sri Lanka (Ceylon), Arabia, Somali and South Africa. The density of distribution was more in Bay of Bengal and adjoining water bodies. The maximum number was recorded in the night collection from a station situated in the Malacca Strait where the depth was only 60 m, the temperature, salinity, dissolved oxygen ranged from 29.40-29.65°C, 32.66-34.94‰ and 3.24-4.45 ml/l. The zooplankton at the station was only 160 ml/1000 m<sup>3</sup>.

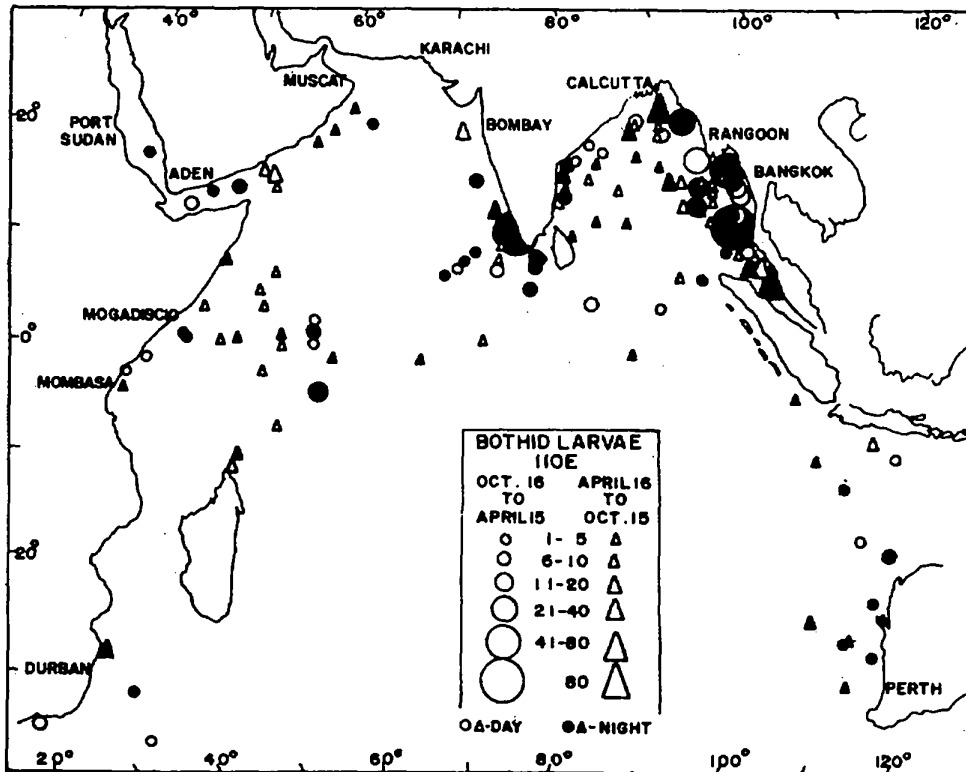


Fig. 1—Seasonal and diurnal variations of bothid larvae in the Indian Ocean

Though the environmental conditions of the neighbouring stations were almost similar, bothid larvae were not represented. It is noted that the environmental conditions of majority of the stations from where bothid larvae were collected ( $5/1000\text{ m}^3$ ) had temperature ranging between  $11.14$  and  $30.30^\circ\text{C}$ , salinity (15.09) 28.69 and 36.57‰ and dissolved oxygen between 0.17 and 6.69 ml/l.

The larvae showed preference to night as well as to NE monsoon period (Fig. 1) with highest average number in September and the lowest in October, but showed regional difference (Fig. 2). The lowest density had the highest frequency of occurrence both in Arabian Sea and Bay of Bengal (Table 1).

No direct relationship between the volume of plankton and number of larvae was observed. In the Arabian Sea, the maximum number of larvae ( $111/1000\text{ m}^3$ ) was recorded in highest volume of zooplankton ( $667.7\text{ ml}/1000\text{ m}^3$ ) (Fig. 3A) while the second highest ( $15/100\text{ m}^3$ ) was from a zooplankton biomass of  $255\text{ ml}/1000\text{ m}^3$  and  $125\text{ ml}/1000\text{ m}^3$ . In the Bay of Bengal, the maximum number was  $320/1000\text{ m}^3$  from a zooplankton biomass of  $160\text{ ml}/1000\text{ m}^3$  (Fig. 3B). The next highest densities were 160, 60 and 53 from zooplankton biomass of 300 ml, 100 ml, and 50 ml respectively. In the south west Indian Ocean the maximum number was  $15/1000\text{ m}^3$  from a zooplankton biomass of  $60\text{ ml}/1000\text{ m}^3$  and in the south east Indian Ocean it was 10 from zooplankton biomass of 37.5 and  $33.8\text{ ml}/1000\text{ m}^3$  (Fig. 3C, D).

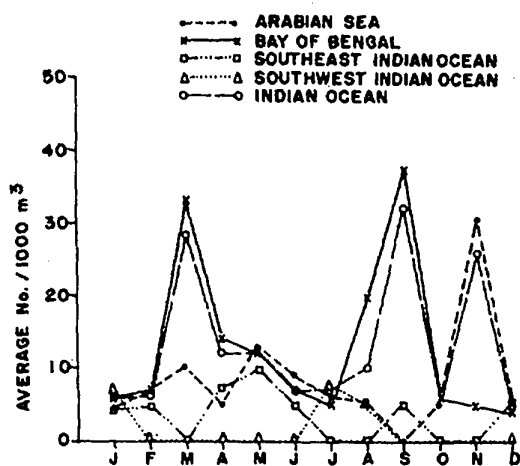


Fig. 2—Monthly variation of bothid larvae in different water bodies

#### Species diversity and distribution pattern

Even though about 70 species of adult bothids are recorded from the Indo-Pacific region, only 23 species of larvae belonging to 9 genera were present in the Indian Ocean. Their total number and frequency of occurrence are given in Table 2. Based on the density and regional preference of each group four

Table 1—Relationship between number of bothid larvae/ $1000\text{ m}^3$  and frequency of occurrence

Bothid larvae (Range)	Frequency of occurrence				
	Arabian Sea	Bay of Bengal	SW Indian Ocean	SE Indian Ocean	Andaman Sea
1-5	38	30	6	10	16
6-10	13	14	3	3	10
11-20	4	12	1	0	11
21-40	0	4	0	0	8
41-80	0	5	0	0	3
above 81	1	2	0	0	0

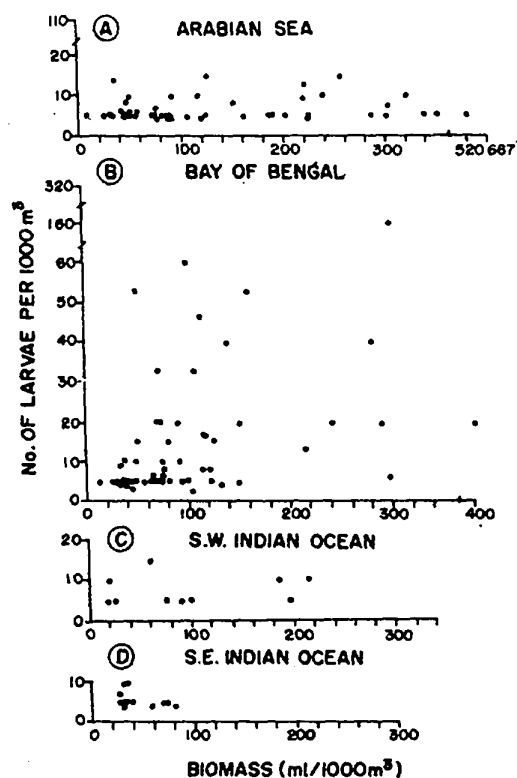


Fig. 3—Bothid larvae in relation to zooplankton biomass in (A) Arabian Sea, (B) Bay of Bengal, (C) South west Indian Ocean, (D) South east Indian Ocean

types of distribution pattern could be recognised. (Figs 4-11).

- (a) Northern Indian Ocean—*Engyprosopon grandisquamis* and *E. multisquama* (Fig. 4).
- (b) Neritic (coastal or nearshore)—*Engyprosopon cocosensis* and *E. latifrons* (Fig. 5).
- (c) Scattered—*Crossorhombus valde-rostratus*, *C. azureus*, *Engyprosopon sechellensis*, *Bothus myriaster*, *B. pantherinus*, *Arnoglossus tapeinosoma* and *A. aspilos aspilos* (Figs 6-9).
- (d) Rare (isolated)—*Engyprosopon xenandrus*, *E. mogkii*, *Bothus mancus*, *Arnoglossus elongatus*, *A. intermedius*, *A. imperialis*, *Psettina ijimae*, *Chascanopsetta lugubris*, *Parabothus polylepis*, *Laeops macrophthalmus*, *Asterorhombus intermedius* and *Bothus* sp. (Figs 9-11).

In the IIOE samples the most abundant group of bothid larvae was *Engyprosopon grandisquamis* contributing 23.2% of the total larval population. *Arnoglossus tapeinosoma* and *Engyprosopon latifrons* occurred next in abundance to *E. grandisquamis*, contributing to 12.8 and 11.9% respectively. *Engyprosopon cocosensis*, *E. multisquama* and *Bothus pantherinus*, contributed only 8.6, 7.3 and 6.5% respectively leaving four still less abundant species such as *Arnoglossus intermedius*, *Crossorhombus azureus*, *A. aspilos aspilos*, and *C. valde-rostratus* contributing 4.5, 3.7, 3.5 and 3.2% respectively. The next 5 species account for 7.1% and the other six species together form only 2.7% indicating their sparse occurrence.

The species represented in the Arabian Sea, Bay of Bengal, southwest and southeast Indian Ocean were respectively 18(23.1%), 23(69.4%), 8(3.8%) and 8(3.7%).

Table 2—Larvae of Bothid species, total number and frequency of occurrence

Taxa*	Arabian Sea		Bay of Bengal		SW Indian Ocean		SE Indian Ocean	
	TN*	FO*	TN	FO	TN	FO	TN	FO
1. <i>Parabothus polylepis</i>	0	0	30	2	0	0	0	0
2. <i>Crossorhombus valde-rostratus</i>	10	2	28	5	20	4	5	1
3. <i>C. azureus</i>	5	1	34	7	15	2	19	4
4. <i>Engyprosopon cocosensis</i>	36	4	128	3	5	1	0	0
5. <i>E. latifrons</i>	49	2	187	6	0	0	0	0
6. <i>E. mogkii</i>	10	1	4	1	0	0	0	0
7. <i>E. grandisquamis</i>	39	5	41	14	0	0	5	1
8. <i>E. sechellensis</i>	27	4	20	1	0	0	9	2
9. <i>E. multisquama</i>	71	2	73	6	0	0	0	0
10. <i>E. xenandrus</i>	9	2	5	1	0	0	10	1
11. <i>Bothus myriaster</i>	25	4	15	2	5	1	0	0
12. <i>B. mancus</i>	7	1	0	0	0	0	0	0
13. <i>B. pantherinus</i>	18	4	93	5	5	1	12	2
14. <i>Bothus</i> sp.	0	0	10	1	0	0	0	0
15. <i>Asterorhombus intermedius</i>	4	1	3	1	0	0	0	0
16. <i>Psettina ijimae</i>	0	0	25	2	0	0	0	0
17. <i>Arnoglossus tapeinosoma</i>	77	15	161	14	5	1	10	1
18. <i>A. aspilos aspilos</i>	35	6	25	5	10	1	0	0
19. <i>A. elongatus</i>	11	2	20	1	0	0	0	0
20. <i>A. intermedius</i>	19	2	66	3	0	0	4	1
21. <i>A. imperialis</i>	0	0	0	0	10	1	0	0
22. <i>Laeops macrophthalmus</i>	5	1	0	0	0	0	0	0
23. <i>Chascanopsetta lugubris</i>	0	0	30	3	0	0	0	0

\*TN = Total number, FO = Frequency of occurrence

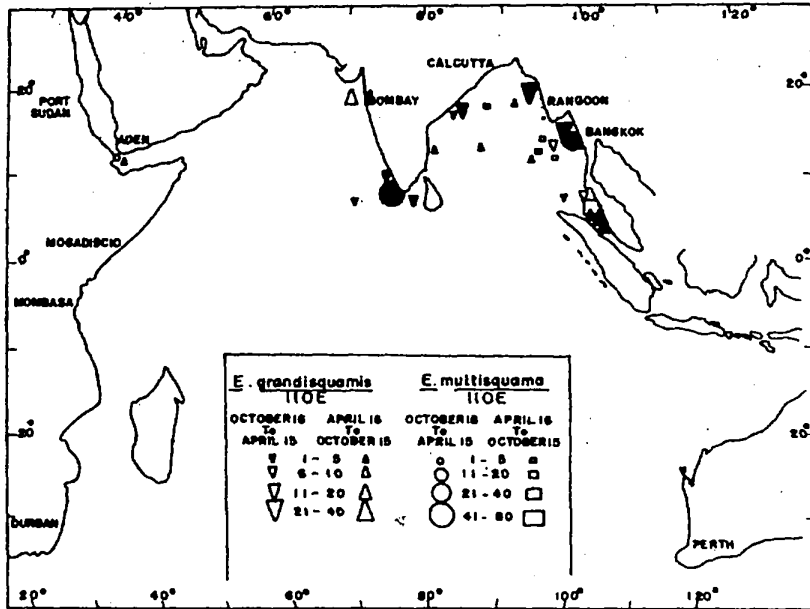


Fig. 4—Distribution of *Engyprosopon grandisquamis* and *E. multisquama* in the Indian Ocean

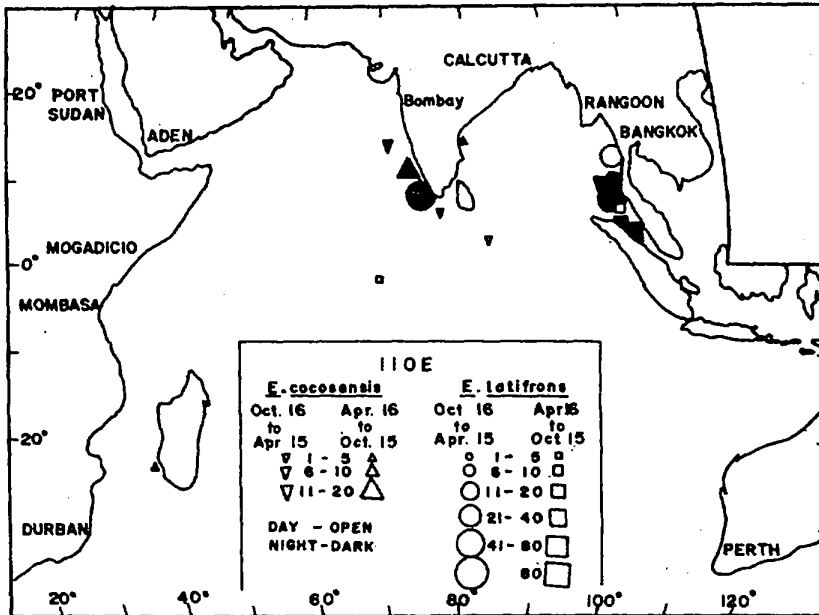


Fig. 5—Distribution of *Engyprosopon cocosensis* and *E. latifrons* in the Indian Ocean

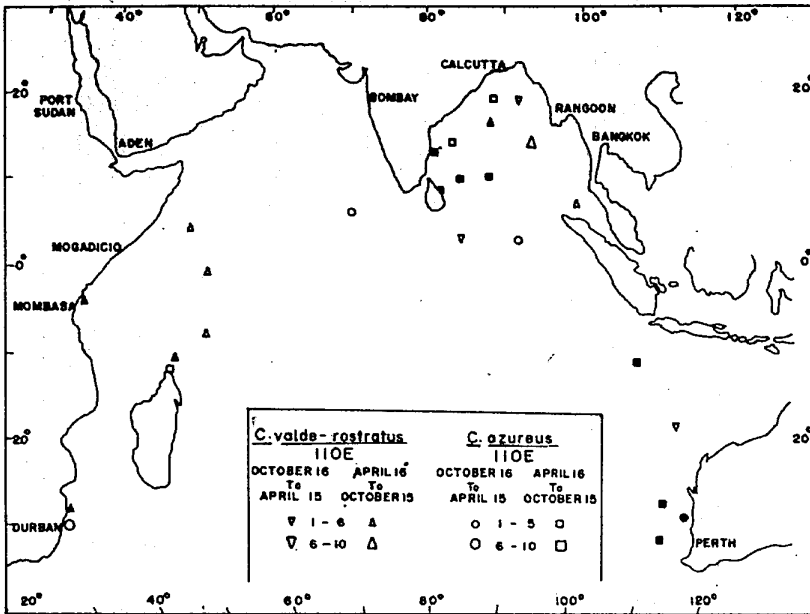


Fig. 6—Distribution of *Crossorhombus valde-rostratus* and *C. azureus* in the Indian Ocean

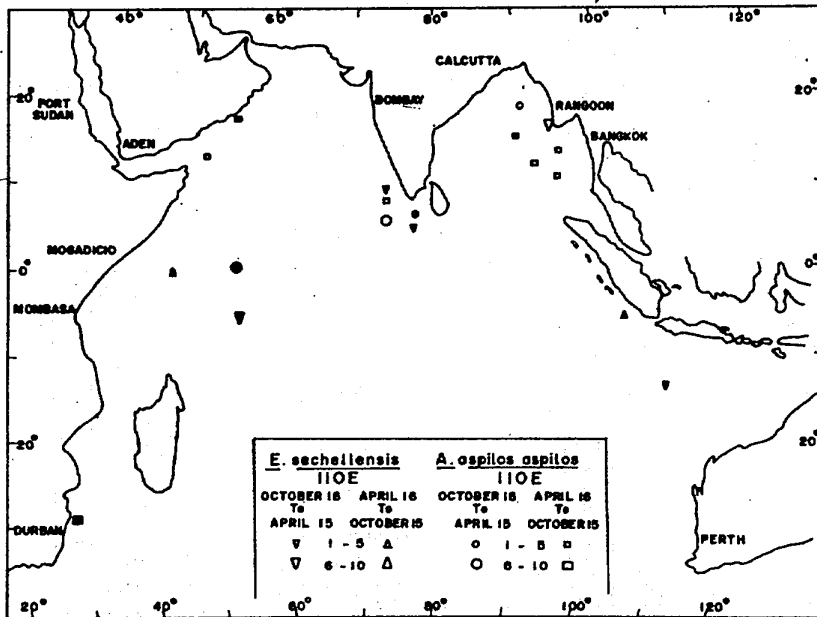


Fig. 7—Distribution of *Engyprosopon sechellensis* and *Arnoglossus aspiolos aspiolos* in the Indian Ocean

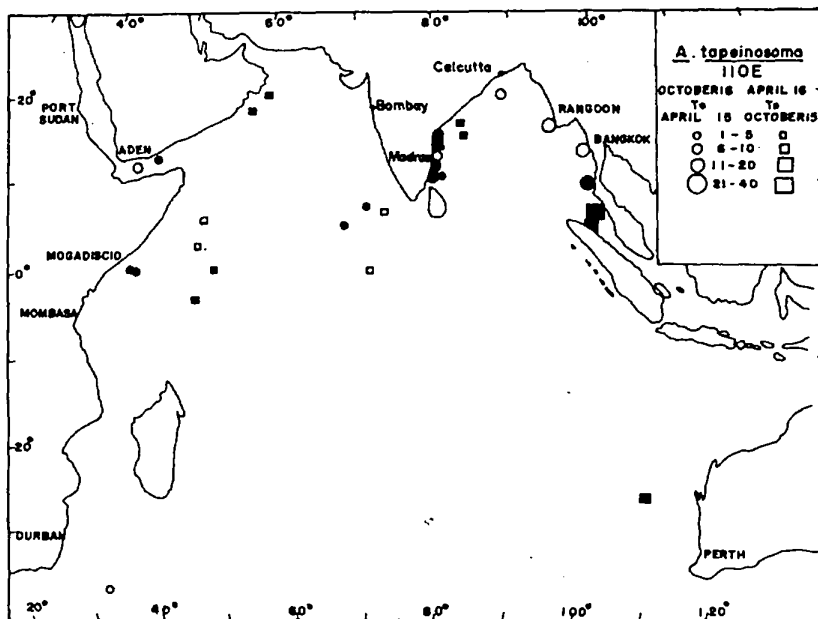


Fig. 8—Distribution of *Arnoglossus tapeinosoma* in the Indian Ocean

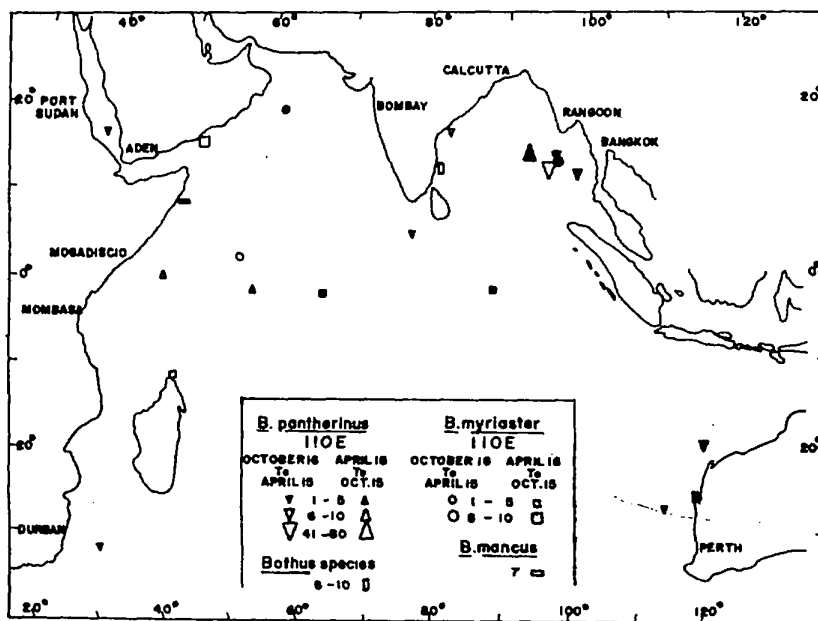


Fig. 9—Distribution of *Bothus myriaster*, *B. pantherinus*, *B. mancus* and *Bothus* sp., in the Indian Ocean

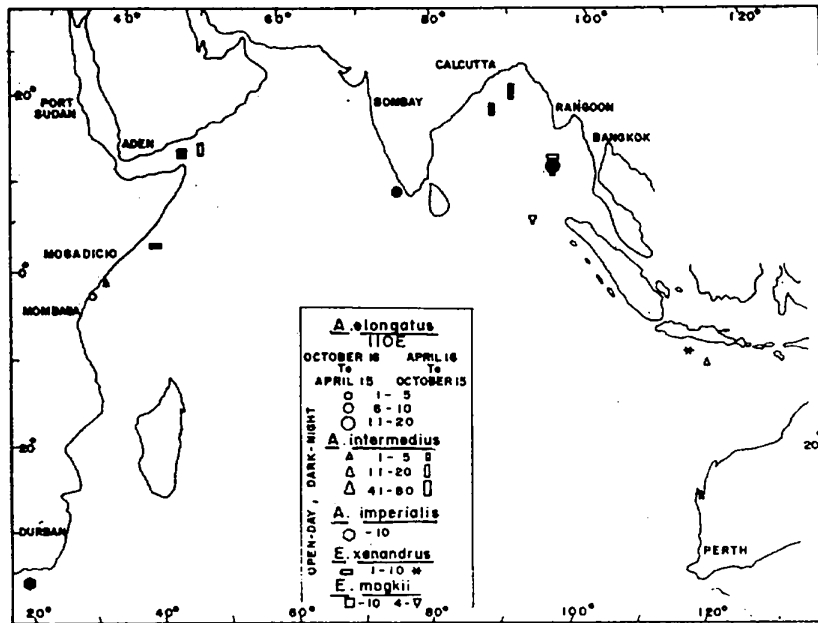


Fig. 10—Distribution of *Arnoglossus elongatus*, *A. intermedius*, *A. imperialis*, *Engyprosopon xenandrus*, and *E. mogkii* in the Indian Ocean

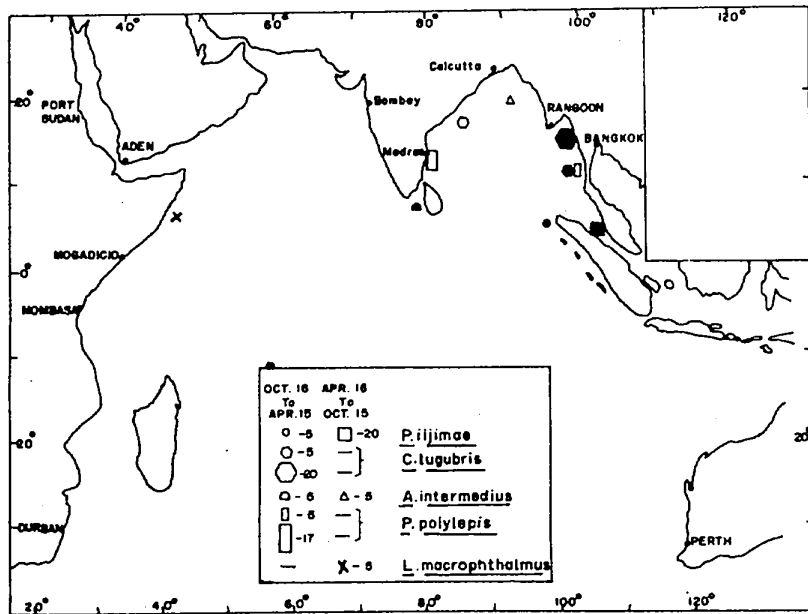


Fig. 11—Distribution of *Psettina ijimae*, *Chascanopsetta lugubris*, *Asterorhombus intermedius*, *Parabothus polylepis* and *Laeops macrophthalmus* in the Indian Ocean



### Seasonal variation

In the Indian Ocean effect of monsoon is well defined north of 10°S. Data were segregated into two seasons namely the SW monsoon (April 16 to October 15) and NE monsoon (October 16 to April 15).

The total number of bothid larvae contained in the zooplankton samples collected from the Indian Ocean were only 1977. Of this 1032 (52.2%) were collected from 72 stations during NE monsoon period and the remaining 74 stations during SW monsoon period. Numerically the bothid larvae were slightly higher during NE monsoon period as compared to SW monsoon period but they were found in more number of stations during SW monsoon period, suggesting a uniform pattern of distribution (Fig. 1). *Arnoglossus tapeinosoma*, a dominant species in the Arabian Sea even though found to occur in both seasons a preference was shown to the NE monsoon season (Table 3). *Engyprosopon multisquama*, *E. latifrons*, *E. grandisquamis* and *Arnoglossus aspilos aspilos* which come next in order of abundance also exhibited a pattern of distribution as in *A. tapeinosoma*. *Engyprosopon cocosensis*, *Bothus myriaster*, *B. pantherinus*, *Arnoglossus intermedius*,

*Crossorhombus valde-rostratus* on the other hand showed preference to SW monsoon period.

In Bay of Bengal, the dominant species was *Engyprosopon grandisquamis*. The larvae of this species were found to occur in both seasons, preference being shown to SW monsoon season. The larvae of *Engyprosopon cocosensis*, *E. latifrons*, *Arnoglossus tapeinosoma* and *Bothus pantherinus* dominated during the NE monsoon period.

### Distribution of bothid larvae during day and night

A detailed analysis of the data revealed that in the Arabian Sea the maximum number of larvae (111/1000 m<sup>3</sup>), were contained in the plankton samples taken at night (Fig. 1). The distribution of the grade 11-20 larvae were found equally distributed during day and night. The lowest grade 1-5 was found more in the samples taken at night. 70% of the larvae were contained in 60.7% of the night samples.

Eleven species of bothid larvae were found dominant in the night samples (Table 4). Of those the larvae of *Engyprosopon cocosensis*, *E. mogkii* and *E. sechellensis* were found only during night and the remaining *E. latifrons*, *E. grandisquamis*, *E. multisquama*, *E. xenandrus*, *Arnoglossus elongatus*,

Table 3—Seasonal variation of major species of Bothid flat fish larvae

Species	AS*		BB*		SWI*		SEI*	
	SW*	NE*	SW	NE	SW	NE	SW	NE
<i>Engyprosopon cocosensis</i>	25	11	5	123	5	0	0	0
<i>E. latifrons</i>	5	44	87	100	0	0	0	0
<i>E. mogkii</i>	0	10	4	0	0	0	0	0
<i>E. grandisquamis</i>	13	26	287	127	—	0	0	5
<i>E. sechellensis</i>	5	22	0	20	0	0	5	4
<i>E. multisquama</i>	0	71	53	20	0	0	0	0
<i>E. xenandrus</i>	5	4	5	0	0	0	10	0
<i>Psettina ijimac</i>	0	0	20	5	0	0	0	0
<i>Crossorhombus azureus</i>	0	5	30	4	15	0	14	5
<i>C. valde-rostratus</i>	10	0	20	8	20	0	0	5
<i>Arnoglossus aspilos aspilos</i>	15	20	20	5	10	0	0	0
<i>A. elongatus</i>	0	11	0	20	0	0	0	0
<i>A. tapeinosoma</i>	35	42	61	100	0	5	10	0
<i>A. imperialis</i>	0	0	0	0	0	10	0	0
<i>A. intermedius</i>	15	4	66	0	0	0	0	4
<i>Bothus pantherinus</i>	10	8	15	78	0	5	0	12
<i>B. myriaster</i>	22	10	5	10	5	0	0	0

\*AS=Arabian Sea, BB=Bay of Bengal, SWI=South west Indian Ocean,

\*SEI=South east Indian Ocean, SW=South west monsoon, NE=North east monsoon

*A. tapeinosoma*, *Bothus pantherinus* and *B. myriaster* were present both during day and night with dominance at night. *Crossorhombus azureus*, *C. valde-rostratus* and *A. intermedius* were found only in the day collections whereas *A. aspidos aspidos* though present both during day and night were found more during day.

In Bay of Bengal even though there was not much difference between the number of collections containing bothid larvae, 73.7% of the larvae were present in the samples taken at night. Of the nine species which showed affinity towards darkness, *Psettina ijimae*, *Arnoglossus elongatus*, *A. intermedius* and *Bothus myriaster* were found only during night. Those of *Engyprosopon cocosensis*, *E. latifrons*, *E. grandisquamis*, *Crossorhombus azureus* and *Arnoglossus tapeinosoma* though present both during day and night showed preference to darkness. *Engyprosopon mogkii*, *E. sechellensis* and *E. xenandrus* were present only during day, but all of them were contained in one and the same collection, hence difficult to assess their preference. *Engyprosopon multisquama*, *Crossorhombus valde-rostratus*, *Arnoglossus aspidos aspidos* and *Bothus pantherinus* showed definite preference to day time

though they were found in collections taken both during day and night.

In the southwest Indian Ocean the distribution of samples containing larvae were equal but 53.3% of the larvae were found in the night. *Arnoglossus aspidos aspidos*, *A. imperialis* and *Bothus pantherinus* were found only during night whereas *Engyprosopon cocosensis*, *Crossorhombus azureus*, *Arnoglossus elongatus* and *Bothus myriaster* were found during day. *Crossorhombus valde-rostratus* though found during day and night showed preference to darkness.

The southeast Indian Ocean showed a different picture, 74.3% of the larvae were contained in 76.9% of the stations which were taken at night. *Engyprosopon grandisquamis*, *E. sechellensis*, *Crossorhombus azureus*, *Arnoglossus aspidos aspidos*, *Bothus pantherinus* were found only in the plankton samples collected at night whereas *E. xenandrus*, *Crossorhombus valde-rostratus* and *Arnoglossus intermedius* were found only during day time.

#### Distribution of bothid larvae in the seas around Andaman and Nicobar Islands

Out of 355 stations sampled bothid larvae occurred only in 48 stations (13.5%). Their diversity pattern is

Table 4—Day and night variation of major species of larvae of Bothid flat fishes

Bothid taxa	*AS		*BB		*SWI		*SEI	
	*D	*N	D	N	D	N	D	N
<i>Engyprosopon cocosensis</i>	0	36	3	125	5	0	0	0
<i>E. latifrons</i>	5	44	30	157	0	0	0	0
<i>E. mogkii</i>	0	10	4	0	0	0	0	0
<i>E. grandisquamis</i>	18	21	36	378	0	0	0	5
<i>E. sechellensis</i>	0	27	20	0	0	0	0	9
<i>E. multisquama</i>	4	67	43	30	0	0	0	0
<i>E. xenandrus</i>	4	5	5	0	0	0	10	0
<i>Psettina ijimae</i>	0	0	0	25	0	0	0	0
<i>Crossorhombus azureus</i>	5	0	14	20	15	0	0	19
<i>C. valde-rostratus</i>	10	0	23	5	5	15	5	0
<i>Arnoglossus aspidos aspidos</i>	19	16	20	5	0	10	0	10
<i>A. elongatus</i>	5	6	0	20	5	0	0	0
<i>A. tapeinosoma</i>	30	47	57	104	0	0	0	0
<i>A. imperialis</i>	0	0	0	0	0	10	0	0
<i>A. intermedius</i>	19	0	0	66	0	0	4	0
<i>Bothus pantherinus</i>	5	13	58	35	0	5	0	12
<i>B. myriaster</i>	15	17	0	15	5	0	0	0

\*AS=Arabian Sea, BB=Bay of Bengal, SWI=Southwest Indian Ocean  
SEI = South east Indian Ocean, D=Day, N=Night

in Table 1. As in the case of IIOE collections, taken 25 years ago, bothid larvae seem to prefer nearshore stations (Fig. 12). The highest density of 52 larvae/1000 m<sup>3</sup> was found at offshore stations (latitude 08°32' long. 92°41'). The larvae were contained in the plankton samples taken both during day and night as well as in south west and north east monsoon. They were in 31 out of 48 samples taken during day and 30 stations fall during south west monsoon period. The larval occurrence and incidence were maximum in the month of July. The species composition being *Engyprosopon grandisquamis*, *E. latifrons*, *E. mogkii*, *E. multisquama*, *E. cocosensis*, *E. sechellensis*, *E. xenandrus*, *Arnoglossus aspidos*, *A. elongatus*, *Psettina ijimae* and *Bothus pantherinus*.

### Discussion

The present study may help to find out the spawning grounds and seasons and also provide the data for the stock assessment and management of bothid fishery resources. The vertical migration of fish larvae appeared to be influenced by light rather than temperature<sup>22</sup>.

Wooster *et al.*<sup>23</sup> indicated that the level of productivity recorded for the Somali-Arabian regions is about 3-4 times more than the rest of the Arabian Sea. Panikkar<sup>24</sup> showed that the productivity of the northern part of the Arabian Sea to be many more times higher than Bay of Bengal suggesting higher fishery potential. The areas of high productivity in terms of fish larval abundance overlapped at several places<sup>25</sup>. Nevertheless, the distribution of bothid larvae of the Indian Ocean showed that 45.9% was found in the Bay of Bengal, whereas it was only 38.4% in the Arabian Sea<sup>16</sup>. Hence Bay of Bengal is to be reckoned as the cradle for the bothid fish larvae.

Peter<sup>26</sup> observed that the maximum number of larvae were not positively correlated with samples of larger biomass, but from samples which were neither high nor low. However, George<sup>27</sup> has reported a positive correlation from the coastal waters of southwest coast of India. In the case of bothid larvae there was no correlation between the number and zooplankton biomass.

The effect and pattern of the prevailing current is one of the important factors that facilitates the distribution of the larvae. Since the fish larvae are capable of free swimming, to some extent they can resist water movements but not with strong currents. The fish larvae being the least protected, form easy

prey to the predators, may also contribute to their low density together with natural mortality.

The volume of water filtered during the collection of samples is an important factor that determine the true representation of the species of the stratum sampled. McGowan<sup>28</sup> has shown that for collecting fish larvae the amount of water to be filtered in order to include all species was in excess of 10000 m<sup>3</sup>. However, the relationship between the number of species and the volume of water filtered was logarithmic, about 80% of the fish larval species were found in about 1000 m<sup>3</sup>. But only 200 m<sup>3</sup> of water was filtered from majority of the stations during IIOE. Hence when accounting for the number of species contained in these samples due allowances have to be given.

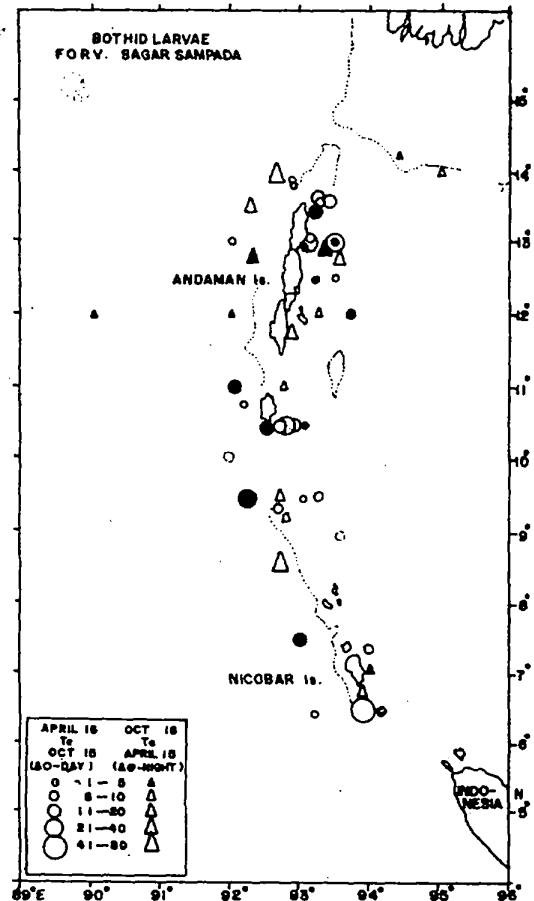


Fig. 12—Seasonal and diurnal variation of bothid larvae in the seas around Andaman Nicobar area

Variation in the number of fish larvae in some of the collections might be due to the patchiness or predation or both. The uneven distribution of larvae could also be due to the tendency of adult fishes to release clumps of eggs as well as choice of food. Factors determining the composition of species may be directly caused by predation pattern of the different trophic levels in the plankton. Lebour<sup>29</sup> showed that as chaetognaths preyed upon fish larvae, their vertical distribution overlapped with that of fish larvae.

Cushing<sup>30, 31</sup> has stated that coincidence of food supply with larval distribution is important and probably critical for their survival. George<sup>27</sup> found relatively poor abundance of fish eggs and larvae during Jan.-April along the southwest coast of India. The NE monsoon also recorded good catches of larvae especially from the west coast of India. During the period November to March, postmonsoon conditions prevail creating a northerly current. This causes upwelling leading to plankton blooms. There after a gradual rise in the sea temperature resulting from the recession of the upwelling process, provide the fish fauna with favourable environmental conditions along the southwest coast of India. This may explain the distribution of bothid larvae as they were dominant during NE monsoon period (October 16 to April 15) in the Arabian Sea with the maximum number of larvae occurring along the south west coast of India during that period. The maximum plankton biomass always coincided with the peak period of upwelling followed by larval abundance brought about by the prevailing upwelled water from the mesopelagic region to the surface.

In short, *Engyprosope latifrons*, *E. grandisquamis* and *Arnoglossus tapeinosoma* showed preference to darkness, irrespective of the area of collection. All other species exhibited different degree of preference to day or night in different regions. This may be due to the ecological factors prevailing in such regions which may have influence in their growth and distribution.

Several authors have reported more number of fish larvae in the night collections than day. Some have<sup>32,37</sup> reported a larval catch as high as seven times in the case of clupeids and four times in the case of pilchards during night than day and also nocturnal abundance of *Sardinops saerula* and *Rastrelliger kanagurta*. Ahlstrom<sup>38</sup> has also stated that no consistent difference could be noted in the larvae of *Trachurus symmetricus* in California and Baja California waters between day and night. But

Boomprakob & Debaranon<sup>39</sup> recorded large number of postlarvae of *Rastrelliger neglecta* congregating 5-10 m during day, sinking to greater depths from dusk to night exhibiting some kind of positive phototropism. In the case of bothid larvae, a preference to darkness was observed in most of the species studied.

Avoidance of the net by the larvae, the diurnal vertical migration and their phototaxis reaction exhibited by several groups could be the possible reason for the high count of larvae in the night hauls. According to Ahlstrom<sup>38</sup> several kinds of fish larvae preferred diurnal vertical migration. In this study the samples collected from 200-0 m contained both pelagic and bathypelagic species during day hauls. So the effect of vertical migration in such sampling is comparatively less. The possibility of bathypelagic forms from greater depths migrating to upper layers cannot be ruled out. It is also reported that towing speeds < 100 cm/sec cause increased avoidance of the sampler by the larvae. Lalithambika Devi<sup>12</sup> has reported that most of the fishes in tropical waters release eggs during night, suggesting importance of sampling during night while conducting ichthyoplankton surveys.

The results from the IIOE material while providing interesting first hand information from the vast area covered have given invaluable data on the distribution of the bothid larvae. Nevertheless for accurate mapping of the incidents, relative abundance, seasonal occurrence, population density, interspecific and intraspecific relationship etc. more detailed attempts based on larger number of collections restricted to areas within the EEZ would be beneficial. The Indian effort or collaborative attempts by interested countries with in the Indian Ocean arc would be desirable.

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