*J. mar. biol. Ass. India*, 1975, 17 (1) : 56 - 72

# DISTRIBUTION OF SIPHONOPHORES ALONG THE WEST COAST OF INDIA AND THE LACCADIVE SEA

K. RENGARAJAN

*Central Marine Fisheries Research Institute, Cochin 682 018*

ABSTRACT

A study has been made of the occurrence and distribution of siphonophores of the west coast of India and the Laccadive Sea based on 331 epipelagic zooplankton samples collected during the cruises of R. V. *Varuna*. A total of 47 species have been identified and their distribution pattern along the coast and in the oceanic regions determined. Based on their distribution in space, the species are broadly classified into neritic forms, oceanic forms and the species occurring both in the neritic and oceanic waters. Six species belong to the neritic region, fifteen to the oceanic region and twentysix species are distributed in both the oceanic and the neritic waters. The meso and bathy pelagic siphonophores *Marrus orthocannoides*, *Bargmania elongata*, *Rosacea plicata*, *Lensia lelouveteau*, *Abyla haeckeli* and *Heteropyramis maculata* were encountered in the upper 200 m layer and their occurrence in the epipelagic region is of interest.

*Frillagalma vityazi*, *Amphicaryon peltifera*, *A. ernesti* and *Marrus orthocannoides* have been recorded from the Indian Coast for the first time.

The possibility of using siphonophores particularly *Marrus orthocannoides* and *Lensia lelouveteau* as indicators of upwelling in oceanic regions in the Arabian Sea is also discussed.

## INTRODUCTION

IN RECENT years considerable amount of work has been carried out on the geographical distribution of pelagic and bathypelagic planktonic organisms from the major oceans of the world and also on their influence on fisheries. Though a good deal of work has been done on general zooplankton and their occurrence along the Indian Coast, very few works have been undertaken on the distribution of various groups of marine zooplankton. A few notable investigations on the distribution of siphonophores from different oceans are of Alvarino (1964, 1967, 1974), Daniel (1974), Moore (1949, 1953), Patriti (1964, 1965, 1966, 1970) and Pugh (1974, 1975).

The present investigation was initiated to understand the distribution pattern of siphonophores in the pelagic division of the sea along the west coast of India and the Laccadive Sea, as there is no information about their distribution in this region. This preliminary study has aided detailed investigations on the quantitative abundance of siphonophores in the continental shelf and oceanic waters, their occurrence in relation to hydrological conditions during different seasons and to find out whether siphonophores could be used as indicator species of water movements.

The author is greatly indebted to Dr. E. G. Silas, Director of the Central Marine Fisheries Research Institute for suggesting this problem, constant guidance, encouragement, helpful suggestions and critically going through the manuscript. He is also thankful to his colleagues Dr. P. V. Ramachandran Nair, Shri C. P. Ramamirtham and Shri K. J. Mathew for the discussions he had with them.

## MATERIAL AND METHODS

This investigation is based on 331 zooplankton samples collected during the cruises No. 1 to 3, 7, 8, 30, 31, 42 to 44 and 100 to 106 of the Research Vessel *Varuna* along the west coast of India and the Laccadive Sea during January, 1962 to December, 1963 and from August, 1966 to February, 1967. The area covered by these cruises lies between 68° 30′ E & 77° 25′ E and 08° 00′ N & 21° 36′ N. In the accompanying figures the day stations are indicated by open circles and the night stations by closed circles. The 200 m and 75 m depth contours have also been shown.

Most of the samples were collected using the Indian Ocean Standard net and a 1 m diameter Nansen net by vertical hauls from 200 m to surface in the oceanic waters or from 5 m above the bottom to surface in the shelf areas and all the samples were preserved in 5% formalin in sea water buffered with 1% Hexamine.

The siphonophores were sorted, identified upto species level and enumerated. The occurrence of different species was plotted on the charts.

The *Varuna* station list including various particulars was published in the *Indian Journal of Fisheries*, Volume 11, No. 2 from pages 736 to 965; Volume 12, No. 1 from pages 238 to 457 upto stations 2000 and by Rengarajan (1973) from 2015 to 2079. The details of the stations from 3479 to 3660 are given in the Annexure at the end.

## DISTRIBUTION OF SIPHONOPHORES

A total of fortyseven species of siphonophores were identified from this region, five were physonects and the remaining fortytwo calycophores. Of these, four species namely *Frillagalma vityazi, Marrus orthocannoides, Amphicaryon peltifera* and *A. ernesti* are recorded for the first time from the Indian Coast. Since the collections were from 200 m depth to surface, all species were from the epipelagic region only. However, some species known to be available only in the deeper waters have also been encountered in the upper 200 metres.

Based on the present investigations the species of siphonophores are grouped broadly into three categories namely neritic species, seen only in the continental shelf area, oceanic species found beyond the shelf edge and the species that occurred both in neritic and oceanic waters (Table 1).

## SPECIES DISTRIBUTION

Distribution of various species of siphonophores belonging to 22 genera is discussed below.

**Agalmidae**

*Agalma elegans* (Fig. 1) was found along the west coast of India between Veraval and Cochin in both neritic and oceanic waters, more abundantly beyond 75 m depth. This species was not normally found between the shore and 75 m line except off Karwar and Calicut. *Agalma okeni* (Fig. 1) occurred abundantly between Mangalore and Cochin. Stray occurrence of this species was recorded off Bombay in the oceanic region and near Karwar. *Halistemma rubrum* (Fig. 2) was widely distributed both in neritic and oceanic waters. *Halistemma* sp. (Fig. 2)

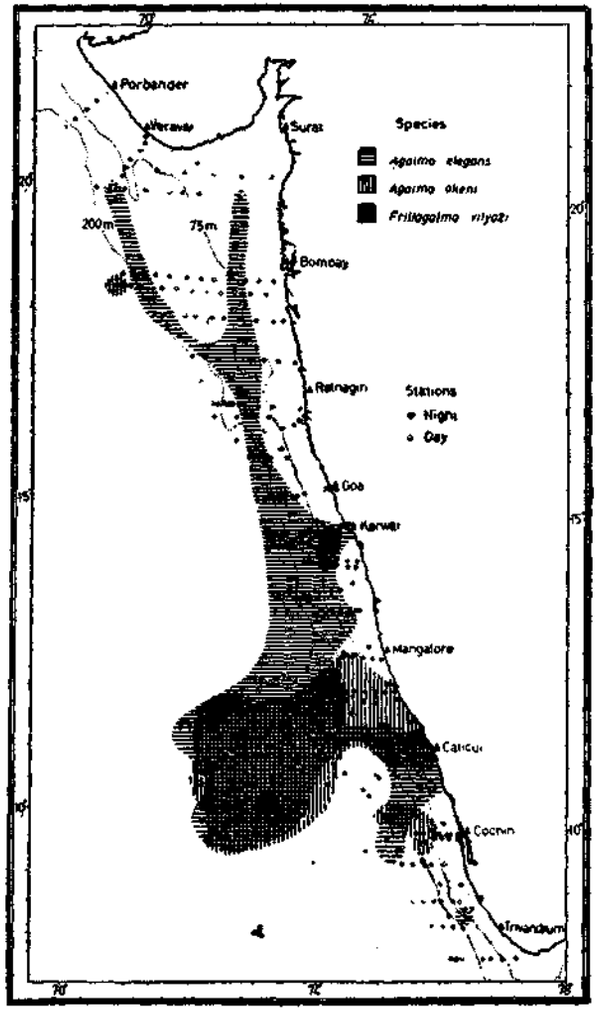


Fig. 1. Distribution of *Agalma elegans*, *A. okeni* and *Frillagalma vityazi*.

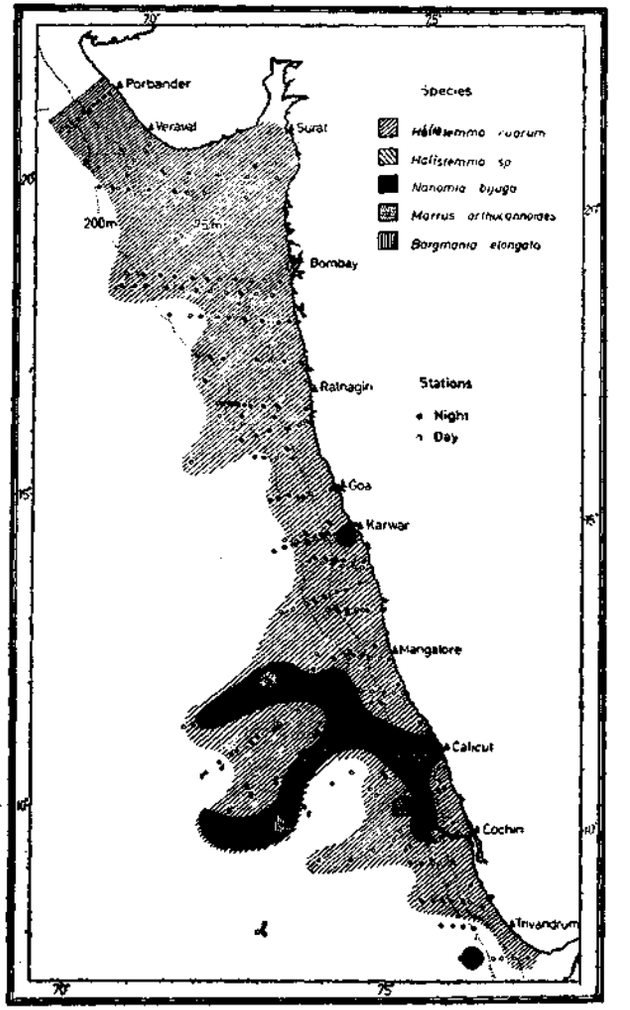


Fig. 2. Distribution of *Halistemma rubrum*, *Halistemma* sp., *Nanomia bijuga*, *Marrus orthocannoides* and *Bargmania elongata*.

apparently a young colony with cluster of gelatinous bracts whose distal facets were not clear, and with male and female gonophores was recorded from station No. 764 (Rengarajan, 1973). The specific identification of this specimen (from an oceanic station) was not possible and hence described here as *Halistemma* sp. *Nanomia bijuga* (Fig. 2) is sympatric with *Agalma okeni*, but it was not found beyond north of Karwar. *Frillagalma vityazi* (Fig. 1) was recorded from an oceanic station (No. 3655) near Kalpeni in Lakshadweep area. This was first obtained from the eastern Indian Ocean during a cruise of R. V. *Vityaz* and described by Daniel (1966). This is the second record of the species and that too from the Indian Coast. A single nectophore and two bracts of *Marrus orthocannoides* (Fig. 2) were recorded for the first time from Lakshadweep area from Stn. No. 3564.

TABLE 1. *Species of siphonophores occurred in different environments along the west coast of India and the Laccadive Sea in the upper 200 m layer*

| Neritic species | Oceanic species | Species occurring in both neritic and oceanic waters |
|---|---|---|
| *Amphicaryon ernesti* | *Halistemma* sp. | *Agalma elegans* |
| *Sulculeolaria angusta* | *Frillagalma vityazi* | *Agalma okeni* |
| *Lensia tottoni* | **Marrus orthocannoides* | *Halistemma rubrum* |
| *Lensia multilobata* | **Bargmania elongata* | *Nanomia bijuga* |
| *Muggiaea delsmani* | *Amphicaryon peltifera* | *Hippopodius hippopus* |
| *Lensia* sp. | **Rosacea plicata* | *Vogtia glabra* |
| | *Rosacea cymbiformis* | *Sulculeolaria chuni* |
| | *Rosacea* sp. | *S. quadrivalvis* |
| | *Vogtia pentacantha* | *S. turgida* |
| | *V. spinosa* | *Diphyes chamissonis* |
| | *Sulculeolaria monoica* | *D. dispar* |
| | **Lensia lelouveteau* | *D. bojani* |
| | *Lensia fowleri* | *Lensia subtiloides* |
| | **Abyla haeckeli* | *L. campanella* |
| | **Heteropyramis maculata* | *L. hotspur* |
| | | *L. subtilis* |
| | | *L. cossack* |
| | | *Eudoxoides mitra* |
| | | *E. spiralis* |
| | | *Chelophyes contorta* |
| | | *C. appendiculata* |
| | | *Abylopsis eschscholtzi* |
| | | *A. tetragona* |
| | | *Bassia bassensis* |
| | | *Ceratocymba leuckarti* |
| | | *Enneagonum hyalinum* |

*Deep water species.

**Pyrostephidae**

Eight nectophores of *Bargmania elongata* from an oceanic station off Cochin in Lakshadweep area (No. 3586) during the cruise of *Varuna* were collected in a vertical haul from 200 m to surface (Fig. 2).

**Prayidae**

The little known species *Amphicaryon peltifera* was represented by two persistent and two second nectophores from the Lakshadweep region (Fig. 3). Another species, *Amphicaryon ernesti* was recorded off Karwar within 75 m depth contour and it was not seen at the other stations (Fig. 3). The occurrence of the former species in the oceanic water and the latter in the neritic waters is of interest.

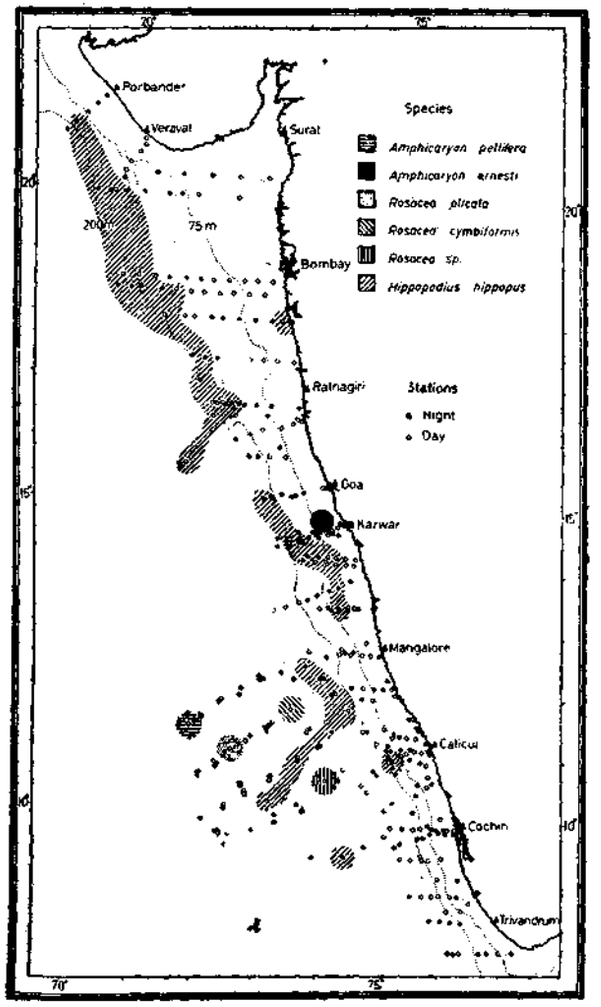


Fig. 3. Distribution of *Amphicaryon peltifera, A. ernesti, Rosacea plicata, R. cymbiformis, Rosacea* sp. and *Hippopodius hippopus.*

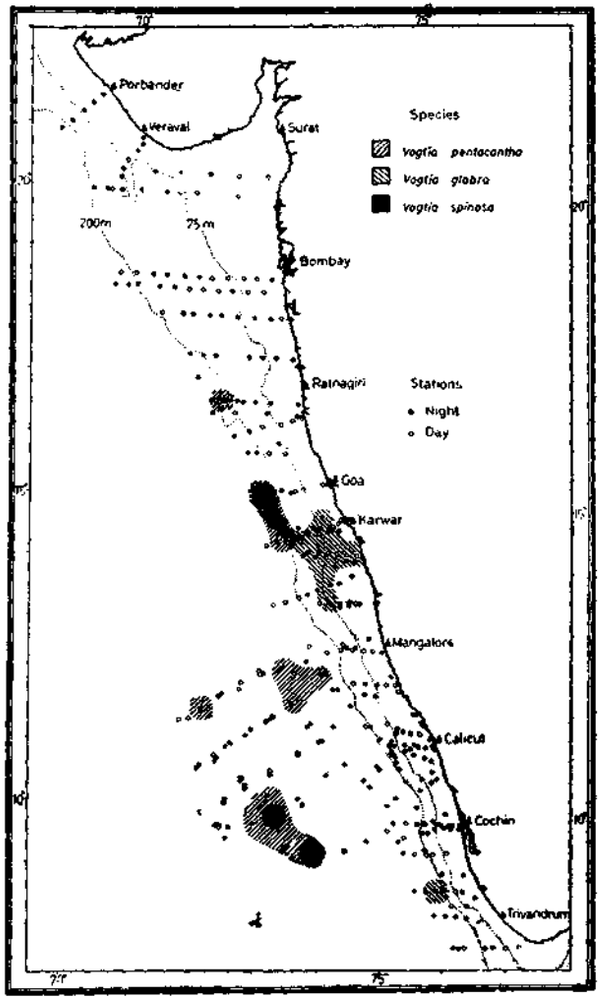


Fig. 4. Distribution of *Vogtia pentacantha, V. glabra* and *V. spinosa.*

*Rosacea cymbiformis* and *Rosacea plicata* were present in Stn. Nos. 3643 and 3640 respectively near the Lakshadweep group of islands (Fig. 3). The latter was recorded by Alvarino (1967) between 2200 m and 2600 m depth off San Diego, whereas this species was collected in the epipelagic waters during the present investigations. A single young specimen of *Rosacea* sp. (Fig. 3) was also collected from the same area (Stn. No. 3588) and its specific characters were not clear.

**Hippopodidae**

*Hippopodius hippopus* (Fig. 3) was distributed between Cochin and Porbander, more abundantly beyond the 75 m depth contour. Very rarely it was found to occur close to shore (Stn. No. 973) and it was not encountered south of Cochin. One of the oceanic species *Vogtia pentacantha* (Fig. 4) showed a scattered distribution between Ratnagiri and Cochin and close to the continental shelf edge at two stations (No. 963 and 2052). *Vogtia glabra* (Fig. 4) occurred between Goa and Mangalore in the neritic waters and in the oceanic waters at two Stns. 2071 and 3524. Another oceanic species *Vogtia spinosa* (Fig. 4) was recorded for the first time from the Arabian Sea (off Goa and off Cochin). Earlier this species was collected from the oceanic waters below 400 m (Alvarino, 1964) in the Indian Ocean.

**Diphyidae**

*Sulculeolaria chuni* (Fig. 5) is widely distributed along the coast, particularly on the continental shelf edge. The nearshore waters are devoid of this species. *Sulculeolaria quadrivalvis* (Fig. 5) was found to sporadically occur along this region off Veraval, Bombay, Goa, Karwar, Calicut and Trivandrum and in Lakshadweep area. *Sulculeolaria turgida* (Fig. 6) was found only in waters off Murud, Karwar and Calicut. A neritic species *Sulculeolaria angusta* (Fig. 5) was found sympatric with *S. turgida*. They occurred between 75 m and 200 m depth line in the neritic region that too only from four stations (No. 977, 1778, 3483 and 3659) off Veraval, Murud, Karwar and Calicut respectively. *Sulculeolaria monoica* (Fig. 5) found in the oceanic area between Ratnagiri and Cochin, but at Stn. No. 2024 it occurred just at the continental shelf edge.

*Diphyes chamissonis* (Fig. 6) is very widely distributed in the Arabian Sea almost in all stations. *Diphyes dispar* and *D. bojani* (Fig. 6) were sympatric to each other and found throughout the coast except between Karwar and Mangalore.

Ten species of *Lensia* were recorded from this part of the Indian Coast. Of these, *Lensia subtiloides* was very common and widely distributed both in oceanic and neritic waters (Fig. 7). *Lensia campanella* and *L. hotspur* (Fig. 7) were found throughout this coast except between Goa and Mangalore and sympatrically distributed in other areas.

A single anterior nectophore of *Lensia lelouveteau* (Fig. 7) was recorded from an oceanic station (No. 943) off Goa. *Lensia cossack* (Fig. 8) was found only from four stations along the continental shelf edge except off Murud where it was found at 75 m depth. The other three places of occurrence are off Mangalore, Karwar and Ratnagiri. *Lensia subtilis* (Fig. 8) was present only in the coastal waters near Cochin and off Ratnagiri. A single anterior nectophore of *Lensia tottoni* (Fig. 7) made its representation in the coastal water off Calicut. *Lensia fowleri* (Fig. 8) an oceanic species, was seen near Ratnagiri and off Cochin. *Lensia multilobata* was

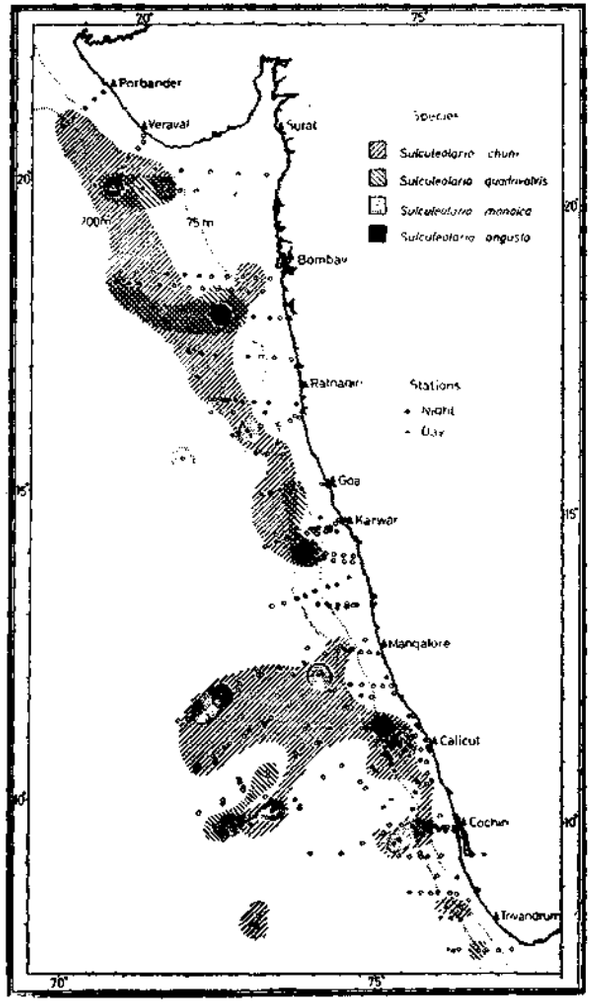


Fig. 5. Distribution of *Sulculeolaria chuni, S. quadrivalvis, S. monoica* and *S. angusta.*

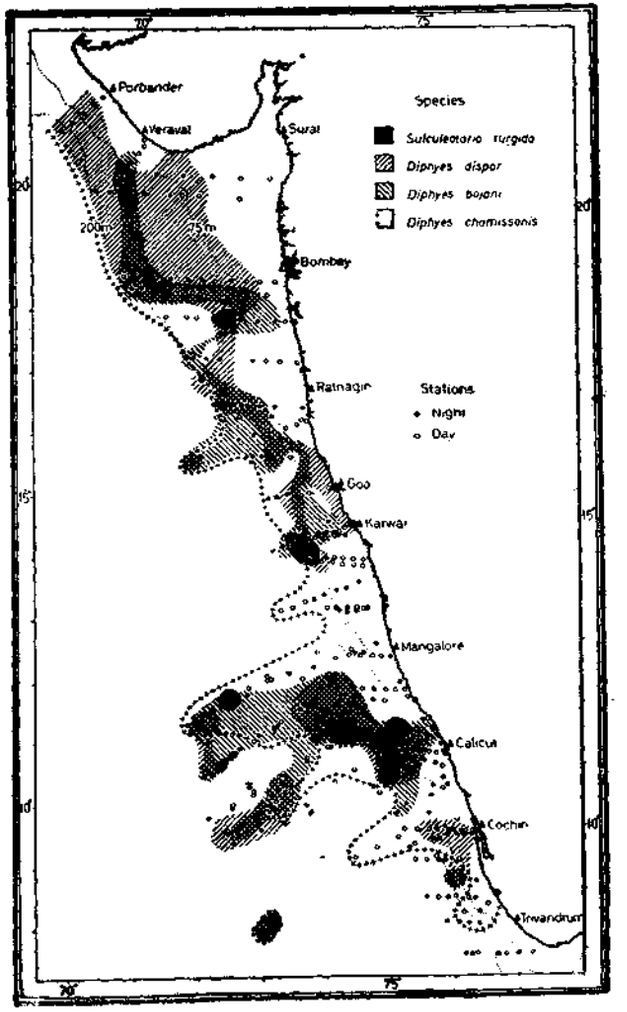


Fig. 6. Distribution of *Sulculeolaria turgida, Diphyes dispar, D. bojani* and *D. chamissonis.*

collected only at Stn. No. 970 near Ratnagiri in neritic waters. An anterior nectophore with abnormal characters of *Lensia* sp. was recorded from Stn. No. 747 in the neritic waters off Calicut and it was found difficult to assign it to any known species of *Lensia* because of its broad and smooth nectophore completely occupied by the nectosac and the presence of a large, stumpy, elongate and finger-like somatocyst (Rengarajan, 1973).

A true neritic species *Muggiaea delsmani* (Fig. 8) was found concentrated in the nearshore waters off Veraval, Ratnagiri, Calicut and Cochin. This was also recorded from the Cochin Backwater area (Rengarajan, 1974).

*Eudoxoides mitra* (Fig. 8) a cosmopolitan species was very common in this region, except in certain pockets along the Maharashtra Coast, and between Karwar and Mangalore. *Eudoxoides spiralis* (Fig. 8) was present in the neritic waters near Ratnagiri, in the neritic and oceanic waters off Mangalore and in oceanic waters off Cochin.

*Chelophyes contorta* and *Chelophyes appendiculata* (Fig. 9) were very common and sympatric throughout the coast and oceanic area of the Lakshadweep.

**Abylidae**

*Abyla haeckeli* (Fig. 10) a rare mesopelagic species was obtained from Stn. No. 3578 in the Lakshadweep.

*Abylopsis eschscholtzi* and *Abylopsis tetragona* (Fig. 10) were very common and sympatric and continuously distributed along the west coast of India and Lakshadweep.

*Bassia bassensis* (Fig. 11) another cosmopolitan species is widely distributed in the area investigated.

The peculiarity in the distribution pattern of *Ceratocymba leuckarti* (Fig. 11) is that it occurred only between Porbander and Goa with a stray and single appearance near Calicut. *Enneagonum hyalinum* (Fig 11) distributed along the Gujarat Coast, off Bombay and along the southwest coast of India from Karwar to Cape and in the Lakshadweep area. It also occurred in the deeper waters with its high concentration between 415 m and 435 m depths (Pugh, 1974).

**Clausophyidae**

*Heteropyramis maculata* (Fig. 11) is one of the rare species recorded from *Varuna* Stn. No. 943 off Goa. It was also recorded from 1500 m depth and below by Totton (1954).

## DISCUSSION

Daniel (1974) has mentioned that only *Diphyes chamissonis* and *Lensia subtiloides* are 'true neritic species'. However, the present collections clearly indicate that these two species occur in the oceanic waters in large numbers (Fig. 6 and 7).

The oceanic species *Vogtia pentacantha, Sulculeolaria monoica* and *Lensia fowleri* rarely occurred at one or two stations along the continental shelf edge.

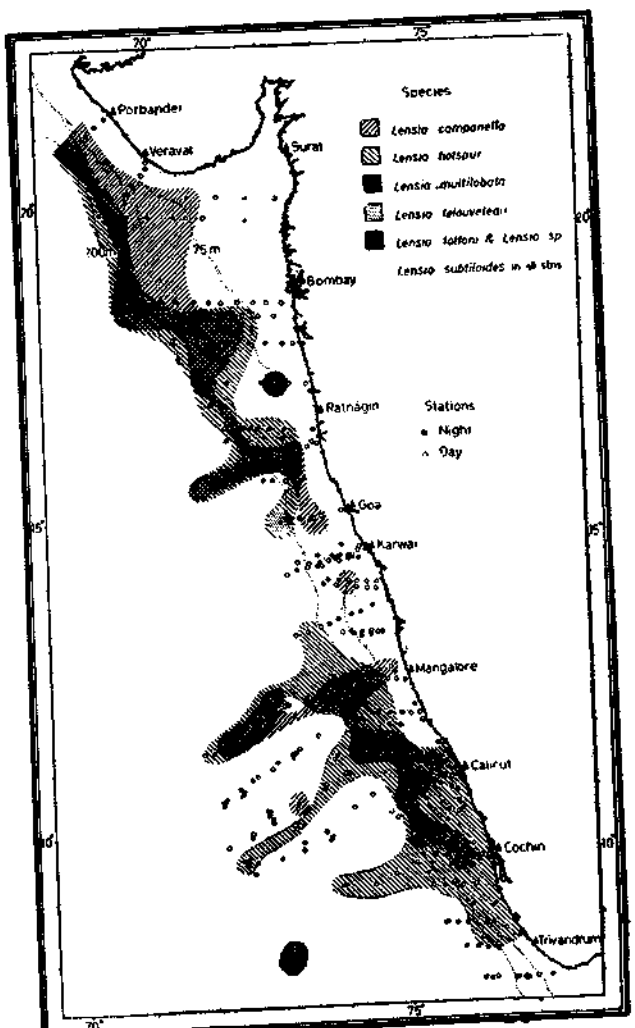


Fig. 7. Distribution of *Lensia campanella, L. hotspur, L. multilobata, L. lelouveteau, L. tottoni, L. subtiloides* and *Lensia* sp.

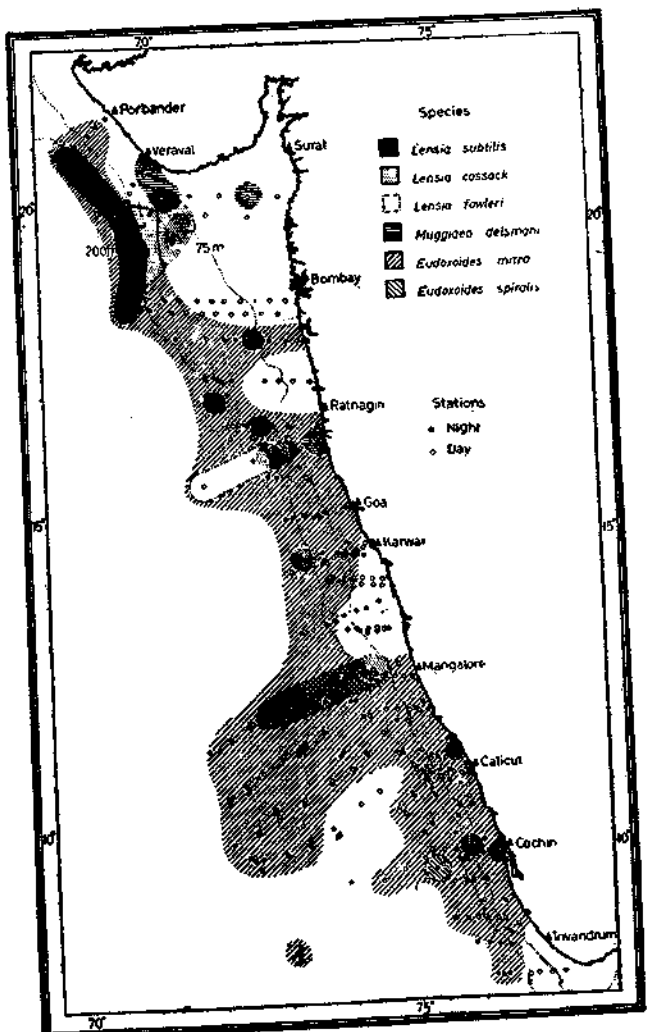


Fig. 8. Distribution of *Lensia subtilis, L. cossack, L. fowleri, Muggiaea delsmani, Eudoxoides mitra* and *E. spiralis.*

The stray occurrence of these three species might be due to oscillations of adjacent waters.

The deep water siphonophores *Marrus orthocannoides, Bargmania elongata, Rosacea plicata, Lensia lelouveteau, Abyla haeckeli* and *Heteropyramis maculata* were present in the upper 200 m water column.

*Marrus orthocannoides* was first recorded as a cold water species (temperature range 4.85°C - 8.35°C) by Totton (1954) from sample collected between 1400 m and 700 m in the western tropical Indian Ocean. Alvarino (1964) recorded this species from the Indian Ocean below 400 m depth during the *Monsoon* Expedition. She classified this as a mesopelagic species. Pugh (1974) found this species in an IKMT oblique haul from 475 m to surface off Fuerteventura in Canary Islands where the water temperature ranged between 11.5°C and 22.0°C. During the present investigation a single nectophore and two bracts of the species were present in a vertical haul from 200 m to surface at which station the temperature was 20.16°C at 200 m and 14.93°C at 300 m depth.

Totton (1954) described *Bargmania elongata* from a vertical haul from 370 m to surface and subsequently recorded it from *Discovery* Stn. No. 4246 from 1600 m depth (Totton, 1965). Alvarino (1967) observed this species between 1250 m and 250 m off San Diego and classified it as mesoplanktonic. Stepanyants (1967, 1970) recorded it in the north Pacific and classified it as a bathypelagic species. He also collected it between 4000 m and 3000 m and at 5240 m from the abyssal region. Pugh (1974) collected this species between 360 m and 950 m in great concentration between 500 m and 625 m, off Fuerteventura in the Canary Islands and indicated that *Bargmania elongata* was more mesopelagic than bathypelagic as suggested by Stepanyants (1967, 1970). The occurrence of this species in the upper 200 metres of our oceanic waters may be an indication of the water mass being brought up from the deeper layers.

*Rosacea plicata* was also collected from the pelagic oceanic waters during the present investigations, whereas it was recorded between 2000 m and 500 m by Patriti (1965). Leloup (1955) classified this as a mesoplanktonic species. Bigelow and Sears (1937) grouped as a bathypelagic species. Alvarino (1967) collected this species between 2200 m and 2600 m during day time and between 225 m and 450 m during night off San Diego and also considered as a mesoplanktonic form. However, the presence of *Rosacea plicata* in the upper 200 m is significant and interesting.

Another rare and bathypelagic dipyhid, *Lensia lelouveteau* was collected in the 200 m to surface in vertical plankton haul during these investigations. Leloup (1955) classified this as a mesoplanktonic species. Alvarino (1967) observed this between 1325 m and 2630 m depth during day time and between 700 m and 2630 m during night off San Diego. Patriti (1965) observed this species between 500 m and 1200 m in the Gulf of Gascogne. Pugh (1974) recorded this off Fuerteventura in the Canary Islands between 900 m and 960 m depth. It may be considered to be more a mesopelagic than a bathypelagic species.

*Abyla haeckeli,* a rare mesoplanktonic abylid was obtained from 200 m to surface in vertical haul. This was also earlier collected by Alvarino (1964) from below 400 m and classified as mesopelagic.

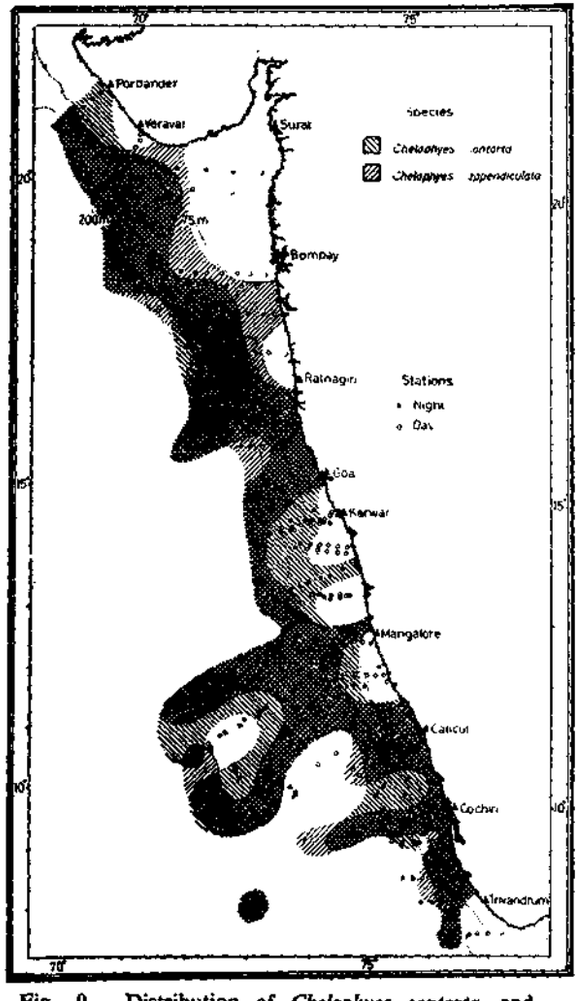


Fig. 9. Distribution of *Chelophyes contorta* and *C. appendiculata*.

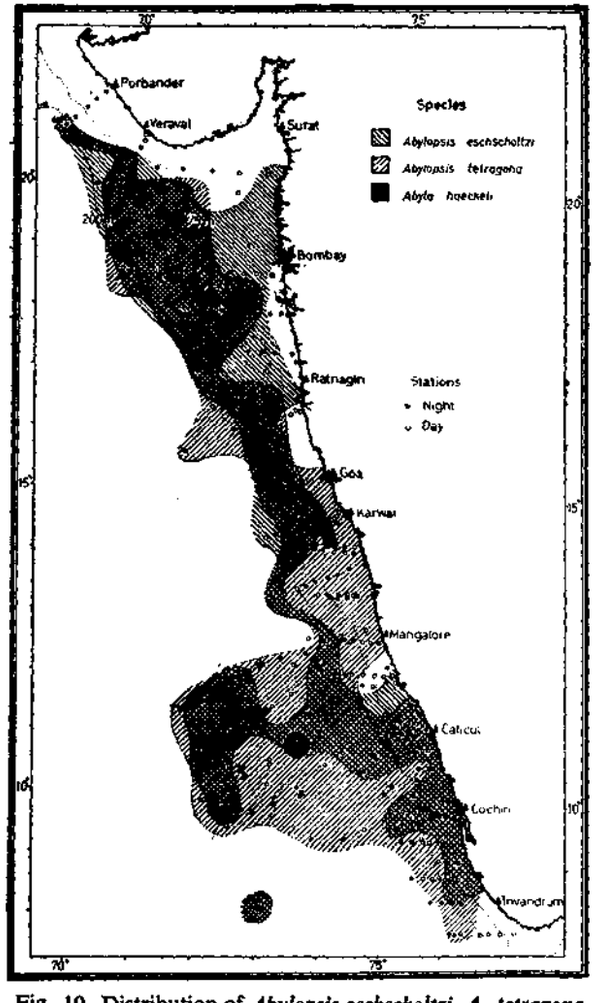


Fig. 10. Distribution of *Abylopsis eschscholtzi*, *A. tetragona* and *Abyla haeckeli*.

One of the six deep water species of siphonophores collected in the upper 200 m layer is *Heteropyramis maculata*. This was recorded by various authors from different depths – from 800 m to 200 m (Leloup, 1934), 450 m to 150 m (Totton, 1954), from below 3000 m to surface (Alvarino, 1967), 400 m to 200 m (Patriti, 1970), 660 m to 500 m and at 50 m (Pugh, 1974).

Thus, it is evident that *Marrus orthocannoides, Bargmania elongata, Rosacea plicata* and *Abyla haeckeli* collected from the Lakshadweep regions during December 1966 and *Lensia lelouveteau* and *Heteropyramis maculata* collected in the oceanic waters off Goa in April, 1963 are meso/bathypelagic species.

An attempt is made here to find out the probable causes which brought these species to the pelagic region. One of the possible causes is the movement of deeper waters to the upper 200 m water column. Jayaraman (MS) classified the upwellings along the Indian Coast and adjacent seas into three categories. According to him they are:

" i. Coastal upweling caused by winds transporting surface waters away from the coast and replacement of these surface waters by waters emerging up from below;

ii. Upwelling in the open ocean as a result of divergence of some permanent current system, such as equitorial upwelling; and

iii. A third type of upwelling, though not upwelling *sensustricto*, caused by major currents passing over deep submarine ridges resulting in the transport of deeper waters nearer to the surface. This type is probably present in the Laccadive region."

The third type of 'upwelling' may be more appropriate here, because the presence of Lakshadweep group of islands and connected ridges in that area might have influenced this type of passing over and upwelling by which the deeper water along with its organisms might have come up to the upper layers.

The vertical temperature profiles for Stn. No. 3564 (the station at which *Marrus orthocannoides* was observed) and adjacent stations indicate that the upper layers between 0 m and 75 m have a wide temperature range and the thermocline is observed at about 30 m to 35 m. Between 75 m and 200 m the waters are more or less isothermal, the temperature range being 20°C to 22°C. The fact that the particular species is observed in the collection from 200 m to surface is again in conformity with the temperature tolerence limit mentioned by Pugh (1974) *viz.*, 11.5°C to 22.0°C. The upper limit of temperature is quite clearly evidenced in the present investigation as can be seen from the temperature profile (Fig. 12).

It has been observed that subsurface divergence zones exist in the Laccadive area during December - February period, while investigating the relationship between plankton abundance and hydrography in the Laccadive Sea. These divergence phenomenon can also help the upward migration of fauna which are usually ahbitating the deeper layers, to such levels upto which the temperature tolerence of the species is possible (Ramamirtham, per. comm.).

From the above facts, *Marrus orthocannoides* may be regarded here as an indicator of vertical upward transport of water from the deeper regions. The other

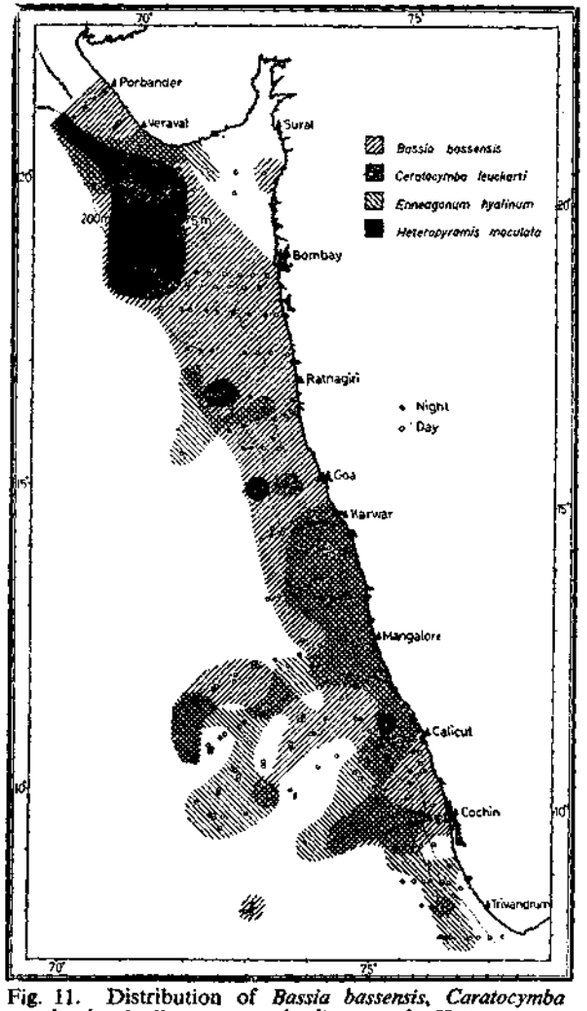


Fig. 11. Distribution of *Bassia bassensis*, *Caratocymba leuckarti*, *Enneagonum hyalinum* and *Heteropyramis maculata*.

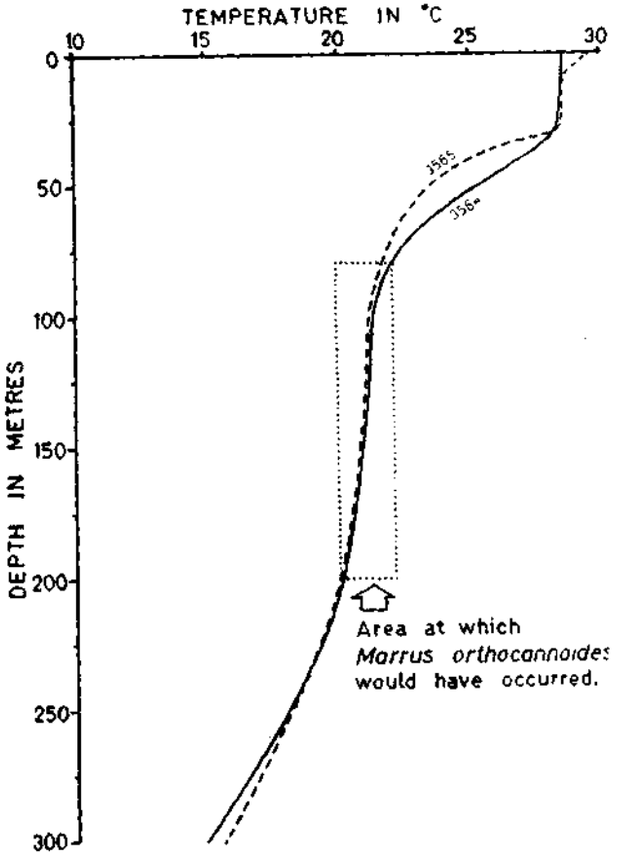


Fig. 12. The vertical temperature profile for the stations 3564 and 3565 of the R. V. *Varuna* Cruise.

two mesoplanktonic siphonophores *Lensia lelouveteau* and *Heteropyramis maculata* collected off Goa might have probably been transported from the deeper regions by upwelling and this area is noted for this phenomenon.

The result of any plankton investigation particularly the species composition, their seasonal occurrence and quantitative abundance in relation to hydrological conditions will mainly depend upon the regular and uniform sampling method. In this context, the present investigations along the west coast of India and the Laccadive Sea have given encouraging and interesting results.

The quantitative seasonal abundance of different species in relation to hydrographical conditions and their influence in the marine food chain and other related aspects are being investigated in detail based on plankton samples collected regularly and uniformly over a period of several years.

## ANNEXURE

*R. V.* VARUNA *Station Particulars (from Station 3479 to 3660)**

| Station No. | Date | Time | Position Latitude N | Position Longitude E | Depth at Station (m) |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| 3479 | 23- 8-1966 | 1845 - 1850 | 14° 45′ | 73° 50′ | 40 |
| 3480 | ,, | 2005 - 2025 | ,, | 73° 40′ | 60 |
| 3481 | ,, | 2120 - 2205 | ,, | ,, | ,, |
| 3483 | 24- 8-1966 | 0315 - 0400 | 14° 15′ | 73° 28′ | 106 |
| 3484 | ,, | 0450 - 0530 | ,, | 73° 38′ | 70 |
| 3485 | ,, | 0620 - 0640 | ,, | 73° 48′ | 60 |
| 3486 | ,, | 0740 - 0810 | ,, | 73° 58′ | 50 |
| 3487 | ,, | 0905 - 0930 | ,, | 74° 08′ | 45 |
| 3488 | ,, | 1025 - 1055 | ,, | 74° 18′ | 35 |
| 3490 | ,, | 1600 - 1615 | 13° 30′ | 74° 25′ | 40 |
| 3491 | ,, | 1715 - 1735 | ,, | 74° 15′ | 40 |
| 3492 | ,, | 1830 - 1845 | ,, | 74° 05′ | 50 |
| 3493 | ,, | 1940 - 2000 | ,, | 73° 55′ | 60 |
| 3495 | 25-8-1966 | 0130 - 0155 | 12° 45′ | 74° 10′ | 170 |
| 3496 | ,, | 0330 - 0400 | ,, | 74° 20′ | 100 |
| 3501 | ,, | 1340 - 1405 | 12° 07′ | 75° 07′ | 40 |
| 3503 | ,, | 1620 - 1645 | 12° 00′ | 74° 40′ | 90 |
| 3504 | ,, | 2030 - 2110 | ,, | 74° 32′ | 80 |
| 3505 | ,, | 2200 - 2215 | 11° 15′ | 74° 54′ | 65 |
| 3506 | ,, | 2320 - 2335 | ,, | 74° 03′ | 60 |
| 3507 | 26- 8-1966 | 0030 - 0045 | ,, | 75° 12′ | 50 |
| 3508 | ,, | 0210 - 0220 | ,, | 75° 23′ | 40 |
| 3509 | 7- 9-1966 | 0730 - 0830 | 08° 00′ | 77° 11′ | 60 |
| 3510 | ,, | 0930 - | ,, | 76° 58′ | 90 |
| 3511 | ,, | 1130 - | ,, | 76° 48′ | 180 |
| 3512 | 7- 9-1966 | 1415 - | 08° 00′ | 76° 38′ | 720 |
| 3513 | ,, | 1615 - | ,, | 76° 28′ | 800 |
| 3514 | ,, | 1815 - | ,, | 76° 18′ | 960 |
| 3515 | ,, | - | ,, | 76° 08′ | 1150 |
| 3516 | 8- 9-1966 | 0035 - | 08° 33′ | 75° 50′ | 980 |
| 3517 | ,, | 0250 - | ,, | 76° 00′ | 600 |

* The Indian Ocean Standard Net was used for collecting zooplankton samples.

ANNEXURE CONTD.

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| 3519 | ,, | 0535 – | ,, | 76° 20′ | 50 |
| 3521 | ,, | 0950 – | 08° 55′ | 76° 17′ | 30 |
| 3522 | ,, | 1105 – | ,, | 76° 07′ | 50 |
| 3523 | ,, | 1230 – 1255 | ,, | 75° 57′ | 55 |
| 3524 | ,, | 1420 – | ,, | 75° 47′ | 200 |
| 3525 | ,, | 1555 – 1655 | ,, | 75° 37′ | 400 |
| 3526 | ,, | 1800 – | ,, | 75° 27′ | 270 |
| 3527 | 9–9–1966 | 0630 – 0705 | 09° 32′ | 75° 46′ | 180 |
| 3528 | ,, | 0750 – 0835 | ,, | 75° 36′ | 170 |
| 3529 | ,, | 0935 – 1020 | 09° 32′ | 75° 26′ | 1300 |
| 3530 | ,, | 1120 – 1205 | ,, | 75° 16′ | 1800 |
| 3531 | ,, | 1310 – | 09° 58′ | 75° 06′ | 1500 |
| 3532 | ,, | 1445 – 1530 | ,, | 75° 16′ | 700 |
| 3533 | ,, | 1615 – 1640 | ,, | 75° 26′ | 300 |
| 3534 | ,, | 1735 – 1755 | ,, | 75° 36′ | 180 |
| 3535 | ,, | 1832 – 1847 | ,, | 75° 41′ | 60 |
| 3539 | 7–11–1966 | 1405 – 1515 | 16° 39′ | 71° 51′ | 1300 |
| 3540 | ,, | 1545 – 1625 | ,, | 71° 56′ | 400 |
| 3541 | ,, | 1715 – 1800 | ,, | 72° 00′ | — |
| 3542 | ,, | 1835 – 1920 | ,, | 72° 05′ | 215 |
| 3543 | ,, | 2010 – 2045 | ,, | 72° 12′ | 110 |
| 3544 | ,, | 2205 – | 16° 30′ | 72° 40′ | 110 |
| 3547 | 8–11–1966 | 1015 – 1035 | ,, | 72° 09′ | 22 |
| 3549 | ,, | 1200 – 1305 | 16° 29′ | 71° 49′ | 300 |
| 3561 | 6–12–1966 | 1105 – 1215 | 12° 05′ | 74° 05′ | 1100 |
| 3562 | ,, | 2135 – 2215 | 12° 20′ | 73° 50′ | 1200 |
| 3563 | 7–12–1966 | 1105 – 1310 | ,, | 73° 21′ | 1850 |
| 3564 | 7–12–1966 | 1605 – | 12° 20′ | 72° 51′ | 2000 |
| 3566 | 8–12–1966 | 0215 – 0300 | 11° 55′ | 72° 09′ | 1600 |
| 3567 | ,, | 0510 – 0600 | 11° 41′ | 71° 52′ | ,, |
| 3568 | ,, | 0755 – 0850 | 11° 32′ | 71° 37′ | 1500 |
| 3569 | ,, | 1140 – | 11° 09′ | 71° 44′ | 500 |
| 3570 | ,, | 1405 – 1500 | 10° 54′ | 71° 56′ | 1600 |
| 3571 | ,, | 1600 – 1645 | 10° 57′ | 72° 06′ | ,, |
| 3572 | ,, | 1930 – | 11° 06′ | 72° 20′ | 1800 |
| 3573 | 9–12–1966 | 1130 – | 11° 23′ | 72° 46′ | 1700 |
| 3574 | ,, | 1440 – 1555 | 11° 34′ | 73° 03′ | 1800 |
| 3575 | ,, | 2330 – | 11° 30′ | 73° 37′ | 2000 |
| 3576 | ,, | 2340 – | 11° 30′ | 73° 37′ | 2000 |
| 3577 | 10–12–1966 | 0305 – 0410 | 11° 15′ | 73° 53′ | ,, |
| 3578 | ,, | 0700 – 0750 | 11° 00′ | 73° 30′ | 1900 |
| 3579 | ,, | 1000 – 1205 | 10° 43′ | 73° 06′ | 1700 |
| 3580 | ,, | 1400 – 1505 | 10° 27′ | 72° 42′ | ,, |
| 3581 | ,, | 1900 – 2025 | 10° 13′ | 72° 20′ | ,, |
| 3582 | 11–12–1966 | 1020 – | 10° 00′ | 72° 00′ | 425 |
| 3583 | ,, | 1340 – 1455 | 09° 51′ | 72° 14′ | 2000 |
| 3584 | ,, | 1645 – 1740 | 09° 40′ | 72° 29′ | 1600 |
| 3885 | ,, | 2100 – | 09° 52′ | 72° 48′ | 1800 |
| 3586 | 12–12–1966 | 0125 – 0220 | 10° 00′ | 73° 10′ | 1900 |
| 3587 | ,, | 0450 – 0550 | 10° 22′ | 73° 33′ | 2000 |
| 3588 | ,, | 0850 – 0945 | 10° 38′ | 73° 57′ | 2750 |
| 3589 | ,, | 1220 – 1320 | 10° 51′ | 74° 18′ | 600 |
| 3590 | ,, | 1615 – 1715 | 10° 33′ | 74° 39′ | 2050 |
| 3591 | ,, | 2119 – 2310 | 10° 15′ | 75° 00′ | 950 |
| 3592 | 13–12–1966 | 0210 – 0300 | 10° 15′ | 75° 30′ | 900 |
| 3593 | 17–12–1966 | 1215 – | 14° 45′ | 74° 00′ | 36 |
| 3594 | ,, | 1332 – | ,, | 73° 50′ | 53 |
| 3595 | ,, | 1500 – 1515 | ,, | 73° 40′ | 62 |
| 3596 | ,, | – | ,, | 73° 30′ | 80 |
| 3597 | 17–12–1966 | 1750 – | 14° 45′ | 73° 20′ | 104 |
| 3598 | ,, | 2100 – | 14° 15′ | 73° 28′ | 110 |
| 3599 | 18–12–1966 | 0825 – | ,, | 73° 38′ | 89 |

ANNEXURE CONTD.

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| 3600 | ,, | 1040 – 1105 | ,, | 73° 48′ | 66 |
| 3601 | ,, | 1200 – 1215 | ,, | 73° 58′ | 58 |
| 3602 | ,, | 1315 – 1345 | ,, | 74° 08′ | 49 |
| 3603 | ,, | 1450 – 1500 | ,, | 74° 18′ | 33 |
| 3605 | ,, | 2350 – 2400 | 13° 30′ | 74° 25′ | 37 |
| 3606 | 19–12–1966 | 0300 – | ,, | 74° 15′ | 45 |
| 3607 | ,, | 0200 | ,, | 74° 05′ | 55 |
| 3608 | ,, | 0400 – 0415 | ,, | 73° 55′ | 67 |
| 3609 | ,, | 0600 – 0630 | ,, | 73° 45′ | 78 |
| 3610 | ,, | 1110 – 1145 | 12° 45′ | 74° 10′ | 150 |
| 3611 | ,, | 1350 – 1415 | ,, | 74° 20′ | 78 |
| 3612 | ,, | 1525 – 1545 | ,, | 74° 30′ | 55 |
| 3613 | ,, | 1655 – 1715 | ,, | 74° 40′ | 42 |
| 3614 | ,, | 1810 – 1825 | ,, | 74° 47′ | 18 |
| 3615 | ,, | 2315 – 2330 | 12° 18′ | 74° 57′ | 28 |
| 3616 | 20–12–1966 | 0740 – 0750 | 12° 12′ | 75° 03′ | 20 |
| 3617 | ,, | 0850 – 0915 | ,, | 74° 53′ | 51 |
| 3618 | ,, | 1015 – 1035 | ,, | 74° 43′ | 64 |
| 3619 | ,, | 1215 – 1240 | ,, | 74° 33′ | 107 |
| 3620 | ,, | 1320 – 1405 | ,, | 74° 21′ | 183 |
| 3621 | ,, | 1900 – | 11° 32′ | 74° 40′ | 173 |
| 3622 | ,, | 2200 – 2230 | ,, | 74° 53′ | 73 |
| 3623 | ,, | 2355 – | ,, | 75° 06′ | 56 |
| 3626 | 8– 2–1967 | 0800 – 0900 | 11° 17′ | 74° 51′ | 350 |
| 3627 | ,, | 1220 – 1330 | 11° 34′ | 74° 32′ | 550 |
| 3628 | ,, | 1600 – 1750 | 11° 51′ | 74° 19′ | 1200 |
| 3629 | ,, | 2010 – 2200 | 12° 05′ | 74° 03′ | 1400 |
| 3630 | 9– 2–1967 | 0015 – 0105 | 12° 20′ | 73° 54′ | 1600 |
| 3632 | ,, | 0920 – 1020 | 12° 20′ | 72° 50′ | 1800 |
| 3633 | ,, | 1255 – 1355 | 12° 00′ | 72° 27′ | 1600 |
| 3634 | ,, | 1600 – 1645 | 11° 53′ | 72° 09′ | ,, |
| 3635 | ,, | 2000 – 2115 | 11° 41′ | 71° 52′ | ,, |
| 3636 | 10–2–1967 | 1105 – 1235 | 11° 31′ | 71° 48′ | ,, |
| 3637 | ,, | 1505 – 1605 | 11° 09′ | 71° 44′ | 1400 |
| 3638 | ,, | 1915 – 2010 | 10° 48′ | 71° 51′ | 1600 |
| 3639 | 11– 2–1967 | 0945 – 1035 | 10° 57′ | 72° 06′ | 1620 |
| 3640 | ,, | 1240 – 1345 | 11° 07′ | 72° 21′ | 1700 |
| 3641 | ,, | 1745 – 1845 | 11° 23′ | 72° 46′ | 1800 |
| 3642 | ,, | 2145 – 2225 | 11° 34′ | 73° 03′ | ,, |
| 3643 | 12– 2–1967 | 0935 – 1020 | 11° 46′ | 73° 21′ | 2500 |
| 3644 | ,, | 1245 – 1340 | 11° 30′ | 73° 37′ | 2000 |
| 3645 | ,, | 1615 – 1700 | 11° 15′ | 73° 53′ | 2100 |
| 3646 | ,, | 2000 – 2100 | 11° 00′ | 73° 30′ | 1900 |
| 3647 | 13– 2–1967 | 0935 – 1010 | 10° 43′ | 73° 05′ | ,, |
| 3648 | ,, | 1235 – 1325 | 10° 28′ | 72° 42′ | 1750 |
| 3649 | ,, | 1630 – 1730 | 10° 14′ | 72° 20′ | 1700 |
| 3650 | ,, | 2040 – 2200 | 10° 00′ | 72° 00′ | 2400 |
| 3651 | 14– 2–1967 | 0855 – 0940 | 09° 50′ | 72° 14′ | 1780 |
| 3652 | ,, | 1130 – 1230 | 09° 40′ | 72° 28′ | 1840 |
| 3653 | ,, | 1500 – 2030 | 09° 52′ | 72° 48′ | 1850 |
| 3654 | ,, | 2145 – 2245 | 10° 07′ | 73° 10′ | 1600 |
| 3655 | 15– 2–1967 | 1210 – 1305 | 10° 22′ | 73° 34′ | 2100 |
| 3656 | 22– 2–1967 | 0835 – 0950 | 11° 32′ | 75° 30′ | 19 |
| 3657 | ,, | 1035 – 1055 | 11° 32′ | 75° 18′ | 45 |
| 3658 | ,, | 1220 – 1300 | ,, | 75° 06′ | 56 |
| 3659 | ,, | 1720 – 1740 | ,, | 74° 53′ | 72 |
| 3660 | ,, | 2015 – 2115 | ,, | 74° 04′ | 188 |

## REFERENCES

ALVARINO, A. 1964. Preliminary report on Chaetognatha, Siphonophora and Medusae. *In:* Preliminary results of Scripps Institution of Oceanography–Investigations in the Indian Ocean during Expedition *Monsoon* and *Lusiad* 1960 - 1963. S.I.O. Reference No. 64 - 19 : 103 - 108 and 200 - 212.

————1967. Bathymetric distribution of Chaetognatha, Siphonophorae, Medusae and Ctenophorae off San Diego, California. *Pacific Sci.*, **21** (4) : 474 - 485.

————1974. Distribution of siphonophores in the regions adjacent to the Suez and Panama Canals. *Fish. Bull.*, **72** (2) : 527 - 546.

BIGELOW, H. B. AND M. SEARS 1937. Siphonophorae. *Rep. Danish oceanogr. Exped., Medit., Biology*, **2** : 1 - 144.

DANIEL, R. 1966. On a new physonectae, *Frillagalma vityazi* gen. nov., sp. nov. (Siphonophora: Coelenterata) from the Indian Ocean. *Ann. Mag. nat. Hist., London*, **9** (13): 689 - 692.

————1974. Siphonophora from the Indian Ocean. *Memoirs of the Zoological Survey of India*, **15** (4) : 1 - 242.

JAYARAMAN, R. (MS). Present status of upwelling.

LELOUP, E. 1933. Siphonophores Calycophorides et Physophorides provenant des campagnes du Prince Albert ler de Monaco. *Resultats des campagnes scientifiques Albert ler Prince de Monaco*, **87** : 1 - 67.

————1955. Siphonophores. *Report on the scientific results of the* 'Michael Sars' *north Atlantic Deep Sea Exped.*, **5** (11): 1 - 24.

MOORE, H. B. 1949. The zooplankton of the upper waters of the Bermuda area of the North Atlantic. *Bull. Bingham Oceanographic collection, Yale University*, **12** (2) : 1 - 97.

————1953. Plankton of the Florida current. II. Siphonophora. *Bull. Mar. Sci. Gulf and Carribean*, **2** : 559 - 573.

PATRITI, G. 1964. Les Siphonophores calycophores du Golfe de Marseille. *Recueil des travaux de la Station marine d'Endoume, Faculté des science de Marseils*, **35** : 185 - 258.

————1965. Contribution a l'etude de siphonophores calycophores recueillis dans le Golfe de Gascogne. *Ibid.*, **37** (53): 151 - 160.

————1966. Contribution a l'etude de siphonophores calycophores recueillis dans le Golfe de Gascogne (3e note). *Ibid.*, **41** (57) : 109 - 116.

————1970. Note sur deux nouvelles espèces du genre *Lensia*, recueillies dans les eaux du large de Tulear (S. W. de L'Ocean Indien, Madagascar). *Ibid.*, suppl. **10** : 103 - 106.

PUGH, P. R. 1974. The vertical distribution of siphonophores collected during the Sond Cruise, 1965. *J. Mar. Biol. Ass. U. K.*, **54** : 25 - 90.

————1975. The distribution of siphonophores in a transect across the North Atlantic Ocean at 32° N. *J. exp. mar. biol. Ecol.*, **20** : 77 - 97.

RENGARAJAN, K. 1973. Siphonophores obtained during the cruises of R. V. *Varuna* from the west coast of India and the Laccadive Sea. *J. mar. biol. Ass. India*, **15** (1): 125 - 159.

————1974. On the occurrence of siphonophores in the Cochin Backwater. *Ibid.*, **16** (1): 280 - 286.

STEPANYANTS, S. D. 1967. Siphonophores of the seas of the U. S. S. R. and the North western part of the Pacific Ocean (In Russian). *In* : *Opredeliteli po faune SSSR*, **96** : 1 - 216.

————1970. Siphonophores of the southern part of the Kurile-Kamchatka Trench and the adjacent area. *Trudy Institute Okeanologia, Akademiya Nauk, SSSR*, **96** : 222 - 235.

TOTTON, A. K. 1954. Siphonophora of the Indian Ocean, together with systematic and biological notes on related species from the other oceans. *Disc. Rep.*, **27** : 1 - 161.

————1965. A Synopsis of the Siphonophora. *British Museum (Nat. Hist.)*, Pp. : 1–230.