J. mar. biol. Ass. India, **47** (1) : 20 - 30, Jan. - June, 2005

Occurrence and distribution of the planktonic shrimps of the genus *Lucifer* in the EEZ of India

Geetha Antony

Central Marine Fisheries Research Institute, Cochin – 682 018, India

Abstract

The distribution and abundance of decapod shrimps of the family Luciferidae De Haan, 1849 under the super family Sergestoidea Dana, 1852 in the Exclusive Economic Zone of India were studied based on 918 zooplankton samples collected during 37 cruises of FORV *Sagar Sampada*. All the seven species recorded elsewhere in the world namely, *L. typus* H. Milne Edwards, *L. hanseni* Nobili, *L. penicillifer* Hansen, *L. faxoni* Borradaile, *L. chacei* Bowman, *L. intermedius* Hansen and *L. orientalis* Hansen have been found to occur in the Indian EEZ of which the last three are new records. *L. penicillifer* is the predominant species in the eastern Arabian Sea and the Bay of Bengal and *L. typus* in the island ecosystems of Lakshadweep and Andaman-Nicobar. The neretic region of the Indian EEZ up to 50 m depth supports 51% of these shrimps, the mid-shelf between 50 and 100m harbours 29%, whereas 12% occur in the outer shelf (100 and 200m) and 8% in the deep zone (>200 m). The presence of *L.penicillifer* in the eastern Arabian Sea and *L.hanseni* in the Lakshadweep waters is reported for the first time. Matrix of correlation revealed the highest co-occurrence of these shrimps in the Andaman-Nicobar waters wherein six of the *Lucifer* species co-exist. Diagnostic characters used in species identification are given and illustrated.

Key words: *Lucifer* spp., occurrence, distribution, abundance, EEZ of India

Introduction

The epiplanktonic shrimps of the genus *Lucifer* play a vital role in the foodweb of the warm neretic waters and estuaries of the lower latitudes constituting the forage of shore fishes and large shrimps (Omori, 1977; Rajagopalan *et al.*, 1992). In the coastal waters of India, lucifers constitute 27% of the total zooplankton and rank next to copepods in numerical abundance (Qasim *et al.*, 1978). Their contribution to the estuarine population is higher, accounting for 39% of the total estuarine zooplankton (Haridas, 1982). Antony *et al.* (1990) also elucidated the presence of lucifers in large numbers forming a sizable percentage of the decapods throughout the year exhibiting peak dominance during the southwest monsoon and the immediate post monsoon months along the southwest coast of India and also at localized centres on the east coast such as Chennai, Visakhapatnam and Orissa. Realising its importance as an intermediary link in the coastal food web of Indian waters and their possible utility as feed in culture

systems, studies were conducted to discern the systematics, biology and ecology of this important group of shrimps in the different hydroclimatic zones of the EEZ of India.

The author is grateful to Dr. P.S.B.R. James, former Director, Central Marine Fisheries Research Institute, for granting study leave to undertake this study in partial fulfilment of the Ph.D programme. She is grateful to Retd. Prof. (Dr.) A. Antony for the guidance received and to Prof. Dr. N.R. Menon, former Director, School of Marine Sciences for the material and facilities provided. The author is also grateful to Dr. K.J. Mathew, Retd. Principal Scientist, for suggesting the topic, advice and for critically going through the manuscript and to Smt. T.S. Naomi, Scientist (SG) for her advice and encouragements.

Material and methods

The present study was based on 918 samples collected using the Bongo - 60 net of 0.33 mm mesh attached with a pre-calibrated digital flow meter. The net was operated in oblique hauls at shallow stations from near the bottom and at deeper stations from 150 m to surface in all the 37 research cruises of FORV *Sagar Sampada* conducted during 1985-1992 (Fig.1). The lucifers were sorted out from a minimum of 5 ml of zooplankton sample. Aliquots were made whenever the biomass deter-

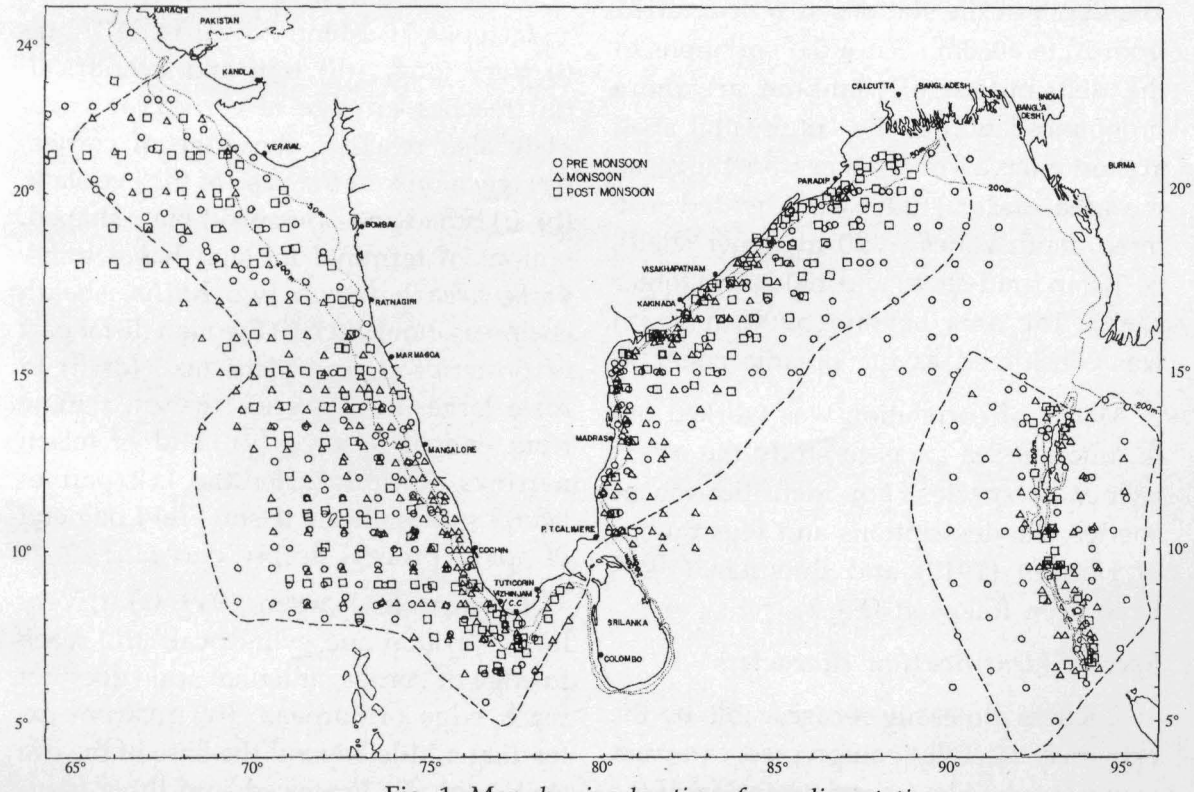

Fig. 1. *Map showing location of sampling stations*

mined by displacement volume method exceeded 5 ml. The number of organisms per 1000m^3 of water estimated per half a degree square pooled for the years was taken as the index of abundance with reference to area (Mathew *et al.*, 1990).

The study area comprising of the entire EEZ of India covering 2.015 x 10^6 km^2 was divided into six sectors as follows: Eastern Arabian Sea into southwest (Lat.5° 30′-15° 30′ N), northwest (Lat.15° 30′-22° 30′ N) and Lakshadweep (Lat.8° 00′-12° 30′ N; Long. 71° 00′-74° 00′ E); the Bay of Bengal into southeast (Lat.5° 30′-15° 30′ N), northeast (Lat.15° 30′-22° 30′ N) and the Andaman and Nicobar Sea (Lat. 5° 00′ - 14° 30′ N; Long. 85° 00′ - 95° 00′ E). The depth at the stations sampled varied from 20 to 4060m. Since the variations in the distribution of plankton are more pronounced within the continental shelf at short intervals of distance from the coast, the area under study was divided into three depth zones: < 50 m (inner shelf), 50-100 m (mid-shelf) and 100-200 m (outer shelf). The area beyond >200 m depth was considered as the oceanic zone.

Matrix of correlation was worked out in different sea areas to study the co-existence of species. For identification of species, the descriptions and illustrations of Hansen (1919) and Bowman (1967) have been followed (Fig.2).

Species identification characters

Lucifers are easily recognizable by the extremely laterally compressed carapace, elongate tube-like frontal extension of the carapace, very distinctive stalked eyes and the complete absence of gills. Characters that have been considered for identification of the species are listed below:

(a) Eye stalk: (i) length of eye stalk, (ii) shape of eye stalk, (iii) length of first antennular joint to the front margin of the eye and (iv) length of rostrum.

(b) Petasma: (i) terminal portion of sheath, and (ii) processus ventralis.

(c) Processes on sixth abdominal segment of male – shape and direction.

(d) Telson: (i) ventral protuberance, and (ii) spines on the telson.

(e) Marginal apical process of exopod of uropod.

L. typus H. Milne Edwards, 1837 **(a)** (i) Very long, (ii) thin and cylindrical, (iii) reaches to edge of cornea; antennal scale also reach to the edge of cornea, (iv) reach only to the base of the eye stalk. **(b)** (i) Broad and obtuse, (ii) plate shaped, bottom of terminal incision has a transverse area between two horns, sheath encloses a hook. **(c)** (i) Swollen distal part of posterior process bent up. **(d)** (i) In male large, its posterior margin remote from end of telson, (ii) end of telson narrows abruptly after the last pair of lateral spines on the telson. **(e)** Long end of apical process deeply curved.

L. orientalis Hansen, 1919 **(a)** (i) Very long, (ii) thin and cylindrical, (iii) reach to edge of cornea, antennal scale does not reach edge of cornea, (iv) rostrum extending a little beyond the base of the eye stalk. **(b)** (i) Produced into three trian-

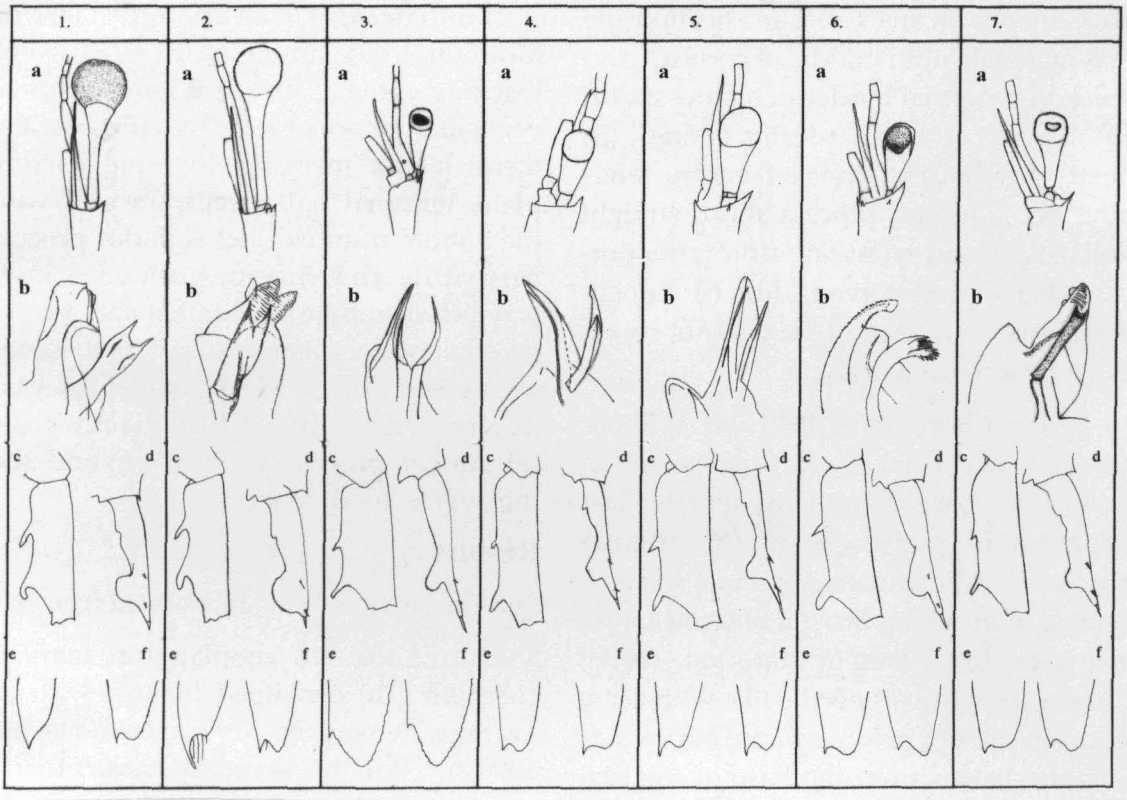

Fig. 2. *Diagnostic features of* **1.** L. typus **2.** L. orientalis **3.** L. hanseni **4.** L. chacei **5.** L. faxoni **6.** L. penicillifer **7.** L. intermedius

(a) anterior end of cephalothorax of male-lateral view (x 15); (b) distal third of petasma from the inner side (x 180); (c) sixth abdominal segment of male (x 15); (d) telson lateral view (x 45); (e) apex of exopod of uropod – male (x 45); (f) apex of exopod of uropod – female (x 45)

gular lobes, transverse lines on two lobes, (ii) plate shaped, terminal incision deep, tapering to acute end, sheath does not enclose a hook. **(c)** Swollen distal half of posterior process only feebly bent. **(d)** (i) More semiglobular ending distally at apex. **(e)** Terminal margin considerably oblique.

L. hanseni Nobili, 1905 **(a)** (i) Short to moderate, (ii) thick and tubular, (iii) extend slightly beyond cornea, (iv) not reaching statocyst. **(b)** (i) Acute (ii) slender needle with acute end. **(c)** Sixth abdominal segment in male much deeper, in proportion to its length; anterior process shorter than the posterior and placed nearer to second process than to the base of the segment. **(d)** (i) Short and broad in proportion to its length with several prickles. **(e)** Small marginal tooth terminate much in advance of the upper terminal angle.

L. chacei Bowman, 1967 **(a)** (i) Very short, (ii) increase gradually in thickness from base, (iii) over reach very considerably in male, reach somewhat beyond in female; last segment of peduncle of sec-

ond antenna in male reaches beyond the eye, in female upto middle of cornea, (iv) reach to proximal border of statocyst. **(b)** (i) Sheath curved, apically acute, (ii) nearly needle like directed ventro laterally. **(c)** Anterior process short, straight and placed more backwards, posterior process slender and curved. **(d)** (i) Longer than broad. **(e)** Apical process not reaching upper terminal angle.

L.faxoni Borradaile, 1915 **(a)** (i) Short, (ii) stout and conical, (iii) over reach in male, less considerably in female; last segment of peduncle of 2nd antenna reaches middle of cornea in male while in female to proximal margin of cornea, (iv) reach to distal end of statocyst. **(b)** (i) Sheath straight, (ii) needle like with acute end. **(c)** Anterior process placed backwards – more distant from the base of the segment than from the second process. **(d)** (i) Prominent, (ii) two pairs of equidistant lateral spines. **(e)** Apical process reaches beyond upper terminal angle.

L.penicillifer Hansen, 1919 **(a)** (i) Short, (ii) conical, (iii) extends slightly beyond cornea. **(b)** (i) Expanded as an oblique plate, distal part curved with small tubercles on the inner side, (ii) slender plate terminates in a bipartite brush of numerous chitinous threads. **(c)** Anterior process very acute and curved. **(d)** (i) Swollen section on ventral surface small, situated further away from tip of telson, (ii) last pair of lateral spines close to the tip of telson. **(e)** Short triangular tooth not reaching beyond upper distal angle, long end considerably oblique.

L. intermedius Hansen, 1919 **(a)** (i) Moderate, (ii) sub-cylindrical, (iii) not reaching cornea. **(b)** (i) Rounded, transverse lines on inner side, two plates at the distal lateral margin, (ii) long narrow plate, terminal part deeply incised with the bottom rounded. **(c)** Anterior process very acute and curved, positioned midway between base of segment and second process; posterior process tapers to rather obtuse end. **(d)** (i) Much smaller directed downwards and slightly backwards. **(e)** Apical process reaches beyond the transverse hind margin.

Results

Species composition and abundance

Out of the 918 zooplankton samples collected, 910 contained lucifers with an average density of 3199 specimens per 1000 m^3. All the seven species hitherto recorded in the genus, were encountered in the samples (Table 1).

The numerical abundance of lucifers showed considerable variations in the different areas. Maximum density was recorded in the eastern Arabian Sea where

Table 1. *Numerical abundance and percentage composition of* Lucifer *spp.in the EEZ of India*

Species	Density (No/1000 m^3)	Composition (%)
L. penicillifer	1514	47.3
L. hanseni	725	22.7
L. typus	651	20.4
L. chacei	288	9.0
L. intermedius	17	0.5
L. orientalis	3	0.09
L. faxoni	1	0.03

the average number per 1000 m^3 was 4142 (53%) whereas in the Bay of Bengal it was 2991(38%) and 727 (9%) in the Andaman and Nicobar Sea.

In the eastern Arabian Sea, *L. penicillifer* dominated over the other species with a contribution of 48% followed by *L. hanseni* (29 %) and *L. typus* (21 %). The other species namely *L. chacei, L. faxoni* and *L. orientalis* together constituted only less than 0.6% of the total population.

In the Bay of Bengal, *L. penicillifer* dominated (50 %) followed by *L. chacei* (26 %), *L. typus* (14 %), *L. hanseni* (10%) and *L. intermedius* (1 %). *L. orientalis* and *L. faxoni* together formed 0.5%.

In the Andaman and Nicobar waters, *L. typus* was the most dominant species (55%) followed by *L. hanseni* (28 %), *L.chacei* (9 %) and *L. penicillifer* (8 %). *L. faxoni* and *L. intermedius* together formed 0.4%. *L. orientalis* was not observed in the area.

Sectorwise variations in species abundance

The southwest sector was the most populated followed by northwest contributing to 27 % and 22 % respectively. The northeast and southeast sectors in the Bay of Bengal contributed to 16% and 15% of the total lucifers. While the Lakshadweep waters accounted for 5%, the seas around Andaman-Nicobar Islands supported 15% of the lucifers occurring in the EEZ of India (Table 2).

Depthwise variations in species abundance

Distribution according to distance from coast indicated that the extent of offshore distribution of each species varied (Table 3).

Variations were observed in the horizontal distribution of lucifers in the different areas. The population density was the highest in the neretic waters of the eastern Arabian Sea and the northern Bay of Bengal, mid-shelf of the southern Bay of Bengal, Andaman and Nicobar Sea and

Table 2. *Sector wise numerical abundance of dominant* Lucifer *spp. (No./1000 m^3)*

Species	1	2	3	4
East. Arabian Sea				
Northwest (15° 30′ -22° 30′ N lat.)	1976	888	1396	2
Southwest (5° 30′ -15° 30′ N lat.)	2563	1692	800	25
Lakshadweep (8° 00′ - 12° 30′ N lat.; 71° 00′ - 74° 00′ E long.)	1264	200	419	17
Bay of Bengal				
Northeast (15° 30′ - 22° 30′ N lat.)	1866	270	374	441
Southeast (5° 30′ -15° 30′ N lat.)	966	303	453	1216
Andaman & Nicobar Sea	58	200	397	69

1. *L.penicillifer*, 2. *L.hanseni*, 3. *L.typus*, and 4. *L.chacei*

Table 3. *Depthwise occurrence (%) of dominant* Lucifer *spp. in the EEZ of India*

Species	1	2	3	4
Inner shelf (<50m)	44	76	13	30
Mid-shelf (50-100 m)	36	16	21	49
Outer shelf (100-200m)	14	6	24	15
Oceanic (>200m)	6	2	42	6

1. *L.penicillifer*, 2.*L. hanseni*, 3. *L.typus*, 4. *L.chacei*

in the oceanic waters around Lakshadweep. Numerical abundance of the species in the different depth zones indicated regional variations in the seas around India (Table 4).

Discussion

The available information on the distribution of *Lucifer* spp. revealed that the oceanic species, *L. typus*, occurring between latitudes 40° N and 40° S showed a circumglobal distribution. The rest of the species occurring between the equator and approximately Lat.30° N and 30° S are inhabitants of estuarine and coastal waters restricted to either the Atlantic, the

Table 4. *Depthwise numerical abundance of* Lucifer *spp. in the EEZ of India (No./1000 m³)*

Species	1	2	3	4	5	6	7*
East.Arabian Sea							
Northwest							
< 50m	4599	12690	0	0	0	0	0
50-100m	7251	2475	1006	1	0	1	2
100-200m	1512	980	1082	1	0	0	0
> 200m	100	53	1593	3	0	0	1
Southwest							
< 50m	8451	13744	951	44	0	0	0
50-100m	3577	1623	666	54	1	0	0
100-200m	2026	385	210	22	0	3	0
> 200m	1457	223	885	13	1	10	2
Lakshadweep							
100-200m	512	18	5	0	0	0	0
> 200m	261	203	424	16	0	11	2
Bay of Bengal							
Northeast							
< 50m	4807	802	67	1798	270	0	0
50-100m	4538	658	224	918	24	0	0
100-200m	813	133	387	15	109	0	0
> 200m	742	80	480	82	38	1	1
Southeast							
< 50m	3428	1152	198	1615	24	0	0
50-100m	2135	1007	158	4933	0	0	1
100-200m	1771	189	232	1630	23	0	0
> 200m	271	92	573	550	1	0	1
Andaman & Nicobar Sea							
< 50m	136	232	149	114	0	0	0
50-100m	76	399	192	12	0	0	1
100-200m	10	360	552	164	0	0	4
> 200m	51	165	425	72	1	0	3

1. *L.penicillifer*, 2.*L.hanseni*, 3. *L.typus*, 4.*L.chacei*, 5.*L.intermedius*, 6.*L.orientalis* and 7.*L.faxoni*.
* No. of specimens

Indo-west Pacific or the eastern tropical Pacific Ocean (Omori 1975). Four species, *L. hanseni* (Menon, 1940), *L. typus* (George and Paulinose,1973), *L. penicillifer* (Ganapathy and Ramanamurthy, 1975) and *L. faxoni* (Nair *et al.*,1981) have been reported earlier from the Indian waters. The present study revealed that all the seven species of the genus *Lucifer* are present in the seas around India of which three species, *L.chacei* Bowman, *L.intermedius* Hansen and *L.orientalis* Hansen are new records here. Numerical estimations revealed *L.penicillifer* to be the dominant species in the EEZ of India followed by *L.hanseni, L.typus, L.chacei, L.intermedius, L.orientalis* and *L.faxoni.*

Earlier records of *L.penicillifer* from the Indian waters are from the east coast (Ganapathy and Ramanamurthy, 1975; Achuthankutty *et al.*, 1980; Nair *et al.*, 1981) and Andaman Sea (Madhupratap *et al.*,1981a). The present study has shown that this is the most abundant species and enjoyed a wide distribution in the EEZ of India extending throughout the west and east coasts including the seas around the island territories. The species is recorded for the first time from the eastern Arabian Sea. Areas of large concentration occurred here as a dense inshore band extending from Lat. 10^0 to 13^0 N and 15^0 to 22^0 N. The concentration between Lat.8^0 and 10^0 N was most intense with highest (1, 22, 219) in the inshore waters (Lat.9^0 - 10^0 N).

L.hanseni formed a major component in the estuaries along the coast of India (Haridas,1982). The occurrence of this species has been reported at various localities in the coastal waters of the eastern Arabian Sea (Madhupratap *et al.*, 1981b; Naomi, 1986), in the Bay of Bengal (Achuthankutty *et al.*,1980) and in the Andaman Sea (Madhupratap *et al.*, 1981a). The present study indicated that the occurrence of this species is widespread all over the shelf and the adjacent oceanic waters of India. In the Andaman Sea, higher abundance was along the east coast of the island system. The species is reported for the first time from Lakshadweep waters.

The distributional records of *L.typus* in Indian waters show that its occurrence has been sporadic in the estuaries and nearshore areas but common in the oceanic waters in the eastern Arabian Sea (Goswami, 1983; Paulinose *et al.*, 1987) and Andaman Sea (Madhupradap *et al.*, 1981a). The present study indicated that the species enjoyed a wider distribution over the entire eastern Arabian Sea and the Bay of Bengal including Andaman waters. Areas of high concentration were localised in the eastern Arabian Sea between Lat.18° and 22°N,a narrow belt between Goa and Mangalore and high density pockets at other areas, off Cochin, Visakhapatnam and around Lat. 10° N in the west Andaman Sea.

L.chacei is widely distributed from Madagascar and from southern Japan to Hawaii (Bowman, 1967; Hayashi and Tsumura, 1981) but so far not reported from the Indian seas. Its occurrence in the present study area is reported for the first

time. Areas of high population density were found localised in the neretic provinces of the Bay of Bengal between Lat.10°-16° N and Lat. 20° -21° N. In the eastern Arabian Sea, its occurrence was sporadic but was widespread in the Andaman Sea.

L.faxoni, identified as an indicator of coastal waters of America and Africa (Omori, 1977), has been reported earlier in an area between Visakhapatnam and Madras (Nair *et al.*, 1981). The present study indicated that the species occurred in the eastern Arabian Sea (Lat. 8° 13′ N), in the Bay of Bengal (Lat.18°-19° N) and in the sea to the west of north Andamans and east of Middle and Little Andamans.

L.orientalis is reported to be widely distributed in both offshore and coastal waters of Indo-Pacific, encompassing east coast of Africa (Kensley, 1971), northern Arabian Sea (Khan, 1976), Malay Archipelago- South China Sea (Cai and Chen,1965; Ma *et al.*, 1992) and eastern Central Pacific (Omori,1992). Their occurrence in the EEZ of India is recorded for the first time. In the eastern Arabian Sea, the species occurred between Lat.16° -17°N, 9°-14° N and 5°- 6° N with the maximum concentration between Lat. 9° and 10° N in the outer shelf. Except for an incidence in the outer shelf all occurrences were in the oceanic waters.

Omori (1977) while reviewing the distribution of *L. intermedius* has indicated its presence in the Gulf of Oman and from the Malacca Strait to Japan. This species has not been recorded from the Indian seas. The present study indicated its wide spread occurrence in the Bay of Bengal with higher density at 18° N Lat. along the shelf and sporadic occurrence in the eastern Arabian Sea and Andaman and Nicobar areas.

Based on the extent of their offshore distribution, the present study indicated that the five species of lucifers inhabiting the Indian seas could be classified into three groups: oceanic, neretic and intermediate. *L. typus* and *L. orientalis* can be considered as oceanic groups, *L.hanseni* as neretic (inshore) and *L. penicillifer* and *L. chacei* as intermediate groups. Of the migrant species, *L. intermedius* showed more coastal affinities and *L. faxoni* to intermediate depths. Seasonal temperature fluctuations (Bowman and Mc Cain, 1967), trophic factors (Petit, 1973), dispersion and adaptability to the environment (Omori, 1977) and turbidity (Hendritx and Estrada, 1994) are the factors ascribed for the spatial influx of *Lucifer* spp.

Neretic epiplankton are exposed to considerable abiotic and biotic stress such as fluctuations of hydrographic gradients, predation and competition. As a result of these severe pressures, generally the species diversity of neretic species is lower (Omori, 1977). Co-occurrence of two species in one sample was not unusual but three species in one sample was seldom found together. Omori (1977) reported the frequent co-occurrence of three species of *Lucifer* along the southern coast of Japan and the coast of South Africa. However, the author has indicated that the lesser

number of species from the Indian Ocean may be due to inadequate sampling.

Matrix of correlation revealed co-occurrence of *L. typus, L. pencillifer* and *L. hanseni* as well as among *L. faxoni, L. chacei* and *L.hanseni* in the four sectors of the west and east coasts of India. However *L. typus* did not co-occur with *L. chacei* indicating that the environmental conditions required for the two species were different. In the eastern Arabian Sea, the southern sector showed co-existence of five species while in the northern sector and Lakshadweep waters, four species co-existed. Co-occurrence was the least in the northern Bay of Bengal where only three species, *L. hanseni, L. penicillifer* and *L. chacei* co-existed. The southern sector of the Bay of Bengal showed co-existence of four species. In the Andaman Sea, six species co-occurred viz., *L. typus, L. hanseni, L. chacei, L. penicillifer, L. faxoni* and *L. intermedius.*

Omori (1977) reviewed the geograpical distribution of *Lucifer* spp. and found that the maximum number of species occurred in the Malay Archipelago- South China Sea region between Lat. 100°E and 140°E. Andaman Sea is connected to the South China Sea through the Strait of Malacca and it is reasonable to infer that the higher species diversity in the Andaman Sea may be due to the gene flow between these two areas. Co-existence of six species of these shrimps in the area indicates faunal richness around this island system, a unique area characterised by higher geographical complexity representing all the major ecosystems of the tropical waters like estuaries, mangroves, fringing coral reefs, minor upwelling zones and coastal and oceanic areas.

References

Achuthankutty, C.T., M. Madthupratap, V.R.Nair, S.R.S. Nair and T.S.S. Rao. 1980. Zooplankton biomass and composition in the western Bay of Bengal during late south west monsoon. *Indian J. mar. Sci.*, **9**: 201-206.

Antony Geetha, K.J. Mathew and T.S. Naomi. 1990. Studies on the distribution and abundance of the genus *Lucifer* collected during the cruises of FORV *Sagar Sampada. In*: Mathew K.J. (Ed.) *Proc. First Workshop Scient. Result. FORV Sagar Sampada.* Department of Ocean Development, New Delhi. p. 129-136.

Bowman, T.E. 1967. The planktonic shrimp, *Lucifer chacei* sp. Nov.(Sergestidae: Luciferinae) the Pacific twin of the Atlantic *Lucifer faxoni. Pacific Sci.*, **21**: 266-271.

———— and J.C. Mccain. 1967. Distrubution of the planktonic shrimp *Lucifer* in the Western North Atlantic. *Bull. Mar. Sci.*, **17**: 660-671.

Cai, B.J. and C.Chen. 1965. Taxonomic study of *Lucifer* off southeast coast of China – *Shiamen Da Shue Shew Pau.;* **12**: 111- 122 (In Chinese).

Ganapati, P.N. and K.V. Ramanamurthy. 1975. Distribution and abundance of the planktonic shrimp, *Lucifer* in the nearshore waters off Visakhapatnam. *Curr. Sci.*, **44**(10): 350.

George, M.J. and V.T. Paulinose. 1973. On a collection of planktonic Decapoda (Penaeidea) from the southwest coast of India. *IOBC Handbook*, **5**: 60-69.

Goswami, S.C. 1983. Production and zooplankton community structure in the lagoon and surrounding sea at Kavarathi Atoll (Lakshadweep). *Indian J. mar. Sci.*, **12**: 31-35.

Hansen H.J. 1919. The Sergestidae of the 'Siboga' Expedition. *Siboga Exped. Monog.*, **38**: 1-65.

Haridas, P. 1982. Zooplankton studies in the Cochin environs. *Ph.D. Thesis*, Cochin University of Science and Technology, 203 pp; 31 Figs.

Hayashi, K.I. and S.Tsumura. 1981. Revision of the Japanese Luciferinae (Decapoda, Penaeidea, Sergestidae). *Bull. Jap. Soc. Sci. Fish.*, **47**: 1437-1441.

Hendriktx, M.E. and F.D. Estrada – Navarrete. 1994. Temperature related distribution of *Lucifer typus* (Crustacea : Decapoda) in the Gulf of California. *Rev. Biol. Trop.*, **42**(3): 579-584.

Kensley, B.F. 1971. The family Sergestidae in the waters around Southern Africa (Crustacea, Decapoda, Natantia). *Ann. S. Afr. Mus.*, **57**:215-264.

Khan, M.A. 1976. Luciferinae (Crustacea, Decapoda, Sergestidae) collected from Manora Channel (northern Arabian Sea). – *Agriculture Pakistan*, **27**: 113-117.

Ma, Zhaodang, Song, Qingyun. 1992. A Preliminary study on the *Lucifer* from the Kuroshio region of the East China Sea. *J. Oceanogr.Huanghai Bohai Seas/Huangbohai Haiyang*, **10**(4):53-62.

Madhupratap, M., S.R.S. Nair, C.T. Achuthankutty and V.R. Nair. 1981a. Major crustacean groups and zooplankton diversity around Andaman – Nicobar Islands. *Indian J. mar. Sci.*, **10**: 266-269.

————————, V.R Nair, S.R.S.Nair and C.T. Achuthankutty. 1981b. Thermocline and zooplankton distribution. Ibid.**10** : 262-265.

Mathew, K.J., T.S. Naomi, Geetha Antony, D. Vincent, R. Anil Kumar and K. Solomon. 1990. Studies on zooplankton biomass and secondary and tertiary production of the EEZ of India. *In*: Mathew K.J. (Ed.) *Proc. First Workshop Scient. Result. FORV Sagar Sampada.* Department of Ocean Development, New Delhi. p. 59-70.

Menon, M.K. 1940. The life history of decapod crustacea from Madras – II. *Bull. Madras Govt. Mus. N.S., Nat. Hist. Sect.*, **3** (6): 1-47.

Nair, S.R.S., V.R. Nair, C.T. Achuthankutty and M.Madhupratap. 1981. Zooplankton composition and diversity in the Western Bay of Bengal. *J. Plank. Res.*, **3** (4): 493-508.

Naomi, T.S. 1986. On the zooplankton of the inshore waters of Karwar during 1980-81. *Indian J. Fish.*, **33**(3):336-346.

Omori, M. 1975. The systematics, biogeography and fishery of epipelagic shrimps of the genus *Acetes* (Crustacea, Decapoda, Sergestidae). *Bull. Ocean Res. Inst.*, Univ. Tokyo.**7**: 1-91.

————————1977. Distrubution of warm water epiplanktonic shrimps of the genera *Lucifer* and *Acetes* (Macrura, Penaeidea, Sergestidae). *Proc.Symp. Warm Water Zooplankton. Spl. Publ.*, NIO, GOA. p. 1-12.

———————— 1992. Occurrence of two species of *Lucifer* (Dendrobranchiata: Sergestoidea: Luciferidae) off the Pacific coast of America. *J. Crust. Biol.*, **12** (1): 104-110.

Paulinose, V.T., S.C.Goswami and V.R.Nair. 1987. Planktonic decapoda and stomatopoda (Crustacea) from the Arabian Sea. *Mahasagar*, **20** (2): 99-107.

Petit, D. 1973. Zooplankton of the Nosy – Be region : VIII spatial – temporal distribution of the genus *Lucifer* (Decapoda: Sergestidae) in the province Neritique. *Cah. Orstom Ser. Oceanogr.*,**11** (3):373-385.

Qasim, S.Z; M.V.M. Wafar, Sumitra Vijayaraghavan, Joseph P. Royan and L.Krishnakumari. 1978. Biological productivity of coastal waters of India from Dabhol to Tuticorin. *Indian J. mar. Sci.*, **7**: 84-93.

Rajagopalan, M.S., P.A. Thomas, K.J Mathew, G.S Daniel Selvaraj, Rani Mary George, C.V. Mathew, T.S. Naomi, P.Kaladharan, V.K. Balachandran and Geetha Antony. 1992. Productivity of the Arabian Sea along the south west coast of India. *Bull. Cent.Mar.Fish.Res. Inst.*,**45**: 9-37.