J. mar. biol. Ass. India, 1992, 34 (1 & 2) : 218-221

LIVER AND KIDNEY DAMAGE IN GREY MULLET *LIZA PARSIA* (HAMILTON AND BUCHANAN) ON EXPOSURE TO AN ORGANOPHOSPHATE 'NUVAN'

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ABSTRACT

In bioassay experiments with *Liza parsia* to 'Nuvan' for acute exposure, the 48 and 96 hr LC50 were found to be 0.750 and 0.482 ppm respectively in a brackishwater medium of salinity $10 \pm 1.0‰$, temperature $27.5 \pm 1.5°C$ and pH 6.0 ± 0.5. For sub-lethal effects the fishes were exposed to 1/5th and 1/15th concentrations of this 96 hr LC50 value for 45 days. In histological investigations of liver and kidney of the fishes from both these acute and sub-lethal exposures, disorders such as vacuolation, extensive coagulative necrosis with pyknosis, karyorrhexis and karyolysis in liver tissue and enlargement of renal tubules, necrosis of epithelial tubular cells in kidney were observed. Safe levels for long-term use are yet to be found out.

INTRODUCTION

PESTICIDES are synthetic chemicals widely used for protecting crops from pests. Though their short-term benefits are undeniable, they are considered hazardous because of interference with the environment. Pesticides wherever applied, ultimately find their way into water bodies affecting aquatic fauna.

The backwaters and estuaries in general serve as nurseries for many organisms including several commercially important fishes and prawns. *Liza parsia*, a brackishwater fish of economic importance inhabiting both the coasts of India, spends most of its lifetime in estuarine condition where it is subjected to toxicity by several pollutants discharged into the environment.

As organochlorine persists in the environment and accumulates in different tissues, its use as pesticide in agriculture, has given rise to criticism in recent years prompting to prefer organophosphates by most of the agriculturists. The water soluble organophosphate insecticide 'Nuvan' is widely used in the Kolleru region of Andhra Pradesh for control of ectoparasites such as *Lernea*, *Argulus*, etc. (Muthu *et al.*, 1988). But the long-range effects of this practice are not known.

Several studies have identified histological disorders in liver and kidney of fishes exposed to pollutants (Mukherjee and Bhattacharya, 1975; Bass *et al.*, 1977; Konar, 1977; Sastry and Malik, 1979; Goel and Garg, 1980; Dubale and Shah, 1981; Kumar and Pant, 1981; Ramalingam and Reddy, 1981; Akkilendra Naidu *et al.*, 1983; Bakthavathsalam *et al.*, 1984; Desai *et al.*, 1984; Rashatwar and Ilyas, 1984; Radhaih *et al.*, 1986; Razani *et al.*, 1986; Gupta and Dalela, 1987; Mukhopadhyay *et al.*, 1987; Ram and Satyanesan, 1987; Bhatnagar *et al.*, 1987).

The degree of damage to the organs help in determining the level of toxicity. The liver

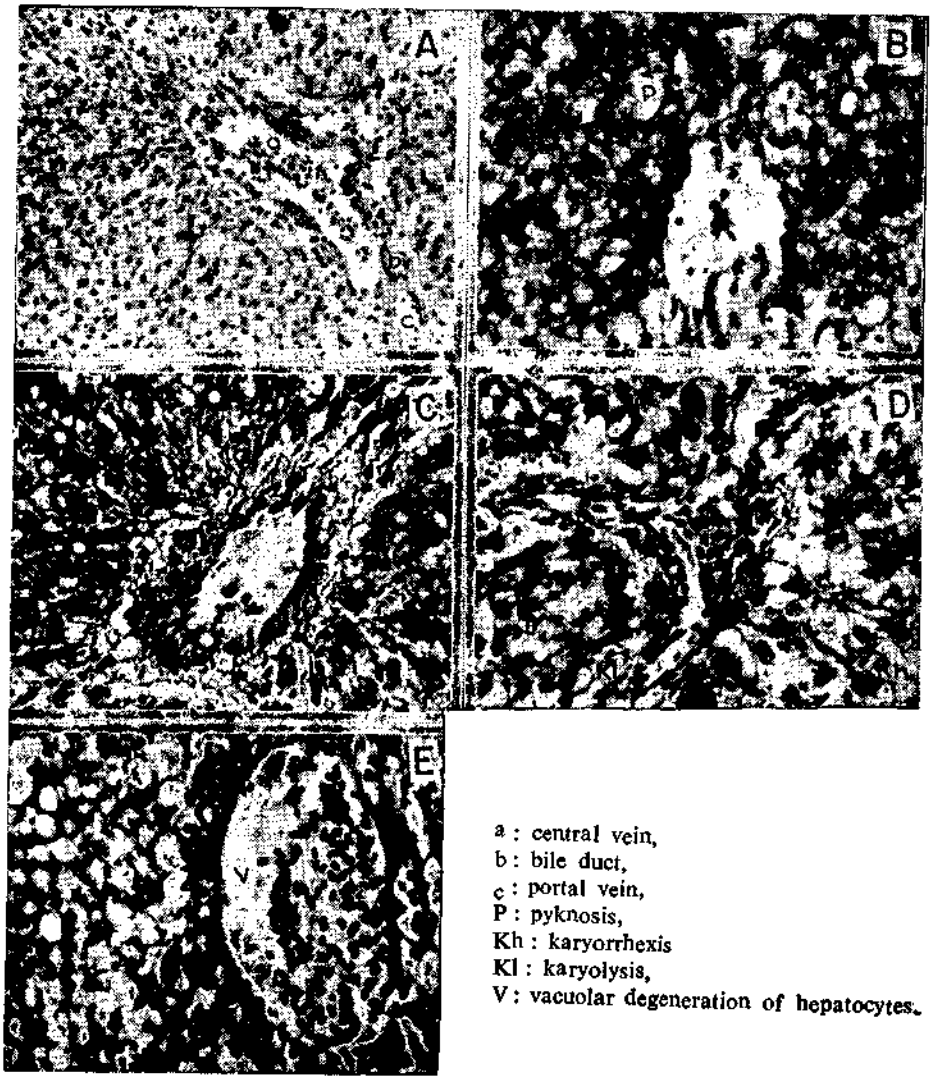

PLATE I. Cross-section of liver (H & E) — A : normal (X 100), B : exposed to 48 hr LC50 for 48 hrs (X 400), C : exposed to 96 hr LC 50 for 96 hrs (X 400), D : exposed to 1/15th 96 hr LC 50 for 45 days (X 400), E : exposed to 1/5th 96 hr LC50 for 45 days (X 400).

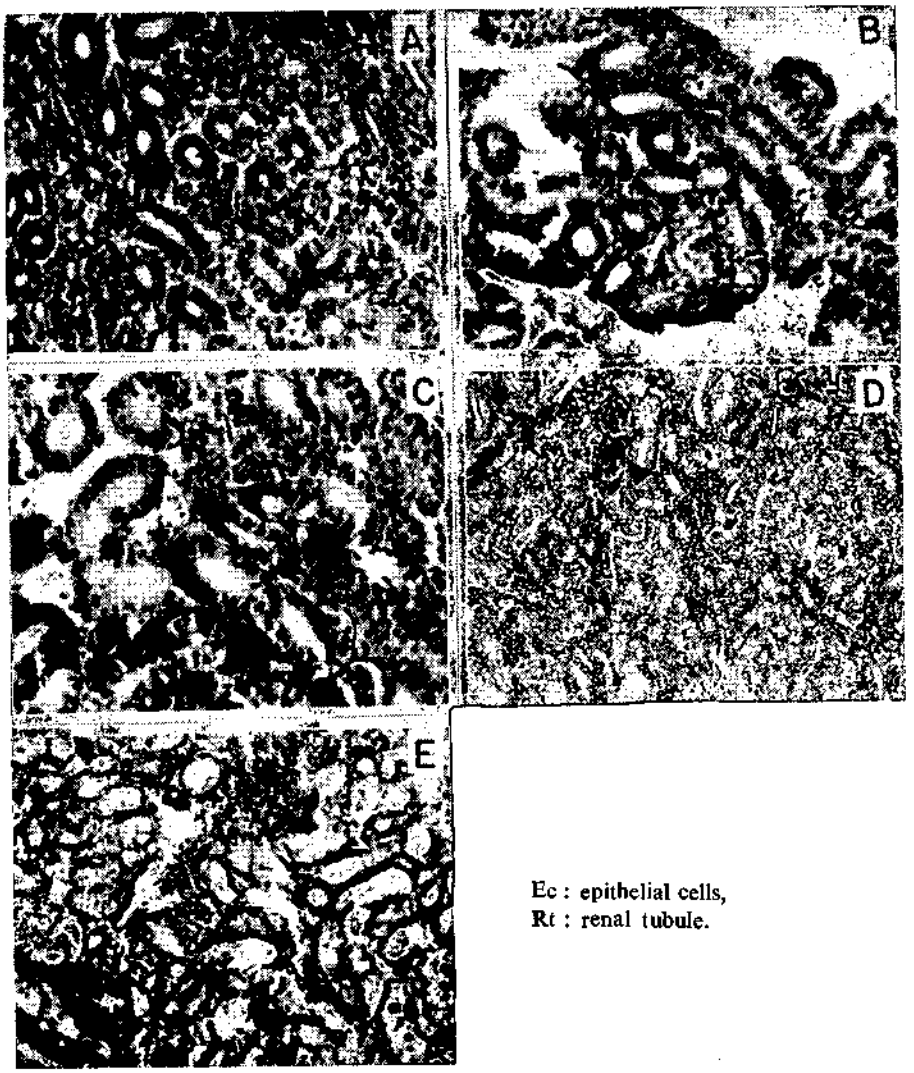

PLATE II. Cross-section of kidney (H & E) — A : normal (X 200), B : exposed to 48 hr LC50 for 48 hrs (X 200), C : exposed to 96 hr LC50 for 96 hrs (X 200), D : exposed to 1/15th 96 hr LC 50 for 45 days (X 40), E : exposed to 1/5th 96 hr LC50 for 45 days (X 200).

and kidney of teleosts are 2 vital organs which get affected by pollutants. The present investigation was undertaken to study the histological changes caused by 'Nuvan' on the liver and kidney of grey mullet *L. parsia*.

Material and Methods

L. parsia of 85-120 mm sizes and 6.50-13.25 g weight were collected live from brackish-water canals of Puduvypeen area, near Cochin and acclimatized to laboratory condition for about 2 weeks by maintaining them in plastic pools of 2 tonne capacity containing water of salinity 10.0 ± 1‰, pH 6.0 ± 0.5 and temperature 27.5 ± 1.5°C. To avoid fungal attack of test animals the medium was treated with 11 mg of malachite green per 100 litres of water. The fish were fed once a day.

The commercial grade 'Nuvan' of Ciba-Geigy composed of 'Dichlorvos 76% m/m Emulsifier 10.6% m/m and Solvent 13.4% m/m' was used for the preparation of stock solution.

A static bioassay was conducted after APHA-AWWA-WPCF (1975) and Reish and Oshida (1987). The 48 hr and 96 hr LC50 values were found by 'Probit analysis' on computer. For sub-lethal effects the fishes were exposed to 1/5th and 1/15th concentration of the 96 hr LC50 for 45 days.

The liver and kidney of test animals exposed to lethal and sub-lethal concentrations were used for histological studies. The tissues were fixed in Bouin's fluid for about 24 hrs and then processed by routine histological techniques. Sections of 4-5 μ were stained with haematoxylene and eosin and mounted in DPX. Photomicrographs were taken using and Olympus Universal Research Microscope.

Results

The LC50 values for 48 and 96 hr were respectively 0.750 and 0.482 ppm.

In normal liver the hepatocytes are polygonal and have distinctive central nuclei with densely stained chromatin margins and prominent nucleoli. The portal triad and hepatocytes in transverse section of normal liver are shown in (Pl. I A). Palate I A : a, b and c show the central veins, bile duct and portal vein respectively of the portal triad. Fishes sacrificed after acute exposure to 'Nuvan' (*e.g.* 48 hr LC50 and 96 hr LC50 for 48 and 96 hr respectively) showed extensive coagulative necrosis with pyknosis, karyorrhexis, karyolysis and vacuolar degeneration of cytoplasm of hepatocytes (Pl. I B, C). In sublethal concentration (*e.g.* 45th day in 1/15th 96 hr LC50) vocuolar degeneration, pusning of nuclei to one side, karyolysis and pyknosis were observed (Pl. I D), but in sections of fishes exposed to 1/5th 96 hr LC50 for 45 days showed the similar observations, but of greater magnitude (Pl. 1 E).

Sections of kidney of an unexposed fish showed normal size and structure of renal tubules and epithelial cells (Pl. II A). Fishes sacrificed after acute exposures to 48 hr LC50 and 96 hr LC50 showed enlargement of renal tubules (Pl.II B, C). After sub-acute exposure to 1/15th 96 hr LC50 for 45 days vacuolation of epithelial cells of renal tubules were observed (Pl. II D). On exposure to 1/5th concentration of 96 hr LC50 for 45 days, marked necrosis and extensive desquamation, and flattening were observed in the tubular epithelial cells (Pl. II E).

Discussion

Casillas *et al.* (1983) reported disturbance in orientation of hepatic ducts in *Parophrys vetulus* exposed to lethal concentration of carbon tetrachloride and op ned destruction of connective tissue as its possible reason. Vacuolation is reported by Razani *et al.* (1986) in *Brachydanio rerio* chronically exposed to phenol and by Sastry and Malik (1979) in *Channa ptaunctus* after sublethal exposure to

dimecron. But enlargement of nuclei was also seen by the latter authors. Along with vacuolation and degeneration of cytoplasm, Konar (1977) observed in *Heteropneustes fossilis* and *Labeo rohita* exposed to acute concentration of phosphamidon and heptachlor, also swelling of hepatocytes. Going a step further Slooff *et al.* (1983) observed enlargement of the whole liver of fish collected from polluted surface waters in the Netherlands caused mainly due to hypertrophy of hepatocytes. Vacuolation, disorientation, enlargement of nuclei and hypertrophy of cells were clearly seen along with condensation or even disappearance of nuclei in the present study. The stress on exposure to 'Nuvan' might have drawn all reserve food in liver and caused the above changes.

Gupta and Dalela (1987) reported degeneration and disolution of epithelial cells of renal tubules and hypertrophy and necrosis of renal cells in histological sections of the kidney of *Notopterus notopterus* on sublethal exposure to phenolic compounds. Similar observations were made by Csepai (1978) in *Cyprinus carpio* exposed to Anthio 40 EC, Satox 20 WSC and Basudin 10 G and Konar (1977) in *Heteropneustes fossilis* and *Labeo rohita* chronically exposed to DDVP, phosphamidon and heptachlor. The deformation of renal tubules was observed by Bakthavathsalam *et el.* (1984) on *Anabas testudineus* chronically exposed to Furadon. According to Dubale and Shah (1981) the process of destruction is a function of dosages and period of exposure and they opined that the renal tubules of kidney are the first to be affected by pesticidal stress. Rashtwar and Ilyas (1984) reported the histopathological changes in kidney to lead to cloudy swelling of renal tubules in *Nemacheilus denisonii* acutely exposed to phosphamidon. In the present study also the swelling of renal tubules in acute exposure was evident. Changes like vacuolation of epithelial cells of renal tubules and pronounced enlargement of the tubules were observed in the histological sections at higher sublethal concentration and prolonged exposure only and it draws support from the observations of Dubale and Shah (1981).

'Nuvan' in higher concentration is very toxic. Casual exposure to it as a lotion for treating ectoparasites may not be harmful. However, detailed long-term study is needed.

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J. mar. biol. Ass. India, 1992, 34 (1 & 2) : 222-230

STUDIES ON THE COMMON ROCKY EGYPTIAN CHITON *ACANTHOPLEURA GEMMATA* (MOLLUSCA : POLYPLACOPHORA) IN THE NORTHWESTERN RED SEA

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ABSTRACT

In the present study on *Acanthopleura gemmata* (Blainville, 1825), rectification of the species name, its distribution and abundance in the northwestern part of the Red Sea, and the intraspecific variation within intermittent subpopulations have been achieved. Within each natural population, two forms, one banded and the other non-banded have been distinguished. The main differences in shell characters, girdle elements and radula features of the two forms have been investigated.

INTRODUCTION

THE POLYPLACOPHORAN *Acanthopleura gemmata* is one of the commonest in the rocky intertidal area in the Indo-Pacific province (Ferreira, 1986). Several studies on polyplacophorans have been carried out on the coastline of the Red Sea (Fretter, 1937; Gunnar and Rupert, 1981; Iredale and Hull, 1923, 1927). In these studies ten species of chitons have been recorded, but their identification and description were to some extent poor, as most of the authors agreed that the largest and most common species are those related to genus *Acanthopleura*. Savigny (1827) restricted and classified the common large Egyptian chiton under the name of *Oscabrion* sp. Abd El-Moneim (1983) made an extensive study on the morphology and macroanatomy of the common banded Egyptian chiton and named it as *Acanthopleura spiniger*. But he did not recognized that every *Acanthopleura* species population has two forms, one with banded girdle (which he described) and the other with unbanded girdle that he neglected.

In this study the distribution and abundance of the two forms along the Egyptian coastline has been recorded and morphometric data on specimens from several populations including the two forms, have been obtained to evaluate, if these forms are intraspecific varieties or they are distinctly two different species.

The authors wish to express their gratitudes to Prof. Dr. Ahmed A. El-Samahy, Vice-President of Assiut University (Sohag), Dr. Mohammed M. Ibrahim, Dean of Faculty of Science (Sohag) for providing facilities during the course of this study. They also thank to all members of the Department of Zoology for their valuable help and encouragment. Special thanks to Mr. Khalaf Aly and Mr. Mohammed Ibrahim for their good assistance.

MATERIAL AND METHODS

Sampling was carried out along the coasts of the Northwestern part of the Red Sea; from north of Marsa Alam City to north of

ada City, Egypt (Fig. 1), during Decem- 1986 to January 1989. Collections were done at 10-20 km intervals and where the coast is accessible for sampling. The specimens were collected from the supralittoral to the lower mid inter-tidal zones during the low tide at day time, using a sharp knife to release the specimens from the big rocks, dead coral blocks and large stones. To lift the stones

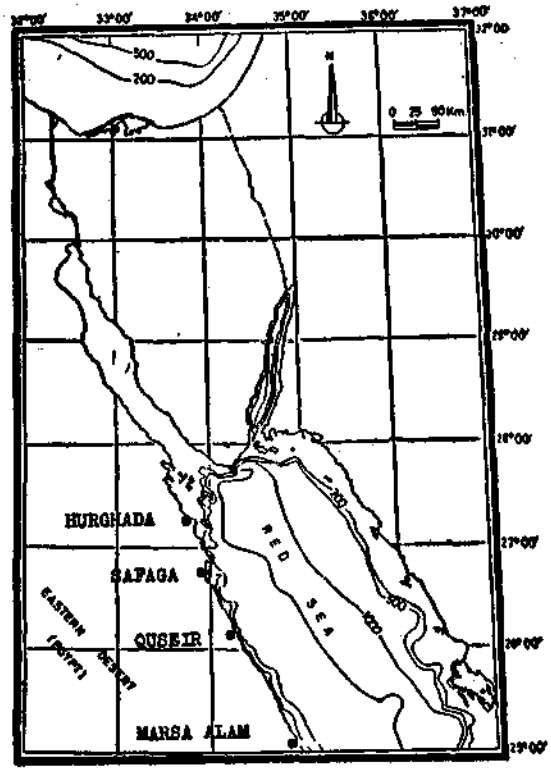

FIG. 1. The study area along the coast of the northeastern part of the Red Sea.

a stick with three metal hooks was used and both the rocks and coral blocks were returned back to their original position to maintain the chiton populations unharmed.

The collected specimens were kept in labelled plastic container containing sea water. Some of the collected specimens were preserved in 10% formalin in sea water, while the others were left for observing and recording the natural colour of the shell valves and girdle. Morphometric characters were measured tusing a vernier calliper with a minimum limit of 0.1 mm.

In the field, just before removing the specimens from rocks and stones, the whole length and width of each specimen, the total length of the shell valves, and the width of the fourth valve were measured. In the laboratory, the previous field data were repeated on preserved specimens. Besides, the absolute measurements of the anterior and posterior valves after disarticulating them from their individuals, diameters and distributions of ocelli on the surfaces of shell valves, upper-surface and lower surface girdle elements (spinelets and scales) and the teeth of the radular organ were recorded. The latter were measured using a Binocular Research Microscope provided with micrometer eyepiece. Drawings and photographs were made using a Camera Lucida and Photo-camera, attached to the above mentioned microscope.

RESULTS

Acanthopleura gemmata (Blainville, 1825)

General body form

The collected specimens were oval in shape, roundbacked and bilaterally symmetrical. The average width/length of the adult specimens is 0.6 (SD = ± 0.1, n = 131). No sexual dimorphism was recorded in the investigated specimens although there was two colour patters within the species populations. (Fig. 2 and 3 a, b).

Shell

As in all Polyplacophora, the shell is made up of eight articulated overlapping calcareous plates or valves which are very thick and robust. The anterior plate (I) which overhangs the mouth and the posterior plate (VIII)

which overhangs the anal aperture, are semicircular, while the six intermediate plates (II-VII) are roughly rectangular (Fig. 4 a, b). The eight valves arranged in a single continuous series forming a solid oval armour over the dorsal body wall (Fig. 3 a, b). A transverse section of one of the plates (Fig. 5) reveals several layers, two of which are of special taxonomic interest. These are the tegmentum or outer layer which may be differently coloured

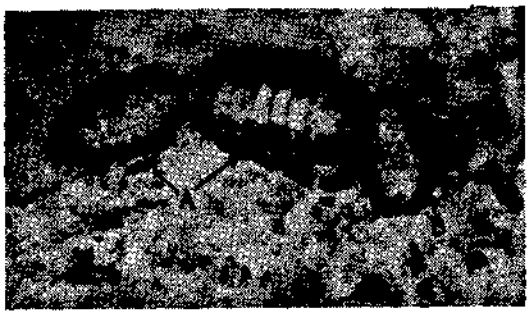

FIG. 2. *Acanthopleura gemmata* (Blainville, 1825): a. Banded form and b. Non-banded form.

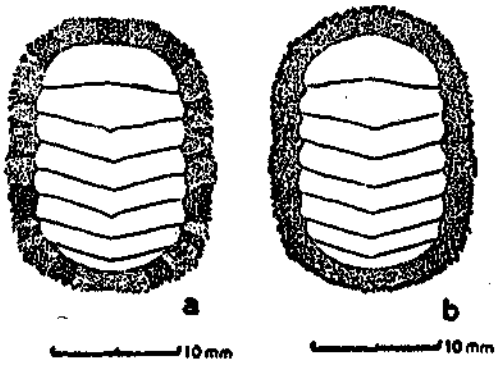

FIG. 3. *Acanthopleura gemmata*: a. Banded form and b. Non-banded form.

and sculptured, and the whitish innermost non-porous layer, 'the articulamentum' which is an intercalation within the hypostracum. The articulamentum serves for a better insertion of the shell plates in the perinotum. Examination of the tegmentum of the plates showed a grayishgreen to grayishbrown colour, the tegmentum of the anterior shell plate has only one anterior region, while that of the intermediates have one median (jugum) and two lateral areas (Fig. 4 a). Each of the latter has two regions which are not always easily distinguishable, but sometimes can be defined into an inner small triangular part (pleura) and an outermost smaller rectangular part (lateral). The tegmentum of the posterior plate (VIII) has almost a raised central apex (mucro) and divided into two areas, one is upper to the mucro (central) and the other postmucro (posterior).

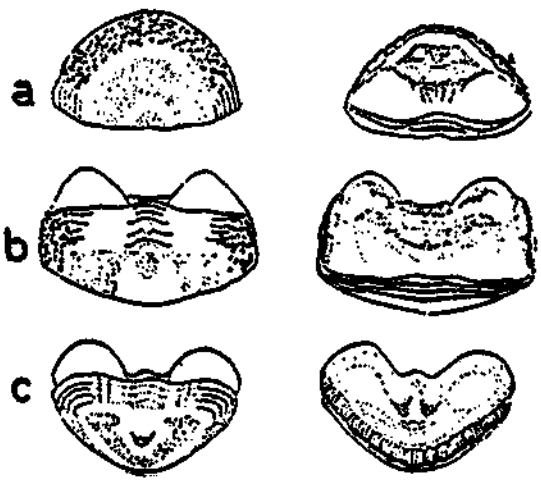

FIG. 4. Dorsal (left row) and ventral (right row) views of: a. The anterior valve, b. intermediate valve and c. posterior valve of both forms of *Acanthopleura gemmata*.

Anterior valve and postmucro area of posterior valve are similarly sculptured with round to elongate granules, in addition to a number of longitudinal white streaks on the anterior valve (Fig. 4 a).

Central areas of the intermediate and the posterior valves are almost featureless, but the pleural ones have smaller to obsolete (vestigial) granules, and thin, well-defined

transverse lamellae appressed across jugal areas of the intermediate valves.

In small specimens, mucro of the posterior valve is central, but somewhat posterior in larger individuals, while postmucro is strongly convex in both small and large specimens.

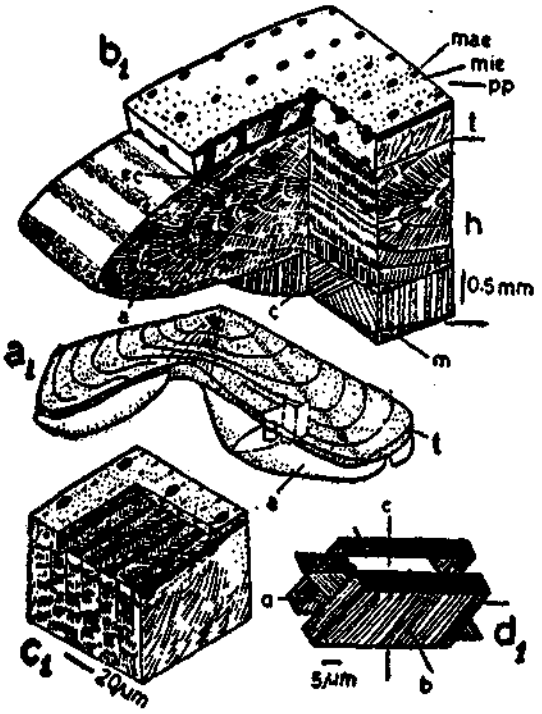

FIG. 5. Morphology of an intermediate shell valve (after Hass, 1976) : a_1, whole plate, b_1, block diagram showing the shell layers, c_1, block diagram of the tegmentum and d_1, crossed lamellar structure of the hypostracum with crystallographic axes (a, b, c). a - articulamentum, c - crossed lamellar structure of the hypostracum, ec - esthete canal, h - hypostracum, m - myostracum, mae - macresthete, mie - micresthete, t - tegmentum and pp - properiostracum.

The averages of the tegmental length and width of valve I and VIII, are 0.52 (± 0.06 and 0.46 (± 0.07) respectively, the mean of the tegmental widths of valve I/VIII is 1.0 (± 0.08).

Occasionally, even without the aid of magnification, one can detect small dully pigmented to darkish glossy dots on the dorsal side of the shell plates in both banded and unbanded forms called ' micrethetes and macrethetes ', having a similar distribution patterns (Fig. 4, 5). These are perforations containing a terminal caps of a highly sensitive nervous epidermal stands, round to oval in shape, range from 43.4 to 73.4 μm in diameter, randomaly distributed on the anterior valve, postmucro area of the posterior valve, and the anterior parts of lateral areas of each intermediate shell valve.

The articulamentum of each shell valve including the two forms is larger than the tegmentum. Its colour varies from brown to bluish brown. As we proceed, extensions of the articulamentum (insertion laminae) are preserted on the anterior edge of anterior valve, on the posterior edge of posterior valve, and on the posteriolateral edges of intermediate shell valve (Fig. 4 b).

Insertion teeth irregularly spaced, sometimes fused together. On valve I, these are divided into nine to twelve teeth by eight or eleven slits, seven to eleven poorly defined teeth on valve VIII, resulting from incomplete slits, particularly towards the midline ; teeth of posterior valve often recurved forwards and fused anteriorly to put an extension beyond buttressing, transverse and round ' callus '. The intermediate shell valves are similar in both forms in having two lateral insertion teeth on each side. Slit formula (not always clearly determinable) are nearly constant in the two forms, 7/11-1-6/10. In midline, the mean of the insertion plate length/tegmental length is 0.19 (in both forms). Anterior extensions of the articulamentum on the intermediate and anal valves are termed ' sutural laminae ' each of which is well developed and covered by the valve in front. In the two forms, these are subtriangular on valve II

to subrectangular on valve VIII. The sutural laminae of each of intermediate valves are separated from each other by a smooth semi-circular groove (jugal sinus). Sinus plate is mostly smooth. The ratio of sinus width/ width of sutural lamina of valve VIII are equal in both forms 0.86.

exhibiting another form (Fig. 3 a, b). it encircles the shell valves which studded with white to dark gray, brown, or black spinelets. The latter are pointed, blunt, straight to curved, somewhat conical (Fig. 6, 7) and measure 1.1 mm (±0.2) in length and 0.2 mm (± 0.04) in width, with smaller to minute spinelets between them.

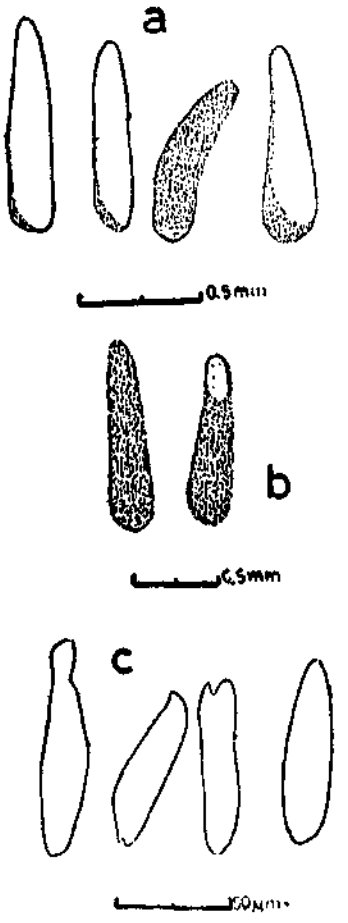

FIG. 6. Girdle elements : a. Girdle upper surface spinelets of the banded form, b. Girdle upper surface spinelets of non-banded form and c. Needle like elements of the two forms.

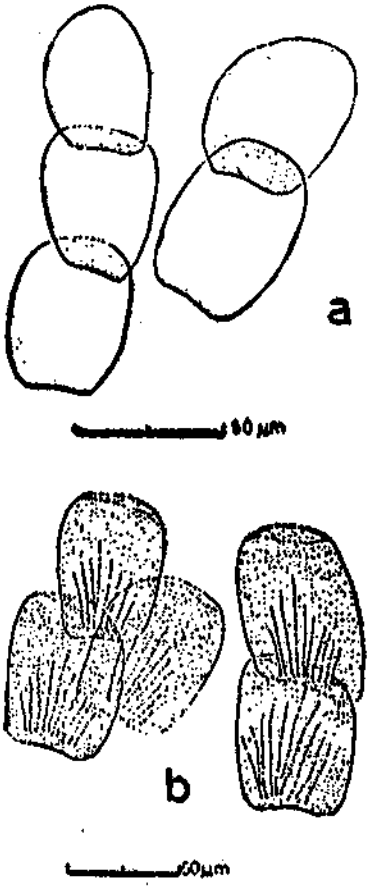

FIG. 7. Girdle lower surface scale of *A. gemmata* : a. in the banded form and b. in the non-banded form.

Girdle

Girdle is thick, flexible, muscular, wide, often banded in most individuals exhibiting the common form, unbanded in few individuals

In some individuals of the two forms, pointed ; crystaline, and needle-like elements (Fig. 6 c), with diameters of 70×20 µm are present. These are found isolated or in clusters interspersed amidst spinelets. Girdle

bridges often free from spinelets or any other elements.

Undersurface paved with imbricate, transparent to black scales in the common form (Fig. 7 a) and only black in the second form, rectangle to squarish in both forms, about 56 × 41 μm. These scales have radiating striations from the basal edge of each scale towards the outer margin in specimens of the second form only (Fig. 7 b). Gills are similar in both forms, with 52-70 plumes on each side.

Radula

In both the forms ; radula averaging 39% of specimen length (range 35-49%, SD = 1.73%, n = 18) ; extends within the radular sac. The teeth of the radula are arranged in 63 successive transverse rows of mature teeth (range 45-85, SD = 1.6%, n = 18). Each row is 'stepped' or V-shaped, with each tooth anterior to the next most distal tooth one.

among them from station 5 (Fig. 1). The width of the median tooth at anterior blade is 110 μm ; first lateral teeth about 500 μm long, 320 μm wide at anterior blade ; L_2 pair or the major lateral teeth (the main working teeth) bear highly magnetized dark caps, each has a relatively broad unicusped blunt black blade with its pointed and thin end, directed towards the radular center. It measures 360 μm in greatest width. Also the major lateral teeth have a tubercle of about 200 μm long as a nearly triangular knob in shape, protruding from the inner edge at a level close to the head ; outer marginal teeth is 370 μm high and 260 μm wide (length/width 1.4).

Distribution and Abundance

The species are confined to the intertidal zone, from the upper neap tide to lower neap tide, especially at the mean water tide level. The data show that the highest densities

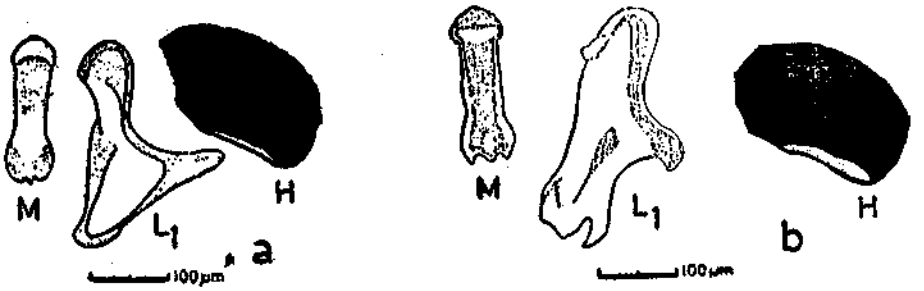

Fig. 8. Radula structure of *A. gemmata* : a. banded form, b. non-banded form L_1, H and M are : first lateral, head of major lateral and median tooth respectively.

As in all polyplacophorans, there are eight lateral teeth (L_1 to L_8) on each side of the median or 'central' tooth (M). The teeth are attached to an elastic radular membrane. The L_2 and L_5 pairs are the most elongate ones.

Radular features (Fig. 8) rather constant in both forms with no significant difference

occur in north stations, especially stations 7 (18.3/m²), while decrease in northernmost stations (0.1/m²) near to the mouth of the Suez Gulf (Fig. 9).

Remarks

The two forms in *Acanthopleura* species are extremely similar in radula features, but some differences in their structures are also noted

(Fig. 8 a, b). The central tooth which has a nearly rod-like shape with a proximal broad triangular base of attachment, supported by three basal knobs (teeth) and a sharp broad blade in the banded form, but in the unbanded one the base of attachment supported by one basal knobs (teeth) and free and provided with a sharp narrow blade.

The Major lateral tooth: provided with a tetragonal inner edge in the unbanded form rather than one pointed end in the banded form.

Discussion

The genus *Acanthopleura* comes under the subfamily Acanthopleurinae (Van Belle, 1983),

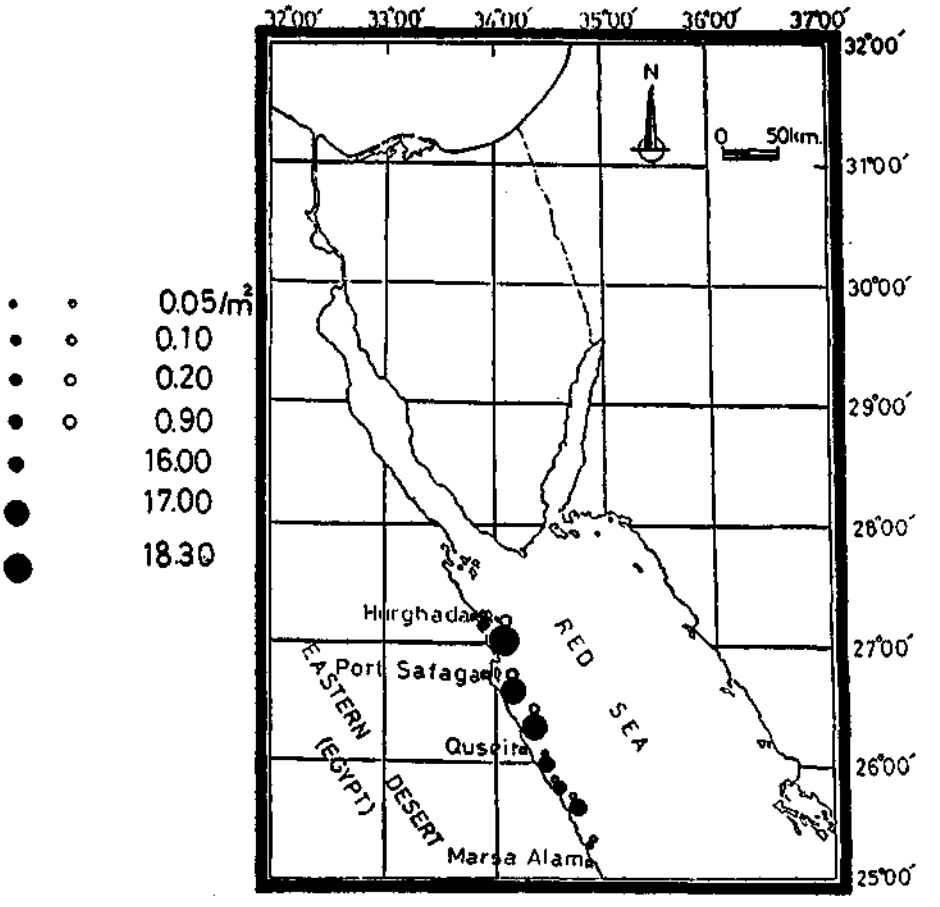

Fig. 9. Distribution and abundance of the banded and non-banded forms of *A. gemmata*. Solid and open circles denote to the banded and non-banded forms respectively.

The 1st lateral teeth: with a concave and a convex base of attachment for the banded and unbanded forms respectively. In the former, there is a basal pointed end towards the outer edge and a stronger sharp blade at the free end.

with the genera *Liolopleura*, *Enoplochiton* and *Squamopleura* suppressed as synonyms.

Acanthopleura attains greatest species diversity in the Central Indo-Pacific (Ferreira 1986). In the 'fertile triangle' (Briggs, 1974)

of the Indo-Malayan region (Ekman, 1953), with a 'center of origin' at Taiwan where five species (*A. spinosa*, *A. gemmata*, *A. japonica*, *A. miles* and *A. loochooana*) have been recognized (Ferreira, 1986). The differential diagnosis of *Acanthopleura* species may be quite difficult at times, particularly when one is faced with species with such a wide geographical distribution.

The commonest chiton species of *Acanthopleura* in the Red Sea was studied by some authors under different names as, *Acanthopleura vaillanti* (Rochebrune, 1882) from the Gulfs of Suez and Aqaba, *A. spiniger* (Abd El-Moneim, 1983; Guirguis, 1978) from north of Hurghada and Qusier, *A. haddoni* (Gunnar and Rupert, 1981; Winckworth, 1927) from Aden and Barim Island, Yemen.

Most of those authors erected their identification of the species on its external morphology and macro-anatomy. Recently, revision of the genus *Acanthopleura* by Ferreira (1986) depending on the morphometric data revealed that the most common species, present virtually everywhere in the tropics is *A. gemmata*.

In this study, all the morphometric data obtained for specimens from different localities along the Egyptian coastline in the Red Sea agree with Ferreira's conclusion on *A. gemmata*, but examination of several *A. gemmata* populations revealed that some diagnostic characters are present among the individuals of the same population, these characters are summarised as follows :

1. There are two coloured forms, one with banded girdle and high density and the other non-banded with low density ; the girdle of the banded form is provided with dark gray, brown, to black spinelets alternating with a white spinelets in between, a character used by Haddon (1886) for the differentiation of the genus *Acanthopleura*, but the girdle of the non-banded form in the same population has only brown to black spinelets.

2. In both forms, posterior valve has well developed insertion teeth with 6-10 slits in between, a single major feature for the differentiation of *A. gemmata* from other species as *A. japonica*, *A. gaimardi* and *A. hirtosa* in temperate waters (Ferreira, 1986).

3. There are no significant differences in the morphometry between the two forms and that of *A. gemmata* described by Ferreira (1986).

4. The distribution of ocelli (light sensitive organs) are the same in both forms.

5. Lower surface girdle elements (scales) have the same dimensions in both forms, but with a darker colour and some striations in the non-banded form.

6. Measurements of radular teeth are remarkably constant in the two forms with the exception of some differences in their structural features (Fig. 8 a, b).

From the previously mentioned articles, we can conclude that the common Red Sea large chiton species relates to *A. gemmata* described by Ferreira (1986) and the variations of some diagnostic characters of the individuals within their populations may be intraspecific-variations, unless further cytogenetic investigations show otherwise.

Concerning the distribution of *A. gemmata* in the Red Sea, it was recorded by Pears, (1978) and Rochebrune (1882) in the Gulfs of Suez and Aqaba, Abd El-Moneim (1983) and Guirguis (1978) from north of Hurghada and Qusier, Winckworth (1927) from Aden and Barim Island ; Yemen and in Elat, Gulf of Aqaba (Ferreira, 1983). These records may give an indication that the species has an intermittent distribution in the Red Sea, but this study revealed that the species has a continuous

distribution pattern, at least in the Northwestern part of the Red Sea, and where a suitable intertidal habitat is available. The species is always confined to the rocky shores in the intertidal zone 0-2 m, along the Egyptian coastline in the Red Sea, with specimens often exposed at low tide, especially at mean water tide level. Also the density of the species increases as one proceeds from south of Marsa Alam City to northern part of the Red Sea, then decreases again at stations lying north to Hurghada City, and this may agree with the conclusion of Pearse (1983) that the Gulf of Suez environment apparently places extreme physiological stress on northern Red Sea biota.

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HATCHABILITY OF THE FIRST CYSTS OF *ARTEMIA* PRODUCED IN SALT-PANS IN BANGLADESH

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ABSTRACT

Hatchability was investigated in Bangladesh-produced cysts of *Artemia*, the first such cysts to be produced in salt-pans in that country, using imported stock from Great Salt Lake (USA). Optimal hatching conditions of 25°C temperature, 25 ppt salinity and 0.14 × 10^{16} quanta/sec/cm² light intensity were defined. The maximum hatch achieved in the Bangladesh material by this means was 39%, compared with 70% in control cysts imported directly from the USA.

Since the Bangladesh material, unlike the USA cysts, may not have experienced low environmental temperatures during diapause, further experiments involving chilling were carried out. The USA cysts hatching rate was not increased by this means, but the Bangladesh material hatching rate was increased to nearly 60%. The production in preliminary trials of *Artemia* cysts with a potential hatching rate not much lower than that of the parent stock, gives encouragement for further development of *Artemia* culture in Bangladesh.

INTRODUCTION

IN RECENT years, increased demand has resulted in world-wide efforts to extend the geographical range of the culture of brine shrimp *Artemia salina* L. in salt-pans and saline lakes, sometimes in developing countries (Sorgeloos, 1980). This necessitates the optimization of hatchability rates of harvested cysts in each new source. One such potential new source locality is in Bangladesh where the first cysts from field trials have been produced using imported USA cysts from Great Salt Lake, Utah (Mahmood, 1990). The present study sets out to determine the suite of conditions which would provide optimal hatching in the Bangladesh-produced material, particularly bearing in mind the different climate regime and lower environmental temperature which the Utah parent stock would experience.

During the course of this work much help and advice was provided by Dr. D. A. Jones, Dr. J. F. Wickins, Dr. A. R. Yule and Mr. M. Budd, to whom we are most grateful.

MATERIALS AND METHODS

The source material for the present study was produced in two experimental ponds, each 45 m² in area, at Chanua, Banskhalii Chittagong, Bangladesh (Mahmood, 1990), *Artemia* nauplii hatched in seawater (35 ppt) from 30 g of Great Salt Lake cysts were introduced into the ponds in mid-January, 1989. Each pond was initially fertilized with

180 g of urea and 3.6 kg of dry chicken manure, and subsequently with additions of these fertilizers at 45 g and 900 g.wk^{-1} respectively. The trials lasted for 3 months, during which time the salinity of the ponds rose from 60 to 120 ppt and noon temperature from 22 to 34°C. At the end of March 1989, a total of 517 g dry weight of cysts was harvested, p epared by washing and sun-drying, from which representative material was studied for hatchability at the Marine Science Laboratories, Menai Bridge, U.K.

A small quantity of dry cysts of *Artemia* was placed in filtered sea water (32 ppt.) in solid watch glass and mixed by micropipette. Immediately, with the micropipette, random samples, each of 10 cysts, were then transferred one by one from the watch glass to multi-chambered petridishes each containing 5 ml of filtered sea water. Each petridish contained 25 chambers and two such petridishes were used to carry out 50 replicates, for each combination of environmental factors tested. Incubations were then carried out for 50 hours in various factor combinations, *viz.* 15, 20, 25, 30 and 35°C (at 32 ppt and 0.14×10^{16} quanta/sec/cm^2 ; 5, 10, 15, 20, 25, 30, 35, 40, 45 and 50 ppt (at 25°C and 0.14×10^{16} quanta/sec/cm^2; dark, 0.14×10^{16} and 0.60×10^{16} quanta/sec/cm^2 (at 25°C and 32 ppt) ; and cooling to 2.5°C and — 22°C for different time periods with subsequent incubation at 25°C, 32 ppt and 0.14×10^{16} quanta/sec/cm^2.

The cumulative numbers of nauplii emerging were counted under a binocular microscope at five hour intervals. Cumulative hatch numbers at each temperature, salinity, light and chilling treatment were then tested by analysis of variance, significant differences being determined by the Tukey or Bonferroni test. In each case the results with Bangladesh-produced cysts of *Artemia* were compared with results from control experiments using csysts obtained direct from the parent stock in Great Salt Lake (USA).

Results

Table 1 shows the effects of temperature, salinity and light on the hatching percentage of Bangladesh cysts of *Artemia* compared with Utah controls. The optimal conditions for the experimental groups and the control groups were 25°C, 25 ppt and 0.60×10^{16} quanta/sec/cm^2 light intensity, and 25°C, 10 ppt and 0.14×10^{16} light intensity respectively.

Table 1. *Maximum cumulative hatch percentages of Bangladesh and USA cysts of* Artemia *at various temperatures (at 32 ppt and 0.14×10^{16} light intensity), various salinities (at 25°C and 0.14×10^{16} light intensity) and at various light intensities (at 32 ppt and 25°C). ± Standard deviation. Asterisked values are significantly lower ($P < .05$) than the underlined maximum values, as determined by the Tukey test*

	Bangladesh	USA
Temperature (°C)		
15 ..	19.8 ± 9.4*	31.0 ± 12.2*
20 ..	23.0 ± 11.8	47.6 ± 13.9*
25 ..	28.0 ± 16.7	68.6 ± 12.0
30 ..	20.2 ± 12.2*	64.4 ± 8.4
35 ..	12.6 ± 7.5*	51.2 ± 12.6*
Salinity (ppt)		
5	27.4 ± 15.9*	59.4 ± 13.9
10 ..	30.0 ± 12.3*	67.6 ± 11.9
15 ..	31.8 ± 16.5	67.4 ± 11.7
20 ..	31.6 ± 10.3	63.0 ± 9.7
25 ..	38.8 ± 17.7	56.8 ± 14.6*
30 ..	35.6 ± 11.3	62.4 ± 12.7
35 ..	33.6 ± 13.1	55.4 ± 15.7*
40 ..	31.6 ± 8.7*	56.2 ± 15.9*
45 ..	28.8 ± 10.0*	60.2 ± 12.7
50 ..	22.8 ± 7.8*	62.6 ± 15.6
Light incubation (quanta/sec/cm^2)		
0.00 (dark) ..	17.4 ± 8.8*	55.0 ± 9.5*
0.14×10^{16} ..	28.0 ± 16.9	68.6 ± 12.0
0.60×10^{16} ..	29.8 ± 10.4	66.8 ± 10.6

The effects of chilling cysts at 2.5°C for various lengths of time are given in Table 2. These show for Bangladesh cysts a markedly increased cumulative hatch following chilling at 2.5°C for 40 hours, but with no statistically significant effect of chilling on the cumulative hatch of parent USA material. Table 3 plots the maximum cumulative hatch values after 1, 5 and 10 days chilling at -22°C, with subsequent culture in optimal conditions derived from the initial experiments, which were the highest of all hatching values obtained for Bangladesh material. The values after chilling for 5 and 10 days were not significantly different from each other ($P < 0.05$) and were only just over 10% lower than the control hatching rates using Utah material.

The temporal pattern of hatching obtained in a range of conditions for Bangladesh and Utah cysts is illustrated in Fig. 1 and 2. These confirm the additive improvement of percentage hatching in the Bangladesh material by combining optimum conditions of salinity, temperature, light and chilling. Not only was the maximum hatching percentage obtained only about 2% less than that in controls, but the initial rate of hatching was indeed slightly better than in controls.

Discussion

The important role of *Artemia* in aquaculture demands a continuous effort to improve hatching and culturing conditions and present results sought to define optimum conditions for the hatchability of the first Bangladesh produced cysts of *Artemia*.

The lowest temperatures at which *Artemia* appears to survive, except as cysts, is 6°C and the maximum temperature that *Artemia* populations tolerate has been reported to be close to 35°C (Persoone and Sorgeloos, 1980). Optimal temperatures for early larvae of *Artemia* appear to be close to the reported optimum hatching temperature of approximately 30°C (Von Hentig, 1971), though in

Table 2. *Maximum cumulative hatching percentages (± s.d.) of Bangladesh and USA cysts of* Artemia *after different chilling times and kept subsequently at 32 ppt, 25°C and 0.14 × 10^{16} light intensity (quanta/sec/cm²). Asterisked values are significantly higher than non-chilled controls, as determined by the Bonferroni test ($P < .05$.)*

Chilling at 2.5°C Time (Hrs.)	Bangladesh Non-chilled controls	Bangladesh Chilled	USA Non-chilled controls	USA Chilled
10 ..	2.46 ± 19.8	24.2 ± 19.6	68.6 ± 12.0	69.2 ± 10.5
20 ..	22.4 ± 17.0	22.2 ± 15.3	65.2 ± 12.0	62.0 ± 13.6
40 ..	26.4 ± 17.4	28.0 ± 22.7*	65.6 ± 15.1	64.0 ± 10.9
60 ..	28.2 ± 18.1	38.2 ± 22.4*	61.6 ± 12.5	62.2 ± 15.3

Table 3. *Maximum cumulative hatching percentages (± s.d.) of Bangladesh and USA cysts of* Artemia *after different chilling times and kept subsequently at 25 ppt., 25°C and 0.14 × 10^{16} light intensity (quanta/sec/cm²)*

Chilling at -22°C Time (days)	Bangladesh	USA
1 ..	42.8 ± 13.0	67.4 ± 10.9
5 ..	58.8 ± 15.7	68.6 ± 10.6
10 ..	60.4 ± 15.0	68.0 ± 9.7

this there is some variation from race to race (Sorgeloos, 1975). Present results confirm that temperature is a significant influencing factor on the hatchability of Bangladesh-produced cysts of *Artemia*, the maximum cumulative hatch occurring at 25°C. Qualitatively, but not quantitatively, the hatching pattern of Bangladesh produced cysts was similar to that of Great Salt Lake material used as controls the lower hatching rate of the Bangladesh material requiring further explanation.

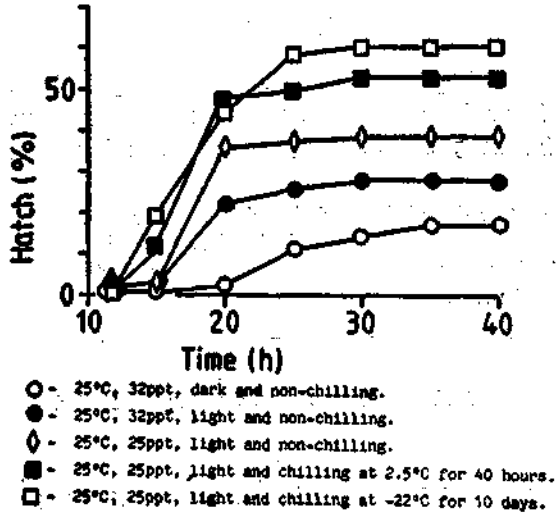

FIG. 1. Cumulative hatching percentage of Bangladesh produced cysts of *Artemia* in different hatching conditions.

For reasons of practical convenience natural sea water is often used to hatch *Artemia*. This presumably arises, because it is generally accepted that *Artemia* is a euryhaline organism, with a wide salinity tolerance variously reported as 3 - 300 ppt (Bayly, 1972) and 35-110 ppt (Vanhaecke *et al.*, 1984), with some geographical variation. However, most authors now agree that hatching rates are greatest at salinities of less than that of sea water (Sorgeloos, 1980; Vanhaecke *et al.*, 1980; Bruggeman *et al.*, 1980; Vanhaecke and Sorgeloos, 1983; Thun and Starrett, 1987). This was confirmed in the present study in which it was shown that 25 ppt is the optimum salinity and 15-35 ppt is the optimum range for the maximum hatchability of Bangladesh-produced cysts, of *Artemia*. In the control experiments, Great Salt Lake stock showed little variation in hatching rate over the range 5-50 ppt salinity, but highest rates were again in low salinities at 10-15 ppt. Present results therefore confirm the suggestion that use of a low salinity medium assures increased hatching outputs (Vanhaecke and Sorgeloos, 1983). This and demonstration of higher energy content nauplii hatched in low salinities (Vanhaecke *et al.*, 1980, following Clegg, 1964 and Conte *et al.*, 1977) argue strongly for the use of low salinities for the hatching of *Artemia* in commercial hatcheries.

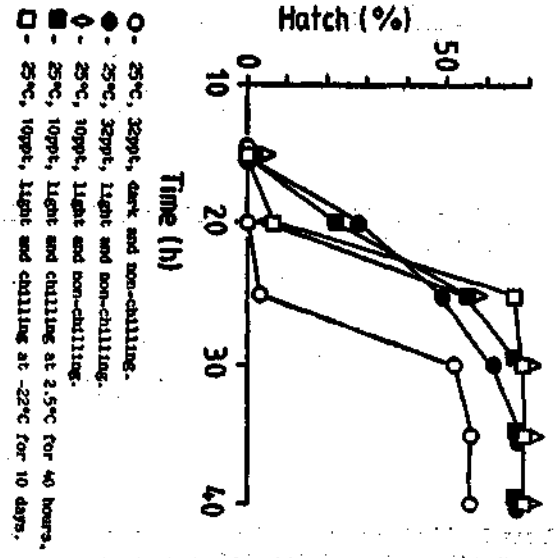

FIG. 2. Cumulative hatching percentages of Great Salt Lake (USA) cysts of *Artemia* in different hatching conditions.

Light conditions also influence the hatching efficiency of *Artemia* cysts (Sorg loos, 1980), an increase in hatching rate occurring in light, as compared to controls incubated in darkness (Sorgeloos, 1973). This is confirmed in the present study, cultures under illumination showing statistically increased hatching efficiency in both Bangladesh and control USA

Artemia cysts. The mechanism of light enhancement of hatching is not yet fully understood, but Sorgeloos and Persoone (1975) have reported that a minimal dose of light energy is needed to trigger onset of metabolism in the encysted embryo. Light absorption by the cyst chorion has been studied in *Artemia* by Iwasaki *et al.* (1980) and important differences in this characteristic between strains have been reported (Persoone and Sorgeloos 1980; Vanhaecke and Sorgeloos, 1980; Bruggeman *et al.*, 1980; Vanhaecke *et al.*, 1981) suggesting that there may be strain differences in light requirements. Hatching rate may also vary with exposure times and wave length as well as with light intensity (Van Der Linden *et al.*, 1985).

The results discussed so far clearly demonstrate that, even when optimum conditions of temperature, salinity and light are used for the hatching of Bangladesh *Artemia*, that the hatching rates of 30-40 % are significantly below the hatch rates of 70 % in control stocks obtained directly from Great Salt Lake. This led to consideration of the possibility that the Bangladesh produced cysts may not have experienced such low temperatures during diapause as the parent stock in N. America might experience in winter. Experiments involving chilling of the cysts confirmed that this appeared to be so. Climatic adaptations resulting in strain-specific temperature responses among *Artemia* would not be surprising since similar temperature related adaptations occur in geographically separated populations of other invertebrates (Lavens and Sorgeloos, 1987).

The exact biochemical mechanisms involved in the diapause process are not yet fully understood (Clegg and Conte, 1980). However, pre-incubation in low temperature is probably an effective factor in terminating dormancy in *Artemia* from temperate latitudes (Lavens *et al.*, 1986). From the present study this treatment appears to be necessary for such a strain even after a complete generation at subtropical latitudes. Several other diapause inhibition methods reported as effective for *Artemia*, including exposure to repeated dehydration and hydration, U.V. irradiation, cosmic radiation, magnetic fields, organic solvents, peroxide treatment and manipulation of internal pH (Lavens *et al.*, 1986), were no considered in the present study.

The maximum hatching achieved in the present study using combined optimal hatching conditions after exposure to chilling for some hours or days is only about 12 % less than the maximum hatching achieved using USA cysts as controls. This seems not unreasonable for the first batch of such cysts produced in Bangladesh from material imported from the USA. It offers promise for further improvements with increased experience of this culture technique in Bangladesh and offers considerable scope for commercial development in the technique in the country.

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DIVERSIFIED FISHING TECHNIQUES*

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ABSTRACT

In India fishing activities, prior to independence were the prerogative of the traditional fishermen employing indigenous fishing craft and gear. Subsequently, mechanisation was initiated to improve the socio-economic condition of the fishermen and augment fish production by various developmental measures taken by the government through the Five Year Plans and foreign assistance leading to the introduction and establishment of modern methods of fishing like shrimp trawling and purse seining. Constant efforts were made to improve the gear and craft used in this sector. Entry of large number of vessels resulted in the reduction of catch per unit effort for prawns. New resources identified can be exploited by using diversified fishing technique developed in the country to increase the fish catch. These diversified fishing techniques are discussed and suggestions made for further improvement.

INTRODUCTION

FISHING was carried out from time immemorial as an hereditary avocation involving the whole household through generations with crude implements. The ignorance, illiteracy, penury and conservatism hindered improvement and progress. During the colonial rule, the function of the administration was only revenue collection with some developmental measures for revenue augmentation. When the country became independent, developmental planning was promoted and it was only from the Second Five Year Plan onwards that substantial fishery development activities were envisaged, and through successive plans significant strides have been made and the production has reached the present level of 1.8 million from 0.5 million tonnes.

* Presented at the 'Symposium on Tropical Marine Living Resources' held by the Marine Biological Association of India at Cochin from January 12 to 16, 1988.

The authors express their gratitude to Dr. C. T. Samuel, Professor and Head, Department of Industrial Fisheries, Cochin University of Science and Technology for the valuable suggestions and for the permission to publish this paper.

FISH PRODUCTION IN INDIA AND DEVELOPMENT

During the sixth Five Year Plan the growth rate of fish production was 3.1% per annum as against the almost stagnated growth during the previous plan. A growth rate of 3.5% is targeted for the seventh Plan. It has been planned to increase fish production to 2 million tonnes and export earnings to Rs. 700 crores as against the present Rs. 400 crores.

The programme of motorisation began with the introduction of mech nised craft primarily for gill netting, but as this period of introduction coincided with the striking of rich

prawn grounds along the southwest coast and development of export oriented industry based on shrimp the need arose for adoption of these vessels for trawling for prawn. This resulted in the introduction of larger vessels with more power. The mechanised trawlers became totally oriented towards shrimp trawling and a saturated point has been reached abruptly in many areas all along the coast. Although the initial plan envisaged was modernisation of all the fishing activities with the gradual phasing out of the traditional crafts, now all types of crafts fish in the same narrow coastal belt. The estimated number of these type of crafts in the maritime States and Union torritories are 1,83,345 traditional crafts; 15,292 motorised crafts and 22,906 mechanised crafts (Varghese, 1986). There are about 165 fishing vessels of more than 20 GRT making a total of 2,06,466 numbers.

Though the motorisation programme of traditional craft was first initiated by Indo-Norwegian Project and later by the Indo-Bulgarian Project, the fishermen has taken it up only recently and there are at present 6,934 crafts in Kerala out of the 15,292 crafts in the country.

Fishing Activities

The estimated population of fisherfolk in the country is about 71 lakhs, out of which 14 lakhs are actively engaged in fishing in inland and marine sectors. About 5 lakhs fishermen operate 1.8 lakh traditional craft and contribute about 62.16% of the marine fish production and the share of mechanised vessel is 37.84%.

The above information is furnished to indicate the intensive fishing activity that is going on in the narrow coastal belt. The introduction of purse seiners, numbering about 250 in Karnataka and 70 in Kerala added one more dimension to the problem. These vessels, more or less, vie with each other for the same resource, at the same area leading to conflict and law and problems.

Need for Diversification

Resources of the EEZ with an area of about 2 million sq. km of which 0.86 million is off the west coast, 0.56 million off the east coast and 0.60 million around Andaman and Nicobar Islands remain untapped and offer vast fishery potential.

Therefore, the need for diversification of fishing activities is more relevant at present than ever before. Hence an attempt is made to bring out the technologies available and also suggestions are made to develop suitable new technologies to harvest the resources. Potential resources of the region has been worked out by many agencies and workers. George *et al.* (1977) estimated a potential of yield of 4.5 million tonnes which is about 3 times the present harvest and split-up for the inshore continental shelf and slope and residual area of EEZ are 2.5, 1.5 and 0.5 million tonnes respectively. Another split up is: pelagic resources 2.1 million tonnes; prawns, lobsters and other crustaceans 0.3 million tonnes; cuttlefish and squids 0.2 million tonnes.

Potential of the SW coast, lower east coast, upper east coast and Andaman and Nicobar and Lakshadweep area are 1.4, 0.9, 0.7, 0.016 and 0.009 million tonnes respectively.

Extensive exploratory fishing operations conducted by the FSI, INP (presently IFP), FAO/PFP, and Indo-Polish survey have identified fishery resources capable of supporting intensive fishing activities. The resource are of: Seranids, Lutjanids and Lethrinids of the NW coast, Wadge Bank and Gulf of Mannar; Megalaspis all along the coast; Carrangids and Barracuda along the upper east coast; Lesser sardines of the Gulf of

Mannar ; mackeral and Periacanthus of the SW coast and east coast ; and ribbonfishes, eels, sharks, rays and cephalopods of the NW coast.

Different Fishing Methods

Fisheries research institutions have developed different harvest technologies which can be adopted to exploit the identified resources. Different fishing methods suitable for exploitation of these resources are discussed below.

Gill netting is a selective fishing method and C.I.F.T. has conducted extensive research. This net can be effectively used for tapping the resources of seer, tuna, pomfret and sharks using motorised crafts 7-9 m length all along the coast. At present it is operated only in certain States *viz.* Kerala, Gujarat, Tamil Nadu. The economics of this energy efficient fishing method is well understood and the fishermen in areas were such crafts are not working should be encouraged to take up. One impediment is the cost of nylon net. Polypropylene is a cheap substitute for nylon and the research in this regard may vigorously be pursued.

Shark long lining is employed from mechanised boats, only along Maharashtra and Gujarat Coasts and in Kerala to a limited extent. Although the technology is known, it should be demonstrated in other areas with improved line hauling devices to increase the catching efficiency by way of using more number of hooks. In areas where more shrimp trawlers are in operation, some of the boats can be engaged in long lining particularly during the poor prawn fishing season. Long line fishing is also energy efficient and fishermen may be encouraged to take up this method.

Trolling is a method for capture of pelagic predatory fishes such as seer, tuna, barracuda, etc., employed in the country. Improved technology has been developed by C.I.F.T. as an exclusive fishing technique, so it can be carried out during the lean season of shrimp fish ng and during sailing to fishing grounds, to supplement the normal catch with high priced varieties. Pole and line fishing is practised around Lakshadweep Islands, but the main constraint for the development of this effective methods for exploitation of the abundant resources is the non-availability of live-bait in sufficient quntities. If live-baits could be cultured and supplied, the resources could be better exploited. Tuna long lining is another method for the exploitation of tuna, shark, marlin and sailfishes. The design, construction and operation of the tuna long-line have been described by many authors and no difficulty is experienced in the construction of the gear. FSI has been operating the gear since long, followed by the IFP and CIFNET. They have located extensive fishing grounds and have reported good seasonal landings. But what is required is the detailed study of the highly migratory tuna, so that the gear can be operated in places where shoals frequent. The ground is located based on movement of water masses, places of convergence of currents, etc. Unless such details are identified, the operations may not become economically feasible. Hence it is imperative that the C.I.F.T. may take up a a coordinated project involving all the research institutes, fisheries organisations and universities.

Purse seining for sardine and mackerel in the country is an inshore one when shoals approach towards shore. If shoals do not surface and approach the inshore region, fishery would be a failure for which other causes are also attributed. There is little work to show whether shoals are remaining away from the shore and not surfacing. There is need for further work to establish this and catch the under water shoals by purse-seining guided by sonar which was successfully used in Iceland Herring purse seining. Purse

seining for submerged shoals could be improved by effective search and collection of information on the area of concentration of the shoals. Some attempt has already been done and it should be followed up to improve the status of the purse seining fishery.

Pair bottom and mid water trawling is yet another diversified fishing method, the effectiveness of which have been amply demonstrated by the different fishery institutes. The vast resources of the Wadge Bank (anchovies and the resources located by the Indo-Polish survey along the NW coast can be tapped using these fishing methods. These methods can be carried out effectively even from small vessels including the purse seiners which can be converted for pair trawling without much expenditure. It has been proved world over that pair fishing is much more effective than single boat trawling particularly from small vessels as fishes are not frightened by the vessel and towing warp. Similar classes of vessels can be effectively used for capture of cephalopod resources using bottom pair trawling much in the fashion of Taiwanese method.

Mexican method of out-rigger trawling is practiced in the upper east coast and the recently introduced 16.5 m wooden out-rigger trawlers are working successfully. This efficient method is worth trying in other parts of the country.

Traps form an efficient fishing gear for capture of perches found among the rocky bottom where no other fishing technique can be adopted. These resources were identified and the possibility of economic exploitation have been demonstrated. In spite of this, the resources possibly available all around the country remain unexploited. The construction and fishing technique is simple and the cost of the gear is comparatively low. The deck arrangement of the vessel demands no costly equipment. An echo sounder would facilitate easy location of the ground. Thus the technology developed can effectively be used for tapping the resources.

Presently, cephalopods commands a high price in foreign markets. They are incidental catches in the bottom trawls. Other methods like jigging and lift netting are still in the experimental stage in this country. Analysis of the catch data of the chartered vessels operating particularly the pair trawling would furnish information on the resources of cephalopods. As these vessels are taking common resources, it should be made obligatory on their part to give accurate information of their catches. This information and the results of the work being carried by C.I.F.T. can develop appropriate technology.

Conclusion

The diversified fishing techniques suggested for the successful exploitation of the untapped resources would yield enhanced harvest as envisaged in the plan. The research institutions and fisheries organisations must take lead to introduce the diversified methods by intensive extension activities. As transfer of technology is still in infancy, required impetus may be given for the quick dissemination of the new technology.

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J. mar. biol. Ass. India, 1992, 34 (1 &2) : 241-245

THE CEREBRAL NEUROSECRETORY SYSTEM IN THE BRACKISHWATER TIGER PRAWN *PENAEUS MONODON* (FABRICIUS)*

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ABSTRACT

Histomorphology of the cerebral ganglion of a penaeid prawn *P. monodon* has been studied by means of classic neurosecretory staining techniques. Three kinds of neurosecretory cells namely A, B and C are distinguished on the basis of their shape, size and tinctorial characteristics of the cytoplasmic inclusions. Heterogeneous distribution of neurosecretory cells in five major groups like B_1, B_2, B_3, B_4 and B_5 has been discussed in relation to the phylogenetic status of *P. monodon*. Further occurrence of deeply stained tiny cell cluster at the mid-ventral plane of the ganglion is also reported. Intracerebral axonal tracts leading to optic lobe suggests dispatch of neurosecretory material/cellular products through axonal processes and from the body of secretory neurons as well.

INTRODUCTION

SINCE the work of Enami (1951) a comprehensive account on the cytomorphic characteristics of orientation of cerebral neurosecretory cells (NSC_s) have been furnished in *Gecarcinus* and *Cambarus* by Bliss and Welsh (1952) and Bliss *et al.* (1954) respectively. Later many other investigators (Miyawaki, 1955; Parameswaran, 1955, 1956; Durand, 1956; Matsumoto, 1958; Nagabhushanam and Rao, 1966) attempted to locate the grouping of NSC_s and their subsequent participation for transport of neurosecretory material (NSM) in the central nervous systems of *Telmessus*, *Paratelphusa*, *Oronectes* and *Scylla*, etc. Fragmentary reports, however, are on record with respect to the structural identity of brain NSC_s in natantia. Involvement of these cells for the release of NSM through axons has casually been traced upon in *Caridina laevis* (Pillai, 1961), *C. weberi* (Nagabhushanam and Vasantha, 1972), *Penaeus kerathurus* and *P. japonicus* (Ramadan and Matta, 1976) apart from their locations and ill-defined groupings.

The objective of the present investigation is to reveal the microanatomical profile of the structure, nature, distribution and groupings of the brain NSC_s in tiger prawn *Penaeus monodon* (Fabricius). This is necessary to evaluate the functional status of the neurosecretory perikarya in the course of varied physiological conditions.

The first author expresses his sincere gratitude to Dr. A. V. Natarajan, former Director, CIFRI, Barrackpore for his kind permission of study leave to carry out this investigation. He is also thankful to Dr. K. Alagarswami, Director, CIBA, Madras for encouragement

* Formed a part of Ph.D. Thesis, Calcutta University, 1986.

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in publishing this paper. The authors are grateful to Prof. (Dr.) K. C. Ghosh, former Head, Department of Zoology, Calcutta University, Calcutta for providing them necessary laboratory and library facilities.

Material and Methods

The specimen (63-152 mm) used for this study were female tiger prawn *P. monodon*. They were collected from the brackishwater culture ponds at Kakdwip, 90 km south of Calcutta. Both Carnoy's (Absolute alcohol 60 ml + Chloroform 30 ml + Glacial acetic acid 10 ml) and aqueous Bouin's (Picric acid saturated solution in distilled water 75 ml + 40% Formaldehyde 25 ml + Glacial acetic acid 5 ml) fixed brains were used for cytomorphic probe. Tissues were dehydrated in alcohol, cleared in xylene and embedded in tissuemat (M.P. 56-58°C). Serial frontal sections (7-10μm) were stained in Gomori's Chrome alum haematoxylin phloxin — CAH — (Bargmann, 1949) (1% haematoxylin 50 ml + 3% chrome alum 50 ml + 5% $K_2Cr_2O_7$ 2 ml + 5% H_2SO_4: 1 ml); Heidenhain's azan (Gurr, 1956); aldehyde fuchsin — AF (Cameron and Steele, 1959) (0.50 gms of dry crystals dissolved in 100 cc of 70% alcohol) and resorcin fuchsin — RF (McGuire and Opel, 1969) (1 gm resorcin fuchsin dry dye dissolved in 90 cc. of 70% alcohol + 2 cc (12N) HCl). Always maximum diameters of both cells and nuclei were taken into account by oculometer for determination of their dimensions. Olympus (light) microscope was used for the present study.

Results

Macroscopic studies

It is confined to the cephalic region of the brain and is well protected by calcified carapace. It is situated deep beneath the carapace in the mid-line behind the eyes and above the epistoma.

Virtual exposition of anatomically three distinct lobes — the proto, deuto and triotocerebrum of the brain is not well discernible. The dorsal most lobe of the brain or protocerebrum always remains conspicuous in contrast with other two lobes — a condition which necessitates to designate it as 'cerebral mass'.

Microanatomical studies

Cell groups: In general, five NSC groups like B_1 through B_5 are encountered. B_1 remains extended from the ventral to dorsal and at the supradorsal region it is represented by bilateral anterodorsal patch which bears resemblance with hexapod parasintercerebralis region (Pl. I A). B_2 group is restricted anterolaterally and essentially comprises of two sets of small cluster to each half of the brain (Pl. I B). The third NSC group B_3 is rather extended at the lateral margin and encountered at the mid-dorsal plane of the brain (Pl. I C). The small but conspicuous B_4 group is located at the postero-lateral profile and demonstrates possession of conspicuous NSC types (Pl. I D). The last or the fifth NSC group B_5 is restricted to the postero-medial part of the ganglion and has much resemblance with B_1 group (Pl. I E). Of the five NSC groups, B_1 and B_5 remain unpaired while the rest are paired. Indeed, majority of the NSC groups are encountered at the medial than either dorsal or ventral plane of the ganglion in question. Spatial arrangement of NSC groupings is dependent upon the confluence of the neuropilar mass which is rather distinct at the dorsal than the ventral profile.

Neurosecretory cell types

A type: Largest of all the cell types with an average diameter of 60 μm and are either round or pear-shaped with or without axonal processes. Nuclei remain oval to round with an average diameter of 21 μm. The cytoplasm is more or less homogeneously distributed with secretory inclusions. Sometimes aggregation of NSM in the form of clusters

are noticeable in the vicinity of the axon hillock. Vacuoles within the cytoplasm are not seldom and may contain secretory granules. Evidence for both axonal and peripheral discharge of NSM are often encountered (Pl. I D, F).

B type : These are medium types of cell ranging from 12 to 24 μm with an average diameter of 18 μm. They may be oval, polygonal or pear-shaped in appearance and have axonal processes. The vesicular nuclei with average diameter of 9 μm are centric and possess ill-defined nucleoli. The fine cytoplasmic inclusions are scarcely distributed within the perikarya. Occurrence of peripheral vacuoles lacking secretory inclusions and coalescence of these vacuoles are often detected. Occasional transport of NSM, through axonal processes, is visible (PL. I D, F).

C type : Size ranges of these types of cells vary from 12 to 16 μm and possess average diameter of 14 μm. They are either oval, round or polygonal in shape and may have with or without axonal processes. Round nuclei with conspicuous intranuclear material are mostly centric and have average diameter of 10 μm. Discrete secretory inclusions are often distributed within the cytoplasm where presence of vacuoles is not scarce (PL. IF).

Tiny type : In association with the aforesaid types of unique identifiable neurons, existence of a few cluster of tiny deep stained cells is also noticed and their distribution is chiefly restricted at the midventral plane of the brain. Critical observations reveal that average size of this category of cells is 5 μm and are round in shape. The nuclei are, however, disproportionately large and possess average diameter around 3 μm. Sometimes possession of very short axon like processes devoid of NSM are detected in these cells (PL. I B).

Distribution of neurosecretory cell types : As regards groupwise distribution of NSC types both A - and B - cells are encountered in all the NSC groups while C - cells are restricted in B_1, B_3 and B_5. The tiny cell groups, however, are confluent with the B_2 - than any other cell groups.

Neurosecretory products of the ganglion : Majority of the NSC types do expel their elaborations through axonal transport. Evidence for the transport of NSM through the axonal tracts originating especially from B_1 and B_2 groups has been explicitly clear when intracerebral course of the axonal bundle. on their way to optic lobe is followed upons Besides these, migration of neurosecretory product in cells especially belonging to B_4 group is accomplished in a manner which can be considered as peripheral discharge. In consequence, intercellular deposition of NSM becomes conspicuous (Pl. I D).

Discussion

Location of NSC_s in the supraoesophageal ganglion of *P. monodon* reveals exposition of several cell groups. Probe on the occurrence of cerebral cell groups in crustaceans has been made to elucidate their interrelationship with respect to transport and/or release of secretory material (Matsumoto, 1958). Existence of five major groups of NSC_s in the decapodan brain is attributed as a usual feature in sub-orders like reptantia and natantia. Besides these, special emphasis has been paid to probe into details concerning indispensability and characterization of a particular group so as to categorise the latter into sub-groups (Bliss *et* al., 1954 ; Matsumoto, 1958). In the present study, the orientation of NSC groups in the brain exhibits close resemblance with that of *C. laevis* (Pillai, 1961) and *C. weberi* (Nagabhushanam and Vasantha, 1972) with reference to their morphological features and uniformity in appearance. Whether concentration of NSC_s in the form of groups in aquatic mandibulates especially natantia (*P. monodon*) has any implication with regard to their taxa or

due to diversity of behavioural and phenomenal potential within the individual of a particular group in connection with the involvement of large number of NSC is still obscured (Rowell, 1976).

Classification of NSC$_s$ in the species under study is principally based on their shapes size (in descending order) and morphological characteristics of the secretory product which, in fact, advocated by most of the crustacean neuroanatomists. Accordingly, three principal types of NSC have been distinguished in the body of the cerebral ganglion and is in conformity with the observations of other investigators (Enami, 1951 ; Bliss *et al.*, 1954 ; Pillai, 1961 ; Nagabhushanam and Rao, 1966). Indeed, such classification of NSC$_s$ is in no way stressing upon standard principle as the previous investigators followed different methods of characterisation and thus reveals 'lack of uniformity'. Furthermore, most of the earlier workers attempted to classify the neurosecretory perikarya that are located in the eyestalk and at length applied the same principle throughout the nerve centres including cerebral ganglion and ventral nerve chain (Durand, 1956) where axons from the 'perikarya of origin' terminate to neurohaemal organs of the protocephalic neurosecretory system. Although major emphasis has been given to the distribution of cell types in decapodan brain (Parameswaran, 1956 ; Ramadan and Matta, 1976) not much concrete data concerning the involvement of cell types for the formation of groups have been recorded yet (Bliss *et al.*, 1954 ; Pillai, 1961 ; Nagabhushanam and Vasantha, 1972 ; Ramadan and Matta, 1976). It was Matsumoto (1958) who first made an attempt to describe comparatively the structural entity of all the NSC groups that are available in the brain of five species of crabs. In their studies on both crab and prawn, Nagabhushanam and Rao (1966) and Nagabhushanam and Vasantha (1972) described four to five groups of NSC and in the former they have mentioned the groupwise distribution of cell types while in the later this is lacking. In our study on *Penaeus*, the existence of the NSC group is in partial agreement with crab and crayfish (Bliss *et al.*, 1954), five species of crabs (Matsumoto, 1958), a crab (Nagabhushanam and Rao, 1966) and a prawn (Nagabhushanam and Vasantha, 1972). In so far the total number of groups, only five are encountered in *P. monodon* in contrast with maximum seven out of which two can be considered as special for containing cells like D and E types as reported by Matsumoto (1958). Although Nagabhushanam and Vasantha (1972) described five groups of brain NSC$_s$ in prawn *C. weberi*, no clarification with regard to their composition has been attempted. In *Penaeus*, however, clear indication for the distribution of cell types in each group is understood. Trend for the distribution pattern of the major cell types demonstrates close parallelism with that of Matsumoto (1958). But a difference in their (A and B types) dimension as well as cytomorphological features exists. In fact, A type with its smaller dimension in *P. monodon* is found to be distributed in all the groups instead of B_1, B_2 and B_4 of five species of crab (Matsumoto, 1958), while more or less identical pattern in the distribution of B type is observed in all the NSC groups in both the cases. Thus all that matters is the cytomorphological characteristics and not with pattern of orientation. Homogeneous confinement of a particular cell type to a group(s) as envisaged by Matsumoto (1958) or Nagabhushanam and Rao (1966) is not tenable in *P. monodon* where heterogeneous composition is the rule.

In view of the available information (Pillai, 1961 ; Nagabhushanam and Vasantha, 1972 ; Ramadan and Matta, 1976) concerning the intracerebral neurosecretory pathways in decapod crustacea, it is increasingly clear

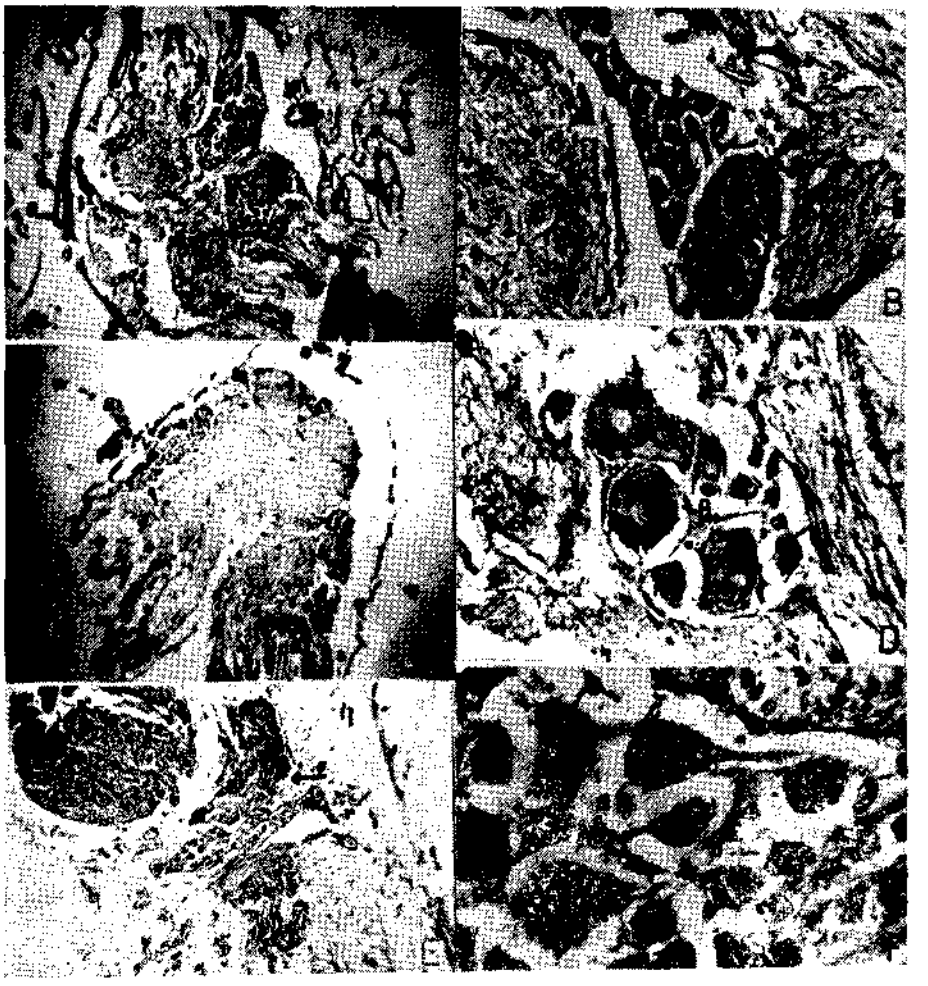

PLATE I A. The cerebral ganglion of *P. monodon* showing bilateral disposition of B_1 neurosecretory cell group (AF-reaction, × 150), B. B_2 group deep at the base of the optic nerve peduncle. Note the cluster of intensely stained tiny cells (arrow) and their relationship with B_3 group (AF-reaction, × 375), C. distribution of neurosecretory cells in B_3 group girdling at the lateral margin of the brain (Azan-reaction, × 150), D. exhibiting small group (B_4) enriched with CAH-positive A and B cell types at the posterolateral part of the brain. Note peripheral discharge (arrow) from some of the neurosecretory cell bodies (× 375), E. postero-median B_5 group situated at the ventral profile of the brain. Note its discontinuity with the B_1 group following neuropilar invasion (arrow) (AF-reaction, × 150) and F. a typical group (B_1) containing AF-positive A, B and C types of cell. Note microanatomical distinction and secretory cycle in these unique identifiable neurons (× 1500).

that axonal migration from the perikarya of origin exists for eventual discharge of the active principle (hormone ?) into the circulation. Alternatively, the possibility that the pericaryons may liberate active principle directly into the tissue fluid — a fact that has been considered more particularly in connection with the NSC_s of the thoracic ganglia in decapod Crustacea (Parameswaran, 1956; Matsumoto, 1958; Miyawaki, 1960) is not ruled out. Our findings, on the cerebral neurosecretory pathways in *Penaeus*, clearly indicate axonal migration via optic lobe from restricted NSC groups (B_1 and B_2) in contrast with other NSC groups where, of course, direct discharge cannot be discounted. In fine, morphophysiological characteristics, nature and localisation of NSC_s in groups coupled with their involvement for the discharge of neurosecretory elaboration in the supraoesophageal ganglion of *P. monodon* represents a heterogeneous picture so as to substantiate the concept of species specification despite the existence of eco-variable factors.

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A CRITICAL STUDY ON THE BAD EFFECTS OF UPWELLED WATERS ON FISHERIES, AS EXEMPLIFIED BY THE SITUATION OF THE KERALA-KARNATAKA REGION OF THE WEST COAST OF INDIA

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ABSTRACT

The inter-seasonal oscillation of the deoxygenated layer off the Kerala-Karnataka Coast and its encroachment to shallower regions of the shelf due to upwelling and its effects on both demersal and pelagic fisheries of the region were studied in detail. The results in broad, indicated that the oxygen depletion worked out differently on pelagic and demersal groups of fishes stressing the need for studies of tolerance limits of different species of fishes for deoxygenation of waters and the toxic effects of bacteria on fishes, as upwelling areas are known for heavy bacterial loads.

INTRODUCTION

THE REGIONS of upwelling are well-known for their fertility and their consequent fish-production (Wooster *et al.*, 1967). However, the depleted conditions of dissolved oxygen on account of upwelling is generally believed to be the cause for reduction of fish catch especially pelagic, even though the surface, and sub-surface waters are enriched by nutrients uplifted in the process of upwelling.

Favourable conditions exist in the waters off southwest coast of India (Kerala-Karnataka region) for upwelling process during summer (pre-monsoon and monsoon), especially during monsoon (Sharma, 1968 ; Sastry and D'Souza 1972 ; Lathipha and Murty, 1978). Deoxygenated waters of the deeper layers creep-up towards shallower regions across the shelf. The oscillating conditions across the shelf of the deoxygenated waters in descrete seasons over the year and their influence on both pelagic and demersal fish landings were critically studied in the present paper.

The author acknowledges with thanks the benefit he derived in discussing with Mr. K. N. Kurup and Mr. K. Prabhakaran Nair, Scientists of CMFRI, Cochin, about various commercial species of fishes from the Indian waters, Thanks are also due to Dr. P. S. B. R. James. Director of CMFRI for his permission to go through the fish catch records of the Institute.

MATERIAL AND METHODS

UNDP/FAO Pelagic Fisheries Project had collected hydrographic data by organising a good number of systematic cruises conducted during the years 1971-1975 covering the southern and sotuhwestern coasts of India. The cruise-wise dissolved oxygen data presented in their reports number 3 and 16, (UNDP/FAO Pelagic Fisheries Project 1973, 1976) between Quilon in the South and Karwar in the North of the southwest coast of India (from 9°N to 15°N have been considered here. Treating arbitrarily 1 ml/l of dissolved oxygen as index of upper limit of oxygen deficiency of water the depth at which this isoplith of low oxygens

occurred has been determined in each of the, vertical sections. Selecting the three main seasons namely, monsoon (June to August/ September), post-monsoon (November to January) and pre-monsoon (March to May), the seasonal depths of locations of the 1 ml/l isoplith of dissolved oxygen were determined for the four self-cross sections, Karwar, Kasaragod, Cochin and Quilon (Fig. 1). The catches of fishes from the same region (Kerala-Karnataka) and for the same period were taken from the quarterwise landings of the CMFRI fish catch records. The species considered among demersal fishes were elasmobranchs, catfishes, perches, soles, prawns and other crustaceans. Sardines, mackerel, ribbonfish, anchovies, tunnies, carangids, seerfishes, baracudas, hilsa, billfish and mullets were the pelagic fishes available in this area. It was the general case that oilsardine and mackerel constituted the major fisheries among the pelagic, predominated by oilsardine. (Fishery Resources Assessment Division, 1982, 1986). In the annual catches for the years under study, oilsardine contributed 59% and mackerel 26% of the pelagic catches and the rest of the species each contributed about 5% or even less. Hence, oilsardine and mackerel together were treated to represent pelagic fisheries from the area. Following a special technique (Murty, 1985), the quarterwise fish landings were converted into monthwise landings from which the seasonwise landings were prepared. The seasonal catch figures were expressed in percentage of the annual (all the three seasons put together) catches of the demersal and pelagic fisheries separately (Fig. 2).

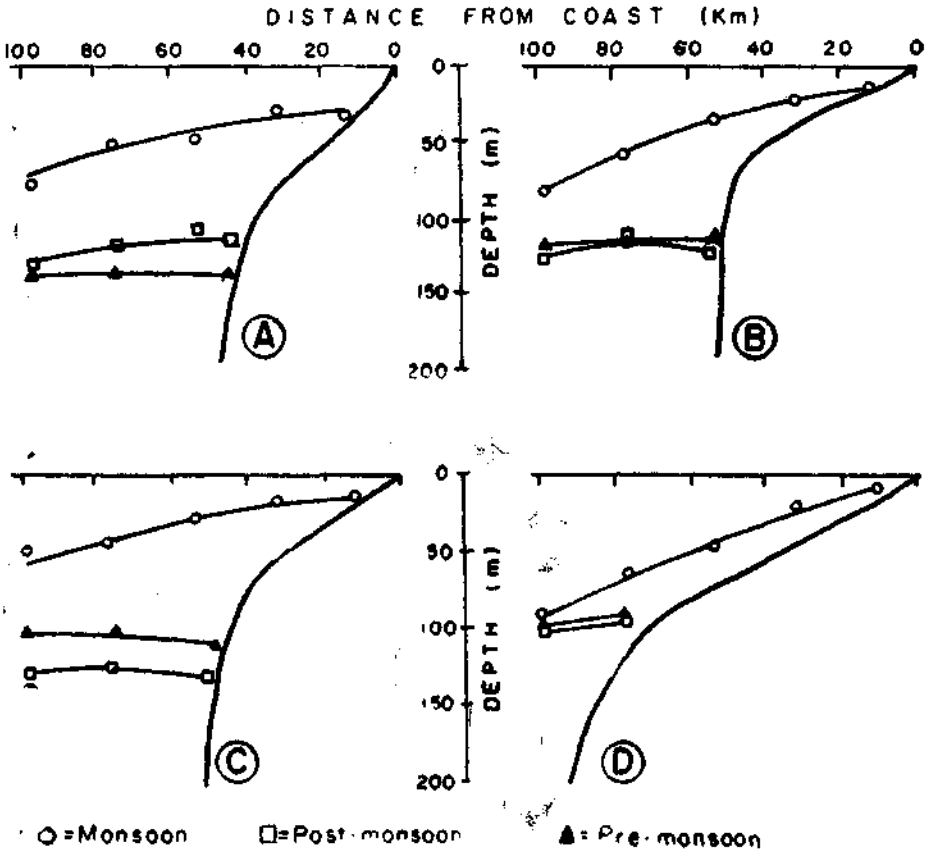
Results and Discussion

Deoxygenation

It is clear from Fig. 1 that the deoxygenated waters were limited to the slope region beyond the shelf edge (below 100 m depth) during pre-monsoon and post-monsoon periods. During monsoon period the poorly aerated waters entered over the shelf region. The upslope of the 1 ml/l isoplith of dissolved oxygen towards coast is a clear indication of upwelling during monsoon. The rate of upwelling is estimated generally from the time rate of ascent of upsloping isopliths of parameters of temperature, density or dissolved oxygen towards the coast, or from the temperature difference from the sea surface and a suitable depth within the Ekman layer. Many authors made estimations of upwelling rate in the shelf waters of the southwest coast of India. Treating the stable thermal conditions of winter as reference, a conservative estimate of the average rate of upwelling in the waters by middle of monsoon period was made as 35 cm/day by Murty (1981). By detailed studies of vertical sections of temperature and dissolved oxygen, Narayana Pillai (1982) found that upwelling in these waters ranged between 23 cm/day and 86 cm/day. Johannessen *et al.* (1987) made an estimate of upwelling at the rate of 150 cm/day. Longhurst and Wooster (1990) used the trends of pre-monsoon (March and April) sea level changes as an index of secular studies of remotely forced upwelling in these waters.

Unlike temperature, dissolved oxygen is a nonconservative property of sea water, due to biological and bacteriological interferences and this is especially true in the case of neritic waters. Therefore, it may be said that the parameter, dissolved oxygen, serves only as a rough index of upwelling. Coastal upwelling occurs largely within a few tens of kilometres (Wooster, 1978) from coast. From the tendency of isotherms to run parallel to the coast, Cushing (1971) observed that the boundary of the California upwelling ranged from 100 km to 200 km off shore. It may be inferred from Fig. 1 that upwelling occurred, in the northern

region, Karwar, within 100 km from coast monsoon and pre-monsoon. It occurred from a at a depth of about 100 m from sea surface, as little more far off distance and from more deep-



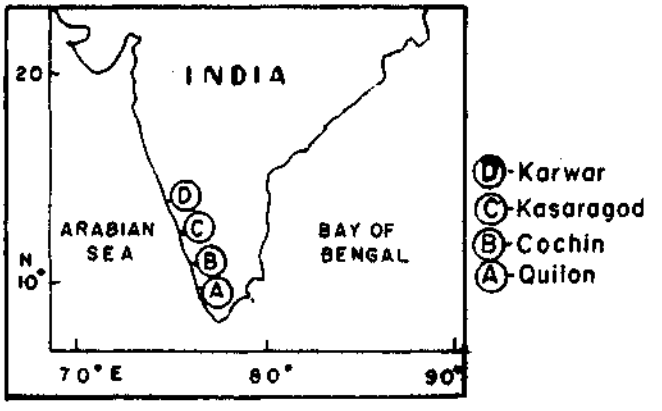


FIG. 1. Encroachment of deoxygenated water at different cross-shelf sections.

indicated by the coincidence of locations at off er waters in the middle (Kasaragod - Cochin) shore of the 1 ml/l isolines of oxygen during and southern (Quilon) regions. By comparing

the rise of 1 ml/l isolines of dissolved oxygen during monsoon over the shelf in all the four places, we may infer that upwelling was weak and limited to narrow layer from the shelf bottom in the region of Karwar. In the middle and southern regions, upwelling was more intense and it infringed into a wider column of water. The influence of upwelling, perhaps through the process of diffusion, extended to as close to the coast as 10 m bathymetric contour in the northern region (Karwar), to 10-15 m depth in the middle region (between Kasaragod and Cochin) and only upto 30 m depth in the southern region (Quilon). Following a different method (summer minus winter dynamic depth variations), Lathipha and Murty (1978) obtained similar results on regional differences of intensity of upwelling along the southwest coast of India.

Fisheries

Fisheries operations are traditionally conducted with canoes (non-mechanised fishing boats) in the depth range of 15-25 m, while the mechanised fishing vessels operate in the depth range of about 26-60 m. However, fishing operations with mechanised vessels would not exceed 80 m bathymetric contour of the shelf bottom. There were no major changes in craft, gear or fishing effort from year to year, during the study period (1971-1975). Introduction of purse seines was only a later development (Jacob *et al.*, 1982) in Indian marine fisheries. Purse seines, 500-600 m in length and 50-60 m in depth with the mesh size 20-30 mm came into effect for pelagic fishing operations only in later half of 1979 in the waters of Cochin for the first time. Therefore, fishery-independent factors would have played a major role in affecting the fisheries.

Out of the total annual landings of the demersal fishes, more than half of them (56%) were captured during monsoon season (Fig. 2). The remaining fraction was shared more or less equally by the other two seasons. The catches of demersal fishes during monsoon period were the highest, when the poorly aerated waters occupied the entire range of fishing depths of bottom-trawl operations in the waters.

In this connection, it may be mentioned that Banse (1959) observed that the demersal fishes disappeared from a band of shelf bottom in the depth range of about 20-40 m in these waters in September-October, 1958. Comparing with dissolved oxygen close to the sea bed in the area, he attributed the disappearance of demersal fishes to the poorly aerated waters, even though Banse (1968) observed that on some occasions the trawl catch rates were higher in certain regions of poorly aerated waters. Further, he advanced a conception of poorly aerated 'band' of shelf region in the depth range of 20-40 m which he recommended to avoid for profitable trawling from either side of the band, but not within the band during the upwelling period, *i.e.*, monsoon season (Banse, 1959).

Such a band, if existed, required to be flanked by two equally valued isolines of dissolved oxygen on the shelf bed. It means that a layer of deoxygenated water has to be sandwiched between two aerated layers. The band thus imposes the condition that the dissolved oxygen values should go on increasing with depth from the lower border of the band, similar to the values maintaining their increase towards sea surface from the upper edge of the band. There was no report of increase of oxygen with depth at any level over the shelf of these waters in cruises conducted by FAO/UNDP Project vessels '*Rastrelliger*' and '*Sardinella*' or by Indo-Norwegian Project vessel R. V. '*Varuna*'. There is no scope for existence of such a 'band' of dissolved oxygen with a clear lower margin on the shelf bottom in these waters, resulting from upslope of isolines due to upwelling effect. How-

ever, it would be possible to come across 'patches' of oxygen-deficient water at certain locations of shelf floor due to intense bacterial decomposition of dead organic substances deposited at those locations.

The seasonality of pelagic fisheries presented a contrasting picture from that of the demersal. More than half (57%) of the annual catch of pelagic fishes was got during post-monsoon period, where as it was one-fourth (27%) during pre-monsoon and only one-sixth (16%) during monsoon period (Fig. 2). Analysis of oilsardine and mackerel catches (Virabhadra Rao, 1973) for the decade of years, 1956-1965,

Longhurst and Wooster (1990) opined that any invasion of the shelf by water with low oxygen tension would tend to exclude oilsardine along with other pelagic as well as demersal species from the coastal region. But the catches of demersal species were very high during monsoon, even though almost the entire bottom of the shelf was occupied by oxygen-deficient water. So, demersal species were not affected, at least at their fishable age, by the low oxygen water on the shelf bottom. Regarding pelagic fishes of which oilsardine have the lifespan of about 2 to 3 years (Antony Raja, 1969), if deoxygenation alone was the question of inconvenience for

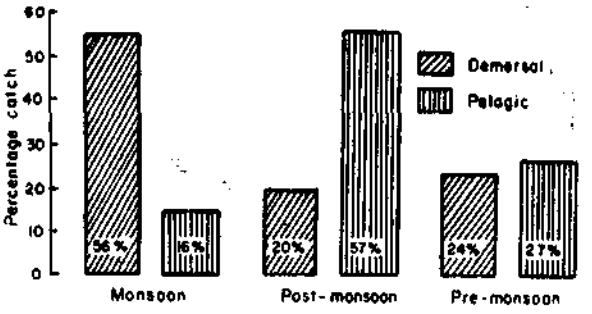


FIG. 2. Seasonal apportionment of fish catches (separate percentages for demersal and pelagic fisheries).

from Kerala-Karnataka Coast indicated that the monsoon or pre-monsoon catches constituted only about one-sixth of the post-monsoon catches of the same fishes. The fact that pelagic catch was lowest during monsoon and it improved tremendously by subsequent season (post-monsoon) might tempt one to believe that the retreat of deoxygenated water to the deeper depths beyond the shelf edge by post-monsoon favoured pelagic fishes with good column of aeration in the shelf waters from sea surface. But, the pelagic fish catch during pre-monsoon was almost equally poor as that of monsoon, even though the entire volume of water present in the shelf was free from deoxygenation during pre-monsoon period.

them, the pelagic fishes could have stayed in the water column overlying 1 ml/l isoline within the shelf itself where there was a plenty of water space with oxygen tension even during monsoon season. Therefore, the deleterious effects of deoxygenation during monsoon on pelagic fishery is only superficial. Other environmental parameters possibly with the combination of biotic factors might be responsible for the seasonal shift of the pelagic fisheries.

Thus, the inter-seasonal trends of bulk catches of fishes, whether they are demersal or pelagic, did not explicitly relate to the derogatory effects of oxygen deficiency in the waters. But, there were a number of

instances on record that trawling near Cochin resulted in very poor catches, when the poorly oxygenated water was prevalent at the bottom (Banse, 1959 ; Sankaranarayanan and Qasim, 1969) and a few instances of mass mortality of fish in open parts of the Arabian Sea associated with oxygen depleted waters (Panikkar, 1969). In the abnormal cases, mass mortality was related being death by volcanism, by poisonous gases, chiefly H_2S (Margaretha Brongersmasanders, 1948) and by abrupt change in temperature and in salinity of the sea waters caused by passing cyclones (Nakai, 1939). All such instances are aperiodic and not prolonged. In the light of those correlating instances it is hard to neglect the bad effects of deoxygenation on the fishes. Thus, some of the individual instances yielded results opposite to the interseasonal bulk results.

Inferences

It is a usual tendency to link up the dwindling catches of fish to the immediate or apparent cause of low oxygen in the waters. The contrasting seasonal response of demersal and pelagic fisheries for the shelf-inundated poorly aerated waters stresses the need for determining tolerance limits of the concerned species for low oxygen by conducting physiological and behavioural studies of fishes by simulated experiments under controlled conditions from board research vessels.

The real reason for dwindling catches may perhaps be sought in the toxic effects of bacterial load which is predominant in upwelling areas. It is therefore necessary to be cautious in interpreting the fluctuations of fisheries to the effect of depletion of oxygen caused by upwelling. There is an urgent need for a systematic bacteriological study in the direction of their toxic influences on fishes, especially in case of mass mortality and enmass depletion of fishes from a particular region.

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NOTES

OBSERVATIONS ON THE WHALES *BALAENOPTERA EDENI, B. MUSCULUS* AND *MEGAPTERA NOVAEANGLIAE* WASHED ASHORE ALONG THE INDIAN COAST WITH A NOTE ON THEIR OSTEOLOGY

ABSTRACT

The Baleen whales *Balaenoptera edeni, Balaenoptera musculus* and the *Megaptera novaeangliae* were reported from the Indian Coast. The skull of a *B. edeni* washed ashore in Dhanuskodi Island in the Gulf of Mannar and that of *Megaptera novaeangliae* from the Malabar Coast were studied. The identity of *B. edeni* was confirmed based on the study of its nasal bones. Biological significance of the occurrence of whales washed ashore along the Indian Coast is also discussed.

JAMES AND SOUNDARARAJAN (1984) summarised the information on the whales washed ashore along the Indian Coast and discussed the probable reasons for their strandings. Further, the declaration of the Indian Ocean as a Marine Mammal Sanctuary has focused the attention of the International Agencies like International Whaling Commission, World Wildlife Fund and IUCN to study the Marine Mammals of the Indian Ocean (Alling *et al.*, 1982; Alling, 1986; Leatherwood, 1985; Mohan, 1985 a, b, 1987; James and Mohan, 1988 a, b, Payne, 1987). Investigations of the 'Tulip' Expedition have brought to light a wealth of information on the distribution, abundance and behaviour of humpback whale, blue whale, Bryde's whale and the smaller cetaceans (Whitehead, 1985; Alling, 1986; Alling *et al.*, 1982; Leatherwood, 1985, 1986).

As the information on the osteology of the whales occurring along the Indian Coast is meagre, the skull of Bryde's whale *Balaenoptera edeni* and the lower jaw of Humpback whale *Megaptera novaeangliae* are studied. Though *B. edeni* has not been so far reported from the Indian Coast, *B. borealis* a closely related species has been repeatedly reported along the coast. (Venkataraman *et al.*, 1973; Anon., 1988). Some of the earlier records of '*Balaenoptera* sp.' are *B. edeni*. The Blue whale *B. musculus* appears to be a common species along the Indian Coast (Jones, 1953; Danial, 1963; Kewalramani, 1964; Nair and Jeyaprakash, 1987). But *M. novaeangliae* is not common along the Indian Coast. It has been reported earlier from the southwest coast of India by Mathews (1947), Chacko and Mathew (1954) and Muthiah *et al.* (1988). However its 'song' was recorded from the Northern Indian Ocean and Sri Lanka (Leatherwood, 1985; Whitehead, 1985).

Observation

A male *B. edeni* of length 13.0 m was washed ashore at Beypore near Calicut (12° 20'N - 76° 30'E) on 2-7-1979. It was characterised by about 55 throat grooves extending utop naval. Flippers were 1.03 m in length forming about 1/12 of the total length (Pl. I A). Another

carcass of the same species measuring 13.52 m in length was observed in one of the islets near Dhanuskodi Island in the Gulf of Mannar (9°02' N-79°30' E) on 20-2-1983. The skull and other parts of the skeleton were collected with great difficulties. The carcass was in a highly decomposed state. It was mutilated by the fishermen searching for 'Ambergeris'. The skeleton is kept at the museum of the Regional Centre of CMFRI, Mandapam Camp The details of the measurements are given in Table 1.

A female blue whale (*B. musculus*) of length 19.2 m was washed ashore at Paravana (12° 10'N — 76°30'E) near Calicut on 29-9-1988. The length of the flippers were 2.5 m forming about 1/7 of the total length. There were about 80 throat grooves reaching the umblicus.

To study the relationship between the total length of *B. musculus* stranded along the Indian Coast and the northern latitudes of their stranding, these parameters were plotted against each other using the formula $Y = a + bx$, where X = total length and Y = the Northern latitudes. The following relationship was obtained:

$$Y = -2.11 + 0.99\ X.$$

The correlation coefficient 'r' was 0.89 indicating a close relation between the length

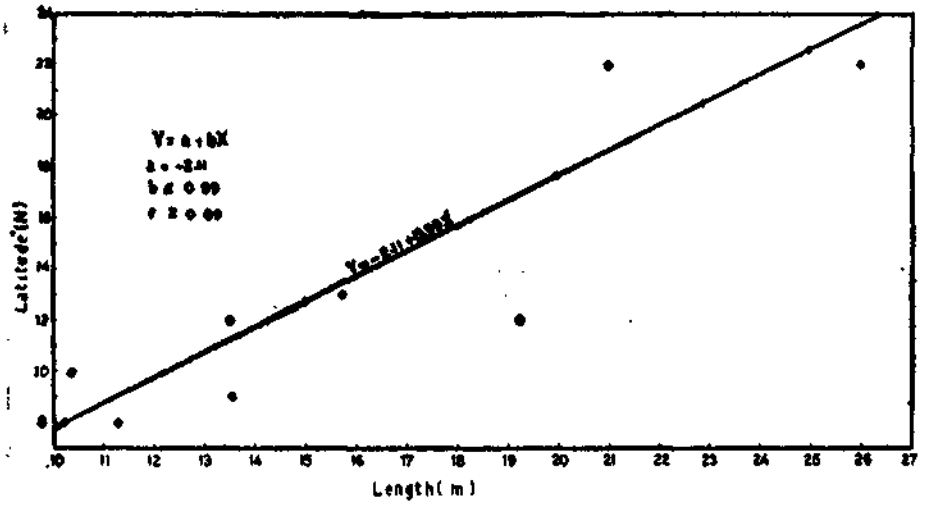

FIG. 1. Relation between lengths of *B. musculus* washed ashore along the Indian Coast and the latitudes of their occurrence.

TABLE 1. *Measurements (mm) on the skull of* Balaenoptera edeni *measuring* 13.5 m

Characters			% of Condylobasal length
Condylobasal length	..	2450	
Length of rostrum	..	1380	56.3
Width of premaxillaries (in the middle)	..	235	9.6
Width of rostrum at base	..	692	28.2
Greatest perorbital width	..	755	30.8
Lease supraorbital width	..	1042	42.5
Width of premaxillaries	..	225	9.2
Greatest width of post temporal fossae	..	1080	44.0
Greatest width of pterygoid	..	155	5.1
Greatest length of ramus	..	2445	99.8
Distance from tip of rostrum to internal nares	..	1530	62.4
Greatest width of external nares		124	5.0

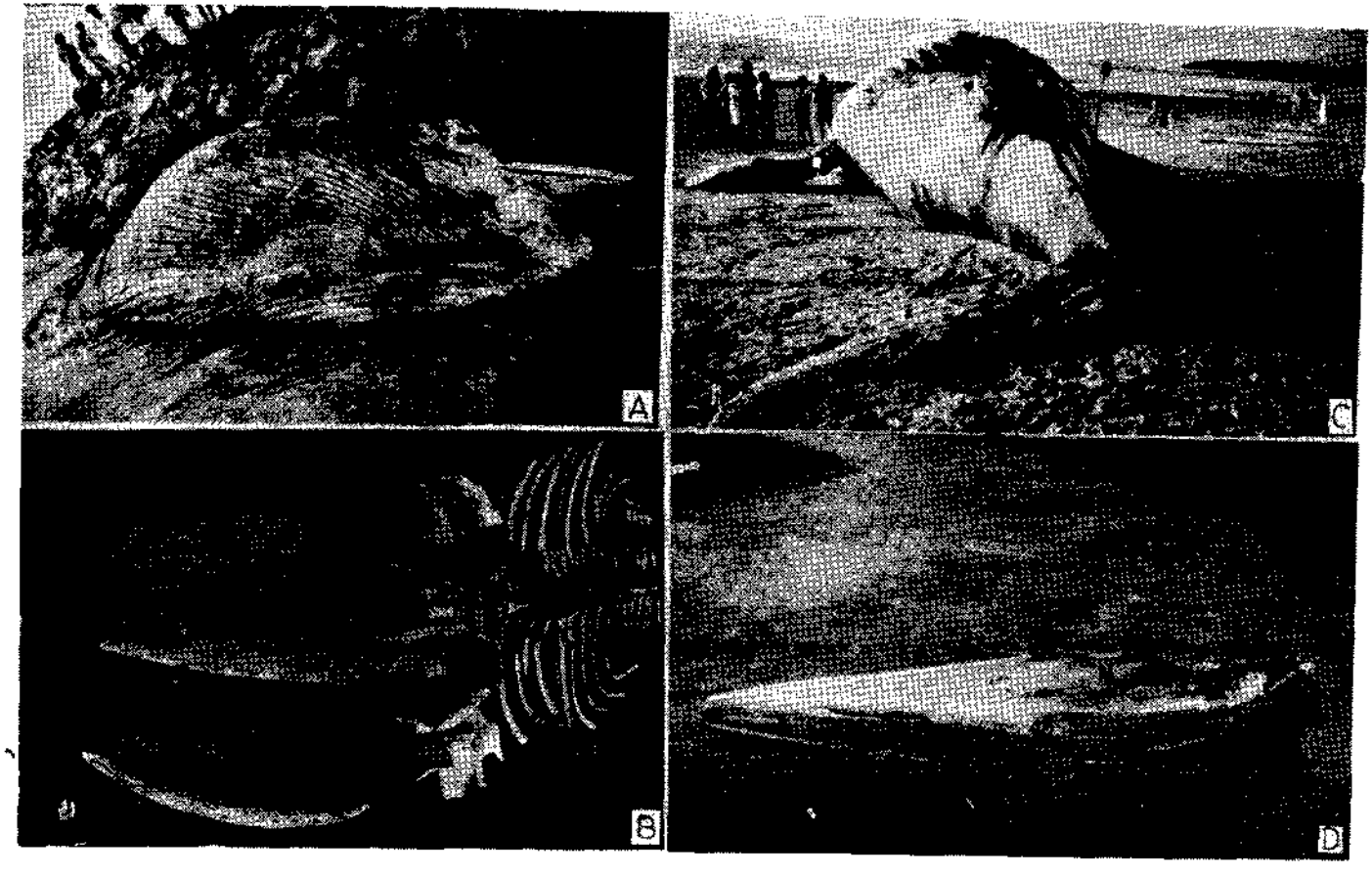

PLATE I A. *Balaenoptera edeni*, 13 m washed ashore near Calicut, B. Skeleton of *Balaenoptera edeni*, 13.5 m washed ashore near Dhanuskodi on 20-2-1983 : (*a*) Nasal bone, C. *Megaptera novaeangliae* (Humpback whale), 14.3 m washed ashore near Kasaragod on 15.1.1988 and D. Lower jaw bone of humpback whale washed ashore near Kasaragod.

of the whales washed ashore and its proximity to the equator (Fig. 1). It was observed that the calves of the whales were found nearer to the equator (Fig. 1) indicating its breeding there.

The lower jaw bone (Pl. I D) of female humpback-whale of length 14.3 m which was washed ashore near Kasaragod (12°20'N and 79°05'E) was studied for the first time in India. The jaw bone measured 3.17 m in length and is kept in the museum of the Research Centre of CMFRI, Calicut.

Remarks

B. edeni is one of the common species of baleen whales found between 40°S and 40°N preferring warm waters (Gaskin, 1972). It has been reported from Sri Lankan Coast in large numbers (Payne, 1987) and from the Indo-Pacific (Ohsumi, 1981 ; Leatherwood, 1986). However it is desirable to study the identifying characters of *B. edeni* and *B. borealis* in details as their range of distribution overlaps and they have some external similarities.

The author is thankful to Mr. M. P. Sivadasan for his help in the preparation of this note.

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AGE AND GROWTH OF THE CLAM *SUNETTA SCRIPTA* (L) IN VELLAR ESTUARY, EAST COAST OF INDIA

ABSTRACT

Length frequency method was not helpful in detecting age and growth of *Sunetta scripta* because of its prolonged breeding periods at Porto Novo waters. All the other methods *viz.* probability plot and von Bertalanffy's equation showed general agreement in the growth pattern. *S. scripta* attained 17.55, 26.63, 32.48 mm during 1st, 2nd and 3 year respectively and life span of this species was 3 to 4 years.

Sunetta scripta is an economically important clam in appreciable quantities at different places in east and west coast of India (Mohan and Damodaran, 1972). Despite its great food value and culture prospects, the biology of the species is little understood. A few reports are available on the rate of growth and age in clam species (Rao, 1952 ; Kalyana-sundaram and Kasinathan, 1983 ; Jayabal, 1984). Age and growth studies provide an insight in the age class structure, changes in abundance and the relation of the stock to their relation to fishing. The present study deals with age and growth of the clam *S. scripta.*

The authors thank Prof. K. Krishnamurthy, Director for facilities provided and MAB Project Department of Environment, New Delhi for financial support.

Materials and methods

Random samples of *S. scripta* were collected at monthly intervals for a year between October 1984 and September 1985 from the shores of Porto Novo (11°30'N ; 70°46'E).

Growth rate was determined by probability plot method (Cassie, 1956 ; Harding, 1949), von Bertalanffy's equation (von Bertalanffy, 1938 ; Pantalu, 1963) and Ford Walford graph (Walford, 1946), shell length (greatest antero-posterior length) was measured to the nearest 0.1 mm using a vernier calliper. The data were arranged in size groups of 1.5 mm intervals. As the number of total observations varied in different months, size frequencies were converted into percentages.

Results and discussion

Length-frequency distribution : Size groups 6.2-7.7 mm were present during October 1984, March, April, May and June 1985 while maximum height of *S. scripta* (35-0 - 36.5mm) present during November 1984, January April, July and August 1985. During December 1984, size groups 25.4 - 26.9 mm showed peak abundance. The groups 12.6 - 15.7 mm 17.4 - 22.1 mm and 23.8 - 31.7 mm were present in all months. Size groups 22.2 - 23.7, 31.8 - 33.3 mm were available throughout the year except January and March 1985 respectively.

Due to continuous breeding habits (Dravida-mani, 1985) of *S. scripta* length frequency method did not give any clue. Secondly some year classes may not be represented in the catches and overlapping the distribution of older size groups is likely to yield erroneous results by Peterson's method.

The cumulative percentage of occurrence of different size groups was plotted on arith-

matic probability paper to note the point of inflection. Growth of *S. scripta* was 6.9 mm in 0 year and was 17.55, 26.63, 32.48 mm during 1st, 2nd and 3rd year respectively. The life span appears to be 3 to 4 years (Fig. 1).

This method is used for species which have prolonged spawning periods. The probability method of separating the polymodel length frequency distribution has been used to find out modal lengths of different year classes. This method is found to be very useful in getting a higher degree of accuracy in sorting out the different size groups contributed from different broods.

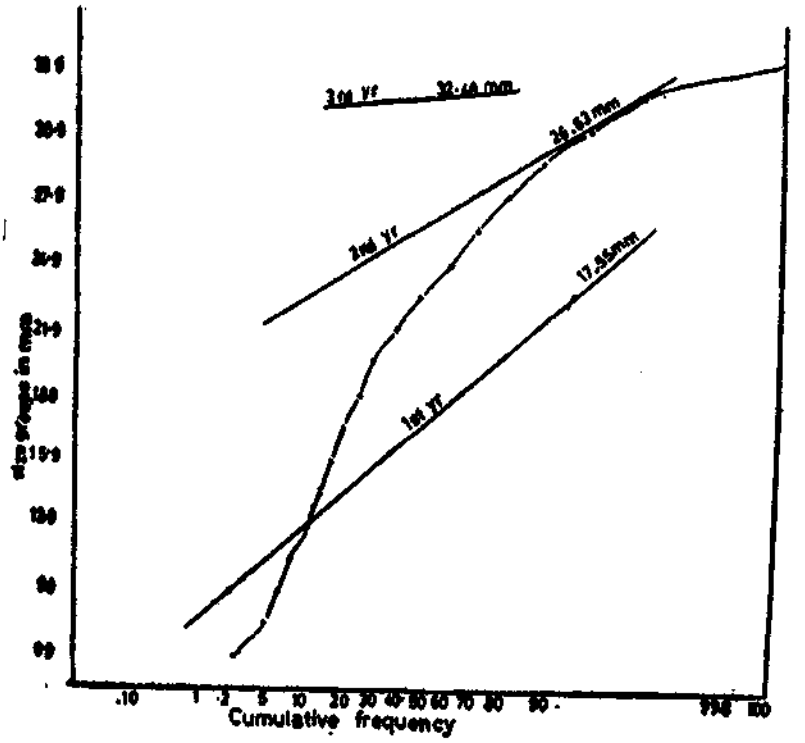

FIG. 1. The cumulative (%) occurrence of different size groups of *S. Scripta*.

Von Bertalanffy's growth equation: Length calculated for different years using this equation plotted along with the observed length for some period showed a general agreement in the growth pattern. For this growth curve, it could be observed that the '0' year clam attains 6.41 mm, the 1st year 17.49 mm, 2nd year 25.91 mm and the 3rd year clam 32.30mm.

Ford-Walford graph

Ford-Walford graph constructed for *S. scripta* by plotting Lt + 1 against Lt, where Lt is the height of the animal at a particular age. The straight line obtained from the Lt against Lt + 1 when intersected by 45° diagonal from the origin. Lœ (length at infinity) was attained, it was found to be 52.48 mm in *S. scripta*.

In the mouth of Vellar Estuary, *Katelysia opima* (Kalyanasundaram and Kasinathan, 1983) has a length of 26.65, 36.62 and 43.15 mm during 1st, 2nd and 3rd year respectively. Growth of *Meretrix meretrix* (Jayabal, 1984) attained 47 mm and 61.5 mm during 1st year

2nd year respectively. But the growth of the present species was 17.55 mm, 26.63 and 32.48 mm during 1st, 2nd and 3rd year respectively and longivity of the species is 3 to 4 years. This result agrees well with the longivity of *K. opima* and contradict with the longivity of *M. meretrix* (Jayabal, 1984).

Growth rate at 1st and 2nd year was high when compared to 3rd and 4th year which is similar to that observed earlier in Porto Novo waters (Kalyanasundaram and Kasinathan, 1983; Jayabal, 1984).

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ARTHROPOD FAUNA OF LITTORAL ZONE IN TWO ISLANDS OF HOOGHLY ESTUARINE COMPLEX, WEST BENGAL, INDIA

ABSTRACT

This study analyses the species composition and density of macro-arthropod fauna of four littoral zones, two each in Chuksar Island and Sagar Island. Characteristics of these zones were the dominance of insects, specially staphylinid beetles.

IN RECENT TIMES, the studies on marine and estuarine littoral ecology has gained immense momentum in tropical and temperate zones. In India, the pioneer work on benthos was

done by Annandale (1907), Choudhury *et al.* (1980, 1984), Bhunia and Choudhury (1981); and Nandi and Choudhury (1983) initiated studies in Hooghly estuarine complex. But all these studies bypassed the presence of insects in the littoral zone. Not only in India, but all over the world, insects have been ignored as an estuarine or marine component (Cheng, 1976). Although insects are reported along the seashores, but there is considerable lack of literature related to the ecology of marine insects (Wong and Chan, 1977). This has tempted the authors to study the insect dominated littoral zones of the said estuary.

Authors are grateful to the authorities of S. D. Marine Biological Research Institute, Bamankhali, Sagar Island and to the Director, Z.S.I., Calcutta.

Materials and methods

The present survey was conducted in Chuksar Island and Sagar Island, situated between 21°30'N and 22°15'N and 88°0'E and 89°5'E.

TABLE 1. *Abiotic factors at four stations*

	Soil-tempe-ture (°C)	Soil-mois-ture (%)	Water salinity (‰)
Station I ..	22	22.8	21.53
Station II ..	25	19.7	22.70
Station III ..	27.5	14.4	16.49
Station IV ..	25	9.2	14.89

At first, the collection spots were identified by the marks of reworked sand on the exposed sandflats. Building of small mounds were caused mainly by the activities of staphylinid beetle which dig tunnels at the time of receding tide (Smith and Hein, 1971 ; Evans *et al.*, 1971). Samples were collected during the post-monsoon months (November to February, 1983-84) with the help of a corer, covering 25 cm^2 surface soil. In each station, three 1 m^2 plots were marked and five samples were collected from each plot. Repeated removal of soil from exactly the same place during consecutive fortnight collection was avoided.

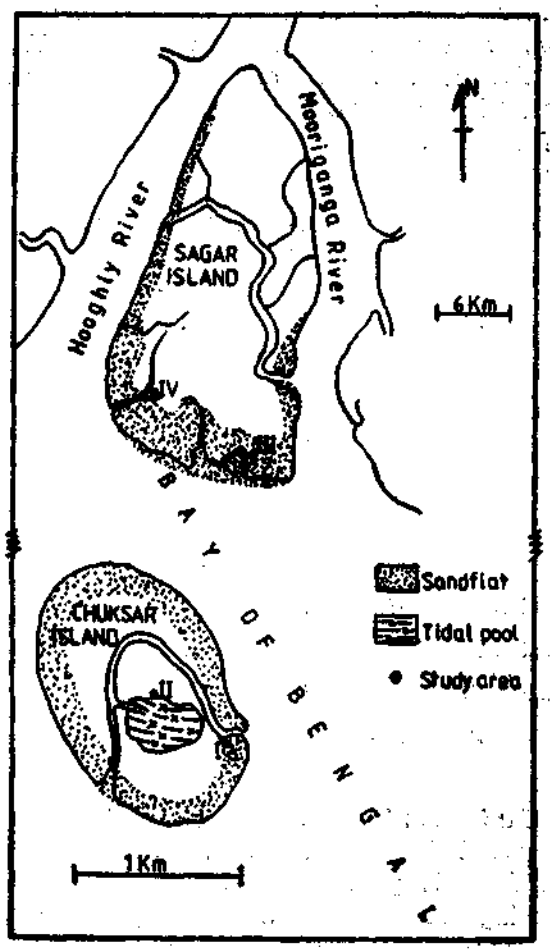

FIG. 1. The position of study areas at Chuksar Island and Sagar Island.

Soil temperature, soil moisture and water salinity was measured during the time of sampling.

Statistical analysis such as relative abundance, dominance index and spcies diversity index was calculated by using standard accepted formulae (Odum, 1971).

Description of collection sites

Station I: This station was situated in Chuksar Island which was completely uninhabited by man. The island was traversed by a narrow creek and the actual collection spot was at the mouth of the creek (Fig. 1). The collection area was totally devoid of any plant life and experienced heavy wave action. Twice a day the area was inundated by tide water.

Station II: The narrow tidal creek which traversed the Chuksar Island made a considerable tidal pool at the heart of the island. During ebb it was completely exposed and got inundated during flowtide. In this station collections were made on the bank of the tidal pool (Fig. 1), *i.e.*, on the hygropsammon zone which was just beyond the waterline. Substratum of the sampling area was muddy due to gradual deposition of silt. The nearby vegetation was very poor and represented only by grass and succulents *e.g. Porteresia coaretata, Salicornia* sp., *Sueada* sp. and *Ipomia* sp.

Station III: It was located in the southern part of Sagar Island. Collections were done by the sides of a small blind channel (Fig. 1) originating from Gangasar Creek. This area was partly surrounded by large stable dunes which was mainly covered by two creepers *viz. Ipomia* sp. and *Launia* sp. Dune base was covered by a spiny green grass *Porteresia coaretata*. A small patch of luxuriant, but gradually diminishing mangroves existed on the landward side of the main creek. The collection site was inundated during each high tide which lasted for about 1 hour.

TABLE 2. *Relative abundance (%) of different species in four stations*

	INSECTA									CRUSTACEA				ARACHNIDA	
	B. (H.) helferi	*B. (H.) birmanus*	*B. (H.) dilutipenis*	*T. interpunctatus*	*Georysus* sp.	*Tackys* sp.	*Saldapsula* sp.	Dermaptera	TOTAL	*Ampelisca* sp.	*Telorkestia* sp.	*M. intermedia.*	TOTAL	*Lycosa* sp.	TOTAL
Station I	91.6	..	4.2	1.7	..	..	..	..	97.5	1.25	..	1.25	2.5	..	..
Station II	74.4	17.4	6.9	..	..	..	..	..	98.7	..	1.3	..	1.3	..	..
Station III	66.2	19.5	..	..	1.3	..	5.2	..	92.2	2.6	3.9	..	6.5	1.3	1.3
Station IV	56.2	12.4	..	..	..	15.7	..	6.3	90.6	6.3	..	..	6.3	3.1	3.1

Station IV: This site was also in Sagar Island and was situated at the end of a blind channel (Fig. 1) originating from the Beguakhali Creek. Huge sand dunes protecting this spot which were well covered by *Ipomia* sp. and *Launia* sp. Few *Acanthus* sp. and *Salicornia* sp. was also present. On the landward side of the dunes a large (about 10 sq. km) mangrove forest was in existence where *Phoenix* sp. predominate.

Results and discussion

Estuary is a transitional zone between the freshwater and the sea and therefore the typical estuarine forms are unique in their habits. The physical conditions in estuaries are very stressful and the species diversity correspondingly low. But estuary is a nutrient trap and so this region is packed with life. Insects were the most successful group to occupy the present sites of investigation. In all four stations the relative abundance of insects were more than 90% (Table 2). Among insects *Bledius* (*Hesperophilus*) *helfert* population always headed the list (Fig. 2). B. (*H.*) *birmanus* was present in station II-IV and occupied a major portion of the insect fauna. Another staphylinid beetle *B.* (*H.*) *dilutipenis*, was recorded from both the collection sites of Chuksar Island, but totally absent in Sagar Island. *Trilophus interpunctatus*, *Georyssus* sp., *Tachys* sp., *Salduncula* sp. and Dermaptera were the other insect species which were encountered only in one station of the four described. Amphipods represented by two species *viz.* *Ampelisca* sp. and *Telorkestia* sp., were present in all four stations. Crabs (*Metaplax intermedia*) were recorded from station I only. Spider *Lycosa* sp. was the only representative of class Arachnida. Both the stations of Sagar Island inhabited by *Lycosa* sp., but the stations of Chuksar Island were devoid of it. In extreme environments dominant species are fewer in number. Station I was subjected to maximum wave action and tidal interplay; salinity was also very high here (Table 1). In station I, dominance index was maximum (84.3%) and correspondingly species diversity index was minimum (0.169). In station II, III and IV, dominance were divided into more number of species and hence dominance indices were comparatively low (Table 3). Species diversity indices

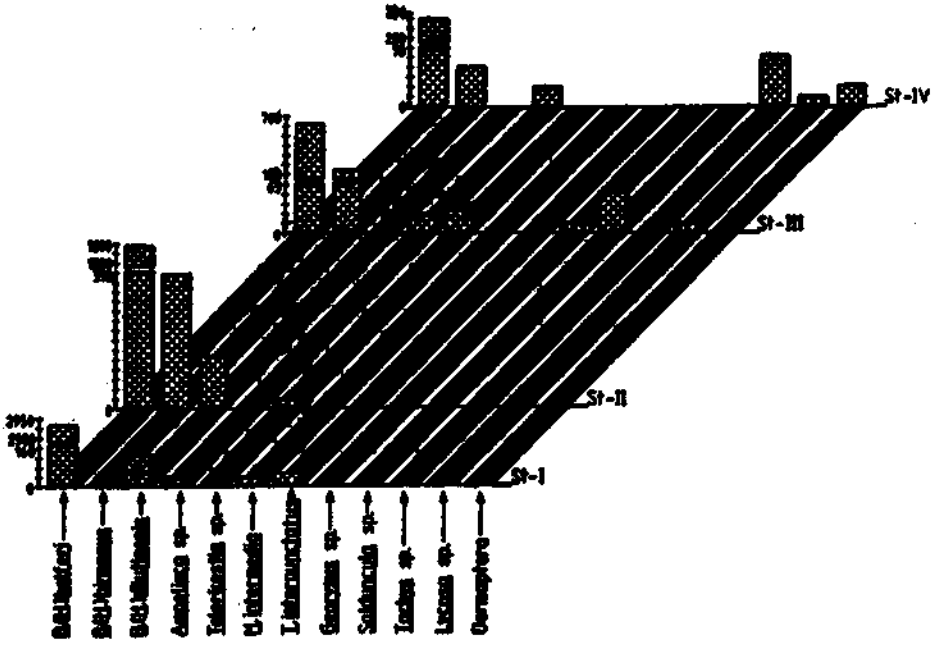

FIG. 2. Population density (No/m²) of different species at four stations.

TABLE 3. *Species diversity index and dominance index of four stations*

	Station I	Station II	Station III	Station IV
Species diversity index ..	0.169	0.332	0.468	0.577
Dominance index (%) ..	84.3	58.8	48.2	36.5

of station II-IV were 0.332, 0.468 and 0.577 respectively (Table 3); it proves that when the effect of the physical factors over environment decreases the number of dominant species as well as species diversity increases. During extreme environmental conditions, only a few species are adapted to it, but they grow maximum in number which might be due to less competition.

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COMPARATIVE STUDIES ON THE FEEDING HABITS OF MARINE AND ESTUARINE CARANGIDS

ABSTRACT

The gut contents of 42 species of carangid fishes occurring at Visakhapatnam on the east coast of India are analysed. Of these eleven species also occur in Godavary and Vellar Estuaries on the east coast. The gut contents of *Alepes djedaba* from Visakhapatnam region, Godavary Estuary and Vellar Estuary and of *Alepes kalla* from Visakhapatnam and Vellar Estuary are compared.

CARANGIDS constitute a commercially important group of fishes along the Indian Coast. The juveniles and subadults of some species are also reported from the estuaries and brakish-water areas where they constitute a fishery. Some of the earlier work done on the food of carangids was based on observations on single species. Chacko (1949) analysed the food of *Caranx hippos* and *Caranx sansun* from the Gulf of Mannar. Bapat and Bal

(1952) gave a brief account of the food of *Chorinemus toloo*. Datar (1954) and Sreenivasan (1975) reported the food and feeding habit of *Selaroides leptolepis*. Kagwade (1965) reported the food of *Caranx kalla*. Reuben (1969) investigated the food of Malabar trevally *Carangoides malabaricus* from Bay of Bengal. Sreenivasan (1979) gave an account of feeding biology of the scad *Decapterus* Novo. The present investigation is on the qualitative analysis of the food contents of the horse mackerels collected for the systematic study.

The author is grateful to Prof. S. Dutt, under whose guidance this investigation has been carried out.

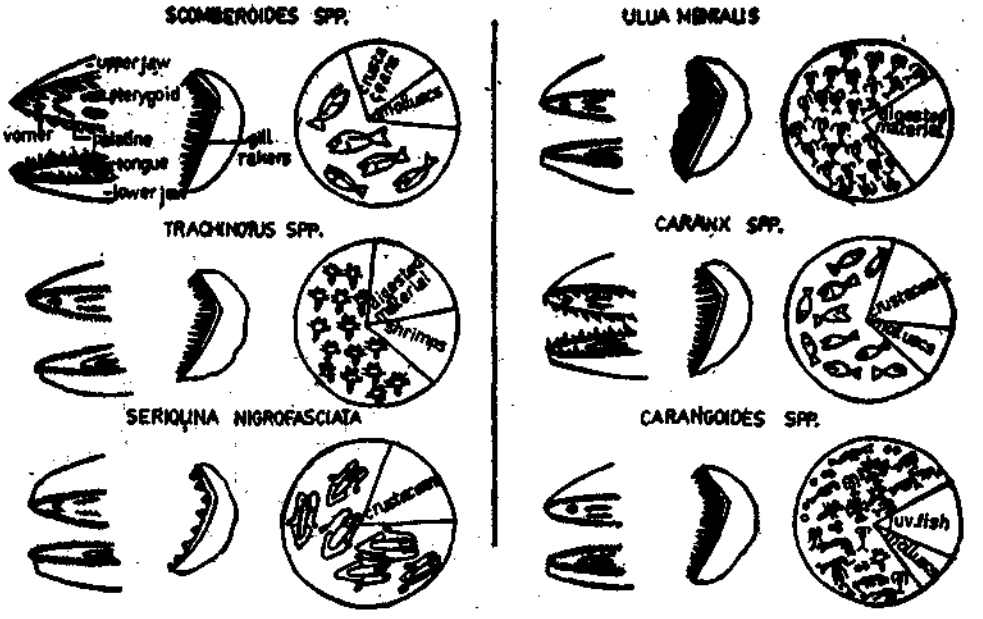

FIG. 1. Relation between dentition, gillrakers and stomach contents in carangid fishes.

dayi from Cochin region. Venkataraman (1961), while giving the food and feeding relationships of the inshore fishes off Calicut region on the Malabar Coast, described the food of *Caranx kalla* and *C. djedaba*. Rao (1967) while giving an account of food and feeding habits of fishes from trawl catches in the Bay of Bengal, described the food of a few carangid species such as *Chorinemus lysan*, *Atropus atropus*, *Caranx sexfasciatus*, *Carangoides malabaricus*, *C. chrysophrys* and *C. armatus* from Visakhapatnam region. Venkatramani and Natarajan (1983) described the food of *C. malabaricus* and *Alepes kalla* from Porto

Material and Method

The present study is based on the monthly and fortnightly samples obtained from the trawl catches at Visakhapatnam during 1977 to 1985 and also from samples collected from the Gautami-Godavari Estuary (Yanam) and Vellar Estuary during 1985. Based on the state of distention of stomachs, the intensity of feeding was recorded, they were classified as empty, 1/4 full, 1/2 full, 3/4 full and gorged depending on the amount of food present in the stomochs. The food elements were identified as far as possible upto family or genus level depending upon the intactness of

organisms and the state of digestion. A total of 435 specimens belonging to 42 species 17 genera and 4 subfamilies were studied.

Discussion

The carangid fishery at Visakhapatnam starts generally during August to March with peak season from September to February. At this time the inshore waters are rich in plankton comprising a large variety of edible zooplankton after the monsoon period. Hence it seems that carangids and most other fishes utilise the continental waters with plenty of food as feeding grounds and breed elsewhere. This abundance of zooplankton is also noticed in the stomachs of the fishes.

length were noted to consume microplanktonic forms like copepods and larval crustaceans. Horse mackerels are generally pelagic in habitat (a few are demersal) and they are generally carnivorous in habit. The change in the food pattern between the juvenile and adult carangids is dependent upon the area of filtration formed by the gill apparatus as demonstrated by Magnuson and Helt (1971). Sreenivasan (1979) has also observed the change in the food pattern of juvenile and adult scad *Decapterus dayi*.

Eventhough planktonic forms such as chaetognaths (*Sagitta*, *Krohnitta*), coelenterates, ctenophores (*Pleurobrachia*, *Beroe*), urochor-

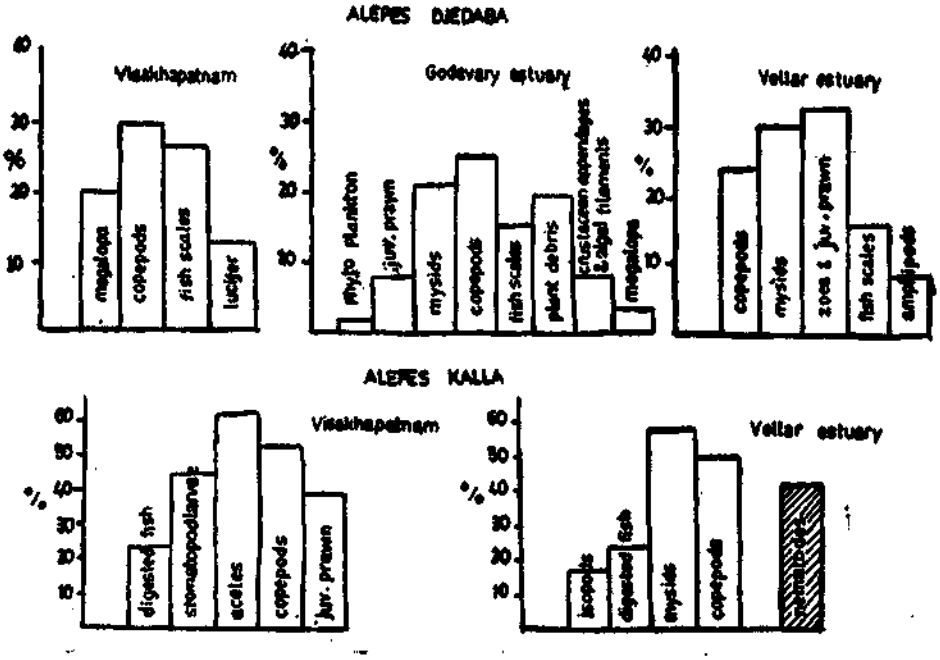

FIG. 2. Percentage occurrence of food items in the stomachs of *A. djedaba* and *A. kalla*.

It appears from Table 1 that the main food constituents of carangids are macroplanktonic forms, such as shrimps (*Acetes* spp.) prawn larvae, crab larvae, stomatopod larvae, squids and juvenile fishes like clupeids, leiognathids, etc. Fishes below 10 cm in total

dates (*Oikopleura*, *Fritillaria*, *Doliolum* and *Salpa*), polychaetes, ostracods and echinoderm larvae are very common in the plankton of this region, they are absent in the gut contents of carangids. It shows that Horse mackerels are selective in the food habits.

TABLE 1. *Stomach contents of carangids collected from trawl catches at Waltair region*

Species	No. of specimens examined	No. of specimens with empty stomachs	Size range (TL in mm)	Total gill rakers	Stomach contents	Remarks
1	2	3	4	5	6	7
Scomberoides commersonianus	25	8	84-1000	13-19	Juveniles have small fish, cephalopods and fish scales. Adults have anchovies and teleost remains	Well developed canine teeth on jaws.
S. tala	3	1	190-193	12-13	Digested remains of cephalopods, teleost fish and decapod crustaceans	same
S. lysan	25	10	202-421	21-26	*Acetes*, juvenile clupeid fishes	same
S. tol	30	18	181-344	22-27	Stomatopod larvae, *Anchoviella*, *Acetes*, *megalopa*, copepods like *Pontella*, *Labidocera* & *Lucifera*, zoea and mysis stages of prawns	same
Trachinotus blochii	5	2	120-185	14-19	Digested material, appendages of shrimps	Jaw teeth feeble, pharyngeal teeth molari form.
T. russellii	6	2	155-432	23-25	Digested material, megalopa larvae	same
T. baillonii	2	—	262-300	23-25	Digested material, crab juveniles	same
Elagatis bipinnulatus	4	..	281-350	35-37	Juveniles of prawn, crab and remains of teleost fishes	
Gnathanodon speciosus	8	1	45-60	26-30	*Acetes*, ostracods, copepods, mollusc larvae, leiognathid juveniles and sand grains	
Sertolina nigrofasciata	6	2	260-345	8-10	*Loligo*, juvenile prawns	Demersal feeder Gill rakers reduced in size.

TABLE 1. (*Contd.*)

1	2	3	4	5	6	7
Seriola rivoliana	2	—	280-310	15-16	Juvenile squids, juvenile fish	Gill rakers not reduced in size.
Decapterus russelliii	38	—	142-214	44-51	Acetes, juvenile prawns, juvenile leiognathids, juvenile clupeids, *Stolephorus* spp. fish scales. Contained the same variety of organisms	
D. macrosoma *D. maccarellus* and *D. kurroides*						
Megalaspis cordyla	43	12	84-365	25-33	Juveniles have copepods like *Labidocera*, *Undinula* & *Eucalanus*, Megalopa, mysids. Adults have *Anchoviella*, spp., leiognathids, sciaenids, *Rastrelliger* spp. *Trichiurus* spp.	
Alectis ciliaris	3	...	148-174	19-21	Megalopa, lucifer, juvenile teleost and crustacean remains and cuttlefish juveniles.	
A. indicus	20	13	87-190	31-36	*Acetes*, stomatopod larvae, juvenile cephalopods.	
Uraspis helvius	10	—	140-267	19-25	Digested remains of fish and crabs.	
Carangoides malabaricus					*Acetes*, juvenile clupeids, leiognathids, Lucifer, megalopa, mysis, alima larvae and cephalopods.	
C. praeustus, *C. talampanoides*, *C. chrysophrys*, *C. coeruleopinnatus*, *C. ferdau*, *C. gymnostethus*, *C. uii*, *C. hedlandensis* & *C. armatus*, etc.					Contained almost the same variety of organisms.	
Ulua mentalis	2	1	153-155	80	Digested material copepods.	Gill rakers numerous.
Atropus atropus	39	10	149-212	30-34	*Acetes*, alima and crab larvae, copepods like *Temora*, *Pontella*, *Eucalanus* and detritus	Probably a demersal feeder.

TABLE 1. (*Contd.*)

1	2	3	4	5	6	7
Selar crumenophthalmus	18	—	170-263	38-42	*Acetes*, juvenile crabs, fishes, fish eggs, Foraminiferans.	
Alepes djedaba	60	15	130-255	37-45	Copepods, Lucifer, megalopa, cycloid scales.	
A. kalla	25	7	78-178	36-45	Copepods, *Acetes*, prawn larvae stomatopod larvae.	
A. melanoptera	12	2	168-240	25-31	Copepods, *Acetes*.	
A. vari	13	2	131-343	32-36	*Acetes*, *copepods*, megalopa, juvenile clupeids.	
Caranx sixfasciatus	18	4	102-252	22-25	Juveniles feed on *Acetes* and larvae of crustaceans. Adults feed on juveniles of clupeids, leiognathids engraulids, trichiurids and cephalopods.	canine teeth on jaws
C. sem., *C. melampygus*					Feed on same catgory of organisms.	
C. ignobilis and *C. tille*						

Instances of food preferences have also been observed earlier by Sreenivasan (1974) in *Megalaspis cordyla* where even the larvae show selectivity of feeding preferring only a few of the many copepods found predominantly in the environment. Karuna (1959) and Venkatramani (1983) have reported an instance of cannibalism twice in the guts of *A. atropus*. There appears some correlation between the maturity of the fish and feeding intensity. Strikingly the stomachs of immature and spent forms are empty. But in a few instances full stomachs were observed even in ripe females of *D. russellii*.

A comparison of food constituents of marine and estuarine carangid species

Most of the juveniles and subadults of carangids enter the estuaries or brackishwater which they utilise as feeding grounds. Species such as *S. commersonianus*, *A. kalla*, *A. djedaba*, *A. mate*, *C. sexfasciatus*, *C. sem*, *C. ignobilis*, *C. melampygus*, *C. malabaricus*, *C. gymnostethus* and *C. crysophrys* are recorded from Godavari Estuary as well as Vellar Estuary. Some specimens of *A. djedaba* and *A. kalla* are collected from Godavari Estuary, Vellar Estuary and from Visakhapatnam Coast. Since they are collected in the same season and they belong to the same length group a comparative study made regarding the gut contents of *A. djedaba* from all the three regions and of *A. kalla* between Vellar Estuary and Waltair region.

Specimens of *A. djedaba* (130-185 mm TL) from Visakhapatnam Coast have copepods such as *Temora*, *Pseudodiaptomus Centropages*,

etc. *Lucifera*, megalopa larvae and teleost scales in their guts. Phytoplankton or filamentous algae are not observed in the stomachs of fishes examined from this region. Specimens of *A. djedaba* (125-154 mm TL) from Godavari Estuary have mostly digested material of unknown origin, copepods such as *Temora*, *Oncaea*, etc., juvenile prawn, crustacean appendages, megalopa larvae and mysids in their guts. In addition most of the stomachs have plant debris, algal filaments, sandy clay and cycloid scales. Phytoplankton is represented by *Coscinodiscus* and *Thalssiothrix*. Specimens of *A. djedaba* (90-182 mm TL) from Vellar Estuary have mostly mysids, juvenile prawns, zoea larvae, amphipods, copepods, cycloid scales and sand grains in their guts. Phytoplankton or algae are absent in the stomachs.

Specimens of *A. kalla* (80-150 mm TL) collected from Visakhapatnam region have copepods, *Acetes*, juvenile prawns, alima larvae and digested fish remains in their stomachs. Specimens of *A. kalla* (65-145 mm TL) collected from Vellar Estuary have mostly copepods, mysids, isopods, digested fish remains and grains in their stomachs. The presence of phytoplankton, algal filaments, plant debris and clay particles in the stomachs of *A. djedaba* collected from Godavari Estuary may be due to their abundance in the surface regions, and the presence of which in the stomachs appear to be strange, because the carangids are considered as selective feeders. Specimens of *A. djedaba* and *A. kalla* collected from Vellar Estuary have mostly mysidy and juvenile prawns, which are replaced by *Acetes* spp. in most of the specimens from Visakhapatnam region. Sand grains are abundant in the stomachs of *A. djedaba* and *A. kalla* collected from the estuaries. The remaining food items such as copepods and fish scales are same in all three regions. Probably *A. djedaba* also shows scale feeding behaviour since fish are absent in the diet and teeth are feeble in this species.

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LENGTH-WEIGHT RELATIONSHIP AND RELATIVE CONDITION OF *LEIOGNATHUS BREVIROSTRIS* (VALENCIENNES) FROM THE PALK BAY

ABSTRACT

The length-weight relationship of *Leiognathus brevirostris* which supports a commercial fishery in the Palk Bay at Mandapam is found to be logarithmic, expressed by the formula : Log W =—4.8512 + 3.004 Log L indicating an isomometric growth pattern of the fish in its natural habitat. The mean relative condition of the species is 0.996 which denotes the normal well being of the fish in this region.

THE SILVERBELLY fishery of Mandapam region is constituted principally by two species, namely *Leiognathus jonesi* and *Leiognathus brevirostris*. The latter ranks second in respect of its production. The average annual landings of this species during 1985-1987 amounted to 8.54 tonnes forming more than 18% of the total catch of Silverbellies. Though a detailed study on the biology and fishery of *L. brevirostris* was reported by James and Badrudeen (1975), information on Length-weight relationship is not available. Hence a study was undertaken to elucidate this relationship and the relative condition to add to the existing knowledge on the biology of the fish.

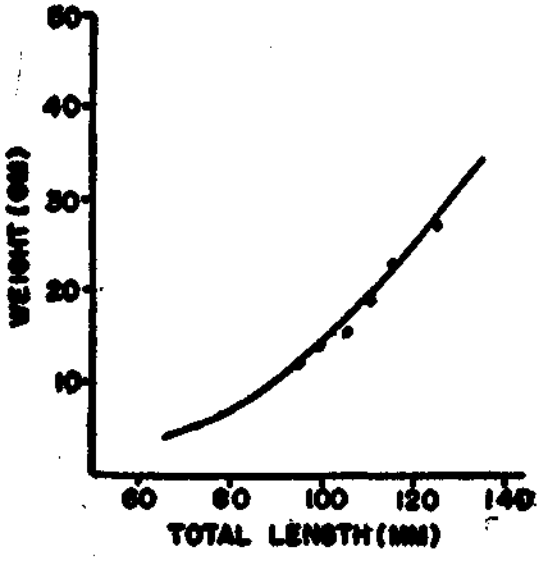

FIG. 1. Length - weight relationship of *L. brevirostris*.

The authors are grateful to Dr. P. S. B. R. James, Director, Central Marine Fisheries Research Institute, Cochin for his kind encouragement.

The material for the present study was collected from the catch landed by trawlers operating in the Palk Bay off Mandapam. A total of 267 fishes ranging from 65 mm-138.0 mm in total length were used to study the length-weight relationship and relative condition of the fish. The total length of the fish measured from tip of the snout to the tip of the caudal lobe were grouped in 5 mm class interval. After removing the external moisture, each of the fish was weighed. The average weight was calculated for each class intervals. The length-weight relationship was calculated by employing Hile's (1936) Parabola : $W = CL^n$ where 'W' is the weight in grams, 'L' is the total length in mm and C and n are constants. The value of Log C and n are determined by fitting a line to the logarithms of L and W.

The relative condition (Kn) was estimated by employing the formula W/w where 'W' is the empirical weight and 'w' is the calculated weight.

The length-weight relationship of *L. brevirostris* is found to be Log $W = -4.8512 + 3.004$ Log L. The empirical and calculated weight of the fish at different sizes were given in Table 1 and Fig. 1. The length-weight relationship indicates closely the cubic law ($n = 3.004$) which describes the isometric growth of the fish.

The relative condition (Kn) of *L. brevirostris* ranged between 0.96 and 1.11 with a mean value of 0.996. It shows that the condition of the fish is good in the ecosystem.

TABLE 1. *Length-weight relationship and the relative condition factor (K_n) of* L. brevirostris

T.L. (mm)	No. of fish	Empirical Wt. (g)	Calculated Wt. (g)	Relative Condition (K_n)
65	5	4.40	3.93	1.11
70	9	4.88	4.91	0.99
75	19	5.86	6.04	0.97
80	30	7.08	7.33	0.96
85	39	8.93	8.80	1.01
90	27	10.38	10.45	0.99
95	45	12.13	12.29	0.98
100	24	14.35	14.34	1.00
105	19	15.84	16.60	0.95
110	21	19.28	19.09	1.00
115	10	23.20	21.81	1.06
120	6	25.33	24.79	1.02
125	3	27.66	28.04	0.98
130	8	30.50	31.54	0.96
135	2	34.50	35.33	0.97
			Mean K_n	0.99

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GROWTH AND PRODUCTION POTENTIAL OF YOUNG GROUPER *EPINEPHELUS TAUVINA* (FORSKÅL) REARED IN FIXED NET CAGES

ABSTRACT

Growth of *Epinephelus tauvina* was studied in the fixed cage culture system in Mandapam (Gulf of Mannar) coastal waters employing net cages of 5×5×2 m dimension made of HDPE net material with 20 mm mesh size. The fishes were fed with trash-fish once in 2 days and the culture period varied from 163 days to 334 days. The average growth increment in length was 145.5 mm in 8.71 months at the rate of 16.3 mm/month and the average growth increment in weight was 413.9 g at the rate of 47.5 g/month. The basic growth data were subjected to various statistical analysis and different parameters have been estimated. The asymptotic growth L_{∞} is 671 mm, the growth constant K is 0.4619 and the age at 0 length t_0 is assumed to be 0. The life span is estimated to be 10.7 yrs and the natural mortality coefficient M is 0.4333 at 1% survival level. The optimum age for harvesting is estimated to be 3 yrs and the optimum culture period which can yield the highest production for this species is 28 months for the prevailing age at stocking of 8 months. The cost and return of this culture technique is also discussed.

IN FINFISH culture, rearing of selected species in restricted locals or physical enclosures such as fixed and floating cages within a natural expanse of water like sea, lake, etc. is gaining importance and wide usage in view of its inherent advantages. In recent years, this method has been widely used by several countries apart from Southeast Asian countries where this is practised for the past several decades (Hamsa, 1983). In Malaysia, culture of estuarine groupers (*Epinephelus salmoides* Maxwell) in floating net cages is carried out by many fish farmers commercially on a small-scale (Chua, 1973; Chua and Teng, 1977).

The groupers being different from other cultivable species such as mullets, *Chanos*, etc. in their behaviour and mode of feeding and in order to assess their suitability for cage culture, a research project on the fixed and floating net cages was initiated at Mandapam in 1984. Present account deals on the growth and production potentials of the grouper *Epinephelus tauvina* (Forsskal) reared in fixed net cages.

The authors are grateful to Shri C. Mukundan for his valuable suggestions for the improvements of the paper and to Shri S. Mahadevan for providing the required facilities and guidance at the Regional Centre of CMFRI, Mandapam camp.

Materials and methods

Experimental fish: Juveniles of *Epinephelus tauvina* (Pl. I A) in the size range 139-250 mm were collected alive from drag net operations and special perch-traps. They were initially maintained and fed on trash fish in the wet laboratory for a minimum period of 2-3 weeks before stocking in the fixed net cages.

Culture cages: Net cages of 5 × 5 × 2 m dimension were fabricated with HDPE net material with mesh size of 20 mm. The cages were fixed in shallow waters of 2 m depth near C.M.F.R.I. jetty in the Gulf of Mannar with the help of casuarina poles which were coated with Kriside to minimise fouling. The cages were tied to the poles errected at a distance of 3 m, in such a manner that the

bottom of the net was just about 40-50 cm above the sea bed (Pl. I B). A 70 m long bridge constructed with casuarina and bamboo poles alongside the cages, served as working platform at the time of sampling, feeding and other maintenance work. The poles and net cages were cleaned periodically in order to minimise the fouling mostly by algae and barnacles. The stocking rate was 100 fish/cage and the fish were periodically measured and weighed while changing the net cages.

Food and feeding : The groupers were fed with chopped trash fish at a rate of 10% of their body weight at 48 hours frequency, *i.e.* once in 2 days as recommended by Chua and Teng (1978). They experimentally proved that optimal growth, good food conversion and higher survival rate were obtained in grouper cultured in net cages fed to satiation with one feeding in 2 days. The trash fish used as food were mostly low cost fishes landed by mechanised trawlers as by-catch.

Results and discussion

In all four experiments were carried out during 1984 and the growth data are given in Tables 1-5. It may be seen that after a period of 334 days, the fishes reared in cage 1 have attained average length of 363 mm and average weight of 770 g from the initial

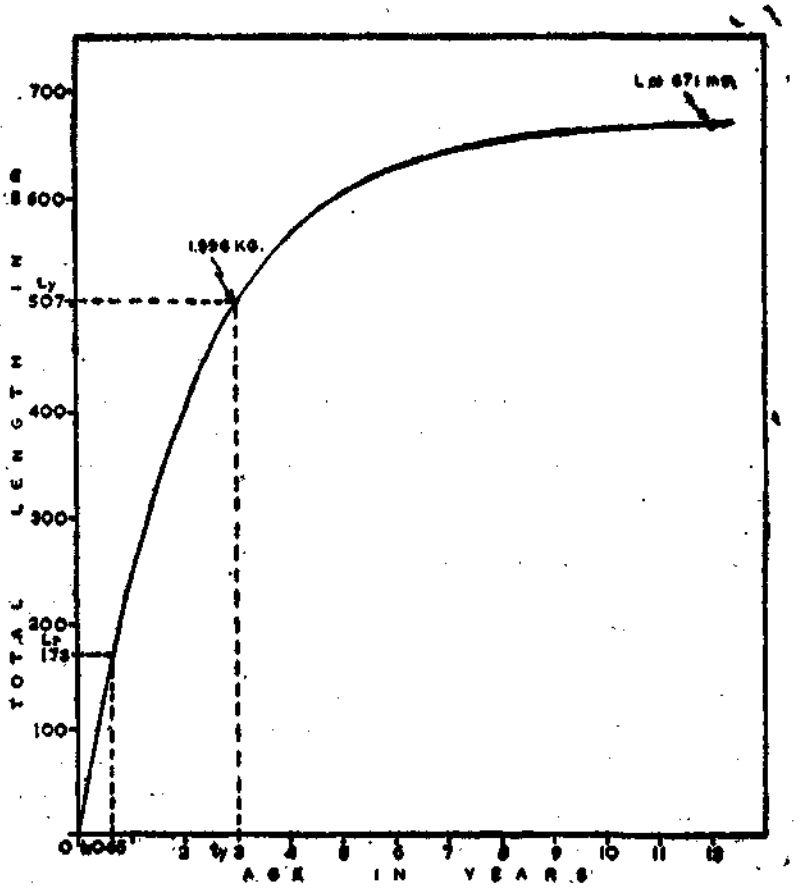

FIG. 1. Growth curve of *E. tauvina* as per the growth parameters obtained from the culture experiments. The age at recruitment into the culture system 'tr', the corresponding length at recruitment, optimum age for harvesting and the corresponding size are indicated.

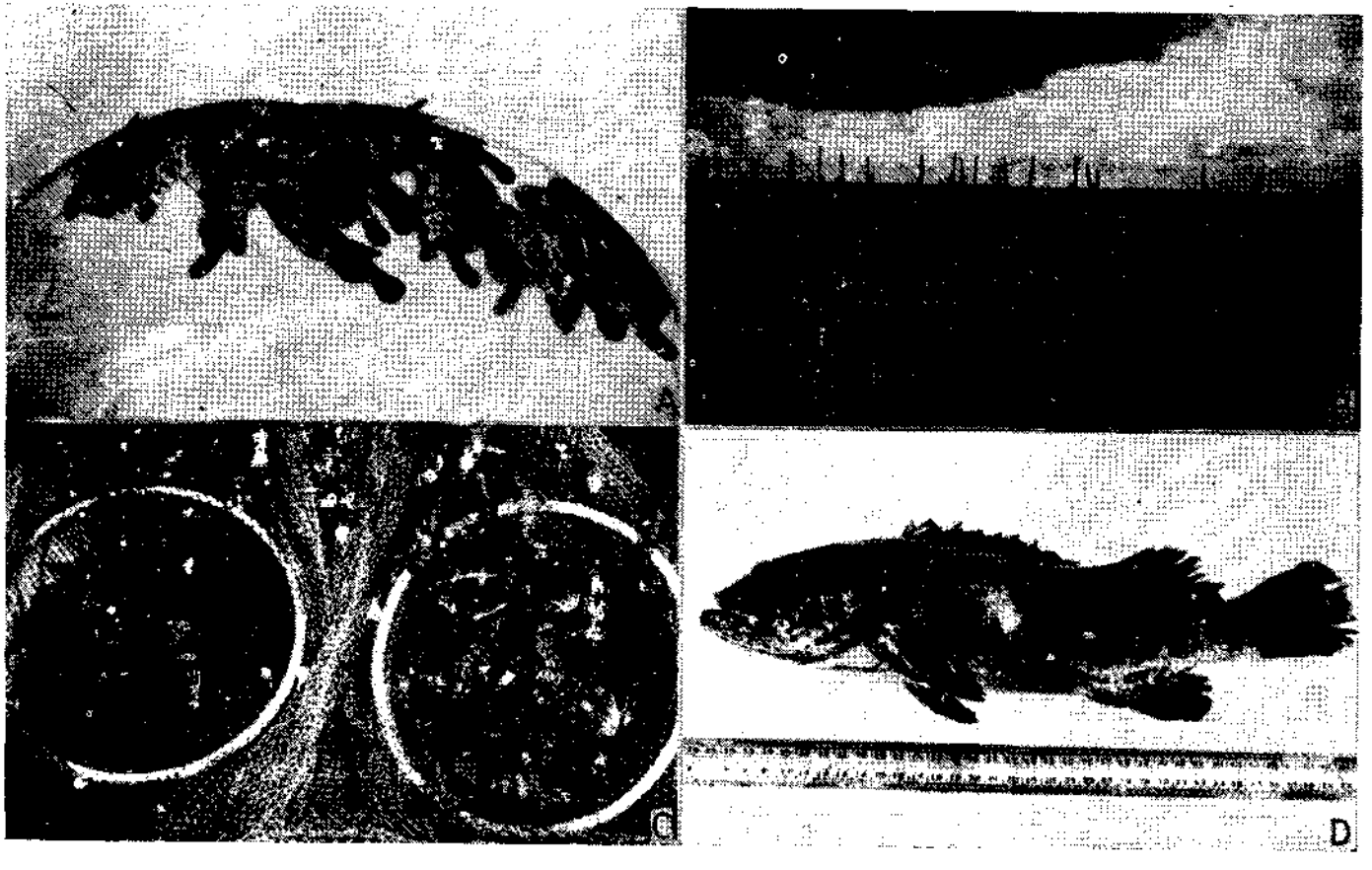

PLATE I A. Juveniles of the grouper *Epinephelus tauvina*, B. Fixed net cage in the sea, C. A portion of harvested *E. tauvina* and D. *E. tauvina* at harvest.

average stocking size of 184 mm and average weight of 92 g with growth rate of 16.4 mm and 61.9 g per month (Table 1). In experiment 2 the fish have grown from 179 mm and 102 g to 265 mm and 288 g at the rate of 16.1 mm and 34.8 g/month in a duration of 163 days (Table 1) and the growth in experiment 3 was from 190 mm and 97 g to 335 mm and 521 g at the rate of 17.1 mm and 50.1 g/month in 258 days (Table 1), whereas in experiment 4 the growth was from 139 mm and 42.5 g to 295 mm and 410 g in 307 days at the growth rate of 15.5 mm and 63.5 g/ month (Table 1). The survival was 97%, 92%, 90% and 79.1% in these 4 experiments respectively.

TABLE 1. *Growth in length and weight of* Epinephelus tauvina *reared in fixed net cages for different duration of time at Mandapam during* 1984

Experimental Cages	Duration of Expt. (months)	Growth increment in mm	Growth rate mm/month	Growth increment in g	Growth rate g/month
1 ..	10.95	179.0	16.4	678.0	61.9
2 ..	5.34	86.0	16.1	186.0	34.8
3 ..	8.46	145.0	17.1	424.0	50.1
4 ..	10.07	156.0	15.5	367.5	36.5
Mean ..	8.71	141.5	16.3	413.9	47.5

The data on the mean length at starting of the culture experiment (L_1), at harvesting (L_2) and growth increment (mm/day) were subjected to further analysis to obtain the asymptotic growth $L\infty$ as per the method of Gulland and Holt (1959) and the growth constant K from the relation $K = \frac{y}{(L\infty - \bar{x})}$ and the results are shown in Table 6. The $L\infty$ is estimated to be 671 mm and the growth constant K 0.4557. In addition to this the average length $\bar{L}$ and growth rate were regressed to obtain 4 sets of growth parameters $L\infty$ and K. Another set of $L\infty$ and K were obtained from the average $\bar{L}$ and growth rate as shown in Table 3. All these estimates were summarised in Table 4 to obtain the average values of different parameters as detailed below.

Assuming in nature that the survival is one per cent among the population of this grouper when they attain a length of $L\infty - 0.5$ cm, the T_{max} is obtained using

$$\frac{Ln\left(1 - \frac{L\infty - 0.5}{L\infty}\right)}{-K} = t - t_0$$

and employing the relation $N_t/N_0 = 0.01 = e^{-MT}$ an estimate of natural mortality 'M' is arrived at as per the example $L\infty$ 692, K 0.4739.

$$T_{max} = \frac{Ln\left(1 - \frac{687}{692}\right)}{-0.4739} = 10.4 \text{ yrs.}$$

$N_{11}/N_0 = 0.01 = e^{-10.4M}$ and $M = 0.4428$ at 1% survival. The mean length at entry (L_r) into the culture experiment 1 is 194 mm and the age is 0.6522 yr. For this study the age at 0 length *i.e.* t_0 is taken as 0 as t_0 is always close to 0 in most cases. The optimum age of exploitation t_y and the potential yield per recruit Y' have been estimated as per Krishnan Kutty and Qasim (1968). The asymptic growth

in weight Wcc have been estimated from the length weight relationship equation :

Log W = — 4.5817 + 2.9130 Log L wherein the length in mm and weight in g (Table 4).

$L_t = 671\ [1-e^{-3\,4619\ (t+t_o)}]$ wherein t_o is assumed to be zero. The growth curve obtained from the estimated values as per the above said equation is given in Fig. 1 wherein the length at recruitment into the

TABLE 2. *Length at starting of culture experiment (L_1), length at termination of the experiment (L_2), average length (L) and growth rate of* Epinephelus tauvina *reared in fixed net cages. The asymptotic growth L_∞ is estimated to be 671 mm by regressing L on the growth rate as per Gulland and Holt* (1959). *The estimates of K were obtained from the relation*

Experimental Cages	L_1 (mm)	L_2 (mm)	$\bar{L}$ (mm) $\bar{X}$	Duration (days) $\bar{Y}$	Growth rate in mm/day	K (Annual)
1 ..	184	363	273.5	334	0.5359	0.4921
2 ..	179	265	222.0	163	0.5276	0.4289
3 ..	190	335	262.5	258	0.5620	0.5022
4 ..	139	295	217.0	307	0.5081	0.4085
Mean ..	173	314.5	243.75	265.5	0.5334	0.4557

TABLE 3. *Estimates of L_∞ and K from the average length ($\bar{L}$) and average growth rate taken from 4 experiments.*

Experimental Cages	Average length $\bar{L}$ in mm	Average growth rate mm/day	L^∞ (mm)	K (annual)
1 ..	279.4	0.5352		0.5669
2 ..	228.7	0.5275		0.4871
			624	
3 ..	258.4	0.5744		0.5735
4 ..	220.0	0.5059		0.4571
Mean ..	246.1	0.5348		0.5165

The average of all these parameters obtained from the 4 experiments have been taken as the reliable estimate and based on this the growth of *E. tauvina* may be expressed as per von Bertalanffy growth equation as followed :

culture system *i.e.* L_r 173 mm and the age t_r 0.6470 year are indicated along with the optimum age of harvesting *i.e.* t_y 3.0 years and the length L_y 507 mm. This is to say that the *E. tauvina* measuring 173 mm aged

8 months and weighing 87 g may be reared to attain a length of 507 mm and weight of 2.0 kg in 28 months. It is desirable to harvest this species when they are 3.0 years old as the yield per recruit of this species estimated to be the highest at this stage, *i.e.* 703 g and this tends to decline in ages either higher or lower than 3.0 years.

Table 4. *Estimates of various parameters obtained from the net cage culture experiments*

Parameters		Expt. 1	Expt. 2	Expt. 3	Expt. 4	Data from Table 6	Data from Table 7	Average
L_∞ (mm)	..	692	675	687	674	671	624	671
K (Annual)	..	0.4739	0.4314	0.4869	0.4068	0.4557	0.5165	0.4619
T_{max} (yr.)	..	10.4	11.4	10.1	12.1	10.8	9.4	10.7
M1% (survival)	..	0.4428	0.4040	0.4560	0.3806	0.4264	0.4899	0.4333
tr (yr)	..	0.6522	0.7143	0.6649	0.5677	0.6543	0.6286	0.6470
ty (yr)	..	2.9865	3.2768	2.9031	3.4766	3.1034	2.7181	3.0774
Ly (mm)	..	524	511	520	510	508	471	507
Wy (g)	..	2,186	2,032	2,138	2,020	1,998	1,603	1,996
Y' (g)	..	778	721	770	668	703	575	703
W_∞/(g)	..	4,915	4,572	4,812	4,552	4,493	3,636	4,497

Yaman (1982) reported a growth of 0.6 kg per fish in 10-12 months in the case of grouper (*Epinephelus* spp.) fed extraneously with trash fish. Lee (1982) recorded the growth in *Epinephelus tauvina* from 100 g to 600-800 g in 6-8 months in net cages floated in Singapore coastal waters. Lanjumin (1982) obtained a growth of 600-700 g/fish from 150-200 g in 5-6 months in *E. tauvina* cultured in the floating net cages in Indonesian coastal waters. In the present study, the growth rate of *E. tauvina* cultured in fixed net cages in Indian conditions is significant and comparable with elsewhere.

At Mandapam (Gulf of Mannar) the culture period could not be extended beyond 11 months as the culture cages are exposed to the fury of strong southwest monsoon wind from June to September every year. A part of the net cages and supporting wooden structruers were uprooted during this study. In order to extend the culture period, two alternatives are available (*a*) artificial breakwater may be provided to protect the cages from wind and wave action during monsoon or (*b*) cage culture may be carried out in relatively calm area. Otherwise this work can be carried out only during October to April at Mndapam and during monsoon period intensive seed collection work may be carried out in addition to the preparatory work for the ensuing season for cage culture.

The other problem is the settlement of fouling organisms on the net cages and wooden structures. The net cages suspended in the coastal waters of the Gulf of Mannar were found infested mostly by algae and smaller bivalve molluscs. The casuarina poles on the other hand had only barnacles as foulers. The cages and other supporting structures were periodically cleaned to control the fouling organisms. The problems of fouling in cage fish culture have been discussed in detail by Milne (1972, 1979).

The economics of rearing *Epinephelus tauvina* in a fixed net cage worked out is given in

Table 5. The operational cost of a single cage of 5 × 5 × 2 m size was Rs. 3,750 and the value of fish harvested in a crop was Rs. 5,760. The net profit out of a single harvest after a period of eleven months was Rs. 2,010. The method is simple and economically viable and can be easily adopted by the fish farmers. When the culture period is extended to 28 months instead of 11 months, the total expenditure is Rs. 6,455, gross income is 14,400 and the net income is Rs. 7,945 which works out to an annual income of Rs. 3,405 against Rs. 2,193 per annum of 11 months.

TABLE 5. *Estimated cost and return outlay of a single 5 × 5 × 2 m fixed net cage for a culture period of 11 months presenty employed and proposed culture period of 28 months*

	Culture period 11 months	Culture period 28 months
A. Operational expenses :	Rs.	Rs.
Cost of palmyrah poles (8 Nos.) ..	200	200
Cost of net material including fabrication charges ..	1,500	1,500
Cage installation charges ..	100	100
Cost of Seeds 400 Nos @ Rs. 0.5/seed ..	200	200
Cost of feed (Trash fish) ..	650	1,655
Labour charges for feeding and maintenance ..	1,100	2,800
Total ..	3,750	6,455
B. Gross Income :		
Sale of 360 Nos. (assuming a survival rate of 90%) of marketable fish weighing 750-800 g each @ Rs. 20 per kg (after 11 months) ..	5,760	—
Sales of 360 Nos. of fish weighing 2.0 kg each @ Rs. 20 kg (after 28 months).	—	14,400
C. Net Income ..	2,010	7,945
D. Net Income per annum ..	2,193	3,405

From the recent findings it is evident that the fishes of *Epinephelus tauvina* are highly suitable for cage culture as their growth and survival rates are found to be good. The availability of grouper seeds also indicates the possibility of planning and developing cage culture into a viable small-scale commercial farming in the cosatal areas around Mandapam where the young groupers occur in fairly good numbers.

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EFFECTS OF DIFFERENT PHOTOPERIODS ON DIATOMS *THALASSIOSIRA FLUVIATILIS* AND *SKELETONEMA COSTATUM*

ABSTRACT

Effects of different photoperiods on growth of *Thalassiosira fluviatilis* and *Skeletonema costatum* revealed that both the species preferred longer duration of light for their maximum growth. The growth of *T. fluviatilis* was higher than that of *S. costatum* in different photoperiods. In *T. fluviatilis* maximum growth was observed at continuous light (24 hrs) and in *S. costatum* at 20.4 LD cycles. Short term exposure to light like 8 and 6 hrs did not enhance good growth in both the species.

LIGHT is one of the significant physical parameter that controls the productivity of the aquatic ecosystem and responsible for the temporal variability in local production. The neritic species might be adapted to utilize the light that occurs for only short periods of time (Harris and Piceinin, 1977). Studies on the effects of photoperiod on unicellular algae have been made by Paasche (1967, 1968), Hobson (1974), Admirral (1977), Nelson and Brand (1979), Chisolm and Brand (1981) and Brand and Guillard (1981). The present work deals with the effects of various photoperiods on growth of two centric diatoms *Thalassiosira fluviatilis* and *Skeletonema costatum*.

Material and methods

Thalassiosira fluviatilis and *Skeletonema costatum* were isolated by single cell isolation method from phytoplankton samples collected from the mouth region of the Vellar Estuary (11°29'N; 79°49'E). Unialgal culture of *T. fluviatilis* and *S. costatum* was grown in F/2 medium (Guillard and Ryther, 1962) under 3000 lx continuous light at 30‰ (Temp) 28±2°C, pH 7±0.5). During preliminary study, 3000 lx light intensity was found to promote maximum growth of *T. fluviatilis* and *S. costatum*. The different durations were determined by running the experiments at various exposure periods to light.

Exponentially growing cultures were inoculated in 100 ml of F/2 medium and subjected to 24, 20, 16, 12, 8 and 6 hrs light of 3000 lx intensity for a period of 3 weeks with a subculturing schedule once in five days to fresh medium. After three weeks, aliquotes of the cultures were inoculated in duplicates to experimental flasks having 100 ml medium and incubated at various photoperiod as given above for one week. Growth rate was determined using Guillard's (1973) formula of

$$K = \frac{\log_2 (N_1/N_0)}{t_1 - t_0}$$

Where K = divisions/day, N_1 and N_0 are cell concentration at the end and beginning of a period of time $t_1 - t_0$ days.

Results

The effects of different photoperiods on growth of *T. fluviatilis* and *S. costatum* is shown in Fig. 1. Both the species showed highest division rates at continuous light (24 hrs). *T. fluviatilis* exhibited higher division rate than *S. costatum*. *T. fluviatilis* showed low division rate at 6 : 18 Light : Dark (LD) cycle and it represented 49% of the final yield obtained at continuous light. At 16 : 8 and 12:12 LD cycles, there was not much significant variation observed in growth rate. *S. costatum* showed maximum division rate at 24 hr exposure and it decreased in lower incubation period. The final yield increased at 20 : 4 LD cycle by 3.2% over the cell number obtained at continuous light and it decreased to 85.7, 77.9, 82.6 and 79.4% to that of 24 hrs. exposure at 16, 12, 8 and 6 hr incubation period respectively.

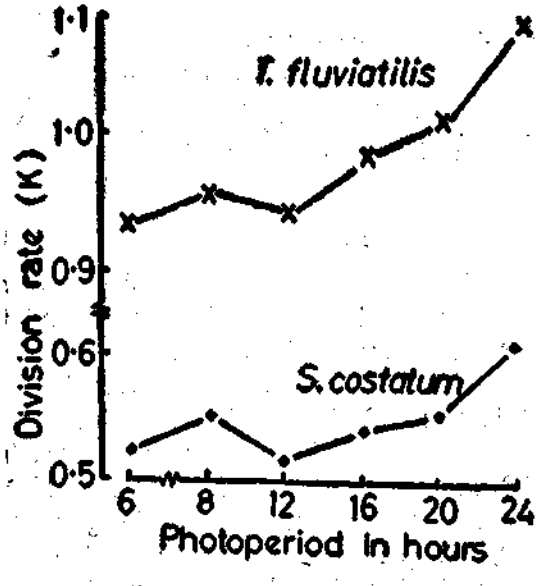

FIG. 1. Effects of various photoperiods on division rate of *T. fluviatilis* and *S. costatum*.

Discussion

In the present investigation, since the inocula were taken from culture grown previously in continuous light, erratic results were obtained at first when the culture was incubated at various photoperiods. But after nearly 10-18 generations had passed in 3 weeks duration the cell counts taken in the two series of experiments were found to be closely similar. In *T. fluviatilis* the division rate differed significantly in different photoperiods. In *S. costatum* except in continuous light, light and dark cycle did not cause much variation in the division rate. In general, both the species were found to grow at their maximum when incubated in longer duration of light. The present result could be compared with that of Brand and Guillard's (1981), where *Asterionella glacialis*, *Ceratium candelabrum*, *Gonyaulax polydera*, *Hymenomonas carterae* and *T. pseudonana* reproduced more rapidly in continuous light than in the light and dark cycles. *Bacteriastrum delicatulum*, *Biddulphia* sp., *Corethron criptulum*, *Cyclocoolithina leptopora*, *Ditylum brightwellii*, *Helmaulans hauckii*, *Streptotheca tamnis* and *Thalassiosira* sp. grow exponentially in 14 : 10 LD regime (Brand and Guillard, 1981). In *S. costatum* though the cell division was highest at continuous light, maximum cell density occurred at 20 : 4 LD cycle. This suggest that

S. costatum needs a few hours of darkness for maximum growth.

In coastal and adjacent water bodies, the photosynthetic light duration is an unpredictable one. The phytoplankton of these habitats should be adapted to utilise with its maximum efficiency, the light available at short duration. The present investigation suggests that *S. costatum* and *T. fluviatilis* are adapted to variations in photoperiod.

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DISEASES OF CHAETOGNATHS FROM THE ARABIAN SEA

ABSTRACT

Three different diseases, provisionally assigned as spot disease, swell disease and tail rot disease, were observed in chaetognaths *Sagitta enflata* Grassi and *S. bedotti* Bernaneck. The first two diseases showed high percentage of occurrence. The spot disease is caused by fungi and the tail disease is by bacteria. The cause of swell disease is not yet known. The present report on the disease of chaetognaths is recorded for the first time from the Arbian Sea.

KNOWLEDGE on the diseases of chaetognaths is very limited (Nagasawa and Marumo, 1984 ; Nagasawa and Nemoto, 1984). Nevertheless, studies on the diseases of fishes, decapod crustaceans and bivalves were made owing to the economic importance and hence information are available. However, general reviews on the parasites of chaetognaths (Hyman, 1959 ; Alvarino, 1964 ; Ghirardelli, 1969) contained no information about the diseases. Santhakumari (1986) recorded a ciliate parasite from Indian Coast. According to Kinne (1980) no marine organism seems to be completely free from potential disease agents and animals belonging to all systematic groups contain members which can act as agent or host.

Chaetognaths are important in the sense that they are exclusively carnivores and are the abundant group of the plankton community in the sea. *Sagitta enflata* and *S. bedotti* are the common species occur in large numbers in the coastal waters of India (Nair, 1972).

So far no work has been reported on the diseases of chaetognaths from Indian waters so the present report is worth recording.

Zooplankton samples were collected with Bongo net of 0.5 m mesh size and preserved in 4% formaldehyde solution in sea water. Chaetognaths were examined under the binocular microscope. Chaetognaths having diseases were separated and examined in detail.

A preliminary report is given here on three diseases, temporarily assigned as spot disease, swell disease and tail disease. Nagasawa and Nemoto (1984) described the tail disease.

Spot disease

The most common disease among two chaetognath species was the spot disease. The spots were almost round in shape and brownish in colour. The spots were found all over the body (Pl. I A). The spots were caused by the fungi. This infection was noticed both in *S. enflata* and *S. bedotti*. 12 per cent infection was noticed in this set of collection.

Swell disease

Certain areas of the body surface was projected outwards. These projections got enlarged and in many cases these were found in ruptured condition. The muscles were distorted as shown in Pl. I B. Upto 5 such swell areas were observed in a single specimen. This disease apparently seems to cause death of the animal. This disease was also noticed in both the species, but not as frequent as the spot disease. Instances of this disease was more pronounced in *S. bedotti*. The percentage of infestation was found to be 4.8.

Tail disease

A portion of the tail of some of *S. enflata* specimens were found to be opaque. Incidence of this disease was very low compared to the other two diseases. Nagasawa and marumo (1984) described it as bacterial disease from Japan waters. She observed that the bacteria infected specimens died within 24 days.

Observation on live material in the laboratory will be carried out in future and the details will be known about the exact cause of all these diseases.

The author is thankful to the Director, National Institute of Oceanography, Dona Paula, Goa for providing facilities.

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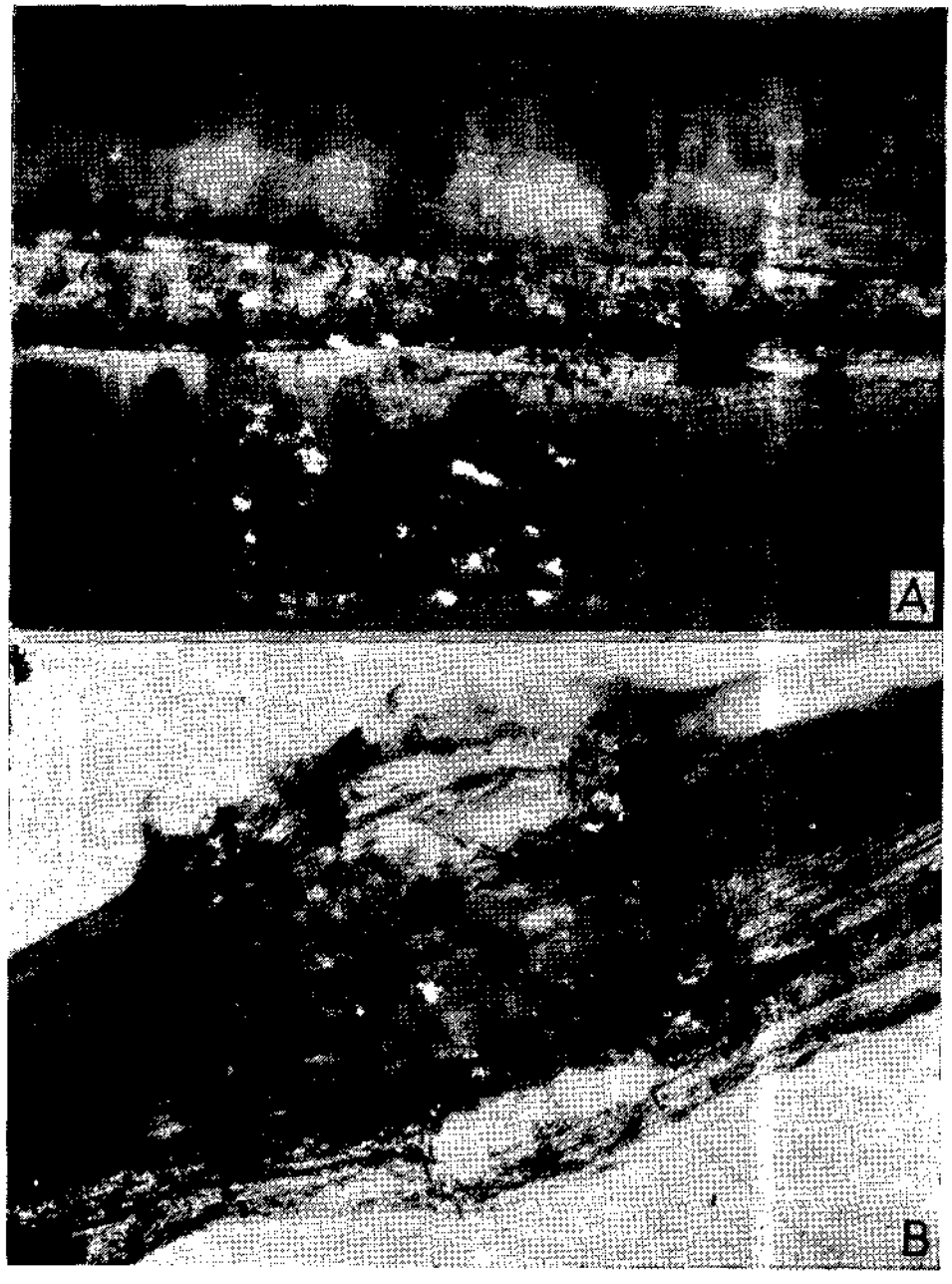

PLATE I A. Spot disease of *S. enflata* and B. Swell disease of *S. bedotti*.

GROWTH PERFORMANCE OF *RHIZOPHORA MUCRONATA* IN FIELD AND LABORATORY CONDITIONS

ABSTRACT

Large scale mangrove plantations are undertaken for the west coast of Maharashtra State in India. The attempts are being made for the first time and base line data for successful afforestation programme is not available. Therefore, to generate necessary scientific data, present study was undertaken. The species used is *Rhizophora mucronata*. It is found that the survival percentage is more under fresh water conditions. However, the growth measured in terms of height is more under field conditions. This is attributed to the altitudinal difference. However, survival/mortality is a direct effect of salinity.

THE GLOBAL status of mangrove ecosystem was reported to be endangered (Pannier, 1979). These ecosystems in last decade suffered from lot of human pressure. Pannier (1979) emphasized the conservation of mangroves as an 'urgent need'. In India, especially, mangroves face extensive human interferences. The mangroves along the coast of Maharashtra State are under constant stress due to human activities, large areas have become devoid of mangroves. So as to change this situation steps are being taken to afforest the barren mangrove areas (Social forestry reports). However, for this kind of afforestation necessary information is not available. From this point of view present study was undertaken.

Rhizophora mucronata (Lamk.) is a common species of this area. It is an important species for afforestation programme. The regeneration of this species under laboratory conditions is studied by Bhosale (1978, 1985). However, a study on its growth under fresh water and field conditions was lacking.

Material and methods

The experiment started on 5th June 1987 in a view of celebrating the world Environment day. It was a joint effort of Social Forestry Department, Ratnagiri and the mangrove group of Shivaji University, Kolhapur. Nearly twenty thousand propagules of *R. mucronata* were planted directly in the field at a distance of 1 m. The location was Shirgaon area near Ratnagiri city. This area had some plantations of previous year (1986) also. The observations were continued on growth performance after plantation by social forestry.

Another site of direct plantation with *R. mucronata* propagules is along Kalbadevi Estuary, planted in June 1988 by Social forestry group. The nursary was raised at Kolhapur in June 1987 and 1988. The growth performance of the seedlings is given in Tables 1 to 5.

Results and discussion

The study was carried out by belt transect method. At Shirgaon two belts are considered with three rows in each belt. The Table 1 gives the performance of seedlings planted directly in the field in June 1986. In the Ist belt, total seedlings considered were 66 (sample size) while in IInd there were 60. The monthly observations on seedling survival and height above collar were recorded. The survival was 91 to 92% in November 1987. However, in December 1988 it was found declined to 63 to 74%. It indicates

that even after one year growth, there can be mortality.

The height above collar is 33.95 cm in November 1987 which in November 1988 reached upto 63.74 and 59.5 cm in two belts respectively. In December 1988 it reaches to 66 and 61 cm respectively. In the month of December 1988 the number of primary and secondary branches was recorded. In both transects the record of average number of primary branches per plant is 7 while secondary branches are 5 in Ist belt and 6 in the IInd one. In September 1988, flower buds were recorded for the Ist time after plantation (more than two years). In December 1988 15.03% plants (from two belts) were found with flower buds, while the prop roots were recorded in 45.08% plants. The observation on flowering and prop root formation indicates that two-year old *R. mucronata* seedlings can be taken as mature plant. The area where these propagules were planted in muddy with fine textured soil and receives daily tidal water. Hordjowigeno (1986) has reported that *Rhizophora* is found in muddy soil. This may be the reason why the seedlings at this place show better growth.

In 1987, additional area was covered for plantation at Shirgaon. The total area under plantation is 15 ha. Table 2 depicts the results recorded for plantations of 1987. In this case the two belts with 285 and 213 seedlings in each belt were considered. In November 1987 the survival was 75 and 76% while in November 1988 it is lowered down to 23 to 30%. The mortality is observed where soil has hard and tidal flow is restricted.

TABLE 1. *Growth performance of* R. mucronata *propagules after direct plantation in the field in June* 1986

	Belt	Nov. '87	Dec. '87	Jun. '88	Nov. '88	Dec. '88
Sample size ..	I	66	66	66	66	66
	II	60	60	60	60	60
Living seedlings ..	I	61	60	60	49	49
	II	55	55	54	40	38
Survival % ..	I	92.42	90.90	90.90	74.24	74.24
	II	91.66	91.66	90.00	66.67	63.33
Mortality % ..	I	7.58	9.10	9.10	25.76	25.76
	II	8.34	8.34	10.00	36.33	36.67
Height above collar (cm) ..	I	33.95	37.84	51.30	63.74	66.47
	II	33.94	39.09	51.63	59.55	61.23

The height above collar recorded was 19.73 cm and 16.53 cm in November 1987 while in November 1988 it reached upto 38.44 and 30.36 cm. In December 1988, the height reached 39.94 and 32.56 cm respectively. Average number of branches recorded in two belts is 4 and 3 while total number of leaves are 18 and number of scars are 24 in each belt. In these belts branching is observed from the collar.

The growth performance of *R. mucronata* under the nursery condition is given in Table 3. The survival is more than that in the field (1987). The survival percentage decreased from 67 and 69% (June 1988) to 23 to 30% (November 1988) under field conditions while in nursery the decrease is upto 63 and 60%.

The plantation area is 13 ha along Kalbadevi Estuary (June 1988). The total number of propagules planted was 32,500. Four belts with 75 seedlings in each were considered. The belt I is towards main stream while IV is away from stream (Landward side). Here the belts are right angle to tide direction. The results recorded in Table 4. The survival percentage varied from 77.33 to 97.34. The height above collar recorded in August 1988 ranges from 19.85 to 30.47 cm. It increased in December 1988 to 37.07 cm as lowest and 48.46 cm as highest average record. The average number of leaves in three belts are 6 while in IVth belt number of leaves are 8. The leaf scars in all belts are 6 in number.

TABLE 2. *Growth performance of* R. mucronata *propagules after direct plantation in the field in June* 1987

	Belt	Nov. '87	Dec. '87	Jun. '88	Nov. '88	Dec. '88
Sample size ..	I	285	285	285	285	285
	II	213	213	213	213	213
Living seedlings ..	I	216	216	193	68	67
	II	164	164	149	64	63
Survival % ..	I	75.79	75.08	67.72	23.86	23.50
	II	76.99	76.99	69.48	30.04	29.57
Mortality % ..	I	24.21	24.92	32.28	76.14	76.50
	II	23.01	23.01	30.52	69.96	70.43
Height above collar (cm) ..	I	19.73	22.15	26.87	38.44	39.94
	II	16.53	17.69	21.14	30.36	32.56

TABLE 3. *Growth performance of* R. mucronata *propagules under nursery condition (Plantation June* 1987)

	Nov. 1987	Dec. 1987	Jun. 1988	Dec. 1988
Total propagules ..	30	30	30	30
Living seedlings ..	28	28	19	18
Survival % ..	99.33	99.33	63.33	60.00
Mortality % ..	6.67	6.67	36.77	40.00
Height above collar (cm) ..	21.85	24.96	27.29	30.04

Simultaneous experiment with sample size and living seedlings 20, was run under laboratory conditions. The propagules were planted in June 1988. Under nursery conditions all the seedlings are living upto December 1988 in which the height above collar increased from 4.76 (Aug.) to 9.91 (Sep.), 14.00 (Oct.) 18.83 cm in December 1988.

From Table 4 it is clear that under field conditions initial growth above collar is fast upto August. However, the rate of further growth measured in terms of height is low as compared to garden conditions. Further, it should be noted that the plants under laboratory conditions are at 667 m from MSL. Therefore, the difference in height may be attributed to altitudinal difference. However, survival/mortality may be a direct result of salinity. The effect of salt on mangroves is reported to adverse (Shinde, 1981;

Adrini, 1958 ; Henckel, 1973 ; Bosale *et al.*, 1983). Further, Henckel (1963) has pointed out that vivipary in Rhizophoraceae itself is an adptative features for escape of seed from the hazardous effect of salt. The salt tolerance is slowly acquired during the ontogeny (Henckel, 1963 ; Joshi *et al.*, 1972 ; Lotschert and Liemann, 1967). In the present study it is found that leaf fall is greater under salinity conditions than under fresh water. This supports our view that salinity is responsible for higher mortality under field conditions.

TABLE 4. *Growth performance of* R. mucronata *under field trials by direct plantation in the field in June* 1988

	Belt	Aug.	Sep.	Oct.	Nov.	Dec. 1988
Living seedlings ..	I	64	64	63	58	58
	II	73	63	62	59	58
	III	74	69	67	66	66
	IV	74	74	74	74	73
Survival % ..	I	85.34	85.34	84.00	77.33	77.33
	II	97.34	84.00	82.66	78.67	77.33
	III	98.67	92.00	89.33	88.00	88.00
	IV	98.67	98.67	98.67	98.67	97.34
Height above Collar (cm) ..	I	19.85	29.68	31.31	34.34	37.07
	II	24.66	35.87	39.74	44.38	46.28
	III	28.62	39.45	42.40	46.20	48.18
	IV	30.47	40.33	43.62	46.85	49.46

Sample size 75 propagules per belt.

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ON THE OCCURRENCE OF A LARVACEAN TUNICATE (UROCHORDATA) IN THE MANGROVE WATERS OF HOOGHLY ESTUARY, INDIA

ABSTRACT

A larvacean tunicate is recorded for the first time from the mangrove waters of Sundarbans. Salient diagnostic features of the tunicate are illustrated and hydrological parameters of the habitat are elucidated.

ON 27TH NOVEMBER 1986, 200 specimens of larvacean tunicate were collected during the plankton sampling in the Saptamukhi River (21°43'N to 21°46'N and 88°18'E to 88°19'E) on board *R.V. Sagarputra* of Calcutta University. It was for the first time that a larvacean tunicate was recorded and recognised in the Hooghly Estuary, the western part of the Sundarbans. Later on these planktonic tunicates were obtained frequently throughout the year, but few in number. Saptamukhi River is one of the seven tributaries of the River Ganges. It expreiences tidal influx twice daily with a maximum highest high tide of 5 metres. The southern mouth of the river faces the Bay of Bengal.

The conical net of bolting silk (0.5 m diameter) of 0.0695 mm aperture was used for plankton collection. The tunicates were sorted out under a binocular, fixed in 4% buffered formaldehyde and some of them after proper dehydration, stained with eosin and mounted with D.P.X. for permanent slides. Drawings were made with the help of a camera lucida.

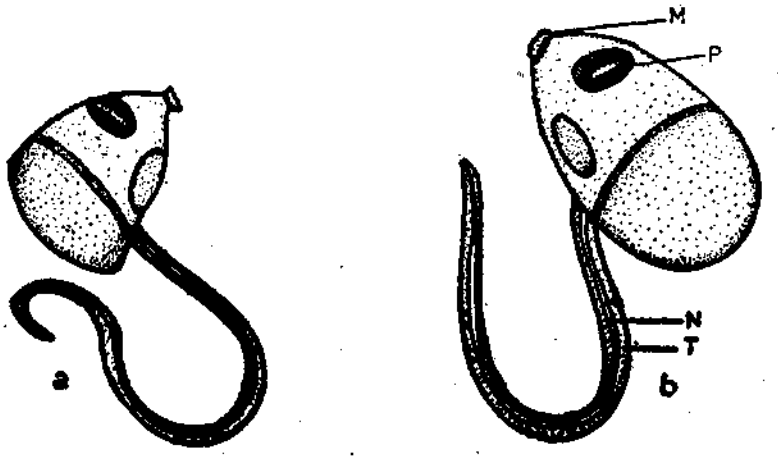

FIG. 1. A tunicate larvacean from Hooghly Estuary (X 40). (M = Mouth, N = Notochord, P = Pharyngeal opening and T = Tail).

Hydrological parameters (Salinity, D.O., pH) of the habitat water were analysed by the method of Strickland and Parson (1969).

The authors are indebted to S. D. Marine Biological Research Institute, Sagar Island and Department of Marine Science, Calcutta University for laboratory and infrastructural

facilities. Financial support from D.S.T. and DOEn, New Delhi is thankfully acknowledged.

Description and discussion

The Hoogly Estuary experiences three pronounced seasons throughout the year. The premonsoon (March to June) is the dry season with occasionally high temperature. The monsoon season (July to October) receives heavy rainfall and the postmonsoon (November to February) comprises partly of the winter season with comparatively lower temperature and lesser precipitation. It has been found that the number of larvacean found in Saptamukhi River increases during the postmonsoon period when the salinity of the surrounding water mass becomes more than 20‰.

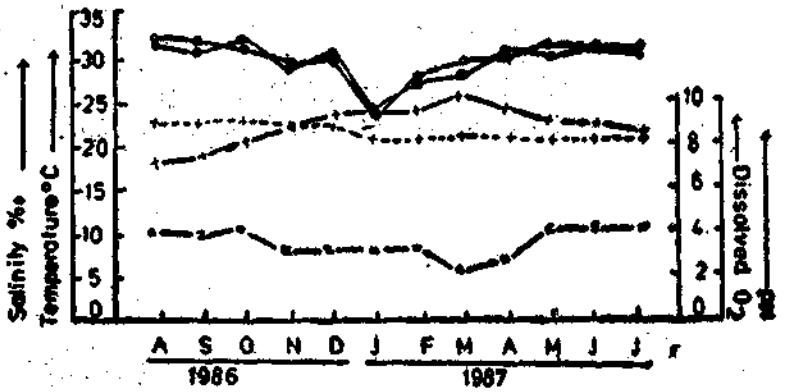

Fig. 2. Hydrology of the habitat water (○ ——— ○ Water temperature, + ——— + salinity, +– – – – + pH, ●——● Air temperature and = ——— = dissolved oxygen).

Members of appendicularia found in Hoogly-Matla estuarine complex possess the following salient features :

These are transparent free swimming planktonic tunicates measuring 0.5 mm to 0.8 mm long (except the tail) ; the body is enclosed in a transparent oval house secreted by the epithelium, but most of the fixed materials are devoid of covering ; a long tail centrally supported by notochord originates from the ventral part of the body ; papilated mouth mid is located at the anterior end ; the intenstine opens directly to the outside ventrally ; the anterior end of the body is narrower than the posterior (Fig. 1 a, b). There are only two pharyngeal clefts one on each dorsolateral side of the anterior end and each opens directly to the exterior.

The appendicularians are the most specialised of all tunicates, belonging to the class larvacea of the Subphylum Urochordata and phylum chordata. The class larvacea contains 70 species grouped in 13 genera and 3 families. These are found in the surface marine plankton throughout the world. These are adult and neotenic forms retaining most of the larval tunicate characters. Members of the appendicularia found in the Hoogly-Matla estuarine complex are very close to the members of the family Oikopleuridae. Further work to determine their generic and specific status are in progress.

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DISTRIBUTION OF CHAETOGNATHA OFF QUEEN MAUD LAND, ANTARCTICA

ABSTRACT

Chaetognaths from the zooplankton samples collected during the third Indian Scientific Expedition to Antarctica (1983-84) between the latitude 67°30′S and 68°30′S and longitudes 14°00′E and 20°00′E off Queen Maud Land, outside the pack ice were studied. This investigation revealed the occurrence of *Eukrohnia fowleri*, *E. hamata*, *Sagitta gazellae* and *S. tasmanica*. Among these four species, *E. hamata* formed 93% of the total chaetognaths. The numerical abundance of chaetognaths from the stations located in the southern, middle and northern latitudinal grids was studied and the spatial distribution of the species was reported.

THE DISTRIBUTION of chaetognaths of the Southern Ocean was extensively studied by David (1955, 1958, 1965). Further, the chaetognaths from the Antarctic Ocean were reported earlier by Ritter-Zahony (1911), Burfield (1930) and recently by Alvarino *et al.* (1983 a, b), Hagen (1985), Kapp and Hagen (1985), Hagen and Kapp (1986) and Srinivasan and Mathew (1988). Altogether 14 species of the genera *Eukrohnia* (*E. bathyantarctica* David 1958, *E. bathypelagica* Alvarino 1962, *E. fowleri* Ritter-Zahony 1909, *E. hamata* (Moebius 1875) *Heterokrohnia* (*H. fragilis* Kapp and Hagen 1985, *H. longicaudata* Hagen and Kapp 1986, *H. longidentata* Kapp and Hagen 1985, *H. mirabilis* Ritter-Zahony 1911) and *Sagitta* (*S. gazellae* Ritter-Zahony 1909, *S. macrocephala* Fowler 1905, *S. marri* David 1956 *S. maxima* (Conant 1896), *S. planctonis*, Steinhaus 1896, *S. tasmanica* Thomson 1947) are so far known from the Antarctic waters.

The aim of this study is to examine the chaetognaths off Queen Maud Land and study the spatial distribution of the species involved based on the samples collected from 21 stations.

Material and methods

The material for this study was collected by the second author during the Third Indian Scientific Expedition to Antarctica, from 21 stations located between 67°30′S and 68°30′S and 14°00′E and 20°00′E off Queen Maud Land, Antarctica. The zooplankton samples were collected as open oblique hauls from 100 m to surface with a 60 cm mouth diameter Bongo net having a mesh size of 0.4 mm. A TSK flow meter was attached to the net for estimating the quantity of water filtered. The samples were preserved in 4% neutralised formaldehyde. The volume of the zooplankton was determined by displacement method as followed by Mathew (1986). The chaeto-

gnaths from the entire samples were sorted out, identified, numerically counted and standardised for 1,000 m^3 of water filtered. The details of the sampling stations are given in Table 1.

TABLE 1. *Details of the zooplankton sampling stations*

Station No.	Date	Time Hrs.	Position		Station Depth (m)	Zoopln. cc/1000 m^3	Chaetognaths/ 1000m^3
			Lat. °S	Long. °E			
1	2-3-1984	1100	68°30′	14°00′	3528	20.95	446
2	2-3-1984	1730	68°30′	15°00′	3739	36.53	240
3	2-3-1984	2030	68°30′	16°00′	3484	38.49	126
4	2-3-1984	2340	68°30′	17°00′	3710	185.13	528
5	3-3-1984	0240	68°30′	18°00′	3982	96.12	784
6	3-3-1984	0600	68°30′	19°00′	4163	25.42	18
7	3-3-1984	1335	68°30′	20°00′	3801	41.29	15
8	3-3-1984	1645	68°00′	20°00′	4072	63.44	95
9	3-3-1984	1855	68°00′	19°00′	4163	45.51	92
10	3-3-1984	2140	68°00′	18°00′	4163	107.85	656
11	4-3-1984	0045	68°00′	17°00′	3891	216.35	154
12	4-3-1984	0445	68°00′	16°00′	3800	91.66	122
13	4-3-1984	0800	68°00′	15°00′	3759	134.91	17
14	4-3-1984	1100	68°00′	14°00′	3077	116.53	224
15	4-3-1984	1515	67°30′	14°00′	3352	142.15	433
16	4-3-1984	1730	67°30′	15°00′	2996	248.83	929
17	4-3-1984	2000	67°30′	16°00′	4072	54.57	231
18	4-3-1984	2230	67°30′	17°00′	4525	119.35	115
19	5-3-1984	0100	67°30′	18°00′	4344	188.69	100
20	5-3-1984	0400	67°30′	19°00′	4549	32.30	16
21	5-3-1984	0655	67°30′	20°00′	4254	74.62	19

Results and discussion

The average zooplankton biomass from the investigated area was 99.8 cc per 1,000 m^3 and the biomass for the stations occupied in the southern latitudinal grid (64.88 cc/1,000 m^3) was less than the biomass obtained from the middle (108.51 cc) and northern latitudinal grids (121.81 cc). So a two-fold increase in the zooplankton production was observed between the southern and northern latitudinal grids.

The average numerical count for the 21 stations was estimated and found to be 255 per 1,000 m^3 of water. Further the average number of chaetognaths from the stations located in the southern, middle and northern latitudinal grids was 308 specimens per 1,000 m^3, 194 per 1,000 m^3 and 263 per 1,000 m^3 respectively. So altogether, 40% of the specimens were from the southern latitudinal grid, 34.5% from the northern grid and the remaining 25.5% from the middle grid. This does not give a clear picture of increase or decrease of cheatognaths from south to north or north to south latitudes. As pointed out by Mathew (1986) chaetognaths were highly irregular in distribution with random aggregations.

The numerical abundance of chaetognaths was inversely proportional to the zooplankton

biomass. The average number of chaetognaths per station per 1,000 m³ from northern latitudinal grid was 263, where the zooplankton biomass was 121.81 cc. Whereas the chaetognath number per station per 1,000 m³ in the southern latitudinal grid was 308, where the zooplankton biomass was only 64.88 cc. However, in the case of euphausiids, more number per station (301/1,000 m³) was found in the northern grid stations, where the zooplankton biomass was also more and less numbers were found in the middle (168) and southern (146) grid stations, where the zooplankton biomass was also less.

Spatial distribution studies clearly show that the chaetognaths were well concentrated in the southern sector between 16°00'E and 19°00'E (Fig. 1 a). Further, the overall spatial distribution of chaetognaths indicates the abundance of these organisms in the middle and western region of all the three latitudinal grids than in the eastern region.

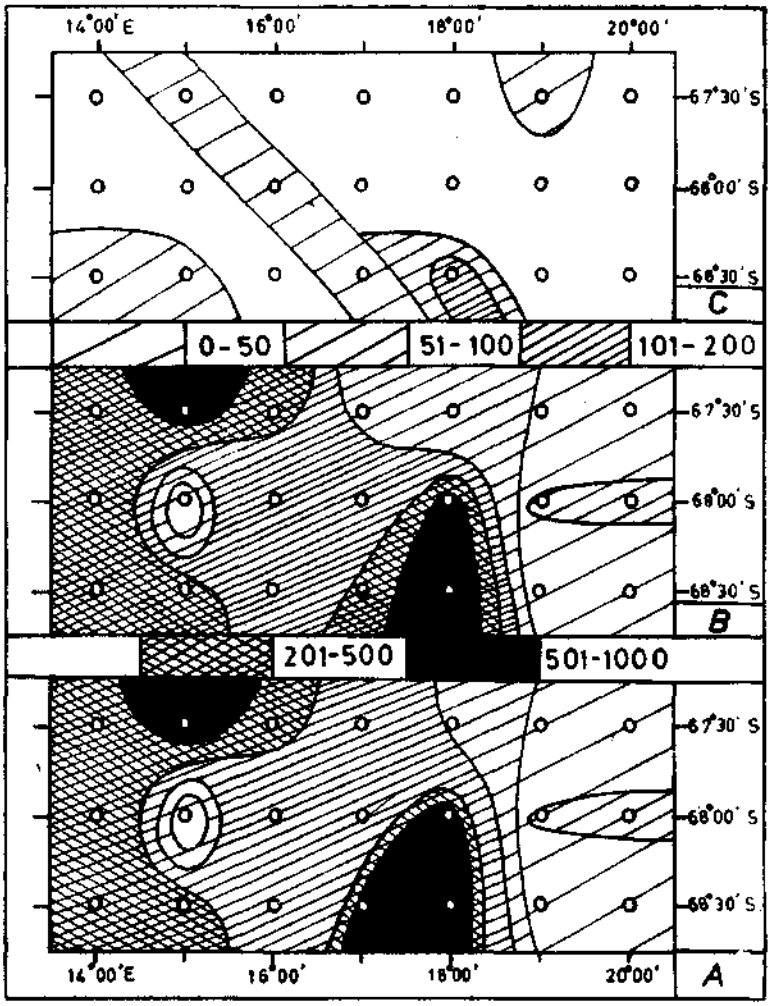

FIG. 1 a. Spatial distribution of Chaetognatha, b. Spatial distribution of *Eukrohnia hamata* and c. *Sagitta gazellae*.

Among the 12 zooplankton groups (Amphipoda, Appendicularia, Chaetognatha, Copepoda, Euphausiacea, Fish eggs, Fish larvae, Gastropoda, Ostracoda, Polychaeta, Pteropoda and Siphonophora) found in the samples, Chaetognatha occupied the third place in the order of abundance (1.34%), the Copepoda was the dominant group (91.39%) followed by Fish eggs (3.93%) (Mathew, 1986). Chaetognaths were found in all the samples and they were represented by *Eukrohnia fowleri*, *E. hamata*, *S. gazellae* and *S. tasmanica*. Among these four species, *E. hamata* was the dominant one and it formed 93% of the total chaetognaths followed by *S. gazellae* (4%), *S. tasmanica* (2%) and *E. fowleri* (1%). *E. hamata* was found in all the samples from the 21 stations. The concentration of *E. hamata* was more in the middle and western sector of all the three latitudinal grids than in the eastern sector of three latitudinal grids (Fig. 1 b).

S. gazellae was noticed only in seven stations and they were very few in number. In the northern most latitudinal grid, it was found in the second and sixth stations. In the middle latitudinal grid, it occurred only in the third station and in the southern most latitudinal grid, it was noticed in the first, second, fourth and fifth stations (Fig. 1 c). So the distribution of this species was more or less in a diagonal manner.

E. fowleri formed only 1% of the total chaetognaths and this was found in three stations (18, 19, 20) located in the northern most latitudinal grid. *S. tasmanica* formed 2% of the total chaetognaths and it was found in only one station (5) located in the southern most latitudinal grid.

The authors thank Dr. Asket Singh, Zoological Survey of India, Calcutta, Dr. A. N. T. Joseph, Marine Biological Station, Madras and Dr. P. S. B. R. James, Director, Central Marine Fisheries Research Institute, Cochin for the facilities provided. The second author is indebted to Dr. H. K. Gupta, leader of the expedition for all the facilities given on board the ship FINNPOLARIS.

Zoological Survey of India,
Marine Biological Station, Madras.

M. SRINIVASAN
K. J. MATHEW*

* *Central Marine Fisheries Research Institute, Cochin.*

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ON A SPECIMEN OF TRIPTERYGIID FISH *ENNEAPTERYGIUS NASIMAE* HODA WITHOUT A PELVIC FIN

ABSTRACT

A mature male tripterygiid fish *Enneapterygius nasimae* Hoda 1983, 35 mm in total length, without a right pelvic fin collected from the Karachi Coast of Pakistan on November 14, 1979 is reported here.

IN EARLY FISHES, the pelvic fins were located well behind the pectorals, aiding in controlling the vertical level through the water, while in higher teleosts including family Tripterygiidae, they moved forward to the thoracic region (Pl. I A) and in association with the pectorals, provided a 'four-wheel' braking system (Harris, 1938). Reduction or mal. formation or otherwise abnormally formed pelvics have been reported in many fishes (Marr, 1945; Lea, 1965; Tandon, 1965; Hettler, 1966; Radhakrishnan, 1973; Alvarez-Leon, 1980). The present communication relates to a specimen of the male tripterygiid fish *Enneapterygius nasimae* Hoda 1983, measuring 35 mm in total length, collected along with other tripterygiids from the Karachi Coast of Pakistan at Buleji (66°48'E, 24°51' N) on November 14, 1979. The right pelvic fin of this fish was absent and had not developed (Pl. I B, C), although body colouration and meristic/morphometric characters were found compatible with the previous descriptions of the species (Hoda, 1983). X ray analysis revealed that the right pelvic fin structures were lacking (Fig. 3) and the left pelvic fin was normally supported by its girdle. The right pelvic region did not show any injury or external thickening, being covered uniformly with normal scales.

The meristic and morphometric characters of the abnormal *E. nasimae* are given below : TL 35.0 mm, SL 28.5 mm. First dorsal fin (D_1) : III, first spine height 5 mm, base 4 mm; second dorsal fin (D_2) : XIII, first spine height 3.0 mm, base 9.5 mm; third dorsal fin (D_3) : 9, third spine height 4.5 mm, base 4.5 mm; anal fin : 20, spine height 3.2 mm, base 12 mm. Origin of anal fin at the level of 6th ray of D_3; caudal fin : 13 with 4 procurrent rays, length 6.5 mm. Head length 8.0 mm, breadth 6.5 mm, height 6.5 mm. Snout 3.0 mm; eye orbit 3.5 mm; body depth at D_3 6.0 mm, at D_8 5.0 mm; caudal peduncle 3.0 mm; preanal distance 14.0 mm; predorsal distance till D_1 6.1 mm, till D_2 9.0 mm, till D_3 19.0 mm. Cleft of mouth 4.0 mm, maxillary reaches anterior orbit, interorbital concave 1.0 mm; scales strongly ctenoid, lateral line scales 40 with 16 pored scales, transverse scales 2-1-5. Vertebrae 10 + 24.

Proportional measurements are as follows :

In TL : Body height at D_1 5.83, at D_2 5.83, at D_3 7.00; caudal peduncle 12.67; predorsal at D_1 5.74, at D_2 3.89, at D_3 1.84; preanal distance 2.50.

In SL : Body height at D_1 4.75, at D_2 4.75, at D_3 5.70; caudal peduncle 9.50; predorsal distance at D_1 4.67, at D_2 3.17, at D_3 1.50; preanal distance 2.04.

In HL : Height 1.6 ; body height at D_1 1.33, at D_2 1.33, at D_3 1.60 ; eye 2.29 ; snout 2.67 ; caudal peduncle 2.67 ; pectoral 0.76, caudal 1.14 ; first spine of D_1 1.60, first spine of D_2 2.67, third spine of D_3 1.78. Caudal fin length in pectoral 1.50.

In blenniids the pelvic fins no longer function as pedestal for support in their benthic habitat and thus functionally these fins are the least important. In blenniids there is no selective advantage in having pelvic fins (Springer, 1968 ; Goslin, 1971). The absence of the pelvic fin in this specimen supports this suggestion. In the absence of mechanical injury, this retardation or malformation in the early stages of development was retarded, but subsequently has little effect on the physiological functioning and growth of the abnormal specimen of *E. nasimae* under study.

The author is thankful to Dr. David A. Clayton of the Department of Zoology, Faculty of Science, Kuwait University, Kuwait for his critical reading of the typescript and offering valuable suggestions for its improvement and to Dr. Seiro Kimura of Fisheries Laboratory, Kyushu University, Fukuoka, Japan for kindly X raying the abnormal specimen.

Centre of Excellence in Marine Biology,
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S. M. SHAMSUL HODA

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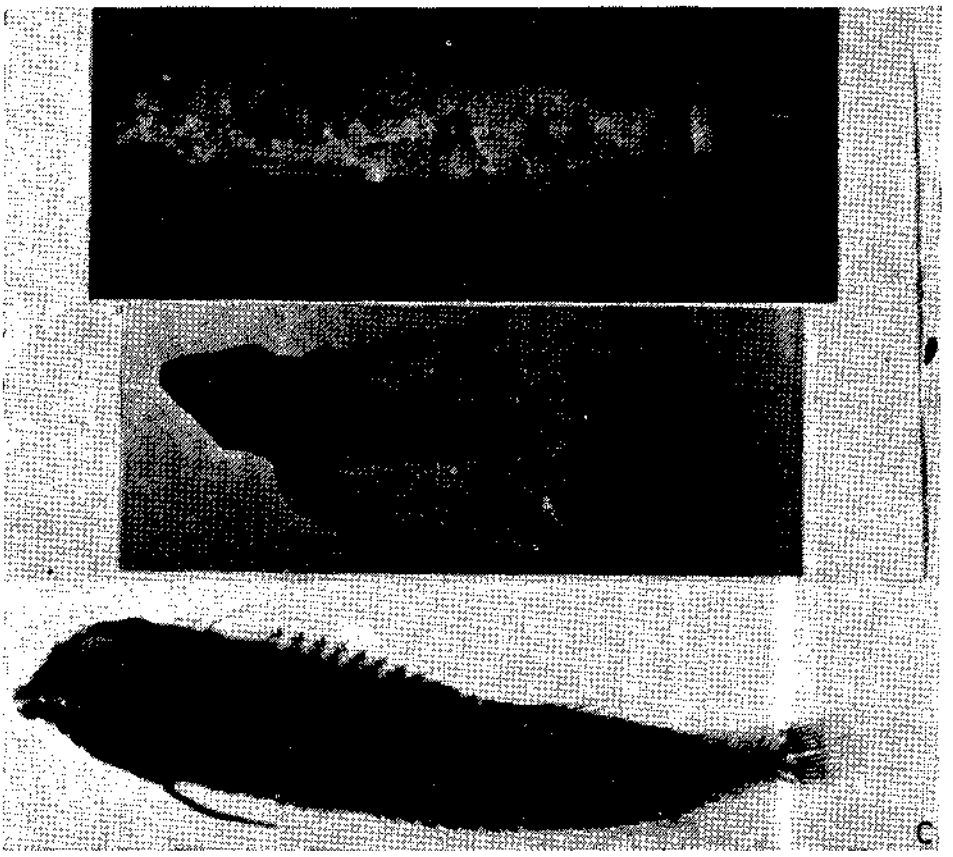

PLATE I A. Female *Ennzapterygius nasimae* Hoda. Paratype. 28 mm SL., B. Abnormal male of *E. nasimae* 30 mm TL, showing absence of right pelvic fin and C. X ray photograph of the abnormal male *E. nasimae*.

ANNUAL REPORTS

ANNUAL REPORT OF THE SECRETARY FOR THE YEAR 1991

President Dr. P. S. B. R. James, Vice-President Dr. C. T. Samuel and Members of the association,

I am very happy to welcome the members to the 33rd General Body Meeting and to present the Annual Report for the year 1991.

The membership position shows an increase compared to the previous year. The present membership position is as given below :

	Life member	*Individual member*	*Institution member*	*Total*
Indian ..	186 (173)	269 (260)	85 (82)	—
Foreign ..	36 (34)	10 (10)	105 (105)	691 (664)

I am very happy to report that, as mentioned in the last General Body meeting, in order to generate interest among students in the objectives and activities of the Association, an Inter-Institutional Science Quiz Competition was conducted by the Association at Cochin on 20-2-1992. The response was very good and five teams representing various Institutions participated in the competition. Other than the first and second prizes (Rs. 500/- and Rs. 300/- respectively), all participants were given certificates also. On the whole, it was a very successful programme which attracted many students.

As all of you are aware, the Association instituted Fellowship to eligible members in recognition of their long standing membership and contributions to the Association. Till todate, 134 Fellowships were given. This year 7 members have become eligible and Fellowship will be given to them shortly.

I am also happy to inform the members that for the year 1991-92, the ICAR has sanctioned a grant of Rs. 40,000 towards printing of the Journal. On behalf of the Association, I would like to record our sincere gratitude to the Indian Council of Agricultural Research for this kind gesture.

I wish to express my sincere thanks to the President and Office Bearers and especially to Dr. N. Gopalakrishna Pillai, Associate Secretary for the help and co-operation in the working of the Association. I also would like to thank Mrs. Lakshmy for her sincere help in the secretarial work of the Association.

Thank you all.

Sd.

Cochin-31.
29-5-1992.

V. K. PILLAI
Secretary

ANNUAL REPORT OF THE EDITOR FOR THE YEAR 1991

Respected President, Vice-President, Distinguished Members and friends,

The year 1991 was yet another successful year in the publication of the Journal of the Marine Biological Association of India. The Journal Volumed 33 was issued during December 1991 with 46 papers and 13 notes totelling 59 articles, and running to 460 pages.

The processing and editing of manuscripts for Vol. 34 for the current year 1992 were taken up at the end of 1991. This volume 34 is fast progressing at the C. L. S. Press, Madras with 31 papers and 12 notes comprising 43 articles and it is scheduled to release sometime in September 1992, *i.e.* well before the end of 1992.

By completing Volume 34, we have 44 papers received for the Symposium on Tropical Marine Living Resources and 81 papers received for the regular Journal, totalling to 125. These 125 papers and notes will be quite sufficient for 1993 and 1994 and 44 Symposium papers will be completed in Volume 35 for 1993 and Volume 36 for 1994 along with some of the regular papers received for the Journal.

I personally feel heartened that the support and help extended by all members of the Association has enabled me to bring out the Journal on time and I am thankful to them. I sincerely thank Dr. P. S. B. R. James, President of our Association for his support and encouragement. I profusely thank Shri P. T. Meenakshisundaram, Joint Secretary and Dr. C. P. Gopinathan who has been co-opted as Associate Editor from August 1991, for their wholehearted timely, continued co-operation and help for the publication of the Journal. I gratefully thank and appreciate the support extended by Shri A. D. Thomas Stephen and his staff at the C. L. S. Press, Madras for their continued co-operation in bringing out the Journal on time. Mrs. Lakshmy Janakiraman, the Association staff has my appreciation for the assistance rendered. I extend my sincere thanks to all members of the Executive Council and members of the Association who are always extending their co-operation.

Thank you all.

Sd.

Cochin-31,
29-5-1992.

K. RENGARAJAN
Editor

ANNUAL REPORT OF THE TREASURER FOR THE YEAR 1991

Dear President, Vice-President, members of the Association and guests,

I have the honour to present the audited statement of accounts for the year ended 31st December 1991. During the year under report Rs. 38,577.98 has been received under the membership subscription and entrance fee againts Rs. 40,811.00 during 1990 showing a decline of Rs. 2,233.02 in the current year when compared to that of in 1990. Through sales of Journals reprints and memoirs the amounts realised in 1991 and 1990 were Rs. 26,580.50 and Rs. 54,327.85 respectively indicating a steep fall of Rs. 27,747.35 during the current year over that of in the previous year. However, an increase of Rs. 3,126.50 was realised in the sales of special publications and Symposium Proceedings of Crustacea, Mollusca, Indian Ocean, Corals and Coral Reefs, Coastal Aquaculture and Endangered Marine Animals and Marine Parks, the sales during 1991 and 1990 being Rs. 25,345.75 and Rs. 22,219.25 respectively. Under the Bank interest the amounts realised in 1991 and 1990 were Rs. 15,885.95 and Rs. 14,533.90 respectively thus showing an increase of Rs. 1,352.05 during 1991 over that of 1990.

This year the overall receipts stood at Rs. 1,36,323.43 against payments of Rs. 1,04,560.16 thus showing an excess income of Rs. 31,763.27. During 1990 overall receipts amounted to Rs. 1,59,583.91 with an excess income of Rs. 47,423.39. Thus during 1991 overall receipts as well as excess income were less than those in 1990.

We are grateful to the I.C.A.R. for the grant of Rs. 20,000/- for the publication of the Journal during this year. Members are requested to enlist new members and help to increase the sale of publications of the Association to improve its income so as to meet the mounting expense in the coming years towards printing the Journal and other items. Any suggestions to improve the finances of the Association are welcome.

I am thankful to the President and all other Office Bearers of the Association for their valuable advice and support. I am thankful to Shri K. E. Rangaswami, Chartered Accountant for having audited the accounts and sending his report in time to enable me to present the annexed audited statement of accounts for the year 1991. I am also thankful to Shri G. Subbaraman of CMFRI for his valuable help in this regard.

Thanking you,

Sd.

Cochin-31,
29-5-1992.

K. ALAGARAJA
Treasurer

REPORT OF THE AUDITOR TO THE MEMBERS OF THE MARINE BIOLOGICAL ASSOCIATION OF INDIA, ERNAKULAM, COCHIN-31

I have audited the attached Statement of Affairs of THE MARINE BIOLOGICAL ASSOCIATION OF INDIA as at 31st December, 1991 and also the annexed income and Expenditure account for the year ended 31st December, 1991 and report that :

1. I have obtained all the information and explanation which, to the best of my knowledge and belief, were necessary for the purpose of the audit.

2. The books of accounts are maintained on cash basis.

3. The Statement of Affairs and the income and expenditure account referred to in this report are in agreement with the books of account.

In my opinion and to the best of my information and according to the explanation given to me, the said accounts give a true and fair view :

(*a*) In the case of the Statement of Affairs, the state of affairs of the Marine Biological Association of India, Ernakulam as at 31st December, 1991 and ;

(*b*) In the case of the Income and Expenditure account, the excess of income over expenditure for the year ended on 31st December, 1991.

Sd.

Madurai.
16-3-1992.

K. E. RANGASWAMI
Chartered Accountant

THE MARINE BIOLOGICAL ASSOCIATION OF INDIA, ERNAKULAM, COCHIN, INDIA

Statement of Affairs as at 31st December 1991

As at 31-12-1990	Liabilities	As at 31-12-1991		As at 31-12-1990	Assets		As at 31-12-1991
Rs. P.		Rs. P.	Rs. P.	Rs. P.		Rs. P.	Rs. P.
	General Fund						
	Balance as per last year ..	2,02,975.14			Cash with Treasurer ..	2,658.40	
					Cash with Office Bearers on postage ..	238.09	
	Add			284.14			2,896.49
	Excess of income over expenditure	9,971.93			*Cash at Banks*		
	Symposia receipts ..	24,918.25			Indian Bank, Ernakulam ..	22,805.73	
2,02,975.14			2,37,865.32		United Commercial Bank,		
3,990.91	Due to Treasurer ..	—			Ernakulam ..	193.94	
				21,792.21			22,999.67
				40,000.00	Fixed Deposit with Indian Bank ..		1,50,000.00
				1,20,866.90	Short Term Deposit with Indian Bank ..		38,810.30
				8,254.30	Typewriter ..		8,254.36
				864.00	Bicycle ..	864.00	
					Less: Written off ..	864.00	
							—
				14,904.50	Furnitre ..		14,904.50
2,06,966.05			2,37,865.32	2,06,966.05			2,37,865.32

Per my report annexed

Sd.

K. E. Rangaswami

Chartered Accountant

Madurai,
16-3-1992.

Sd.

K. Alagaraja

Treasurer

THE MARINE BIOLOGICAL ASSOCIATION OF INDIA, ERNAKULAM, COCHIN, INDIA

Income and Expenditure Account for the year ended 31*st December* 1991

Year ended 31-12-1990	Expenditure		Year ended 31-12-1991	Year ended 31-12-1990	Income		Year ended 31-12-1991
Rs. P.			Rs. P.	Rs. P.			Rs. P
9,600.00	To Salaries to staff	..	10,600.00	707.50	By Entrance fee	..	931.00
1,245.97	,, Printing and Stationery expenses	..	2,459.40	40,103.50	,, Subscription	..	37,646.98
9,186.15	,, Postage expenses	..	9,466.05	14,533.90	,, Interest from Bank	..	15,885.95
74,246.75	,, Printing charges for Journal	..	74,250.95	54,327.85	,, Sale of Journal, Reprints and Memoirs	..	26,580.50
14,238.10	,, Interest to Bank	..	—				
3,653.55	,, Miscellaneous expenses	..	3,792.85	127.50	,, Sale of Special publications	..	427.50
—	,, Cost of bicycle written off	..	864.00	20,000.00	,, Grant-in-aid from I.C.A.R. for Journal	..	20,000.00
21,340.73	,, Excess of income over expenditure	..	9,971.93	3,711.00	,, Miscellaneous receipts	..	9,933.25
1,33,511.25			1,11,405.18	1,33,511.25			1,11,405.18

Per my report annexed

Sd.

K. E. Rangaswami

Chartered Accountant

Sd.

K. Alagaraja

Treasurer

Madurai,

16-3-1992.

THE MARINE BIOLOGICAL ASSOCIATION OF INDIA, ERNAKULAM, COCHIN, INDIA

Receipts and Payments Account for the year ended 31st December 1991

RECEIPTS	Rs. P.	Rs. P.	PAYMENTS	Rs. P.	Rs. P.
To Opening Balance			By Printing and Stationery ..		2,459.40
Fixed Deposit with Indian Bank, Ernakulam.	40,000.00		,, Postage excluding advance ..		9,466.05
Short term deposit with Indian Bank, Ernakulam ..	1,20,866.90		,, Printing charges for Journal ..		74,250.95
Cash at Indian Bank, Ernakulam ..	21,314.97		,, Salary to staff ..		10,600.00
Cash at United Commercial Bank, Ernakulam	477.24		,, Miscellaneous expenses including Audit fee		3,792.85
Advance with office bearers on postage ..	284.14		,, Cash paid to Treasurer ..		3,990.91
		1,82,943.25	*Closing balance*		
To Entrance fee ..		931.00	Fixed Deposit with Indian Bank, Ernakulam	1,50,000.00	
,, Membership subscription ..		37,646.98	Short Term Deposit with Indian Bank, Ernakulam ..	38,810.36	
,, Interest from Bank ..		15,885.95	Cash at Indian Bank, Ernakulam ..	22,805.73	
,, Sale of Journals, Reprints and Memoirs ..		26,580.50	Cash at United Commercial Bank, Ernakulam	193.94	
,, Sale of special publications ..		427.50	Advance with Office Bearers on postage ..	238.09	
,, Symposium on Crustacea ..		2,310.00	Cash with Treasurer ..	2,658.40	
,, Symposium on Mollusca ..		2,227.50			2,14,706.52
,, Symposium on Indian Ocean ..		290.00			
,, Symposium on Corals and Coral Reefs ..		843.75			
,, Symposium on Coastal Aquaculture ..		13,776.00			
,, Symposium on Endangered Marine Animals and Marine Parks ..		5,471.00			
,, Grant-in-aid from I.C.A.R. for Journal ..		20,000.00			
,, Miscellaneous receipts ..		9,933.25			
		3,19,266.68			3,19,266.68

Per my report attached

Sd.
K. E. RANGASWAMI
Chartered Accountant

Madurai,
16-3-1992.

Sd.
K. ALAGARAJA
Treasurer

REGISTRATION OF NEWSPAPERS (CENTRAL) RULES 1958

Statement about ownership and other particulars about newspaper

JOURNAL OF THE MARINE BIOLOGICAL ASSOCIATION OF INDIA

FORM IV

(SEE RULE 8)

1. *Place of Publication* — Cochin.

2. *Periodicity of its publication* — Half-yearly.

3. *Printer's Name* — Mr. A. D. Thomas Stephen.
   Nationality — Indian.
   Address — The C. L. S. Press, 10 Vepery Church Road, Vepery, Madras-600 007.

4. *Publisher's Name* — Dr. K. Rengarajan, for the Marine Biological Association of India.
   Nationality — Indian.
   Address — C.M.F.R.I. Campus, Dr. Salim Ali Road, Cochin-682 031.

5. *Editor's Name* — Dr. K. Rengarajan.
   Nationality — Indian.
   Address — C.M.F.R.I. Campus, Dr. Salim Ali Road, Cochin-682 031.

6. *Names and addresses of individuals who own the newspaper and partners or shareholders holding more than one per cent of the total capital* — Marine Biological Association of India, C.M.F.R.I. Campus, Dr. Salim Ali Road, Cochin-682 031.

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