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ISBN 978-81-923002-1-4

Handbook of Marine Prawns of India

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Central Marine Fisheries Research Institute

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2013

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Publication Production & Co-ordination
V. Edwin Joseph
Officer-in-charge
V. Mohan
Technical Officer
Library & Documentation Centre

ISBN 978-81-923002-1-4

Printed at St. Francis Press, Kochi-682 018

Preface

Central Marine Fisheries Research Institute realized the importance of crustaceans as an exportable resource and started concentrating on prawn fisheries research and development since 1960s. CMFRI conducted a 'Symposium on Crustacea' in collaboration with the Marine Biological Association of India (MBAI) in 1965 to get an idea on the existing information on the biology and fisheries of Crustaceans. The Institute also published 'Bulletin 14' entitled 'Prawn Fisheries of India' in 1969 which brought to light the complete information on taxonomy, biology and fisheries of the commercial species of prawns in general and penaeid prawns in particular. Since then many studies were conducted on various aspects of prawn fisheries during the last 40 years. The prawn landings increased from 62,767 t forming 9.2% of the total marine fish landings in 1961 to 4,60,028 t forming 12% of the marine fish landings in 2011. The sea food exports gradually increased from 15,732 t valued at Rs.3.92 crores in 1961-62 to 6,12,641 t valued at Rs.8363.53 crores by 2006-07 and to 8,13,091 t valued at Rs. 12,901.47 crores in 2010-2011. Frozen shrimp continued to be the major export item accounting for 51.35% of the total foreign exchange realizations during 2010-11.

The institute realising the need to update the information on prawn fisheries is timely bringing out this critical information as 'Handbook of Marine Prawns of India'. The book covers almost all the aspects of capture fisheries of prawns contributed by the present and former scientists of the institute. Authors have taken care to include all the information about the biological aspects of the species concerned. Wherever necessary results obtained in the laboratory culture experiments were also recorded in addition to the studies made on wild stocks. Importance was given to highlight the population dynamics and stock assessment to design proper management measures. Added attraction of the book is a set of fine photos annexed to the chapter on taxonomy along with tables and well-illustrated figures.

I hope that this book will be handy to all sections of entrepreneurs, researchers and students interested in capture fisheries. It is also useful to the scientists and policy makers to design proper management measures to obtain optimum yield from the resource.

I congratulate all the contributors and editors for taking all pain and precautions in bringing out this publication. Also I specially thank Shri. V. Edwin Joseph, Officer-in-Charge, Library and Documentation Centre for his efforts of coordination in bringing out the book in an excellent manner.

Kochi
01-03-2013

Dr. G. Syda Rao
Director

Children pooling the catch of Ginger prawn caught by bag net at Veraval

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Metapenaeus affinis

Plate - i

Penaeus (Fenneropenaeus) indicus H. Milne Edwards, 1837

Penaeus (Fenneropenaeus) merguiensis De Man, 1888

Penaeus (Fenneropenaeus) penicillatus Alcock, 1905

Mechanised Trawlers at Porbander Fishing Harbour, Gujarat

1

Taxonomy

The penaeoid prawns (Superfamily Penaeoidea) constitute a diverse group of marine decapods with over 400 species (Ma *et al.,* 2009). Globally distributed, and inhabiting both shallow waters and abyssal zones below 5000 m, they occupy different trophic levels of the food chain at various water depths in the ocean (Pérez Farfante and Kensley 1997). This group includes most of the prawns of high economic value that account for over one-third of the annual wild crustacean catch (FAO, 2009).

Penaeoidea is considered to have four families, namely Aristeidae, Solenoceridae, Penaeidae and Sicynoiidae (Holthuis 1980; Liu and Zhong 1994; Dall *et al*., 1990; Hayashi 1992; Chan 1998). However, the most recent classification scheme gives Penaeoidea five families, by adding the family Benthesicymidae (Pérez Farfante and Kensley 1997; Martin and Davis 2001). Benthesicymidae was traditionally considered as a subgroup of Aristeidae, and the suggestion that this should be ranked as a family suggested by Crosnier in 1985 was not seriously noticed. As for the other four families, Sicyoniidae is believed to be close to Penaeidae while Solenoceridae is allied with Aristeidae. Such a subdivision of the superfamily coincides with the distinct adult habitat choices of the families; the penaeids and sicyoniids usually inhabit littoral waters while the aristeids and solenocerids are mostly deep-sea species (Burkenroad 1934, 1936; Pérez Farfante 1969; Dall *et al*.,1990). However, detailed discussion of the overall phylogenetic relationships amongst the penaeoid families and genera have been limited, and only two comprehensive schemes have been proposed by Kubo (1949) and Burkenroad (1934), the former scheme mostly based on a very complicated set of characters based on a rather limited genera proposing Sicyoniidae as the most primitive and Penaeidae as the most advanced group with Solenoceridae being intermediate between Aristeidae and Penaeidae. Burkenroad (1936) on the other hand, constructed a scheme of all the genera known and considered Solenoceridae as the most primitive group based on fossils and Sicyoniidae as the most advanced.

The above morphologically inferred phylogenies were challenged by recent phylogenetic studies with noticeably contrasting conclusions: probably revision of the present classification may be necessary when more information is generated on the basis of phylogenetic analysis using 16 S or Co1 genes. Ma *et al*., (2009) utilized PEPCOY NAK gene sequence to investigate phylogenetic relationships within penaeoidea following the most recent classification of Pérez Farfante and Kensley (1997). They used 7 of 9 genera in Aristeide, 2 of 4 genera in Benthesicymidae, 19 of 26 genera in Penaeidae, the single genus of Sicyoniidae and 8 of 9 genera in Solenoceridae in a total of 46 species. However, only limited species distributed along the Indian coasts were included in the study. A comprehensive study using markers with better resolution of all available species from Indian coasts is needed to decide between alternate hypotheses on the evolution of penaeoidea.

Shrimps and prawns constitute a diverse group of crustaceans varying in size from microscopic to about 35 cm body length (measured

dorsally from the posterior orbital margin to the end of the telson, excluding the rostrum and the appendages). They belong to the suborder Macrura Natantia and differ from the lobsters (Macrura Reptantia) in having a laterally compressed body with well developed abdominal appendages (pleopods), a narrow sternum and a distally tapering telson.

The terms 'shrimp' and 'prawn' are not related to any known taxonomic group. Although the term 'shrimp' is applied to smaller species, and 'prawn' to large forms, there is no clear distinction between both terms and their usage is often confused or reverse in different countries or regions (Chan 1998).The term 'prawn' is used throughout the text in this book. However, the term 'shrimp' used by original authors and species common names are reproduced as such.

Although there are about 4,048 species of prawns known to date, they are subdivided into four major groups, namely Dendrobranchiata (68 species, 533 species), Stenopodidea (12 genera, 71 species), Caridea (389 genera, 3,438 species) and Procarididea (2 genera, 6 species) (De Grave and Fransen 2010). Although the carideans are a majority, only a few are abundant enough to be of interest to fisheries. Most of the commercial prawns belong to the Penaeoidea; at present, only less than 300 species of prawns are of economic interest worldwide and of these only about 100 comprise the principal share of the annual world catch (Chan 1998). List of families occurring along the Indian coast (Arabian sea and Bay of Bengal including Andaman and Nicobar Islands and Lakshadweep Islands) is given in the table.

Most of the commercial species of prawns belong to the superfamily penaeoidea. Studies on penaeoids are more comprehensive and at present 5 families, 23 genera and 121 species (including the introduced species) are known to occur along the Indian coast including the Lakshadweep and Andaman and Nicobar Islands, with the penaeidae being the most important family (Radhakrishnan *et al*., 2011). As species of penaeidae are generally of moderate to large in size occupying large quantities in shallow waters along the continental shelf in trawlable bottoms, they are fished extensively by trawls, gillnets and seines. Large scale pond culture of penaeid prawn is practiced in India, the prominent species being *Penaeus monodon* and recently the exotic species *Litopenaeus vannamei* was introduced for culture. Species of the penaeoid families Aristeidae and Solenoceridae are mainly

Infraorder	**Penaeidea**
Superfamily	Sergestoidea
Family	Luciferidae
Family	Sergestidae
Superfamily	Penaeoidea
Family	Aristeidae
Family	Solenoceridae
Family	Penaeidae
Family	Sicyoniidae
Family	Benthesicymidae
Infraorder	**Stenopodidea**
Family	Stenopodidae
Family	Spongicolidae
Infraorder	**Caridea**
Superfamily	Pasiphaeoidea
Family	Pasiphaeidae
Superfamily	Oplophoroidea
Family	Oplophoridae
Superfamily	Nematocarcinoidea
Family	Nematocarcinidae
Family	Rhynchocinetidae
Superfamily	Palaemonoidea
Family	Gnathophyllidae
Family	Hymenoceridae
Family	Palaemonidae
Subfamily	Palaemoninae
Subfamily	Pontoniinae
Superfamily	Processoidea
Family	Processidae
Superfamily	Psalidopodoidea
Family	Psalidopodidae
Superfamily	Alpheoidea
Family	Alpheidae
Family	Hippolytidae
Family	Ogyrididae
Superfamily	Bresilioidea
Family	Disciadidae
Superfamily	Pandaloidea
Family	Pandalidae
Family	Thalassocarididae
Superfamily	Crangonoidea
Family	Crangonidae
Family	Glyphocrangonidae

deep water forms and are now being intensively exploited. In contrast, species of the penaeoid family Sicyoniidae are generally small, and have no commercial potential. Though several species of Aristeidae, Solenoceridae and Benthesicymidae are reported from Indian waters by different authors, some species have not been reported later as they did not appear in regular landings. In India, an average 3,97,524 t of prawns (penaeids and non-penaeids) are landed annually (2008-10) and majority is exported.

Sergestid shrimps are usually small and genus such as *Acetes* is important from the fisheries point of view. An estimated average 1,596,26 t of non- penaeids (2008-10) are annually landed by *dol* nets and trawl nets mainly along the northwest and northeast regions. Some of the non-penaeids such as pandalids contribute significantly to the deep sea landings and are fairly with good commercial value.

Prawns landed along the Indian coast are generally marketed as fresh or frozen and majority are exported. The species of *Acetes* are usually processed into shrimp paste or dried and used for fresh/prawn/poultry feed manufacture.

Studies on the taxonomy of Indian penaeid prawns belonging to the families Aristeidae, Benthesicymidae, Penaeidae, Sicyoniidae and Solenoceridae are dealt with by several authors (Milne Edwards H., 1837; Miers 1884; Bate 1888; Wood-Mason 1891; Wood-Mason & Alcock 1891a & b; Alcock & Anderson 1894, 1899; Anderson 1897; Alcock 1899, 1901, 1905 & 1906; Alcock & Macardle 1901; Nobili 1903; Alcock *et al*., 1907; De Man 1908, 1911 & 1920; Kemp 1910, 1915 & 1917; Kemp & Sewell 1912; Balss 1925; Sewell 1934; Nataraj 1945 & 1953; Kurian 1953, 1954, 1964 & 1965; Menon 1956; Mehendale and Tembe 1958; John and Kurian 1959; Kunju 1960a & b; George *et al*., 1963; George 1964, 1966, 1969, 1972, 1975b, 1979 & 1980; Ramamurthy 1964; George and Rao 1966a & b; Nair *et al*., 1967; George and Muthu 1968 a & b; Muthu 1965, 1972a & b; Thomas 1968, 1969, 1970, 1972b, 1977, 1979 & 1986; Muthu and George 1971; Mohamed and Suseelan 1973, Muthu & Manickam 1973; Kathirvel *et al*., 1976; Silas and Muthu 1976a & b; Kagwade 1978; Rao 1984; Crosnier 1988; Ravindranath 1989; Ramaseshaiah and Murthy 1991; Suseelan 1996; Pathan and Jalihal 1997; Dineshbabu 2004; Kathirvel *et al*., 2007). A total of 120 species of penaeid prawns have been recorded from the inshore and deep sea regions of the Exclusive Economic Zone of India, which worked out to 29.9% of World known 401 penaeid prawn species, as listed by Pérez Farfante & Kensley (1997). The Indian species are mostly caught either by trawl or dredge since 1837 to 1934 and later mostly by exploratory and commercial trawling. Out of 120 species, 63 are recorded in the littoral region, 27 species are from deep sea, where depth ranged from 200 to 1,500 metres. Some are pelagic species and few are recorded from the Deep Scattering Layer. In the present account, an attempt has been made to provide taxonomical keys for the identification of different families and genera.

Classification

Subphylum: Crustacea Pennant, 1777
Class: Malacostraca Latreille, 1802
Subclass: Eumalacostraca Grobben, 1892
Superorder: Eucarida Calman, 1904
Order: Decapoda Latreille, 1802
Suborder: Dendrobranchiata Bate, 1888
Superfamily: Penaeoidea Rafinesque, 1815

Key to the Superfamilies of the Suborder Dendrobranchiata

1. Some thoracic somites with at least 3 branchiae on each side. At least 11 branchiae present on each side ..... **Penaeoidea**

Never more than 2 branchiae per thoracic somite; never more than 7 or 8 branchiae per side ..... .**Sergestoidea**

Superfamily: Penaeoidea Rafinesque-Schmaltz, 1815

Diagnosis: All five pairs of pereiopods well developed; Pleurobranchia present at least on somite IX (that of third maxilliped); Some somites with at least three branchiae on each side ; Total number of well developed gills on each side at least 11. The keys for families and genera as well as figures are the modified version of those given by Pérez Farfante and Kensley (1997).

Most of the commercial species of prawns belong to the Superfamily Penaeoidea, which is divided into families Aristeidae, Benthesicymidae, Penaeidae, Sicyoniidae and Solenoceridae. Among them, family Penaeidae comprises more species of commercial value prawns.

Keys for 5 families of Penaeoidea

1. Postorbital spine present ..... **Solenoceridae**
   Postorbital spine absent **2**
2. Integument rigid and stony; 3rd to 5th pereiopods uniramous, lacking endopods ..... **Sicyoniidae**
   Integument never stony; 3rd to 5th pereiopods biramous **3**
3. 1 to 3 (occasionally 3) rostral/postrostral teeth ..... **Benthesicymidae**
   More than 2 rostral/postrostral teeth **4**
4. Prosartema well developed ..... **Penaeidae**
   Prosartema reduced to setose ..... **Aristeidae**

Family: Penaeidae Rafinesque-Schmaltz, 1815

The generic system of the family was revised by Pérez Farfante and Kensley (1997) and as a result a new generic arrangement has been proposed for the family. However, for each species treated here, the generic epithet *Penaeus*, preferably qualified at the first mention by Flegel's proposal, namely to follow the rules of zoological nomenclature by placing the sub-genus names in brackets between the traditional genus name *Penaeus* and the relevant species name at first mention, for example *Penaeus (Fenneropenaeus) indicus* has been adopted. The family now includes 26 genera and 216 species and subspecies world wide (Tavares *et al.*, 2009).

Diagnosis: Body compressed, comparatively slender; Rostrum well developed, extending to or beyond distal margin of eye and armed with dorsal and sometimes also with ventral teeth; Carapace without postorbital spine; antennal and hepatic spines usually present; cervical sulcus ending well ventral to dorsal midline; posterior abdominal segments carinate; telson sharply pointed, with or without lateral spines; antennule with foliaceous prosartema, flagella of about same length; 3rd to 5th pereiopods biramous; petasma semi-open or semi-closed; second pleopod of males bearing appendix masculina only, lacking appendix interna and distolateral projection; thelycum open or closed. Colour: Body colour varies from semi-translucent to dark grayish green or reddish, often with distinct spots, cross-bands and/or other markings on the abdomen and uropods.

Habitat, biology and fisheries

Usually adults inhabit marine; however juveniles and sub-adults are often found in brackish water and estuaries. Penaeids are mostly benthic and mainly found on soft bottom of sand and/or mud, but a few species of *Funchalia* are pelagic and others are known to inhabit coral reefs (e.g. the genera *Heteropenaeus*, *Trachypenaeopsis* and some *Metapenaeopsis*). Some penaeids, *Parapenaeus* and *Penaeopsis* occur in deep water at depth of more than 750 m. The sexes are separate and easily distinguishable by the presence of a copulatory organ (petasma) on the first pair of pleopods of males, while the females have the posterior thoracic sternites modified into a sperm receptacle process (thelycum), which holds the spermatophores after mating. The shape of the petasma and thelycum is often specific and useful for species identification. The eggs are small and released directly into the water. The larvae are planktonic.

At present 19 genera and 71 species of penaeids are known to occur along the Indian coast and adjoining seas. Among these, the genus *Penaeus* is of great economic importance. Penaeids are caught extensively by trawls, seines and artisanal gears. The genus *Metapenaeus* and *Parapenaeopsis* are of primary importance from fisheries point of view and often landed together with *P. (F) merguiensis*, *P. (F) indicus*, *P. semisulcatus* and *P. monodon*. The other genera seems to be less abundant, although *Metapenaeopsis* and *Trachypenaeus* are frequently found among prawn landings and have some commercial value. The deep water genera

2

Prawn fisheries

2.1 Andhra Pradesh

Andhra Pradesh with a coastline of 974 km and a continental shelf of 33,227 sq km supports a marine fishery of considerable magnitude. The annual marine fish landings of the state ranged from 1,51,435 to 2,33,276 t during 1996-2006 contributing about 7.2% to the country's marine landings. It ranks fifth among the Indian states in marine fish production, after Kerala, Gujarat, Maharashtra and Tamil Nadu. Prawns forming as much as 11.3% to the state's marine fish landings are an important item of export earning foreign exchange. In addition the two major estuaries of the rivers Krishna and Godavari, the innumerable small estuaries and the semisaline Lake - the Kollair Lake (1.5 lakh ha) and the brackish water lagoon the Pulicat Lake (46,000 ha) contribute to the wealth of prawn fishery. With a brackish water area of 1,50,000 ha suitable for prawn culture, 39,537 t of prawns were produced in an area of 33,754 ha during 2009-10. A number of fish landing centers spread over the nine districts contribute to the growth of the fishery along with major fishery harbours at Visakhapatnam and Kakinada and minor fishery harbours at Narasapuram, Machilipatnam, Nizampatnam and Krishnapatnam. As the marine prawn fishing industry contributes substantially to the wealth of the state, it attracted the attention of researchers in biology as well as in the economy of the operations. Notable among them are Poliakov (1962), Subrahmanyam (1966, 1967b), Subrahmanyam and Ganapati (1971), Sreekrishna and Narayanappa (1970), Satyanarayana and Narayanappa (1972), Muthu (1968), Muthu *et al*. (1975), Narasimham *et al*. (1979), Rao (1978, 1979, 1985, 1987, 1988a, 1988b, 1988c, 1993b, 1994, 1995, 1999, 2000, 2001, 2009), Rao and Krishnamoorthi (1990), Rao and Varma (2001a, 2001b), Rao *et al*. (1980, 1993), Alagaraja *et al*. (1987), Lalithadevi (1987a), FAO (1993), Dixitulu (2001), Kasim *et al*. (2001), Maheswarudu (MS), Rao *et al*. (2008) and Reuben *et al*. (1989).

CMFRI carried out census of marine fisheries in 2005. Accordingly, Andhra Pradesh has a marine fishermen population of 5.09 lakhs and 41,039 fishing crafts among which 24,386 are non-mechanized, 14,112 motorized, 2,541 mechanized and 1,802 are trawlers of different dimensions operating gill nets, trawl nets, drag nets and multitude of other fishing nets and gears. The state has all the infrastructure facilities like ice plants, processing plants and cold storages. There are 206 ice plants with a production capacity of 2,299 t/day, 29 freezing plants of 287 t/day capacity and cold storages of the capacity of 4,265 t at Visakhapatnam, Kakinada, Bhimavaram, Nellore and other places, all catering to the need of seafood export industry.

Exploratory and experimental fishing

Sekharan *et al*. (1973) analyzing the data of the Government of India exploratory vessels for the period 1961-65 indicated that prawns formed only 2% of the landings as the net operated was a fish trawl with a cod end mesh size of 30-40 mm. Reuben *et al*. (1989) also indicated that prawns formed only negligible proportion of the trawl catches. However, the vessels of Government of Andhra Pradesh operating from Visakhapatnam and Kakinada indicated very rich prawn fishing grounds along

this coast paving the way for commercial operations for prawns.

The operations of the experimental vessels of the Central Institute of Fisheries Technology proved the existence of rich prawn fishing grounds off Kakinada. In a 9-month experimental study from July 1963 to March 1964 from a 9.1 m mechanized boat Sebastian *et al*. (1965) observed that prawns formed about 18.59% of the total trawl fish caught off Kakinada and that December-March period was the best season with a peak in February. Shreekrishna and Narayanappa (1970), based on a 3-year study during 1963-66, also off Kakinada from the same boat, stated that the prawns formed 22.50% of the catch and observed that prawns are available throughout the year with two peak seasons, one from November to February and the other in April-June. Later Satyanarayana and Narayanappa (1972) reviewed the results of experimental trawling for the period 1964-70 and evaluated the efficiency of different gears tested for catching prawns and concluded that prawns are an important resource forming as much as 25-30% of the trawl catches in various experiments.

Craft and gear

The traditional gears like shore seines, boat seines and gill nets operated by *masula* boats, *navas* and catamarans were harvesting the prawn resources in the past. In recent years, trammel nets (disco-nets) became very popular in harvesting shrimps by non-mechanized boats. Chennubhotla *et al*. (1999) described various artisanal crafts and gears used for catching fish. Of these crafts, catamaran, Kakinada nava, Masula boat, shoe doni and fibre-glass boat are used for catching prawns. In recent years some of these varieties of boats have been mechanized with outboard motors and inboard engines of different horse power. The artisanal gears used in prawn fishing are *pedda vala, alivi vala, nylon alivi vala, iraga vala, disco vala, ila vala, pakkadevu vala* and *gidasa vala* or *thoka vala.*

In addition to these, trawlers of different dimensions are operated along the Andhra Pradesh coast (Rao, 1993a). They are *pablo* (9.14 m OAL), *royya* or *pomfret* (9.6 m OAL), *sorrah* (11.2 m OAL), *sona* (13.1 m OAL), mini trawler (16 m OAL) and large trawler (23.19-26.95 m OAL). Trawl nets of different dimensions are used as per the OAL of the vessels. The *pablos* (wooden boats) of 9.14 m over-all-length (OAL) with inboard engines of 40 HP were first introduced at Kakinada in 1964. This boat was able to operate trawl nets up to 20 m depth only as they did not have a mechanical winch. The *pomfret* (or *royya*), the second generation of mechanized wooden craft of 9.75 m OAL fitted with engines of 45-65 HP, was designed for trawling with a mechanized winch. These boats were first introduced at Kakinada in 1966 and at Visakhapatnam in 1968. In later years they spread to the smaller ports like Narasapuram, Machilipatnam, Nizampatnam and Krishnapatnam in Andhra Pradesh. *Sorrah*, the third generation trawler introduced in 1967 was a failure and formed only a negligible portion of the fleet.

In the earlier years 1967-75, the mechanized boats (small trawlers) were harvesting the resources of the 10-40 m depth zone by conducting single day fishing. They operated at a maximum distance of 20-30 km from their port of operation. In 1973, the mechanized boats of Kakinada and Visakhapatnam started to migrate to Paradeep in the fair weather season of October-January, exploiting the resources around this port. A major breakthrough occurred in 1974, when a few mechanized boats started night fishing and landing good quantities of prawns at Kakinada. Since then night fishing became a regular practice. With this change, the profitability of small mechanized boats increased considerably and as a result the fleet increased year after year. This led to a reduction in the profit margin and as a consequence, a few boats ventured for 3-4 days fishing covering a distance of 60-70 km from the port of operation. This type of voyage fishing or stay fishing started in 1981 made it possible for the small mechanized boats to fish all along the northeast coast down to 70 m depth, concentrating in the 10-50 m depth range. However, these boats could still not exploit the rich prawn resources of the *Sand Heads* region.

The two imported trawlers exploiting the prawn resources in deeper waters in 1972 proved the economic viability of large trawlers (Rao, 1987). The large trawler fleet rapidly increased in size when the new fisheries harbour was opened at

Visakhapatnam in 1978. About 38 Mexican trawlers were added to the fleet in about one year and gradually increased from 40 in 1982 to 182 in 1991. However, the maximum that was ever operated was only 125 (in 1988-89). They have been operating all along the northeast coast between Kalingapatnam and S*and Heads* off the West Bengal coast with Visakhapatnam as base. Rao (1987) gave design of the gear, construction of the vessels and operational details of the large trawlers.

The *mini trawler*, a 16 m OAL wooden craft with 145-180 HP engine was introduced in 1981. The number of mini trawlers gradually increased from six in 1986 to 78 in 1990. However, these numbers came down to 20 by 1998. They operate at the same depths and in the same areas as the large trawlers. Rao (1987) described the characteristics and the operational details of the mini trawlers. The most important technological development in the northeast coast, particularly in Andhra Pradesh in recent years has been the introduction of *sona* boats. They became very popular in the wake of increased fuel prices and desire to extend the voyage up to 15 days to minimize fuel costs. As these boats were landing huge quantities of prawns resulting in increased earnings, the operators began to call them *sona* boats (Rao, 1999). These boats introduced at Kakinada in 1987 (Chittibabu *et al*., 1988) gradually spread to other ports also. Salient features of different types of trawlers operated from Andhra Pradesh along the northeast coast are furnished in Table 1.

Table 1. Salient features of different types of trawlers operated in Andhra Pradesh

Specification	Large trawler	Mini trawler	*Sona*	*Royya*
Type of hull	Steel	Wood	Wood	Wood
Over-all-length (m)	23.19	16.00	13.10	9.75
Breadth (m)	7.33	5.08	4.10	2.90
Draft (m)	3.08	2.15	2.80	1.07
HP of engine	380.00	145.00	102.00	60.00
GRT	115.80	42.00	18.00	-
NRT	78.80	12.80	5.50	-
Chill tank capacity	3.50	No freezing facility	-	-
Chill tank temperature ^{0}C	-2	No freezing facility	-	-
Fish hold capacity	25	7.5	-	-
Fish hold temperature ^{0}C	-18	-18	-	-
Type of net		**Four seem trawl net**		
Length of head rope (m)	26.25	21.54	18.50	16.50
Cod end mesh size (mm)	30.00	25.00	15.00	15.00
Weight of otter boards (kg)	200.00	75.00	60.00	40.00
Trawling speed in knots	2.50	2.00	2.00	2.00
Crew compliment	12	8	6	6
Endurance in days	23	10	8	2

Source : Rao, 1993a.

Prawn landings

The annual prawn landings during 1980-2005 are given in Figure 1. The annual prawn landings varied widely during this period from 10,387 t in 1987 to 31,682 t in 1999. The penaeid prawn landings fluctuated from 9,431 t in 1987 to 26,467 t in 1999 while the non-penaeid landings varied from 956 t in 1987 to 5,851 t in 1983.

The percentage comp osition of penaeids and non-penaeids for different periods is given below:

Period	Non-penaeids	Penaeids
1980-84	26.27	73.73
1985-95	9.67	90.33
1996-00	15.13	84.87
2001-05	13.36	86.64

There appears to be four distinct periods in the landing pattern of penaeids and non-penaeids in Andhra Pradesh. In the first 5-year period of 1980-84 the proportion of non-penaeids in the landings was very high (26.27%) and it came down to 9.67% during 1985-95 period. Once again the proportion was high in the 5-year period of 1996-2000 (15.13%) and declined in 2001-2005 (13.36%). It is quite possible that mesh changes of the cod ends of trawl nets influenced the landing pattern of non-penaeids.

2.10 Non-penaeid prawns

The non-penaeid prawns constitute a characteristic fishery resource along the northwest coast of India bordering Maharashtra and Gujarat states, which accounts for nearly 90% of their landings in the country. The resource comprises the tiny epiplanktonic shrimps occurring in coastal waters.They are predominantly caught by the bag nets ('*dol* nets') operated in the sea where strong tidal currents enable the bag nets to sustain horizontally and catch them along with other pelagic resources of the region such as Bombay-duck, Golden anchovy and Ribbonfishes.

The catch of non-penaeids in India (Fig. 1) showed an increasing trend from 21,934 t in 1961 to about 1.77 lakhs t in 1998,with an average annual catch of 82,677 t that contributed 4.6% to the total marine fish landings of the country. The increasing trend in the catch of non-penaeid prawns from 1961-1975 was largely due to mechanization of the crafts used for operation of bag nets, which enabled the use of more number of "nets and also more number of trips with every tide. But, "rise in the catch from 1988" onwards is largely attributed to reduction of cod end mesh size of trawl nets which resulted in very heavy catch of *Acetes* species, one of the major constituents of the non-penaeid prawns in the bycatch landed by trawlers in Gujarat (Kizhakudan and Tumber, 2003). Other major species constituting the non-penaeid prawn resource along the northwest coast are *Nematopalaemon tenuipes* and *Exhippolysmata ensirostris*.

In Maharashtra, the average annual catch of non-penaeid prawns during 1961-2010 was 44,139 t that contributed 53.4% to the total non-penaeid prawn catch of 82,677 t in India. The catch of non-penaeid prawns constituted 15.9% in total fish landings and 56.2% of total prawn catch of the state. During this period, the catch fluctuated from the maximum of 83,952 t which contributed to 38.2% in the total fish landings in 1972 to the minimum of 14,886 t in 1995 (4.7%) in the state (Fig. 2). These fluctuations did not explain any particular trend, but for the very poor catch in 1994-95 that could be due to very heavy exploitation of the resource by trawlers in the neighbouring Gujarat state in the same period. Interestingly, in Maharashtra the trawlers bring only one species of non-penaeid prawns namely *Nematopalaemon tenuipes* and rarely *Acetes* spp, unlike in Gujarat.The possible cause could be that the former species has

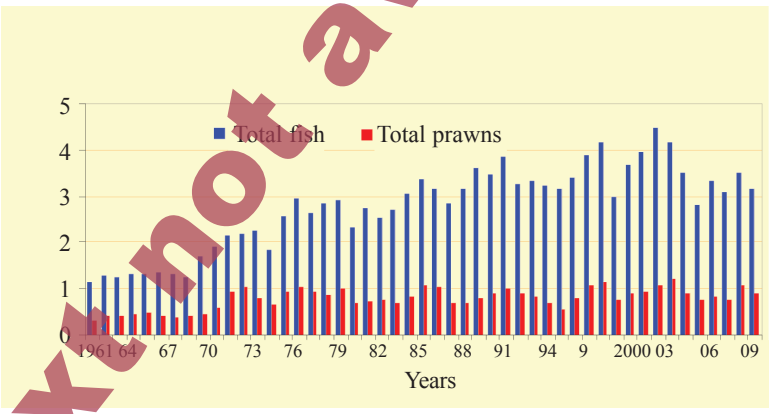


Fig 1. Non-penaeid prawn landings (in 10^3 t) in India from 1961-2010

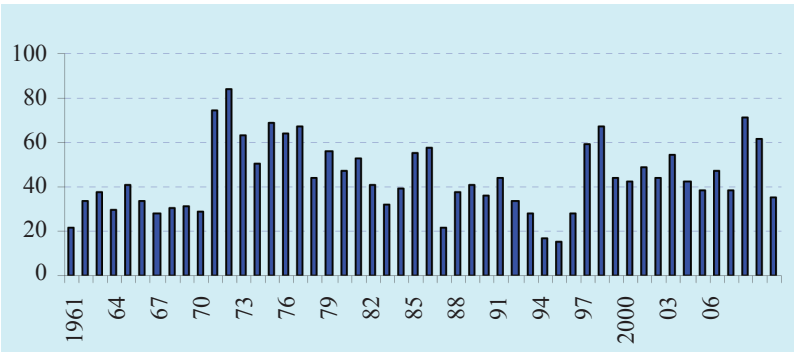


Fig 2. Non-penaeid prawn landing (in 10^3 t) in Maharashtra

better demand in fresh condition in Maharashtra, while the latter gets decomposed rapidly so that fishermen discard it at sea along with the low value by-catch.

During 2001-2010, the average annual catch of non-penaeid prawns in Maharashtra was 48,053 t that was equivalent to 32.9% to the total non-penaeid prawn catch of the country, while in the state it constituted 14% of total fish landings and 52.7% of the total prawn catch.

Gear-wise catch

Bag net is the principal gear for catching non-penaeid prawns in Maharashtra. Smaller bag net, called 'Bokshi' is operated in inshore creeks for catching non-penaeid prawns along with Bombay-duck, golden anchovy and juveniles of many species of prawns and fishes. The resource is also caught as by-catch in trawl nets in addition to small meshed shore seines. Since tidal amplitude and the tidal currents are high along the northern coastline of the state, the bag nets are operated only in northern Thane, Mumbai and Raigad districts and evidently the non-penaeid prawns are landed in these districts only. In southern Ratnagiri and Sindhudurg districts these prawns are occasionally landed by trawlers and shore seines.

During 2001-2010, the average annual catch of non-penaeid prawns was 48,053 t of which the major share came from bag nets (84.2%) followed by trawl nets (14.1%) and the rest (1.7%) from other gears (Fig. 3).

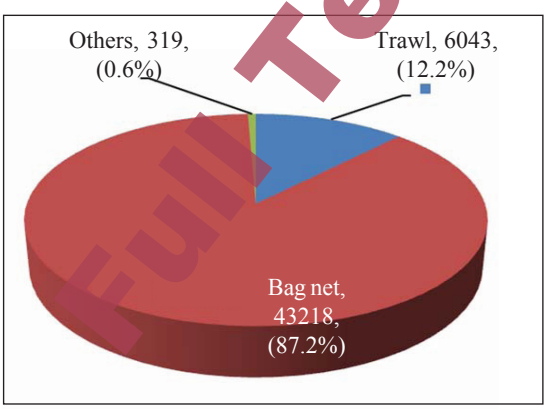


Fig 3. Gear-wise catch of non-penaeid prawns in Maharashtra during 2001-10

In the bag nets (Fig. 4), catch of non-penaeid prawns during 2001-10 ranged from 32,517 t in 2007 to 60,385 t in 2008 with annual average of 40,164 t. The catch rate was, however, minimum (11.02 kg/haul) in 2004 and maximum (22.54 kg/haul) in 2009 with an average catch rate of 15.6 kg/haul (Fig. 4) during the period.

In trawlers, the annual catch during 2001-10 ranged from 2,706 t in 2010 to 12,317 t in 2004 with an average of 6,702 t and the catch rate from 0.47 kg/hour in 2007 to 1.83 kg/hour in 2004 (Fig. 5). The average annual catch rate during the period was 1.05 kg/hour.

In 2001-2010 other gears, which mainly included non-mechanized 'Bokshi' nets landed an average of 821 t of non-penaeid prawns.

Raje and Deshmukh (1989) pointed out that fishermen at Versova, depending on the availability of fish make use of different meshed cod ends for the bag net operation. At the beginning of the fishing season in September-October, when Bombay duck, golden anchovy, ribbonfishes, penaeid prawns and pomfrets are plenty in the catch the fishermen use large meshed cod ends (>25 mm), but change over to smaller meshed cod end (<15 mm) for catching non-penaeid prawns during December to May when fish and penaeid prawns abundance is poor. This method is now followed almost all along Thane district in general, and Arnala, Vasai and Uttan landing centres in particular, where not only large meshed cod ends (up to 40 mm) are used but also overall length and dimensions of the bag nets are reduced to catch juveniles of the most sought after silver pomfret. Such modified bag nets (called '*Karlidol*'net) facilitate filtering off non-penaeid prawns, and therefore composition of their catch in bag nets is different.The percentage contribution of non-penaeid prawns in bag nets used at different centres in Maharashtra is given in Fig. 6. During 2001-10, the percentage composition of non-penaeids in Raigad district (MH-5 zone) was as high as 67.4% followed by Versova (44.4%), Arnala (27.9%) and Vasai (6.7%), where bag nets are operated in open sea. In the nets operated in inshore creeks and observed at Sassoon docks and NFW in Mumbai, their percentage in total fish landings was only 21.7% and 17.1%.

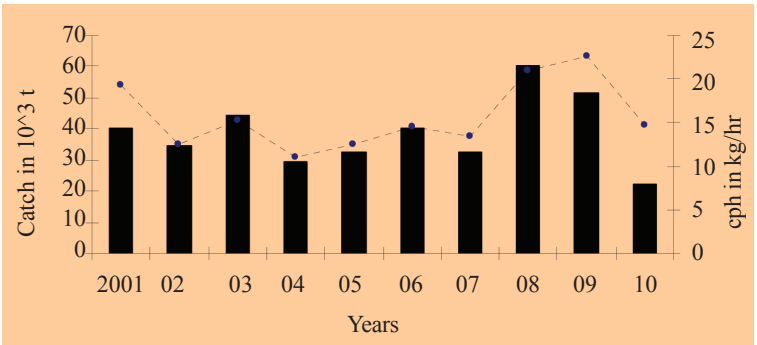


Fig 4. Year-wise catch and catch rate of non-penaeid prawns by bag nets

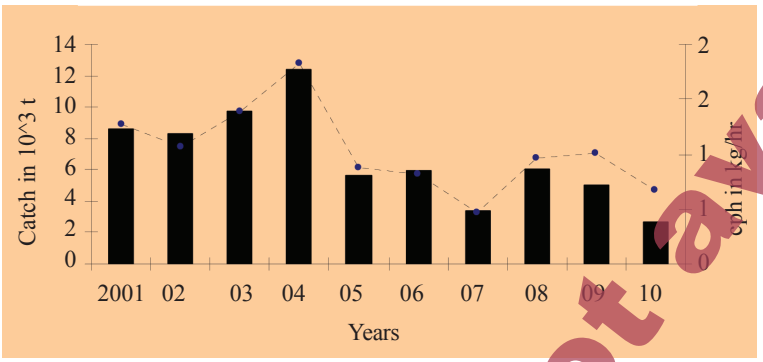


Fig 5. Year-wise catch of non-penaeid prawns by trawlers

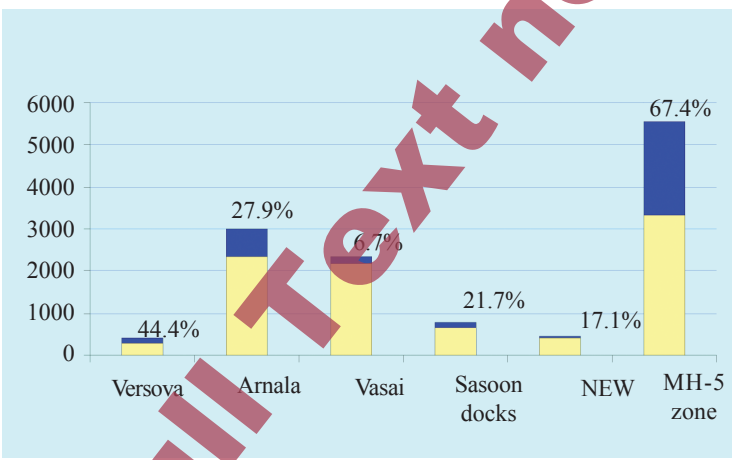


Fig.6. Total fish and non-penaeid prawn catch (t) in offshore bag nets

Species composition

Major species contributing to the non-penaeid prawn fishery are *Acetes indicus*, *Nematopalaemon tenuipes* and *Exhippolysmata ensirostris*. The epipelagic prawns belonging to the genus *Acetes* are represented by four species namely *A. indicus*, *A. johni*, *A. japonicus* and *A. sibogae* in Maharashtra. Among the species *A. indicus* and *A. johni* are generally caught in bag nets operated in the open sea waters while *A. japonicus* and *A. sibogae* are noticed seasonally in inshore creeks. *N. tenuipes* is also planktonic while *E. ensirostris* is littoral benthic but occasionally surfaces to get trapped in bag nets along with other penaeid prawns. *Exopal -aemon styliferus*, a species close to *N. tenuipes*, occurs in estuarine waters and forms small percentage of non-penaeid prawns in the inshore bag nets. In addition, a number of species belonging to the family Palaemonidae occur in the bag nets operated in the inshore waters during monsoon, but none of them supported a regular fishery.

The composition of species supporting the non-penaeid prawn fishery at different landing centres and zones during 2001-2010 is given in Table 1. At almost all the centres, excepting Vasai, *Acetes* spp. predominated and constituted 58.2-82.4% of the non-penaeid prawn fishery. At Vasai, the bag nets with larger mesh size are selectively used for pomfrets which filter off *Acetes* spp. but retain good quantity of *N. tenuipes* from February to May. From the estimated species wise landings, an average species composition for the state has been arrived at by giving appropriate weightage for the centres and zones. Accordingly, during 2001-2010 *Acetes* spp. formed 73.9%, *N. tenuipes* 23.2%, *E. ensirostris* 2.8% and *E. styliferus* 0.1% of the non-penaeid prawn fishery in the state.

2.11 Deep-sea prawns

From the beginning of this century, large varieties of prawns belonging to families Penaeidae, Pasiphaeidae, Oplophoridae and Pandalidae have been reported from the west coast of India, particularly from southern regions beyond the continental shelf (Alcock 1901, 1906; de Man 1911, 1920; Calman 1939; John and Kurian 1959; Kurian 1964; George 1966; George and Rao 1966b; Suseelan and Mohamed 1968 and Suseelan 1974, 1989). However, existence of some of these species in commercially exploitable concentrations in these deeper waters has been brought to light only recently. Silas (1969) and Mohamed and Suseelan (1973) gave general accounts on the distribution and relative abundance of common species of prawns of the shelf-edge and upper continental slope of the southwest coast. Detailed review on deep-sea fisheries of India has been given recently by Rao (2009).

The rapid development that has taken place in the 60's in the prawn processing and export industry of India has not only intensified the exploitation of the inshore prawn resources but also prompted the search for new resources. A concerted effort in finding out the extent of such resources can be said to have commenced only from 1967 when some newly acquired trawlers of the erstwhile Indo Norwegian Project (INP) started exploratory trawling and charting of the deep-sea grounds lying off the Kerala coast.

Exploratory surveys by INP vessels

The INP Vessels *M.V. Klaus Sunnana*, *M.V. Velameen* and *M.V. Tuna* and the research vessel *R.V.Varuna* were the first to conduct detailed surveys along the southwest coast. The area covered by these operations lie between latitude 8° N and 14° N off southwest coast of India and in the depth range of 120-430 m. These areas are characterized by certain physical features, which are significantly different from the conventional trawling grounds of the inshore region. Mohamed and Suseelan (1973) analysed the operations of these vessels during 1965-1968 and gave a detailed account of the findings.

The exploratory vessels *Klaus Sunnana*, *Tuna* and *Velameen* made 190 hauls in 22 cruises at depths ranging from 200 to 395 m, mostly off Quilon and Alleppy and *R. V. Varuna* made 96 hauls from depths varying between 124 m and 430 m. Of the 286 hauls, 37 contained no catch whatsoever and in the remaining 249 hauls the catch varied from 1 kg to 2,510 kg per haul of approximately one hour duration and amounted to a total yield of 63,928 kg including fish, prawns, lobsters and other crustaceans. The overall catch per hour of trawling (CPH) worked out to 231.62 kg and that of prawns alone to 89.5 kg. The 24,700 kg of prawns landed formed a little over 38% of the total catch. Prawns were obtained in 207 hauls and their catch varied from 0.5 kg to 930 kg per haul of one-hour duration.

Although about 18 species of penaeid and non-penaeid prawns were observed in the catches, only about 8 species constituted the bulk of the catch. The common species of prawns that constituted the deep-sea catch were *Heterocarpus woodmasoni*, *H. gibbosus*, *Plesionika spinipes*, *P. martia*, *P. ensis*, *Metapenaeopsis andamanensis*, *Penaeopsis rectacuta* and *Aristeus alcocki*. While one or the other species of prawns showed concentration in particular areas, the catches were always of heterogeneous nature and contained several species in varying proportions. *Oplophorus gracilirostris*, *Parapenaeus investigatoris*, *Hymenopenaeus aequalis* and *Solenocera hextii* were also landed occasionally in considerable quantities. Prawns were by no means, the only catch obtained in these operations. As stated already, fishes accounted for more than half the landed weight of the catches. The common species of fishes in the by-catch were *Chlorophthalmus agassizi, C. bicornis*, *Cubiceps natalensis, Epinnula orientalis* etc. Although these fishes accounted for the bulk of the catch they were seldom retained on board as they were of very little value in relation to the prawns caught. The Indian deep-sea lobster and portunid crabs were the other common items in the by-catch.

A general appraisal of the distribution of these prawns, made possible by these exploratory work shows that the species composition and the intensity of their distribution vary from place to place

Chapter 3

Species

3 Species

3.1 Penaeus indicus

It was Perez Farfante (1969) who first split the Genus *Penaeus* into sub-genera and then into genera. But a number of taxonomists have not accepted the splitting of the Genus *Penaeus* into five or six separate genera. Lavery *et al*. (2004) made detailed mitochondrial DNA sequences on samples collected from almost all the countries in the world and rejected the idea of splitting the genus *Penaeus* into different genera.

Penaeus indicus H. Milne Edwards, 1837 is closely related to *P. merguiensis* (de Man, 1888), and *P. penicillatus* (Alcock, 1905) differing only in a very few characters. For a long time identification of these three species posed problems. Muthu and Rao (1973) conducted detailed studies on *P. indicus* and *P. merguiensis* and gave clear cut distinguishing characters based on colour pattern of the antennal and antennular flagella and the pleopods and disposition of rostral teeth. This study also helped in distinguishing *P. penicillatus* from *P. merguiensis*. The ever increasing demand and economic value make this resource highly esteemed in capture fisheries as well as in culture practices. This species prefers sandy or muddy bottom. It is a eurythermal and euryhaline species which can tolerate up to 45‰ salinity (del Mundo, 2000). Though they are available up to a depth of 90 m, it is abundant in coastal areas less than 30 m depth (Fischer and Bianchi, 1984). The juveniles of this species migrate to estuaries and the adults return to the sea for breeding.

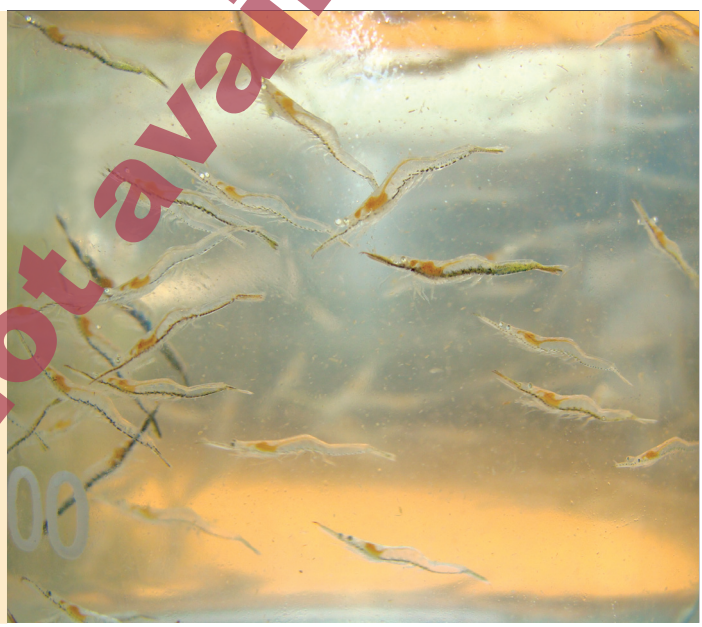
Distribution

Penaeus indicus is an Indo-Pacific species (western and eastern Indian Ocean, North-west, western central and eastern central Pacific Ocean), reported from Australia, Bangladesh, China, Comoros, Djibouti, French Polynesia, Hong Kong, India, Indonesia, Japan, Kenya, Madagascar, Malaysia, Mauritius, Mayotte, Mozambique, Pakistan, Papua New Guinea, Philippines, Reunion, Seychelles, Somalia, Tahiti, Tanzania, Thailand and Yemen. In Kenya it forms 79-90% of the shrimp catch (Brusher, 1974).

In India this species is available all along the coasts but the occurrence is poor along the Maharashtra coast (Kunju, 1967a) and absent along the Gujarat coast. *P. indicus* has been reported earlier from Kandla (20.8%), Tuna-sangadh (15.6%) and Lunei (48.8%)) of Kutch coast (Ramamurthy, 1963 a) and also from different landing centres (0.5-90%) of Kutch coast during 1962-63 (Deshmukh, 1975). Shaikhmahmud and Tembe (1960) have recorded considerably good numbers (12.6%) of this species in the prawn landings of Sassoon Docks, Mumbai. According to Kunju (1967), the *Penaeus* species available along these coasts is *P. penicillatus* which had earlier been described as a variety of *P. indicus* (Alcock, 1906) but subsequently has been raised to the status of a separate species. Along the east coast it is available in good quantities up to Andhra coast and gradually gets replaced by *P. merguiensis* and *P. penicillatus* along the Orissa-West Bengal coast. It is of great commercial value along the coasts of Kerala, Tamil Nadu and Andhra Pradesh

Chapter 4

Larval Development



Larvae of *Penaeus monodon*

4

Larval Development*

Apart from *Penaeus monodon, P. indicus, P. semisulcatus, Metapenaeus dobsoni, M. affinis, M. monoceros, M. brevicornis* and *Parapenaeopsis stylifera* for which larval development studies have been successfully completed by CMFRI, the complete larval development of a number of species of penaeid prawns has been traced from eggs spawned in the laboratory in many parts of the world. The larval stages of *Penaeus japonicus* (Hudinaga, 1942) *P. orientalis* (Oka, 1967), *P. latisulcatus* (Shokita, 1970), and *Metapenaeus joyneri* from Japan (Lee and Lee, 1968), *Penaeus monodon* from Philippines (Villaluz *et.al.,*1969), *Metapenaeus bennette* (Morris and Bennet, 1951), *Penaeus esculentus*(Fielder *et. al.,*1975) from Australia, *Penaeus merguiensis* and *Metapenaeus monoceros* (Raje and Ranade, 1972b) from India, *Penaeus trisulcatus, Parapenaeus longirostris* and *Sicyonia carinata* (Heldt, 1938), from the Mediterranean sea and *Penaeus setiferus* (Heegaard, 1953), *Penaeus duorarum* (Dobkin, 1961), *Penaeus aztecus* (Cook and Murphy, 1971), and *Sicyonia brevirostris* (Cook and Murphy, 1965) from the Gulf of Mexico have been described. A detailed study of the larval characters of the eight Indian penaeid species presented in this Bulletin, with the descriptions of the other species referred to above. A comparison has resulted in a clear understanding of the general pattern of development of the morphological features of the nauplius, protozoea, mysis and postlarval stages of the penaeid prawns and has brought to light certain generic characters by which the larvae belonging to the genera *Penaeus, Metapenaeus* and *Parapenaeopsis* could be identified. The earlier work of Cook (1966) on the generic characters of the penaeid larvae of the Gulf of Mexico region does not cover the typically Indo-Pacific genera *Metapenaeus* and *Parapeneopsis* which are of great commercial importance in the latter region. This lacuna was partly filled by the work of Haq and Hassan (1975), who have described some of the generic characters of the larvae belonging to the genera *Penaeus, Metapenaeus* and *Parapenaeopsis* from Pakistan waters. However, during the present study the authors have found additional morphological features which appear to be characteristic of these three genera. Further they found for the first time some characters by which even the nauplius stage of these three genera can be distinguished. The larvae of different species belonging to the same genus, however, are so similar that specific identification of the larvae is not possible, except for some stages of *Metapenaeus*. A summary of the observations on penaeid larval development is presented here.

Egg stage

A very narrow perivitelline space (about 15µ in width) appears to be characteristic of the eggs of all the species of *Penaeus* described so far. The eggs of *Metapenaeus* species (except *Metapenaeus dobsoni)* possess a narrow perivitelline space of 20 to 30µ in width. The eggs of *M. dobsoni* are peculiar in having a very wide perivitelline space which is about 85µ in width. The perivitelline space of the eggs of *P. stylifera* is 60µ wide. The diameter of the yolk mass was more or less the same (0.22 - 0.24 mm) in all the eight species of penaeid eggs studied bythe authors, the differences in the egg diameter being due to differences in the width of the perivitelline space which develops only after fertilization. The

Chapter 5

Identification of post larvae

5

Identification of post larvae*

The possibility of using the postlarval abundance in brackish water areas to predict the subsequent abundance of adult prawns in the sea has been discussed by Baxter (1963), Christmas *et al.,*1966), George (1963a), Berry & Baxter (1969) and Rao (1972). For work of this nature the specific identity of the postlarvae is essential, especially in a multi species fishery. This is also necessary for selective stocking in prawn culture operations.

Various criteria have been used by previous workers for the identification of the postlarval penaeids. Williams (1959) found that the post-larvae of *Penaeus setiferus, P. duorarum* and *P. aztecus* could be distinguished on the basis of (a) the shape of A1 scale and (b) the extent of the rostrum and the extent of the pereiopods in relation to the eye. Ringo and Zamoro (1968) found that the presence of minute spines on the dorsal carina of the 6th abdominal segment in the postlarvae of *P. aztecus* and *P. duorarum* is a taxonomic character which could be used to separate them from the postlarvae of *P. setiferus* which lack these spines. Mohamed *et al.,* (1968) have described the first postlarval stage of *P. indicus, M. monoceros, M. affinis* and *Parapenaeopsis stylifera* and used the number of telsonic spine, number of rostral spines, presence or absence of long setae on the distal lateral aspect of the 6th abdominal segment, the presence or absence of posteromedian dorsal spine on the 5th and 6th abdominal segments and the general body colour as criteria for identifying them. Subrahmanyam and Rao (1968) used the number of chromatophores on the ventral side of the body (especially on the 6th abdominal segment) and on the antennular peduncle to identify the postlarvae of *P. indicus, P. monodon,* and *P. semisulcatus.* Prawirodihardjo *et al.,* (1975) have used the pigmentation of the uropod and telson to distinguish between the postlarva of *P. monodon* and *P. semisulcatus.*

In trying to identify the postlarvae found in the brackish waters around Madras, it was found that the chromatophore pattern on the tail fan provided a very reliable criterion for identifying the early postlarval stages. The chromatophores were visible even in material fixed in formalin for 15-20 days if the specimens were kept in dark place away from light. The pattern is more important than the colour or number of chromatophores. On the basis of the chromatophore pattern on the tail fan the post-larvae eight species of penaeids viz. *Penaeus indicus, P. merguiensis, P. semisulcatus,*

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2.10 Non-penaeid prawns	:	V. D. Deshmukh
2.11 Deep-sea prawns	:	G. Nandakumar K.N. Rajan Josileen Jose K. Chellapan
2.12 Estuarine prawns	:	G. Sudhakara Rao A.P. Dineshbabu P.T. Sarada Joe K. Kizhakudan
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3.2 *Penaeus monodon*	:	G. Sudhakara Rao
3.3. *Penaeus semisulcatus*	:	M. Rajamani
3.4 *Parapenaeopsis stylifera*	:	P.T. Sarada
3.5 *Metapenaeus monoceros*	:	G. Sudhakara Rao
3.6 *Metapenaeus dobsoni*	:	S. Lakshmi Pillai
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