CHAPTER 1
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Fish and fisheries make an important contribution to the world's food supply, and are a source of income for over 100 million people who depend directly or indirectly on fisheries for their livelihood (Anon., 1996a). The global fish production has risen to about 100 million metric tons (Anon., 1995) and this is regarded as being at or close to the maximum biological limit. Projected population growth over the next 10-15 years implies an increase in global demand of about 20 million metric tons if per capita consumption remains steady. Asia is believed to face the greatest gap between supply and demand. To satisfy the demand will require improving the management of fisheries, making better use of the catch and increasing production through aquaculture.

India is one of the leading fish producing countries in the world and an important supplier of fishery products in the international market. The country's prominence in the world market is mainly through the export of crustacean products which remained the back bone of the fishery industry for nearly half a century. Among the seafood items exported from the country, crustaceans comprising of prawns, lobsters and crabs accounted for about 45% in terms of weight and 70% in terms of value of the total export earnings of Rs. 35,000 million from the marine products during the year 1995-96 (Anon.,1996b, 1997).

Among crustaceans, crabs occupy the third rank, the first and second positions being given to prawns and lobsters on account of their demand in the overseas market. According to Suseelan (1996 b) an average of about 25000 t of crabs are exploited annually from the marine sector, of which over 50% is landed along
the Gujarat and Tamil Nadu coasts. Being a commodity of lesser export value in the processed form, no commercial operation is directed towards this resource in a big way in the country. However, with the modernisation of fishing methods, crabs are increasingly landed as bycatches of shrimp trawlers and other fishing units throughout the country.

Out of 8 species of commercially important portunid crabs of India (Rao et al., 1973), the mud crabs of genus *Scylla* are exceptionally important due to their large size and better nutritive value and hence in great demand in the domestic market. The mud crab emerged as a commodity for export in live condition in 1982 (Raj, 1992) which marked the beginning of a flourishing export industry for the crab which remained unimportant for ages. Mud crabs support fisheries of considerable magnitude in the South East Asian countries like Philippines, Indonesia, Thailand, Malaysia and in countries bordering the Bay of Bengal (Anon., 1992b). According to available information, nearly 30,000 metric tons of mud crabs are exploited annually in the Indo-Pacific region of which about 40% is contributed by Philippines and the rest mainly by Indonesia and Thailand (Anon., 1995). India is estimated to have a potential resource of about 8400 t of mud crabs (Prasad, 1990). The export of live mud crabs from India to countries like Singapore, Malaysia and Hongkong stimulated increased exploitation of mud crabs from their natural habitats such as brackishwater lakes, estuaries, mangrove areas and inshore waters during the past 10-15 years and the fishing pressure on this limited resource is ever on the increase. The attractive prices offered for live crabs in the export trade prompted efforts to culture mud crabs in some parts of India as practised in a more organised manner in the South East Asian countries (Kathirvel, 1995; Babu, 1995; Suseelan et al., 1995; Suseelan, 1996 a). As a result of this renewed interest in mud crab production and export, India has been able to make a steady progress in live crab export, the quantity exported increasing from 36 t in
1987-88 to 728 t valued at Rs.52 million in 1993-94 (Anon., 1996b).

As in the case of any other valuable aquatic resource, development of mud crab fishery will be possible only through careful management of the wild stock at sustainable yield level and additional production through aquaculture. In India the capture fishery for mud crab is in a disorganised manner (Srinivasagam & Kathirvel, 1992) and the culture fishery is only in the infant stage, that too based on natural seed resources. There has not been any systematic investigation on mud crabs of India so far. The taxonomic status of mud crabs is still a controversial subject and little is known of their biology/larval history in the country. The techno-economic viability of mud crab culture also is not established in a convincing manner to lure entrepreneurs to take up large scale mud crab farming with confidence. This is because of the lack of scientific basis to plan culture programs for successful results. Considering the gaps in our knowledge on this group a study on the fishery and culture prospects of mud crabs was taken up with particular reference to Kerala coast and the results are presented in the thesis.

Review of Literature

A perusal of the available literature on the brachyuran crabs would reveal that most of the earlier works on this group relate to taxonomic aspects as could be evident from the classical works of Linnaeus (1758), Fabricius (1798), de Haan (1833), Dana (1852), Wood-Mason (1871), Henderson (1893) and Alcock (1895, 1896, 1898, 1899 a, 1899 b, 1899 c, 1900) from different parts of the world including the Indian subcontinent. Later, many authors have contributed greatly to the systematics of Indian Brachyura particularly from the mainland, the notable contributions being those of de Man (1908), Kemp (1915, 1923), Gravely (1927), Chopra (1931, 1933, 1935), Chopra and Das (1937), Panikkar and Aiyar (1937), Pillai (1951), Chhapgar (1957) and Sankaran kuttty (1966). Faunistic accounts of brachyuran crabs of Andaman-Nicobar Islands have been dealt with by Alcock (1899a), Chopra

Information on the fishery of crabs of Indian waters is available from the works of Rai (1933) who dealt with the magnitude of production together with information on some aspects of the biology of crabs of Bombay coast. Later, Chopra (1936, 1939) furnished details of crab fishery of Indian coast in general. Chidambaram and Raman (1944), Prasad and Tampi (1952) and Chacko and Palani (1955) dealt with the crab fishery of east coast, whereas Menon (1952), George and Nayak (1961) and Chhapgar (1962) reported on the crab fishery of the west coast. An annotated bibliography of the fishery and biology of edible crabs of India was published by George and Rao (1967). The crab fishery of India was reviewed in greater detail by Rao et al. (1973). Since then many authors have reported on regional crab fisheries, which included accounts of Jones and Sujansinghani (1952), Prasad and Tampi (1952), Chacko et al. (1953), Chacko and Palani (1955), Chacko (1957), Chacko and Rajagopal (1964), Balasubramanian (1966), Thomas (1971), Mohanty (1973 a, b), Datta (1973), Ansari and Harkantra (1973), Mohanty (1975), Srinivasagam (1975), Ameer Hamsa (1978), Radhakrishnan (1979), Lalitha Devi (1985), Sreenivasagam and Raman (1985) and Joel and Raj (1987).

Various aspects of the biology of portunid crabs have been documented from about the middle of this century, the notable contributions from India being those of Krishnaswamy (1967), Rahman (1967), Chandran (1968), Pillai and Nair (1968, 1971 a & b, 1973a, 1975), Nagabhushanam and Kulkarni (1977), Ajmalkhan and Natarajan (1979), Joel and Sanjeevaraj (1982), Sethuramalingam et al. (1982), Pillai and Subramoniam (1984), Bawab and El.Sherif (1988) and Jacob et al. (1990).

The contributions of Fasten (1926), Nath (1932), Iyer (1933), Cronin (1947), Ryan (1967a,b), Adiyodi (1968), Langreth (1969), Chiba and Honma (1971, 1972),
Vasisht and Relan (1971), Diwan and Nagabhushanam (1974), Joshi and Khanna (1982a,b) and Adiyodi and Subramoniam (1983) on the reproductive biology of portunid crabs are considered as classical works which have been profusely referred to in the subsequent studies world over.


Larval development of brachyuran crabs of India has been studied by many workers like Menon (1933, 1937, 1940), Prasad (1954) and George (1958) based on plankton collections. Later many workers have traced out the larval history of brachyuran crabs by rearing berried females in the laboratory and then constructing the larval history by separating further stages from the plankton samples. Naidu (1950, 1954, 1955, 1959, 1960a, b, 1962, 1972, 1974) studied the early development of many species and postlarval development of few species of crabs. Prasad and Tampi (1953, 1957) could hatch out the first zoa of Neptunus pelagicus and Thalamita crenata in the laboratory. Sankolli (1961) described the early larval stages of the leucosid crabs Philyra coralicola and Arcania septemspinosa.

Later, the larval history of several species including the commercially important portunids was traced out fully or partly through laboratory rearing by

Investigations on mud crabs began with the first record of Cancer serratus in the middle of 18th century by Forskal (1755). This was followed by the studies of several workers like Herbst (1796), Fabricius (1798), de Haan (1833), Milne Edwards (1834), Dane (1852) and Stimpson (1907) from differed parts of the Indo-Pacific region. Detailed taxonomic revision of the genus Scylla de Haan was made by Estampador (1949 a, b) which was subsequently reviewed by Stephenson and Campbell (1960) who suggested the need for more work on the group. Quite recently Fuseya and Watanabe (1996) from Japan proposed three species for genus Scylla on the basis of variation noticed through electrophoretic analysis.

From Indian waters references to the occurrence of species of mud crabs have been made from about the close of 18th century with the report of Fabricius (1798) who described Portunus tranquebaricus based on specimens obtained from Tanquebar (Tharagampady of Tamil Nadu coast). Subsequently authors like Alcock (1899), de Man (1908), Kemp (1915), Gravely (1927), Pears (1932), Chopra and Das (1937), Panikkar and Aiyar (1937), Pillai (1951), Naidu (1953), Chhapgar (1957, 1962), Balasubramanian (1966), Rekha (1968), and Premkumar and Daniel (1971) made mention of species of Scylla while dealing with the fishery and faunistic accounts of portunid crabs. Detailed taxonomic investigations on the group from India were undertaken by Joel and Raj (1980, 1983) from Pulicat lake along the Tamil Nadu coast, Kathirvel (1981) and Radhakrishnan and Samuel (1982) from Cochin backwaters along the Kerala coast. Quite recently Kathirvel and Srinivasagam (1992 b) made a critical review of the taxonomic studies on mud crabs and suggested the existence of two distinct species along the Indian coast.

Information on the fishery and biological aspects of mud crabs from differ-
ent parts of the Indo-Pacific are available from the works of Heasman and Fielder (1977), Williams and Hill (1982), Hill (1984b) and from the reports and papers presented at the seminar on the mud crab culture and trade, held at Surat Thani province of Thailand in 1991 (Cholik and Hanafi, 1992; Khan & Alam, 1992; Jayamanne, 1992; Lee, 1992; Tookwinas et al., 1992; Larda and Mondragon, 1992; Ahmed, 1992).


Various aspects of the reproductive physiology of *S. serrata* have been documented, of which the studies of Ezhilarasi and Subramoniam (1980) on spermathecal activity and ovarian development and those of Ezhilarasi (1982) and Nagabhushanam and Farooqui (1982) on biochemical changes during ovarian maturation are noteworthy. Nagabhushanam and Farooqui (1981, 1982b) worked on the photoperiodic stimulation of ovary, while Rangnekar and Deshmukh (1968) and John and Sivadas (1978, 1979) studied the effect of eye stalk ablation on ovarian maturation of *S. serrata*. The effect of hormones on ovarian development was dealt with by Sarojini *et al.* (1985, 1990). Anatomy of male reproductive system of mud crab was dealt with by Gupta and Chatterjee (1976). Uma and Subramoniam (1979, 1982) worked on the histochemical characteristics of spermatophore layers and biochemical aspects of seminal plasma and spermatophore of *S. serrata*. Jayalectumi and Subramoniam (1989) reported on the cryopreservation of spermatophore and seminal plasma of this species. Heasman *et al.* (1985) reported on the mating and spawning behaviour of *S. serrata*.

The biochemical aspects and nutritive value of mud crabs have been dealt with by many workers like Gangal and Magar (1964), Chinnamma George and James (1971), Deshmukh and Rangnekar (1973), Hackman (1974), Senthikumar and Desai (1978), Kannan and Ravindranath (1980), Radhakrishnan and Samuel (1985) and Chinnamma George *et al.* (1986).


The crab farming methods around the world have been described by Bardach et al. (1974) and Pillay (1990). Cowan et al. (1984) dealt with in detail the crab farming methods practised in Japan, Taiwan and Philippines.

Mud crab farming methods in Philippines include Polyculture, monoculture and fattening as described by Escritor (1970, 1973), Pagcatipunan (1972), Catanaoan (1972), Robles (1978), Lapie and Librero (1979), Lavina (1979, 1980), Lijavco *et al.* (1980), Baliao *et al.* (1981), Larde (1992) and Samonte and Agbayani (1992). Sivasubramaniam and Angell (1992) reported an average production of 111 kg of crabs, 500 kg of milkfish and 52 kg of shrimp from polyculture ponds and 339 kg of mud crab from 1 ha monoculture pond in Philippines. The state of art of mud crab culture in Malaysia has been described by Ferdouse (1990) and Chong (1992). According to Chong (1992), mud crab farming in Malaysia involves both grow-out culture and fattening. Pond culture is subsistence in nature producing less than 50 t per year whereas fattening, which is mostly practised in floating net cages, produces more than 600 t. Chen (1990) dealt with in detail the crab farming methods practised in Taiwan. Unlike in other countries, mud crab farming here is a well organised industry with nursery, grow-out and fattening operations and the yield varies from 5000-9000 crabs/ha. Taiwan is reported to have achieved success in hatchery production of mud crabs with survival rate upto 60% and a production rate of 6000 seed/t of rearing water (Sivasubramaniam & Angell, 1992). Inspite of several attempts to culture mud crabs in Srilanka (Rhaphel, 1970, 1972; How-Cheong & Amendakoon, 1992; How-cheong *et al.*, 1992; De Silva, 1992) the mud crab farming in the country is still in its infancy. Recently Samarasinge et al. (1992) successfully cultured mud crabs in an old semi-inten-
sive shrimp culture pond and achieved a production of 394 kg/3900 m²/115 days and reported a survival of 43.7%. Several workers have attempted experimental culture of mud crabs in Thailand, and some of the notable trials were those of Bindakul (1975), Varikul et al. (1972), Hanvivatanki (1990), Prinpanapong and Youngwanichsaed (1992) and Rattanachote and Dangwatankul (1992). Harvey (1990) and Suresh (1991) dealt with in detail the status of mud crab farming in Thailand, while Hanvivatanki (1990) discussed about the economics of mud crab fattening in Surat Thani province of Thailand. According to Suresh (1991) mud crab farming in Thailand is either fattening (to produce gravid females) or a short term culture involving stocking crabs of 200-300 g weight and raising them to 400-500 g weight in about a month’s time. From Indonesia, Gunarto et al. (1987) described about the mud crab culture at different salinity levels and Gunarto and Cholik (1990) about the effect of stocking density. Cholik and Hanafi (1992) reviewed the fishery and culture of mud crabs in Indonesia in great detail.

Mud crab culture is in its infant stage in Bangladesh (Ahmed, 1992), while it is an age old practice in China where farming is done in about 1400 ha with a total annual production of 2000 t (Yalin & Qingsheng, 1994). There is virtually no mud crab farming in Australia, but many have pointed out its potential there (Hill, 1984a; Cowan, 1984; Gillespie & Burke, 1991). Japan is unique in having very large scale programme for replenishing depleted marine fishery resources including crabs by hatchery bred seedling in the natural water beds and mud crab seedlings were stocked in lake Hamans as part of such programmes, (Cowan, 1984; Sivasubramanian & Angell, 1992). Japan is also reported to have achieved species-wise seed production of mud crabs (Fuseya & Watanabe, 1996).

In India, the prospects of mud crab culture was pointed out as early as the middle of this century (Naidu, 1955). Subsequently, Radhakrishnan and Samuel (1980), Nagabhusanam et al. (1982), Chandrasekaran and Perumal (1993),