2.1 Indian Brachyura - A Review

Studies on brachyuran fauna of Indian seas were initiated by Milne Edwards (1834), Henderson (1893) and de Man (1888 a, b) and they mostly dealt with the deep sea species. Later several authors dealt with various aspects of the brachyuran crab fauna of Indian sub continent including the fishery aspects, biological studies, diversity, systematics, ecological aspects and culture techniques.

The important notable works related to the brachyuran fauna of Indian waters include that of Kemp (1917, 1919); Gravely (1927); Chopra (1931), Chopra and Das (1930, 1937); Pearse (1932), Panikker and Aiyyer (1937); Pillai (1951); Prasad and Thampi (1952, 1953); Menon (1952); Jones and Sujansinghani (1982); Chacko et al. (1953), Naidu (1953); Chacko (1956, 1957), Chhapgar (1957, 1962); George and Nayak (1961); Sankarankutty (1965); Thomas (1971); Ramamurthy (1972); Rao et al. (1973); Raman and
Srinivasagam (1978); Jameson et al. (1982); Srinivasagam and Raman (1985); Chakraborty et al. (1986); Thomas et al., (1987); Joel and Raj (1987); Manna (1988); Prasad and Neelakantan (1989); Balasubramanian (1993); Sukumaran and Neelakantan (1997); Roy and Das (2000); Ravichandran et al. (2001); Bijukumar et al. (2007); Soundarapandian et al. (2008); Funde et al. (2009); Josileen (2001, 2011).


Ecological aspects of crabs including the zonation, habitat preferences, distribution and abundance of crabs in varying environmental conditions were dealt with by Pearse (1932), Balasubramanyan (1966), Rajinder et al. (1976), Roy and Das (2000), Ravichandran et al. (2001), Ajmal khan and Ravichandran (2009), Pandya and Vachhrajani (2010), Trivedi et al. (2012), Devi et al. (2013).
Studies related to larval development of crabs was dealt with by many workers including Naidu (1953), Anil (1997), Kathirvel et al. (2004), Josileen (2001).

Faunistic accounts of Brachyuran crabs of Andaman-Nicobar Islands have been dealt with by Alcock (1899), Chopra (1935), Sankarankutty (1961a), Premkumar and Daniel (1971), Reddy and Ramakrishna (1972), Kathirvel (1983), Pretzmann (1984), Deb (1985a, b) and Kumaralingam et al. (2012) while Borradile (1902), Sankarankutty (1961b), Meiyappan and Kathirvel (1978) and Suresh (1991) dealt with the crabs of Lakshadweep Islands.

2.2 Diversity of Brachyuran crabs- A Review

The earlier works on the brachyuran crab diversity were mostly restricted to the eastern coast of India and Bay of Bengal (Kemp, 1917, 1919; Gravely, 1927; Chopra and Das, 1930, 1937). The brachyuran fauna of west coast of India was first dealt with by Pillai (1951), who studied the crabs of Travancore waters. Later, Chhapgar (1957) gave a detailed account on the marine crabs of Bombay state along with their geographic distribution. An extensive study on the brachyuran crabs of Killai backwaters was done by Sethuramalingam (1983) and recorded 10 species of crabs from the backwaters. Later in 1991, Sethuramalingam and Ajmal Khan dealt with the brachyuran crabs of Parangipettai coast and provided descriptive keys with detailed figures. As a part of the biodiversity project on Gulf of Mannar biosphere reserve, Jayabaskaran et al. (1999) studied the brachyuran crabs of Gulf of Mannar.

A Comparative study on the brachyuran crab diversity of Pichavaram mangroves and artificially developed mangroves of Vellar estuary was done
by Ajmal Khan et al. (2005). Similar work was later conducted by Ravichandran and Kannupandi (2007) and Soundarapandian et al. (2008), who documented the biodiversity of brachyuran crabs in Pichavaram mangroves. Bijukumar et al. (2007) documented the brachyuran crab diversity landed as by-catch from the trawlers in the Kerala coast and recorded forty three families represented under 11 families and 22 genera, including 8 commercially exploited species. Roy and Nandi (2008) undertook a comparative study on the brachyuran crab diversity of three major brackish waters of India, viz., Chilka Lake, Pulicut Lake and Vembanad Lake. Brachyuran crab diversity of sub-littoral zones and mangrove regions Karwar estuary of Karnataka was studied by Haragi et al. (2010) and Bandekar et al. (2011) respectively. An annotated checklist of brachyuran crabs from the Pondicherry mangrove regions was provided by Satheeshkumar and Khan (2011). Kumaralingam et al. (2012) recorded the brachyuran diversity of Ritchieo’s archipelago, Andaman and Nicobar Islands; meanwhile the brachyuran diversity of Mudasal Odai and Nagapattinam coast of Tamil Nadu was dealt with by Sakthivel and Fernando (2012). While studying the decapod diversity from the mangrove ecosystem of Uran, Maharashtra, Pawar (2012) recorded 13 species of brachyuran crabs, which accounts to 50% of the total decapods fauna of the region. Trivedi et al. (2012) and Trivedi and Vachhrajani (2012) dealt with the diversity of brachyuran crabs of Gulf of Kutch as well as the Saurashtra coast of Gujarat state respectively, while the diversity of brachyuran crab fauna of Mahi and Dhadar estuaries of Gujarat was studied by Shukla et al. (2013). An extensive study on the diversity of brachyuran crabs of the mangrove ecosystems of Tamil Nadu was conducted by Frederick and Ravichandran (2013). Roy and Nandi (2013)
studied in detail the diversity of marine brachyuran crab communities of the west coast of India, taking into account all the maritime states located on the west coast of India.

The comparative study on the brachyuran crab diversity of Chilka Lake, Pulicut Lake and Vembanad Lake, conducted by Roy and Nandi (2008) revealed the occurrence of 18 species of brachyuran crabs from Vembanad Lake, which is much lower when compared with the other two brackish water lakes. Hence they pointed out the need for a season-wise survey for a period of at least two years to assess the exact brachyuran diversity of Vembanad Lake. In this context, Devi et al. (2014) conducted an extensive study on the Cochin backwaters, located at the northern tip of the Vembanad Lake for a period of two years and could record a total of 24 species from the Cochin backwaters.

2.3 Habitat Ecology of Brachyuran Crabs- A Review

Wide range of studies is available on the brachyuran crabs regarding the ecology, habitat characteristics, its interactions with the environment, the influence of environmental parameters on their life activities, effects of changing environmental conditions on them etc. The feeding ecology and behavioural ecology of some selected crab species from the Kenyan mangroves was studied by Dahdough-Guebas (1994). Percival (2002) made an extensive report on the substratum preferences of Japanese shore crab *Hemigrapsus sanguineus*. Shirley et al. (2004) studied the effect of salinity fluctuations on the population of oyster reef crabs. Lee (2004) dealt with the ecological factors determining the settlement of post larvae and the dynamics of adults of velvet swimming crab, *Necora puber*. Mokhtari et al. (2008)
reported the population ecology of the fiddler crab *Uca lactea annulipes*, while the feeding ecology of the American crab *Rithropanopeus harisii* was studied by Hegele-Drywa and Normant (2009). Influence of substratum characteristics on the spatial distribution of Ocypodid crabs has been dealt with by several carcinologists, viz., Lim *et al.* (2005) who conducted the studies on *Uca annulipes* and *U.vocans* from Pulau Hantu Besar, Singapore; Bezzera *et al.* (2006) on the *U. leptodactyla, U. rapax, U. thayeri* and *U. maracoani* from the tropical mangroves of Brazil, Saher and Qureshi (2012) on *U. sindensis* from the Pakistan coast. The substratum preferences of mud crab, *Scylla paramamosain* was studied by Xue-lei *et al.* (2009) and stated that the settlement of juveniles and the burrowing habits of crabs depend on the particle size of the sediments.

An extensive study on the habitat preferences of crabs in the Pichavaram mangrove environment of south-east coast of India was done by Ravichandran *et al.* (2007). Spatial distribution and substratum preferences of the Ocypodid crab *Macrophthalmus depressus* was studied by Pandya and Vachhrajani (2010) from the Gujarat coast. Ethnoecology of *Scylla serrata* was studied in detail by Nirmale *et al.* (2012). Trivedi *et al.* (2012) studied the diversity and habitat preferences of brachyuran crabs in the Gulf of Kutch. A detailed account of the habitat ecology of the herring bow crab, *Varuna litterata* of the Cochin backwaters was given by Devi *et al.* (2013). Arya *et al.* (2014) carried out an extensive study on the role of brachyuran crabs for the assessment of chemical pollution in the environment and described them as an effective bio monitoring tool.
2.4 Systematics of Brachyuran Crabs- A Review

A perusal of the available literature on the brachyuran crabs would reveal that most of the earlier works on the brachyuran crabs were on the taxonomic aspects. The earliest classic works on the taxonomy of crabs include that of Linnaeus (1758), Fabricius (1798), De Haan (1833), Dana (1852a, b, c), Wood Mason (1871), Boas (1880), Miers (1886) Ortmann (1892), Henderson (1893) and Alcock (1895, 1896, 1898, 1899, 1900, 1901), Bouvier (1896), Borradiile (1907), Balss (1957), Glaessners (1969) from different parts of the world including the Indian sub continent. Later, several carcinologists from different parts of the world, paid attention on the brachyuran fauna belonging to different families. Stephenson (1972) provided a checklist of the Portunid crabs of the Indo-west Pacific region, and according to his findings there are as many as 270 valid species existing under this family in this region. An extensive study on the fiddler crabs belonging to Family Ocypodidae was done by Crane (1975). Guinot (1977, 1978) proposed a new classification of brachyuran crabs based on the male and female genital openings, while Rice (1980) classified them on the basis of larval characteristics. A detailed monograph of the crabs of Japan and the adjacent seas was provided by Sakai (1976), which is widely referred in the systematic account of brachyuran crabs. Lucas (1980) dealt with the spider crabs of the family Hymenosomatidae, with special reference to Australian species, while Davie (1982) dealt with the mangrove crabs of Australia. Jones (1984) provided a comprehensive review of crabs inhabiting the mangrove ecosystem. A review of the grapsid crabs of American mangroves was studied by Abele (1992). Tan and Ng (1994) provided an annotated checklist of brachyuran crabs from the mangroves of Malaysia and
Singapore. Ng et al. (2008) gave an annotated checklist of the extant brachyuran crabs of the world, which comprises over 10,500 names treated, including 6,793 valid species and sub species, 1271 genera.

In the national scenario, Chhapgar (1957) gave a detailed description on the marine crabs of Bombay state along with a valid identification key, which is widely used currently. Sethuramalingam and Ajmal Khan (1991) dealt with the brachyuran crabs of Parangipettai coast including the mangrove species and provided descriptive keys with detailed figures. As a part of the biodiversity project on Gulf of Mannar biosphere reserve, Jayabaskaran et al. (1999) studied the brachyuran crabs of Gulf of Mannar and provided figurative keys for the identification of marine crabs.

However, several researchers have dealt with the taxonomy of the commercially important mud crab species (Kathirvel, 1981; Radhakrishnan and Samuel, 1983; Joel and Sanjeevaraj, 1983; Kathirvel and Srinivasagam, 1992; Kathirvel et al., 2004; Devi and Joseph, 2013a; Trivedi and Vachhrajani, 2013; Padate et al., 2013; Balasubramanian et al., 2014; Mandal et al., 2014 a, b; Devi and Joseph, 2015).

2.5 Systematic Account of mud crabs belonging to Genus *Scylla* – A Review

The first record of mud crabs was made by Forskal (1775) and he designated this newly found crab as *Cancer serratus*. Later several carcinologists from different parts of the Indo-Pacific region concentrated on this species (Herbst, 1796; Fabricius, 1798; De Haan, 1833; Milne Edwards, 1834; Dana 1852a,b,c; Stimpson, 1907). Estampador (1949) gave a detailed taxonomic account of genus *Scylla*, where he recognized three
Review of Literature

species and a new sub species from Philippines. Serene (1952) also reported
the occurrence of four forms of Scylla in Vietnam. These works were
subsequently reviewed by Stephenson and Campbell (1960) and Holthius
(1978) and they pointed out the inconsistent and variable nature of the
distinguishing characters. Fushimi (1983) and Oshiro (1988) reported the
presence of three forms of mud crabs in Japan. The genetic variability
analysis of mud crabs were studied by Fuseya and Watanabe (1996) and
they proposed three species for genus Scylla on the basis of variations
noticed through electrophoretic analysis. Fushimi and Watanabe (1998)
described the major problems persisting in the identification of mud crabs.
Mean while, Keenan et al. (1998) collected mud crab specimens from the
Red Sea and throughout the Indo-Pacific regions and classified them into
four species, Scylla serrata, Scylla tranquebarica, Scylla olivacea and
Scylla paramamosain, on the basis of morphological, morphometric and
molecular analysis.

In India, reference to the occurrence of mud crabs was first reported
by Fabricius (1798), who described the mud crabs specimens collected from
Tranquebar (Tharagambady of Tamil Nadu coast) and designated them as
Portunus tranquebaricus. Succeeding this, many authors viz., Alcock
(1899), De Man (1909), Kemp (1915), Gravely (1927), Pearse (1932),
Chopra and Das (1937), Panikker and Aiyyer (1937), Pillai (1951), Naidu
(1953), Chhapgar (1957, 1962), Balasubramanian (1966), Rekha (1968),
Premkumar and Daniel (1971) have mentioned the existence of mud crabs,
which was designated as Scylla, while dealing with various aspects such as
fishery, biology etc.
Later, the taxonomy of mud crabs of Indian waters was dealt with by Kathirvel (1981), Radhakrishnan and Samuel (1982), Joel and Sanjeevaraj (1983) and Kathirvel and Srinivasagam (1992). Kathirvel (1981) recorded two species of *Scylla* from Cochin backwaters, larger species being *Scylla oceanica* and smaller one being *Scylla serrata*. Later in 1982, Radhakrishnan and Samuel reported the occurrence of a subspecies *Scylla serrata serrata* from Cochin backwaters on the basis of morphological characters. Joel and Sanjeevaraj (1983) studied the taxonomy of *Scylla* from Pulicat lake and reported that the occurrence of two species, namely *S. tranquebarica* and *S. serrata*. Taxonomy of mud crabs from India were then critically analysed by Kathirvel and Srinivasagam (1992) and stated that the two species of mud crabs found to occur in Indian waters is *S. serrata* and *S. tranquebarica*. In contrast to their findings, Shaji *et al.* (2006) stated that the two species occurring in the Indian waters is *S. serrata* and *S. olivacea*. However, some of the recent studies also claims the occurrence of more than two apparent mud crab species from Indian coastal waters, namely, *S. serrata*, *S. tranquebarica* and *S. olivacea*, on the basis of external morphology (Devi and Joseph, 2013 a; Trivedi and Vachhrajani, 2013; Devi *et al.*, 2014). Quite recently, the studies conducted by Mandal *et al.*, (2013, 2014 a, b), Balasubramanian *et al* (2014) and Devi and Joseph (2015) confirms the findings of Shaji *et al.* (2006), i.e., the two species of mud crabs that exist in the Indian waters is *S. serrata* and *S. olivacea*. 