TRAINING MANUAL ON
CRUSTACEAN TAXONOMY

International Training Workshop on

Taxonomy of Crustacea

(ITWOTAC 2016)

20-23 September 2016

Edited by

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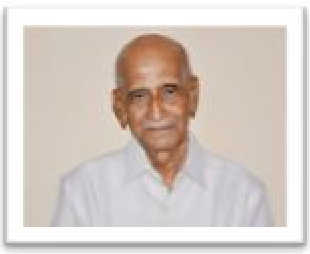

Dedicated to

Prof. N. Krishna Pillai (1921–2013)

Dept. of Aquatic Biology & Fisheries, University of Kerala

For his outstanding contributions to crustacean research in India

CONTENTS

STATE OF ART- CRUSTACEAN TAXONOMY IN INDIA

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Preface: *This state of art report on Crustacea was prepared by Dev Roy and K. Venkatarman for the release (2015) during the Centenary Celebration of Zoological Survey of India. This manuscript was updated with recent information by Biju Kumar, Department of Aquatic Biology and Fisheries, University of Kerala Thiruvanadapuram and used for the* ***International Worshop on Taxonomy of Crustacea*** *organized by Univeristy of Kerala. This report still needs addition of more information on various taxa. Later this draft will be used for publication in a standard journal for a wider audience of researchers.*

Introduction

Crustacea is one of the most morphologically diverse groups of extant organisms in the planet. The recent classification considers Crustacea as a subphylum under phylum Arthropoda and recent molecular studies considers most of the crustaceans belong to Pancrustacea clade other than hexapods (Rota-Stabelli *et al.*, 2010). The morphological disparity of crustaceans is evident from the size variations as their recorded sizes vary from about 0.1mm in *Stygotantulus stocki*, a species of crustacean living as an ectoparasite on harpacticoid copepods (McClain and Boyer, 2009) to a maximum leg span size of approximately 3.7 m in the giant Japanese spider crab *Macrocheira kaempferi* (Martin and Davis, 2001).

There are over 67,000 species of crustacenas and the majority of crustaceans are aquatic, living in either marine or freshwater environments; because of taxonomic diversity and numerical abundance marine crustaceans are often referred to as “insects of the sea”. As the dominant marine arthropods, crustaceans occupy a central and essential position in aquatic food webs as they form major chunk of the zooplankton, serve as scavenger and pelagic predators and as parasites (Hosie *et al.*, 2015). They are also economically significant as highly valued food of humnas, including shrimps, crabs and lobsters. They abount in ecosystems such as coral reefs in tropical habitats where the opportunities for niche specialisation are highest and many species form symbiotic relationships with large benthic invertebrates such as corals, echinoderms, ascidians, sponges and molluscs (Hosie *et al.*, 2015).

Crustaceans vary in great deal in shape and form, making it difficult to define easily recognized traints common to all the taxa, and the modifications are much more pounounced in parasitic forms, Yet there are few characters common to all the crustaceans. They are readily distinguished from other arthropods in having biramous appendages, possession of two pairs of antennae at some stage of their life cycle and paired saccatenephridia either in the second antennal segment or in the second maxillae. In fact, they are the only arthropods with a median naupliar eye. The range of morphological diversity among crustaceans far exceeds that of the insects (Brusca and Brusca, 2003).

The scientific study of crustaceans commenced with Aristotle, who described crabs and few other decapods and grouped them under Malacostraca. Linnaeus treated Malacostraca under Insecta. Linnaeus made the group Insecta optera to contain the crustaceans, spiders and myriapods. De Monet and Lamarck (1744-1829) split Linnaean Insecta into three classes namely Crustacea, Hexapoda and Arachnida. The name Crustacea was coined by Cuvier in 1800 and Lamarck included crabs, lobsters and water fleas etc. in this class. In 1845, von Siebold, combined Crustacea, Arachnida and Hexapoda under an independent group to which he gave the name Arthropoda.

Several International expeditions in the 19th and 20th century in Bay of Bengal region enriched early knowledge on crustacean diversity. The Austrian fregatte 'Novara' during its world cruise (1857-1859) touched Madras and Nicobars and collected a good number of crustaceans, especially the stomatopods, decapods, cirripeds and and isopods. The German steam boat 'Valdivia' made an expedition during 1898-1899 covering 268 stations around the west coast of Africa, Gulf of Guinea, the Antarctic sea and a large part of the Indian Ocean including Nicobars to explore the Deep-Sea. The results were subsequently published in 24 volumes in Wissenschaftliche Ergebnisse der Deutschen Tiefsee-Expeditions auf dem Dampfer "Valdivia"- 1898-1899 (Scientific results of the German deep-sea expedition on the steamer "Valdivia"- 1898-1899). During the course of expedition, a good deal of information on brachyuran crabs was collected from Sombrero Channel and Great Nicobar. Altogether, 14 species of crabs belonging to 13 genera and one species of stomatopod and a variety were reported (Doflein, 1904; Jurich, 1904).

Historically, Fabricius (1775) was the first to report crustacea from India. Herbst (1783-1804) in his monographic work on "Krabben und Krebse" recorded and described several new species from India. Subsequently, H. Milne Edwards (1834-1840) in his monumental work, Histoire naturelle des Crustacés, comprenant l'anatomie, la physiologie et la classification de ces animaux: 1-468, 1-532, 1-638, 1-32, Plates 1-42. Librairie encyclopédique de Roret, Paris (Vols. 1-3) and A. Milne Edwards in his several research papers recorded and described several crustaceans from India. Heller (1865) during "Novara Expedition" collected many species, such as stomatopods (one species), decapods (96 species), cirripeds (three species) and isopods (five species) from Madras (= Chennai) and Nicobars. However, serious studies of the group in India commenced with the joining of Wood-Mason (1869) in the Indian Museum. The naturalists of the Indian Museum arranged a Wood-Mason expedition in deep-waters of the Andaman Sea. Thus, Wood-Mason was the first to carry out biological investigation on the deep water flora and fauna of Andaman on board the vessel "S. S. Undaunted".

RIMS "Investigator" (1881-1926) carried out surveys in Bay of Bengal, Andaman, Arabian Sea and Lakshadweep Sea and had revealed a wealth of knowledge on crustacean fauna in waters off the Indian coasts and islands. Wood-Mason carried out studies of the Indian marine and freshwater crustaceans resulting in a series of papers and monographs. His contributions from different parts of the country have enriched the Crustacea collections of the then Indian Museum. Prior to the establishment of the Indian Museum, some works on the Crustacea were done and collections of those groups were housed in the Museum of the Asiatic Society of Bengal, which formed the nucleus of the present National Zoological Collections of the Zoological Survey of India, Kolkata.

Alcock made outstanding contributions viz. Catalogues of the Indian Crustacea and his series of Memoirs on the Crustacea collected by R.I.M.S.S. 'Investigator' are well known to carcinologists of the world. As Alcock, took great interest in the study of crabs (both anomuran and brachyuran) and prawns, the collections of crustaceans in the Zoological Survey of India probably, represent the best available in any museum in the world. Likewise, Annandale, Sewell, Nilsson-Cantell and Kemp made special studies on Copepoda, Cirripedia, Crab and Stomatopoda of the Indian region. As a result of the studies undertaken in the Indian Museum and subsequently in the Zoological Survey of India for nearly hundred years, the Crustacea Division possesses one of the richest collections of these animals.

Jetkins (1910) carried out investigations on shallw-water fauna of the Bay of Bengal by the Bengal Fisheries Steam-trawler "Golden Crown" during 1908-1909 and collected a good deal of information on the fauna of upper portion of Bay of Bengal between 15 and 30 fathom lines but very little on the crustacean fauna. Apart from these, two other vessels, "Fraser" and "Lady Fraser" also made commendable collections of crustaceans especially the brachyuran crabs during pre-independence period from mouth of River Hugli. Chopra (1933-1935) studied and reported 52 species of brachyuran crabs out of these collections which contained several new species and even new genera.

In the post-independence era, a number of national and international explorations ('Sagar Sampada', R.V. 'Varuna', Indo-Norewegian

Vessel 'Kolava', M.T. 'Ashoka', 'Chota Investigator') were carried out and brought collections containing new species and thereby enriched our knowledge on crustacean fauna of the country.

Susselan *et al.* (1990) made an intensive study of deep-sea crustacean resources from south-west coast of India during 40th and 42nd cruises of FORV Sagar Sampada and reported 15 species of prawns, three species of crabs, two species of lobsters and one species of stomatopod between 60 and 777 m depth and noted maximum abundance of prawns in between 290 and 370 m depth.

Subphylum Crustacea

Class **Branchiopoda**

Branchiopods are small crustaceans inhabiting many of the freshwater and saline inland waters of India. They have well adapted to temporary water bodies as most species have eggs resistatnt to drying. Their gills are flattened lobes projecting from the bases of the trunk appendages, hence the name Branchiopoda ('gill feet'). The crustacean class Branchiopoda reported from India includes fairy shrimps/brine shrimps (Anostraca), tadpole shrimps/shield shrimps (Notostraca), clam shrimps (Diplostraca; suborders Spinicaudata, Laevicaudata, and Cyclestherida), and water fleas (Cladocera).

Branchiopoda supports a morphologically diverse group of ecologically important forms, most of which are freshwater (Brendonck, 2008). Recent review of the large branchiopod crustacean fauna of the Indian subcontinent by Rogers and Padhye (2015) commented that though 86 nominal species have been reported for India, many of the species listings are not valid, most Indian endemic taxa are poorly described (and some lack type materials) and updated the number of valid species as 42 species including 16 anostracans, 2 notostracans, 3 laevicaudatans, 21 spinicaudatans and a single species of cyclestherid. Padhye and Dahanukar (2015) reported on the distribution and abundance of lrage branchiopods in northern Western Ghats, while Padhye *et al.* (2015) prepared first faunal inventory of large branchiopods of Western Maharashtra.

Order **Anostraca**

Anostracans commonly inhabit ephemeral ponds, lakes and lagoons. The bodies of the animals are elongated, with borad flattened appendages projecting from the thorax. No carapace is present so the segmentation of the body is visible. Recent molecular studies of the group have resulted in better understanding of phylogenetic relationships amongst the families and genera. These studies have resulted to the discovery of two suborders within Anostraca and two cryptic families, Parartemiidae and Tanymastigidae (not represented in India). Recently Rogers (2013) have presented a checklist of 353 valid species and subspecies belonging to 42 valid genera and subgenera under 10 families in this order out of 764 nominate species across the world. These have been arranged under 31 genera under 10 families. Among these, 13 species belonging to six families and seven genera are so far known from India.

Pre-1900

Baird (1860) described a species, *Streptocephalus dichotomus* from India without citing exact locality. He After a gap of 36 years, Alcock (1896) described another species of anostraca, *Branchipus (Streptocephalus) bengalensis* from flooded rice fields near Calcutta (now known as Kolkata). Later on, this species was merged with *Streptocephalus dichotomus* by Gurney (1906).

1901-1947

Gurney (1906) described an anostracan, *Streptocephalus simplex* from Kachchh district of Gujarat. Kemp (1911) studied anostracans of the Indian Museum and reported two species, *Pristicephalus priscus* and *Streptocephalus dichotomus*. Bond (1934) while working on phyllopods of Indian empire reported two new sub-species, namely, *Streptocephalus simplex echinus* and *Streptocephalus simplex longimanus* from a tank of Godavari Town, the then Madras Presidency (now in West Godavari district, in the State of Andhra Pradesh) and Mahabalipuram, Madras Presidency (now in the state of Tamil Nadu).

1948 -2016

Raj (1951) first recorded the genus Branchinella from India and described a new variety *Branchinella kugenumaensis madurai* from Madurai, Tamil Nadu. In 1966, Shull also recorded the same species in rainwater pool near Ahwa of South Gujarat. Tiwari (1958) described a new species of the same genus, *Branchinella biswasi* from Sambhar Lake, Rajasthan. In 1970, Malhotra and Duda reported another new anostracan species, *Brachinecta acanthopenes* from paddy fields in Kashmir valley, Kashmir. Baid (1975) described the species *Branchinella sambhariana*. Radhakrishna and Prasad (1976) recorded *Streptocephalus spinifer* from Guntur district of Andhra Pradesh. Velu and Mumuswamy (2007) described a new species of fairy shrimp, *Branchinella nalurensis* from South India. Velu and Mumuswamy (2005) also updated diagnoses for the Indian species of the genus *Streptocephalus*. Belk and Esparza (1994) reported *Streptocephalus echinus* from Chingleput district, Tamil Nadu. Belk and Esparza (1995) have reviewed Anostraca of the Indian subcontinent. Further, Belk and Brtek (1995) have published a checklist of Anostraca which also includes 9 species from India. Very recently, Rogers *et al*. (2013) in their review work on large brachiopod crustacea of South East Asia merged several Indian species. Rogers and Padhye (2014) described a new species, *Streptocephalus sahyadriensis* of the family Streptocephalidae from Western Ghats with a key to the Asian species. Padhye and Ghate (2016) reported on a new species of *Leptestheria* (*L. gurneyi*) from Western Maharashtra.

Order **Notostraca**

Notostracans commonly known as tadpole shrimps are found only in temporary pools and puddles after rain. They are placed under a single family Triopsidae. Out of 16 living species belonging to a single genus, only three species occurs in India (Gurney, 1925; Tiwari, 1951; Das, 1970).

Pre-1900

Packard first reported Notostraca from India. In 1871, he described a new species, *Apus himalayanus* based on two specimens collected from a stagnant pool of Himalaya mountains, North India.

1901-1947

During this period, Walton (1911) recorded a species of *Triops (Apus)* from Bulandshahr district of United Province, presently in the state of Uttar Pradesh and pointed out its resemblance to *Triops (Apus) cancriformis* ((Bosc). Gurney (1925) recorded two species, *Triops (Apus) cancriformis* from Kashmir and *Triops (Apus) asiaticus* from Panchgani in the then Bombay state (presently, state of Maharashtra). Mahabale (1939) recorded *Triops* from Ahmedabad as *Apus cancriformis*.

1948-2016

Chacko (1950) reported *Triops (Apus) sundanicus* based on collection of a single female specimen from Nagasunni Temple Tank in Tirunelveli district of Tamil Nadu. Later, Raj (1971) reported T Chacko (1950) reported *Triops (Apus) sundanicus* based on collection of a single female specimen from Nagasunni Temple Tank in Tirunelveli district of Tamil Nadu. Later, Raj (1971) reported *Triops granarius* on the basis of more collections of both male and female specimens from the same district and opined that Triops (Apus) sundanicus recorded by Chacko actually belonged to this species. Tiwari (1951) gave an account of Indian species of *Triops* collected from various localities of India, such as Rajasthan, Maharashtra and Tamil Nadu and described two new species, viz., *Triops (Apus) orientalis* and *Triops (Apus) mavliensis*. Mathur and Sindhu (1956) reported *Triops* from Pilani, Rajasthan without giving its species identity. Shanbhag and Inamdar (1968) also collected *Triops* from shallow water ponds of Port Okha, Gujarat and reported the same as *Triops mavliensis*. Das (1970) described a new species, *Apus kashmirensis* from Kashmir. Nath (1975, 1985) studied *Triops cancriformes* from Kashmir valley and discussed on the taxonomic status of *Apus kashmiriensis*. He also recorded the species *Triops cancriformes* in Poonch valley (Nath, 1979). Ghate and Shetty (1997) recorded *Triops granarius* from a large pool on the Alandi road and also on stone quarry at Talegaon near Pune, Maharashtra.

Order **Diplostraca**

The order Diplostraca which represents clam shrimps and water fleas, presently consist of four suborders, viz., Spinicaudata, Laevicaudata, Cyclestherida and Cladocera. In India, the suborder Spinicaudata is presently, represented by three families and 42 species, Laevicaudata by one family and four species and Cyclestherida by one family and one species and Cladocera by 10 families and 215 species.

Pre-1900

Baird (1849) in his monographic work on the family Limnadidae (Conchostraca now under Spinicaudata) described three new species, namely, *Estheria boysii*, *E. polita* and *E. similis* from India without mentioning the exact locality ofcollection. Later, Baird (1859, 1860a, b) added three more new species to the suborder Spinicaudata, viz. *Estheria compressa*, from freshwater pools of Nagpur including the sole cyclostherid species, Estheria *Cyclostheris hislopi* of the suborder Cyslestherida.

1901-1947

Sars (1900) described two new species of *Eulimnadia - E. gibba* and *E. similis* (Eulimnadiidae) and one species of *Leptestheriella - L. nobilis* (Leptestheriidae) from Southern India. Kemp (1911) recorded two species, *Pristicephalus priscus* and *Streptocephalus stoliczkae* while dealing with the asiatic species housed in Indian Museum. Daday (1913) described five new species, viz. *Caenestheria immsi, Caenestheriella annandalei, , Lynceus indica, Eocyzicus bouveri* and *E. orientalis* from various parts from India, viz., Kumaon Hills, Simla Hills, Tanjore, Sholingur, Gingi etc. Gurney (1930) described a new species, *Limnetis (Lynceus) indicus* from Madurai. Bond (1934) also described three new species, namely, *Eocyzicus deterrana*, *E. hutchinsoni* (Cyzicidae) and *Eulimnadia margaretae* (Limnadiidae) from Punjab and two species, namely, *Streptocephalus simplex echinus* and *Streptocephalus simplex longimanus* from Godavari Town and Mahabalipuram respectively.

1948-2016

Brehm (1950) recorded Cyclostheris hislopi from India. Karande and Inamdar (1959) reported a new species, Leptestherilla gigas from India. Tiwari (1959, 1962, 1965) described four new species, namely, *Caenestheria misrai, C. roonwali, Eocyzicus pellucidus* and *Leptestheria jaisalmarensis* from Rajasthan. In 1965, Nayar also reported four new species, viz. *Eocyzicus acuta, Eulimnadia ovata, Leptestheria longimanus* and *L. longispinosa* from Rajasthan. Tiwari (1966) erected a new genus of clam shrimp, *Sewellestheria* from Sambhar Lake. Nayar and Nair (1968) while working on conchostraca of South India reported two new species, viz., *Leptestheriella maduraensis* and *Eulimnadia mich*aeli from Madurai and Trichur respectively. Das and Akhtar (1971) described a new species, *Eocyzicus wulari* from Kashmir. Tiwari (1972) commented on the taxonomic status of two branchiopod species described from Kashmir. Royan and Alfred (1971) and Royan and Sumitra (1973) described a new species each from Madurai and Tuticorin, Tamil Nadu. Radhakrishna and Durga Prasad (1976) described a new species, *Eulimnadia gunturensis* from Guntur, Andhra Pradesh. Battish (1981) recorded three new species, namely, *Lynceus vasishti, Eocyzicus dhilloni* and *Caenestheriella ludhianata* and a new subspecies, *Eulimnadia ovata inversa* from Punjab. Durga Prasad and Simachalam (2004) while reviewing the genus *Eulimnadia* of the Indo-Malayan region described a new species, *Eulimnadia indocylindrova* from Andhra Pradesh. Ghate and Patil (1995) and Ghate *et al.* (2001) recorded three species *Leptestheriella maduraensis, L. jalsalmerensis* and *Eulimnadia michaeli* from Pune, Maharashtra. Balaraman and Nayar (2004) described a new species, *Lynceus alleppensis* and Babu and Nandan (2010) described two species of clam shrimps, namely, *Eulimnadia azisi* and *Leptestheria dumonti* from Kerala. Simachalam-and Timms (2012) described two new species belonging to the *genera Eocyzius* and *Leptestheriella*. Durga Prasad and Simhachalam (2009) have published a list of clam shrimps from India reporting as many as many as 35 species (30 belonging to Spinicaudata, 4 to Laevicaudata and 1 to Cyclestherida).

Order **Cladocera**

The Cladocera is by far the most diverse and speciose group within the Diplostraca (earlier included under Branchiopoda), with about 640 species worldwide (Korovchinsky 2000), which is more than half of the total diplostracan species described. It is an ancient group of Palaeozoic origin (Forró, 2008) containing 209 species from India. They are mostly fresh water with only a very few marine and estuarine species, inhabiting primarily still and slow-flowing waters. Sars (1865) recognised four tribes namely, Haplopoda, Ctenopoda, Anomopoda, and Onychopoda within Cladocera which are still accepted; these groups are now treated as infraorders (Martin and Davis, 2001). Among these, Anomopoda is the most speciose group containing five families, 75 genera (Dumont and Negrea, 2002), and nearly 560 species (Korovchinsky, 2000); this is followed by

Ctenopoda with eight genera and 47 species (Korovchinsky, 2000), Onychopoda 10 genera with 34 species (Rivier, 1998), and the monotypic Haplopoda with a single species.

In India, Anomopoda is represented by seven families, 26 genera and 182 species, Ctenopoda by two families, eight genera and 24 species, Onychopoda by two families, five genera and seven species and Haplopoda by a single family, single genus and single species.

Pre-1900

The suborder Cladocera is documented in India since the later half of the nineteenth century. Baird (1860) was pioneer in describing a species of this group, mamely, Daphnia newporti from Nagpur.

1901-1947

Gurney (1906, 1907) reported on the cladocerans of Indian Museum Tank, Kolkata. Sewell (1926) while investigating fish mortality in Indian Museum Tank recorded six species of cladocerans. In 1934, he reported on the cladocerans of Salt Lakes, Lower Bengal) Brehm (1936) reported 23 species belonging to 18 genera from Punjab, Kashmir and Ladakh which were collected during North Yale Expedition.

1948-present

Brehm (1950b) recorded 11 species of cladocera from different parts of India, Naga Hills (Nagaland), West Bengal, Bihar, Madhya Pradesh, Simla Hills (Himachal Pradesh) and described three new species, *Sinodiaptomus ganesa*, *Phyllodiaptomus peregrinator* and *Arctodiaptomus euacanthus*. In 1952, he described a new species of the genus *Diaphanosoma* from Bombay and in 1953, he reported 23 species based on specimens collected from West Bengal, Sikkim, Andhra Pradesh, Uttar Pradesh, Karnataka, Tamil Nadu, Pondicherry and Nepal. Petkovski (1968), Shirgur and Naik (1977), Rao *et al.* (1998), Korinek *et al.* (1999) while working on cladocera have described several new species (*Indialona ganapati*, *Holopedium ramasaronii*, *Diaphanosoma (Neodiaphanosoma) chandramohani*) from various parts of India. Fernando (1980a, b) found 61 species of Indian cladocera with specific information about the absence of large cladocera. Rane (1983– 2005) described 15 new species belonging to families Bosminidae, Chydoridae, Sididae, Daphnidae and Moinidae. Rane (2009) enlisted 15 species belonging to 13 genera and six families from Bhimshankar Wildlife Sanctuary, Maharashtra.

Among the notable contributions of this period on the group are “Fauna of India” by Michael and Sharma (1978). Murugan *et al.* (1998) recorded 109 species in India. Raghunathan and Suresh Kumar (2002) published a checklist of Indian cladocera, while Padhye (2012) made corrections to the checklist of cladocera of India. Chatterjee *et al.* (2014) published an annotated checklist of Indian Cladocera and concluded there are 137 valid taxa, of which most records belong to species groups that need revision worldwide and noted insufficiencies of cladocera taxonomy in India.

Information on cladocera fauna from different states of North-east India, other than Assam, Meghalaya, Tripura is and Manipur is very sketchy. Brehm (1950) and Biswas (1965) recorded a single species each from Changchang Pani in Naga Hills (now in the state of Nagaland) and Kameng division (now in Arunachal Pradesh). Patil (1976) reported 17 species belonging to five families under 13 genera from Northeast India, of which, three were new records to India and 14 to the region. Out of 17 species, 14 were recorded from Meghalaya and three from Manipur. Later on, Biswas (1980) recorded 15 species from Ward Lake, Shillong (Meghalaya) and six species each from Guwahati and Lakhimpur (Assam). In 2002, Sinha reported *Bosmina tripurae* from Assam. In recent times, Sharma and Sharma (2008, 2009) took much initiative in exploring the cladoceran faunal diversity of North-east India, Loktak Lake (Manipur) – a Ramsar Site and in floodplain lakes of Assam. Hattar *et al.* (2004) reported nine species of cladocera under seven genera and six families from Saipung Wildlife Sanctusry/Narpuh Reserve Forest of Jaintia Hills, Meghalaya. Venkataraman *et al.* (2002) while dealing with wetland faunal resources of Tripura reported 49 species of cladocera belonging to 28 genera and seven families. It is evident that no information/ very little is known about cladocera fauna particularly from the states of Mizoram, Arunachal Pradesh, Nagaland. Very little is known on the cladocera of Sikkim. Venkataraman (1998) recorded *Alonella nana* and *Bosmina longirostris* from Sumdung Lake and Nagi Upper Dam, Sikkim. Later, Venkataraman *et al.* (1999) reported an arctic species, *Holopedium gibberum*

Zaddach from Chhangu Lake of Sikkim, This was not only a new record for India but also for the Asia.He also studied morphology of the species, *Eurycercus lamellatus* (Müller) collected from Changu Lake, Sum Dung Lake and Tadong (East Sikkim) and Tik Juk Lake (West Sikkim).

A number of researchers have investigated cladoceran fauna from the state of West Bengal. Gurney (1906, 1907), Sewell (1926, 1934), Sharma (1978), Venkataraman (1994, 1998), Venkataraman and Das (1993a, b, 1994, 2001), Venkataraman and Nandi (1997), Venkataraman *et al*. (2000) while studying zooplankton diversity of Haora district recorded. Venkataraman and Das (1993) reported upon the cladocerans of southern West Bengal. Chandrasekhar (1998, 2004) studied cladoceran diversity of Baroni pond and Adra Lake of West Bengal.Further, Chandrasekhar and Chatterjee (2002), Chatterjee and Chandrasekhar (1999) investigated cladoceran fauna of Malda district and Jawaharlal Nehru Park, Burnpur, Burdwan district. Nandi *et al*. (1993, 1999, 2001a, b, 2005, 2007) also studied cladocerans from wetlands of North and South 24 Parganas, Haora, Hugli, Birbhum, Bankura, Puruliya, Darjiling and Jalpaiguri Districts, .

Biswas (1964a, b) described two new species of cladocera from Rajasthan. In 1966, 1971, Biswas dealt with forty-five species of cladocerans pertaining to the families Sididae, Daphnidae, Macrothricidae and Chydoridae from this state. Nayar (1971) reported 17 species of cladocera also fromthis state. Venkataraman (1998) reported the species *Alona cannellata* Brehm, 1934 from Keoladeo National Park, Bharatpur as new report from India. Sharma *et al*. (2012) studied cladocera from 77 water bodies of seven districts of South Rajasthan State and recorded as many as 54 species.

Chandrasekhar and Chatterjee (2002) studied cladocera fauna of Dimna and Jublee Park lakes, Jharkhand and recorded nine species belonging to five genera and three families. Alam and Khan (1998) recorded the cladocera *Leydigia acanthocercoides* (Fischer, 1854) from Aligarh, Uttar Pradesh. Nine species belonging to six genera are known to occur from this region (Khan and Siddiqui, 1974; Haque and Khan, 1994). Qadri and Yousuf (1977) carried out limnological investigation of Beehama Spring near Srinagar, Kashmir and reported four species of planktonic cladocera.

In Tamil Nadu, Rajagopal (1962) initiated the work on cladocera. After a short gap, Michael (1973) made a detailed study on cladoceran fauna of Madurai area. The planktonic and high altitude cladocerans of Tamil Nadu have been investigated and reported by Raghunathan (1983, 1985). Venkataraman and Krishnaswamy (1984a, b) recorded the occurrence of two species namely, *Leydigia ciliata* and *Daphnia projecta* from Tamil Nadu. Hudec (1987) described a new species of the family Moinidae. Venkatakumar (1993) dealt with cladocerans of the family Sididae. Sureshkumar *et al*., (1999) recorded a species of the family Chydoridae from the state and studied its developmental stages. Venkataraman (1998) reported two species, namely, *Alona pseudanodonta anodonta* Daday, 1905 and A. *holdeni* Green, 1952 from Madurai, Tamil Nadu as the first record from Indian waters. Venkataraman (1999) reported on the cladocerans of South Tamil Nadu.

Chandrasekhar (2004) reported 30 species from Hyderabad and its environs, Andhra Pradesh. The cladocera of Periyar Lake, Kerala has been worked out by Subhash Babu and Nayar (2004) and a total of 23 species has been recorded from this lake. Patil and Gouder (1988) reported 22 species belonging to 17 genera and six families from Dharwad of Karnataka state which contained a new record from India. Raghunathan (1988, 2006), Raghunathan and Rane (2001) and Raghunathan and Sureshkumar (2006) have studdied intensively cladocera fauna of Karnataka and presently, a total of 41 species belonging to 19 genera and 6 families are known from the state.

Estuarine/backwater cladocera: Rajagopal (1962), Madhupratap (1981), Chatterjee *et al*. (1995) and Manikannan *et al*. (2011) studied cladocerans of estuarine and coastal waters of India. Pillai and Pillai (1973) recorded two species of cladocerans namely, *Evadne tergestina* and *Penilia avirostris* from Cochin backwater and studiesd their abundance, seasonal distribution and temperature-salinity relationship. Raghunathan and Srinivasan (1983) studied cladocerans of the plankton community in Ennore estuary, Chennai. Sakthivel and Haridas (1974) observed synchronization in the occurrence of *Trichodesmium* bloom and swarming of *Creseis acicula* Rang (Pteropoda) and *Penilia avirostris* from off Cochin. Madhupratap (1981) studied the estuarine and coastal water cladocerans of southwest coast of India. Naomi *et al*. (1990) reported distribution of cladocera in the Eastern Arabian Sea and the Bay of Bengal. They noted highest concentration of cladocera in the shelf off Cochin while in Bay of Bengal population density as recorded off Paradip was more than that observed off Madras.

Order **Leptostraca**

Leptostraca consists of a group of small marine benthic crustaceans (except the genus *Nebaliopsis*which has a wide pelagic geographical distribution in the Southern Hemisphere). It is the sole extant order in the subclass Phyllocarida with a long geological history dating back to Cambrian. A single family, Nebalidae belonging to this order is known from India. The genus *Nebalia* consists of around 31 species world-wide, of which, a single species *Nebalia longicornis* was reported by Pillai (1959) from Krusadai Island, Tamil Nadu.

Class Malacostraca

Order **Stomatopoda**

Pre-1900

Fabricius (1798) first reported stomatopods from India; he described three species from Fredericksnagore (= present day Serampore) of West Bengal coast, Bombay (= present day Mumai) and 'India Orientali' (exact locality not known). Subsequently, Latreille (1828) also recorded three species, which were obtained from China and Pondichéry (now Puducherry). Among these, two were new to science. Heller (1865) recorded the species, *Gonodactylus chiragra* from India. After a short gap, Wood-Mason (1875, 1876 and 1895) reported 10 new species, namely, *Gonodactylus glyptocercus, G. platysoma, Lysiosquilla multifasciata, Coronis spinosa, Squilla foveolata, S. stridulans, S. supplex, S tenuispinis, Clorida decorata* and *Chloridella latreillei* from Indian waters. Henderson (1893) reported 10 species from India which consisted mostly from Madras and Rameswaram (9 species). Thurston (1895) also published a list of 8 species from Gulf of Mannar. These species were the same as those reported earlier by Henderson (*op. cit.*).

1901-1947

Lanchester (1903) reported two new varieties of *Gonodactylus chiragra* from Minicoy. Jurich (1904) worked on the collections of stomatopods collected by "Valdivia" during its expedition in 1898-1899 and reported the sole species, *Squilla leptosquilla* and its variety *dentata* from a depth of 296 m at Great Nicobar (Valdivia station 208). In 1913, Kemp in his monographic work reported 97 species and varieties from the Indo-Pacific region, of which, 44 were recorded from India. In 1921, Kemp and Chopra, reported 15 species from the region. Gravely, (1927) reported two species from Gulf of Mannar while Chopra (1934) reported 13 species from Sandheads, West Bengal coast (mouth of river Hugli).

1948-Present

Tiwari and Biswas (1951) described a new species, *Squilla bengalensis* from Salt Lake, Kolkata and Piali river, Uttarbhag and added notes on 8 others. Chhapgar and Sane (1966) published a key for stomatopods of Bombay listing as many as 17 species from the region. Later, in 1968, they described two new species, *Squilla bombayensis* and *Squilla denticauda* from the same region. Shanbhogue (1967) described a new species, *Heterosquilla jonesi* from Minicoy. Alikunhi (1967) reported 18 species. Ghosh in a series of papers (1975, 1976, 1977, 1984, 1990, 1995a, b, 1999) reported several species from West Bengal, Orissa, Goa, Andaman and Nicobar islands and Lakshadweep including five new species, viz. *Manningia andamanensis,Gonodactylus arabica, G. minikoiensis, Acanthosquilla dighaensis* and *Harpiosquilla paradipa*. Manning (1975, 1978) described four new speies, namely, *Chorisqu*illa *andamanica, Oratosquilla hindustanica, O. pentadactyla* and *O. subtilis* from India. Dutt and Ravindranath (1975) dealt with stomatopod crustacean of Andhra Pradesh recording 6 species under 5 genera and 3 families. Shanbhogue (1975) published a list of stomatopods from the Indian Ocean region which contained 115 species under 27 genera of four families. In a subsequent publication, Shanbhogue (1987) reported 30 species belonging to 14 genera and 3 families from seas around India based on collections at Central Marine Fisheries Research Institute, Mandapam and Cochin. Kathirvel (2008) also dealt with the diversity Indian stomatopods. However, the first checklist of Indian stomatopods was published by Dev Roy and Gokul (2012). Jayabarathi *et al.* (2013) recorded *Gonodactylellus viridis* from seagrass habitat of the South Andaman coast.

Order **Bathynellacea**

Bathynellaceans are a group of primitive ancient freshwater syncaridians which consists of a group of small (1.0-3.4 mm), blind, worm-like animals with short, weak legs occurring interstitially in subterranean habitats. They are found in all continents except Antarctica and some of the Atlantic (Carribean and Pacific islands (Fiji, New Caledonia). World-wide there are 219 species under 66 genera, of which, 23 species of bathynellaceans belonging to 7 genera and two families have been reported/described from India by Ranga Reddy and his associates (2001-2014). They also erected two new genera namely, *Indobathynella* and *Serbanibathynella* from India. More recently, Ranga Reddy and Totakura (2015) described the second species of the genus *Atopobathynella – A. paraoperculata* from the interstitial hyporheic zone of the River Krishna, Andhra Pradesh.

Order **Decapoda**

Mohamed and Suseelan (1973) and Sulochanan *et al*. (1991) dealt with deep-sea prawn resources of south-west coast of India and deep-sea crustacean resources of the Indian EEZ. Dev Roy (2014) made an inventory of decapod crustaceans from India and reported a total of 1655 species belonging to 567 genera and 115 families along with a list of new families and new genera described from India. Radhakrishnan *et al.* (2012) published an annotated checklist of the penaeoid, sergestoid, stenopodid and caridean shrimps of India and recorded 37 species (343 marine and 94 freshwater forms). Of late, Samuel *et al.* (2016) published a checklist of shrimps on the Indian coast and listed a total of 364 species from India.

Suborder **Dendrobranchiata**

Pre-1900

Fabricius (1798) erected the genus *Penaeus* based on a specimen collected by Daldorff from Tranquebar on the Coromandel coast of India (presently in Tanjore district of the State of Tamil Nadu). He described the prawn as *Penaeus monodon* which is the type for both genus and the family. In 1830, H. Milne Edwards described a new species, *Acetes indicus*. Later, H. Milne Edwards (1834) recorded seven species of penaeid prawns, namely, *P. monoceros, P.indicus, P. monodon, P. affinis, P. brevicornis, P. crassicornis, P. styliferus* and a species of sergestid, *Acetes indicus* from Indian coasts. Heller (1865) reported three new species of prawns, *Alpheus crassimanus, Anchista notata* and *Leander distans* from Nicobars. He also recorded the species *Hippolyte gibbosus* from Nicobars. Miers (1878) reported 5 species of penaeid prawn from Indian water, of which, two species namely, *Penaeus hardwickii* and *P. dobsoni* were described from India. Bate (1881) reported 7 species of penaeid, viz. and one species of sergestid shrimps from India. Wood-Mason (1891) described a new sergestid, *Sergestes rubro-guttatus*. Henderson (1893) reorded seven species of paenid prawn from various parts of India. Alcock and Anderson (1894) described *Sergestes hamifer*.

1901-1947

Nobili (1903) reported nine species of penaeid prawns from Chennai, Puducherry, Bombay and Mahe. Kemp (1917) reported three species of sergestids from east and west coast of India. Natarajan (1942) recorded 12 species of penaeid and four species of sergestid shrimps of the genus *Acetes* (including a new variety) from the erstwhile Travancore. Achuthankutty and George (1973) and Achuthankutty and Nair (1976) described two new sergestid shrimps, *Acetes sibogalis* and *A. orientalis* from Cochin backwater and Goa respectively.

1948-Present

George *et al*. (1963) described a new species of prawn, *Metapenaeus kutchensis* from the Gulf of Kachchh. George (1972) dealt with the zoogeographic distribution of Indian penaeid prawns. In 1979, he dealt with the taxonomy of Indian prawns. Kurian (1964, 1965) dealt with deep water prawns and lobsters of Kerala coast. Nataraj (1945, 1953) described two new species of the genus *Solencera*. George (1964) reported the species *Metapenaeus burkenroadi* from Alleppey. This was a new record to Indian water. George and Rao (1966) described a new species *Metapenaeus alcocki* from Gulf of Kachchh. Muthu (1965) recorded the prawn, *Metapenaeus ensis* (De Man) for the first time from Indian water. In 1968, he recorded 9 species of penaeid prawns for the first time from east coast of India. Muthu (1969) described a new species, *Parapenaeopsis indica* from Kakinada. George and Muthu (1968a) described a new species of the genus *Solenocera - S. waltairensis* from Andhra coast. They also reported *Metapenaeopsis barbata* (De Haan, 1850) for the first time from India (1968b). Thomas (1968) reported the occurrence of 4 species of penaeids, viz, *Penaeus latisulcatus* Kishinouye, 1900, *Trachypenaeus pescadoreensis* Schimtt, *T. sedili* Hall and *Parapenaeo*psis *uncta* Alcock for the first time in Palk Bay and Gulf of Mannar.

Thomas (1970a, b) described a new species *Trachypenaeopsis minicoyensis* from Lakshadweep and also first time recorded the species *Metapenaeopsis borradaili* (De Man) from the same location. He also recorded four species of alpheid shrimps, *Alpheus rapax* Fabricius, 1798, *A. euphrosyne* De Man, 1897, *A. distinguendus* De Man, 1909 and *A. malabaricus songkla* Banner and Banner, 1966 from southeast and southwest coast of India (Thomas, 1976). In 1976, he first time reported 6 species of penaeids from Andaman and Nicobar Islands and seven species of deep-sea penaeids, caridea and astacidea in 1977 from Gulf of Mannar. Achuthankutty (1975) recorded the occurrence of *Acetes australis* from Cochin and *Acetes vulgaris* from Goa. Achuthankutty and George (1973) and Achuthankutty and Nair (1976) described two new species, *Acetes sibogalis* and A. *orientalis* from Cochin backwater and Goa respectively. Thomas (1974) reported three species of penaeids and one species each of alpheid and gnathopsyllid shrimps from Lakshadweep. Later, Thomas (1986) reported 17 species of penaeid and two species of sergestid prawns from Goa. Silas and Muthu (1976) described a new species of penaeid prawn, *Metapenaeus krishnartii* from Andaman Islands. Seshagiri Rao (1988) reported four species of penaeid prawns from Lake Kolleru, Andhra Pradesh. Nandi *et al.* (1983) reported the occurrence of the species *Penaeus japonicus* from Hooghly estuary. Kagwade (1983) reported *Metapenaeus kutchensis* from Bombay. Suseelan (1989) dealt with the commercial deep-sea prawn of south-west coast of India. In 1990, Suseelan, reported two species, namely, *Heterocarpus sibogae* De Man and *Plesionika williamsi* Forest for the first time from off Quilon, Arabian Sea. Out of these two, *P. williamsi* was a new record from Indian waters. Chaudhari and Jalihal (1993) provided a field key to the seed of penaeid prawns along the Konkan coast of India. Aravindakshan (1996) reported *Parapenaeopsis stylifera* from Mumbai. Chanda and Bhattacharya (2002-2004) described three new species of penaeid prawn, namely, *Melicertus similis*, *Fenneropenaeus konkani* and *Parapenaeopsis longirostris* from India. Chanda and Roy (2004) recorded 14 species of penaeid prawns from Gujarat, of which, two species, *Metapenaeus eboracensis* Dall, 1957 and *M. mastersii* (Haswell, 1879) were new record to the state as well as to India. From Digha coast of West Bengal, 21 species of penaeid and two species each of solenocerid, alpheid shrimps are known (Goswami, 1992; Chatterjee *et al.*, 2007). Reddy (1995) reported five species of penaeid and one species of sergestid shrimp from Chilka Lake. Further, Aravindakshan *et al.* (1987) reported the occurrence of *Acetes johni* Nataraj and *A. japonicus* Kishinouye in Bombay waters.

Suborder **Pleocyemata**

Pre-1900

Fabricius (1775) first reported *Alpheus malabaricus* from India. Fabricius (1798) described three species of palaemonid prawns, *Palaemon brevimanus, P. coromandelianus, P. lar* and two species of alpheid shrimps, *Alpheus avarus* and *A. rapax* from “India Orientali” without mentioning specific locality of the species. Latreille (1806) reported the species *Alpheus flavescens* from “Indiae Orientalis Oceano”. After a gap of about 30 years, H.Milne Edwards (1837) recorded three species, *Palaemon carcinus, P. longirostris,P. lamarrei* from the Gangetic delta. In 1844, H. Milne Edwards described another new species, *Palaemon malcomsonii* from Nagpur. In 1868, Bate also described a new species of palaemonid prawn, *Macrobrachium gangeticum* from the River Ganges at Rajghat, Banaras. This was followed by the work of Miers (1878) who reported three species from India including one new species *Metapenaeus dobsoni* from Mangalore, Karnataka. Wood-Mason and Alcock (1891) reported nine new species of the genus *Glyphocrangon – G. andamanensis, G. caeca, G.*

caecescens, G. gilesii, G. investigatoris, G. prionotota, G. smithi, G. unguiculata and *G. wood-masoni* from coasts of India and Andaman and Lakshadweep Islands. Nobili (1903) reported nine species of palaemonid and a single species of caridean prawn from Puducherry and Mumbai. Henderson (1893) recorded nine species of palaemonid prawns containing three species, namely, *Leander tenuipes, Palaemon dayanus* and *P. altifrons* and one species of *Caridin*a, six species of alpheids, one species of rhynchocinetes. Alcock and Anderson (1894) reported a new species, *Palaemonella laccadivensis* from Lakshadweep sea.

1901-1947

Alcock (1905) reported 21 species of prawn from India and its adjacent countries. Among these, four species and one variety, namely, *Parapeneopsis acclivirostris, P. nana, P. stylifera* var. *coromandelica, P. uncta* and *Trachypeneus asper* were new to science; one genus *Atypopeneus* was also erected. De Man (1906) described a new species of palaemonid prawn, *Palaemon (Parapalaemon) hendersoni* from from Darjeeling. In 1908, he reported *Palaemon (Eupalaemon) lamarrei* from brackish water pools of Canning. Annandale and Matthai (1910) described three new species while working on the palaemonid prawns of South India. Henderson and Matthai (1910) described *Palaemon nobilis* and *P. dubius* from Chingleput district. Kemp (1913) studied palaemonid, alpheid, crangonid and atyid shrimps of Chilka Lake and described five new species and a subspecies, viz., *Pontophilus hendersoni, Urocaris indica, Periclimenes demani, Ogyrides striaticauda, Athanus polymorphus* and *Alpheus paludicola*. In the same year, he also described two new atyid shrimps, *Caridina excavata* and *C. hodgarti*. Kemp (1917) reported the species *Paratya curvirostris* (Heller) of the family Atyidae from Tezpur (Assam) and Manipur Hills. Kemp (1924) described the prawn, *Palaemon cavernicola* from Siju cave in Garo hills, Assam (presently, in the state of Meghalaya). Natarajan (1942a) reported upon the occurrence of *Caridina gracilirostris* and *C. laevis* among aquatic vegetation in submerged paddy fields of Kuttanad, erstwhile Travancore. In the same year, he also recorded 6 species of palaemonid and 2 species of alpheid shrimps from Travancore. Natarajan (1942b) recorded 12 species of palaemonid and 4 species of *Acetes* from Travancore. Tiwari (1947a, b) described two new species of palaemonid prawns, *Palaemon villosimanus* from Pulta, Kolkata and *Palaemon choprai* from Banaras, Uttar Pradesh. Chopra and Tiwari (1947) studied palaemonid and atyid shrimps of erstwhile Patna state, presently in the state of Odisha and two species of palaemonid prawn and two species of atyid shrimps, of which, *Caridina nilotica* var. *chauhani* was created as new to science .

1948-Present

Tiwari (1955) described five new species and subspecies, *viz*., *Palaemon assamensis* with 2 subspecies, *Palaemon assamensis assamensis* and *Palaemon assamensis peninsularis*, *Palaemon banjare* and *Palaemon canarae*. Tiwari and Pillai (1973) studied palaemonid prawns of Andaman Islands. George and George (1964) reported the caridean prawn, *Thalassocaris lucida* in the stomach of the fish, *Neothunnus macropterus* (Temmnick and Schlegel). Rabindranath (1980) studied eulittoral palaemonids of Visakhapatnam coast. He also worked on *Acetes* shrimps of Krishna estuary. Anantha Raman (1980) and Anantha Raman *et al*. (1978) reported the occurrence and distribution of freshwater prawns in and around Bangaluru city, Karnataka. Tiwari and Pillai (1968) described a new species of the genus *Caridina* from Trivandrum while Thomas *et al*. (1973) reported another new species of the same genus from Cochin backwater. Further, Tiwari and Pillai (1973) studied prawns of the genus *Macrobrachium* from Andaman and Nicobar Islands. Dutt and Ravindranath (1974) recorded *Palaemon (Palaemon) concinnus* from irrigation canal off Nizampatnam. Later, Dutt and Ravindranath (1975) reported a species of the genus *Caridina* - *Caridina brachydactyla peninsularis* from a perennial pond and semi-permanent pools in the outskirts of Guntur in Andhra Pradesh. The occurrence of this species was a new record to Indian waters. Pathan and Jalihal (1977) made a revisionary study of some important penaeid prawn genera of Konkan coast of India and revalidated the genus *Mangalura* Miers by designating *M. dobsoni* as its genotype. Sankolli and Shenoy (1979) described a new genus and species of subterranean prawn, *Troglindicus phreaticus* from Ratnagiri coast of west coast of India. Jalihal *et al* (1979) described a new species of atyid shrimp, *Caridina panikkari* from Dharwar, Karnataka. Subsequently, Jalihal *et al*. (1984) described five new species of atyid shrimp, *viz*., *Caridina gurneyi, C. kempi, C. pannikkari, C. shen*oyi and *C. williamsoni* from Dharwar area of Karnataka State. Ganapati and Sastry (1979) and Sastry (1981) studied alpheid shrimps associated with echinoids at Visakhapatnam coast. Jayachandran (1987-1992), Jayachandran and Joseph (1985-1988) and Jayachandran and Raji (2005) described several new species and made new records of palaemonid prawns from south-west coast of India. Jayachandran and Joseph (1989) discussed on the palaemonids of south-west coast of India. Thomas (1986) reported nine species of palaemonid prawns from Goa. Seshagiri Rao (1988) reported five species of palaemonid and four species of atyid prawns from Lake Kolleru, Andhra Pradesh. Pillai (1990) described a new species, *Macrobrachium striatus* from south-west coast of India. Ramaseshaiah and Murthy (1991) recorded *Metapenaeopsis tolensis* from the Coromandel Coast. Reddy (1995) recorded seven species of palaemonid, five species of alpheid, two species of atyid and one species of pasiphaeids from Chilka Lake. Indulkar and Shirgur (1995) reported a new species, *Macrobrachium bombayensis*. Almelkar *et al*. (1999) and Almelkar and Sankolli (2006) described three new species of palaemonid prawns, namely, *M. walvanense*, *M. bombayense* and M. *kulkarni* from Konkan, Maharashtra. Ghosh and Roy (2000) and Ghosh *et al*. (1999) studied prawns of Triupura and Meghalaya respectively. Deb (2000) also reported prawns from Tripura.

Jayachandran (2001) published the monograph "Palaemonid Prawns – Biodiversity, Taxonomy, Biology and Management", contained complete descriptions of 21 genera under the Subfamily Palaemoninae and 70 genera under the Subfamily Pontoniinae. Klotz (2008) described the species *Macrobrachium agwi* from Alipurduar district of West Bengal. In 2010, Unnikrishnan *et al*. described a new species of palaemonid prawn, *Macrobrachium* from Ithikkara river of south-west coast of India. Pillai and Unnikrishnan (2012-2014) described five new species, viz., *Macrobrachium abrahami, M. prabhakarani* and *M. snpurii* from Kerala. They also conducted DNA barcode and molecular phylogeny studies of some of the species. Jalihal *et al*. (1984) described five new speces of *Caridina* from Dharwar district of Karnataka. Silas and Jayachandran (2010) described a new species of *Caridina* from hill-streams of Mahendragiri estate of Kanyakumari district. Mariappan and Richard (2006) while investigating freshwater prawns of Kanchipuram and Thiruvallur districts reported a new species of the genus *Caridina*. Jayachandran *et al*. (2008) studied caridian shrimp resources of the state of Kerala. Unnikrishnan *et al*. (2010) reported the new species from upper reaches of Ithikkara river, Kerala. Komai and Shanis (2011) described a new species of the genus *Parastylodactylus* from Kerala coast of India. Prakash *et al*. (2011) discovered a shrimp, *Pycnocaris chagoae* Bruce from Lakshadweep. Valarmati and Raghunathan (2013) reported 6 species of *Caridina* and 14 species of *Macrobrachiu*m from the state of Karnataka. From Digha coast of West Bengal, 11 species of palaemonid prawns are known (Goswami, 1992; Chatterjee *et al*., 2007). Ghatak and Ghosh (2008) studied freshwater prawns of Goa reporting 4 species of palaemonid prawns of which, one species was a new record to the state. Prakash *et al*. (2015) recorded six species of caridean shrimps (*Ancylomenes magnificus, Periclimenes soror, Stegopontonia commensalis, Gnathophyllum americanum, Guerin Meneville* and *Gnathophylloides mineri*) from the Gulf of Mannar and Lakshadweep water.

Infraorder Anomura

Pre-1900

Fabricius (1787) reported three species from 'India Orientali', namely, *Cancer miles, Pagurus miles, Pagurus clypeatus, Aniculus aniculus*. Heller (1865) recorded 11 species of hermit crabs, nine species of porcellanid crabs and two species of mole crabs from Madras and Nicobars. Among these, two species of hermit crabs, namely, *Coenobita violascens* and *Diogenes avarus* and six species of porcellanid crabs, *viz*., *Porc*ellana *barbata, P. bellis, P. inermis, P. militaris, P. penicillata* and *P. pisoides*, were new to science. Henderson (1893) reported 25 species of hermit, seven species of porcellanid and one species each of albunid, Galatheid and mole crabs from Southern India. These included a new genus *Troglopagurus*, five new species of hermit crabs, *viz.*, *Diogenes affinis, D. costatus, D. planimanus, D. violaceus* and *Troglopagurus mannarensis* and one new species of prcellanid crab, *Raphidopus indicus* were collected from Madras, Rameswaram and Tuticorin. Thurston (1895) recorded 16 species of hermit crabs, one species of mole crab, two species of albunids and seven species of porcellanid crabs. Alcock and Anderson (1899) reported one species of hermit crab, *Pylocheles miersi*, 12 species of galatheids, viz., *Munida comorina, Munidopsis hemingi, M. iridis, M. goodrigii, M. moresbyi, M. rosacea, M. trifida, Ptychogaster hendersoni, P. investigatoris,Uroptychus bacillimanus, U. cavirostris, U. fusimanus* and two species of lithodids, namely, *Paralomis indica* and *P. investigatoris* on the basis of collection dredged by 'Investigator' during the surveying season 1897-98 from Travancore coast and Andamans. Except, *Munidopsis rosacea* and *M. trifida*, all were new to science.

1901-1947

Alcock (1901) reported, 10 species of hermit crabs, three species of lithodes crabs, five species of porcellanid crabs . Among these, one genus *Parapylocheles* and *Munida vigiliarum* were new to science. Alcock (1905) further reported 14 more species and five new varieties. Nobili (1903) reported nine species of hermit crabs, *viz.*, *Clibanarius longitarsus, C. padavensis, Coenobita cavipes, Diogenes affinis, D. avarus, D. custos, D. miles, D. planimanus* and *Pagurus strigatus* and two species of mole crabs, namely, *Albunea symmysta* and *Hippa asiatica* from Pondichéry and Mahè. Southwell (1909) reported three species of hermit crabs, namely, *Diogenes investigatoris, Clibanarius infraspinatus* and C. *humilis*, eighr species of porcellanid crabs, *viz.*, *Porcellana serratifrons, P. gaekwari, P. tuberculosa, Polyonyx obesulus, P. hendersoni, Petrolisthes bosci, P. armatus*, and *Petrolisthes* sp., one species each of galatheid, *Galathea elegans* and one species of munidid, *Munida spinularifera* from Okhamandal in Kathiavar district of Gujarat. This contained two new species of porcellanids, *Porcellana gaekwari* and *Polyonyx hendersoni*. Kemp (1913) studied hermit crabs of Chilka Lake and reported six species. Henderson (1915) reported 9 species including a new species, *Clibanarius olivaceus* from Lake Chilka. Sundara Raj (1927) studied intertidal hermit crabs of Krusadai Island and its neighbourhood reporting 14 species under two families. Reddi (1935) worked on the hermit crabs of Porto Novo coast reporting as many as 10 species namely, *Diogenes custos, D. diogenes, Pagurus hessii, P. punctulatus, Clibanarius aquabites, C. arethusa, C. longitarsis, C. olivaceus, Coenobita cavipes* and *C. rugosus*. Gravely (1927) studied porcellanid and albunid crabs of Krusadai and its nearby islands reporting as many as nine species. Chopra and Das (1930) described the species *C. nathi*.

1948-Present

Kamalaveni (1950) described a new genus, *Neopagurus* and one new variety of *Diogenes custos* from the collections housed in the Indian Museum. Sankarankutty (1961a) described a new genus of porcellanid crab, *Pseudoporcellanella* which was collected near Manoli Island in Gulf of Mannar. Further, Sankarankutty (1963, 1966) dealt with porcellanid crabs of east and west coasts of India and described a new species, *Porcellanela haigae*. Sankolli (1961) described a new species of hermit crab, *Pagurus kulkarnii* from Walkeshwar, Mumbai. Sankolli (1963a, b) described three new species of porcellanid crabs, namely, *Ancylocheles gravelei, Polyonyx loimicola* and *P. spendidus* from west coast of India.

Sarojini and Nagabhushanam (1968, 1970, 1972) dealt with the pagurid crabs of Waltair coast and decribed a new species from. They also reported the species, *Anapagurus laevis* for the first time from India. Sankolli *et al*. (1977) reported hermit crabs of the genera *Paguristes* and *Clibanarius* of west coast of India. Reddy (1966) reported the hermit crab, *Clibanarius zebra* for the first time from Indian water. Reddy and Ramakrishna (1972) studied pagurids of Andaman and Nicobar islands reporting as many as 20 species under five genera, of which, eight species, namely, *Aniculus aniculus, Clibanarius merguiensis, C. olivaceus, C. arethusa, C. latens, Dardanus guttatus, D. varipes* and *D. vulnerans* were recorded for the first time from these islands. Khan and Natarajan (1981, 1984) worked on the hermit crabs of Porto

Novo coast reporting as many as 20 species belonging to seven genera and three families. Sankolli (1965) and Haig *et al*. (1986) described two new species of mole crabs, namely, *Emerita holthuisi* and *Hippa indica* from south-west coast of India. Nayak and Neelakantan (1985, 1989) described two new species, *D. maclaughlinae* and *Diogenes karwarensis* from Karnataka. Thomas (1989) dealt with hermit crabs of Indian waters. Reddy (1995a, b) reported on the hermit crabs of Chilka Lake and Hooghly-Matla estuary respectively. Eight species, namely, *Coenobita cavipes, Clibanarius affinis, C. clibanarius, C. longitarsus, C. olivaceus, C. padavensis, Diogenes affinis, D. avarus* and *D. investigatoris* were recorded from Lake Chilka. Further, Reddy and Murthy (1998) studied hermit crabs of Mahanadi estuary. Goswami (1992) reported five species belonging to three genera from Digha coast. Dev Roy and Reddy (2008) and Reddy and Dev Roy (2008) reported hermit crabs of Goa and Krishna estuaries respectively. Dev Roy and Reddy (2008) dealt with hermit, porcellanid and mole crabs of Goa reporting as many as 11 species under three families. Hiller *et al*. (2010) reported 10 species of porcellanid crabs from Goa coast. Reshmi and Kumar (2010, 2011, 2013) recorded the hermit crabs *Coenobita brevimaus* and *Coenobita rugosus, Calcinus morgani, Diogenes klaasi, Dardanus lagopodes, Oncopagurus monstrosus* and *Paguristes miyakei* from Indian coast. Komai *et al.* (2012, 2013a, b, 2015) described the new species of hermit crabs *Ciliopagurus grandis, Diogenes canaliculatus, Pagurus spinossior* and *Paguristes luculentus* from Kerala coast of India. Komai *et al.* (2013b) recorded the hermit crab *Ciliopagurus liui* for the first time from Indian Ocean.

Prakash *et al*. (2013a) reported 4 species of porcellanid crabs from Lakshadweep and Prakash *et al*. (2013b) and published a checklist of porcellanid crabs of Indian coastal waters, listing 30 species belonging to 11 genera. Kumaralingam *et al.* (2015) recorded the commensal porcelain crab, *Neopetrolisthes spinatus* from India. Beleem *et al.* (2016) recorded porcelain crabs of western coast of India, while Marimuthu *et al.* (2016) recorded *Albunea occulta* from the Andaman Islands, India. Barathkumar *et al.* (2016) reported on a mew species of sand crab *Jonas kalpakkamensis* from Tamilnadu coast of India.

Infraorder **Brachyura**

Pre-1900

The first scientific study of brachyuran crabs in India dates back to 1775 when Fabricius referred to the ocurrence of a crab, *Cancer globosus* in “Systema Entomologiae where the species was reported to have been collected from the Malabars. In 1781, the same author reported one more species, *Cancer fornicata* from Tranquebar and in 1787, two species, *Cancer ovis* and *C. muricatus* from India. Later on in 1793, *Cancer porcellanus,* and *Cancer vespertilio* and 1798, Fabricius recorded several more species, *Cancer hybridus, C. quadratus, C. tetragonus, C. litteratus, Cancer sexpes, Portunus tranquebaricus, P. annulatus, P. lucifer, P. variegatus, P. truncatus*from India. Herbst (1794-1804) also studied brachyuran fauna of India, namely, *Cancer echinatus, C. armadillus, C. sanguinolentus, C. carnifex,* and *C. setosus* and reported the same in his work *“Versuch Naturgesch. Krabben Krebse”*. All these species were collected from Tranquebar.

Several other European workers like H. Milne Edwards (1834-1837, 1852-1853), Lucas (1850), A. Milne Edwards (1861, 1866, 1867) and Heller (1862, 1865) also reported and described crabs from India. Between 1834-1853, H. Milne Edwards, described/recorded 20 species namely, *Ozius frontalis, Lambrus carenatus, L. echinatus, L. longimanus, Cardisoma carnifex, Plagusia depressa, Sesarma dussumieri, S. quadrata, Metaplax distinctus, M. indicus, Ocypode ceratophthalma, Doto myctiroides, Macrophthalmus affinis, M. carinimanus, M. laevimanus, M. pectinipes, M. semplicipes, M. transversus, O. macrocera, O. platytarsis, Gelasimus annulipes, G. dussumieri, G. marionis, G. vocans* and *Thelphusa leschenaulti, T. indica, Leucosia, craniolaris, Calappa lophos, C. fornicata, Nursia hardwickii, Iphis septum spinosa, Dorippe* sima *Doclea hybrida, D. muricata, D. ovis, Lupea lobifrons, L. tranquebarica, Thalamita sima, Pilumnus vespertilio, Pseudocarcinus bellangerii, P. rumphii* from Bombay, Tranquebar, Pondichery, Coromandel, Malabar and Mahe. Sykes and Westwood (1836) described a new crab, *Thelphusa cunicularis* from the western Ghats. Lucas (1850) reported two species, namely, *Lambrus longimanus* and *Sesarma quadrata* from India. A. Milne edwards (1861-1867) described/ reported 17 species, namely, *Goniosoma callianassa, G. cruciferum, G. quadrimaculatum, G. rostratum, G. sexdentatum, G. truncatum, Neptunus hastatoides, N. pelagicus, N. sanguinolentus, Thalamita crenata, Eurycarcinus orientalis, Actumnus nudus, Carpilodes granulatus, Atergatis laevigatus, Atergatopsis flavo-maculatus, Euxanthus punctatus and Daira perlata* from the mouth of the Ganges, Bombay, Pondichery, Malabar and Nicobars. Heller (1862, 1865) reported 58 species belonging to 37 genera from Madras and Nicobars. One genus namely, *Nectograpsus* and 10 species namely, *Menaethius brevirostris, Tiarinia verrucosa, Thelphusa corrugata, T. wüllerstorfi, Carpilodes granulatus, Macrophthalmus bicarinatus, Nectograpsus politus, Ptychognathus pusillus, Sesarma aspera* and *Gelasimus variegatus* were described as new to science. Among the earlier workers of the eighteenth century, contributions of of Wood-Mason (1871a, b, 1874, 1875, 1891-1893) are worth-mentioning. Wood-Mason (1874) erected a new genus *Hylaeocarcinus* and described the species *H. humii* from Nicobars.

Henderson (1887) described a new species of matutid crab, *Matuta miersii* from Madras. In 1893, Henderson reported 130 species of marine, estuarine and freshwater crabs from various parts of India, of which, 116 species were collected from the Madras coast. The collections contained 8 new taxa, viz., *Telphusa masoniana, T. pocockiana, Lophactaea fissa, Hypocoelus rugosus, Halimede thurstoni, Actumnus verrucosus, Philyra verrucosa* and *P. polita*. Among these, the first two were freshwater forms and the remaining five marine forms. Thallwitz (1892) described a new species of sesarmine crab, *Sesarma punctatum* from Madras. Besides, Thurston (1895), Wood-Mason and Alcock (1891), Alcock (1893, 1895-1900) also contributed significantly to this group. Alcock and Anderson (1899) described and 4 new genera, namely, *Acanthodromia, Benthochascon, Camatopsis* and *Ptenoplax* and 9 new species, *Acanthodromia baffini, Hypsophrys longipes, Homola profundorum, Trachycarcinus glaucus, Benthochascon hemingi, Pilumnoplax sinclairi, Camatopsis rubida, Ptenoplax rubida* and *Pinnoteres abyssicola* from Andaman sea and erstwhile Travancore coast.

1901-1947

During this period, Alcock (1901, 1909, 1910), Borradaile (1902-1903) reported 50 crab species from Lakshadweep which included three new species, viz., *Cryptodromia hirsuta, Cryptodromiopsis tridens* and *Elamena gracilis*. Nobili (1903, 1906) reported 21 species from Bombay, Pondichery and Mahé. Out of 21 species, one species, namely, *Dotilla malabarica* was new to science Doflein (1904) reported 14 species under 13 genera from Sombrero Channel and Great Nicobar *Hypsophrys longipes, Ethusa andamanica, Cyclodorippa uncifera, Pariphiculus coronatus, Randallia pustulosa, Cyrtomaia suhmi typica, Platymaia wyville-thomsoni, Physachaeus ctenurus, Pleistacantha moseleyi, Scyramathia rivers-andersoni, S. globulifera, Benthochascon hemingi, Carcinoplax longimanus indicus, longipes, Psopheticus stridulans, Sesarma sp., Ocypoda ceratophthalma*. Rathbun (1904, 1905) reported two new species of crab, *Potamon (Potamon) wagrakaroensis* and *Potamon (Potamonautes) jacquemontii* from Bellari coast, Karnataka. Henderson (1906) described a new species of coral-infesting crab, *Cryptochirus dimorphus* from Andaman Islands. In 1912, he reported two species of freshwater crab which contained a new species, *Paratelphusa (Liotelphusa) malabarica* from Kavali, Cochin State Forest. In the following year, he described a new variety of fresh water crab, *viz., Paratelphusa (Liotelphusa) malabarica* var. *travancorica* from Ponmudi, erstwhile Travancore. De Man (1908a, b) described three new species, namely, *Sesarma thelxinoë, Tympanomerus stapletoni* and *Pachygrapsus porpinquus* from Andaman Islands and Port Canning. Hornell and Southwell (1909) described a new species of crab, *Pinnoteres placunae* from *Pinno*tere *placunae* at Okhamandal coast in Kattiawar, Gujarat. Kemp (1913, 1915, 1918, 1919a, b) dealt with crab fauna of Chilka Lake and reported 26 species, five of which was described as new. Gravely (1927, 1941) published a comprehensive account of 56 and 29 species of crabs from Krusadai Island and Madras beach respectively. In 1935, Balss reported three species from Madras coast based on collections deposited with the Madras Museum, of which, *Medaeus* *rouxi* was new to science. Chopra (1930, 1931, 1933) described 7 species of crabs namely, *Conchoedromia alcocki*, *Raninoides hendersoni*, *Leucosia rotundifrons*, *Lissocarcinus ornatus*, *Rhynchoplax tuberculata* and *R. tuberculata* var. *attenuipes*, and *Pinnotheres setnai* from Sandheads, Andaman Islands and Lakshadweep sea. This included a new genus *Conchoedromia*. *Rhynchoplax tuberculata*, *R. tuberculata* var. a*ttenuipes*. Chopra and Tiwari (1947), have contributed significantly to the study of brachyuran crab taxonomy in India. Roux (1931) described three new species, namely *Paratelphusa (Liotelphusa) niligiriensis*, *Paratelphusa (Liotelphusa) pusilla* and *Paratelphusa (Barytelphusa) carli* from south-west India.

The two publications of Alcock: "Carcinological Fauna of India" and "Catalogue of the Indian Decapod Crustacea–The Indian Fresh-water Crabs (Potaminidae)" are still indispensible for the study of Indian brachyurans crabs.

1948- 2016

Deb (1985-1998) described 19 new species of crabs, namely, *Neothalamita triangularis*, *Paractaea indica* Deb, 1985; *Paractaea neospeciosa* Deb, 1989; *P. typica* Deb, 1989; *Demania alcocki* Deb, 1986; *D. indiana* Deb, 1986; *Serenius andamanicus* Deb, 1985; *Heteropanope neolaevis* Deb, 1998; *Banareia bengalensis*, *Eurycarcinus bengalensis* Deb, 1998; *Pilumnus investigatoris* Deb, 1987; *P. kempi* Deb, 1987; *P. woodmasoni* Deb, 1987, *Parapilumnus indicus*, Deb, 1987; *P. guinotae* Deb, 1987; *Platypodia andamania* Deb, 1992; *Etisus andamanicus* Deb, 1992; *Myopilum*nus *andamanicus* Deb pertaining to the families Portunidae and Xanthidae from different parts of India along with 23 species, *viz.*, *Actaea consobrina, A. helleri, A. lata, A. margaritifera, A. michaelseni, A. obesa, A. ruppelli orientalis, A. scabra, A. tumulosa, A. variolosa, Banareia banareias, B. kraussi, Colvactaea tumida, Paraactaea garretti, P. sulcata, P. nodosa, Dacryopilumnus rathnunae, Nanopilumnus rouxi, N. barbatus, N. heterodon, Pilumnus rotumdus, Eurycarcinus maculatus, Heteropilumnus ciliatus* recorded for the first time from Indian waters. She also erected two new genera, *Neothalamita* and *Myopilumnus* from North and South Andamans respectively. Deb (1989) published a monograph on on Actaeinae (Xanthidae) of India. Further Deb and Bhadra (1985) and Deb and Ghosh (1993) recorded one species of each of the families Portunidae and Sesarmidae from Indian waters. Guinot (1971) described a new species of crab, *Liagore erythematica* from Calcutta. Chakraborty *et al.* (1986) reported 26 species of five families mangrove estuarine complex of Sundarbans. Bairagi (1995) Bhadra (1995) and Ghosh (1995) reported 21 species of ocypodid, 15 species of portunid and 24 species of grapsid crabs from Hugli-Matla estuary. Bairagi and Misra (1988) discussed taxonomic status of the fiddler crab *Gelasimus acutus* present in Zoological Survey of India.

Deb (1995) reported 28 species belonging to 22 genera and nine families from Lake Chilka, of which, two species was found as new records. Pal and Khora (1999) studied brachyuran crab fauna of Gopalpur coast of Odisha and reported species. The estuarine crabs of the state of Odisha have been investigated by a number of workers. Rao *et al.* (1992), Deb (1998) and Rath and Dev Roy (2011) studied crabs of Rushikulya, Mahanadi, Bahuda, Brahmani-Baitarani, Budhabalanga and Nuanai estuaries respectively. Dev Roy (2013) and Dev Roy and Nandi (2009) studied brachyuran crab diversity in estuaries of Odisha coast. Dev Roy (2012) reported 16 species in mangroves of Odisha coast.

Lalitha Devi (1981) recorded *Pinnotheres gracilis* and *P. alcocki* from Kakinada bay. Nirmala Devi *et al.* (1988) recorded *Ixoides cornutus* from offshores of Visakhapatnam coast. Nirmala Devi and Shyamasundari (1989, 1991) described two new species of crabs, *Pinnotheres hanumantharaoi* and *Demania shyamasundari* from Visakhapatnam coast of Bay of Bengal. Nirmala Devi (1993) also dealt with portunid crabs of Visakhapatnam coast.

Dev Roy and Bhadra (2001) recorded 21 species of brachyuran crabs from estuarine areas of Godavari estuary. Later on, Dev Roy and Bhadra (2005) and Dev Roy and Nandi (2005) reported 103 species of marine and estuarine crabs belonging to 55 genera and 16 families from the state of Andhra Pradesh along with district-wise distribution of these species. Out of these, three species, namely, *Ebalia sagittifera*, *Demania toxica* and *Typhlocarcinus rubidus* were recorded for the first time from Indian water. Rath and Dev

Roy (2010) reported 16 species from Vamsadhara and Nagavali estuaries and Krishna estuary.

Premkumar (1962) recorded the portunid crab, *Podophthalmus vigil* from Sinnur, Porto Novo. Premkumar (1964) described a new species of ocypodid crab, *Ocypoda portonovoensis* from Vellengirayanpattai, Porto Novo. Sankarankutty (1967) published a list of 88 species of crabs from Palk Bay and Gulf of Mannar which contained a new species *Zalasius indica* and twelve species, namely, *Dromidiopsis cranioides, Dorippe polita, Elamena sindensis, Halimus aries, Rhabdonotus pictus*, *Portunus samoensis*, *Charybdis (Charybdis) anisodon, Thalamita parvidens, T. spinifera*, *Metopograpsus frontalis* and *M. thukuhar* were recorded for the first time from Indian waters. Sankarankutty and Rangarajan (1974) recorded the portunid crab, *Charybdis (Goniohellenus) edwardsii*. Prabhadevi and Saraswathy Ammal (1997) recorded the hymenosomatid crab, *Rhynchoplax alcocki* Kemp in Thengapattanam estuary of Tamil Nadu. Jeyabaskaran *et al*. (2000) reported 106 species belonging to 57 genera and 16 families from Gulf of Mannar Biosphere Reserve. Kasinathan *et al*. (2007) reported the occurrence of the spanner crab, *Ranina ranina* from Gulf of Mannar. Dev Roy and Bhadra (2011) reported 94 species of marine and estuarine crabs of the state of Tamil Nadu along with a checklist of 350 species of crabs hitherto known, their distribution within the state and list of species not recorded in the state during the last hundred years. Dev Roy and Nandi (2007) studied brachyuran crab diversity from five coastal habitats of Tamil Nadu state, studied their habitat-wise distribution and zoogeography.Sethuramalingam and Khan recorded 76 species under 38 genera and 13 families from Parangipettai coast.

Chhapgar (1955-1969), Chhapgar and Borgaonkar (1985), Chhapgar and Mundkur (1995) and Chhapgar *et al*. (2004) reported 97 species from the then Bombay Presidency which includes the present day Maharashtra state (68 species), Gujarat (57 species) and part of Karnataka state (12 species). Chhapgar (1955) described two new species and a variety, namely, *Leptodius euglyptus* var. *quadrispinosus*, *Pinnotheres vicajii* and *Pseudograpsus intermedius* from Port Okha, Mumbai. Tikader (1965) reported nine species from Deogad coast of Ratnagiri district, Maharashtra. Chandy (1973) reported 20 species of crabs from Gulf of Kachchh while Ghosh (2004) reported four species of grapsid and two species of sesarmid crabs from Gujarat. Sankolli and Shenoy (1975) recorded *Doclea hybrida* for the first time from Maharashtra and also studied its life history. Aravindakshan and Sundaram (1983) recorded *Calappa lophos* at Sasoon Docks, Mumbai. Aravindakshan and Karbhari (1985) reported three species *Portunus (Monomia) gladiator, P. (Xiphonectes) hastatoides* and *Charybdis (Charybdis) granulate* from Bombay. Aravindakshan *et al*. (1986) reported *Dromia dehaani* in trawler catches off Mumbai coast.

Sekharan *et al*. (1962) recorded the crab *Calappa philargius* from Mangalore market. Ummerkutty and Deb (1972) reported 22 species belonging to eight families and 18 genera from Mysore state (now state of Karnataka). George and Noble (1968) recorded two species of pinnotherid crabs, viz., *Pinnotheres gracilis* and *Pinnotheres modiolicolus* from Karwar.

Pillai (1951) reported 59 species from the erstwhile Travancore describing three new species and a new variety, namely, *Gecarcinus (Cylindrotelphusa) steniops* var. *granulata*, *Huenia platyrostrata*, *Macrophthalmus travancorensis* and *Pinnotheres sanguinolariae*. Antony and Kuttyamma (1971) described a new species of pea crab, *Pinnotheres casta* from the clam *Meretrix casta*. Kathirvel and Gopalakrishnan (1974) recorded the portunid crab *Charybdis (Charybdis) hellerii* from Cochin backwater. Sankarankutty (1969, 1975) reported two new species, namely, *Hexapus estuarinus* and *Xenophthalmus garthii* from Cochin respectively. Suseelan (1971) recorded *Ixa inermis* from off Cochin. Daniel and Chakrapany (1977) reported a gymnopleuran crab from west coast of India. Daniel and Krishnan (1978) recorded a parthenopid crab from interspaces of spines of Sea Urchin. Selvaraj and Kathirvel (1986) reported the occurrence of *Carcinoplax verdensis* Rathbun for the first time from Quilon, Kerala coast.

Dev Roy and Nandi (2005) recorded 12 species from Salim Ali Bird Sanctuary, Goa. Later, Dev Roy and Nandi (2008) reported as many as 47 species under 9 families and 34 genera from the state of Goa. Joshi *et al*. (2011) reported the spider crab, *Acanthonyx euryseroche* from Goa. Kakati and Sankolli (1973) reported the spider crab, *Dehaanius limbatus* from India.

Chhapgar (1956) studied the distributional range of the crab, *Paratelphusa (Oziotelphusa) hydrodromus*. Nath (1982) reported *Potamon (Potamon) atkinsonianum* from Poonch valley, Kashmir. Pretzmann (1963, 1966a-d, 1984), Dutta (1983) studied systematics and distribution of freshwater crabs of Assam. Ghatak and Ghosh (2008) studied freshwater crabs of Goa reporting only one species. Bahir and Yeo (2005, 2007) erected six new genera, namely, *Baratha, Lamella, Pilarta, Snaha, Vanni and Vella* species of fresh water crabs from India. Ghatak and Ghosh (2008, 2010) recorded one and nine species from Goa and Uttarakhand respectively. Dev Roy (2010) studied the distribution of the crab, *Spiralothelphusa hydrodroma* in India. Pati and Sharma (2011) recorded the crab, *Vanni travancorica* from North Karnataka. Pati and Sharma (2013a, b) described two new species, namely, *Travancoriana granulata* from the Western Ghats and *Oziotelphusa ganjamensis* from Ganjam, Odisha. Further, Pati and Sharma (2014) described a new genus, *Ghatiana* along with two new species, namely, *G. aurantiaca* and *G. hyacintha* and one new species of the genus *Guberna toriana*, *G. triangulus* from the mountainous region of Western Ghats. Komai *et al*. (2013) reported a new species of crab, *Travancoriana canaliculatus*. Ng *et al*. (2011) described a new species of hymenosomatid crab, *Neorhynchoplax patnahi* from Patna, Bihar Pati *et al*. (2012) dealt with freshwater crabs of India. Dev Roy and Mitra (2012) recorded two species of crabs for the first time from Himachal Pradesh, Western Himalayas. Dev Roy (2013) studied decapod crustaceans of Indian Museum Tank, an heritage pond of India reporting two species of prawns and one species of freshwater crab. Pati and Sudhadevi (2015) described a new genus and a new species *Arcithelphusa cochleariformis* from Ondayangadi in Wayanad district of Kerala. Ng and Bijukumar (2015) recorded the genus *Afropinnotheres* for the first time from India (Kerala) with the description of the new species *A. ratnakara* from Kerala.

Sankarankutty (1961a, 1962a, b) recorded 92 species of crabs belonging to 54 genera and 10 families from Andaman and Nicobar Islands and erected a new genus *Jonesius* along with 10 new records from Indian waters, namely, *Tlos latus, Pseudomicippa tenuipes, Portunus emarginatus, P. minutus, P. pelagicus, Metopograpsus frontalis, Pachygrapsus minutus, P. planifrons, Ptychognathus dentatus* and *Plagusia depressa* var. *immaculata*. Das and Dev Roy (1989) reported 31 species from mangroves of Andaman Islands. Later, Dev Roy and Das (2000) studied taxonomy and ecobiology of 51 species of crabs from mangrove ecosystems of Andaman Islands. Deb and Rao (1993) published a checklist of brachyuran crabs of Andaman Islands. Dev Roy and Nandi (2012) studied and reported diversity and distribution of 521 species of brachyuran crabs comprising of 246 genera and 56 families from Andaman and Nicobar islands. This study contained two species, *Alox ornatum* and *Drachiella lapillulus* which were new records to India in addition to two other species, *Philyra sagittifera* and *P. scabriuscula* recorded for the first time from Andaman and Nicobar Islands.

Sankarankutty reported (1961b) 36 species under 28 genera and seven families from Lakshadweep archipelago. This contained 15 species, *viz*., *Matuta banksii, Huenia proteus, Tylocarcinus styx, Schizophrys aspera, Micippa philyra, Parthenope horrida, Thalamita tenuipes, T. integra, Charybdis (Goniosupradens) obtusifrons, Portunus granulatus, Carpilodes tristis, C. bellus, Platypodia anaglypta, Cymo quadrilobatus* and *Pilumnus vespertilio* which were not recorded earlier from Indian waters. Meyappan and Kathirvel (1978) recorded two species, namely, *Grapsus albolineatus* and *Cardisoma carnifex* from Minicoy Island.Futrher, Kakati and Sankolli (1973) recorded the crab *Dehaanius limbatus*.

Kumar *et al.* (2011) reported on 43 species of brachyuran crabs from Kerala coast. Kumar *et al.* (2013) recorded 11 species of calappid and leucosiid crabs from the trawl by-catch of Kerala coast, including four new records from India (*Calappa bilineata, Arcania brevifrons, Myra pernix,* and *Euclosiana crosnieri*). Ng and Kumar (2015a) recorded *Afropinnotheres ratnakara* from from the brown mussel, *Perna perna* in southwestern India. A deep-water homolid crab *Moloha tumida* was described from the deep waters off Kerala coast by Ng and Kumar (2015b). Ng and Kumar (2015c) described

Carcinoplax fasciata, a new species of deep-water goneplacid crab from southwestern India. Ng *et al.* (2016) repored on pea crab, Pinnotheres borradailei and a new species *Arcotheres michaeli* from the bivalve *Pinna bicolor.* Jigneshkumar *et al.* (2016) recorded a new species of leucosid crab *Lyphira georgeii* from Gurarat.

Infraorder **Astacidea**

This infraorder is represented in India by a single family Nephropidae which contains 3 genera and 8 species.

Pre-1900

Fabricius (1775) first reported *Astacus malabaricus* from Malabar, the current name of which is *Alpheus malabaricus* (Fabricius, 1775). Wood-Mason (1872) erected a new genus *Nephropsis* along with the description of the new species, *N. stewarti.* In 1885, he described another species of the same genus, *N. carpenteri* from off Aleppey. In 1901, Alcock also reported a new species, *Nephropsis ensirostris.* In 1892, Wood-Mason described the species *Metanephrops andamanicus* from Andamans.

1901-Present

George and Rao (1965) recorded *Nephropsis carpenteri* from off Alleppy. Suseelan *et al.* (1990) collected *Nephropsis stewarti* during its cruises off Quilon at 304-421 m depth.

Infraorder **Palinura**

Infraorder Palinura is represented by two families, namely, Palinuridae and Scyllaridae in India. The former is represented by 5 and the later by 9 genera respectively.

Pre-1900

Earlier reords of lobsters from India are by White (1847), Neuman (1878) and Ortmann (1893). Heller (1865) during his "Novara Expedition" collected and recorded two species of lobsters, *Palinurus dasypus* and *Thenus orientalis* from Madras. In 1893, Henderson (1915) also reported both the species from Madras. Pfeffer (1897) recorded *Panulirus ornatus* from Bengal.

1901-1947

Alcock (1901) reported two species, namely, *Arctus orientalis* and *Panulirus angulatus* from Chennai coast, Gulf of Mannar and Travancore coast. Nobili (1903) recorded *Palinurus polyphagus* from Bombay. Powell (1908) recorded spiny lobster (*Palinurus* sp.) from Bombay and noted its abundance all the year round. Gravely (1927) recorded the species *P. dasypus*.

1948-2016

George *et al.* (1965) reported a rare species of Spiny Lobster from off Calicut during an exploratory fishing cruise off the south-west coast of India. In 1965, George and Rao recorded another species of lobster, *Panulirus longipes* from off Muttom on the south-west coast of India. During an exploratory fishing cruise of R. V. "Kalava" of the Indo-Norwegian Fisheries Project in Indian waters, George and George (1965) recorded the species *Palinustus mossambicus* from off Calicut. George (1967) recorded two species of scyllarid lobsters, *Scyllarus batei batei* and *S. rubens* from Arabian sea off Alleppey, of which, the last species was a new record to the Arabian sea. Pillai (1961) reported on the occurrence of *Microprosthema validum* Stimpson from Pamban while Ranade (1973) recorded another species of the same genus, *Microprosthema semilaevae* from Ratnagiri.

Satyanarayana (1961) recorded lobster from inshore waters off Quilon. Chhapgar and Deshmukh (1961, 1964) reported six species from Bombay. Later, Chhapgar and Deshmukh (1971) and George (1973) dealt with lobster fishery resources of Maharashtra and India respectively. Meiyappan and Kathirvel (1978) recorded *Parribacus antarcticus* and *Panulirus homarus* for the first time from Lakshadweep. Mustafa (1991) described a new spear lobster, *Linuparus andamanensis* from Andaman Islands while Srikrishnadhas *et al.* (1991) described the scyllarid lobster, *Scyllarus tutiensis* from Tuticorin Bay in Gulf of Mannar. From Digha coast of West Bengal, only 2 species of lobsters are known (Goswami, 1992). Kathirvel *et al.* (2007) while reviewing diversity and economical values of Indian Lobsters mentioned about the occurrence of 34 species from Indian waters. Prasad and Tampi (1968) recoded 18 species of palinurid and 20 species of scyllarid lobsters from Indian Ocean, of which, 8 species of palinurid and 5 species of scyllarids are reported to occur in Indian waters. Shanmugham and Kathirvel reported lobster resources and their cultural potential in Indian waters. Pillai *et al.* (1983) studied lobsters of Minicoy atoll.

Infraorder **Thalassinidea**

Pre-1900

Heller (1865) reported the species *Thalassina anomala* as *Thalassina scorpionoides* from Nicobar Islands.

1901-1947

Two species belonging to two genera and two families had been reported from Chilka Lake. Nobili (1903) recorded the species *Thalassina anomala* from Mahe.

1948-Present

Sankolli (1963) first reported *Thalassina anomala* from Bombay. In 1971, while dealing with Thalassionoidea of Maharashtra, he described the species, *Callianassa (Callichirus) kewalramani*, collected from Bombay and Ratnagiri. Gayen and Chowdhury (1973) reported the occurrence of *T. anomala* from Sagar Islands of West Bengal. Das and Misra (1987) conducted biological investigations on *T. anomala* in various localities of Sundarbans while Das and Dev Roy (1989) reported this species from mangrove habitats of Andaman islands. Daniel (1981) studied ecology of the species, *Callianassa (Callichirus) maxima* and observed it as a pest in salt factories at Voyalur in Chingleput district of Tamil Nadu and Manginapudi in Krishna district of Andhra Pradesh. Dubey *et al*. (2012) made an ecobiological investigation of this species at intertidal mudflats of Harinbari and Chemaguri of Sagar Island, Indian Sundarban. Vaitheeswaran (2014) recorded *Axiopsis consobrina* from Gulf of Mannar, southeast coast of India.

Super order **Peracaridea**

Order **Mysida**

The Mysidacea are shrimp-like crustaceans containing a 'brood pouch'. They are mostly marine inhabiting all oceans from deep water to brackish coastal waters, a few species, however, also occur in freshwater. They are very common especially in estuaries and coastal waters, where they often congregate in large swarms. They are not as familiar as the decapod shrimps and prawns and as such are of limited commercial importance. However, they are of considerable importance as primary consumers and as food of fishes and even whales.

Mysidacea comprises of a single order with two suborders–Lophogastrida and Mysida. Only the last suborder is represented in India. About 1000 species are known world-wide, mostly belonging to the suborder Mysida.

Pre-1900

Wood-Mason and Alcock (1891) described one new species, namely, *Gnathophausia sarsii* and one new variety of *G. gracilis* var. *brevispinis* from Bay of Bengal (Investigator Stations, 100 and 102) at 840 and 920-690 fathoms depth.

1901-1947

In the course of report on "Siboga" Hansen (1910) recorded seven species namely, *Anchialina frontalis, A. pennicillata, Lycomysis pusilla, Gastrosaccus bengalensis, G. dunckeri, Leptomusis apiops* and *Uromysis armata* from Bay of Bengal which may or may not have been taken in Indian waters (Tattersal, 1922). Tattersall (1908) described two new species, *Potamomysis assimilis* and *Macropsis orientalis* from brackish waters of Dhapa near Kolkata and Canning respectively.Tattersall (1914) while working on Indian brackishwater mysids erected a new genus, *Indomysis* from a creek at Panavel near Bombay.Tattersall (1915) reported five species of mysidacea from Chilka Lake and described two new species, *Gastrosaccus muticus* and *G. simulans* along with a key to the species of Indian brackishwater mysidae. Subsequently, in 1922 he recorded 53 species from Indian waters and described two new genera, namely, *Prionomysis* and *Idiomysis*. Sewell (1922), while studying hydrobiology and invertebrate fauna of Rambha Bay, recorded three species mysids, *viz*., *Rhopalophthalmus egregius, Macropsis orientalis* and *Potamomysis assimilis*.

1948-Present

Chacko (1950) reported three species from Krusadai Island, Gulf of Mannar. Pillai (1957, 1961, l963a, b, 1964, 1965) consolidated the information on littoral mysids of the Kerala coast and the planktonic mysids from the west coast and the Maldive - Laccadive Islands in the Arabian Sea. Later, he published a comprehensive volume on Mysidacea of the Indian Ocean based on comprehensive collection of zooplankton from Indian Ocean based on the Intemational Indian Ocean Expedition (IIOE). Pillai and Mariamma (1964) reported on a new species of subterranean lepidomysid *Spelaeomysis longipes* from Kerala. Rao and Ganapati (1968) reported two species of mysids – *Gastrosaccus spinifer* and *G. sanctus* from beach sands of Waltair coast, the last one was new record to the Indian fauna. Shyamasundari (1973) and Chandramohan (1983) reported mysidacea from Waltair coast and Godavari estuary respectively. Gupta and Gupta (1984) reported the occurrence of the mysid, *Mesopodopsis orientalis* from freshwater system of Monghyr (Bihar). Pillai discovered a blind mysid *Spelaeomysis longipes* from the subterranean habitats of India. Sarkar and Chowdhury (1986) reported on the abundance of the mysid, *Mesopodopsis orientalis* in Hooghly estuary. Goswami (1992) recorded two species, namely, *Gastrosaccus muticus* and *Rhopalophthalmus egregius* from Digha coast of West Bengal. Panampunnayil and Viswakumar (1991) described a new species, *Spelaeomysis cochinensis* from a prawn culture field at Cochin. Panampunnayil (1993) described two new species of the genus *Anisomysis*, *A. spinata* and *A. truncata* from Lakshadweep archipelago. Biju and Panampunnayil (2009, 2010) reported on the mysids of Maharashtra and Gujarat describing two new species from these states. Panampunnayil and Biju (2006) described four new species from north-west coast of India. Biju and Panampunnayil (2007) also erected a new genus, *Kochimysis*. Biju *et al*. (2010) reported mysids of the Southern Indian Ocean and described two new species. Biju (2014) reported on spatial distribution and population characteristics of *Pseudanchialina pusilla* in the eastern Arabian Sea.

Euphausiacea

Pre-1900

Wood-Mason and Alcock (1891) reported *Thysanopoda microphthalma* from the Bay of Bengal. Alcock and Anderson (1894) reported *T. obtusifrons* from the same waters. Subsequent to that in 1896, Anderson recorded *Bentheuphausia amblyops* from the Bay of Bengal.

1901-2016

Pillai (1957) in his contributions to the pelagic crustaceans off the coast of India described four species and studied their larval stages. Sebastian (1966) reported 23 species of euphausiids from south-west coast of India including Lakshadweep and the Maldive seas. Reuben (1968) obtained specimens of *Euphausia distinguenda* (= *E. sibogae*) from the gut contents of *Carangoides malabaricus* (Bloch and Schneider) caught off from the north-western part of the Bay of Bengal. This was the first record of the species from the Bay of Bengal north of 07° 00´ N. Silas and Mathew (1967) recorded seven genera and 23 species (including one new species) from the deep water plankton collections made by the Indo-Norwegian Project Research Vessel “VARUNA” off the west coast of India. Mathew *et al.* (1990) reported on the distribution of Euphausiacea in space and time in the Indian EEZ and contiguous zones.

Order **Cumacea**

The Cumacea are small crustaceans ranging in length from 0.5 mm to 35.0 mm. They are worldwide in distribution occurring in the oceans from intertidal region to about 8000 m depth. Most of them are marine but a few species are also occur in estuaries and brackish water. There are no freshwater species, however, a few have been reported to penetrate into freshwater. They are an important constituent of the food item of the bottom feeding fishes especially during their larval and post-larval stages.Cumaceans are also known as indicators of hydrographic conditions in the sea. Presently, 77 species belonging to five families and 20 genera are known from Indian waters.

1901-1947

Very little is known about the cumacean fauna of Indian region, the first record being by Calman, in 1904 from the Gulf of Mannar, when he described ten species. In 1916, Kemp while dealing with the Crustacea of Chilka Lake reported two new species of cumacea, namely, *Iphione sanguinea* (Bodotriidae) and *Paradiastylis culic*oides (Diastylidae).

1948-2016

Kurian in a series of papers (1951, 1954, 1961, 1967) contributed to our knowledge on the group from the lakes of Kerala and on the collections received from the Zoological Survey of India collected from the Indian coasts and stations around Andaman Islands. Altogether 23 species of Bodotriidae, 3 species of Diastylidae, 4 species of Nannastaeidae and the lonely species of Campylaspididae, were known from the Indian region till then. Cumacea collected by the research vessel R. V. “Conch” during her cruises off Kerala coast during 1958-1959 were also studied by

Kurian (1965) and the results revealed the discovery of a new species. A thorough study on Cumacea along the Indian coasts during 1980-1984 by Kurian and Radhadevi (1983, 1984), Radhadevi and Kurian (1981) and Radhadevi (1983) revealed 21 more species making the total number of cumacea to 72 under three families. In 1985, Kurian, reviewed cumacea of Indian estuaries. Later, Radhadevi and Kurian (1990) studied cumacea of Visakhapatnam coast and recorded as many as 10 species under two families which included a new species *Eocuma striata*. In this study, one species, namely, *Makrokylindrus (Coalescuma) fistularis* was record for the first time from Indian coast. Haye (2004) described a new species of cumacea from India.

Order **Tanaidacea**

Tanaids are minute shrimp-like crustaceans, mostly within the size ranges of 2.0-5.0 mm with the exceptions of a few species, the adults of which can reach up to 50.0-75.0 mm. They are mostly marine or brackish water forms although a few species also occur in freshwater habitats. They have been recorded at different depths of the ocean from inter-tidal to deep-ocean trenches sometimes exceeding 9000 m.

Stebbing (1905) reported *Konarus crassicornis* from Gulf of Mannar. Chilton (1924) reported a new species of Tanaidacea, *Apseudes chilkensis* from Chilka Lake. Barnard (1935) reported two species from Kerala which contained a new species, *Apseudes gymnophobia*.

Balasubrahmanyan (1962) dealt with Apseudidae of Vellar estuary and Porto Novo, Tamil Nadu. Balasubrahmanyan *et al. (1975) while dealing with the* tanaidacea of Vellar estuary reported the new species, *Apseudes killaiyensis*. Bamber and Chatterjee (2010) reported three species from Andaman Islands, of which, two, namely, *Zeuxo (Parazeuxo) kurilensis*, *Triparatanais* sp. and *Leptochelia* sp. were new to science; they also erected a new genus, *Triparatanais*. Recently, Larsen *et al.* (2013) have described a new species of the family Teleotanaidae, *Teleotanais indiaensisi* from mangroves of west coast of India.

Order **Isopoda**

They are the most variable group of Peracarida comprising of free-living (marine, freshwater and terrestrial) and parasitic species, genera and families (Bănărescu, 1990). The order presently comprises of 325 species belonging to 133 genera and 38 families from India (Dev Roy 2014) including five invasive species.

Pre-1900

The first isopod crustacean reported from India was *Cymothoa eremita* which was recorded as *Oniscus eremita* by Brunnich in 1793 (Dev Roy, 2013). Later, five species viz., *Cirolana* (=*Dolicholana*) *elongata* (Cirolanidae), *Coralana* (=*Cirolana*) *sculpta* (Cirolanidae), *Nerocila depressa*, *Cymothoa* (= *Ceratothoa*) *gaudichaudii* and *Gonotus* (= *Idotea*) *indica* (Idoteidae) were reported by H. Milne Edwards (1840) which were collected from the Malabar region. After a gap of 25 years, Heller (1865) recorded 5 species from India viz., *Lygia gaudichaudii*, *Sphaeroma triste*, *Aega basalis*, *Ceratothoa banksii* and *Sphaeroma triste* of which, two were new to science. In 1866, Bate described a wood-boring crustacean, *Sphaeroma terebrans* (Sphaeromatidae) from India. Later on, Budde-Lund (1879) described two new species viz., *Tylos albidus* (Tylidae) and *Spherillo nicobaricus* (Armadillidae) from Nicobars. In 1884, Schiödte and Meinert recorded a new parasitic isopod species *Nerocila recurvispina* (Cymothoidae) from Calcutta. Budde-Lund (1885) described two new species, *Alloniscus nicobaricus* and *A. pigmentatus*. Alcock and Wood-Mason (1891) reported *Bathynomus giganteus* from Lakshadweep Sea.

1901-1947

Budde-Lund (1904) Stebbing (1907) initiated the study of Indian Isopods with the description of a new species of the genus *Tachaea* from Calcutta. In 1911, he gave a detailed account of Indian isopods and dealt with two genera of the tribe Flabellifera and five genera of the tribe Oniscoidea (terrestrial). Two genera viz., *Parapericyphis* and *Exalloniscus* were created by him as new to science. Lloyd (1908) reported *Bathynomus giganteus* from Lakshadweep Sea.

After, Stebbing, Collinge started work in this group and made important contributions which received adequate attention. Collinge (1914 b, c) published an account of three species pertaining to three genera viz., *Philoscia, Parapericyphis and Cubaris* collected from Port Blair (Andamans) and the Annamalai Hills. Collinge

(1912-22) published two papers on the terrestrial isopods based on materials from the Abor expedition. In the course of this work, he came across two new genera *viz.*, *Rotungus* and *Burmoniscus*, the former was obtained from Kobo, Abor country (= present day Arunachal Pradesh) and the later from the caves near Moulmein (presently, Myanmar). Apart from these, he also described six more species of which, three happened to be new to science. His next contribution to our knowledge of terrestrial isopods of India dates back to 1915, when he worked out the collection received from Madras Province. Of the ten species dealt in the paper, nine species, namely, *Ennurensis hispidus, Philoscia tenuissima, Hemiporcellio carinatus, H. hispidus, Arhina barkulensis, Periscyphis gigas, Cubaris solidulus, C. nacrum* and *C. granuatus*were new to science. This contained two new genera, namely, *Ennurensis* and *Hemiporcellio.* In 1916, Collinge reported 12 new species of the genera *Parapericyphis, Cubaris, and Burmoniscus* from India, Sri Lanka and Myanmar. Out of these, nine species, namely, *Burmoniscus kempii, Cubaris albolateralis, C. cavernosus, C. chiltoni, C. expansus, C. dilectum, C. gravelii*, *C. lobatus* and *C. pusillus* were described from India. Among these, *Burmoniscus kempi* was collected from Maosmai cave near Cherrapunji at an altitude of 4,000 ft. In 1917, he described yet another new species belonging to the the genus *Synidotea* from the Gulf of Mannar. Southwell (1915a, b) reported cymothoid parasites of fishes from Bengal.

Among the earlier workers, Chopra (1923-1947) made important contribution on Indian isopods. Chopra (1923) erected two new genera *Parapleurocrypta* and *Stegoalpheon*. While working on the isopod fauna of Siju cave, Chopra (1924a) described two new species of terrestrial isopods, namely, *Porcellio assamensis* and *Philoscia dobakholi* of the family Oniscidae. In the same year (1924b), on another study, he recorded two myrmecophilous isopods, *Platyarthrus acropyga* and *Cubaris granulatus* from Barkuda Islands, Chilka Lake. Of these two species, the former was a new species while the other isopod, *Cubaris granulatus* was a first time report as ant associates. His contribution (Chopra, 1923-1930) on the Bopyrid Isopods of Indian Decapod Macrura is still considered a classical work in this field both in India and the neighbouring countries. The collection consisting of 36 species and a variety assignable to 13 genera were collected mostly from the Andaman Islands, Gangetic delta, Madras, Gulf of Mannar and Bombay. In 1947, Chopra made another significant contribution on the occurrence of the ancient suborder Phreatoicoidea (Crustacea: Isopoda) for the first time from India based on collection from a pucca well at Lohagara Railway station, 18 miles from Allahabad. Later, several specimens of this species were collected from the wells at Banaras (U.P.). The distribution of this suborder is very interesting from zoogeographuical point of view.

Barnard (1935, 1936) reported on isopods based on the collections obtained by the R.I.M.S. “Investigator”. The collections contained littoral, shallow-water and deep-water species from localities in the whole of Indian region extending from the Mergui archipelago in the east to the Arabian Sea and mouth of Persian Gulf in the west. The collections contained 34 species of which, seven species, namely, *Agarna engraulidis*, *Limnoria septima*, *Cerceis bicarinata*, *Camorta nicobarica* were described as new to science. One genus, *Camorta* was erected as new to science, *Xenanthura orientalis* n. sp. (Barnard, 1935)

1948-2016

In 1950, Chopra and Tiwari described the genus *Nichollsia kashiense* from the material collected from the well in the outer lawn of the Kaiser Castle, Banaras Cantt. Later, Tiwari (1955) described another new species of *Nichollsia*, viz., *N. menoni* collected from an abandoned well at Monghyr (Bihar). In 1955, Tiwari erected a new family Nichollsidae to accommodate the genus *Nichollsia*. Gnanmuthu (1954) described two new sand-dwelling species, *Brevipleonida gracilis* and *Robustura predatoris* from Madras. Joshi and Bal (1959) reported 6 species of littoral isopods from Bombay, of which, two species namely, *Cirolana bombayensis* and *Synidotea worliensis* were new to science while the remaining four species, *viz.*, *Sphaeroma annandalei*, *S. walkeri*, *Synidotea variegata* and *Ligia exotica* were new records to the region.

Bal and Joshi (1959) and Joshi and Bal (1962) studied intertidal isopods of Bombay and described three new species. Pillai (1954, 1963 and 1966) dealt with the intertidal isopods of Travancore, Kerala. Dev Roy (2008a) studied the land and marine isopoda of Goa. Srikrishnadhas and Venkatasamy (2003) reported the occurrence of the giant isopod, *Bathynomus giganteus* from off Toothukudi, Lyla *et al*. (2007) from Chennai coast while Nayak *et al*. (2007) recorded it from off Mangalore coast. Eleftheriou and Jones (1976) during their ecological survey of sandy beaches of west coast of India recorded two species, *Eurydice indicus* and *E. peraticis* and. Of these, the former was a new species being collected from Arathangal (Kerala) and Calangute (Goa). In a subsequent study, Eleftheriou *et al*. (1980) described a new genus and a new species of psammobiotic sphaeromatid isopod, *Tholozodium ocellatum* from intertidal sandy habitat of Goa. Bhat and Bal (1962) recorded the occurrence of *Cleantis natalensis* from Bombay.

Bopyrid isopods of prawns have been investigated by Natarajan (1943), Devi (1982) and Nandi and Raut (1985) from erstwhile Travancore (now the state of Kerala), Kakinada (Andhra Pradesh) and West Bengal respectively. Bourdon (1982) described a new bopyrid species of the genus *Orbione* from the penaeid prawn, *Solenocera choprai*. Thomas (1980) and Jayasree *et al*. (2001) also recorded this group of isopoda from the Gulf of Mannar and Gosthani estuary respectively. Jalajakumari (1993) recorded the bopyrid isopod, *Orbione bonnieri* from Visakhapatnam coast. In 1993, she described a new species of bopyrid isopod, *Athelges neotenuicaudis* parasitic on the hermit crab, *Pagurus kulkarni* at Visakhapatnam coast. Further, Jalajakumari *et al*. (1984-1993) described six new species of isopods, namely, *Synidotea hanumantharaoi, Agarna bengalensis, Gnathia bengalensis, Aegathoa waltairensis, Heteranthura neoanomalus, H. rishikondensis* and *Ligidium rishikondensis* also from the same coast. Dev Roy (2011) published a checklist on bopyrid isopod parasites of shell-fishes of India dealing with 52 species under 26 genera. Subsequently, in 2012, Dev Roy published an updated systematic list of isopod fauna of India comprising of 311 species belonging to 133 genera under 38 families and 8 suborders. Further, Dev Roy (2013) presented marine and estuarine isopod fauna of India comprising of 232 species under 101 genera and 25 families containing 5 species.

Isopod parasites of fishes have been worked out by a number of researchers viz., Nair (1950), Pillai (1954, 1964, 1966a, b), Julka (1970), Joydevbabu and Sanjeeva Raj (1980), Ram (1981), Ghatak and Misra (1983), Misra and Nandi (1986), Jalajakumari *et al*. (1990), Shyamasundari *et al*. (1990) and Jalajakumari *et al*. (1990), Nair (1995). Bijukumar and Bruce (1997) reported the cymothoid species *Elthusa samariscii* (Shiino, 1951) from Kerala. Dev Roy and Mitra (2014) and Dev Roy *et al*. (2013) reported new hosts for the isopods, *Nerocila sigani* and *N. poruvae* respectively. Mitra and Dev Roy (2011) reported a new host for the Aegid isopod, *Alitropus typus* from freshwater system of West Bengal. Dev Roy and Mitra (2014b) reported *Tachaea spongillicola* from West Bengal. Rameshkumar *et al*. (2011) dealt with cymothoid parasites from Indian fishes. Isopod parasites of Indian mysids have been investigated by Sars (1885) and Pillai (1963) and those of Indian euphausiids by Sebastian (1970). Bal and Joshi (1959) studied isopod parasites of fishes of Bombay and reported three new species, *viz.*, *Argathona muraeneae, Nerocila pigmentata* and *Cymothoa cinerea*. Ramakrishna and described a new species of Nerocila.

Wood-boring crustacean received considerable attention of the scientists as they cause considerable damage to wooden structures of maritime areas incurring tremendous loss. Pillai (1955) reported on the wood-boring crustacea of erstwhile Travancore. In 1957, he described a new isopod of the genus *Limnoria* from Kerala. Pillai (1976) dealt with the role of crustacea in the destruction of submerged timber. In 1959, Becker and Kamp while dealing with isopod genus *Limnoria* of Indian coasts described a new species, *Limnoria indica*. In the same year, Srinivasan also described a new species of the genus *Exosphaeroma* from Madras. Subsequently, Ganapati and Nagabhushanam (1955) and Ganapati and Rao (1960) studied crustacean wood-borers of Visakhapatnam and Andamans respectively. George (1963) and Rao and Ganapati (1969) also dealt with the wood-boring isopods. Rao and Ganapati (1969) described a new species of limnorid isopod, *Limnoria (Limnoria) andamanensis* from Andaman Islands. Pillai (1955, 1957) dealt with the wood-boring crustacean of Kerala and also published (1961a) monograph on the group. Purushotham and Rao (1971) reported 15 species of crustacean borers from timbers of Indian coastal waters while Nair and Salim (1994) published a compilation account on the systematics and distribution of wood-boring organisms of Andaman-Nicobar Islands and Lakshadweep Archipelago.

Isopods of mangroves of Andaman and Nicobar islands have been investigated by Das and Dev Roy (1980, 1984a, b, 1985, 1989). Later on, while reviewing the marine wood-borers of mangroves of Andaman and Nicobar Islands, Dev Roy (2008a) recorded as many as nine species of crustacean borers and their crustacean associates from these islands and compared it with other maritime states of India including Lakshadweep. Nair and Dharmaraj (1980) reported on the incidence of timber-boring crustaceans of Vellar-Coleroon estuary.

Terrestrial isopods of India have been investigated by Budde-Lund (1879, 1885), Chopra (1924), Ram and Kumar (1979) and Ramakrishna and Sinha (1993). Ramakrishna (1965) recorded several species of terrestrial isopods from Kameng Division of the North Eastern Frontier Agency (= present day Arunachal Pradesh).In 1969, he described a new species of *Philoscia* based on materials collected from a pit and the surrounding galleries of Lodna Colliery, 13 km from Dhanbad, Bihar (= now in the state of Jharkhand). Verhoeff (1936a) dealt with *several species of* terrestrial Isopods of Madras and other parts of south India and described a new species of the genus *Protracheoniscus* from Ladakh (1936b). In 1957, Arcangeli (1957) erected a new genus *Madrasdillo* from India. Ferrara and Taiti (1982a-c) described six new species, *Nagurus acutitelson, N. havelocki, Anchiphiloscia bocolorata, A. longisetosa, Hybodilla monocellatus* and *Litterophiloscia denticulata* from Andaman and Nicobar Islands. Meli and Taiti (1995) described five new isopods from Andaman Islands, *viz., Adinda carli, A. lobata, A. niligiriensis, A. palniensis* and *A. triangulifera*. Kwon *et al*. (1993) described a new species, *Laureola indica*. Dev Roy (2008b) studied the isopod fauna of Pin Valley National Park, Himachal Pradesh and reported one species.

Coineau and Rao (1972) described two new species, *Angeliera cosettae* and *Microberus andamanensis* from Andaman Islands. Messana *et al*. (1978) described the isopod *Coxicoberus enckelli* from Andaman Islands., Chopra & Singh (1977), Pillai (1963, 1966), Verhoeff (1938), A brief history of isopodological studies in the Indian Museum and subsequently in Zoological survey of India was published by Ramakrishna (1975). Wilson and Ranga Reddy (2011) erected a new genus *Anthracoides*. Ram and Kumar (1979) reported a new species, *Cubaris pataliputraensis*. Schotte (1994) described a new freshwater isopod, *Annina mannai* from West Bengal. George (1946) and Pillai and Eapen (1966) erected two new genera *Megacepon* and *Indanthura* respectively from Kerala. Pillai (1954, 1964, 1966) described three new genera *Amblycephalon*, *Pseudirona* and *Cirolanoniscus* from Kerala. Ramakrishna (1975) described a new species *Porcellio ganesa*. Ramakrishna (1995) described another new species, *Philoscia indirae*. Ramakrishna (1995) published Fauna of India dealing with 30 species under 10 genera. David (1967) reported a new species *Philoscia sacchari*.

Order **Amphipoda**

Amphipoda is one of the speciose group in crustacea. In terms of species richness, it is next to Decapoda and Isopoda. Nearly, 8000 species of amphipods are known. They range in size from tiny 1.0 mm forms to giant deep-sea benthic species reaching 250.0 mm and one group of planktonic forms exceeds 10 cm. They have invaded most marine and freshwater habitats and often constitute a large portion of the biomass in many areas. Amphipods serve an important function in waste decomposition and nutrient cycle. They also play significant role in the trophodynamics of coastal ecosystems.

The principal suborder is Gammaridea. A few gammarideaans are semi-terrestrial in moist forest leaf litter or on supralittoral sandy beaches (e. g. beach hoppers), a few others live in moist gardens and greenhouses (e.g. Talitrus). They are common in subterranean groundwater ecosystems of caves, the majority being stygobionts-obligatory groundwater species. However, most of the gammaridean amphipods are marine benthic species, a few have adopted a pelagic lifestyle, usually in deep oceanic waters. There are many intertidal species, and a great many of these live in association with other invertebrates and with algae.

Pre-1900

Giles was the pioneering worker on Indian amphipod fauna. In a series of publication (1885, 1887, 1888 and 1890), he published several new species, namely, *Melita megacheles, Phronima bucephala, Phronimella hippocephala, Ampelisca lepta, Concholestes dentalii, Elisa indica, Caprella madrasana* and *C. palkii* from Indian waters. Two genera, namely, *Concholestes* and *Elisa* were erected as new from Indian waters (Giles, 1888). Mayer (1890) described three new species from Pamban bridge, Gulf of Mannar besides recording one and two species respectively from Krusadai Islands and Pamban Bridge.

1901-1947

Studies on Indian amphipod fauna started with the installation of R.I.M. S. S. "Investigator". Stebbing (1907b and 1908) reported two new species, namely, *Quadrivisio bengalensis* and *Grandidierella bonnieri* from brackishwater pools of Port Canning. Chilton (1920) reported on the occurrence of *Ampelisca pusilla* from River Ganges. Chilton (1921) reported 17 species belonging to 16 genera from Chilka Lake. This included three new species, viz., *Idunella chilkensis, Niphargus chilkensis* and *Grandidierella gilesi*. Sundara Raj (1927) erected a new genus, *Pseudocaprellina* from Gulf of Mannar. Barnard (1935) reported 27 species from India which contained 6 new species, namely, *Orchestia platensis, Parorchestia notabilis, Parahyalella indica, Grandidierella gravipes, G. macronyx, Photis digitata* and *P. geniculata*. Carl (1934) described a new terrestrial amphipod, *Talitrus decoratus* from the Nilgiris.

1948-2016

Brehm (1950) recorded 2 species of amphipoda from India. Barnar (1957) erected a new genus, *Mandibulophoxus* for Phoxocephalid amphipoda from India. Nayar (1950) described a new species, *Corophium madrasensis* from Adyar estuary, Madras. Further, Nayar (1959, 1965) reported on the amphipod fauna of Madras coast. Rabindranath in a series of publications (1969, 1971a, b and 1972) reported 13 new amphipods, namely, *Microprotopus bicuspidata* (Bogidiellidae), *Ampithoe (Ampithoe) serricauda, Ampithoe (Pleonexes) auriculata, Cymadusa imbroglio* (Ampithoidae), *Gitanopsis subpusilla, Gitanogeiton tropica*, (Amphilochidae), *Pleonexes auriculata* (Ampithoidae), *Gammaropsis anomalus* (Isaeidae), *Listriella similis* (Liljeborgiidae), *Lysianassa indica, Orchomenella mannarensis* (Lysianassidae), *Pontogenia subrostrata* (Pontogeneiidae) and *Podocerus walkeri* (Podoceridae) . Rabindranath (1975) dealt with 4 species of ampeliscid amphipods from Indian region. Pillai (1954) reported *Palinnotus natalensis* from erstwhile Travancore. Later, Pillai (1957) worked on the pelagic amphipoda of Travancore. Rao and Ganapati (1968) reported three species of amphipods, *Eriopisella* sp., *Harpinia crenulata* and *Melita* sp. from interstitial sediments of Waltair coast. Coineau and Rao (1972) reported a new species *Ingolfiella (Tethydiella) kapuri* from Andaman and Nicobar Islands. Surya Rao (1972) published a list of 132 species of gammaridean amphipods belonging to 54 genera and 24 families from intertidal region of Indian coast. Rao (1988) reported 11 species of amphipods belonging to 10 genera from Lake Kolleru (Andhra Pradesh). Venkataraman and Wafar (2005) reported the occurrence of 139 species of amphipods from the Indian Seas. From the Indian coast, 164 species of amphipods belonging to 68 genera were recorded (Tambe and Desh Pande, 1964; Sivaprakasam, 1968a, b; 1969 a, b)

The caprellid amphipods have been investigated by a number of workers (Swarupa and Radhakrishna, 1983; Guerra-Garcia *et al*., 2010). Sivaprakasam (1977) reviewed the caprellid fauna of India reporting as many as nine species from Tamil Nadu and Kerala coasts. Presently, 12 species of this family are known to occur along the coasts of India.

Asari (1983) described two new species *Victoriopisa papiae* and *Quadrivisio lobata* from Andaman and Nicobar Islands while Sasidharan (1983) described a new species of littoral amphipoda, *Anamixis barnardi* from south India. Kanakdurga *et al*. (1985) described a species of amphipod *Hyale gopalaswamyi* commensalic with sponge. Earlier, Kanakdurga *et al*. (1981) reported two new species, *Elasmopus rishikondiensis* and *E. visakhapatnameensis* from Andhra Pradesh. Ruffo (1985) created a new genus *Josephossella* with the species *Josephosella andamana* from Andaman Islands. Lyla *et al*. (1998) studied brackishwater amphipods of Parangipettai coast. Raja *et al*. (2013) studied the diversity of amphipods in the continental shelf sediments of southeast coast of India based on samples collected on board FORV Sagar Sampada during cruise numbers 260, 275 and 290 at various depths and reported the occurrence of 44 species under 29 genera and 17 families. Senna *et al*. (2013) described a new species, *Bogidiella totakura* of the family Boigoidellidae from bore wells in Andhra Pradesh. Intertidal amphipods from mangrove ecosystems have been reported by various workers, viz., Andaman mangroves (Das and Dev Roy, 1989), Sundarban mangroves (Mandal and Nani, 1989), Pichavaram mangroves (Kathiresan, 2000) and Pondichery mangroves (Satheeshkumar, 2011). A total of 11 species belonging to nine genera under five families are known as a result of these studies.

Compared to marine components, freshwater amphipods are poorly known. Freshwater amphipods have been studied by Stebbing (1907), Stephenson (1931), Seshagiri Rao (1988) and Nath (1994) and as many as 16 species are so far known. Stebbing (1907) erected a new genus, *Quadrivisio* along with the new species, *Q. bengalensis* from brackish water pools of Canning. In 1908, he described another new species, *Grandidierella bonnieri* from brackish water pond of the same locality. The subterranean amphipod fauna has been investigated by Holsinger *et al*. (2006) and Messouli *et al*. (2007). Holsinger *et al*. (2006) described the new species, *Bogidiella indica* from south-east coast of India. One of the significant contributions in recent years on Indian amphipod fauna is the erection of a new family of subterranean amphipod, Kotumsaridae by Messouli *et al*. (2007).

Class Maxillopoda

Subclass Theostraca-Cirripedia

Pre-1900

Reinhardt (1850) reported the species, *Lithotrya nicobarica* from Nicobars. This was the first cirriped species described from India. In 1854, Darwin reported two species from Tuticorin. Heller (1865) recorded three species of cirripedes namely, *Balanus tintinnabulam*, *Lepas anserifera* and *Chthamalus dentatus* which were collected from Madras and Nicobars. Anderson (1871) reported the genus *Sacculina* from the Andaman Islands.

1901-1947

Borradaile (1903) described 18 species of this group from the collections made in the Indian Ocean and in the Maldive and Lakshadweep Archipelago. This list contained two species, *Chelonobia testudinaria* and *C. caretta* from Lakshadweep. The most important contribution to our knowledge of the cirripedes of India is that of Annandale (1905-1924) who in a series of papers described several cirripeds in the Indian Museum collected from Ceylon, India and the Andaman Seas. Annandale (1911) reported rhizocephalan parasite, *Sacculina carcini* Thompson, 1911collected off from the mouth of the River Hugli. In the same year, Annandale created a new genus *Sesarmaxenos* for its species *monticola* which was obtained from Mount Harriet, Andaman Islands. Gruvel (1907) described the operculate barnacles of the Indian Museum. Later, in 1927, Sundara Raj recorded 5 species of cirripeds from the Krusadai Islands. In 1938, Nilsson-Cantell, in his monographic work reported 63 species of cirripedes belonging to 6 families from Indian waters.

1948-2016

Daniel (1952, 1953a, b) described two species and one subspecies, namely, *Lepas bengalensis*, *Conchoderma indicum* and *Pollicipes polymerus madrasensis* from Madras and Krusadai Islands, east coast of India. Daniel (1956) recorded 42 species and varieties belonging to five families and 13 genera from Madras coast. This is one of the major contributions on Indian cirripedes during post-independence period. Further, Daniel (1958, 1962a) reported two new species, *Balanus (Semibalanus) madrasensis* and *Balanus (Semibalanus) sinnurensis* from Madras and Porto Novo respectively. Daniel (1962b) described a new species of platylepadid barnacle, *Platylepas multidecorata* from the green turtle, *Eretmochelys* sp. at Little Andaman. In 1963, Daniel and Ghosh described another new species of cirriped, *Balanus (Megabalanus) squillae* which was collected from stomatopod (*Squilla* sp.) at Madras. Bhatt and Bal (1960) recoded 4 species from west coast of India, of which, three species namely, *Balanus amphitrite hawaiiensis* Broch, *Balanus amphitrite malayensis* Hoek and *Chthamalus challengeri* Hoek were new records to India. Dinamani (1965) reported a pedunculate cirriped from the gills of *Puerulus sewelli*. Premkumar and Daniel (1968) reported a new species *Balanus (Membranobalanus) roonwali* from sponges of Tamil Nadu coast. Wagh and Bal (1969) recorded two species of inter-tidal barnacles, *Balanus amphitrite stutsburi* Darwin, 1854 and *Tetraclita (Tetraclita) squamosa rufotincta* Pilsbry, 1916 from India. Of these two, the first species was collected from Trombay near Bombay and Mangalore and the second one from Okha and Veraval. Wagh (1973) also commented on the probable transportation of *Balanus amphitrite stutsburi* by ships to Indian waters. Daniel (1985) reviewed estuarine cirripedes of India. Balakrishnan reported *Conchoderma virgatum* (Spengler) on *Diodon hystrix* Linnaeus (Pisces). Boschema (1957) described a rhizocephala, *Heterosaccus indicus* from the portunid crab, *Portunus pelagicus* from India. After a gap of 37 years, Hameed (1993) also recorded the same rhizocephalan species from the same host. In 1959, George discovered another rhizocephalan parasite, *Heterosaccus ruginosus* from another portunid crab, *Neptunus sanguinolentus*.

Subclass Branchiura

The branchiura commonly known as carp-lice or fish lice are a group of ectoparasitic crustaceans of uncertain positions within the class Maxillopoda. They are usually found on fishes but a few species are also reported from amphibians and invertebrates. They occasionally reach high in numbers and cause fish mortalities (Hora, 1943; Nandi and Das, 1991) in aquaculture operations, or more rarely in wild populations of fish. Often they become abundant in aquaria resulting in the death of ornamental fish. Their size varies from few millimeters to over 30 mm long. Usually the females are somewhat larger in size than the males. About 200 species of argulids are known world-wide. These are accommodated in six genera under a single family Argulidae in the order Arguloida. From India, 16 species and subspecies under a single genus *Argulus* are so far reported. Among them, nine species occurs exclusively in India.

Pre-1900

No work

1901-1947

Hora (1943) was the first to report branchiura from India. He reported *Argulus foliaceous* from Bengal and noted mass mortality among carp fisheries of Bengal.

1948-2016

Ramakrishna (1951) described two species, namely, *Argulus bengalensis* (from West Bengal) and *A. giganteus* (Andhra Pradesh) and a variety of *A. siamensis peninsularis* (exact locality not cited). In 1959, Ramakrishna described another new species, *A. puthenveliensis* from Kerala. Malaviya (1958) reported *A. in*dicus from Jabalpur, Madhya Pradesh. Sundari Bai (1973) recorded *A. siamensis* from Bangalore. Tripathi (1975) described two new species, *A. boli* and *A. parsi*. Thomas and Devaraj (1975) reported two new species, namely, *A. cauveriensis* and A. *foliaceous* from River Cauvery. Prabhavathy and Sreenivasan (1976) reported *A. japonicus* from Tamil Nadu. Devraj and Hamsa (1977) reported the new species, *A. quadristriatus* from Tamil Nadu. Natarajan (1982) described a new species, *A. mangalorensis* from Karnataka. Brar and Battish (1993) reported *A. bengalensis*, *A. indicus, A.monody, A. schoutedeni* and *A. siamensis* from Punjab.

Order Calanoida

1901-1947

Members of Calanoida belonging to subclass Copepoda were investigated by Sewell (1912, 1913) from the coastal region of the Bay of Bengal, Sewell (1914, 1919-24) and Chilka Lake. Sewell (1924) reported 21 species of calanoid copepoda under 5 families and 8 genera from Chilka Lake describing a new species, *Isias tropica*. Sewell (1929) extensively studied the collections made from the Indian seas by R.I.M.S. ‘Investigator’ and published the results in the *Memoirs of the Indian Museum* based on collections from the surface living and mid-water Copepods made during the years 1910-1925. This monograph dealt with 8 families, viz., Calanidae, Eucalanidae, Paracalanidae, Pseudocalanidae, Actideidae, Euchaetidae, Phaeronidae and Scolecithricidae. Kiefer (1939) in Scientific Results of the Yale North India Expedition reported species from Kashmir, Ladak and Nilgiris.

1948-2016

Brehm (1950a, b) recorded 11 species from India, of which, two, namely, Sinodiaptomus ganesa and Phyllodiaptomus peregrinator were new to science. Sewell, Krishnaswamy (1953) contributed to our knowledge on the Calanoid copepoda (13 families of Madras coast). Ummerkutty (1963) described a new calanoid copepod belonging to the genus *Ridgewayia*. Kasturirangan (1963) furnished a detailed workable key for the identification of the more common planktonic Copepoda of Indian coastal waters. Sehgal (1960) described the copepod *Heliodiaptomus alikunhi* from Puri district of Odisha. Reddiah (1964a, b) described two new species from Assam namely, *Neodiaptomus kamakhiae* and *Tropodiaptomus lakhimpurensis*. In 1965, he also described two species of the genus *Arctodiaptomus* from Khasi and Jaintia hills, the then Assam (presently in the state of Meghalaya). Dumont and Ranga Reddy (1973) described a new species of calanoid while reviewing the genus *Phyllodiaptomus*. Abraham (1970) reported the occurrence of *Acartia plumosa* T. Scott in west coast of India. Roy (1977) described a new species of the genus *Pseudodiaptomus* from Nancowry Island. Rajendran (1979a, b) erected a new genus, *Spicodiaptomus*, described two new species, *Spicodiaptomus chelospinus* and *Allodiapto*mus *triuttani* and also reported the species *Neodiaptomus handeli* Brehm (Rajendran 1979 c) from Madurai, south India. Ranga Reddy (1987, 1988) while studying taxonomic revision of the genera *Allodiaptomus* Kiefer and *Megadiaptomus* Kiefer described one species each from these two genera. Dumont and Ranga Reddy (1993) resurrected the genus *Phyllodiaptomus* and described a new species, *Phyllodiaptomus wellekensae* from South India. . Silva *et al*. (1994) described a new genus *Keralodiaptomus* from a temporary pond in Mattam, Kerala. Ranga Reddy (1992, 2013) and Ranga Reddy *et al*. (1990) described three new species, namely, *Eodiaptomus shihi* from Central India, *Neodiaptomus prateek* from Assam respectively. Ranga Reddy *et al*. (1990) described a new calanoid, *Arctodiaptomus (Rhabdodiaptomus) michaeli* from Kashmir.

Order **Harpacticoida**

Pre-1900

Wolfenden (1900) studied harpacticoid copepods of the Laccadive and Maldive Islands, reporting as many as 115 species.

1901-1947

Sewell (1924) recorded 18 species of harpacticoids belonging to 8 families and 11 genera containing two new species, *Amphiascus scotti* and *Laophonte secunda* and two new varieties, *Harpacticus clausi* var. *orientalis*, *Parategastes sphaericus* var. *similis*, *Idyaea ensifera* var. *indica* and *Nitocra typical* var. *lacustris*from the Chilka Lake (Odisha) and Sewell (19) nine species from the Salt Lakes, Kolkata. Further, Sewell (1947) in his monograph on the harpacticoids collected by John Murray Expedition and R.I.M.S. 'Investigator' dealt with six species from Indian waters. Among these, four species were recorded from Nancouri Harbour (Nicobar Islands) and two from Lakshadweep.

1948-2016

Krishnaswamy (1953-1959) described 21 species belonging to ten families from Madras and 90 species pertaining to 22 families from the Madras coast, Waltair, Porto Novo, Mandapam Camp, Krusadi Islands and its environs and also from Hare Islands off Tuticorin. He also erected the genus *Sewellina*. Ummerkutty (1960) gave an account of two new taxa from the Gulf of Manner. Rao (1967) described a new species of sand-dwelling harpacticoid copepod of the genus *Arenopontia* and studied its life-history. Rao (1969) reported 37 species from the marine beach of Waltair. Ranga Reddy (1979) recorded a harpacticoid copepod from India. Fiers (1987) described a new species from West Bengal. Rao and Ganapati (1968, 1969) while studying interstitial fauna inhabiting sandy beaches of Waltair reported as many as 46 species, of which, *Arenosetella setosus, A. noodti, Pararenosetella clavata, Leptastacus waltairensis, Psammastacus spinicaudatus, Paramesochra denticulate, Schizopera indica* and *Ameira bengalensis* were new to science. Rao (1969) studied interstitial fauna of sea beaches of Odisha. Ranga Reddy (1979) described the species *Enhydrosoma radhakrishnai* from Lake Kolleru, Andhra Pradesh. Wells (1971) studied harpacticoid copepods of two beaches of southeast coast of India and reported two new species, *Stenhelia (Delavalia) madrasensis* (from Madras) and *Apodopsyllus camptus* (from Porto Novo). Wells (1980) in their revisionary work on the genus *Longipedia* reported two species from Andamans, of which, one was new to Science. Radhakrishna and Reddy (1978) described a new species, *Stenhelia (Delavalia) krishnaensis* from South India. Rao (1991) while studying meiofauna of Lakshadweep recorded one species belonging to 42 genera and 18 families. Karanovcic and Pesce (2001) described a new genus *Rangabradya* from a freshwater well at Guntur.

Karanovic and Ranga Reddy (2004) also described a new genus and species of the family Diosaccidae. In 2005, they also reported the genus *Hemicyclops* for the first time from Indian subterranean waters. Among the important contributions on the group are harpacticoid copepod fauna of Andaman and Nicobar Islands by Wells and Rao (1987) which contained 127 species under 17 families from Andaman and Nicobar Islands and reporting two new genera (*Apolaophonte* and *Langia*) and as many as 42 new species, *viz. Brianola hamondi, Canuellina nicobaris, Scottolana oleosa, S. rostrata, S. tumidiseta* (Canullidae), *Arenosetella tricornis, Halophytophilus abrerrans, H. simplex, Noodtiella mielkei, N. ornamentalis* (Ectinosomatidae), *Eupelte aurulenta* (Peltidiidae), *Diarthrodes brevipes, Neodactylopus trichodes* (Thalestridae), *Parasten*helia *oligochaeta* (Parastenheliidae), *Balucopsylla triarticulata, Helmutkunzia variabilis, Stenhelia (Delavalia) brevis*eta, *Stenhelia (Delavalia) clavus, Stenhelia (Delavalia) fustiger, Stenhelia (Delavalia) hirtipes, Stenhelia (Delavalia) mixta, Stenhelia (Delavalia) ovalis, Stenhelia (Delavalia) paraclavus, Stenhelia (Delavalia) valens, Schizopera* spinifer (Diosaccidae), *Karllangia arenicola bengalensis, Nitocra quadriseta, Parevansula elongatus* (Ameiridae), *Oniscopsis dimorphus, Phyllopodopsyllus crenulatus, P. gracilipes, P. stigmosus, P. tenuis* (Tetragonicipitidae), *Arenotopa dyadacantha* (Cylindropsyllidae), *Cletodes dentatus, Enhydrosoma pectinatum* (Cletodidae), *Afrolaophonte ensiger, Apolaophonte hispida, Langia maculate* and *Laophontina sensillata* (Laophontidae).

Rao (1993) while dealing with meiofauna of Little Andaman recorded 50 species of harpacticoids which contained two new species, *Ectinosoma andamanica* and *Stenhelia (Delavalia) andamanica* from West Bay and East Bay respectively. Ranga Reddy and Defayee (2008) recorded the genus *Rybocyclops* in the subterranean groundwaters of southeastern India describing a new species and also discussed its biogeographic significance. Sivaleela and Venkataraman (2009) reported seven species from Gulf of Mannar.

It may be mentioned that the Family Parastenocarididae was known by only 20 species from Asia with no record from India. Ranga Reddy (2001) for the first time reported the family with five species from the river Krishna at Vijayawada; three of which were new to science. Presently, the family consists of three genera and 11 species. Among these, 10 species are known exclusively from the state of Andhra Pradesh.

Order **Cyclopoida**

Pre-1900

During this period, Bassett-Smith (1898) described a new genus, *Helleria* and 14 new species of parasitic copepods, viz., *Bomolochus triceros, B. tetradonis, Caligus parvus, C. cybii, C. hirsutus, C. phipsoni, C. longicaudus, C. bendeni, Hilleria armata, Lernanthropus trifoliatus, L. polynemi, Peroderma branchiate, Chondracanthus elongatus* and *Brachiella appendiculosa* from fishes of the then Bombay (now Mumbai).

1901-1947

Southwell and Prashad (1918) described the species *Ergasilus hamiltoni* from West Bengal. Sewell (1924) recorded 19 species of cyclopoid copepods under eight families and 12 genera and described three new species, *Cyclopina longifurca, Halicyclops tenuispina* and *Saphirella indica* from Lake Chilka. Gnanamuthu (1947-1957) in a series of publicatins dealt with cyclopoid copepods of the Madras coast. Menon

(1947) and Lindberg (1935-1947) dealt with cyclopoid copepods of India

1948-2016

Sewell (1949) in his monograph on the littoral and semi-parasitic cyclopoida collected by John Murray Expedition and R.I.M.S. 'Investigator' dealt with 26 species from Indian waters, of which, 13 namely, *Asteropontius nicobaricus, Hemicyclops indicus, Anthessius investigatoris, Preherrmannella adduensis, P. nicobarica, Macrochiron (Macrochiron) spinipes, Macrochiron (Paramacrochiron) malayense, Kolleria andamanensis, K. camortensis, Orientopsyllus investigatpris, Cymbasoma nicobarica, Monstrilla investigatoris* and *Botryllophillus indicus* were new to science. Redkar *et al*. (1949, 1951), Brehm (1950), Rao (1950, 1951), Krishnaswamy (1953) and Sebastian (1964-1968) enriched our knowledge on this group. Karamchandani (1953) described *Ergasilus batai* from West Bengal. Pillai (1959) described two new species of the genus *Clausidium*, namely, *C. chelatum and* C. *travancorense* from shrimp of the genus *Callianassa*. Bennet (1961-1974) described five parasitic copepods, *viz*., *Bomolochus jonesi, B. sardinellae, B. varunae, Anodontostoma chacunda* and *Pumiliopsis spathepedes* from fishes. Kurian (1961) and Malati (1961) reported on parasitic cyclopoids of fishes of Kerala and Bombay respectively.

Ummerkutty (1960-1970) reported four new genera *Paralepeopsyllus, Nearchinotodelphys* from *Sewellopontius* and *Indomyzon* and described 21 new species of marine cyclopoid copepod, namely, *Asteropontius littoralis, A. sewelli, Cryptopontius graciloides, C. orientalis, Hemicyclops intermedius, Pseudoanthessius agilis, Macrochiron (Macrochiron) rigida, Lichomolgus holothuriae, L. serratipes, L. brevifurcatus, L. indicus, Ridgewayi krishnaswamyi, R. typical, Pseudanthessius anormalus, P. brevicauda, Paralepeopsyllus mannarensis, Tisbintra jonesi, Danodes panikkari, Sewellopontius rectiangulus, Parapeltidium nichollsi, Porcellidium unicus and Ebhinolaophonte tropica* from Palk Bay and Gulf of Mannar. Tripathi (1960) described a new species, *Heterochondria longa* from Rishikluya estuary, Odisha. In a series of papers, Pillai (1961-1967) dealt with Cyclopoid Copepoda pertaining to the families Bomolochidae, Taeniacanthidae, Caligidae, Anthosomatidae, Eudactylinidae, Dichelesthiidae and Lernaeoceridae parasitic on South Indian fishes. Sebastian and George (1964) reported a new species, *Lernaeenicus anchoviella* from Palk Bay and studied its immature stages. Rao (1964) described a new cyclopoid, *Stellicomus pambanensis* parasitic on starfish. Rangnekar (1953-1963), Rangnekar and Murti (1950-1972) and Rangnekar *et al*. (1953) dealt with parasitic copepods of fishes of Bombay. Raj (1923) described a new species from the gills of *Wallago attu*.

Reddiah (1960, 1961, 1962) studied copepods associated with bivalves of Indian waters and described four new copepods, namely, *Conchyliurus bombasticus, C. fragilis, C. maximus* and *Ostrincola portonoviensis* which were associated with the bivalve, *Meretrix casta*. Out of these three, the first two two species were subsequently recorded from Ratnagiri coast of Maharashtra by Ranade (1973). Reddiah (1966) reported two new species of the genus *Pseudanthessius*, namely, *P. madrasensis* (on crinoids) and *P. minutus* (on tunicates) from Madras Harbour and in 1969 erected a new genus of *Pseudomacrochiron* with its species *P. stocki* from Marina beach, Madras. This species was found to be associated with a medusa. Ummerkutty (1960-1970) described four new genera namely, *Paralepeopsyllus, Nearchinotodelphys, Sewellopontius* and *Indomyzon* and 22 new species, namely, *Asteropontius littoralis, A. sewelli, Cryptopontius graciloides, C. orientalis, Hemicyclops intermedius, Indomyzon, qasimi, Pseudoanthessius agilis, P. anomalus,P. brevicauda, Macrochiron (Macrochiron) rigida, Lichomolgus holothuriae, L. serratipes, L. brevifurcatus, L. indicus, Ridgewayi krishnaswamyi, R. typica, Paralepeopsyllus mannarensis, Tisbintra jonesi, Danodes panikkari, Sewllopontius rectiangulus, Parapeltidium nichollsi, Porcellidium unicus and Ebhinolaophonte tropica*from Palk Bay and Gulf of Mannar. Malhotra and Jyoti (1972) described a new copepod parasite, *Lernea kashmirensis* from the fish stone-loach in Kashmir. Hamid and Pillai (1973a, b), and Jayasree and Pillai (1976) described five new species of parasitic copepod, namely, *Trebius kirtii, T. javanicus, T. sepheni, Caligus parapetalopsi* and *Lernanthropus nemipteri* from Kerala. Further, Hameed (1976, 1977) described three new species of two genera, namely, *Lepeophteirus* and *Pseudocaligus* from Kerala.

In 1974, Pillai and Hameed described a species *Pseudotaeniaca*nthus *longicauda* of the family Taeniacanthidae from Kerala. Pillai and Natarajan (1977) reported five new species, viz., *Bomolochus multiceros, Nothobomolochus trichuri, Caligus distortus, Hermilius tachysuri* and *Lepeophtheirus latigenitalis* from fishes of Kerala. Bennett and Chellam (1977) described the species *Peroderma tasselum*. Radhakrishnan (1977) described a new species, *Peniculisa wilsoni* from the fish *Diodon hystrix* in Kerala. Prabha and Pillai (1979-1986) reported 41 species from coastal waters of Kerala and described two new genera, *Pseudechetus and Kabataella.* Out of 41 species, 18 species namely, *Anuretes* chelates, hoi, *A. plataxi, A. rotundus, A. shiinoi, A. yamaguti, Thysanote polyfimbriata, Caligus callyodoni, C. kirtii, C. pomadasi, C. reniformis, Hermilius ariodi, Kabataella indica, Lepeophtheirus rotundigenitalis, L. shiinoi, Pseudechetus fimbriatus, Pseudanuretes indicus* and *P. pomacanthodi* were described as new. Nair and Pillai (1985) described three new species of cyclopoid copepods *Stellicola stebbingi*, *Kombia curvata* and *Pennatulicola corallophilus* associated with corals from Gulf of Mannar and Lakshadweep. Pillai (1985) in his contribution on Parasitic copepod fauna of India dealt with 314 species from India containing 5 new species, namely, *Ceratochondria hoi, Caligus chrysophrysi, C. holocentri, Sagum enneacentri* and *S. tuberculatum* and erected a new genus, *Tuxophoropsis*. Ranjit Singh and Bensam (1998) reported a new species of *Peroderma*. Ho *et al*. (2000) described a new genus *Bactrochondria* and three new species, namely, *Bactrochondria papilla*, *Acanthochondria zebriae* and *Heterochondria petila* from flatfishes of Kerala. Lakshmipyari and Gambhir (2012) described a new species of Pentastomid copepod, *Raillietiella bifurcaudat* from a wall lizard in Manipur. Totakura and Ranga Reddy (2015) studied ground water cyclopoid copepods of peninsular India and reported 12 species which included one new genus *Brevicyclops* and eight new species, viz., *Halicyclops martinezi, Rybocyclops defayeae, Brevicyclops asetosus, B. brevisetosus, B. viduus, Anzcyclops indicus, Haplocyclops (Kifercyclops) primitives* and *H. (K.) godavari* from hyporheic and phreatic habitats in the coastal deltaic belt of the rivers Krishna and Godavari in earstwhile Andhra State.

Subclass Ostracoda

Ostracods commonly known as “mussel shrimps” are There are nearly 8,000 living species of ostracods of which, about 2000 species are of recent non-marine origin. These are accommodated roughly under under 200 genera. Of the described living species, 7000 belong to subclass Podocopa and 600 to subclass Myodocopa (Cohen 1998). Two families namely, Cyprididae (1000 species) and Candonidae (550 species) represent about three-fourths of the extant ostracod fauna. Rest 11 families comprise the remaining one-fourth of the species.

Pre-1900

Sowerby (in Malcolmsoni) was the first to initiate ostracod studies in India. In, 1840, he described *Cypris cylindrica* along with *Cypris subglobosa* from the deccaninter-trappean sedimentary beds of the Sichel Hills, Andhra Pradesh. Carter (1857) in his Geological papers on western India mentioned about the occurrence of three species of ostracoda in the freshwater deposits of Bombay. Subsequent works of Baird (1859) revealed the occurrence of four species of ostracods, namely, *Cypris subglobosa* Sowerby, C. *cylindrica* Sowerby *var. major* Baird and *C. dentata-marginata* Baird from freshwater pools of Nagpur.

1901-1947

In 1907, Gurney described a single species each from Lower Bengal and Chakradharpur. Klie (1927) described two new species from Punjab, Darjeeling and Cherapunji.

1948-2016

Brehm (1950b) reported two species, namely *Stenocypris malcolmsoni* and *Strandesia* sp. from India. Hartmann (1964) in his extensive studies on Asiatic Ostracoda listed 25 species, inclusive of two new genera, 13 new species and one new subspecies from the Indian sub-continent. Deb (1972) while working on the ostracods of Delhi recorded four species, of which, two, namely, *Newnhamia fenestrata* King, 1855 and *Cypris ravenala* Brehm, 1938 were new to India. Nasar and Deb (1975) made a new record of the ostracod *Cypridopsis ochracea* from India. Deb and Nasar (1977) described a new species, *Cypricerus munshii* of the family Cypridae. Deb (1973) recorded the genus *Sclerocypris* for the first time from India describing two new species. Earlier, this genus was hitherto known to be confined to South Africa. Victor and Michael (1975, 2008) described nine new species of fresh water ostracods from Madurai, Tamil Nadu. Victor and Fernando (1979) studied the ostracod fauna of India reporting as many as species 56 freshwater valid and five doubtful species. In 2008, they described two more species. Jain (1977) studied recent freshwater ostracods of Chilka Lake while Singh (1974) reported several new species from Kashmir. Deb (1984) reported four species from Bihar, of which, three were reported as new. Gupta (1984, 1988a, b) described four new species, *Indocandona biharensis, I. krishnakantai, Candonopsis urmilae* and *Prionocandona kantii* from Monghyr, Bihar including the two new genera, *Indocandona* and *Prionocandona* . Deb (1972) reported 20 species from Rajasthan and raised the total number of ostracod species to 34. Habibnia and Mannikeri (1988) reported freshwater ostracods of perennial ponds of Manda and Khinyan villages near Jaisalmer Town and discussed their zoogeographical affinities and provinces. Deb (1973) recorded the ostracod genus *Sclerocypris* for the first time from India along with the description of two new species. Malik and Harshey and Shrivastav (1983) reported four species from Jabalpur and Amarkantak, Madhya Pradesh, all of which were new records to Indian ostracod fauna. George *et al*. (1993) described two new species of fresh water ostracoda of the genus *Parastenocypris – P. goddeerisi* and *P. achandii* from Kerala. Singh (1994) reported 6 freshwater species from the Mansar lake of Jammu and discussed their ecology with water characteristics. Studies on freshwater ostracods of Dharwad region, Karnataka were initiated by Vaidya (1987) and Mannikeri *et al*. (1987, 1989). Mannikeri and Vaidya (1987, 1990) reported 6 new species from the lakes and ponds of Dharwad city. Vaidya (1996) gave a brief note on zoogeographical distribution of recent freshwater freshwater ostracods from Dharwad. Battish (1977) described several new species from India including a new genus. Battish (2000) published a synopsis of the Recent Indian freshwater ostracoda enlisting 208 species under 43 genera. Patil (2002) and Patil and Talmale (2002) studied freshwater ostracods of Ujani (7 species) and Nathsagar wetlands (9 species), Maharashtra. Patil and Talmale (2005) published a checklist of freshwater ostracods of Maharashtra dealing with 38 species belonging to 16 genera and four families. Deb (1983) reported ostracods of Maharashtra describing as many as 18 new species, namely, *Cypris debi, C. elongata, C. globosa, Eucypris compressa, E. Sonia, E. gomti, E. munia, E. indica, E. inequalis, E. ellipticalis, E. himani, Cyprinotus malini, Cypricercus indrani, Stenocypris khopoliensis, S. sohni* and *Cypretta gargi* from the state and also erected a new genus *Sataracypris*.Harshey (2008) enlisted 26 species of ostracods of 11 genera and two families from various water bodies of Jabalpur and its surroundings.

Puri (1966) while studying ecology of distribution of recent ostracods of the Indian Ocean reported 44 species from the region. Maddocks (1968) dealt with the commensal free-living ostracods of the genus *Pontocypria* Müller, 1894 from the Indian and Southern Oceans. Jacob (1969) made an investigation on the distribution and abundance of planktonic ostracods of the Indian Ocean based on data from I. I. O. E. reporting as many as 24 species. Pillai (1970) observed *Pyrocypris* species during February-April 1967 and noted stray population of this species during November 1966 along the Bombay coast. James (1972), 1973) described a new species of ostracod and also reported a rare halocyprid from the Arabian Sea in 1973. George and Nair (1980) gave an account of the distribution of planktonic ostracods of the northern Indian Ocean and recorded as many as 32 species belonging to 18 genera and 2 families. Ostacods of theAndaman Sea has been investigated by Stephen and Meenakshikunjamma (1996). Further, Rosamma and Meenakshikunjamma (1996) studied the distribution pattern of 12 species of ostracods around Andaman and Nicobar islands. Varghese (2000) reviewed the distribution and abundance of ostracods in the inshore as well as the oceanic regions of the Indian Seas.

Ostracod fauna of Indian estuaries is now well-documented. Estuarine ostracods have been investigated by Varma *et al*. (1993), Bhandari and Singh (2006), Annapurna and Rama Sharma (1985). Varma *et al* (1993) reported 25 species from the Tekkali creek which included three new species. Besides, two species were also recorded for the first time from Indian waters. Shyam Sunder *et al*. (1995) recorded 33 species of Recent Ostracoda (containing five new species and one species reported for the first time from Indian waters) from the Goguleru creek and nearby beaches of the east coast of India. From the Krishna and Gautami-Godavari estuaries, Bhandari and Singh (2006) recorded 24 species of ostracods belonging to 14 genera. Hussain (1998) for the first time gave a detailed systematic account of 52 ostracod species along with their ecological preferences from the sediments of Gulf of Mannar off Tuticorin, along the east coast of India. Hussain and Mohan (2000, 2001) reported 26 species from the Adyar estuary. In addition, Hussain *et al*. (1998) reported two new species from off Tuticorin. Mohan *et al*. (2001) identified 51 osrtracod taxa as belonging to 40 genera, 22 families, three superfamilies and two suborders of the order Podocopida off Karikattukuppam. They also described four new species. Gopalakrishna *et al*. (2007) reported 61 species belonging to 48 genera and 20 families, of which, the ostracod namely, *Leptocycythere pulchra* is a new distributional record to Indian water while, two species, namely, *Hemitrachyleberis siddiquii* and *Neocytheromorpha reticulata* constitutes new records to west coast of India.

Information on ostracod fauna of Indian mangroves is very limited. Kumar and Hussain (1997) reported 10 ostracod species from Pitchavaram mangroves. In a subsequent study, Arul *et al*., (2003) recorded a total of 29 species from the sediments of Pitchavaram mangroves. They also dealt with the diagnosis of these species along with their ecology.

Among the notable works on this group, discovery of a new ostracod genus by Hart, Jr. *et al*. (1967) deserves worth mention. *Microsyssitria indica* has been described by these workers as a commensal on the wood-boring isopod, *Sphaeroma terebrans* collected in two estuarine habitats of Kerala. This ostracod is now placed in the new subfamily Microsyssiitrinae under Entocytheridae.

Status of the Taxon

Earlier, Venkataraman and Krishnamoorthy (1998) estimated the number of crustacean species to 2934+. However, as per the present enumeration, there are 4258 crustacean species so far reported from India, which comprise 6.24% of the global crustacean species. Group-wise, Decapoda contributes highest diversity of 1655(44.81%) species in India, followed by Copepoda 1016 species (27.2%), while Notostraca represents only 3 species in the country.

(a) Global status:

Globally, 59, 813 species belonging to 8004 genera and 860 families are known. Among the various groups, Decapoda supports the maximum number of species, followed by copepod (14, 000 species) and Isopoda (11, 000 species).

(b) **Indian status**

Among the groups representing higher diversity, it is found that decapoda represents 44.81 % of total crustacean diversity of India while contributing to 6.24% of the total crustacean diversity of the world. Similarly, copepod and isopoda represents 27.24% and 8.366% diversity of India.

Habits and Habitats

Crustaceans commonly include forms such as prawns, crabs, hermit crabs, shrimps, mantis shrimps, water fleas, woodlice, fish-lice, barnacles, lobsters, etc. They are mostly aquatic, breathing by gills or by the general surface of the body. They are well known for their remarkable adaptations. They are mostly marine and comprise a major component of zooplankton communities. Some occur in freshwater, while others inhabit estuaries and even to brine pools as plankton or benthos. Several estuarine forms are also adapted to purely freshwater conditions. Marine forms are mainly intertidal, pelagic or abyssal in their habit. Abyssal forms descend down to great depths of the sea extending hundreds of fathoms.There are also some crustaceans that are adapted to live on land while some others lead a cavernicolous life.

Furthermore, some crustaceans also occur as parasites on a wide variety of animals including the crustacean themselves.

Crustaceans usually live solitary or gregarious life. Most of them are brilliantly colored, some shows protective colorations while some others exhibit mimicry. Several decapod crustaceans carry sponges, alcyonarians and ascidians on the carapace. Hermit crabs are found to live together with other animals such as sea-anemone and gastropod molluscs, the sea-anemone and hermit-crabs acting as commensals. Some crabs and prawns live inside the mantle cavity of bivalves and echinoderms respectively.

Crustaceans are important to man in many ways. They are valued as food and mainly contribute to the marine and coastal fisheries, while a large numbers of crustaceans, virtually myriads, form food to other marine animals. Among the commercially important crustaceans, prawns occupy a dominant place due to their abundance and value in marine and coastal fisheries. Almost all the species of prawns and some crabs are edible. A large number of these crustaceans are consumed for their nutritional value. Most of the economically important species live in the sea or in estuaries. Penaeid prawns are the commonest among them.

Some crustaceans are of medicinal value. There are some crustacean forms which are detrimental to man in the transmission of diseases. In the tropics, they play an important role in the life cycle of some parasites. Some crustaceans like barnacles cause economic loss to man as fouling organisms while wood-boring isopods cause considerable damage to wooden jetties, poles and boats etc.

5. Biological diversity and its special features:

Among the invertebrates, Crustacea represents third largest diversified group next to insects and arachnids in India (Table 1; Figs. 1-3).

Table 1. Estimated number of crustacean family, genera and species reported so far from the world and India.

Faunal group	Global diversity			Indian diversity			Remarks
	Family	Genus	Species	Family	Genus	Species	
Notostraca	1	2	16	1	2	3	
Conchostraca	5	15	450	5	9	45	
Cladocera	12	52	600	12	58	214	
Anostraca	7	25	200	6	6	14	
Cirripedia	47	203	1025	1 5	46	119	
Copepoda	219	2300	14000	97	335	1060	
Branchiura	1	4	200	1	1	14	
Ostracoda	54	693	7500	32	111	332	
Leptostraca			31	1	1	1	
Stomatopoda	17	68	350	10	35	75	
Bathynellacea	3	23	253	2	7	23	
Mysida	6	140	1023	2	34	93	
Cumacea	8	102	800	5	15	56	
Euphausiacea	2	12	90	1	7	23	
Amphipoda	157	840	6700	44	99	202	
Tanaidacea	21	100	850	3	9	10	
Isopoda	120	700	11000	22	155	319	
Decapoda	180	2725	14756	115	560	1655	
Total	**860**	**8004**	**59, 813**	**375**	**1384**	**4258+**	

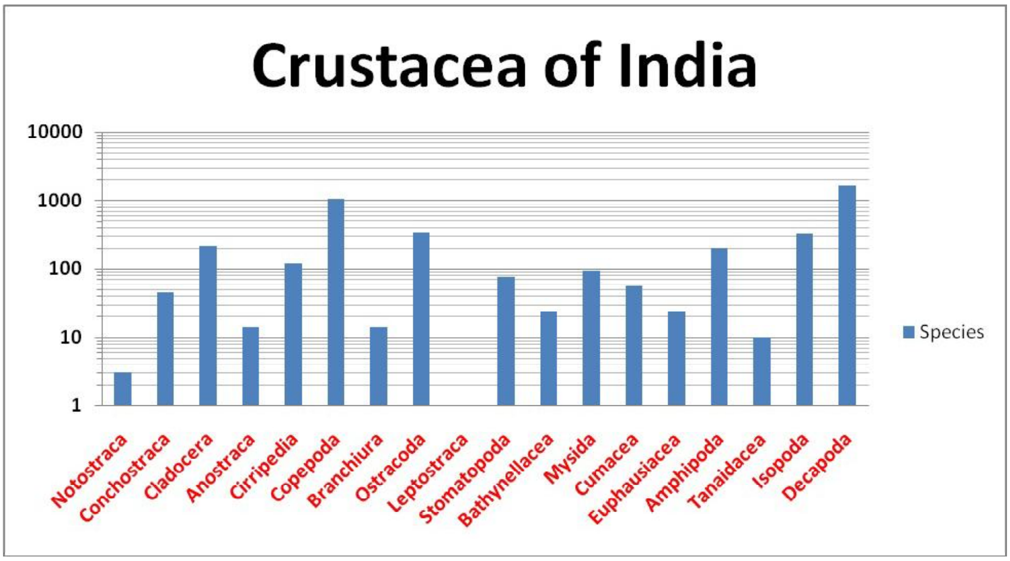

Fig. 1. Number of crustacean species reported so far from India (Data in Logrithmic scale).

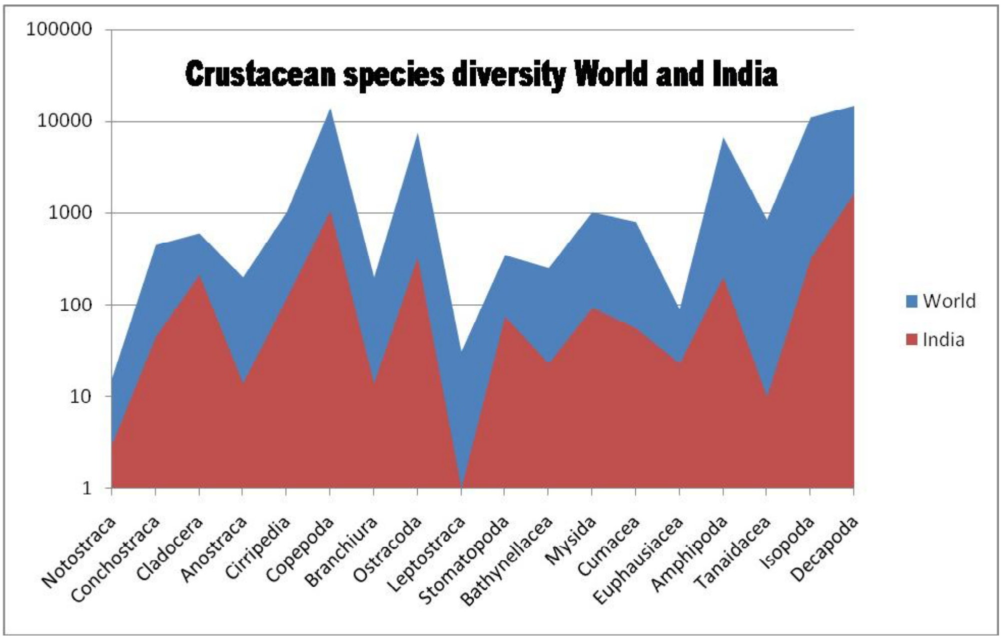

Fig. 2. Comaparison of crustacean species diversity in the world and India (Data in Logrithmic scale).

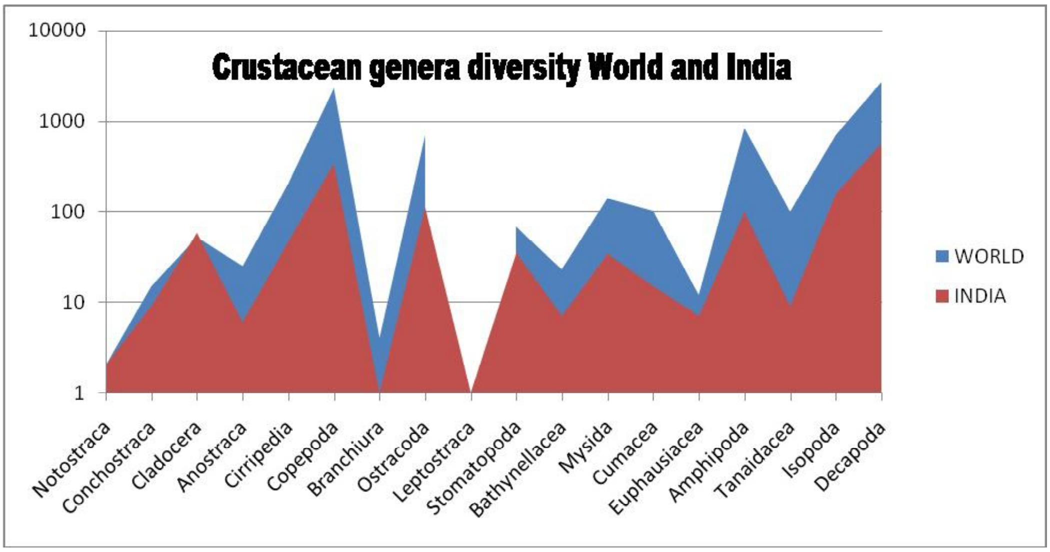

Fig. 3. Comaparison of crustacean genera diversity in the world and India (Data in Logrithmic scale).

6. Endemicity

A large number of crustaceans are endemic to India. Highest endemicity is encountered in copepod followed by decapoda. Several endemic species are reported under monotypic genera among the group highest monotypic genera is known from Cladocera. Data on monotypic genera is very scanty.

Earlier record indicates 11 monotypic cladoceran genera but this number is now reduced to one due to addition of one or more species to these monotypic genera either through description of new species or revisionary works.

7. Threatened taxa

Of the 4258 species of crustacea, 78 species are threatened according to IUCN. Of these, 78 threatened species, 17 species are listed as Critically Endangered, 32 species as Endangered, 22 species as Vulnerable and seven species as Near Threatened. Out of the 3731 species of known crustacean from India, 74 species (21.63%) are yet to be evaluated and 81 species (23.68%) are still under the data deficient category.

Out of 4258 species, only 89 species are considered as threatened by IUCN. As per IUCN Red List of Threatened Species,

In the IUCN (2008) Red List, 89 species of crabs and copepods are included from India in various categories such as nearly threatened, vulnerable, least concerned and data deficient. According to Raghavan *et al.* (2014) the Western Ghats region is home to 49 species of caridean shrimps (69% endemism) and 39 species of gecarcinucid crabs (92% endemism) and three species (3%) of decapod crustaceans from the region are threatened with extinction, while more than half (51%; 48 species) are Data Deûcient.

Values

Crustacea is known to man since ancient times and have served them as sources of food and legend. They are an important item of luxary food market world-wide.

As a food source: Crustaceans are important to man as sources of food. A large number of crustaceans, especially the decapods such as lobsters, shrimps, prawns, crabs and cray fishes form important food-items for men world-wide. Other crustaceans, such as barnacles and mantis shrimps or “squillas” are also used as human food in several parts of the world, although they are not consumed in India.

Blanomorph barnacles are considered a delicacy in some parts of the world. Freshly cooked barnacles, especially the goose neck barnacles locally known as percebes are highly esteemed as delightful food in Spain and Portugal which has resulted in overharvesting and even poaching in French territorial waters. Barnacles cost 150 euros a kilogram, roughly 199 dollars. They are harvested in northern coast, particularly in Galicia and even imported from Morocco and Canada. There is a large demand for barnacles in Chile also. The Mud lobster, *Thalassina anomala* is considered an important food source in Fiji (Pillay, 1985). Several upogebiids are harvested for local consumption in different parts of the world such as *Upogebia major* in Japan and Korea, *Austinogebia wuhsienweni* in China and *A. edulis* in Taiwan, while a species of callianassid, *Lepidophthalmus turneranus* is used as food in the Gulf of Guinea. Freshwater crayfish are consumed along the Gulf coast, the Mississippi river and in the Pacific Northwest. Mysidacea, namely, *Neomysis intermedia, N. japonica* and *Acanthomysis mitsukurii* are harvested in thousands of tons each year in Japan. These are cooked, dried and eaten. Although they do not constitute any major fisheries, they are, however, fished in some of the South-east Asian countries, such as India, China and Korea. They support kolim (mysid) fishery in North Konkan coast (Patil and Sankolli, 1991).

Interestingly, during Greely Expedition to the arctic, it is reported that the seven rescued members owed their lives to minute amphipod crustaceans.

Role in food chain

Crustaceans are important in the marine food chain as a prey source for a variety of animals such as whales, fish, pinnipeds etc. Copepods play a vital link in the food web. Many commercial and non-commercial fishes are mostly dependent on copepods as a food source during a part of their larval life.

As indicator species

The barnacle *Balanus amphitrite* is considered as an indicator for metal pollution. Ostracods are useful for environmental monitoring. They are sensitive to small changes in salinity and water quality and respond negatively to pollution. Amphipods are regarded as ideal bioindicators for shallow environments and oil spills. US agencies are known to employ amphipods in bioassays to test toxicities, particularly of marine environments.

As Pest

In many areas of tropics, Thalassina anomala is considered a pest (Holthuis, 1991; Pillay and Kutty, 2005). They cause damage to bunds of prawn ponds and also to embankments making leakage of water and may even collapse due to their burrowing activity. Paddy fields and backyards of houses in the proximity of mangrove creeks in India are also subject to this kind of damage (Sankolli, 1963). They have been recorded as pest in salt factories in Voyalur and Manginapudi of Tamil Nadu and Andhra Pradesh respectively (Daniel, 1981).Triops have been recorded as a pest of rice cultivation in Kashmir and elsewhere in the globe.

As scavenger

Several species of many families of isopods are important scavengers of decaying material. Isopods of the family cirolanidae are well known in cleaning up decaying dead fish. The terrestrial slaters or wood-lice feed innocuously on decaying leaves and wood. Ocypodid crabs are also known to act as scavengers and help in cleaning of beaches.

As intermediate host

Copepods are disease vectors for human parasites in tropics and sub-tropics. They carry disease causing sporozoans that parasitise malarial mosquitoes. Freshwater Cyclops serve as intermediate hosts for the human guineaworm (Dracunculus) which was earlier very common in India, Egypt and Central Africa.

In Egypt, Napoleon's soldiers were troubled by a pernicious 'Guinea Worm. The freshwater copepod, Cyclops found in India, Arabia and Africa acted as the intermediate host and got transmitted with the drinking water.

In medicine

In China, fossil crabs are rare finds. The natives of China believe high medicinal properties of fossil crabs which may act as antidote for neutralizing various types of poisons and are effictive in curing opacity and other eye diseases. They are also highly regarded as vermifuge. The dishes of Scylla and Portunus crabs are used for convalescing malaria patients and asthma sufferers. Parathelphusa soup is used for colds. In Jamaica, it is believed that the fiddler crab can cure deafness and earache. The raw juice pressed from river crayfish is used therapeutically in cases of fever and diarrhea in Korea. However, much of the therapecutic value ascribed to these crustaceans in different parts of the world needs scientific or biomedical proof for proper scientific validation.

In Biotechnology

Thoracican barnacles has intrigued scientists relating to the means by which they attach themselves to surfaces as they grow on a wide range of substrata, both natural and synthetic, for, if the nature of their 'organic adhesive' is determined and produced commercially, they may find applications in fields such as dentistry (Weber et al.). Commensalic or symbiotic forms with other marine organisms have their ability to produce chemicals to prevent the host overgrowing them. As such, isolations of chemical deterrents may be invaluable in designing new drugs for restricting or reducing cell growth in man and other animals.

As pets

Hermit crabs are among the most popular crustacean pets. Cray fish is kept as pets in freshwater aquariums. Among crabs, *Geosesarma dennerle* and *G. hagen* are popularly sold as pets and have been lurking in home aquariums for years. Despite their creepy claws and bright yellow eyes, Vampire crabs are increasingly popular pets. Shrimps, especially caridean shrimps aer extensively used these days in aquarium keeping.

As recreation

Freshwater copepods of the genera Mesocyclops and Macrocyclops have been used for control of the container breeding mosquitoe species of Aedes, Anopheles and Culex. Conservation: Protection status/Wildlife (Protection) status: No crustacean species occurring in this state has been enlisted under Wildlife (Protection) Act. However, as per IUCN (2008) list, 89 species of crabs and copepods occurring in India are under threatened, vulnerable, least concerned and data deficient category. However, it may be mentioned that out of 89 species at least two species of freshwater crab, Sartoriana spinigera and Spiralothelphusa hydrodromus are known to occur different parts of India and both the species are very common in this part of the country. Distribution data of the later species as revealed from the studies of Dev Roy (2011) has shown that the species occurs almost in every state of India.

Crustceans represent one of the oldest arthropod groups. They are undoubtedly one of the largest, most diverse and most successful groups of invertebrates on this universe. They exhibit the greatest diversity of any animal group in the planet. Their diversity is high in marine habitats, low in estuaries and high-silt habitats. Conservation status of most species of this group is poorly known. Commercially and recreationally species may be locally reduced or even threatened. The coastal and estuarine areas of Sundarban are covered by extensive mudflats, saline water, brackish water and protected bays. These places support huge numbers of important living resources, which are suitable for marine ranching. Local people indiscriminately utilize these natural resources and some are now completely destroyed. Most of the resources are being over-utilised (e.g. fish stock and shrimp fry) while some remain untouched or under-utilised (mollusks, seaweeds, crabs and offshore fishes). Therefore, sustainable practices, management and conservation of the estuarine and coastal resources and their related ecosystems are needed. The diverse living resources on the estuarine environment play an important role which is economically significant in many ways. In addition, the estuarine resources greatly contribute to the national economy as well as promote the socio-economic well-being of the coastal and often poor communities.

In the coastal and estuarine fisheries, the increase in overfishing is a serious problem due to the use of huge numbers of push or larval nets and estuarine bag nets. In recent years, although a considerable number of shrimp hatcheries have been established, the wild fry collections is still practiced in the coastal area of the country. The loss of other species during the collection of tiger shrimp (Penaeus monodon) post-larvae is well-documented. It is notable that in catching a single species of tiger shrimp, about 26 other species, 29 finfish species and 70 other zooplankton were simultaneously destroyed (Deb, 1945). The fry catchers carefully sort out *P. monodon* fry from the mixed catch and the rest of the plankton including fish and shell-fish larvae are discarded anywhere on the shore. These activities cause great loss of the biodiversity and valuable fishery resources.

Gap Areas

Taxonomic impediment

The taxonomic impediment prevailing in other parts of the world is effervescent in India as well and many institutions working on faunal explorations and documentation lack globally competent carcinologists to carry out extensive surveys and identification, not to speak of infrastructure facilities to support such exploratory research. As revealed by the analysis of publications on taxonomy from the country in the last two decades and analysing the vision documents of marine research institutions, especially in the public sector, taxonomy is not projected as a priority area in many of the research institutions. If at all proposals are placed in paper, no strategies and action plans have been suggested to overcome the taxonomic impediment. Further, human resources in taxonomy for satisfying the increasing demands from various sectors, including marine bioprospecting and biotechnology, is abysmally poor even in institutions dedicated to biodiversity documentation.

One of the ways to circumvent the taxonomic impediment is to promote co-ordinated taxonomic research involving practicing taxonomists. Further, international collaboration in taxonomy should be promoted to document the diversity of all marine taxa in seas around India, as comprehensive databases provide platform for advanced research and policy making towards conservation and sustainable utilisation of resources. Developing trained manpower in taxonomy is yet another priority to promote taxonomy, besides reserving positions for taxonomists in all the marine research institutions and universities to develop globally competent taxonomists from the country. Further, the curricula should be framed in schools and colleges involving taxonomy as a ‘joyful’ activity rather than a ‘cumbersome’ task, with more field oriented activities.

Database

The reports presented in this paper on crustacean taxonomy in India, the major lacuna is the lack of a good quality updated database on crustaceans of India in the public domain. The available checklists are not taxonomically validated. As a foundation element of biology, it is imperative that taxonomy is practised in a highly professional manner, as dubious taxonomy destabilizes the foundation of science, with potentially serious setback in basic and applied research, and therefore publications in predatory journals hamper development of taxonomy in India (Raghavan *et al.*, 2014a). Therefore, publications that appear in predatory journals, without even mentioning anything on voucher specimens and accession numbers would not support taxonomic research. The existing databases have to be strengthened by validating species identity of all the collections by the research vessels of various organisations in India. Good quality handbooks and field guides of various classes of Crustacea form another requirement for strengthening taxonomic research in India.

Ecosystem/taxon based studies

In India, majority of the molluscan studies were conducted in coral reef ecosystems and many of the surveys were conducted as part of compilation of data for general biodiversity databases or all-phyla studies. Extensive and exclusive molluscan surveys are required along continental shelves, sea mounts and deep seas along Indian coast. Ecosystem-based in-depth surveys are required to document species diversity of coral reefs, lagoons, mud flats, sandy beaches, estuaries and backwaters, intertidal and subtidal ecosystems.

Specific taxon based studies are also required to prepare comprehensive databases on crustaceans. In a biodiverse group such as Crustacea, developing taxonomic expertise in each taxon is a difficult task to attain and in such cases services of ‘specialists’ should be sought in collaboration with leading international museums and academic/ research organizations. Studies on crustaceans involved in various kinds of associations, invasive species and planktonic crustaceans are other areas that demand attention of carcinologists in India. Deep sea crustaceans off India and those associated with sea mounts have also not received much attention by taxonomists.

According to Raghavan *et al.* (2014b, 2016) though the freshwater crustaceans of the Western Ghats biodiversity hotspoted are well renowned for its greater endemism, they are poorly studied and the status of many species is poorly known; about 3 per cent of decapod crustaceans from the region are threatened with extinction, while more than half are Data Deûcient. Stock assessments and ecosystem based studies are required for species included in IUCN Red List of Threatened Species of IUCN and in various schedules of Wildlife. A comprehensive conservation status assessment by IUCN is also recommended for crustaceans, especially those in the biodiverse freshwater regions of the Western Ghats and Eastern Himalayas, considering the higher endemism of species and ongoing anthropogenic threats.

In the era where consumptive and non-consumptive values of crustaceans are held with much esteem, the services of taxonomists are all the more important not only to confirm identification of species involved in various economic benefits but also for preparing policy documents for conservation and sustainable use.

Integrative taxonomy

‘Integrative taxonomy’ is defined as the science that aims to delimit the units of life’s diversity from multiple and complementary perspectives (phylogeography, comparative morphology, population genetics, ecology, development, behaviour, etc.) (Dayrat, 2005). Molecular analyses play a very important role in elucidating extent, origin and history of marine biodiversity, and molecular techniques provide adequate information regarding the phylogenetic relationships and divergence times of evolutionary lineages and clades. Understanding the distribution and origin of diversity in the larger marine ecosystems, especially Indo-Pacific is a fundamental problem in biogeography. Further, molecular studies would also facilitate identification of cryptic species and speed up the process of biodiversity documentation. Integrative taxonomic studies involving molluscan species should also be promoted to fully realise the diversity of crustaceans of India. There is a need to develop specific course content focusing on ‘integrative taxonomy’ that needs to be taught first before training in systematics (Pisupati, 2015).

Involving Citizen Scientists and Civil Society

“Making taxonomy a combined study and science that brings on board non-experts and non-biologists to support identification of species as a hobby, passion and love for nature with support coming from trained scientists" (Pisupati, 2015) is the future. In India, the possibility of involving citizen scientists and civil society in biodiversity documentation were not fully explored, though opportunities for such an exercise are tremendous. Long term biodiversity monitoring studies and preparation of inventories can be tried by expanding the network of local communities and civil societies.

Repositories

Collections in the natural history museums and repositories reveal the exceptional natural history and biodiversity of the nation, and act as the source material for the taxonomists and biotechnologists to pursue their research. It also provides identification services on natural objects and rich fauna, flora and minerals resources to user groups. The priority therefore should be to prepare a database of type materials available in each of the repository and to simplify the procedure for sharing the data to practicing malacologists.

All repositories should go for rampant modernisation, with the help of latest science and technology inputs. For examples, leading museums all over the world are in the process of digitisation of collections, which has not been initiated by national repositories in India. The digitisation include taking photographs of the type specimens and preparing 3 D images of the specimens using modern software, preparing DNA fingerprints of type specimens (as technology is now available for preparing DNA barcodes from formalin-preserved specimens) and preparing collections details and maps in GIS platform. The preparation of DNA barcodes has implications for "upstream sample collection and preservation methods, as well as downstream implications for highlighting biorepository specimens available for genetic and genomic research" (Hanner and Gregory, 2007).

As suggested by Cardoso *et al.* (2011) this is all the more important since most species are undescribed (the Linnean shortfall), the distribution of described species is mostly unknown (the Wallacean shortfall), the abundance of species and their changes in space and time are unknown (the Prestonian shortfall) and species ways of life and sensitivities to habitat change are largely unknown (the Hutchinsonian shortfall); and (iv) thinking beyond achieving biodiversity targets fixed by the United Nations Convention on Biological Diversity through Aichi Targets 2020, government should plan urgent strategies and action plans to prepare a comprehensive marine biodiversity data portal in the public domain, publish high quality field guides and monographs on marine taxa, train a set of internationally competent taxonomists to cater to the future demands in biodiversity science, ensure positions for taxonomists in each research institution involved in marine biology studies as well as maritime universities, nurturing young generation of taxonomists through appropriate revisions in curricula, and involving citizen scientists and local communities in biodiversity documentation process.

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CRUSTACEAN FISHERIES IN INDIA: STATUS, TRENDS AND MANAGEMENT

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Introduction

Crustaceans (Crustacea) are a very diverse group of arthropods, comprising almost 68,171 described and accepted species (Brusca & Brusca, 2003). However, Chapman (2009) believes that global list of described and accepted number of species is 47, 000, based on detailed breakup given by Bouchet (2006). Crustacea is the only group of arthropods that is primarily marine, though there are many fresh water species also. A few groups have adapted to life on land, such as terrestrial crabs, terrestrial hermit crabs and woodlice. Crustaceans are among the most successful animals, and are as abundant in the oceans as insects are on land. Morphological diversity is higher in crustacea than in any other taxon on earth (Martin & Davis, 2001). From the fishery point of view, the species belonging to order Decapoda (class: Malacostraca) is the most important group, comprising numerous edible species of shrimps, lobsters and crabs, which inhabit different ecosystems forming a significant portion of aquatic food resources of the world. By virtue of their highly prized edibility, the decapod crustaceans are arguably the most popular invertebrates. This order is comprised of about 2725 genera with about 14756 extant species (De Grave *et al*., 2009). Faunistic record of Indian decapod crustaceans shows that there are 135 species of prawns (penaeid, sicyonid, solenocerid, aristeid, benthesicymid and sergestid) (Radhakrishnan *et al*., 2012), 32 species of lobsters (Radhakrishnan, 2013) and 700 species of crabs that inhabit marine and contiguous estuarine areas.

At present as many as 150 species of edible crustaceans form part of the commercial catches either on a regular basis or as occasional landings. The number of species entering into faunistic list is ever on the increase as a consequence of the extension of fishing activities to deeper water and capture of non-conventional species. A retrospect of India's marine fisheries development during the past four decades would reveal phenomenal increase in exploitation of important crustacean varieties such as shrimps and lobsters on account of their high export value. Enhancement of fishing effort in units as well as fishing hours in deeper grounds, modernization of craft and gear and intensive fishing have resulted in enormous fishing pressure on edible crustacean resources.

India has ever remained as one of the major contributors of marine crustaceans to the world production. Apart from freshwater shrimps and mud crabs, majority of the crustacean capture fishery of India is exclusively consisting of marine species. Crustaceans are landed in all the maritime states of India, but the volume of landings varies from state to state. The landings from east coast of India form only about 19% of the total crustacean landings, while the balance is landed on the west coast of India. Annual average crustacean catch in India during 1985-2015 was 4,08374 t, which form 14% of the total marine fish production (Fig.1).

The percentage of crustacean component in the total marine fish production declined from 17% in 1985-86 to 12% in 2014-15.The edible crustacean resources (1985-2015) include penaeid prawns (54%), non-penaeid shrimps (35%), crabs (10%), and lobsters (0.3%). Stomatopods are used for fishmeal preparation in India. In China and in Southeast Asian countries, the "squilla meat" is a delicacy and some of the stomatopod species from India are also exported in frozen form. Among the states, Maharashtra ranks first in edible crustacean production by contributing about 29% of the total edible crustacean landings followed by Gujarat which contributes 27%, Kerala, 17% and Tamilnadu, 10%. Penaeid prawns fetch good price in the export market, next to live lobsters. Maharashtra and Kerala are the major penaeid prawn producing states of India, contributing 28% and 26%, respectively and Karnataka ranks first in the stomatopod landings (30%). Gujarat (37%). Maharashtra (33%), Tamilnadu (16%) and Kerala (10%) are the chief contributors to the lobster landings (Table 1).

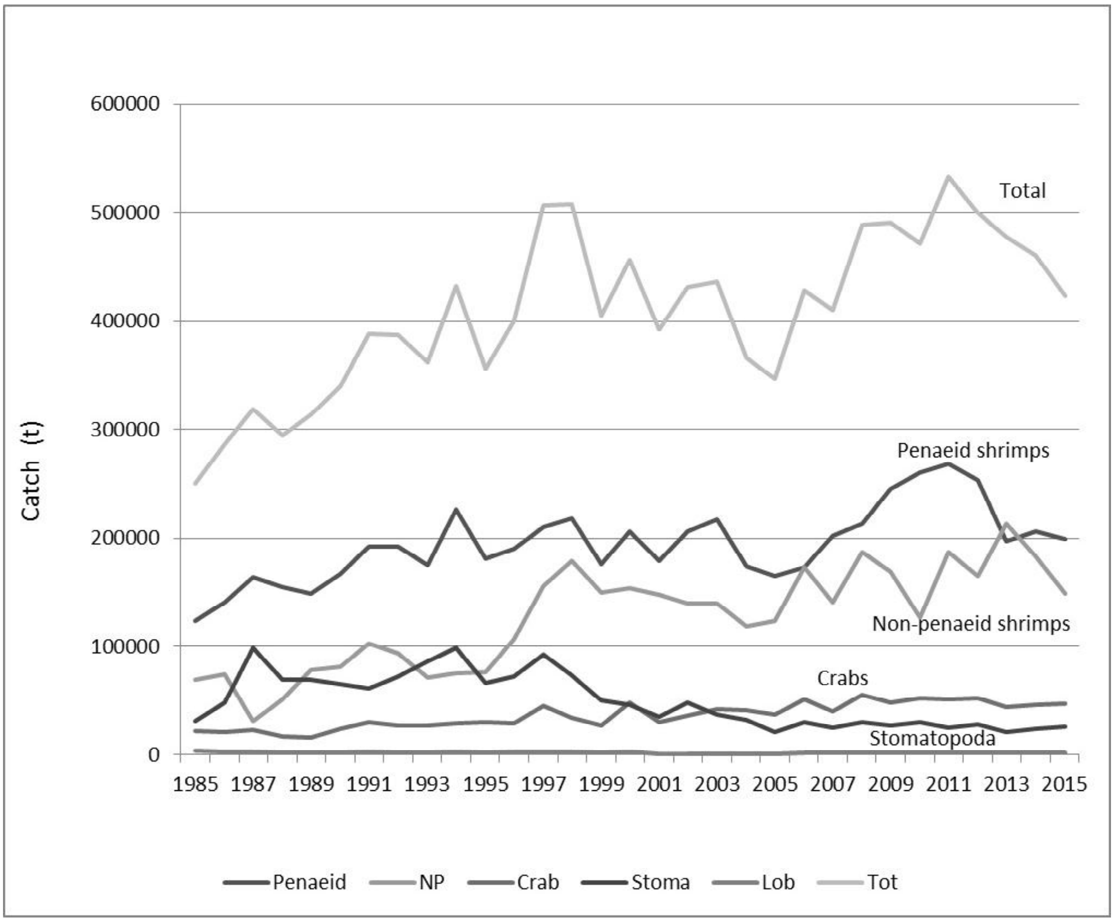

Fig. 1. Annual landing of penaeid prawns, non-penaeid shrimps, lobsters, crabs and stomatopods (1985-2015) in India

Table 1. Species contributing to commercial crustacean fishery of India

Scientific name	Common name	State-wise distribution
Fenneropenaeus indicus	Indian white shrimp	Ke, Ka, Tn, Po, Ap, Wb ,Or
Fenneropenaeus merguiensis	Banana shrimp	Gj, Mh, Ka, Go
Penaeus monodon	Giant tiger shrimp	Tn, Po, Ap, Wb, Or
Penaeus semisulcatus	Green tiger shrimp	Ka, Ke, Po, Tn
Penaeus penicillatus	Red-tail shrimp	Gj, Mh
Melicertus canaliculatus	Witch shrimp	Ka
Metapenaeus dobsoni	Kadal shrimp	Mh, Ka, Go, Ke, Po, Tn
M. monoceros	Speckled shrimp	Gj, Mh, Go, Ka Ke, Tn, Po, Ap
M . affinis	Jinga shrimp	Mh, Ap
M. kutchensis	Ginger shrimp	Gj
M. brevicornis	Yellow shrimp	Po, Mh, Tn, Ap, Wb, Or
Parapenaeopsis stylifera	Kiddy shrimp	Gj, Mh, Go, Ka, Ke, Po, Tn, Ap
P. hardwickii	Spear shrimp	Gj, Mh
P. sculptilis	Rainbow shrimp	Mh, Wb, Or
Trachysalambria curvirostris	Southern rough shrimp	Ka, Ke
Metapenaeopsis stridulans	Fiddler shrimp	Gj, Mh
Solenocera crassicornis	Coastal mud shrimp	Gj, Mh,
S. choprai	Ridgeback shrimp	Gj, Mh, Ka, Ke

(Gj, Gujarat; Mh, Maharashtra; Go,Goa; Ka, Karnataka; Ke, Kerala; Tn, Tamilnadu; Po, Pondicherry; Ap, Andhrapradesh; or, Orissa; Wb, West Bengal)

Craft and gear

In the backwaters and estuaries shrimp juveniles are caught in large quantities in stake nets, cast nets, drag nets, dip nets and small scoop nets operated by traditional fishermen. In the inshore marine fishery, the principal types of gear employed for capture of shrimps are boat seines and shore seines and for deep water fishing trawl nets are used. Small drag nets, dip nets and barrier nets are used in Hoogly estuary and in Chilka Lake traps are extensively used for catching shrimps. On the west coast of India small dug-out canoes (4-6 meters long) are the principal craft used in the backwaters whereas larger dug out (6-10 meters) canoes and catamarans are used in inshore fishery. On the east coast, plank-built canoes and catamarans are employed for shrimp fishing. The shrimp trawls are operated from 7-11 metre long pablo type wooden boats powered with 10-30 H.P diesel engines. A few large boats such as Mexican trawlers and Sona boats were also operating shrimp trawls. The traditional *dol* nets are operated mainly along the northwest coast and Bengal coast to fish non-penaeid shrimps and smaller varieties of penaeid shrimps. Minitrawl and *thalluvalai* (smaller version of shrimp trawl) are regularly operated by indigenous plank-built and wooden small crafts in near-shore waters (4-9m depth range) along the Kerala and Tuticorin-Pamban (Tamil Nadu) coast, respectively to catch mainly shrimps. Trammel net along the Vizhinjam-Manakudy coast and bottom-set gill-net and disco-net along the southeast coast are operated regularly for exploitation of shrimps, lobsters and crabs. In the offshore fishery, trawl net is the most effective gear to exploit shrimp resources. Mostly medium size vessels (38-48') operate trawl net to exploit marine crustaceans from inshore to deep-sea grounds, mainly targeting shrimps. From mid-eighties, most of the trawl units switched over to multiday fishing operations up to 80-100m to exploit mid shelf grounds, combining both day and night fishing. During 1999 onwards, some of the trawlers having higher engine power with modified winches and addition of wire ropes (up to 1,800m) have begun operation in deep-sea grounds off Kerala and South Kanara coast in the depth range of 175-450 m to fish deep-sea shrimps and lobsters.

Prawns

Among crustaceans, shrimps are the most commercially exploited group by virtue of its importance and are the most valuable seafood commodity traded worldwide. Globally, annual exports of shrimp average more than 1.6 million t, fetching a value of over 11 billion US$, and are a major source of employment, income, and revenue globally (Kourous, 2006). Frozen shrimps are the most important marine fishery commodity exported from India in terms of value. In 2007-2008, 1,36,000 t of frozen shrimps worth Rs.3940 crores were exported from India. As in the case of most countries of tropical region, the shrimp fishery of India is also of multi-species in nature. The common species supporting the shrimp fisheries of India belong to two major categories, namely the "penaeid shrimps" and the " non-penaeid shrimps".

Penaeid prawns

The penaeid prawns form the backbone of the sea food industry of the country and is a major foreign exchange earner as well as a source of livelihood to millions of fishermen. Average annual penaeid prawn catch in India during the period, 1985-2015 was 194214 tonnes contributing 7.2% to the total marine fish production. The percentage contribution of maritime states to annual capture fisheries production was Maharashtra, 28%, Kerala, 26%, Gujarat, 15%, Tamilnadu, 11%, Andhra Pradesh, 8% and Karnataka, 5%. (Fig. 2). Farmed shrimps also contribute to the total shrimp production in India. The inshore shrimp fishery is restricted to 15m depth zone. The mechanization of some of the craft has helped in extending the fishing zone farther. Since introduction of trawlers the depth of operation extended from 15 to 40 m and fishing hours around 5 hours per trip. Night trawling and multi-day trawl fishing in the deeper waters began during the early 1980s. In the initial stage, the fishing was extended up to three days and later the number of fishing days were gradually increased even up to 12 days due to higher profitability of fishing operations in the distant waters and on finding new resources in the far off fishing grounds. The technological advancements in navigational aids and fishing gear materials have paved the way for multi-day trawl fishing for the high valued shellfishes such as shrimps.

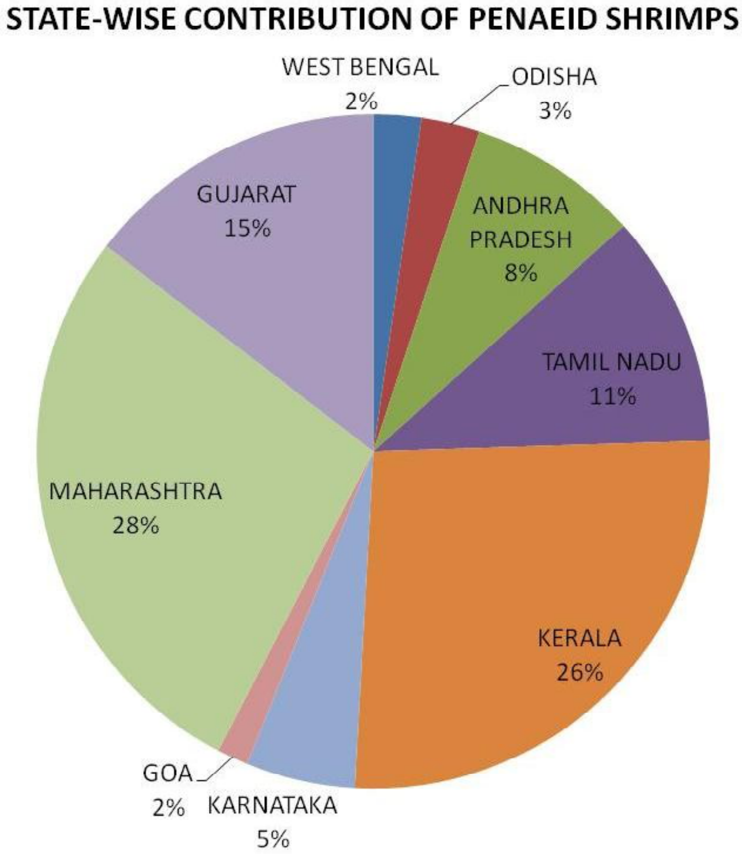

Fig.2. Percentage contribution of states to annual landings of penaeid prawns in India

Distribution of Penaeid prawns

According to Holthuis (1980), the prawns/ shrimps include about 33 genera with about 2,500 species, of which less than 300 species are of economic interest throughout the world. Most of these species come under 5 penaeidean families *viz.*, Solenoceridae, Aristidae, Penaeidae, Sicyonidae and Sergestidae, and three caridian families *viz*, Pandalidae, Crangonidae and Palaemonidae**.** The species belonging to *Penaeus* genus are the bigger sized shrimps and out of the 28 valid species of the genus, only 8 are represented in Indian waters. These species were later classified under subgenus/genus *Penaeus*, *Fenneropenaeus*, *Melicertus* and *Marsupenaeus.* All the eight species recorded from India are listed as shrimps of economic value and are *Fenneropenaeus indicus* (Indian white shrimp), *F. merguiensis* (Banana shrimp), *F. penicillatus* (Red-tail shrimp), *Penaeus monodon* (Giant tiger shrimp), *P. semisulcatus* (Green tiger shrimp), *Melicertus canaliculatus* (Witch shrimp), *M. latisulcatus* (Western King shrimp) and *Marsupenaeus japonicus* (Kuruma shrimp) (Table 1). Practically all of them are marine although some are known to spend a part of their life in the brackish water and even in freshwater. Among other penaeids, *Metapenaeus dobsoni* (Flower-tail shrimp), *M. monoceros* (Speckled shrimp), *M. affinis* (Jinga shrimp), *M. kutchensis* (Ginger shrimp) *M. brevicornis* (Yellow shrimp), *Parapenaeopsis stylifera* (Kiddi shrimp), *P. hardwickii* (Spear shrimp), *P. sculptilis* (Rainbow shrimp), *P. uncta* (Uncta shrimp), *Trachysalambria curvirostris* (Rough shrimp), *Metapenaeopsis stridulans* (Fiddler shrimp), *Parapenaeus longipes* (Flamingo shrimp), *Solenocera crassicornis* (Coastal mud shrimp) and *S. choprai* (Coastal mud shrimp) are commercially important.

Conventional resources such as *P. stylifera, M. dobsoni*, *M. monoceros*, *F. indicus* and *S. crassicornis* were major constituents of penaeid fishery during 1995-2004 along the west coast. With the extension of trawling operations and night fishing, non-conventional resources such as *T. curvirostris, M. stridulans, S. choprai, M. canaliculatus* and *M. japonicus* were added to the fishery. *P. stylifera* dominated the fishery at all centres. However, *S. crassicornis* had emerged as a prime contributor to fishery in Gujarat and Maharashtra. Along North Kanara and Kerala *M. dobsoni* and *P. stylifera* are the major contributors and during last decade dominance of the mid shelf shrimp *S. choprai* was noticed from south Karnataka and north Kerala coasts. Along the southeast coast, *P. semisulcatus* dominated the fishery in South Tamilnadu region along with *M. stridulans.* At Chennai, *M. dobsoni*, *F. indicus* and *M. monoceros* were the major species observed in shrimp landings. Along the Andhra Pradesh coast, *M. monoceros* was the main contributor to the penaeid shrimp fishery. *Metapenaeopsis andamanensis, Aristeus alcocki, Penaeopsis jerryi* and *Solenocera hextii* constituted the deep-sea shrimp landings along the southwest coast of India since 2000.

Fishery

Fenneropenaeus indicus: The species is subjected to commercial exploitation at different stages of their life cycle from both estuarine and marine environments. The entire backwater fishery, therefore, are constituted by '0' year class shrimps. Three-year classes (0, I & II) of this species are represented in the trawl fishery. In the backwater of Kerala, the species is fished almost through out the year. On the other hand, marine fishery is largely seasonal. The estuarine and backwater fishery for the juveniles of the species is carried out in very shallow waters not exceeding 10 metres in depth. But the commercial fishery for adults is generally carried out in coastal waters up to a depth of 50 metres along the Indian coast. In Karnataka and Kerala, the species was found to contribute significantly to the monsoon fishery. In 2007, 16% of the shrimp landing in north Kerala and 9% of the shrimp landing in Andhra Pradesh were constituted by this species. The species is of aquaculture importance and can grow up to 270 mm in total length (TL).

Penaeus semisulcatus: On the east coast, the juveniles of the species have been observed to spend their life from late August to middle of October in areas where sea grass is growing. After the middle of October, the species seems to be fished only from the off shore areas, where the bottom is muddy. The species also form a significant portion of shrimp catches of 'Bheris' of West Bengal, where they attain a length of 76-127 mm TL. Tamilnadu coast is the major fishing ground for this species. At Mandapam landing centre, 67% of the landing in 2007 was constituted by *P. semisulcatus.* At Tuticorin also more than 50% of the shrimp landing was constituted by this species. It can grow up to 250 mm TL and is suggested for aquaculture where salinity is more than 25 ppt.

Penaeus monodon: Like *F. indicus*, this species is also subjected to commercial exploitation at different stages of life from both estuarine and marine environments. The entire backwater fishery is constituted by '0' year class. The species occur in the trawl catches on both the coasts of India and belong to late 0-year to early 1-year class. Specimens over 300 mm. in TL are common in the trawler catches landed from relatively deeper waters of the west coast. In the backwater fishery of Kerala, the species is caught throughout the season in small numbers. In Maharashtra and Gujarat, they are found in commercial catches from August-October. Among commercial species contributing to penaeid fishery, *P. monodon* is the largest in size and grows more than 300 mm TL and is widely used in shrimp farming.

Metapenaeus dobsoni: The fishery in backwater is constituted by the '0' year and a marine fishery is represented by 1 year class. During monsoon months when the mud banks are formed in various places along the coast, shoals of these shrimps approach the nearshore areas to make it possible for fishermen to catch them. The population caught from the backwaters and estuaries range from 30-70 mm TL where as in the marine fishery, size range from about 60-125 mm TL. Juveniles are fished in backwaters, estuaries and paddy fields ranging from 1 to 15 meter depth. Young adults and adults are caught from sea in depths from 15 to 30 metres. In marine inshore areas, the fishery is largely seasonal from June to September. The offshore fishery extends from November to June. In brackish waters of Kerala, the fishery extends from middle of November to April. It is one of the dominant species in the marine fishery of Goa, Karnataka and Kerala.

Metapenaeus monoceros: Only '0' year class contributes to the backwater fishery of Cochin.

In the trawl catches, 3-year classes have been recorded. The backwater fishery constitutes shrimps of 56-90 mm TL and the inshore fishery is represented by sizes ranging from 40-120 mm TL and are mostly juveniles. The adults are caught in the trawl fishery and the size range from 90-175 mm TL. The maximum size observed on the south west coast is 180 mm TL but in higher latitudes shrimps as large as 200 mm TL is common and are caught from a depth of 50-100m. The species is abundant in backwaters from March-June and in November. The fishing season in the trawl fishery is from November-December. In Mumbai waters, the fishery commences during the rainy season, July-August. In Chilka Lake, it is abundant during November to June. *M. monoceros* contribute significantly in the offshore landings of Gujarat, Karnataka and Andhra Pradesh. From 1995 onwards the species is the major contributor in the shrimp landings of Mangalore and Visakhapatnam.

Metapenaeus affinis: In the backwater fishery, only '0'year class (30-120 mm TL) is represented. The inshore and offshore fishery is mostly represented by I and II year class (71-130 mmTL). In the trawl fishery, the II year class generally enters the fishery in the first half of the season and the I year class in the latter half (121-140mmTL). In the backwater fishery, the species is abundant from January to June. The peak season for the species in the trawl fishery is from December to February in Cochin, January to March in Mumbai and January to August in Calicut. The inshore fishery of the Kerala coast intensifies after the formation of mud banks (annual). In Maharashtra, *M. affinis* contribute significantly to the offshore shrimp landing of the state.

Metapenaeus brevicornis: In Hooghly estuary, I and II year class of the species mainly form the fishery and occasionally '0' and III year classes also contribute to the fishery. In the Hooghly estuary, the catches range in size between 15 and 115 mm TL and in the inshore fishery size range from 40-110 mm TL in length. They occur in shallow waters ranging 4-7 meters in depth. The species is found throughout the year and the peak season is from January to March in Mumbai coast and July to February in Gulf of Kutch area. In Hoogly estuary it is fished through out the year with bulk landings during November to February.

Parapenaeopsis stylifera: In the inshore waters, the species is abundant up to 22 metres especially from the depth ranges of 12 to 20 meters. The population is composed of 0, I and II year classes, with a size range of 10-145mm TL. At Veraval, the species support a good fishery during October to December period. On the Mumbai coast, the shrimp is caught through out the year. The peak season for fishing is from January to May in Karnataka and Kerala. Although the species occurs all through the year on the west coast of India, it abounds the inshore waters from November-December to May-June and offshore waters in September to October. In 2004-2005, *P. stylifera* formed 40% of the shrimp fishery at Cochin Fisheries harbor and 71% of the shrimp landing of Neendakara landing centre was represented by the species.

Parapenaeopsis hardwickii: The species forms less than 1% of the annual shrimp landing of India. On the Mumbai coast and Gujarat, the species contribute considerably to the shrimp catch, and the fishery starts in November and continues up to May and the peak season is November and January. The size ranges between 55-65 mm TL in the case of males and 80-100 mmTL in females.

Solenocera crassicornis: The species forms a major fishery in Gujarat and Maharashtra. At Veraval and Mumbai, the species occur in the fishery throughout the year. Peak season of the fishery is during March to April and a secondary peak was observed during December to January. The size ranged from 35 to110 mm TL.

Solenocera choprai: This species was emerged as a major fishery in Gujarat and Karnataka during the last decade. In Maharashtra and north Kerala also it forms a significant fishery. Peak production of *S. choprai* along the Karnataka coast is during the post-monsoon season (August to September). The total length ranged from 46 to 120 mm TL; mean length of males was 74 mm TL and that of females 86.3 mm TL.

Biology

Penaeid prawns are heterosexual and females are generally larger than males. Growth rate varies in different species at different phases of life depending on the habitat and environment.

Among commercial species contributing to the penaeid fishery, *P. semisulcatus*, *F. indicus* and *P. monodon* are larger in size and grows to a total length (TL) of 250, 270 and 300 mm TL, respectively. Length ranges of smaller species such as *P. stylifera*, *M. dobsoni*, *S. crassicornis* and *S. choprai* are 46-145 mm, 31-115 mm and 35-110 mm and 46-120 mm TL, respectively. Penaeids feed mainly on animal food item and decomposing organic matter. They have high fecundity and number of eggs varies between species, mainly in proportion to size of females and ovary weight. The estimated fecundity of *F. indicus* measuring 200 mm TL was 7.3 lakh; 3.9 lakh at 163 mm TL for *M. monoceros*, 1.6 lakh at 120 mm TL for *M. dobsoni* and 1.01 lakh at 102 mm TL for *S. crassicornis*. Though spawners are available throughout the year, there are species-wise peak-spawning periods, which may vary between years mainly due to environmental factors. Life span of penaeid shrimp is about 2 to3 years and mainly 0-year group contributes to shrimp fishery.

Aristeus alcocki popularly known as 'Red ring' is the most sought after deep-sea shrimp by exporters (25%). Available in the depth range of 350-500 m off south Kerala coast and Mangalore, the species measures between 81 and 185 mm TL. *M. andamanensis* is the dominant species in deep-sea shrimp catch with length range of 70-130 mm TL.

Stock assessment and management options

Stock assessment of various species of shrimps for developing appropriate exploitation strategies for effective management of the fishery was carried out by research workers based on the data on fishing and population characteristics of the species collected from different fish landing centres. The stock assessment studies conducted on major commercial penaeid shrimp species of the Indian coast showed that annual yields *of F. indicus, P. monodon* and *P. semisulcatus* on the east coast and *M. dobsoni*, *M. monoceros* and *P. stylifera* on the entire coast had reached the Maximum Sustainable Yield (MSY). It was suggested to fix catch quotas for three major species, *F. indicus*, *P. semisulcatus* and *P. monodon* for Andhra Pradesh, Orissa and Tamil Nadu states for mechanised and non mechanised gears. However, implementing such regulations is practically difficult as the fishing vessels from these states fish beyond their jurisdiction and land their catch in ports of other states. *P. stylifera* is the most important contributor to the penaeid shrimp fishery along the west coast and mortality studies show that this species along Kerala coast is facing heavy fishing pressure. The average annual yield of *P. stylifera* along Calicut coast at the present level of exploitation is very nearer to MSY and it is advisable to maintain the same level of fishing effort. In *M. monoceros,* even though the average annual yield during 1985-89 was marginally lower than the MSY of 10,993 t, the catch during later years exceeded the MSY level. Since increasing the effort was not economically attractive it was suggested to maintain the existing fishing effort to obtain optimum yields. Similar results were obtained in *S .choprai* stock assessment studies from Karnataka during 2003-2005. Studies on *M. monoceros* along Kerala coast have indicated that there was no adverse effect of fishing on the exploited stock of this species from south west coast off Cochin. In the case of *M. dobsoni* it is suggested that the indigenous gears may be allowed to exploit this coastal species, especially during monsoon months, as the catch consisted mainly of larger size groups, which would have spawned twice or thrice. In conclusion, in a multispecies fishery it is rather difficult to suggest harvesting strategies exclusively for each stock. Since shrimps are the most important commercial species targeted by the multi-day trawlers, in order to understand the impact of increase in effort on shrimp resources caught by these vessels, CEDA analysis was carried out with catch and effort of shrimps landed in Karnataka during 2002-2006. In the case of penaeid shrimps, MSY was calculated as 4,374 t and *fMSY* **a**s 18,64,945 hours, which is equal to 22,469 units in terms of fishing hours per unit in 2006. By taking 2006 effort level as base line 22% reduction in effort is recommended for exploiting the resource at MSY level.

Detailed study on the population dynamics and stock assessment of commercial shrimps has showed that the average annual yield of most of the species has reached the MSY level. It was observed that increase in fishing effort may not result in substantial improvement in penaeid shrimp yield and therefore may not be economically viable. Reduction in number of fishing vessels as well as fishing hours along with increase in cod-end mesh size of shrimp trawl to atleast 25 mm are the practical management measures which can be effectively implemented to get a sustainable yield of penaeid shrimp resource.

Estuaries and backwaters are nursery grounds for many commercially important penaeid species *(M. dobsoni, M. monoceros and F. indicus*) and act as a source of recruitment for inshore stock. Large-scale destruction of juveniles takes place in this environment as a result of indiscriminate fishing mainly by stake nets. Today, unauthorized stake nets far exceed the licensed ones and these nets should be removed permanently. Total ban of export of shrimps below a fixed minimum size is recommended to sustain the fishery. Capture of juvenile shrimps is uneconomical and leads to national loss worth crores of revenue in foreign exchange.

Enforcement of temporary closure of the fishery is an effective option in the conservation of the shrimp resource. During the southwest monsoon closure of fishing along the west coast acts as a natural conservation measure. Ban on monsoon trawling in the first half of the monsoon season is in vogue in Kerala for the last 14 years. This partial ban has prevented the capture of undersized shrimps in June and July resulting in increased availability of larger shrimps in the post ban period. However, the trawl ban did not benefit the shrimp fishery, as the post-ban catch of *Karikkadi (P. stylifera*) did not show much improvement when compared with the pre-ban period. Maharashtra and Tamilnadu have also imposed trawling ban in recent years. Cod end mesh size of the trawl net in operation along the Indian coast is generally ranging between 15 and 20 mm, which results in large scale capture of juveniles and undersized shrimps and these are often discarded. The regulation on minimum cod end mesh size of trawl nets is to be strictly implemented and monitored by the maritime governments. Operation of *minitrawl* with a cod end mesh size of 10 mm operated along the Kerala coast and t*halluvalai* in Gulf of Mannar and Palk Bay regions cause heavy destruction of juvenile population of *Karikkadi (P.stylifere*) and green tiger shrimp *(P. semisulcatus),* respectively. Fishing by these types of gears should be completely banned by either compensating the fishermen involved or by offering alternate jobs. Trawling within 10 m depth by commercial trawlers as well as *mini* trawlers should be completely stopped in order to avoid exploitation of juvenile shrimps. Existing laws should be strictly implemented to avoid sectoral conflicts.

At present inshore areas are overexploited. Extension of fishing to areas beyond conventional fishing grounds has to be encouraged by offering suitable subsidy. Marine fishing regulation laws delimit area of operation of different types of gears and vessels to safeguard the interest of different sectors. These laws are often breached than complied with. Finally, the number of trawl units operated should be restricted based on the stock assessment study. The respective state governments should stop issuing license to new trawl units for shrimp fishery in inshore waters. Natural stocks of heavily exploited shrimp species can be replenished by large-scale sea ranching of the post-larvae.

Experimental searanching for stock enhancement

During 1985-86 CMFRI initiated experimental searanching of the green tiger shrimp *P. semisulcatus* at the Regional Centre, Mandapam Camp with the objective of studying the impact of searanching of hatchery produced juveniles on stock enhancement. *P. semisulcatus* is the most important component of the shrimp fishery in Palk Bay region of Tamil Nadu, probably due to the vast expanse of sea grasses and seaweeds which offer an ideal habitat for the early juvenile stage. This shrimp being an endemic species with limited movement was considered to be the most suitable species for searanching. An experimental hatchery with 1 million production capacity/year was established in Mandapam. Postlarvae produced in the hatchery were initially released in the Pillaimadam lagoon and were observed to move into the sea within 24 hours. Regular searanching was carried out from 1985 onwards. Nearly 7 million postlarve (PL 20-40) were released between 1985 and 2000 in Palk Bay. Though impact of searanching on the shrimp population could not be delineated from studies on the commercial catches due to small quantity of postlarvae released, the data collected would serve as a base for further studies on the effectiveness of sea ranching to augment the natural stock.

In order to study the growth, movement and recruitment of the released stock into the fishery, tag-recovery studies were conducted during 1991-92 and 1993-94. During 1991-92, 2964 hatchery produced and farm grown shrimp in the size range of 61-110 mm total length were tagged and released in Palk Bay. Wide publicity regarding release of tagged shrimp and reward for return of tagged shrimps if found in commercial catches were given in all the coastal villages bordering Palk Bay. 37 tagged shrimps were recovered within 53 days from catches landed by trawlers operating in shrimp grounds in Palk Bay. During 1993-94, 3384 numbers of *P. semisulcatus* and 3,430 numbers of *F. indicus* were tagged and released of which 42 numbers of *P. semisulcatus* and 19 numbers of *F. indicus* were recovered from trawler catches. While movement of *P. semisulcatus* was restricted within the Bay, *F. indicus* moved away from the fishing grounds in Palk bay and were recovered from Gulf of Mannar. The study showed that the released shrimps were able to survive, grow and get recruited into the shrimp fishing grounds, indicating the positive impact of searanching on stock improvement.

Non-penaeid shrimps

The estimated average annual landing of non-penaeid shrimps in India during 1985-2015 was 1, 26, 159 tonnes. About 86% of non-penaeid shrimp catch of the country was landed along the northwest coast. Gujarat and Maharashtra contributed 48% and 38%, respectively followed by West Bengal (7%) and Andhrapradesh (Fig. 3). Along the northwest coast, this resource is mainly caught by traditionally used bag nets locally called *dol* nets. In 1986, Maharashtra contributed 78% of this resource. But thereafter, shrimp trawlers in Gujarat started commercial exploitation of *Acetes* spp. on a large scale. Reduction of cod-end mesh size of trawl net from 25 mm to 12-15 mm and fishing operation in the coastal sea coupled with the development of fishmeal industry at Veraval were responsible for enormous landing of this resource in Gujarat. In Maharashtra, on the contrary, the trawlers catch only *Nematopalaemon tenuipes*. Owing to deep-sea shrimp fishing in Kerala from 1999, the non-penaeid shrimp catch from this state increased

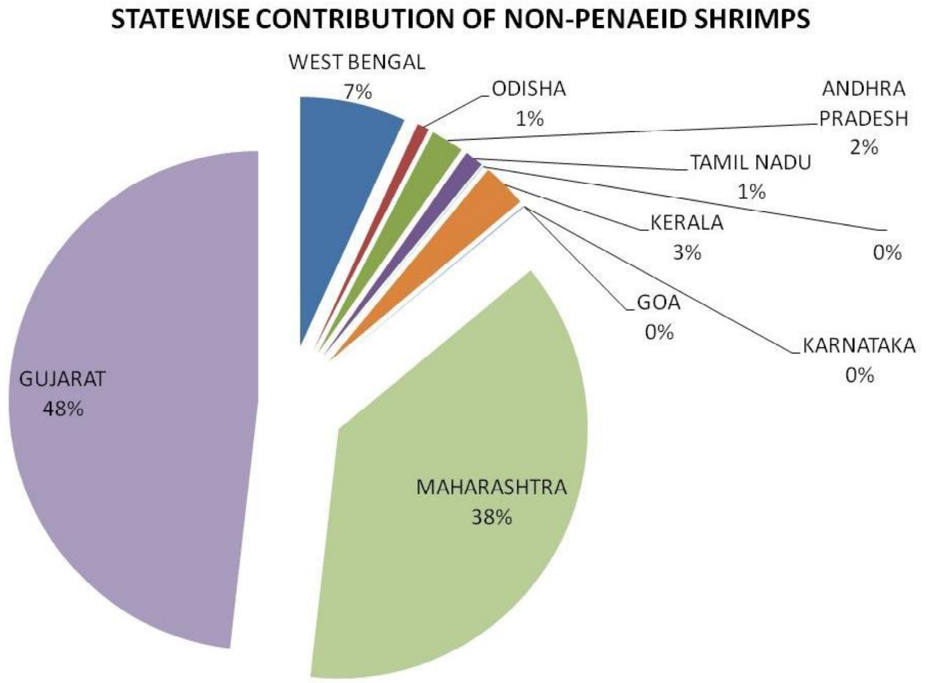

Fig.3. Percentage contribution of states to annual non-penaeid shrimp landings

and amounted to 3.6% of all-India catch. Availability of deep-sea non-penaeids from Tuticorin and Chennai in 2000 resulted in contribution of 1.3% to all-India catch by Tamilnadu.

Distribution of non-penaeid shrimps

The non-penaeid shrimp resource is multispecies, mainly supported by tiny species of genus *Acetes* (Paste shrimp), in addition to *Nematopalaemon tenuipes* (Spider shrimp*)* and *Exhippolysmata ensirostris* (Hunter shrimp). There are 5 species of *Acetes; A. indicus, A. johni, A. sibogae, A. erythraeus* and *A. japonicus.* Among these, first 2 species support commercially important fisheries from marine waters, and the rest are exploited on a low key from estuarine and near shore coastal seas along both along the northeast and northwest regions.

Fishery

The non-penaeid shrimps in Maharashtra as well as in Gujarat show two peaks of abundance, in October-November and in April-May, but in Andhra Pradesh only one peak is noticed in July-September. Along the Gujarat-Maharashtra coast, *A. johni* occurs in huge quantities during October-November and other species were abounding almost throughout the year. *A. indicus* forms bulk of the catch in March-April, *N. tenuipes* in May-June and *E. ensirostris* during June-August and December-January. Pandalid shrimps are the major contributors to deep-sea shrimp fishery which consists mainly of *Heterocarpus woodmasoni, H. gibbosus* and *Plesionika quasigrandis. H. chani* and *P. narwal* were recently reported to occur from southwest coast.

Biology

Acetes indicus: The species is an epipelagic planktonic shrimp, which forms large shoals in coastal waters. Generally, its size ranges from 8 to 38 mm TL, and males and females exhibit differential growth rates of 6.15 mm and 5.96 mm/ month, respectively. Their fishable life span is about 3-6 months. The species breeds almost throughout the year in shallow coastal waters showing peak spawning activity during September to January. The females lay 4,300-10,300 eggs. The species mainly feeds on detritus consisting of fibrous and granular materials of phytoplankton and zooplankton origins.

Nematopalaemon tenuipes: The shrimp exhibits differential growth rates with males and females reaching 57 mm and 64 mm TL on completion of 1 year. The life-span of the species is slightly more than a year. Being a caridean shrimp, it carries yolky eggs attached to its pleopods for incubation. The fecundity varies from 242 to 3,648 eggs.

Exhippolysmata ensirostris: This species is the largest among the coastal non-penaeids and is a hermaphrodite. It is highly predatory and feeds on paste shrimps, polychaetes and young ones of fish and shrimps. It attains 64.8 mm TL in 6 months and 92.8 mm TL at the end of 1 year, and its fishable life-span is about 1 year. Being a hermaphrodite, ovo-testes produce sperms as well as large yolky eggs when shrimps attain 40-45 mm TL. The fecundity ranges from 476 to 13,260 eggs in individuals varying in length from 45 to 99 mm TL. *E. ensirostris* breeds throughout the year with peaks during May-September and December-January.

In the deep-sea shrimp catch, *H. woodmasoni* and *H. gibbosus* of length range 71-125 mm and 91-140 mm TL, respectively were represented. Peak breeding season of these species was January – March. Fishery of *P. quasigrandis,* the dominant species among pandalids in the deep sea shrimp catch, was supported by 71-120 mm length group. Berried females were observed throughout the year, indicating continuous breeding habit.

Stock assessment and management options

Stock assessment studies showed that MSY of non-penaeid shrimp is 64,685 tonnes in Maharashtra and 76,550 tonnes in Gujarat, together forming MSY of 1.41 lakh tonnes for entire northwest coast of India. To achieve this MSY, which is only 20% higher than the present annual average catch, the required effort would be more than double (1.3 times of the present level). Non-penaeid shrimps are not target species for either *dol* nets or trawlers and therefore implementation of management measures is rather difficult. Being the most important group of forage organisms along the northwest coast, the non-penaeid shrimps support huge biomass of economically important fishes in the region. Therefore, one of the reasons for increase in abundance of non-penaeid shrimps leading to their increased catches in the region may be attributed to the removal of these predators by intensive trawling in Gujarat and Maharashtra that commenced in late eighties and nineties. It is evident that on account of their low commercial value but greater importance in marine food chain of important food fishes of the region, large-scale exploitation of non-penaeid shrimp will not be economically feasible.

Heavy decline in the contribution of pandalids in the deep-sea shrimp catch and abundance of juveniles with less representation of berried females indicate that this resource is exploited more than the optimal level. Unlike coastal species, deep-sea pandalids have biological limitations such as slow growth rate, less fecundity and long life-span. Hence, it is advisable to exploit this resource optimally by limiting effort in trawler units and fishing hours. Instead of concentrating on heavily exploited grounds such as Quilon Bank, the trawling should be done in new/under exploited deep-sea grounds for sustainable returns.

Lobsters

Lobsters are one of the highly priced crustaceans in India and are in great demand as a delicacy in the internal market and as a foreign exchange earner in export market. They are widely distributed along the entire coast of the country with maximum landings from the northwest coast, followed by the southwest and southeast coasts. The lobster fishery along the northwest coast comprising Gujarat and Maharashtra, is constituted by palinurid lobster P*anulirus polyphagus* and the scyllarid *Thenus unimaculatus,* which forms incidental catch in trawl nets (Table 2). These two species dominated lobster fisheries till the early 1990s in the country, contributing to nearly three-quarters of the total landing. However, the slipper lobster fishery in Maharashtra witnessed an unusual incidence of collapse by 1994, and has showed no sign of recovery so far. *P. homarus* dominates shallow water lobster fishery along the southwest coast. Landed in small quantities are *P. versicolor* and *P. ornatus*. The major landing centres are at Colachel and Muttom, where indigenous gears such as gill-net, trammel-net and traps are used. The lobster fishery along the southwest coast is dominated by the deep-sea lobster *Puerulus sewelli,* the fishing ground of which is located off Quilon in Kerala State, at depths ranging from 150 m to 400 m. A small scale fishing for *T. unimaculatus* was reported from Quilon from 2004 onwards, which is landing as a bycatch in trawlers operating at 50-70 m. The major species exploited along the southeast coast of India are *P. homarus* and *P. ornatus*, landed mainly by gill-nets along the southern region and *P. homarus* and *T. unimaculatus* by trawlers as by-catch along the northern region of Tamil Nadu. *Linuparus somniosus* is exploited in small quantities from Andaman and Nicobar Islands. The Minimum Legal Size Law promulgated in 2003 by the Ministry of Commerce and Industry, Government of India, and lobster conservation and co-management programmes taken up by the Central Marine Fisheries Research Institute and Central Institute of Fisheries Technology, Kochi, for the fishers are steps taken towards effective management of lobster fisheries.

Table 2. State-wise distribution of lobster species in India

State	**Species**
Gujarat	*Thenus unimaculatus* and *Panulirus polyphagus*
Maharashtra	*P. polyphagus*
Tamilnadu	*P. homarus, P. ornatus, T. unimaculatus*
Kerala	*Puerulus sewelli, P.homarus, T. unimaculatus*

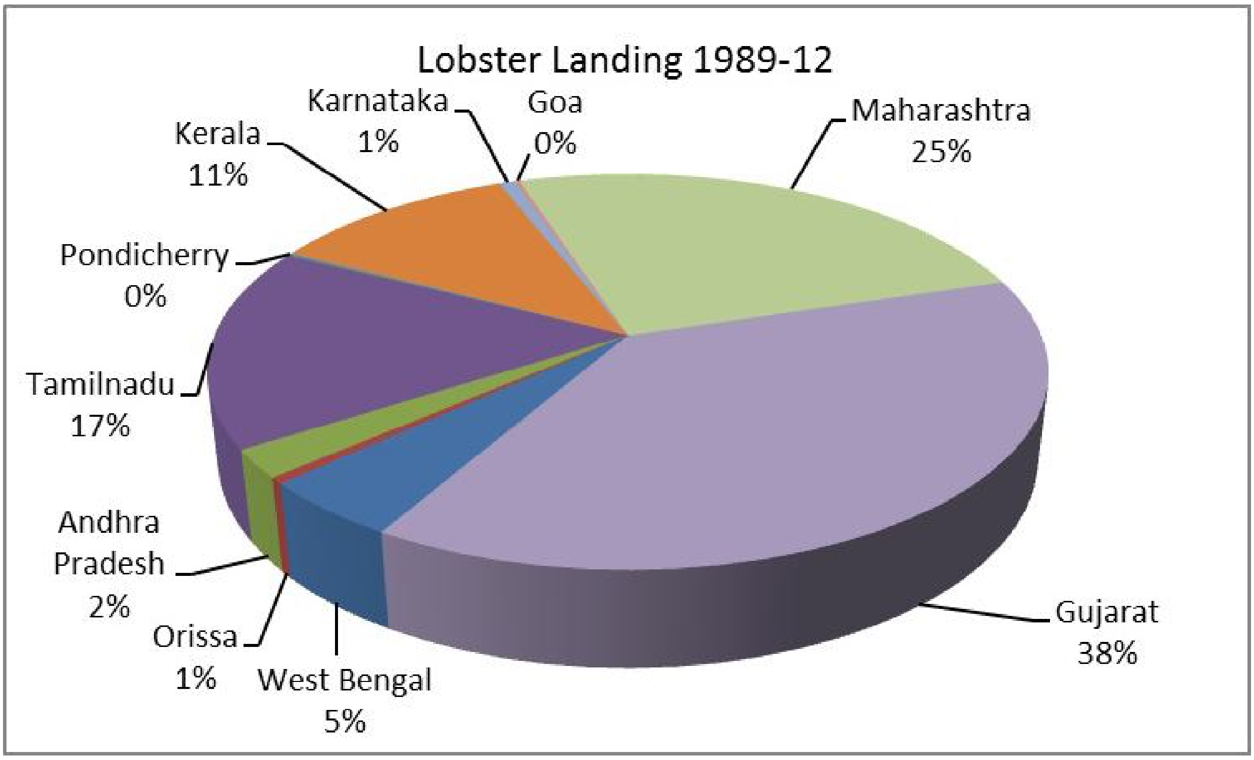

Fig.4. Percentage contribution of states to annual lobster landings

Fishery

In India, annual lobster landings increased from 800 tonnes in 1968 to 3,000 tonnes in 1975, and attained a peak of 4,075 tonnes in 1985. However, the landings declined thereafter, averaging 2,200 tonnes for about 15 years. The catches further decreased to 1,245 tonnes in 2003 and further declined to 1,112 tonnes in 2005. Average landing from 1985-2015 was 1990 tonnes, with Gujarat contributing maximum (38%) and Maharashtra contributing 25% (1989-2012) (Fig. 4). Gujarat recorded its lowest catch of the decade, 182 t in 2003. The percentage composition of catch in Tamilnadu and Kerala was 17% and 11%, respectively. In Maharashtra, the commercial fishery for *T. unimaculatus* was initiated in 1978, with a catch of 1.5 tonnes. The landing reached a maximum of 375 tonnes in 1982. Subsequently the catches fluctuated around 250 tonnes and reached another peak (334 tonnes) in 1986. But, thereafter the catches declined steadily, landing only 2.2 tonnes in 1994. As a consequence, the fishery collapsed, and the species occurred only in small quantities in the following years.

Biology

The total length attained by the spiny lobsters are: *P. homarus* 320 mm, *P. polyphagus* 450 mm and *P. ornatus* 500 mm. Growth rate is identical in juveniles but differential in adults. In *P. polyphagus,* 50% sexual maturity is attained at 205 mm TL for females. Though the species breeds throughout the year, maximum number of females in berry is observed during August-October and recruitment of juveniles measuring < 100 mm (<50 g) generally takes place during December-January. In spiny lobsters fecundity ranges from 50,000 to 1,000,000 depending upon the species and the size of lobster. *P. sewelli* ranges in size (TL) from 76 mm to 190 mm in males and from 71 mm to 205 mm in females. Occurrence of maximum number of immature females in January and smaller size –classes during December –January indicate entry of young ones into the fishery during these months.

Stock assessment and management options

Maximum landing of lobster is reported from the northwest region where *P. polyphagus* dominates fishery. The size ranged from 75 mm to 385 mm TL, those between 160 mm and 230 mm forming mainstay of the fishery in 1998-2002. From the length composition of the two sexes of *P. polyphagus*, the total mortality coefficient (Z), natural mortality coefficient (M), exploitation rate (U) and E_{max} were estimated. The Z for 5-year period for males and females was 1.63. With the mean seawater temperature at 28^{0}C, M for males and females was 0.53 and 0.6, respectively. The relative yield/recruit (Y/R) analysis indicated that yield could be maximized when the exploitation ratios were 0.46 and 0.53 for males and females, respectively. However, the present exploitation ratios are 0.65 for males and 0.63 for females are high, which may not sustain future stock.

As the trawl fishery for lobsters in India does not constitute an exclusive target fishery, optimizing trawlers for lobsters alone is not an option. Observing a closed season for lobsters during the peak breeding season (August-September) is also not practical as trawl ban is already practiced based on the multi-species fishery in different states. Hence, one of the options left is to return egg-bearing females back to sea at least during the peak spawning season (August-September), so that the spawning stock is protected. Heavy recruitment of juvenile lobsters (40-160 g) takes place in December-February and since these undersized lobsters do not fetch remunerative price to the fishermen they can also be returned to the sea. The MLS for export of whole cooked *P. polyphagus* is fixed at 250 g with this motive. These options are possible if it is legalized to catch lobsters only above the size at maturity (205 mm in total length or 220 g size) and returning the egg-bearing females back to the sea. *P. polyphagus* is a hardy species which remain alive for 1-2 hours after it is brought on board by the trawl net. Hence, releasing back the undersized and berried lobsters is recommended. This will protect not only the new recruits but also the spawning stock ensuring future recruitment process. Mesh size regulation is not practical as *P. polyphagus* appears as bycatch in shrimp trawls. The sustainability of *P. polyphagus* fishery at a lower magnitude is attributed mainly to its high fecundity and breeding throughout the year. The long larval phase and the consequent small percent of recruitment shows that the lobster is a highly vulnerable species biologically. The species is also highly vulnerable to fishing due to the gregarious behaviour and the peculiar aggregation during breeding season, which the fishermen are quite aware of. If regulatory measures are not strictly enforced, gradual decline and complete annihilation of the stock, as in the case of *T. unimaculatus* off Mumbai is possible. Intensive exploitation of juveniles of *P. polyphagus* from the inshore reef area by gill nets is to be banned if the lobster fishery is to sustain. Legal ban on fishing of juveniles by the gear is to be enforced by the State Government. In *T. unimaculatus*, which occurs only in small numbers along the coast of Maharashtra, total conservation of the remaining residual population could be achieved by a legal ban on the landing of the species.

Spiny lobster fishery is an open access fishery and any restriction imposed on fishing will be resisted by the fishermen. A part from legal implementation of fishing regulations, education and creation of awareness among the various stakeholders on the negative impact of fishing and marketing juveniles and egg-bearing lobsters may bring a subtle change in the mindset. Establishment of artificial habitats and lobster sanctuaries/reserves in identified locations is desirable.

A participatory management project initiated by CMFRI and CIFT, and funded by MPEDA is making slow progress in changing the mindset of fishermen and traders and may inculcate a sense of responsible fishing and trade. Village-level meeting, distribution of educative posters, stickers and pamphlets, video film shows, ‘V’ notching and releasing of egg-bearing lobsters involving the fishermen and distribution of lobster traps to wean the fishermen away from using the destructive fishing methods are some of the activities implemented under the programme. Enforcement of Minimum Legal Size (MLS) for export is a positive step from the Ministry of Commerce and Industry, Government of India (Table 3). The MLS is arrived at considering the biological features of each species. Kagwade (1988) suggested a minimum of 80 g as tail weight for *P. polyphagus* and 90 g was fixed by the Ministry in 2003. The objective is that MLS should be above the size at first maturity so that the lobsters get an opportunity to breed at least in one breeding season. *P. polyphagus* is mostly exported as whole-cooked and as whole chilled or as tail, whereas *P. homarus* and *P. ornatus* are mostly exported as live or whole frozen/ chilled. In the case of *P. ornatus* the breeding population is mostly protected because of their movement to deeper waters for spawning. However, implementation of a minimum legal

Table 3. Minimum Legal Size for export of lobsters from India

Species	Live /Chilled / frozen	Whole cooked	Tail
Panulirus polyphagus	300 g	250 g	90 g
P. homarus	200 g	170 g	50 g
P. ornatus	500 g	425 g	150 g
Thenus unimaculatus	150 g	-	45 g

size for fishing, closure of fishery during peak spawning in the southern spiny lobster fishery and ban on trammel nets are regulatory measures to be implemented by State Governments. Lobster fishing being a socio-economic activity involving the local fishermen, any regulatory measure shall consider the socio-economic aspects so that the fishermen are not adversely affected.

Crabs

The crab fishery in India is slowly picking up as a major fishery with abundance of edible crabs all along the Indian coast. Crab meat, cut crab and live crabs are exported from India to countries like Japan, USA, France, Hong Kong and Malaysia. Although there are about 700 species of crabs recorded from Indian waters, those commonly used for food belong to family Portunidae. Three species, namely *Portunus sanguinolentus* (Spotted crab), *P. pelagicus* (Reticulate crab) and *Charybdis feriatus* (Cross crab) predominate fishery in the coastal waters. *Podopthalmus vigil*, *C. lucifera*, *C. annulata* and *C. natator* also contribute, though in small quantities, to the fishery. Crabs are caught as bycatch and more than 80% of the total landing is by trawlers. Indigenous gears such as gill nets and traps are also used in selected areas targeting individual species, especially *P. pelagicus*. Crabs are usually caught from a depth of about 10 m to 60 m. Trawlers occasionally go up to 80 m during the post-monsoon months, along the south-west coast. It is the recent advances in fishing technology that has enabled fishermen to venture into deeper waters engaging themselves in multi-day fishing. This has resulted in increased landing of edible crabs, especially *C. feriatus*. Average annual landing of crabs (2003-07) was 42,851 t and maximum landing was in Gujarat (32%) followed by Tamilnadu (28%) (Fig. 5).

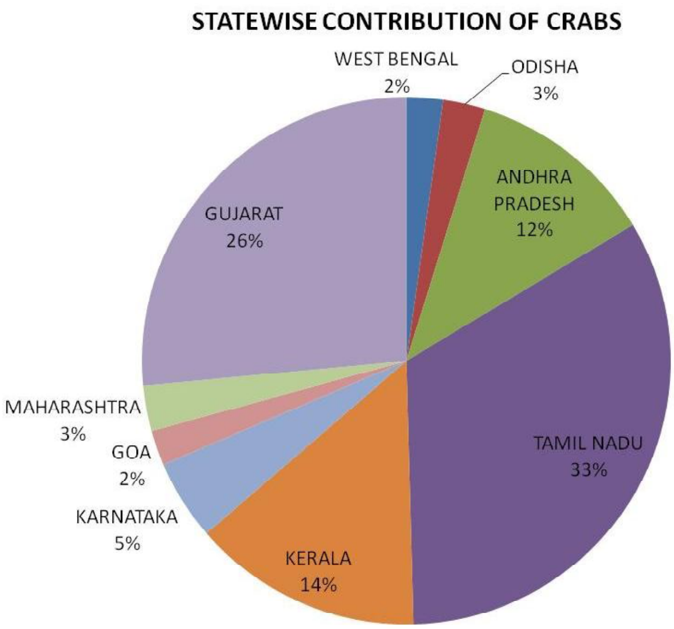

Fig.5. Percentage contribution of states to annual crab landings in India

Table 4. State-wise species distribution of marine crabs

Gujarat	*C. feriatus, C. lucifera*
Maharashtra	*C. feriatus, P. sanguinolentus*
Karnataka, Goa, Kerala	*P. sanguinolentus, P. pelagicus, C. feriatus*
Tamilnadu, Pondicherry	*P. pelagicus, P. sanguinolentus*
Andhrapradesh, Orissa, West Bengal	*P. sanguinolentus, C. lucifera*

Distribution of crabs

C. feriatus dominated the fishery for edible crabs at Veraval in Gujarat, the modal classes ranging from 56 mm to 75 mm carapace width. Inedible species landed often in putrefied form were used for the production of fish meal or manure. In Mumbai waters also, *C. feriatus* predominated the fishery followed by *P. sanguinolentus* and *P. pelagicus* (Table 4). The landings were generally maximum in the third quarter and minimum in the second quarter of the year. Percentage of berried females also seemed to be more in the third quarter. Towards south, in Karwar, *P. pelagicus* dominated the fishery, though further south along the south-west coast, both *C. feriatus* and *P. sanguinolentus* dominated, followed by *P. pelagicus*. Ring seines and hand trawl also landed crabs along the Malpe coast, during the south-west monsoon months. In Kerala, maximum landing was reported during January-May with very little landing in the 3rd quarter of the year.

At Vizhinjam in south Kerala, trammel nets were used from *Vallom* or *Catamarans* during the south-west monsoon months. Bottom–set gill nets were widely used along the coasts of Mandapam and Tharuvaikkulam landing large sized *P. pelagicus*. On the other hand, the trawl landings at Chennai and Visakhapatnam were dominated by *P. sanguinolentus* followed by *P. pelagicus* and *C. feriatus*. The landing of inedible crabs at Visakhapatnam was dominated by *C. callianassa*.

Mud crabs: *Scylla serrata* and *Scylla tranquebarica* are two major species which are known as mudcrabs. Mudcrabs are much in demand in the domestic market and fetches a good price, compared to other species of crab. Mud crabs can be successfully marketed both in domestic and export markets in live condition. Medium and large crab of more than 14 cm CW and weighing more than 400 g. are collected exclusively for export in West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Goa, Maharashtra and Gujarat. Mud crab generally do not figure in marine fisheries but is occasionally found in the fishery especially in the mouth of estuaries.

Fishery

The annual average landing of marine crabs during 1985-2015 was 36317 t. The major landings are in Tamilnadu (33%) and Gujarat (26%), followed by Kerala (14%) and Andhra Pradesh (12%). The coast-wise analysis of the landing during the year 1985-2007 showed that maximum catches were reported from east coast (15,858 t). The landings from the west coast was 15818 t. The percentage contribution from the south east region was 44%, northwest region 29% and south west region 19% of the total landing, during the years 1985-2007. Quarter-wise, landings are generally better during the first quarter followed by the second and fourth quarters. Only small quantities are landed during July-October, along the southwest coast of the country. Sizes between 63 mm and 113 mm (carapace width) formed mainstay of the fishery for *C. feriatus* along the northwest coast. The percentage composition of this species ranged from 5 to 45%, followed by *P. pelagicus* and *P. sanguinolentus*. The remaining species generally came under non-edible groups which are used for preparation of fish-meal or manure. *P. sanguinolentus* constituted about 30-45% of the landings along the southwest and east coasts of the country, followed by *C. feriatus* and

P. pelagicus. Studies carried out along the southwest coast showed that in *P. sanguinolentus*, the size ranged from 71 mm to 160 mm, with sizes between 91 mm and 125 mm forming mainstay of the fishery.

Biology

Studies on the food and feeding habits of *P. sanguinolentus* and *P. pelagicus* showed that they generally feed on smaller crustaceans, fishes and molluscs. Detritus, bits of plant and other organic materials are also noticed in stomatch contents. In *P. sanguinolentus,* the mean monthly growth rates were 10.3 mm and 8.8 mm, attaining a carapace width of 124.1 mm and 112.5 mm on completion of one year, in males and females respectively. In *P. pelagicus,* the average monthly growth rates were 11.0 mm and 9.6 mm attaining a carapace width of 145.2 mm and 132.5 mm by the first year, in males and females respectively. It is indicated that the population of these crabs, exploited by different gears comprises mainly of the 0-year class, the 1-year-olds forming only about 10% or less. However , the gill nets which are used at certain centres, during peak seasons of occurrence of crabs, land large proportion of the one-year-olds, possibly due to the larger mesh size. The 50% level of maturity is generally at 90-105 mm in *P. sanguinolentus* and *P. pelagicus.* In *P. sanguinolentus* on an average 25% to 55% of female crabs were caught in ovigerous condition. Sexes were more or less equally distributed with about 16% of females in immature stage and 45% in berry. In *P. pelagicus,* the size ranged from 71 mm to 165 mm with 29.5% females in berry and in *C. feriatus,* the size ranged from 46 mm to 140 mm, with 37% females in berry. These crabs breed throughout the year with peak seasons and spawning may take place twice or more in a season. Peak breeding and recruitment seasons vary from region to region. In Karnataka peak spawning season for *P. sanguinolentus* was January-February and December. The total number of eggs ranged from 2, 29,000 (90 mm) to 9, 20,000 (160 mm). In *P. pelagicus* peak spawning season was January-March and in *C. feriatus* peak spawning season was March-May. The number of eggs on ovigerous females ranges from about 50,000 to over a million.

Stock assessment and management options

Status of the stocks along the Karnataka coast was assessed in 1997 and 2006. From 'Thompson and Bell yield prediction analysis' it is seen that in the case of *P. pelagicus* any additional effort from the present level will yield only less than 10% additional catch, indicating that increasing the effort for better catch of the resource will not be economical and it is suggested that restricting the catch to MSY level will be the suitable management option for the sustainability of the fishery of the species from Karnataka coast. In the case of *P. sanguinolentus,* it is seen that yield increases with the increasing effort, but an increase of fishing effort by 10 to 20 % from the present level will yield 3 to 4% additional yield indicating that any increase in effort level would not be economical. In the case of *C. feraitus* in 2008 the exploitation ratio of 0.62 against the E_{max} of 0.59 (Beverton and Holt plot). So there is a need to reduce the fishing pressure so as to get maximum yield per recruitment.

With the practice of multi-day fishing which necessitates facilities for freezing or icing the priced catches, crabs get landed usually after sorting. Thus, species and sizes that are not used for human consumption are often discarded at sea. This makes it all the more difficult to estimate the quantity of catches discarded or the quantity of juvenile crabs being caught. In Gujarat, large quantities of crabs are landed in putrefied state and are used for production of fish meal. Studies on the resources of crabs in various maritime states have shown an overall improvement. The sport in catches is attributed to expansion of fishing area into deeper waters by fisherman engaged in multi-day fishing and utilization of species such as *C. feriatus* and *C. lucifera* for human consumption. Analysis of the catch data of crabs over the years shows that there is no drastic decline or sign of over-exploitation of the stock. The slight improvement in the landings may be due to the facts that fishermen now venture into deeper waters for multi-day fishing and that non-conventional species like *C. feriatus* and *C. lucifera* are gaining popularity among consumers. However, it is essential to ascertain rational utilization of the crab resources as demand for this commodity in both in the export and domestic markets of the country is on the increase.

Stomatopods

Mantis shrimps, generally known as 'Squilla' are one of the major crustacean resource caught from sea. It is caught mainly as by-catch and used for fish meal preparation. During 1985-2015, the average annual landing was 49693 t with the highest landing in 1987 (98,614 t). Karnataka (32%) and Maharashtra (26%) contribute maximum to the total annual landings (Fig. 6). The species is very important in the point of view that it forms major food items for most of the demersal fishes. Recent studies show that stomatopod fishery of Chennai coast is constituted by various big sized species caught from varied depths. Bigger species of stomatopods are having great export potential in markets in China where the species is sold as "squilla meat".

A total of 65 species belonging to 23 genera and 8 families are known to occur in the seas. The catch from south-west coast is exclusively constituted by *Orato squilla nepa*, whereas the catch from east coast is composed of multi species (*O. nepa, O. woodmeso, O. interupta* etc). The largest size is attained only in 2 genera, *Harpiosquilla* (310 mm) and *Lysiosquilla* (275 mm).

Future thrust areas for research

The crustacean resources, especially penaeid shrimps and lobsters are high value resources and owing to their economic importance these stocks are intensively exploited in the coastal waters. Despite rapid growth, short life-span and continuous breeding, these resources have been steadily declining. Wide catch fluctuations, decline in catch rates and changes in species composition in the recent past are the indicators of their overexploitation, which call for immediate implementation of management measures. Although management measures such as trawl ban during monsoon have reduced fishing pressure on some of the demersal finfish resources, the remedial measures on crustacean resources have not been fully realized.

Although most of the shrimps exhibit high biotic potential, it is believed that their recruitment is largely influenced by abiotic factors. Most of the penaeid shrimps migrate to deeper areas for breeding and trawling beyond 40 m has resulted in large scale exploitation of the spawning stock. There is apprehension that recruitment overfishing is mostly responsible for the declining

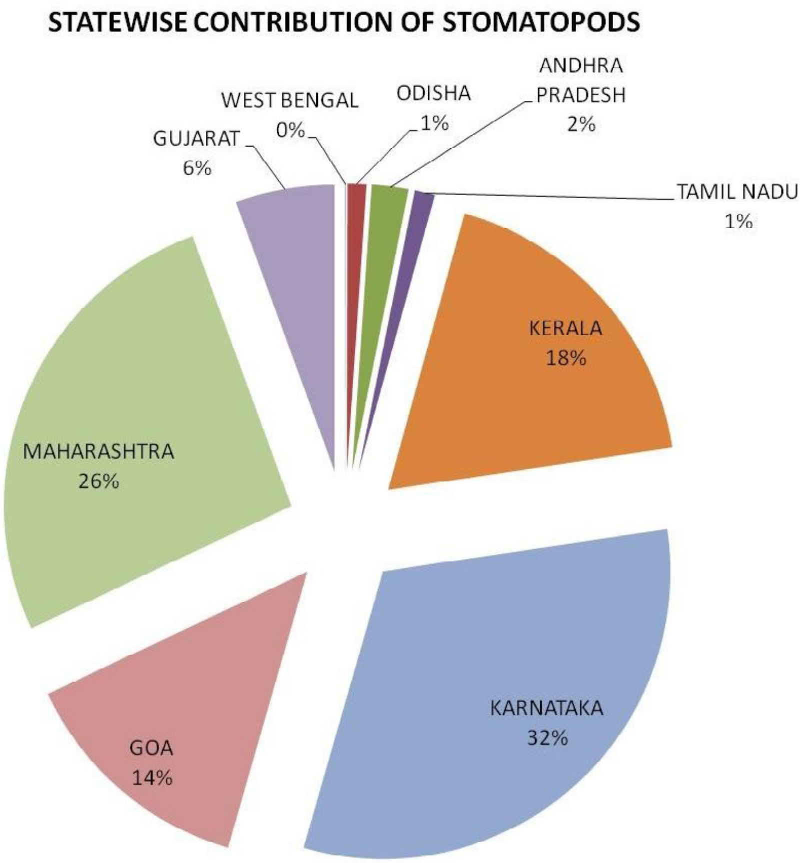

Fig. 6. Percentage contribution of states to annual landing of stomatopods of India

catches. Therefore, it is necessary to understand their reproductive dynamics and the relationship of spawning biomass and recruits and the future research shall focus on studying these aspects. Integration of environmental factors such as rainfall or wind driven surface currents (especially for lobsters) may improvise uncertainties associated with the models used for such studies.

Successive generations (of females) need to produce sufficient 'spawning units per recruits' over their life-span to rejuvenate the stock. For the targeted resources of shrimps and lobsters, which are presently under heavy fishing pressure, the management may require conservation of the spawning stock. Failure to meet this objective is frequently associated with reduction in spawning stock biomass (SSB) to low levels. Reduction of SSB to less than 20% of its unexploited level is often considerable undesirable for stock conservation.

The capture of juveniles constitutes a threat to sustainable fish production. There is need to develop selective fishing gear that has minimal impact on ecosystems, which will reduce exploitation of immature/juvenile fishes and other unwanted catch including the threatened species. The strategic research also should focus on participation of stakeholders in coastal resource management and community development. The fisheries communities should be made responsible for the optimal utilisation and conservation of the resource.

Searanching and establishment of Marine Protected Areas (MPAs) have been widely used for stock enhancement or maintenance of depleted stocks and for increasing coastal productivity. MPAs have several benefits and they may help in protecting important habitats from damage by destructive fishing practices. They may serve as benchmark for undisturbed natural ecosystems that can be used to measure the effects of human activities in other areas and thereby help to improve resource management. MPAs may provide areas where fish are able to spawn and grow resulting in increasing fish catches in surrounding fishing grounds. They also help in preventing certain vulnerable fish population from extinction, which is attributed to environmental fluctuation and climate change.

STATUS OF CRUSTACEAN FISHERY IN INDIA

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Introduction

Crustaceans are a diverse group of arthropods that include commercially valuable species such as lobsters, prawns, shrimps andcrabs and are highly valuable sources of aquatic food protein. There are over 67,000 species of crustaceans and the majority of crustaceans are aquatic, living in either marine or freshwater environments. While in feral water bodies they play vital ecosystem roles as essential components of food webs from predator to scavengers, from the economic point of view crustaceans positively contribute to food security in both producing and exporting countries as highly sought after sea food items. Production and trade of crustaceans are significant economic activities for countries like India. The escalating demand for crustaceans therefore brings in the need for sustainable capture fisheries, sustainable trade and sustainable aquaculture of crustaceans (Bondad-Reantaso*et al.*, 2012). The marine fisheries export of India during the year 2015-16 was 9,45,892 tons, with a total value of Rs. 30,420.83 crores (4,687.94 million USD); frozen shrimp continued to be the major item of export in terms of quantity and value, accounting for a share of 39.53 % in quantity and 66.06% of the total USD earnings (http://mpeda.gov.in).

The crustacean fisheries could be broadly grouped under prawns, lobsters and crabs and of these, the prawns are the most important accounting for about 98% of the marine crustaceans landed. The crustacean fisheries of India have assumed considerable importance in recent years in the economy of the country. Exports of frozen and canned prawns and frozen lobster tails have been steadily on the increase earning very valuable foreign exchange. Crustaceans are landed in all the maritime States of India, but the amount of landings vary from State to State. The landings of East Coast of India form only about 17% of the total crustacean landings, while the balance of about 83% is landed on the West Coast of India. Among the States, Maharashtra ranks first by contributing about 48% of the total crustacean landings in India followed by Kerala which contributes on an average annual production of 28%. In fact, the major crustacean fishery of India are today located in the two States, Maharashtra and Kerala. The production of marine crustaceans in India with its composition forms three broad groups. The penaeid prawns form about 56% of the average annual crustacean production in India (Radhakrishnan *et al.*, 2012). The next group in importance is the non-penaeid prawns forming about 40% of the average annual production of Crustacea. The balance of 4% consists of other crustaceans such as lobsters, cabs and stomatopods.

Prawns

Prawns constitute the most commercially valuable component of the crustacean fisheries resources harvested from Indian seas. Commercial fishing for prawns is thought to have commenced in early 1950s. Average landings increased from 0.58 to 3.48 lakh tonnes during 1961-2015. Prawns contribute to 12.5% if the total annual marine fish landings in India. The prawn production in India form about 15% of the total world production of prawn and shrimps. If the substantial production from backwaters, paddy fields lakes and estuaries etc. are taken into account, the percentage of Indian production to the world production of marine prawns will be about 20%.

A total of 4048 species of shrimps and prawns described from the world oceans. They are categorized under the sub orders

Dendrobranchiata (68 genera, 533 species), Procarididea (2 genera, 6 species), Stenopodidea (12 genera, 71 species) and Caridea (389 genera, 3438 species) as listed by De Grave and Fransen (2010). Nearly 350 species of prawns are of economic interest worldwide and out of these, only about 100 contribute to the principal share of the annual world catch (Chan, 1998). Although the carideans comprise 84.9% of total prawn species, only few are of interest to fisheries. Among the marine species only 8 are commercially exploited. The number of penaeoid species now found in Indian waters is 122, which forms 34.9% of the world species showing high diversity. According to Radhakrishnan *et al.* (2012) this figure is higher than the 107 species reported from Taiwan (Lee *et al.*, 1999), 84 species from Mainland China (Liu and Zhong, 1994) and the 86 species recorded in Japan (Hayashi, 1992).

Table 1. Diversity of prawns in Indian waters.

No.	Family	No. of genera	No. of species
	Suborder DENDROBRANCHIA		
1.	Penaeidae	17	85
2.	Sicyoniidae	1	4
3.	Solenoceridae	5	20
4.	Aristeidae	7	14
5.	Benthesicymidae	4	12
6.	Sergestidae	6	13
7.	Luciferidae	1	7
	Suborder PLEOCYEMATA		
8.	Alpheidae	4	23
9.	Disciadidae	1	1
10.	Hippolytidae	10	17
11.	Ogyrididae	1	2
13.	Crangonidae	6	18
14.	Glyphocrangonidae	1	10
15.	Nematocarcinidae	1	3
16.	Rhynchocinetidae	2	2
17.	Oplophoridae	1	3
	Acanthephyridae	6	10
18.	Gnathophyllidae	1	1
19.	Hymenoceridae	1	1
20.	Paleomonidae	23	62
22.	Pandalidae	9	27
23.	Thalassocarididae	2	4
24.	Pasiphaeidae	5	11
25.	Processidae	2	3
26.	Psalidopodidae	1	1
27.	Stenopodidae	2	2
28.	Spongicolidae	3	3
29.	Axiidae	3	4
30.	Callianassidae	1	1
	Total	**127**	**364**

(Samuel et al., 2016)

An updated checklist of shrimps on the Indian coast (including Lakshadweep and the Andaman and Nicobar Islands) by Samuel *et al.* (2016) records the presence of a total of 364 species classified under 128 genera. The suborders Dendrobranchiata and Pleocyemata of Decapoda account for 155 (42.6 %) and 209 species (57.4 %) respectively. Pleocyemata is represented by three infraorders (Axiidea, Caridea and Stenopodidea), while Caridea has a maximum of 199 reported species (Samuel *et al.,* 2016). Among them the 142 species are described under the suborder Dendrobranchiata. The list also includes *Penaeus vannamei,* introduced to India for promoting aquaculture.

The number of species, genera and family of prawns reported under two suborders are given in Table 1.

Distribution of commercially important species:

The commercially important prawn species are *Penaeus monodon, Penaeus indicus, Metapenaeus monoceros, Metapenaeus affinis, Metapenaeus dobsoni, Metapenaeus brevicornis* and *Parapeneopsisstylifera.* The details of species involved for prawn fishery at different coasts of India are given in Table 2.

Prior to 1960, penaeid shrimps were caught only by indigenous gears such as shore seine, boat seine, gill net and cast net in the inshore seas, while stake net, dip net, drag net, cast net and trap were used in the estuarine region. Introduction of mechanized trawling during 1960s and 1970s to date, annual catch of prawn increased multifold. In the year 1951-1960 the annual average catch was 52,927 tonnes and increased to 57,884 tonnes in 1961-1970, 1,11,128 tonnes in 1971-1980, 1,32,224 tonnes in 1981-1990, 1,94,346 tonnes in 1991-2000 and the catch in the year 2012 was 2,53,241 tonnes (CMFRI, 2013). With the increasing potentialities of export of prawns to the world market, a major portion of the prawn production of India is being processed, mainly for freezing and the frozen products sent to U.S.A. and Japan. Generally, tiny prawns, which do not find export market, are marketed in domestic markets.

Lobsters

Lobsters are found in rocky, sandy or muddy bottoms from intertidal to beyond the edge of the continental shelf of all oceans. They generally live in crevices or in burrows under rocks. They can grow up to the length of 25-50 cm. Among the edible crustaceans, lobsters are one of the most vulnerable by virtue of their delicacy and higher price they command in the export trade. According to FAO, in the year 2010 alone 2,80,000 tonnes of lobsters caught in world oceans, of which 1,88,000 tonnes (67%) was of true lobsters under the family Nephropidae, 80,000 tonnes (28%) was of spiny lobster (family Palinuridae) and about 10,000 tonnes (4%) was of slipper lobsters (family Scyllaridae). Eight species of spiny lobsters including six shallow water and two deep sea species and two species of slipper or sand lobsters constitute the lobster fishery in India. Lobster catch in India is around 2000-3000 tonnes per annum and most of it is exported frozen, whole cooked or live. Maharashtra and Gujarat are the main lobster fishing states followed by Tamil Nadu. Lobsters weighing 200-300g are best suited for whole cooked product while those weighing over 300 to 500g are in demand for live lobster export. Lobsters belonging to the families Palinuridae, Scyllaridae, Nephropidae and Homaridae are marine forms and exploited in considerable quantities from both the littoral and deep sea areas of the world oceans (Kathirvel *et al*., 2007b).

A total of 90 species of lobsters belonging to the families Thaumastochelidae (2 sp.), Nephropsidae (23 sp.), Polychelidae (1 sp.), Palinuridae (29 sp.), Synaxidae (2 sp.), Scyllaridae (23 sp.), Thalassinidae (1 sp.), Upogebidae (2 sp.) and Callianassidae (8 sp.) are to occur in Indian and Pacific Oceans (Holthuis, 1991). In Indian waters, 33 species belonging to seven families are reported (Table 3).

Though lobster species are widely distributed in Indian coast, major fisheries are located in north-west, south-west and south-east coasts (Radhakrishnan and Manisseri, 2003). Kagwade *et al.* (1991) and Radhakrishnan (1995) observed that north-west coast is rich in lobster resources and it contributes to nearly three quarters of the total lobster landing in India. Palinurid spiny lobster *Panulirus polyphagus* (Herbst) and scyllarid *Thenus orientalis*(Lund) predominate in the fishery along north-west coast (Chhapgar and Deshmukh, 1971). However, as a result of the

Table 2. Distribution of commercially important prawns in Indian coast.

Coast	Maritime State	Species	Genera	Family	Distribution of species in Littoral zone	Distribution of species in Deep sea	Dominant species	Fishery season
North-West	Gujarat Maharashtra	32	12	3	32	1	*Palae montenuipes, Hippolys mataensirostris, Acetes indicus, Metapenaeus affinis, M. kutchensis, Parapenaeop sishardwickii, P. stylifera, Solenocera indicus* and *Penaeus indicus*	April to May & November to December
South -West	Goa Karnataka Kerala	52	21	5	34	18	*Penaeus indicus, Metapenaeus dobsoni, M. affinis, M. monoceros, Parapenaeopsis stylifera* and *Macrobrachium rosebergii*	November to April
North-East	West Bengal Orissa	35	10	2	31	4	*Penaeus indicus, P. monodon, P. semisulcatus, Metapenaeus dobsoni, M. affinis, M. brevicornis* and *Palaemon styliferus*	June to September and November to February
South-West	Andhra Pradesh Tamil Nadu Pondicherry	57	18	5	44	13	*Penaeus indicus, P. monodon, P. semisulcatus, Metapenaeus dobsoni, M. affinis, M. brevicornis* and *Palae monstyliferus*	June to August and November to February
Lakshadweep		10	8	3	5	5	*Penaeus indicus, Metapenaeus dobsoni, M. affinis, M. onoceros, Parapenaeopsisstylifera*	November to April
Andaman & Nicobar Islands		48	20	5	30	18	*Penaeus monodon, P. japanicus, Metapenaeus intermedius,*	November to March

(Jones, 1965; Kathirvelet al., 2007a)

absence of regulatory measures, the lobster fishery collapsed in Maharashtra in 1994 and there was no sign of recovery (Deshmukh, 2001). Since from the initiation of lobster fishery in India during 1968 the landing increased from 1968 to 300 tonnes in 1975 and attained peak of 4075 tonnes in 1985. Later on the lobster landing was declined for nearly 15 years with an annual average catch of 2200 tonnes and further declined to 1389 and 1364 tonnes in 2001 and 2002 respectively (Radhakrishnan *et al*., 2005). However, it is marginally increased to 1546 tonnes in 2012 (CMFRI, 2013).

Crabs

Crabs are decapod crustacean under the order Brachyura. They live in world oceans, freshwater, terrestrial ecosystems of tropical and semitropical regions. Many crab species are habitat specific and thus excellent bio-indicators of habitat health and environmental degradation especially coral reefs and mangroves. Crabs support a sustenance fishery of appreciable importance, although its present status is not comparable with that of those major crustacean fisheries such as prawns and lobsters. The crab fishery is supported by the edible crabs belonging to the families Portunidae,

Table 3. Occurrence of lobsters in Indian waters

Sl. No	Family/Species	Habitat	Depth of Occurrence	Distribution in India	Remark
			Family NEPHROPIDAE		
1	*Acanthocaris tenuimana* Bate, 1888	Muddy	160-1640 m	Lakshadweep Sea	Rare
2	*Nephropsis carpentari* Wood-Mason, 1885	Muddy	200-500 m	Lakshadweep Sea, Vishakapatnam coast in Bay of Bengal	Rare
3	*Nephropsis stewarti* Wood-Mason, 1872	Muddy	17-1060 m	West coast, Tamil Nadu coast, Orissa Coast and A & N Islands	Commercially potential
4	*Nephropsis ensirostris* Alcock, 1901	Sandy or Muddy	580-1160 m	Lakshadweep Sea, Chennai coast, and A & N Islands	Rare
5	*Nephropsis suhmi* Bate, 1888	Muddy	750-1150 m	Lakshadweep Sea	Rare
6	*Nephropsis sulcatea* Macpherson, 1990	Muddy	750-1180 m	Lakshadweep Sea	Rare
7	*Metanephropsis anadamanicus* (Wood-Mason, 1894)	Muddy	250-270 m	Andaman Sea	Rare
			Family POLYCHELIDAE		
8	*Polychaelus tiplops* Heller, 1862	Muddy	400-600m	Andaman Sea	Rare
			Family PALINURIDAE		
9	*Linuparus somniosus* Berry and George, 972	Rocky or Sandy or Muddy	215-370 m	A & N Islands	Commercially potential. Season: December to April
10	*Linuparus andamanensis* Mustafa, 1991	Rocky or Sandy or Muddy	400-415 m	Andaman Islands	Rare
11	*Palinustus waguensis* Kubo, 1963	Sandy or Muddy	72-200 m	South-west coast, South-east coast, and A & N Islands	Commercially potential
12	*Panulirus homarus* (Linnaeus, 1758)	Rocky	1-90 m	East and west coasts, Lakshadweep, and A & N Islands	Commercially exploited. Season: December to March
13	*Panulirus penicillatus* (Olivier, 1791)	Rocky and Coral reef	1-4 m	East and west coasts, Lakshadweep, and A & N Islands	Commercially exploited. Season: December to March

14	*Panulirus longipes* (Milne Edwards, 1868)	Turbid waters in rocky and coral reef areas	1-18 m	East and west coasts, Lakshadweep, and A & N Islands	Commercially exploited. Season: December to March
15	*Panulirus ornatus* (Fabricius, 1798)	Sandy or Muddy bottom of turbid waters	1-8 m	East and west coasts, Lakshadweep, and A & N Islands	Commercially exploited. Season: December to March
16	*Panulirus polyphagus* (Herbst, 1793)	Muddy	3-90 m	East and west coasts, Lakshadweep, and A & N Islands	Commercially exploited
17	*Panulirus versicolor* (Latreille, 1894)	Rocky and coral reefs	1-15 m	East and west coasts, Lakshadweep, and A & N Islands	Commercially exploited. Season: December to February
18	*Puerulus sewelli* Ramadan, 1938	Coarse sand, hard mud and shells	180-1300m	East and west coasts, and A & N Islands	Commercially exploited. Season: December to April
19	*Puerulus angulaltus* (Bate, 1888)	Sandy or Muddy	200-550 m	Nicobar Islands	Occasionally caught
			Family SYNAXIDAE		
20	*Palinurellus wieneckii* (De Man, 1881)	Coral reefs and marine caves	9-27 m	Karwar coast, South-west coast and A & N Islands	Rarely caught
			Family SCYLLARIDAE		
21	*Scyllarides elisabethae* (Ortmann, 1894)	Sandy or Muddy or Rocky	37-380 m	Inshore waters of Vizhinjam, and South-west coast	Rare
22	*Scyllarides tridacnophaga* Holthius, 1967	Rocky and coral reefs	5-112 m	South-east and South west coasts	Occasionally caught
23	*Parribacus antarticus* (Lund, 1793)	Sandy and coral reefs	1-20 m	Lakshadweep and South-east coast	Common
24	*Bathyarctus rubens* (Alcock& Anderson, 1894)	Muddy, rocky and hard stone with fragments of shells	183-732 m	Off Cochin and South west coast	Rare
25	*Scammarctusbatei* (Holthuis, 1946)	Sandy or Muddy	16-489 m	Off Kozhicode, South-west coast and A & N Islands	Rare
26	*Petractus rugosus* (Milne Edwards, 1837)	Sandy or Muddy	20-60 m	East and west coasts, and A & N Islands	Frequently caught in trawl at east and west coasts

27	*Chelarctus cultrifer* (Ortmann 1897)	Sandy and Muddy	35-300 m	East and west coasts, and A & N Islands	Common
28	*Eduarctus martensii* (Pfeffer, 1881)	Sandy or Muddy	6-79 m	East and west coasts, Lakshadweep, and A & N Islands	Most common
29	*Biarctuss ordidus* (Steimpson, 1860)	Sand or mud with shell, corals and sponges	1-40 m	East and west coasts	Most common
30	*Thenus orientalis* (Lund, 1793)	Sandy or Muddy	8-70m	East and west coasts, and A & N Islands	Commercially exploited. Season: December to January
			Family THALASSINIDAE		
31	*Thalassina anomola* (Herbst, 1804)	Muddy, living burrows	1-2 m	East and west coasts, and A & N Islands	Frequently caught
			Family CALLIANASSIDAE		
32	*Callianassa audax* (De Man, 1911)	Muddy	1-4 m	Cannanore coast, and South-west coast	Occasionally caught
33	*Callianassa kraussi* Stebbing, 1900	Muddy, inshore seas and brackish water	1-4 m	Cochin backwaters and South-west coast	Rare
34	*Callianassa maxima* Milne Edwards, 1870	Muddy, inshore seas and brackish water	1-5 m	Kayamkulam Lake in Kerala, South-west coast, Chennai coast, Chilka Lake and East coast	Occasionally caught

(Source: Kathirvel et al., 2007b)

Table 4. Estimated marine crustacean landings (in tonnes) in India from 2008 to 2015.

Crustaceans	2008	2009	2010	2011	2012	2013	2014	2015
Penaeid shrimp	213327	232313	260182	267932	253247	196942	205602	199195
Non-Penaeid shrimp	187173	178504	126997	187061	164951	213474	183405	149101
Lobsters	1974	1968	1715	1761	1546	1410	1568	2003
Crabs	55700	47462	52238	50847	52467	44586	46061	47464
Stomatopods	30532	33109	30149	25250	27613	20650	24266	25694
Total	**488706**	**493356**	**471281**	**532850**	**499824**	**477062**	**460902**	**423457**
Total fish landings*	3207205	3163314	3346658	3820207	3948938	3781868	3745978	3515934
Composition of Crustacean	15.24%	15.60%	14.08%	13.95%	12.65%	7.93%	8.13%	8.3%

*Total fish landings includes pelagic fin fishes,Demersal finfishes and shell fishes

Source: CMFRI Annual reports, 2009-10,2011-12,2012-13, 2013-14, 2014-15, 2015-16.

Calappidae, Xanthidae, Gecarcinidae, Ocypodidae and Grapsidae which are exploited. The crabs under the family Portunidae are considered for seafood export trade and their frozen, canned and live categories are fetching a considerable foreign exchange annually. Crabs make up 20% of all marine crustaceans caught, farmed and consumed worldwide, amounting to 1.5 million tonnes annually. Portunid crab *Portunus trituberculatus* accounts for one fifth of the total followed by *Scylla serrata* yields more than 20,000 tonnes annually (FAO, 2006).

The brachyuran crabs contain 6,793 species in 93 families from world. Compilation of the taxonomical identification of several researchers since 1766 to till date revealed a total of 837 species belonging to 255 genera and 32 families from Indian waters. Of which, 226 species belonging to 130 genera and 39 families have been reported from west coast (Dev Roy, 2013). The brachyuran diversity of Lakshadweep is 182 species under 92 genera and 24 families. Andaman and Nicobar Islands are recorded maximum diversity of crabs in India with 582 species belonging to 204 genera and 30 families (Kathirvel *et al*., 2007c). In Indian waters, 750 species of brachyuran crabs occurring in the littoral and deep sea regains. Some species of crabs are euryhaline which can tolerate wide ranges of salinities migrate into estuaries, backwaters and coastal lakes where they grow fast and support sustenance fishery (Vedavyasa Rao *et al*., 1973). In India, 23 species of crabs belonging to the families Portunidae (13 sp.), Calappidae (5 sp.), Xanthidae (1 sp.), Grapsidae (1 sp.), Ocypodidae (2 sp.) and Gecarcinidae (1 sp.) are commercially important. The catches of commercially important crabs obtained largely from central Maharashtra, south Karnataka, North Kerala and southern Chennai coasts. In addition to these marine areas, the estuaries, and brackish water lakes are known to yield considerable quantities of crabs annually. The estuaries of rivers Ganges, Mahanadi, Godavary, Krishna and Cauvery and brackish water lakes of Chilka and Pulicat on the east coast, and the estuaries of Narmada and Tapi and the backwaters of Kerala on the west coast are important from the point of view of crab production. In India, *Scylla serrata*is the most important species contributing to the fishery. In addition to these species *Portunus (Portunus) pelagicus, P. (Portunus) sanguinolentus* and *Sesarmate tragonum* area also occasionally caught (Vedavyasa Rao *et al*., 1973).

The list of commercially importance species of brachyuran crabs of India (Kathrivel *et al*., 2004c) is given below.

1. *Scylla tranquebarica*
2. *Scylla serrata*
3. *Portuus pelagicus*
4. *Portunus sanguinolentus*
5. *Charybdis (Caharybdis) lucifera*
6. *Charybdis (Caharybdis) feriatus*
7. *Charybdis (Caharybdis) annulata*
8. *Charybdis (Caharybdis) natator*
9. *Charybdis (Caharybdis) granulata*
10. *Charybdis (Goniohellenus) smithii*
11. *Podopthalmus vigil*
12. *Thalamita crenata*
13. *Thalamita danae*
14. *Calappa lophos*
15. *Calappa philargius*
16. *Calappa hepatica*
17. *Calappa japonicas*
18. *Matuta lunaris*
19. *Galeene bispinosa*
20. *Varuna litterata*
21. *Ocyo deceratophthalma*
22. *Ocypo decardimana*
23. *Cardisoma carnifex*

Table 5. Percentage composition of different groups of marine crustacean landings (in tonnes) in India from 2008 to 2012

Crustaceans	2008	2009	2010	2011	2012	2013	2014	2015
Penaeid shrimp	43.66	47.08	55.20	50.28	50.66	41.28	44.61	47.04
Non-penaeid shrimp	38.30	36.18	26.95	35.10	33.00	44.75	39.79	35.21
Lobsters	0.40	0.40	0.38	0.33	0.30	0.30	0.34	0.47
Crabs	11.40	9.63	11.08	9.54	10.49	9.35	10.00	11.21
Stomatopods	6.24	6.71	6.39	4.75	5.55	4.33	5.26	6.07

During the initiation commercial crab fishery in 1966, a quantity of 3.315 tonnes of crabs were caught which is about 4% of the total crustacean fishery production (Vedavyasa Rao *et al*., 1973). Further catches were increased up to 28166 tonnes during 1999-2003, of which 4,045 tonnes exported and earned foreign exchange of Rs.57.5 crores. The estimated catch of brachyuran crabs during 2012 was 52467 tonnes (CMFRI, 2013). The demand has been increasing for live and whole cooked crabs in different Asian countries which has resulted indiscriminate fishing pressure on crabs for heavy exploitation in Indian seas.

Stomatopods

Stomatopods or Mantis shrimp form an important crustacean fishery over the years especially in inshore waters. Among the various species recorded from Indian coasts, *Oratosqullia nepa* is the most common. Other species involved for stomotopod fishery are *Harpiosquillar aphidea, Oratosquilla holoschista* and *Oratosquilla woodmasoni.* Stomatopods are caught along with other crustaceans and fishes in large quantities in shrimp trawls and Dol nets. It is estimated that annual production of this groups ranged from 60000 to 90000 tonnes and it constitutes about 20% of the total crustacean landings. The west coast accounts for more than 90% of this catch (Suseelan, 1996). Around 400 species of stomatopods have currently been described worldwide; all living species are in the suborder Unipeltata. In India as many as 139 species of stomatopods under 26 genera and 4 families were reported (Venkataraman and Wafar, 2005).

Historical data on crustacean landings in India

The decadal average (1950-2015) of crustacean landings in India is given in Fig. 1. Except of 1960-69 period, the decadal landings of crustaceans in India registered a steady increase in the last seven decades. The increasing demand for crustaceans in the international market and expansion of fishing areas coupled with introduction of new technologies facilitated this steady increase during the period.

Crustacean landing in 2008-2015

The crustacean fishery in India is mainly constituted by prawn, lobsters, crabs and stomatopods. Earlier records show that he estimated average landing of marine crustaceans in India was nearly to 80,000 metric tonnes which is about one-tenth of marine fish production (Jones, 1965), of which 97.5% is constituted by prawns. In recent years, crustacean fishery in India has assumed considerable importance in the economy of India. Exports of frozen and canned prawns, frozen and live lobsters have been steadily on the increase earning valuable foreign exchange.During 2008-2015, the maximum catch of 532850 tonnes obtained during 2011 it declined to 423457 in 2015 (Table 4). Percentage composition of crustacean landings,which was highest (15.60%) in 2009 declined to 7.93% in

Table 6. State-wise of landings of marine crustaceans (in tonnes) in India during 2012

Maritime states	Prawn	Lobster	Crab	Stomatopod	Total
Gujarat	1,16,699 (85.05%)	328 (0.28%)	16,618 (12.11%)	3,513 (2.56%)	1,37,158
Maharashtra	81,435 (95.5%)	199 (0.2%)	561 (1%)	5,884 (6.9%)	85,272
Goa	2,314 (58.1%)	-	-	1,663 (41.8%)	3,977
Karnataka	12,824 (44.2%)	-	-	14,249 (49.1%)	28,974
Kerala	44,973 (87.2%)	38 (0.07%)	4,384 (8.5%)	2,141 (4.15%)	51,536
Tamil Nadu	24,041 (38.7%)	5,280 (8.5%)	14,909 (24%)	17,891 (28.8%)	62,121
Andhra Pradesh	29,570 (82.1%)	-	5946 (16.5%)	-	36,000
Odisha	80378 (96.8%)	-	2,192 (2.6%)	-	83,004
West Bengal	7,225 (94.4%)	-	313 (4.1%)	-	7,654

Source: Extracted from CMFRI (2013)

2013. In general the data shows overall decline in crustacean landings over the last decade both in quantity and percentage composition, indicating the gradual depletion of these resources due to over exploitation.

The fishery of penaeid shrimp followed by non-penaeid showed higher values during all five years and they constitute 41.28to 55.20% and 26.95to 44.75% respectively during 2008-2015 (Table 5). Composition of lobster is less than 0.47% in all the eight years. The percentage composition of crabs varied from 9.35 to 11.4, while that of stomatopods from 4.33 to 6.71.

The data on state-wise landings of crustaceans for 2012 indicated that catch was high in Gujarat with 1,37,158 tonnes followed by Maharashtra where it was 85,272 tonnes. Whereas in east coast it shown maximum of 83.004 tonnes in Odisha followed by 62,121 tonnes in Tamil Nadu (Table 6). Among the crustaceans composition of prawn was between 82.1% and 96.8% in Gujarat, Maharashtra, Kerala, Andhra Pradesh, Odisha and West Bengal, while it was less than 58.1% in Goa, Karnataka and Tamil Nadu.

Threats to crustacean diversity

Fishing is essential to the livelihood and food security of 200 million people, especially in the developing world, while one of five people on this planet depends on fish as the primary source of protein (www.un.org/events/tenstories/06/story.asp?storyID=800). According to FAO estimate, over 70% of the world's fish species are either fully exploited or depleted. The dramatic increase of destructive fishing techniques worldwide destroys marine biodiversity and entire ecosystems. FAO also reports that illegal, unreported and unregulated fishing worldwide appears to be increasing as fishermen seek to avoid stricter rulesin many places response to shrinking catches and declines fish stocks. Despite is crucial importance for the survival of humanity; marine biodiversity is in ever-greater danger, with the depletion of fisheries among biggest concerns. India is endowed with a rich diversity of 2934 species of crustaceans, several of them supporting commercial fisheries since ancient times. As many as 150 species of this group form part of the commercial catches either on regular basis or as occasional inclusions (Suseelan, 1996). Though this has augmented the production and export of crustaceans in many folds over the years, the changes in fishing pattern involving destructive innovations of fishing gears, excessive fishing pressure and the multifarious activities causing damages to the natural habitat of crustaceans are potential threats to the biodiversity of this important group.

The intensive fishing pressure for prawn within 50m depth line persistently over the past several years has led most of the conventional fishing grounds of Indian coast to a state of over exploitation. In the year 1991 onwards, the annual shrimp production of India has exceeded far beyond the catchable potential estimated for this depth zone (Suseelan, 1996).It is pointed out that stock assessment of the major component species such as *Metapenaeus monoceros*, *Penaeus stylifera, P. indicus, P. semisulcatus* and *P. mondon* among penaeid prawns and *Acetus indicus*, among non-penaeis has also revealed that the coastal prawn resources in India is being fully exploited and in certain cases over fishing is taking place in alarming dimensions.

The landing of lobsters in India is declining trend due to high export value of the resource. The stocks of *Panulirus homarus* and *P. orantus* in southern Tamil Nadu coast and *P. polyphagus* and *Thenus oriantalis* in Gujarat and Maharashtra coasts faced overfishing (Suseelan, 1996). Excessive removal of berried females in capture fisheries severely hampers the renewable capacity of the stocks. The brachyuran crabs *Scylla serrata* and *Scylla tranquebarica* are fished exclusively in estuarine region. With the development of live crab export, the heavy exploitation on mud crabs in recent years posed dwindling of this resource in brackish waters.

Besides, aquatic pollution such as pesticides, industrial effluents laden heavy metals, municipal and domestic sewages, oils and oil dispersants, dumping of radio-active wastes etc. causes the mortality of crustacean larval forms and affects the growth and survival. In order to augment the wild stock of crustacean resources, it is prerequisite to strictly enforce the restriction of fishing effort, allotment of catch quotas, cod-end mesh regulations for fishing nets, restriction on capturing juveniles from nursery grounds and encouraging sea-ranching of heavily exploited species.

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Conservation status of freshwater decapod crustaceans of India

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Introduction

Decapod crustaceanscomprise an incredibly diverse group of invertebrates with ~15,000 species (De Grave et al. 2009), and significant numbers of taxa described every year. They occur in a wide variety of morphological forms, and are distributed in terrestrial, freshwater, estuarine, marine, as well as sub surface and epigean environments (Magris et al. 2010; Lefébure et al. 2006). Decapod crustaceans are key to healthy functioning of aquatic ecosystems,play critical roles in aquatic food webs (Darwall et al.2012), contribute to global food security and livelihoods (Bondad-Reantaso et al. 2012; Stentiford et al. 2012), and are also used as effective indicators of ecosystem health (Pérez-Losada et al. 2008). Freshwater decapod crustaceans around the world are facing a conservation crisis with 33% of crayfish, 27% of shrimps and 16% of crabsfacing an elevated level of extinction risk; and four species of crayfish and two species of shrimp assessed as extinct, and four species of crayfish and ten species of shrimp considered possibly extinct (De Grave et al. 2015; Richman et al. 2015; Cumberlidge et al. 2009). A wide range of anthropogenic stressors are impacting freshwater crabs and shrimps including agro-based and urban pollution, climate change, invasive species and unmanaged harvests (De Grave et al. 2015; Richman et al. 2015; Cumberlidge et al. 2009) necessitating the need for concerted conservation and management efforts to ensure the continued survival of these aquatic invertebrates.

In this chapter, we provide an overview of the conservation status of freshwater crabs and shrimpsof India, and discuss aspects of their endemism, threats and challenges for conservation.

Taxonomic coverage and Data sources

We focus on decapod crustaceans belonging to the families atyidae, palaemonidae (shrimps), gecarcinucidae and potamidae (freshwater crabs) occurring in the freshwater ecosystems within the political boundaries of India. A list of species (and information on their distribution) were extracted from the IUCN Red List of Threatened Species™ (www.iucnredlist.org), and supplemented with taxon specific literature (Bahir & Yeo 2007; Valarmathi2009; Pati et al. 2012; Radhakrishnan et al. 2012; Raghavan et al. 2015; 2016) including all new species descriptions since the year 2012. Taxonomy and nomenclature follows De Grave and Fransen(2011) and De Grave et al. (2009) for shrimps andBahir & Yeo (2005, 2007) andNg et al. (2008) for crabs. For a discussion on taxonomic uncertainties, and reasons for elimination of several names that appears in previous checklists of shrimps and crabs of India, please see Raghavan et al. (2015). Information on conservation status of species was retrieved from the IUCN Red Listof Threatened Species™available online at www.iucnredlist.org.

Freshwater crabs

Ninety four species of freshwater crabs are known to occur in India (67 within family gecarcinucidae and 27 within family potamidae) of which close to 80% are endemic (Table 1 and 2). Majority of the endemic species are representatives of the family gecarcinucidae (Fig 1), of which several have an extremely narrow range of distribution (including many point endemics).

More than half of all freshwater crabs of India are poorly known and have been assessed as ‘Data Deficient’(DD) in the IUCN Red List (Fig. 2). Although only 3% of India’s freshwater crab species are currently known to be threatened, this is likely to change given the fact that over half of the species are DD, and occur in single location(s)subjected to high levels of anthropogenic stress. A re-assessment of these species, with improved information on their distribution and threats may reveal a higher risk of extinction and listing under a threatened category. Species currently assessed as threatened (*Liotelphusaquadrata*, *Oziothelphusa biloba* and *O. wagrakarowensis*) and 'Near Threatened' (*L. gagei*, *L. laevis* and *Maydelliathelphusaedentula*) are all members of the family gecarcinucidae.

Table 1. List of freshwater crabs belonging to the family gecarcinucidae, their endemism and threat status

Species	Red List Status	Endemism (India)
Arcithelphusacochleariformis	Not Evaluated	Endemic
Barathapeena	Data Deficient	Endemic
Barathapushta	Data Deficient	Endemic
Barytelphusamccanni	Not Evaluated	Endemic
Barythelphusacunicularis	Least Concern	Endemic
Barythelphusaguerini	Least Concern	Endemic
Barythelphusajacquemontii	Least Concern	Endemic
Cylindrothelphusasteniops	Least Concern	Endemic
Gecarcinucusedwardsi	Data Deficient	Endemic
Gecarcinucusjaquemontii	Least Concern	Endemic
Ghatianaatropurpurea	Not Evaluated	Endemic
Ghatianaaurantiaca	Not Evaluated	Endemic
Ghatianasplendida	Not Evaluated	Endemic
Ghatiana hyacintha	Not Evaluated	Endemic
Globitelphusabakeri	Data Deficient	Endemic
Globitelphusacylindra	Data Deficient	Endemic
Globitelphusapistorica	Data Deficient	Endemic
Globitelphusaplanifrons	Data Deficient	Endemic
Gubernatorianaalcocki	Not Evaluated	Endemic
Gubernatorianabasalticola	Not Evaluated	Endemic
Gubernatorianaescheri	Data Deficient	Endemic
Gubernatorianagubernatoris	Data Deficient	Endemic
Gubernatorianapilosipes	Data Deficient	Endemic
Gubernatorianathackerayi	Not Evaluated	Endemic
Gubernatorianatriangulus	Not Evaluated	Endemic
Gubernatorianawaghi	Not Evaluated	Endemic

Inglethelphusafronto	Data Deficient	Endemic
Lamella lamellifrons	Least Concern	Endemic
Liotelphusacampestris	Data Deficient	Endemic
Liotelphusagagei	Near Threatened	
Liotelphusalaevis	Near Threatened	
Liotelphusaquadrata	Vulnerable	Endemic
Maydelliathelphusaedentula	Near Threatened	
Maydelliathelphusafalcidigitis	Data Deficient	Endemic
Maydelliathelphusaharpax	Least Concern	
Maydelliathelphusalugubris	Least Concern	
Maydelliathelphusamasoniana	Least Concern	Endemic
Oziotelphusaganjamensis	Not Evaluated	Endemic
Oziothelphusaaurantia	Data Deficient	Endemic
Oziothelphusa biloba	Vulnerable	Endemic
Oziothelphusabouvieri	Data Deficient	Endemic
Oziothelphusakerala	Data Deficient	Endemic
Oziothelphusawagrakarowensis	Vulnerable	Endemic
Pilartaanuka	Data Deficient	Endemic
Sartorianaspinigera	Least Concern	
Sartorianatrilobata	Data Deficient	Endemic
Snahaaruna	Data Deficient	Endemic
Snahaescheri	Data Deficient	Endemic
Spiralothelphusagibberosa	Not Evaluated	Endemic
Spiralothelphusahydrodroma	Least Concern	Endemic
Travancorianacharu	Data Deficient	Endemic
Travancorianaconvexa	Least Concern	Endemic
Travancorianagranulata	Not Evaluated	Endemic
Travancorianakuleera	Data Deficient	Endemic
Travancoriananapaea	Data Deficient	Endemic
Travancorianapollicaris	Data Deficient	Endemic
Travancorianaschirnerae	Least Concern	Endemic
Vanniashini	Data Deficient	Endemic
Vannideepta	Data Deficient	Endemic

Vannigiri	Data Deficient	Endemic
Vannimalabarica	Data Deficient	Endemic
Vanninilgiriensis	Data Deficient	Endemic
Vannipusilla	Data Deficient	Endemic
Vannitravancorica	Data Deficient	Endemic
Vela carli	Data Deficient	Endemic
Vela pulvinata	Data Deficient	Endemic
Vela virupa	Data Deficient	Endemic

Table 2. List of freshwater crabs belonging to the family potamidae, their endemism and threat status

Species	Red List Status	Endemism (India)
Acanthopotamonfungosum	Data Deficient	
Acanthopotamonmartensi	Least Concern	Endemic (Possibly in Myanmar)
Acanthopotamonpanningi	Data Deficient	Endemic
Alcomonlophocarpus	Least Concern	Endemic
Alcomonsuperciliosum	Data Deficient	Endemic (Possibly in Myanmar)
Himalayapotamonambivium	Data Deficient	Endemic
Himalayapotamonatkinsonianum	Least Concern	
Himalayapotamonbabaulti	Data Deficient	Endemic
Himalayapotamonemphyseteum	Least Concern	
Himalayapotamonkausalis	Data Deficient	Endemic
Himalayapotamonkoolooense	Least Concern	
Himalayapotamonmarinelli	Data Deficient	Endemic
Himalayapotamonmonticola	Data Deficient	Endemic
Indochinamonasperatum	Data Deficient	Endemic
Indochinamonbeieri	Data Deficient	
Indochinamonedwardsi	Data Deficient	
Indochinamonmanipurense	Data Deficient	Endemic
Lobothelphusafloccosa	Data Deficient	
Lobothelphusawoodmasoni	Least Concern	Endemic
Potamiscusannandalii	Data Deficient	Endemic
Potamiscusdecourcyi	Data Deficient	Endemic
Potamiscuspealianus	Data Deficient	

Potamiscustumidulum	Least Concern	
Potamongedrosianum	Least Concern	
Quadramonaborense	Data Deficient	Endemic
Tiwaripotamonaustenianum	Data Deficient	Endemic
Trichopotamonsikkimensis	Least Concern	

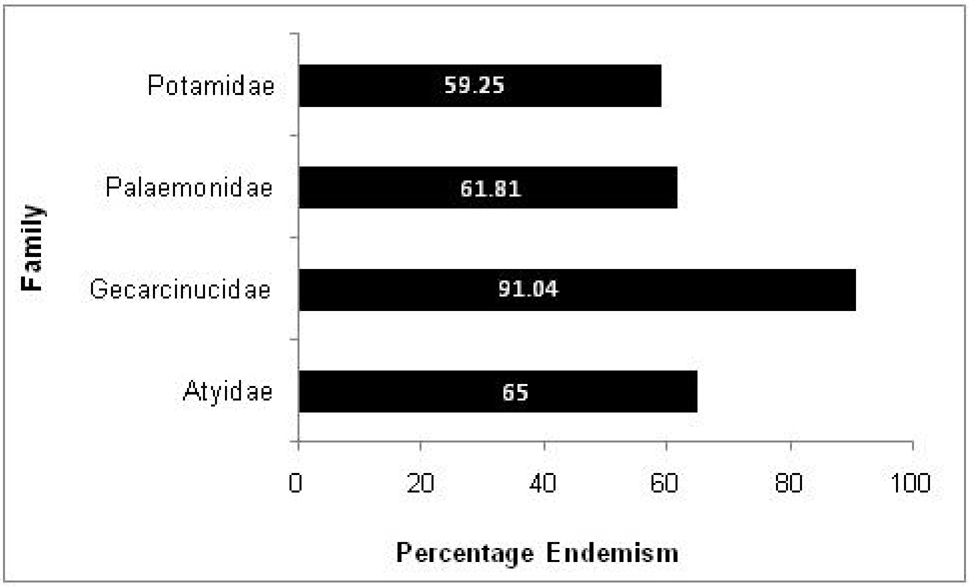

Fig. 1. Percentage endemism within various families of freshwater crabs and shrimps in India

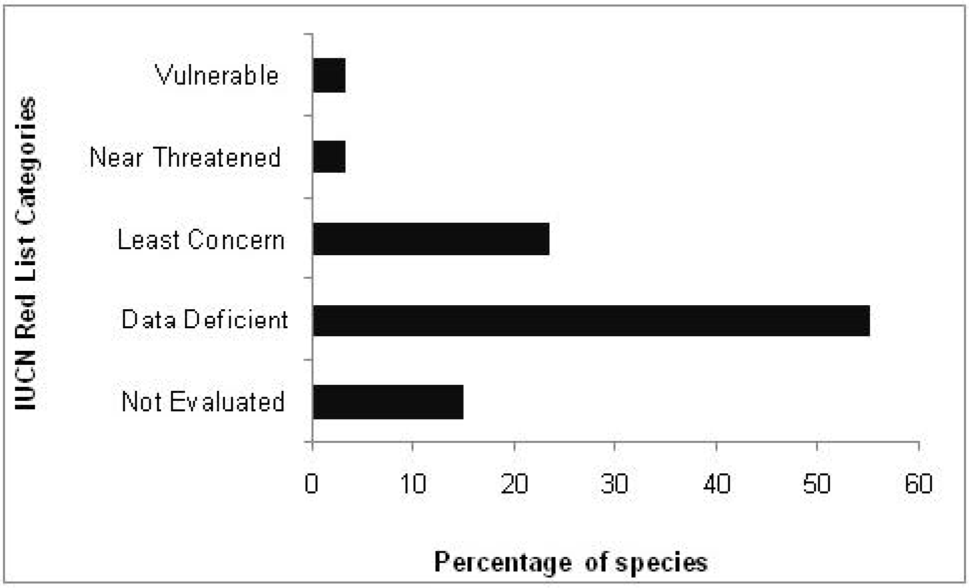

Fig. 2. Percentage distribution of freshwater crab taxa of India in the various IUCN Red List Categories

Freshwater shrimps

Seventy one species and four sub-species of shrimps belonging to two families, atyidae (19 species and one sub species) and palaemonidae (52 species and three sub species) occur in India of which 66% are endemic(Table 3 and 4). Family atyidae is represented by a single genus,*Caridina*while palaemonidae is represented by three genera, *Arachnochium*, *Leptocarpus* and *Macrobrachium*. Species of the genus *Macrobrachium* comprises 90% of the diversity of family palaemonidae. Only two species,*Arachnochiumkulsiense*(Endangered) and *Macrobrachiumgurudeve* (Vulnerable) have been assessed as threatened while 62% of the shrimp fauna (47 species) is assessed as 'Least Concern' and29% (22 species)as 'Data Deficient' (DD) (Fig. 3). Higher percentage of DD species are found within the family atyidae (40%) compared to palaemonidae (25%).

Table 3. List of freshwater shrimps belonging to the family atyidae, their endemism and threat status

Species	Red List Status	Endemism (India)
Caridinababaultibabaulti	Least Concern	Endemic
Caridinabrachydactyla	Least Concern	
Caridinacarli	Data Deficient	Endemic
Caridinachauhani	Least Concern	Endemic
Caridinaexcavata	Data Deficient	Endemic
Caridinagracilirostris	Least Concern	
Caridinagurneyi	Data Deficient	Endemic
Caridinahodgarti	Data Deficient	Endemic
Caridinajalihali	Least Concern	Endemic
Caridinakempi	Least Concern	Endemic
Caridinamathiassi	Data Deficient	Endemic
Caridinanatarajani	Least Concern	Endemic
Caridinapanikkari	Data Deficient	Endemic
Caridinaprashadi	Least Concern	
Caridinapropinqua	Least Concern	
Caridinarajadhari	Data Deficient	Endemic
Caridinashenoyi	Least Concern	
Caridinasimoni	Least Concern	
Caridinatypus	Least Concern	
Caridinavithuraensis	Data Deficient	Endemic

Table 4. List of freshwater shrimps belonging to the family palaemonidae, their endemism and threat status

Species	Red List Status	Endemism (India)
Arachnochiumkulsiense	Endangered	Endemic
Arachnochiummirabile	Least Concern	
Leptocarpusfluminicola	Least Concern	
Leptocarpuskempi	Data Deficient	Endemic
Leptocarpuspotamiscus	Least Concern	
Macrobrachiumabrahami	Not Evaluated	Endemic
Macrobrachiumaemulumkeralauni	Not Evaluated	Endemic
Macrobrachiumagwi	Data Deficient	Endemic
Macrobrachiumaltifrons	Least Concern	
Macrobrachiumassamense	Least Concern	
Macrobrachiumaustrale	Least Concern	
Macrobrachiumbanjarae	Data Deficient	Endemic
Macrobrachiumbirmanicum	Least Concern	
Macrobrachiumbombajense	Least Concern	Endemic
Macrobrachiumcanarae	Data Deficient	Endemic
Macrobrachiumcavernicola	Least Concern	Endemic
Macrobrachiumdayanum	Least Concern	
Macrobrachiumdolichodactylus	Least Concern	
Macrobrachiumelatum	Data Deficient	Endemic
Macrobrachiumequidens	Least Concern	
Macrobrachiumgangeticum	Least Concern	Endemic
Macrobrachiumgurudeve	Vulnerable	Endemic
Macrobrachiumhendersodayanum	Least Concern	Endemic
Macrobrachiumhendersoni	Least Concern	
Macrobrachiumidae	Least Concern	
Macrobrachiumidellageorgii	Least Concern	Endemic
Macrobrachiumindianum	Not Evaluated	Endemic
Macrobrachiumindicum	Least Concern	Endemic
Macrobrachiumjayasreei	Data Deficient	Endemic
Macrobrachiumkistnense	Least Concern	Endemic
Macrobrachiumkulkarnii	Data Deficient	Endemic
Macrobrachiumkunjuramani	Data Deficient	Endemic
Macrobrachiumlamarrei	Least Concern	Endemic
Macrobrachiumlanatum	Least Concern	
Macrobrachiumlatidactylus	Least Concern	
Macrobrachiumlatimanus	Least Concern	

Macrobrachiummadhusoodani	Data Deficient	Endemic
Macrobrachiummalcolmsoniimalcolmsonii	Least Concern	Endemic
Macrobrachiumnobilii	Least Concern	Endemic
Macrobrachiumpeguense	Least Concern	
Macrobrachiumplatyrostris	Least Concern	
Macrobrachiumprabhakarani	Data Deficient	Endemic
Macrobrachiumrosenbergii	Least Concern	
Macrobrachium rude	Least Concern	
Macrobrachiumsankollii	Least Concern	Endemic
Macrobrachiumscabriculum	Least Concern	
Macrobrachiumsiwalikense	Least Concern	Endemic
Macrobrachiumsnpurii	Not Evaluated	Endemic
Macrobrachium striatum	Data Deficient	Endemic
Macrobrachiumsulcatus	Least Concern	Endemic
Macrobrachiumtiwarii	Least Concern	Endemic
Macrobrachiumunikarnatakae	Data Deficient	Endemic
Macrobrachiumveliense	Data Deficient	Endemic
Macrobrachiumvillosimanus	Least Concern	
Macrobrachiumwalvanense	Data Deficient	Endemic

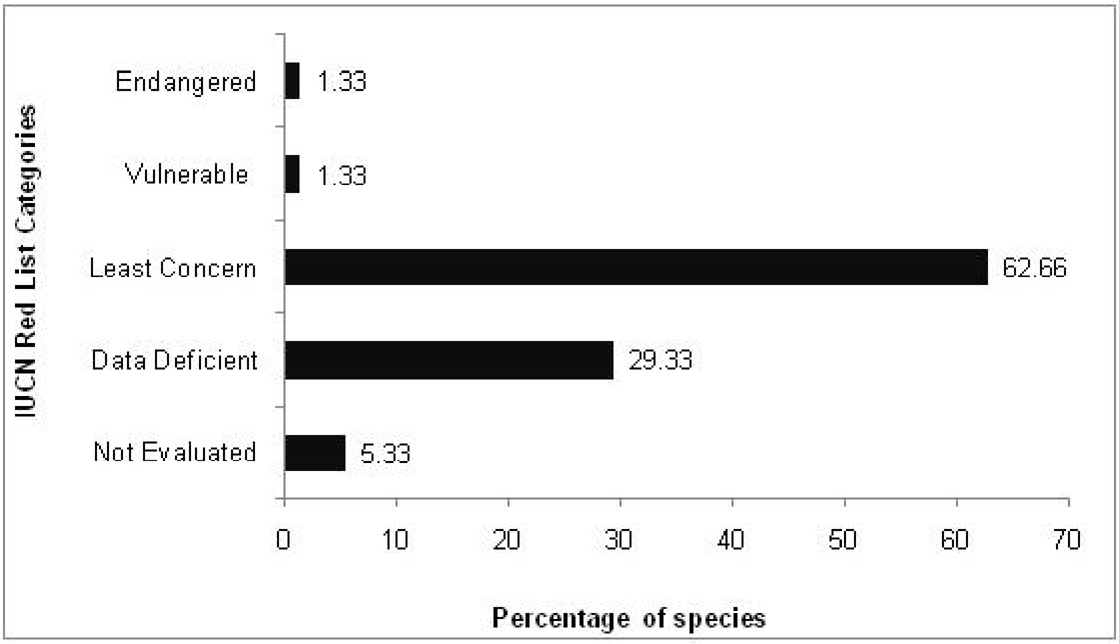

Fig. 3. Percentage distribution of freshwater shrimp taxa of India in the various IUCN Red List Categories

Threats

A range of anthropogenic stressors are impacting the survival of freshwater crabs and shrimps in India. Of prime concern is loss of habitat as a result of increasing urbanization, industrial development and agriculture (see for e.g. Cumberlidge2008; Esser&Cumberlidge2008), and pervasive activities such as sand mining (De Grave & Klotz 2013).

Due to their restricted dispersal abilities and stenotopic habits many freshwater crab specieshave a narrow distribution range and some are point endemics(Yeo et al.2008). Freshwater crabs require pristine water conditions to survive (Yeo et al. 2008)and are extremely sensitive to polluted or silted waters resulting in mortalities when exposed to unfavourable conditions (Bahir et al.2005). This is also the case with freshwater shrimps.

Asian atyid and palaemonid shrimps are becoming increasingly popular in the aquarium pet trade (De Grave et al.2008) More than 600,000 individual freshwater shrimp were exported from India between the years 2005 and 2012 (Raghavan et al. 2015). *Arachnochiumkulsiense*, an endemic species of shrimp of the Kulsi catchment in Assam (North East India) is assessed as 'Endangered', but is harvested for the aquarium trade (De Grave & Klotz 2013).

Conservation

No specific conservation actions are in place to protect freshwater crabs and shrimps in India. Both these groups are poorly known, and there is very little awareness on the importance and need for conservation of these aquatic invertebrates. For example, in the Western Ghats region, 40 sites have been considered as priorities for the conservation of freshwater crab and shrimp taxa (see Raghavan et al. 2015), but very little site based conservation actions are in place or have been planned. Although many Data Deficient species are neglected in conservationprogrammes, they are known to have the potentialto become extinct if they remain unmonitored (Bland et al. 2015). The high levels of data deficiency with regard to the status of freshwater crabs and shrimps in India is a cause for concern given the fact that many species are point endemics subjected to increasing levels of habitat loss and associated anthropogenic pressures.

Research Directions

The aquatic invertebrate fauna of India is beset by the Linnean, Wallacean and Darwinian shortfalls. Unlike fish andamphibians, there have been very few attempts at understanding the diversity and distribution of freshwater decapods in India. Even in terrestrial protected areas of the country from where several studies on fish diversity are available, there is a paucity of data on crabs and shrimps (see Raghavan et al. 2016). Such studies are extremely important as they may result not only in thedescription of several new species, but also contribute to improved knowledge on the distribution range of Data Deficient species(Raghavan et al. 2016). Many species of freshwater crabs and shrimps are only known from their type descriptions and there is absolutely no information on their life history, ecology, population status or location-specific threats. These are critical knowledge gaps hindering the development of on-ground conservation strategies and action plans. Lastly, there is an acute need to overcome the taxonomic impediment with regard to freshwater decapods. For example, the taxonomy of freshwater shrimps is plagued by several uncertainties (see Raghavan et al. 2015 for a discussion) and unless these are cleared, conservation assessments and actions cannot progress at a fast pace.

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TAXONOMY RESEARCH ZOOLOGICAL SURVEY OF INDIA

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Introduction

Kolkata is the cultural capital of India. It is often referred as the cultural and educational hub of India because of not only its rich arts, music and dance but also its historical, cultural, and spiritual attractions. The city has many fascinating centres of attraction, and the Indian Museum, Kolkata is one among them. The Museum is fascinating because of its heritage collections of geological, biological and archaeological exhibits and artefact which bear the stamps of rich history and culture. Museums have historically been centers of education, entertainment and amusements for the public. In the Indian Museum there are plenty of materials as priceless collections to see and learn as part of the public entertainment whether you are a first-time casual visitor or a regular one. Zoological Galleries of the Museum, for example, display curious and amazing exhibits and artefacts of zoological specimens that constitute an integral part of the Natural History Collection of the Indian Museum.

Sir William Jones' tomb

Natural Heritage Collections in Indian Museum

Science of preservation and maintenance of Natural History Collection today is no less prone to criticism and animosities. However, the historical perspective of the Natural History collections of major museum like Indian Museum, Kolkata is often a refreshing experience.

As regards the heritage collection of the Indian Museum, we are much indebted to the British naturalists, archaeologists, bio-geographers and the like. They were dedicated people of the Victorian Era, who were fascinated with the bizarre world around them and anxious to explore it. There were many to whom India still owes its gratitude. The bewildering array of heritage collections of geological, zoological and archaeological exhibits and artefacts what we are seeing today in the Zoological Galleries of the Indian Museum are the product of the relentless pursuit of hobby of exploration and collection by the British pioneers in the formative years of the Museum.

As for the collections in the Zoological Galleries, the pioneers of the British Indian Empire collected curious specimens and artefacts of fauna from different parts of Asia, and as well got the collections in exchange with famous Museums in the world. They had devoted their education and interests to good use of knowing the Nature and its enormous bounty of biological wealth. Given their great contributions, one has to admire their self-motivated purpose and enormous capacity for hard work. They showed determination that well matched their intellectual abilities. They paved the way for a later professional class that proved efficient, but which in retrospect seems to have lacked as much dedication and sheer grit of the earlier pioneers.

Asiatic Society of Bengal and Zoological Survey of India

Sir William Jones in 1784 founded the Asiatic Society of Bengal or, as it was then called, 'Asiatic Society', whose bounds of investigation formed

the geographical limits of Asia. Its aim was, according to Sir William Jones: "to enquire within this geographical limit whatever is performed by man or produced by nature." His vision encompassed the entire range of human knowledge and splendour of nature.

Serious zoological investigations were undertaken in the country in the last quarter of the 18th century. The Asiatic Society of Bengal was the only organization of any importance in India at that time. Its zoological collections had a vital bearing on the Indian Museum with the precious heritage collections in the zoological galleries. The Asiatic Society started collecting zoological and geological specimens since 1796. As part of its mission, it had accepted zoological specimens for identification and report or for safe custody. The increasing collections impelled the Society to have its own building and establish subsequently a museum, which was finally achieved by setting up a museum in 1814. Dr. Nathaniel Wallich was the first Superintendent of the "Museum of the Asiatic Society" and, as well, the in-charge of the Natural History collections, including Geological and Zoological specimens, exhibits and artefacts. In 1914, the Trustees of the Indian Museum published 'The Indian Museum 1814-1014' in commemoration of the hundredth anniversary of the foundation of the Asiatic Society's Museum, which subsequently developed into the Indian Museum. This volume records the growth of the Natural History collections since the foundation of the Museum. It contains a mine of information about the Museum's affairs and many other minutiae of its existence. It provides a fair presentation of the formation of what has become the largest natural history collection in Asia protected and maintained in the Indian Museum, Kolkata.

Zoological Survey of India and Indian Museum

While Indian Museum Authority—the Board of Trustees of the Museum—is the custodian of the Zoological Galleries of the Indian Museum, the Zoological Survey of India is the guardian of the innumerable collection of zoological exhibits and artefacts in the museum. The history and progress of Zoological Survey of India (ZSI) is an integral chapter in the historical development of the Indian Museum itself.

The history of ZSI begins from the days of the Asiatic Society of Bengal, founded by Sir William Jones in 1784. ZSI's establishment was in fact a fulfilment of the dream of Sir William Jones, the founder of the Asiatic Society of Bengal. It was only a natural consequence of the events that the Asiatic Society should become a stronghold of the development of zoological studies. The Asiatic Society of Bengal was the mother institution not only to the Indian Museum (1875) but also to the institutions like the Zoological Survey of India and the Geological Survey of India.

Although the Zoological Survey of India was officially borne only in 1916, its genesis in reality had taken place in 1875 with the opening of the Indian Museum because it existed and developed as it were in embryo for many long years before it was officially brought to birth. The new museum on its inception comprised only three sections:

the Zoological, the Archaeological and the Geological.

The zoological collections of the Asiatic Society of Bengal had formally been handed over to the Board of Trustees of the Indian Museum in 1875, and the collections became the part of the Zoological Section of the Museum. The Section contained the preserved comprehensive zoological collections from India and other countries in Asia.

The Zoological Section of the Museum during the period from 1875 to 1916 steadily expanded, growing to the greatest collection of Natural History in Asia. By the dedicated activity and care of the Curators of the Asiatic Society of Bengal and the Superintendents of the Indian Museum, *viz.*, McClelland, Blyth, John Anderson, James Woodmason, Alfred William Alcock and finally Thomas Nelson Annandale and his colleagues, the museum became richly endowed with a magnificent collection of animals, especially of the larger vertebrate groups. They had expended too much in the systematic exchange of specimens with museums throughout the world enriching the museum collections. Further additions of both land and aquatic fauna to the valuable collections came through during several political and military expeditions, including a number of collections purchased, notably those of Francis Day's Indian Fishes, of Lionel de Niceville's butterflies, of Dudgeon and Green's moths, of van de Poll's beetles and of Godwin Austen's molluscs.

Within the Indian Museum there were many who perceived zoology as foreign to its purpose. However, there were several who realized that if zoology was to play the role the age called for, it must be freed from the constricting tradition of classicism, literature and the arts. This realization grew into a decision. The Zoological Gallery at the Asiatic Society Museum under the care and charge of Dr. Nathaniel Wallich served the impetus for the formation of the Zoological Survey of India, which was later born as an independent organization and inaugurated on 1st July, 1916. Its formal constitution in all essential features was a product of evolution and growth. In this context, it would be unjust to forget two facts. First, it was the Board of Trustees of the Indian Museum which had put forward its proposal for the recognition of the Zoological Survey of India in ignorance that the then Government had already under consideration the formation of a zoological department. Second, the development that placed Zoological Section of the Indian Museum in a position to claim its recognition was due to the scientific work of a succession of naturalists, who had laboured in official obscurity for nearly many decades. The pioneers through their investigations had been preparing the road along which morphologists, biologists, entomologists and ichthyologists may travel in the future.

Dr. Thomas Nelson Annandale, who joined the Indian Museum as Deputy Superintendent in 1904, and later as the Superintendent in 1907, after strenuous years-old-struggle, achieved his aim in establishing the Zoological Survey of India in 1916. He became the Survey's founder director and continued till his premature death in April 1924. Dr. Annandale was Honorary Secretary to

the Trustees of the Indian Museum for several years; he was also the President of the Asiatic Society of Bengal in 1923.

The Imperial Department under the title 'Zoological Survey of India' was primarily concerned with zoological investigation and exercise such advisory functions as may be assigned to it by the government. The Survey was to act *inter alia* as the guardian of the 'Standard Zoological Collections of the Indian Empire, and look after and maintain the Zoological Galleries of the Indian Museum. The Survey acquired the zoological collections of more than a century old from the former museum of the Asiatic Society of Bengal and the Zoological Section of the Indian Museum (1814-1875) in Calcutta. Zoological Survey of India thus became the custodian of the collections of zoological specimens of the Indian subcontinent, stocking and safeguarding the collections from India, Sri Lanka, Myanmar, Pakistan, Bangladesh, Nepal and Bhutan.

The United Kingdom tried to carry all the zoological specimens to British Museum—despite having already with them a huge Indian collection—staking their claim that these collections were from the erstwhile 'British Indian Empire'. Britain was of the view that the infrastructure of the newly born ZSI, and such institutes of the other countries in the subcontinent, will not be able to care, preserve and maintain the hundreds of thousands of zoological specimens preserved dry and in spirit/ alcohol or formalin.

During Dr. S. L. Hora's period the faunal collections became intense. By virtue of his position, he was the Advisor, on zoological matters, to the honourable First Prime Minister of India, Late, Pt. Jawaharlal Nehru. To combat the claim and right for the specimens by the other countries, Dr. Hora was able to convince the Govt. of India to declare the ZSI collections as "National Zoological Collection". Dr. Hora submitted a proposal to the Govt. of India, Ministry of Scientific Research and Cultural Affairs to construct the 'Fire-Proof Spirit Building within the Indian Museum Campus. The building was envisaged to be made fire-proof, acting as a fire-resisting unit, so that all the spirit-preserved specimens would remain safe and protected. This move for constructing the ZSI's own building for such a purpose was made during a period when the financial crisis of the Govt. was very acute. ZSI then had been functioning from hired accommodations, scattered at a few places in Calcutta.

The establishment of a permanent building as a proposal for reorganization and expansion of a Zoological Survey had been suggested and recommended by Lt-Col. R. B. Seymour Sewell, former Director of the Survey (England) as requested by the then Govt. of India, in the year 1945. It was a post war development plan proposed by him shortly after the Second World War was over. He submitted the proposal in the form of a memorandum for the gradual reorganization of the Survey. The important items in the scheme included, albeit other things, a plan for a fire-proof building for the Survey at a suitable place.

During the First Five Year Plan (1951-52 to 1955-56), it became essential for the Government to seriously grapple the question of the reconstruction, growth and development of the Zoological Survey of India. After Dr. Hora, who died in harness on 8th December, 1955, Dr. Mithan Lal Roonwal was appointed Director of the Survey. Dr. Roonwal pursued the matter with the Government of India. During the Third Five Year Plan (1961-62 to 1965-66), the Govt. of India in view of the biological importance of the collections, recognized the same as the "National Zoological Collection" through a gazette notification dated the 11th July, 1964.

The need for finding better accommodation for the department's rapidly increasing collections became urgent and imperative. By 1964, the Fire Proof Spirit Building (FPSB) in the Indian Museum became a reality and ready for occupation. But only three of the six floors of the newly built FPSB, Kolkata, were handed over

to the Zoological Survey of India for its occupation in 1965, and the remaining floors were occupied by Anthropological Survey of India. The Freshwater and Marine Fish Sections, Amphibia Section, Reptilia Section, Crustacea Section, General Non-Chordata Section, and Museum and Taxidermy Section of the Survey started functioning in FPSB. The shifting of these scientific sections, especially the Museum and Taxidermy Section in the ground floor of the FPS Building made it much easier for the Survey to look after the care, preservation and maintenance of the animal-specimen exhibits and artefacts of the Zoological Galleries of the Indian Museum.

Zoological Public Galleries

The maintenance and development of the Zoological Public Galleries of the Indian Museum in Kolkata is one of the important functions of the Survey. These galleries are for the entertainment and education of the public, through display of attractive exhibition-series to stimulate and broaden the minds of those who are not engaged in scholarly research. These galleries open the Book of Nature to the masses. The Museum and Taxidermy Section of the Survey undertakes this work.

In the earlier years, the development of the Indian Museum was intimately bound up with that of the Natural History Section of the Museum. The various superintendents paid special attention to the collections of Natural History, and these were arranged and displayed in large public galleries according to the ideas then in vogue. However, the idea of the utilization of the Museum's collection for the purpose of display and popular education in the Indian Museum was not unfortunately developed to the same extent as the scientific utilization of these collections. The zoological gallery in the Indian Museum was throughout its history facing constraints of inadequate funds to display its faunal exhibits and artefacts in a manner worthy of a national museum.

In the Zoological Galleries of the Indian Museum, the faunal specimens, exhibits and artefacts have been artistically designed and arranged to illustrate the zoology of the Indian subcontinent. Six galleries, cared and maintained by ZSI, are currently functioning in the Indian Museum: one each for Animal Ecology/Ecosystem, Mammals, Birds, Reptiles, Amphibians, and Fishes. The Insect Gallery that was there earlier has been temporarily closed for redevelopment.

The collections of the Zoological Galleries are representatives of the various classes of animals found in Asia particularly in India. However, in order to make the survey of the animal kingdom reasonably complete, several foreign animals are also exhibited. The magnificent display of many priceless exhibits as horns, large mammals, skeletons, etc., is mainly due to the brilliant expertise and legendary craftsmanship of taxidermists of the Survey of the earlier years. It has always been the endeavour of the Survey to arrange the public galleries as effectively as those of modern museums of developed countries.

The value and importance of Natural History collections

The Natural History Museums as places only for public entertainment is no longer considered a pragmatic vision. They are considered as knowledge bank for the future generations and centres of learning. The collection of zoological exhibits in a Natural History Museum like the Indian Museum, Kolkata, reflects historical and present-day patterns of biological diversity. Museum specimens form the basis for research on evolution, speciation, and distribution. They provide basic information on natural and life history traits of animals and important baseline for studies of conservation. A physical specimen can provide a wealth of information, including extraction of DNA samples.

Natural History specimens with data are physical snapshots of species or community evolved in time and space. It is this physical record that makes museum collections so valuable. It is expected that the priceless collection of exhibits and artefacts displayed in the Zoological Galleries of the Indian Museum by the Zoological Survey

of India has been able to bring about the awareness to the public about the rare or endangered and wonderful species conserved for the present and future generations. It is a gratifying recognition to the Survey for the service to the nation it has been rendering since its inception nearly one Century ago.

First phase (1916 – 1930)

The Zoological Survey of India commenced its work with a staff of four scientific officers under the stewardship of Dr. Thomas Nelson Annandale as its first Director.

Dr. Annandale was a brilliant scientist and a man of exceptional ability. He was not a museum naturalist but a lover of animals, and he imparted a live interest to every creature about which he discoursed. His attachment to the department gave it life, whether in science or in a wider public interest. His own research contributions were varied and covered practically all groups of animals. Dr. Annandale not only organised the department on a sound footing, but also established research traditions of the highest order and trained officers which achieved international reputation later on.

The work of the Survey in the early years was primarily exploratory – an attempt to ascertain the general characters of the fauna and types of environment. This was supplemented by detailed taxonomic work on a few selected groups of animals in which members of the staff happened to be specialists, such as in Decapod Crustacea, fishes and sponges. During these early years Dr. B.L. Chaudhuri, Assistant Superintendent published several good ichthyological papers, notably on the fishes of the Ganga and of the Chilika Lake (Odisha).

In 1920 the post of Surgeon – Naturalist, Marine Survey of India, was transferred to the Zoological Survey of India, and consequently Major R.B. Seymour Sewell became an additional member of the Zoological Survey with the rank of Superintendent.

Field work was considered one of the most important duties of the department and thus definite programmes of work were formulated which were carried out over a series of years. A commencement was made, however, a few years earlier by investigations into the lake fauna of Asia; the survey of the Chilika Lake was elaborate and a complete volume of the *Memoirs* was devoted to its results. The first definite survey of the newly established Zoological Survey could be cited as the one undertaken at the request of the medical authorities in India. As the war of 1914-18 drew to its close, the Government became anxious lest the disease schitosomiasis, hitherto unknown in India, might be introduced into the country by Indian soldiers returning from the Middle East. A survey of the Indian freshwater molluscs with a view to investigating the possibility of their acting as vectors of human schistosomaiasis, was undertaken. The materials that were collected in the course of the survey formed the subject of a series of reports on various families of molluscs. As a result of these studies, a knowledge of the systematics, distributions and mutual relationships of the freshwater molluscs of India became available. Perhaps the most interesting survey in the early years was of the Siju Cave in the Garo Hills (Meghalaya) in 1922, the results on which were published in volume 26 of the Records and are of greatest importance in theoretical zoology, specially in cave-dwelling organisms.

Dr. Annandale was away on leave to England for about a year during 1920-21 and in his absence Dr. Stanley Wells Kemp acted as Director. Dr. Kemp's genial personality won him many friends, and the esteem in which he was held by the public and the Government was of immense value to the Survey. He was a zealous and enthusiastic student of natural history, and worked with amazing rapidity. By diligence, thoroughness and industry he worked up. He had the power to convert his conception into accomplished reality. His period of office is notable for the preliminary arrangements ge made for the establishment of a Marine Biological Station at Port Blair in the Andaman Island which, however, did not materialise. Owing to Dr. Annandale's premature death in April 1924, Dr. Kemp again officiated as Director of the Survey but six weeks later he retired on 1st June, 1924 to take up his appointment as the first Director of Research of the *Discovery Investigations*. On Dr. Kemp's retirement, the control of the Survey devolved on the next senior officer, Dr. Baini Prasad, who performed the duties of the Director until July 1925 when Major Robert Beresford Seymour Sewell was appointed to succeed Dr. Annandale.

Major Sewell guided the Survey with the same zeal and thoroughness which marked his scientific researchers. His gift for organisation and meticulous attention to detail not only benefitted the Survey as a whole, but also contributed substantially to the training of the staff. No work was too laborious, too great or too difficult for him.

Zoological Survey of India at 'Kaiser Castle', Benaras (Varanasi), 1942 - 48

The outbreak of the Second World War in this sector in December 1941 posed a threat to the safety of the nation's zoological collections which had been housed in the Indian Museum, Calcutta. It was, therefore, decided by the Government of India to evacuate all primary Type-material and Class I exhibits to the Forest Research Institute at Dehra Dun, and the rest of the vast collections/ library and activities were transferred to Benaras (Uttar Pradesh). The transfer of the Survey's collection and offices to Benaras was completed in a remarkably short time, with comparatively little damage to the collections and 'Kaiser Castle', Benaras Cantt., became the temporary headquarters of the Zoological Survey of India with effect from the 11th May, 1942. Throughout the war and for about three years after its end, the Survey remained at Benaras.

Kaiser Castle lies on one bank: of the R. Varuna, a tributary of the Ganga. It is a large building, or rather a number of semi-detached and detached buildings, in its own compound. The spirit collections of the Survey were stored in a series of rooms and also in the basement in a separate block in the Kaiser Castle. The dry collections of the Entomology Section were stored in another separate building. In the main building were located, among others, the offices, laboratories, library and most of the dry collections, excluding insects.

In September 1943, the R. Varuna flooded, entering the compound of the Castle on the 26th and rising to about a metre above plinth level the following day. In the underground cellars, where 42 racks contained bottles of fishes, the flood water remained at ceiling height for two days and caused chaos. The floods began to recede on the 28th and by the 29th most of the rooms were more or less dry, though the underground cellars had still water in them up to the ceiling. As a result of the flood, large parts of the collections and library, etc. naturally suffered serious damage; labels were washed off or made illegible by silt, and bottles tilted, floated or sank. Not only specimens, but also books and letters were damaged, including Accession Registers. As ill-luck would have it, the Type-Specimens had just been brought from Dehra Dun and in some Sections were being unpacked and arranged. For a considerable time after the floods, all the resources of the Survey were mobilised for salvaging the collections, etc. While the spirit collections in bottles suffered comparatively less damage in the floods, the dry material of invertebrates, insects, and the birds and mammal skins were considerably damaged.

Due to the severe perturbations in funding of our efforts, not only had the activities of the Survey to be severely curtailed but the publication of all its official journals also suspended. Stoppage of the publication of the scientific journals of the department and curtailment of field activities naturally had their toll on the output of research work which was further handicapped by the non-availability of current publications from foreign countries. Given the financial stringency of the times and the heavy budget restrictions, the Survey did surprisingly well.

There was a constant and close collaboration between the Survey and the Fishery organisations in the country. The Survey drew up a scheme for the development of fisheries in India, as a consequence of which the Central Inland and Central Marine Fisheries Research Institutes were established in 1947. Both these institutes, besides being initially nurtured by the Survey, were also headed by officers from the Survey.

In May 1944, Dr. Baini Prashad relinquished charge of the post of the Director on his appointment as Fisheries Development Adviser to the Government of India. Dr. Bishamber Nath Chopra, Assistant Superintendent took over as the Director of the Survey.

Dr. Chopra was a man of exceptional ability and a brilliant scientist. He had greatness of character with a forthright and generous manner, and his lovable nature endeared him to all. In an incredibly short time he set the collections in order. For the few years Dr. Chopra was Director, the researchers at the Survey were necessarily greatly reduced owing to the absence of so many of the meagre staff being away on deputation, but he carried out the duties with indomitable courage and energy.

Shortly after the termination of the Second World War, Lt.-Col. R.B. Seymour Sewell, a former Director of the Survey, residing in England, was invited by the Government of India to submit recommendations for the reconstruction and expansion of the Zoological Survey of India. Lt.-Col. Sewell visited India in 1945 and submitted the following recommendations:

(1) *The reorganisation and expansion of the Zoological Survey of India be taken up forthwith;*

(2) *The programme of work be extended along modem lines to include the study of ecology and the characters of the various habitats, etc., and particular attention be paid to field work; and that as the requisite staff is built up, the study of animal populations should be commenced;*

(3) *The Marine Fishery Station at Karachi must provide accommodation and facilities for certain officers of the Zoological Survey;*

(4) *The post of Naturalist of the Marine Survey of India be resuscitated as soon as the Marine Survey starts to function again;*

(5) *The staff of Zoological Survey of India be expanded and the post of Director re- created forthwith; and that a post of Joint Director be created and an Administrative Officer appointed;*

(6) *The location of the headquarters of Zoological Survey of India be at New Delhi;*

(7) *The Scheme of Training for post-graduate students in preparation for their admission to the Zoological Survey of India, already in operation, be extended for a period of five years; and*

(8) *A new building be created to house Zoological Survey of India and its collections, and the work started as soon as plans are drawn up.*

The above recommendations were kept in abeyance due to the ferment of political unrest prevailing in the country during these years.

Development of Zoological Survey of India in Post-Independence Years

The country's partition in 1947 brought about some disorganisation and months of uncertainty in the Survey. Several officers and non-gazetted staff members opted for service in Pakistan, resulting in a further slowing down of the normal work of the Survey. Besides this, most of the senior officers of the department were away on deputation elsewhere, leaving the Survey greatly understaffed. Dr. Sunder Lal Hora had just a few months earlier (May, 1947) returned to the Survey as its Director, from his assignment as Director of Fisheries, Bengal. Dr. Hora, a near genius, rose into public eminence while working as Director of the Zoological Survey. By diligence, thoroughness and industry he worked up.

He was in truth a most humble and remarkable man - capable, versatile, sociable and ambitious. His dedicated labours have built the unrivalled collections of freshwater fishes in the ZSI and the vast literature relating to it He worked with amazing rapidity. At the Zoological Survey he devoted his .talent to ichthyology and became one of the great ichthyologists of the age. His appointment made little difference to the nature of his work, and he maintained an astonishing output of contributions to scientific journals. His interest were varied; his work on evolution and adaptation in the "torrential" fauna of India, and also on fish and fisheries, is both extensive and of lasting value.

The Zoological Survey of India at 'Jabakusum House', Calcutta, 1948-1987

Towards the close of 1948, the re-shifting of the Zoological Survey to Calcutta was commenced and was completed in early January 1949. Since the major portion of the space which the Survey had occupied in the Indian Museum at Calcutta before its shifting to Benaras was allotted to the newly established Department of Anthropology while the Zoological Survey was still at Benaras, "Jabakusurn House" at 34 Chittaranjan Avenue, Calcutta, was selected to house the new headquarters of the Survey; the Bird and Mammal Section, the Taxidermy Section and the Library were, however, rehoused in the Indian Museum. The departmental chores of the Director greatly increased after the move to Jabakusum House, and the limitations of the new building did not make things easier. The flood of accessions, reflecting public confidence in the institution, was not foreseen. Mammals and birds were already short of space. More serious was the crowding in the insect and spirit room. For a Director who was an ichthyologist, the calls on his time by public bodies concerned with fisheries, were considerable. The position improved in later years when a younger generation of zoologists became available.

The Survey maintained uninterrupted service as a bureau of systematic zoology and attended to technical enquiries on zoological, biological and allied problems. Investigations were carried out on the aquatic and terrestrial fauna of the areas which would be effected by the proposed site of the Rihand Dam and in the Damodar Valley in connection with the river valley projects, with a view to studying the ecological succession of animals before and after the dams were constructed.

In November 1949 an *adhoc* Committee was appointed by the Government of India to examine the Sewell Scheme for the reconstruction and expansion of the Survey, and to suggest how best 'Zoology could be made a living subject in India'. The Committee in its report stressed the following points :

A permanent building for the Survey; (ii) the increase in the gazetted and non-gazetted staff; (iii) the permanent retention of a Curator and staff for the Zoological Galleries of the Indian Museum; (iv) the appointment of a Naturalist for oceanographic work; (v) the appointment of an independent editor for the *Fauna of India* series; and (vi) the allotment of adequate grant for the improvement and growth of the library.

Keeping these recommendations in view and advancements in the science of zoology in other parts of the world, the activities of the Survey were enhanced and reorganised on the following lines under the Five-Year Plans.

(i) First Five-Year Plan, 1951-52 to 1955-56

The all-round development of the scientific activities in the country made it essential for the Government to seriously grapple the question of the reconstruction, growth and development of the Zoological Survey. Towards the close of 1954-55 a small sum was provided for meeting some of the immediate requirements in increasing staff-strength and purchase of laboratory equipment. in 1951 the scientific staff of the department numbered 12, in 1956 it was 17, an increase scarcely sufficient to keep pace even with the accretions. Yet the output of publications during this period, under conditions which, to say the least, we could find burdensome, demonstrates the spirit of the workers at that time. The work of the Zoological Survey as a bureau of systematic zoology increased materially with the tempo of activities in the fields of agriculture, fisheries, forestry, animal husbandry and public health in the country under the First Five-Year Plan; the service of the Survey was utilized by numerous institutions and workers interested in the application of zoological knowledge to practical problems in these disciplines. The marked attention of researches in connection with the applied sciences led to an increase in the number of research students under its training programme. Special surveys of dam sites were organised for the solution of problems connected with fish-passes and fish- ladders, in collaboration with the Central Board of Irrigation and Power. Further, preliminary work of assessment of the wildlife resources of the country was carried out The Director became a member of the newly constituted Indian Board of Wildlife and his advice sought for setting up and reorganisation of Game Sanctuaries, Zoological Gardens, National Parks, and also for the control of export/import of animals. The Survey played a remarkable role in the investigation of ***schistosomiasis*** disease in the Ratnagiri district of Maharashtra where an endemic locus was discovered; scientists of the Survey pinpointed the vector snail, a tiny aquatic pulmonate living in the freshwater ponds of the effected village, which helped in controlling the disease.

There were noteworthy advances in our knowledge of the zoogeographical distribution of fishes in India, based on various reports of fish collections by Dr. S. L. Hora who studied the origin and evolution of hill-stream fishes. Hora (1953) proposed the ***'Satpura'*** hypothesis to explain the present-day distribution of the fauna and flora of the' country. The discovery of a new blind fish, *Horaglanis krishnai* by Dr. A. G. K. Menon from a well in Kerala, was a remarkable find. The trematodes of Indian marine fishes were studied by Dr. B. S. Chauhan with interesting results. Another noteworthy publication was on *Mitres of Indian Waters* by Mr. H. C. Ray published in *Memoirs.*

The Survey was entrusted by the Indo-Pacific Fisheries Council of the FAO of the United Nations, with work of preparing identification keys to the common fishes of the region. Further, a symposium on *Hilsa* and its fishery was organised in 1952, with Dr. S. L. Hora as Chairman of the subcommittee on *Hilsa* of the IPFC. Field surveys were conducted to: (i) Pachmari (Madhya Pradesh) in a search for relict elements of the last Glacial Period; (ii) South Malabar (Kerala) for Malayan elements in the fauna; (iii) Sikkim, in collaboration with the Bombay Natural History Society, for studying the migration of high altitude birds; and (iv) Darjeeling, for studying the rare species of the egg-eating snake *Elachistodon.* The Survey participated in the London based newspaper, Daily Mail's Himalayan Expedition (1954) to Nepal in search of the Abominal Snowman, popularly called Yeti.

A conference of selected zoologists was organised by the Government of India in April 1955 for suggesting a programme for the development of the Survey under the Second Five- Year Plan. They recommended inclusion of ecology and zoogeography as regular subjects of study by the Survey. Further, they suggested the setting up of six regional stations of the Survey in the various parts of the country to undertake intensive surveys of these areas and to serve as extension centres of the activities of Survey.

Dr. Hora died in harness on 8th December, 1955. To him the Survey owes a tremendous debt for its subsequent growth and prosperity, and the prestige it now enjoys. On Dr. Hora's death, the supervision of the Survey devolved on the next senior-most officer, Mr. Mahindra Nath Datta, Zoologist (senior grade). Mr. Datla was a zealous and enthusiastic student of natural history, and his singularly kind and genial disposition endeared him to all. His term of office was very short and he, therefore, had little time to influence the scientific activities of the department.

(ii) Second Five Year Plan, 1956-57 to 1960-61

This period opened with the appointment of Dr. Mahadeva Subra Mani as the Survey's first Deputy Director; he held charge of the department for an interim period from 4th to 23rd July, 1956. In July 1956 Dr. Mithan Lal Roonwal was appointed Director of the Survey. Dr Roonwal was earlier (1942-49) associated with the Survey as one of its officers (in-charge of Bird arid Mammal Section). He rejoined the Survey after a very rich experience as Chic Research Officer in the Forest Research Institute at Dehra Dun. Dr. Roonwal was versatile naturalist and a great administrator. Always an assiduous worker and a prolific writer, Dr. Roonwal's penchant for acquisition brought a large number of specimens in the already over-crowded Survey. One of his first actions as Director was to raise the question as one of principle namely, that collections obtained at the nation's expense were the property of the nation, and therefore of its national institution. Dynamic, daring and dedicated, he steered the Survey through the Second Plan in a fearless manner and gave an astonishing impulse to its growth. He lost no opportunity of bringing the shortage of space for the rapidly increasing collections before the Government. Throughout his tenure his concern had been to build up the collections.

The first two years of the Second Five-Year Plan period were rather uneventful in so far as the development of the department under the plan was concerned since no part of its programme of expansion could be taken up due to delay in the fmalisation of the overall scheme and lack of official sanction. It was only at the urgent insistence of Dr. Roonwal that the money was available in early 1958.

As part of expansion programme of the Survey during the Second Five-Year Plan, six regional centres of research were set up: the Eastern Regional Station was established at Shillong in 1959, the Western Regional Station at Poona in

1959, the Central Regional Station at Jabalpur in early 1960, the Desert and Gangetic Plains Regional 'Station at Jodhpur in June l96O, the Northern Regional Station at Dehra Dun in August 1960. and the Southern Regional Station at Madras in March 1961. As these regional stations were primarily set up to meet the diverse ecological biotopes in different parts of the country research investigations were oriented towards such dimensions. Three new Divisions *viz.* Higher Chordata, Lower Chordata and Lower Invertebrata and several new Scientific Sections *viz*. Marine Survey Unit, Animal Population Studies Unit, Prehistoric Zoology and Arachnida. Were established to initiate and encourage the study of certain hitherto neglected groups. A documentation Unit at Headquarters was also set up. In addition, reorganisation of existing Scientific Sections such as Marine and Freshwater Fish Sections, Protochordata and Amphibia Section, General Non-Chordata Section, and Taxidermy and Museum Section were also made. The scientific strength of specialist officers increased from 14 to 50. Maintenance and development of the National Collections, and of the Zoological Galleries of the Indian Museum, etc. were intensified.

Extensive faunistic surveys of the Rajasthan Desert and the former French pockets in South India (*viz.* Pondicherry and Kariakal areas) were undertaken. A comprehensive survey of the Andarnan and Nicobar Islands was also undertaken. A survey of the Gir forest areas (Gujarat State) was undertaken for a preliminary ecological study of the Asiatic lion in its natural environment. An ecological study of the shipworms of Sunderbans (West Bengal) was also undertaken. In general, emphasis was laid on field survey and study of groups of animals of economic importance. Besides these, the Survey took part in the Indian Cho-Oyu Expedition (1958) in Nepal. The Harvard Yale Expedition (1958) to Sikkirn and Darjeeling for birds, the Indo-German Expedition (1955-58) to different parts of the country, and the Indo-Swiss Entomological Expedition (I958-61) to north-western and north-eastern Himalayas. Special work on locusts and termites was also carried out under two schemes of research financed by Ministry of Food and Agriculture and the Indian Council of Agricultural Research respectively, the work on locusts was on the population dynamics of the Desert Locust of India. While the work on Termites pertained to the study of the Indian fauna, the discovery of a new family (Nicollsidae) of isopods from deep wells, by Dr. K. K. Tiwari (1958) was an interesting find during this period. To relieve congestion at the Headquarters at 'Jabakusum House', an additional branch office of the Survey was opened at 25-B Park Street to house four Sections/Units of the Survey, viz. the Marine Survey Unit, the Animal Population Studies Unit and the Protozoa Section.

The Director, Dr. M. L. Roonwal acted as the Secretary-General, Indian Board for Wild-Life. This Board has an advisory function in regard to the preservation and conservation of wildlife in India.

(iii) Third Five Year Plan, 1961-62 to 1965-66

The Survey continued to maintain and develop the largest zoological collection in the country. The Government of India in view of the biological importance of these collections, recognized the same as the National Zoological Collections through a gazette notification dated the 11th July, 1964.

A Central Card Index Scheme for cataloguing the Zoological Type Collections in the various institutions in South Asia, with financial support from UNESCO, started functioning in the Survey from November 1962. Further, a Centre for Key Zoological Collections for South Asia was also established with the object to prepare a Care! Index of Specimens in the collections of the participating countries of the region.

In order to lay emphasis on the fauna of the Gangetic plains, a separate regional station was set up at Patna (Bihar) carving out some areas from the previously combined Desert & Gangetic Plains Regional Station at Jodhpur. Further, during the Third Plan period, a Publication, Training and Accessories Division was established at the Headquarters which facilitated in co-ordinating the work of the Library, Documentation, Publication, and the Drawing and Photography Sections. A Post-graduate Training Unit was set up to cater to the needs of research scholars for training in field survey work and general principles of taxonomy, etc. A Field Survey Division was also set up to plan and coordinate the faunistic investigations to be undertaken. In addition to these, five new Scientific Divisions were also established, namely Marine Survey, Ecology and Wildlife Conservation, Higher Invertebrates, Identification and Advisory, and Palaeozoology; several new Scientific Sections were also set up, particularly in the Entomology Division. With the establishment of these Divisions, new lines of research were initiated such as on animal behaviour, soil zoology, vertebrate palaeozoology, acarology and nematology, etc. Consequent to these organisational changes, the staff of the Survey both at the Headquarters and its Regional centres, was considerably strengthened by the addition of 54 scientific officers with supporting staff, to undertake the additional responsibilities. A number of research training scholarships and fellowships were instituted for training workers in the various fields of zoology.

An extensive faunistic survey at the construction site of the Nagarjunasagar Dam (Andhra Pradesh) was carried out with the object to study the ecological faunal succession on the completion of the dam. Several other faunistic surveys were also undertaken, the important ones being: (i) Coastal survey of Orissa, Andhra Pradesh, Madras and the Gulf of Mannar for marine organisms, with particular reference to shipworms in the Mahanadi estuary; (ii) the Andaman and Nicobar Islands; (iii) the Western Ghats; (iv) Rajasthan; and (v) Goa. Besides these, several scientists participated in faunistic survey programmes of the International Indian Ocean Expedition (1962-64) on board I.N.S. 'Kistna' and the Russian ship 'Vityaz'. A census of the spotted deer or chital, *Axis axis* Linnaeus in the Dehra Dun Forest Division, was also undertaken in collaboration with the Uttar Pradesh Forest Department, as a result of which it was estimated that 12,000 heads were present in an area of about 1,67,000 acres comprising the Dehra Dun Forest Division. Further, two joint field expeditions, one to the Great Nicobar Island in the Andaman Sea (1966) in collaboration with sister Surveys; and the other to NEFA jointly with the Defence Research and Development Organisation, were conducted. The Survey also participated in the Ross Expedition (1961-62) to the different regions of India for the study of insects, and the Royal Ontario Museum Expedition (1963) to the Anaimalai Hills in Tamil Nadu, for general faunal collections.

Some of the notable publications during these years were: a 600 page 'Bibliographia Acrididiorum' by M. L. Roonwal (1961); a *monograph on the cyprinidfish genus Garra Hamilton* by A. G. K. Menon (1964); and a voluminous *Aid to the Identification of the Commercial Fishes of India* by K. S. Misra (1962). The discovery of a new primate, the Golden langur from Assam during this period by Dr. H. Khajuria, was undoubtedly a remarkable find.

The First Summer School of Zoology in India, organised primarily by e Zoological Survey of India, was held at Simla (Himachal Pradesh) during 1961 wherein most of Universities participated; the proceedings have been published as 'Recent Advances in Zoology'.

The need for finding better accommodation for the' department's rapidly increasing collections at Headquarters became urgent A building at 2 Justice Chandra Madhab Road was rented from September 1961 in lieu of the small premises at 25B Park Street, to house six Sections/Units, viz. the Marine Survey Unit, Animal Population Studies Unit, Freshwater Fish Section, Marine Fish Section, Mollusca Section, Soil Zoology Section and the General Non-Chordata Section. By 1964 the Fire-Proof Spirit Building in the Indian Museum complex, envisaged for the Zoological Survey, was ready for occupation but the plan was bedevilled by the allotment of only three of the six floors to the Zoological Survey. The Freshwater and Marine Fish Sections, Amphibia Section, Crustacea Section, and Museum & Taxidermy Section alone were shifted to the new building.

Dr. M. S. Mani, Deputy Director, led a party in 1963 to U.S.S.R. on Indo-Soviet Cultural Exchange Programme; Dr. K. K. Tiwari and Dr. B. Biswas were members of this team from the ZSI.

In August 1965 Or, M. L. Roonwal left the Survey on his superannuation. Consequently Dr. M. S. Mani again held charge of the Survey as Deputy Director. His outstanding achievement was in inspiring and creating the atmosphere for more productive work. No smile was permitted to escape his pursed lips. The proverbial abruptness of speech of a man who spoke his mind covered his depth of feeling and warmth of heart that his colleagues knew but seldom saw. He could have earned far more in popular writing about insects, birds and plants than he could at the Survey as he was a fluent writer. His term of office was short and he, therefore, had little time to influence the scientific activities of the department. His gift for organisation and meticulous attention to details not only benefitted the department as a whole but also contributed substantially to the training of the staff. Dr. Mani was a most gifted man and of a generous nature.

(iv) Three Annual Plans, 1966-67 to 1968-69/ Fourth Five Year Plan, 1969-70 to 1973-74

This period opened with the appointment of a most distinguished zoologist, Dr. Atam Prakash Kapur as Director of the Survey from 18th May, 1966. Dr. Kapur was an entomologist of an extraordinary calibre and a most sagacious administrator. He devoted himself to the duties of his new office with remarkable zeal and confidence. He was a man completely dedicated, and gifted with the ability to fulfil the dedication. Almost immediately he started a campaign for a new building for the Survey, both for its headquarters and regional centres. The culmination of Dr. Kapur's years of planning was the purchase in 1971 of a plot of land at New Alipore, a posh locality of Calcutta, for its headquarters, and thereby setting at rest, once for all, the efforts to move the headquarters of the Survey out of Calcutta. Throughout his period new channels for the collection of specimens were being opened up.

During the early phase of this period the branch office of the Survey at 2 Justice Chandra Madhab Road was shifted to a more spacious building at 8 Lindsay Street. This new office near the Indian Museum in which the library is housed, naturally facilitated the work of the scientists. Further, a plot of land for the Eastern Regional Station at Shillong was gifted to the ZSI by the Government of Meghalaya, during this period.

A new regional station, eighth in the series, the High Altitude Zoology Field Station was established at Solan (Himachal Pradesh) in September 1968. Three new Scientific and Technical Divisions were also set up at Headquarters, viz. Herpetology, Information & Documentation, and Museum & Taxidermy. Two new Scientific Sections under Entomology Division, viz. Isoptera and Apterygota were also established. Further, a full- fledged Cyto-taxonomy Laboratory was set up at the Headquarters. Another significant development was the creation of two posts of Administrative Officers to relieve the Director of the enormous amount of the routine administrative work of the department.

The most noteworthy field surveys undertaken during this period were in Orissa, Goa and NEF A. While the latter survey was undertaken for the study of insects of medicinal importance, the former two states were selected since they provided an opportunity to study the fauna of diversified ecosystems. Besides these, surveys were also undertaken to Bhutan for birds and insects, Burzahum (Jammu and Kashmir State) for animal remains of pre-historic times, Kerala coastal areas for wood-borers, and the Andaman & Nicobar Islands for marine organisms. The officers of the Survey also participated in the Multi- disciplinary Scientific Expeditions to Daphabum (1969 - 70) and Subansiri (1974 - 75) in Arunachal Pradesh, and Rupkaund and Tons Valley Expedition to Uttar Pradesh. Special emphasis was also given to the survey of national parks and sanctuaries, particularly the Corbett National Park in Uttar Pradesh, the Kanha National Park in Madhya Pradesh, the Hazaribagh National Park in Bihar and the Kaziranga Wildlife Sanctuary in Assam. Further, the Garo hills in Meghalaya, Narmada River Valley in Madhya Pradesh, Western Ghats in Kamataka, and Kodaikanal and Palni Hills in Tamil Nadu, were also surveyed for the study of wildlife. A pilot study on Peacock Survey was taken up with the National Sample Survey Organisation. Some of our Zoologists participated in the Joint Oceanographic Expedition on board the INS "Darshak" in the Arabian Sea during 1973 - 74

and collected data on the sonic scattering layers, and also samples of zooplankton, nekton and benthos.

The highlights of scientific research carried out during these years pertain to the publication of results on the population characteristics of the desert locust, *Schistocerca gregaria* (Forsskal) in India in relation to the swarming cycles; the lady-bird beetles of the Andamans, taxonomic account of the rice stem-borers which are the major insect pests of paddy; revision of Indian Blister-beetles; systematic study of the Indian species of water-beetles of the family Dytiscidae; zoogeography and phylogeny of termites of the genus *Cryptotermes* from the Oriental region; spiders of Sikkim; taxonomic account of the moth genus *Agrotis* and allied genera; Coccids affecting fruit plants in Bihar; Coccidian parasites of Indian birds; aquatic and amphibious molluscs of the Kashmir Valley; wood- boring molluscs of the Mahanadi estuary; amphipods of the east coast of India; trematodes and aquatic beetles of the Andaman and Nicobar Islands; fauna of Rajasthan pertaining to Protozoa, Cladocera, Ostracoda, Coccinellids and Pelecypoda; rediscovery of the rare catfish *Chandramara chandramara;* fishes of the Great Nicobar Expedition, 1966; fishes of the R. Tawi and its tributaries; extinct and vanishing birds and mammals of India; food- habits of water birds of Sunderbans, studies on skulls of Oriental rodents in relation to ecology; population census of Chital or the Spotted deer, *Axis axis* and some wild animals in Dehra Dun Forest Division; fish and mammal fauna of Goa; prehistoric animals of India and their bearing on early Indian cultures; and zoological constituents of the upper sonic scattering layer in the Western Indian Ocean. Further, a Handbook for Zoological Collectors was brought out During this period the scientists were particularly encouraged to submit their results for research degree and as a consequence, numerous workers obtained their Doctorate degrees.

A seminar "Fifty years of Faunistic Surveys of India" covering the period 1916-1966 was organised in May 1969 with the purpose of analysing the broad features of the progress made in the country. In connection with the Wildlife Week, 1972, a set of four unique coloured picture postcards was released.

To advice on the working and future development of the Marine Survey Division, a UNESCO Consultant, Dr. Walter Fischer was assigned to the Survey in early January 1967, for about six months, under the International Co-operation and Cultural Exchange Programme; this Division was shifted to Madras at the fag-end of 1971 as envisaged under the Plan. Further, an Advisory Committee for the Survey was set up by the Government of India in early 1972.

Under the Cultural Exchange Programme between India and the U.S.S.R., a delegation of three zoologists from the Survey, viz. Drs. A. G. K. Menon, A. Daniel and H. Khajuria visited several research institutions in Russia and utilized the opportunity for The highlights of scientific research carried out during these years pertain to the publication of results on the population characteristics of the desert locust, *Schistocerca gregaria* (Forsskal) in India in relation to the swarming cycles; the lady-bird beetles of the Andamans, taxonomic account of the rice stem-borers which are the major insect pests of paddy; revision of Indian Blister-beetles; systematic study of the Indian species of water- beetles of the family Dytiscidae; zoogeography and phylogeny of termites of the genus *Cryptotermes* from the Oriental region; spiders of Sikkim; taxonomic account of the moth genus *Agrotis* and allied genera; Coccids affecting fruit plants in Bihar; Coccidian parasites of Indian birds; aquatic and amphibious molluscs of the Kashmir Valley; wood- boring molluscs of the Mahanadi estuary; amphipods of the east coast of India; trematodes and aquatic beetles of the Andaman and Nicobar Islands; fauna of Rajasthan pertaining to Protozoa, Cladocera, Ostracoda, Coccinellids and Pelecypoda; rediscovery of the rare catfish *Chandramara chandramara;* fishes of the Great Nicobar Expedition, 1966; fishes of the R. Tawi and its tributaries; extinct and vanishing birds and mammals of India; food- habits of water birds of Sunderbans; studies on skulls of Oriental rodents in relation to ecology; population census of Chital or the Spotted deer, *Axis axis* and some wild animals in Dehra Dun Forest Division; fish and mammal fauna of Goa; prehistoric animals of India and their bearing on early Indian cultures; and zoological constituents of the upper sonic scattering layer in the Western Indian Ocean. Further, a Handbook for Zoological Collectors was brought out During this period the scientists were particularly encouraged to submit their results for research degree and as a consequence, numerous workers obtained their Doctorate degrees.

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Dr. A. P. Kapur retired from the Survey in October, 1973. After his retirement there was no regular Director of the Survey for a period of four years and the responsibility for looking after the Survey fell on Dr. Satendra Khera, initially as Deputy Director-in- Charge up to 12th July 1976 and later, on his promotion, as Joint Director-in-Charge. Dr. Khera was an able curator and administrator. His unassuming disposition, keen sense of humour and considerateness endeared him to all. Endowed with an energy seldom equalled, he occupied himself during these years with remarkable zeal. Only few are capable of such a labour. He was completely wrapped up in his work, devoting every moment to scientific investigations and to the care of the institution. He always tried to see how he could help each worker towards better facilities and equipment. He had the faculty of developing a genuine interest in the widely different fields of work going on in the Survey. The improvements in any field of activity, he pursued with persistent and extraordinary thoroughness.

(v) Fifth Five-Year Plan, 1974-75 to 1978-1979 Annual Plan, 1979-80

This period was marked in the diversification of the research programmes of the Survey; ventures involving bio-systematic and bio-ecological aspects of diverse groups of animals were emphasised, along with the formulation of integrated as well as collaborative research projects involving both fundamental and applied aspects. Work at sea was undertaken on board the research vessel “Chota Investigator” harboured at Madras which enabled also to collect the specimens required for study in the laboratory. In May 1977, Dr. Taracad Narayanan Ananthakrishnan, a most distinguished entomologist and an ardent naturalist, was appointed Director of the Survey. Dr. Ananthakrishnan was of a fiery disposition, energetic, of infectious zeal, and this is shown by the influence he exercised on whoever came into contact with him during the few years he stayed in the Survey. As a President or Secretary he was the very soul of societies and associations, being a brilliant speaker. In response to the current needs of zoology, he emphasised the ecological approach to taxonomic studies and this culminated in the setting up of four regional centres of research in the country based on ecology. This unremitting activity excited interest, even in persons from whom this could hardly be expected.

During this period, five new regional research stations were set up, viz. (i) Freshwater Biological Station at Hyderabad to undertake limnological investigations in various water bodies; (ii) Sunderban Field Station at Kakdwip (West Bengal) to explore the fauna of Sunderbans related to the mangrove ecosystem; (iii) Estuarine Biological Station at Berhampur (Orissa) for studying the estuarine fauna of the Mahanadi river system and the Chilka Lake; (iv) Western Ghat Research Station at Kozhikode (Kerala) to explore the fauna of the virgin forests of the Western Ghats and also of Lakshadweep Islands; and (v) Andarnan and Nicobar Regional Station at Port Blair.

A Scientific Evaluation and Implementation Committee was constituted by the Government of India during 1975-76 to evaluate the work of the Survey and to suggest a future programme of work. At their suggestion a comprehensive *State of Art Report on Zoology* was prepared, to mark the completion of 60 years of useful service of the Survey to the nation. This report, published in 1980, briefly synthesises the current state of knowledge of the different groups of the animal kingdom with reference to available information on diverse aspects relating to taxonomy, bioecology, zoogeography, etc; the *Report* also gives an overview of the extent of the unexplored areas of work in different groups as well as in the different habitats, and the available expertise in the Survey, the country and also abroad.

One of the great secrets of success of the Zoological Survey lies in the promptitude with which the collections are worked out and results published. The Survey's journals remained unique among scientific publications in the world. In their ambition to provide the departmental scientists adequate media to publish their results, Dr. S. Khera set up the new series *Occasional Papers of the Zoological Survey of India;* and Dr. T. N. Anarithakrishnan set up three new journals: *Technical Monographs, Bulletin* and *Handbooks of the Zoological Survey of India.* A number of Special Publications were also brought out incorporating the results of the numerous Symposia, Workshops, etc. organised by the Survey.

Survey of national parks, sanctuaries, mountainous regions, river basins and lakes received special attention. The Survey actively participated in the Multi-disciplinary Scientific Survey Expedition organised by the Geological Survey of India, in the mountainous terrain of Subansiri district of Arunachal Pradesh during 1974-75, which enabled the study of the intermixing of the Indian, Indo-China and Himalayan fauna. The Survey continued to participate in the oceanographic expedition on board INS 'Darshak' in the Northern Arabian Sea, to study the zooplankton and benthos of the area. Regular biological samples were also continued to be collected and analysed on board the R. V. *Chota Investigator* for studying the pollution of the biota at Madras. One of our senior Ornithologists, Dr. B. Biswas participated in the Bombay Natural History and World Wildlife Fund Expedition to Ladakh (1976) for the Status Survey of the Black necked Crane, Bar headed Goose and several of the wild goats and sheep. The Survey participated in the Indo-Japanese Entomological Expedition (1978-79) to north-western and southern India, and also in the multidisciplinary, inter-institutional Expedition to Sikkim (l978- 79).

A 'Fauna of India' Project was sanctioned in 1975 as a plan project to ensure a continuous flow of monographs on the different groups of Indian animals, so as to make them available not only to the students, naturalists and research workers in zoology, but also to workers in allied fields of the applied sciences such as medicine, public health, veterinary science, forestry, agriculture, etc. The *Fauna of India* series of monographs is a continuation of the well-known *Fauna of British India* series which were published under the authority of the Secretary of State for India in England. It was sanctioned in the year 1883 and the first volume of the series, on Mammalia (part 1) by W. T. Blanford, appeared in 1888. Since India's Independence in 1947, the Government of India have- assumed the responsibility of publishing the series under its new title, The *Fauna of India.* A number of Indian scientists, mostly from the Survey, were assigned to write volumes in as many as 32 different groups of animals.

The natural environment is man's most precious heritage; its conservation and protection remain one of our cherished ideals. Of late, there has been a widespread and growing concern regarding the destruction of natural ecosystems and the environmental degradation from the biological view point. In order to encourage research on subjects related to environment, the Department of Science & Technology constituted the Indian National Man and Biosphere Committee (MAB) and also the Environment Research Committee (ERC) to provide help in the selection of suitable

projects for support. The National MAB Programme focuses attention on ecological aspects of the environment whereas the ERC in all other subjects related to human environment. The Zoological Survey of India initiated the following research projects under this programme:
(1) Impact assessment of bio-ecological changes in the faunal patterns brought about by partial submergence of Corbett National Park;
(2) Eco-ethological studies and population estimates of the Cercopithccid Primates of Peninsular India;
(3) Status survey of endangered and threatened species of animals and birds of Nanda Devi Sanctuary;
(4) Population census of Rhesus Macaque and Hanuman langur of India; and
(5) Effect of pollution on some organisms in zooplankton, bcnthos and nekton contributing to the food chain in marine environment.

Several new lines of work were initiated with a bias on applicability and utility of research findings in applied fields, cutting across the rigid boundaries of traditional academic disciplines. The research projects of such nature are listed below, several of which were funded by the Department of Science and Technology (DST) and the 'Indian Council of Agricultural Research (lCAR), besides a number of fellowships and associateships funded by the University Grants Commission (UGC) and the Council of Scientific and Industrial Research (CSIR) :
(i) All-India coordinated research project on nematode pests of crops and their control;
(ii) Bio-ecological studies on soil microarthropods with special reference to their role as indicators of soil fertility;
(iii) The biology, ecology and distribution of the giant land snail, *Achatina (Lissachatina) fulica fulica* Bowdich;
(iv) Ecological interaction of the xylophagous (wood-boring) insects of Andaman & Nicobar Islands;
(v) Population periodicity and ecology of vector of Kala-azar in north Bihar;
(vi) Abundance and seasonal fluctuations of Phlebotomid sandflies in north Bihar;
(vii) Filth inhabiting flies of Calcutta;
(viii) Prevention of fouling organisms in the cooling seawater system of the Thermal Plant at Tuticorin (Tamil Nadu);
(ix) Problems facing the Salt Industry in the manufacture of salt along the coast of India;
(x) Meiobenthos of Sagar Islands and its environs;
(xi) Biological rhythms in Indian false vampire, *Megaderma lyra* Geoffroy;
(xii) Study of light attracted insects;
(xiii) Bioecological studies on *Macrosiphoniella sanborni* (Gillette) (Hemiptera: Aphididae) - a pest on Chrysanthemum;
(xiv) Population fluctuations in relation to ecological succession of two species of Thrips;
(xv) Species composition, population fluctuations and ecological succession of some grass infesting Thrips;
(xvi) Population ecology of the most endangered species of mammals and birds in the arid zones of Rajasthan and Gujarat;
(xvii) Parasitic Hymenoptera and other predatory insect resources of northeast Himalaya;
(xviii) Effect of pollution on some organisms in zooplankton, benthos and nekton contributing to the food chain in the marine environment;
(xix) Status survey of endangered and threatened species of birds and mammals at Nanda Devi Biosphere; and
(xx) Ecological and environmental impact of multipurpose river-valley projects with particular reference to the Idukki Project
The large number of joint projects currently underway testifies to well-laid foundations of the department
There was an encouraging increase in the scientific contributions, the following of which deserve special mention: *Index Horana* by K. C. Jayaram; *Siphonophorafrom the Indian Ocean* by R. Daniel; *the Isotima-complex (Hymenoptera: Ichneumonidae)* by J. K. Jonathan; *Studies on Ectoparasites of bats of Rajasthan* and Gujarat by R. Advani & T. G. Vazirani; *Odonata of Western Himalaya, India* by A. Kumar & M. Prasad; *Taxonomic studies of earthworms collected during Subansiri Expedition in Arunachal Pradesh* by J. M. Julka; *Spider fauna of Calcutta and vicinity* by B. K. Tikader & B. Biswas; *Revision of Indian crab spiders (Aranae : Thomisidae)* by B. K. Tikader; *Catalogue of Oriental Dermaptera* by G. K. Srivastava; *Francis Day* (1829-89) *and his collections of Indian Fishes* by P. J. P: Whitehead and P. K. Talwar;

Aphids of economic importance in India by A. K. Ghosh; *Termite pests of Agriculture. in the Indian region and their control* by O. B. Chhotani; *Taxonomic studies on some of the Indian non-mulberry silk moths* by G. S; Arora and I. Gupta; *Taxonomy, biology and ecology of nematodes associated with jute crops* by S. Khera; *Taxonomy and ecology of Chaetognatha of the west coast of . India in relation to their role as indicator organisms of water masses* by T. Srinivasan; and *A monograph of the tongue soles of the genus Cynoglossus Hamilton-Buchanan (Pisces: Cynoglossidae)* by A. G. K. Menon. A special volume of *Records* was brought out on the Andaman and Nicobar fauna. Further, two volumes (Second and Third) on Fishes by K. S. Misra under the *Fauna of India* series, were published, the first volume having been published in 1969. A series of *Aids* to the identification of siluroid fishes by K. C. Jayaram, were also brought out during this period.

Several National Symposia and Workshops were organised during 1977-80 with participants drawn from various universities, national institutions and research organisations. The notable ones were: 'Ecology of Animal Populations', 'High "Altitude Entomology and Wildlife Ecology', 'Tropical Ecology', 'Soil Microarthropods as indicators of soil fertility', 'Techniques in Parasitology', 'Host as an Environment', etc. In addition to these, several training courses, for example 'Taxidermy Training Course', 'Insect Collection and Preservation Course', etc. were also conducted wherein trainees from different agricultural and medical Institutions and Universities participated: Four scientists, viz. Drs K. C. Jayaram, P. K. Talwar, M. Babu Rao and K.V. Rama Rao participated, on invitation, in the FAO/DANlDA Workshop held at Cochin during February 1980, for the preparation of *Species Identification Sheets for Fishery Purposes of the Western Indian Ocean.*

Two more premises at Calcutta were rented to relieve the steadily increasing pressure on the limited space in the existing premises; one at 34 Shashi Bhusan Dey Street to house the Publication Division and the Information/ Documentation Division, and the other at 14 Madan Street to house the Arachnology Division and the Identification/Advisory Division. Further, a building 'May Fair' belonging to the U.S. Consulate, Madras was purchased in 1974, to house the Southern Regional Station. On 18th November, 1976 the foundation-stone laying ceremony of the new building of the Survey's headquarters was performed. On the completion of our building at Shillong in June 1979, our Eastern Regional Station moved into its new home, this being the Survey's first regional centre to have its own building constructed.

(vi) Sixth Five-Year Plan, 1980-81 to 1985-86

The Government of India set up the Department of Environment in November 1980 for dealing with subjects relating to environment and ecology. The Zoological Survey of India was one of the three organisations assigned to it. In response to the identified need for environment conservation with a view to maintaining the health of life-sustaining ecosystems and other environmental resources, the research programmes of the Survey were drawn up. This combination of functions has been extraordinarily stimulating.

In July, 1980 Dr. T. N. Ananthakrishnan prematurely left the Survey and Dr. Krishna Kant Tiwari took over as the officiating Director for a very brief period. Dr. Tiwari was a man of considerable scientific attainments and it is certain that given the necessary time, his impact on the ZSI would have been very marked in view of his wide experience in faunistic investigations. A man of his energy and combativeness took hardly to the confines of a chair. At the ZSI he became the world's authority on Crustacea; his systematic records over the years offered an immense range of zoological knowledge. The most noteworthy activity of the Survey during his short spell as Director was the submission to the Government of India the schemes for the expansion and reorganisation of the department under the Sixth Five- Year Plan.

On 31 st March, 1981 Dr. Benoy Krishna Tikader, a most versatile zoologist, was appointed as Director of the Survey. Dr. Tikader devoted himself to the duties of his new office with remarkable zeal and boldness which characterise his genius, fully conscious of the fact that the time had now evidently arrived at which it is essential to secure the proper co-ordination of the institution as a whole and to ensure its harmonious growth in the future. His zeal as a nature conservationist aided substantially in the evolutionary process of the Survey. To him, obstacles exist only to be overcome and really he succeeded in many cases where others, with a more patient character, would have shrunk back.

Special emphasis was given to programmes relating to environment and ecology. An intensive survey of the Silent Valley (Kerala) was undertaken to assess overall faunal resources of the area in the wake of the possible damage that might occur with the construction of the proposed hydel-project. The two projects funded by the MAB- India, viz. on the Namdapha Wildlife Sanctuary and on Horse-shoe Crabs, steadily progressed in the Survey. The Namdapha Wildlife Sanctuary on the Indo-Burmese Frontier, is the largest surviving chunk of nearly undisturbed rain-forest in the Indian subcontinent and, therefore, holds a unique position in the biogeographic map of the Oriental region and together with the adjacent terrain forms the extreme northern latitude limit of the tropical rain-forest tract; because of its inaccessibility and isolated position it still remains a varietable gene-pool reserve of the fauna of north-east India. The area is being explored to work out a comprehensive account of the diversity of the ecological zones and the quality of the fauna therein, so that the objectives of perception of environmental quality and the faunal resources of the area may be satisfactorily understood. The Neora Valley in the eastern Himalayas, the future of which is causing a grave concern to conservationists because of the contemplated hydel project, was also investigated for a faunal assessment.

The All-India Co-ordinated research project on Ethnobiology : Ethnozoology, funded by DST/ DOE was initiated in April 1982, to study the animal interaction in primitive culture, historical understanding based on the existing primitive culture, tribal practices, etc to open new areas of knowledge and to search for genetic pool of resistant and hardy animal species. Further, assessment of the impact on the faunal resources due to mining in Bihar State and also the proposed Damodar Valley Corporation Hydel Project, were taken up. A status survey of lesser cats of eastern India, a project funded by the World Wildlife Fund, satisfactorily progressed. The other interesting projects investigated during this period were: Eco-Sociology of the lion- tailed Macque, *Macaca silenus,* a project funded by MAB - India; adaptative ecology and taxonomy of the Nilgiri langur, *Presbytis johnii;* Deep-water fishes of India; Blood parasites and other protozoan parasites of the Western Ghats which cause major diseases in vertebrates; Parasitological study of helminths directly connected with public health; and Status and ecology of rare and vanishing birds, etc. The project on the .wood-boring insects of the Andarnan and Nicobar Islands was completed; about 30 species of cerambycid beetles have proved to be potential pests of felled timbers in the area and suitable ecological control measures were worked out. The intensive surveys for the nematode pests associated with paddy crop in certain districts of West Bengal, revealed that the rice root nematode, *Hirschmanniella gracilis* is the most dominant pest of paddy in the area surveyed, and the loss in the yield due to this nematode was estimated to be 13-18; it has been confirmed that carbofuran in granular form is the most effective pesticide against this nematode. Investigations on the epidemic of Kala-azar in north Bihar was one of the most important ventures of the Survey to diagnose the species playing the role as the vector of the disease. Ultrastructural studies on the Indian fauna through the use of Scanning Electron Microscope were initiated in the Survey. Further, applied researches on the effects of present-day agricultural practices (by using chemical fertilizers, chemical pesticides, chemical weedicides, intensive crop rotations) on Collembola (spring-tails) and their relationship to yield of three crops, viz. wheat, jute and paddy, were also taken up during this period.

The most enthralling contribution of the ZSI during these years was the publication of a book entitled *Threatened Animals of India* by B. K. Tikader. This unique book deals with various aspects of conservation of our magnificent wealth of wildlife, mainly of those animals which are struggling hard for their survival. This beautifully illustrated book was formally released by the late Hon'ble Prime Minister, Smt. Indira Gandhi on 13th October, 1983. Besides this, the other equally important publications during this period are several *Fauna of India* volumes - two volumes on Spiders by B. K. Tikader, a volume on Scorpions by B. K. Tikader and B. D. Bastawade, two volumes on Aphidoidea by A. K. Ghosh, and Supplement to Mehra's Trematoda volume by C. B. Srivastava; several books, viz. *Taxonomy of*

Indian Thysanoptera by T. N. Ananthakrishnan & S. Sen; *The Freshwater Fishes of India. Pakistan, Bangladesh. Burma and Sri Lanka* by K. C. Jayaram; *Handbook on Insect Collection. Preservation and Study* by A. K. Ghosh & T. Sengupta; a voluminous handbook on *Commercial Sea Fishes of India* by P. K. Talwar & R. K. Kacker; *Birds of Andaman and Nicobar Islands* by B. K. Tikader; *Glimpses of Animal Life of Andaman and Nicobar Islands* by B. K. Tikader & A. K. Das; *Seashore Animals of Andaman and Nicobar Islands* by B. K. Tikader, A. Daniel & N. V. Subba Rao; a special publication on *Endangered Animals of India* by A. K. Mukherjee; and a book on *Game Fishes of India and Angling* by Raj Tilak & U. Sharma. The other salient publications of this period are : *Coccidia and Coccidiosis of poultry and farm animals of India* by A. K. Mandal; *On the Lepidopterous fauna of Arunachal Pradesh & adjoining areas of Assam in north-east India: Family Arctiidae* by G. S. Arora and M. Chaudhury; *Aphid parasitoids of India and adjacent countries (Hymenoptera: Aphidiidae)* by P. Stary and A. K. Ghosh; *Studies on pholidosis and variability in characters showing sexual dimorphism in various species of Indian Reptiles* by R. C. Sharma; and *Contribution to the knowledge of Mammalian fauna of Jammu and Kashmir, India* by S. Chakraborty.

The Survey organised the First International Workshop on Management of Zoological Collections, in collaboration with the Carnegie Museum of Natural History Pittsburg (USA) during January 1984. This conference dealt exclusively with the Recent Mammals in Tropical Environment. Several participants from as many as 14 countries attended the Workshop. The *Proceedings* of this workshop have been brought out. The Survey regularly set up exhibitions and conversaziones on appropriate occasions, viz. Wildlife Week, World Environment Day, etc. The Survey's participation in the 'India International Trade Fair 1981' was accorded honours.

The ZSI brought out a magnificent calendar for year 1983 with the Birds of Andaman and Nicobar Islands as the theme. This calendar, inspired by Dr. B. K. Tikader, aroused much to increase the public awareness of the country's rich heritage and the importance of the ZSI. The calendar was warmly accepted as highly beneficial by both the Government and the general public. The Emeritus Scientists' Scheme was implemented for the first time in the Zoological Survey. Three of our retired scientists namely, Dr. B. Biswas, Dr. A. G. K. Menon and Mr. G. Ramakrishna were appointed as Emeritus Scientists. The Flexible Complementing Scheme for promotions to the scientists of the Survey, submitted to Government during this period, was accepted in principle after protracted discussions. The ten-storeyed building of the Survey's headquarters reached eight-storeys of construction. The Northern Regional Station at Dehra Dun; and the Southern Regional Station and the Marine Biological Station at Madras, moved into their own buildings. Capital outlay for our buildings at Pune, Itanagar, Solan and Port Blair were approved since it was increasingly clear that some sort of physical expansion woula eventually have to be provided if high standards of research were to keep pace with new development in zoology, to meet the growing demands of the future.

A plan for having an Aquarium-cum-Research Centre at Digha on the West Bengal coast was approved by the Government of India; 6.5 acres of land for this project was graciously gifted by the Government of West Bengal, besides 1.5 acres for staff-quarters.

(vii) Seventh Five-Year Plan, 1986-87 to 1991-92

In June 1986 Dr. B. K. Tikader relinquished charge of the Survey on his superannuation. Consequently Dr. Baldev Singh Lamba, Joint Director, shepherded the department.

A major programme relating to the Prevention of Coastal Pollution is to be initiated. The pollution impact on biological resources will be carefully analysed and realistic measures taken for their protection. The present Marine Biological station of the Zoological Survey of India at Madras will be suitably strengthened. In addition, collaborative programmes will be initiated with the Department of Ocean Development, the National Institute of Oceanography and other relevant agencies.

Data regarding trends in environmental quality would emerge from the monitoring of selected indicators such as extent of forest cover, extent of wasteland, rate of desertification, rate of change in population of endangered species, number of municipalities adequately treating effluents, pesticide residues in water bodies, incidence of acid rain, destruction of fertile land through urbanisation, etc. Much of this information will be generated under various sectoral programmes such as pollution control, etc. But the need for an umbrella structure such as a National Environmental Monitoring Organisation (NEMO) is clear, if environment related information from each sector is to be synthesised into a supporting framework for environmental impact assessment. The actual data storage and dissemination would be carried out under the computerised Environmental Information System (ENVIS). NEMO would have to use the professional expertise and infrastructure within the IITs, Universities, the various Surveys and other governmental and non-governmental organisations.

Natural Living Resources Conservation

There has been lack of adequate inputs of S&T in the natural living resources conservation programmes. This weakness will now be sought to be rectified through reorientation and strengthening of the work of the Botanical and Zoological Surveys of India (BSI, ZSI), and through the Man and Biosphere Research Programme, with particular emphasis on ecosystems approach. Traditionally, BSI and ZSI have been concerned with higher forms of life. Lower plants and animals, including micro-organisms (bacteria and fungi), though very important in ecosystem considerations, have not received due attention. In the Seventh Plan, work would be initiated in these gap areas. Apart from taxonomic investigations and publication of Flora and Fauna of India, BSI and ZSI will take up joint programmes for Survey of Living Resources and Ecological Mapping in collaboration with NRSA and related agencies. Intensive studies will be undertaken for ecosystem analysis of Conservation Areas like Tiger Reserves, Biosphere Reserves, National Parks and selected sanctuaries, for their actual biological content which needs to be conserved.

Programmes will be taken up on modernisation of taxonomic research and organising Biosystematic Centres using computerised facilities and involving multi-disciplinary approaches like cytogenetical, phytochemical, biochemical, ultrastructural, and other experimental techniques. BSI will prepare chromosome, pollen and seed atlases of Indian plants, while ZSI will prepare chromosome atlas of animal species, furatlases of fur animals and atlases of diagnostic morphological characteristics involving some important groups of wild animals of economic value such as turtles, snakes, large lizards, frogs, crabs, mussels, prawns, butterflies, etc.

Environmental Information

For environmental management, the availability of accurate and relevant environmental information is a crucial pre-requisite. Modern data storage and retrieval systems form important components of a scientifically managed environmental data base.

It is proposed to provide a thrust to this through the computerised Environmental Information System (ENVIS). This is a decentralised system with a network of Distributed Information Centres (DICs) on important subject areas in relation to environmental management. Besides strengthening the staff support of ENVIS, for facilitating a greater degree of information analysis and systematic dissemination, the network of DICs is proposed to be expanded. DICs have so far been set up in the fields of Pollution Control, Toxic Chemicals, Coastal and Offshore Ecology, Remote Sensing for Environmental Mapping, Environmentally Sound and Appropriate Technology, Environmental Impact Assessment, Biodegradation of Wastes and Eco-Toxicology. In addition, the following areas are proposed for establishment of DICs in the Seventh Plan: Plant and Animal Ecology, Forestry, Desertification, Urban Planning, Mining, Himalayan Ecology, Instrumentation, Renewable Energy, Health, Project Tiger and Wildlife. DICs are also to be set up in State Departments of Environment and in selected nongovernmental organisations.

The ENVIS Documentation Centre will be strengthened to serve as a Regional Documentation Centre on Environment for South Asia. This would add to its capacity to serve national users and also aid in the exchange of information among countries in South Asia. Through International Information, systems such as IN-FOTERRA, the Centre could be linked to the global network of environmental information systems.

A major programme for publication of environmental status reports, research and policy papers and journals/newsletters for widespread dissemination is envisaged.

The Botanical and the Zoological Surveys of India (BSI and ZSI) were restructured and their objectives redefined for a proper orientation towards ecology and conservation. The major activities of BSI have been the compilation of national and State flora and publication of Red Data Book, survey of plant resources and endangered species and studies on taxonomical, eth-nobotanical and geobotanical aspects. The ZSI undertook exploration and survey of faunal resources, augmentation of national zoological collections, status survey of endangered species, taxonomic studies and publication of fauna of India. Construction of a Marine Aquarium-cum-Research Centre at Digha in West Bengal is nearing completion.

8th Five-year plan 1992-93 to 1996-97

Overview

The scenario of environment and forests continues to cause concern. Destruction and degradation of forests are taking a heavy toll of our soil and water resources. An estimated 6000 million tonnes of top soil with essential nutrients are flowing into the sea every year. Loss of top soil, vegetative cover, unregulated surface run-off with poor recharge of aquifers seriously affect the society and in particular tribals. Overall degradation of nature is also making our resources less productive, leading to impoverishment of the rural population.

Much of the water resources and the air in the country continue to be polluted, affecting human health. Besides traditional domestic pollutants, there is increasing contamination by chemicals, heavy metals and other toxic substances which are thrown into the rivers and the sea due to careless industrial and agricultural practices. Unplanned urban growth and industrialisation are also increasing the levels of pollution.

This environmental degradation seriously threatens economic and social progress of the country. Our future generations may discover that life support systems have been damaged beyond repair.

The causes for environmental degradation are many. The prevailing conditions of poverty and underdevelopment themselves create a situation where people are forced to live in squalor and further degrade their environment. On the other hand, the process of development itself may damage the environment, if not properly managed. In the final analysis, removal of poverty, generation of employment, raising the levels of education and increasing awareness of the people are crucial for protection of environment.

Major Tasks

The major tasks for meeting this challenge are:

1.To protect the natural environment;

2.To regenerate and restore degraded ecosystems and increase their productivity and to generate employment through these activities;

3.To decentralise control over nature and natural resources;

4.To develop and share an understanding of nature and natural processes;

5.To formulate a national policy for environment and an appropriate institutional and legal framework in support of the policy;

6.To ensure co-ordinated and integrated Governmental action aimed at conserving nature and sustainable use of natural resources;

7.To make individuals and institutions more accountable to the people for their actions impinging on environment and ecosystem; and

8.To monitor the state of environment.

These tasks are not independent of each other, but complementary and sometimes overlapping. Many of them are already being performed by the Central and State Governments. However, much greater effort is called for, if the current trend of environmental degradation is to be reversed.

Ganga Action Plan

The Government of India had in February, 1985 set up the Central Ganga Authority with the Prime Minister as Chairman to oversee the implementation of the Ganga Action Plan in view of the magnitude of pollution of river Ganga. The objective of the Ganga Action Plan is to intercept, divert and treat the sewage flowing into the river with a view to improve the water quality and to compel the industries discharging their effluents into the river to conform to prescribed standards. Schemes of low cost sanitation, river front development and construction of electric crematoria are a part of the Action Plan. Two hundred and sixty one schemes spread over Uttar

Pradesh, Bihar and West Bengal have been sanctioned at a cost of Rs.256 crores. As many as 147 schemes were completed during the Seventh Plan. An independent evaluation of Ganga Action Plan - Phase I has been sought from the Ministry of Environment and Forests. A monitoring committee of Ganga Action under the Chairmanship of Member, Planning Commission has been operational during the Seventh five year Plan.

Forest and Wild Life Policy

A "National Forest Policy 1988" was formulated in December 1988 with the principal aim of ensuring environmental stability and maintenance of ecological balance. The Forest Conservation Act, 1980 was amended in 1988 to facilitate stricter implementation and to plug certain loopholes. The rate of diversion of forest land was brought down to about 0.017 million ha. per year from 0.15 million ha between 1951-52 and 1979-80. The loss of actual forest cover as per the interpretation of Landsat imagery made by the Forest Survey of India during 1987 and 1989 is indicated in table 4.2.

A modern Forest Fire Control Project, assisted by UNDP was implemented in Maharashtra and Uttar Pradesh with the objective of devising, testing and demonstrating the principles and techniques of prevention, detection and suppression of forest fires. A scheme on Development of Infrastructure for the Protection of Forests from Biotic Interference is under implementation in various States with a view to preserving and protecting the natural forest wealth and developing adequate infrastructure facilities.

Forest research, education and training have been reorganised to make them more relevant to the present requirements. The Indian Council of Forestry Research and Education has been constituted in order to provide impetus and thrust to research activities and education. Five new research institutes viz. Institute of Wood Sciences and Technology, Bangalore; Institute of Deciduous Forests, Jabalpur; Institute of Forest Genetics and Tree Breeding, Coimbatore;

Institute of Arid Zone Research, Jodhpur and Institute of Rain and Moist Deciduous Forest Research, Jorhat have been set up while retaining the prime role of the Forest Research Institute, Dehra Dun. Each Institute carries out national level research on one or more facets of forestry and also takes care of the regional needs.

The Indira Gandhi National Forest Academy (IGNFA) has also been established at Dehra Dun for the training of Forest Service probationers. A graduate course in the science of forestry has been introduced .in 14 State Agricultural Universities. Around 250-300 graduates benefit from the programme every year. The new complex of the Indian Institute of Forest Management (IIFM) at Bhopal was inaugurated in June, 1988, as an apex research institute in forest management in the country. The Forest Survey of India has been reorganised. It has completed the first stage of the Forest Report including the vegetation maps.

In view of the symbiotic relationship between the tribals and the forest, efforts have been made to associate tribals and other people living in and around forests in general for the protection and development of forests. A centrally sponsored scheme for plantation of minor forest produce including medicinal plants is currently in operation.

Implementation of the 10-point National Wildlife Action Plan (NWAP) has been started. The Wildlife Institute of India has published a comprehensive report incorporating a workable biogeographic classification system. It makes recommendations for a representative network of protected areas based on this classification to bring about overall improvement in protection and conservation of wildlife. Thirty National Parks and 75 Sanctuaries are being provided financial assistance by the Central Government. The number of tiger reserves rose from 15 to 18 in the Seventh Plan. These cover an area of 28,017 sq km located in 13 States.

9th Five-year plan 1997-98 to 2001-2002

Forests, Wildlife and Bio-diversity

Forests are important for maintaining ecological balance and preserving the life supporting system of the earth. They are essential for food production, health and other aspects of human survival and sustainable development.

Indian forests constitute 2% of the world's forest area but are forced to support 12% of the world's human population and 14% of world's livestock population. This is sufficient to indicate the tremendous biotic pressure they face.

Forests in India have been shrinking for several decades owing to the pressure of population on land for competing uses, such as agriculture, irrigation and power projects, industry, roads etc. In India, forests account for about 19.27 per cent of the total land area. On the other hand, in advanced countries, the area under forests is often about a third of the total land area. There is a need to have massive reforestation programmes, control over hacking and grazing and provision of cheap fuel through alternative technologies.

The National Forest Policy (1988) stipulates that a minimum of one-third of the total land area of the country should be brought under forest or tree cover. It is envisaged that this will be achieved by involving local stakeholders like the farmers, the tribals, the women, the NGOs and the Panchayat Raj Institutions (PRIs).

Another concern relating to the state of forest resources is that of bio-diversity and extinction of species. India has a rich heritage of species and genetic strains of flora and fauna. Out of the total eighteen bio-diversity hot-spots in the world, India has two, one is the north-east Himalayas and the other is the Western Ghats. At present, India is home to several animal species that are threatened, including over 77 mammal, 22 reptiles and 55 birds and one amphibian species. For in-situ conservation of biological diversity, India has developed a network of protected areas including national parks, sanctuaries and biosphere reserves. This network, which is being progressively expanded, now covers about 4% of the total land area of the country. As a result of the amendments in 1991 to the Wildlife (Protection) Act, hunting of all species of wild life for commerce or for pleasure has been banned.

10th Five-year plan 2002-2003 to 2005-2006

The thrust areas of the Zoological Survey of India during the Tenth Plan should include:

exploration survey of state fauna (district wise), studies on selected eco systems of the Indian region, survey of conservation areas including tiger reserves, taxonomic studies of faunal components, status survey of endangered species, chromosome mapping and DNA fingerprinting, Zoological Survey of India 45.00 Crores

11th Five-year Plan 2006-07 to 2009-2010

The Botanical and Zoological Survey of India are today facing major challenges in view of the new regime on genetic resources, provisions of the Biochemical Diversity Act, and fast evolving knowledge and information environment. Use of recent trends in organizing information and modern skills in exploration and documentation will be given priority. These institutions will develop into prime repositories of information on plants and animals, and as referral institutes. Collaboration and linkages with other institutions as part of a network will be encouraged.

12th Five-year Plan 2011-2012 to 2015-2016

After an in-depth analysis of the policies and programmes in the Environment, Forestry, Biodiversity, Wildlife and Animal Welfare sectors, 12 monitorable targets (Box 7.3) have been set for the Twelfth Plan. These include three targets in the areas of Environment and Climate Change, four targets in Forestry, three targets under Wildlife, Ecotourism and Animal Welfare, and two under Ecosystems and Biodiversity.

Infrastructure/Technology Upgrade and Investment Strategies

- Strengthening of Botanical Survey of India (BSI) and Zoological Survey of India (ZSI) in terms of manpower and infrastructure to scale up their mandated task of inventorisation of flora and fauna of the country needs to be achieved;
- Validation and updation of the Indian Biodiversity Information System (IBIS), the Indian Bioresource Information System (IBIN), India Biodiversity Portal (IBP) and the Indian Ocean
- Census of Marine Life (IOCoML) needs to be undertaken, for which a consortium of research organisations needs to be created;
- An effort to digitise and make available existing collections of taxonomic collections should be piloted;

• The mandate of different institutes engaged in forestry, biodiversity and wildlife research requires to be broadened to accommodate emerging needs for collaborative multidisciplinary research.

National Zoological Collections

The earliest scientific uses of natural history collections still constitute a prime reason for their existence. Collections are necessary for the solution of problems in both basic and applied sciences. To maintain natural history collections adequately are expensive, to neglect them is too costly and suicidal to contemplate. Modem procedures in taxonomy, combined with greater ease of data processing, not only allow but also demand the consideration of larger samples than in the past. Then too, as man modifies the earth with increasing vigor, species once so common are now found only in museum collections. Specimens that today may be considered for the trash could be our only pre-pollution (chemical-nuclear-thermal) record of a disappearing environment - a biological base-line of irreplaceable value. Natural History Collections, especially in a tropical country, require constant and continuous attention for their preservation, study and research to maintain them in a creditable and scientific condition.

The zoological collections of the Zoological Survey of India are those: (A) Inherited from the Indian Museum, Calcutta; and (B) The result of our own surveys.

A. Collections Inherited from ‘The Indian Museum’, Calcutta

These collections are derived mainly from the following sources:

(i) Old collections of the Asiatic Society of Bengal;

(ii) Marine collections made by successive Surgeon-Naturalists on board the R.LM.S. ‘Investigator’·

(iii) Collections made on certain military and political expeditions;

(iv) Gifts of private donors;

(v) Collections added by purchase; and

(vi) Collections made by officers of the Indian Museum.

(i) Asiatic Society’s Collections

The zoological collections of the Asiatic Society were mainly of vertebrate animals. Well-kno’¥n naturalists were contributors to its magnificient collections many of whom also to its publications: F.H. Stewart, J. Armstrong, Valentine Ball. W. H. Benson, William Blanford, Henry Blanford, W. E. Brooks, Theodore Cantor, John Cockbum, Francis Day, G. E. Dobson, H. H. Godwin-Austen, Thomas Hardwicke, Brian Hodgson, Edward Blyth, Allan Hume, Thomas Hutton, T. C. Jerdon, John McClclland, Geoffrey Nevill, Henry Nevill, J. T. Pearson, Ferdinand Stoliczka, Robert Swinhow, J. Coggin- Brown, W. H. Sykes, WiIliam Theobald, E. B. Sladen, S. R. Tickell, R. C. Tytler, John Anderson, James Wood-Mason, Reginald Warnefold, R. Beaven, etc.

Serious zoological investigations under the auspices of the Asiatic Society were started at the instance of Brian H. Hodgson (1800-1894), a British resident at Kathmandu (Nepal), whose researches on the fauna of Nepal afterwards became a classic of natural history. In the early days of his work in Nepal, Brian Hodgson presented many valuable specimens to the Society’s Museum. John McClelland’s tenure of the post of the Curator of the Asiatic .Society’s Museum was very short; he was apparently appointed to this post in 1839 and retired from it before Edward Blyth’s arrival in 1841. His account of the Cyprinidae or carps in the *Calcutta Journal of Natural History* is particularly noteworthy. Edward Blyth who was appointed Curator of the Asiatic Society Museum in 1841, collected and described the vertebrate fauna of the ‘Indian Empire’ and what he did in this period may be said to have laid the foundations of zoological study in India on a firm basis. In the 21 years during which Blyth was Curator, he formed a large and valuable series of specimens richly illustrative of the ornithology of India and the Burmese Peninsula, and other vertebrate collections of the Museum. To the invertebrates he paid comparatively little attention.

In the long list of donors the names of three distinguished members of the Geological Survey of India stand out. These are William Blanford (with which that of his brother Henry, meteorologist and conchologist, is often associated), Ferdinand Stoliczka and WiIliam Theobald. WiIliam Blanford is best known in connection with the ‘Fauna of British India’, the inception of which was due to his untiring efforts.

To this series he himself contributed the volume on the Mammals and two of the four volumes on Birds. The first volume on the Mollusca which he had begun but left unfinished was completed by Col. H. H. Godwin-Austen. His private collections, gathered together in the course of his geological work in Iran and Ethiopia, and in Orissa and other parts of India, were gifted to the Indian Museum in which the majority of his Types of vertebrates are still in our repository. Ferdinand Stoliczka had an even wider outlook on the animal kingdom than Blanford his investigations had reference to still more diverse groups of animals. In the early days of his work in India, Stoliczka sent the zoological specimens he obtained to Vienna, where several of his Types of reptiles are still preserved, but later on presented the many invaluable collections he made in the East to the Asiatic Society's museum or, later, to the Indian Museum, to which he bequeathed the specimens in his possession at the time of his death. He described a long series of Indian and Malayan molluscs, frogs and reptiles. WiIIiam Theobald's work on the reptiles and the molluscs is of enduring importance, and the collections he made are still of very great value.

With the names of the above donors Blanford, Stoliczka and Theobald must be joined that of Francis Day, Geoffery Nevill and H. H. Godwin-Austen. Francis Day's relentless pursuit of a hobby earned him not only recognition, but also an official post, that of Inspector-General of Fisheries. India owes its still most comprehensive treatise on fishes *(The Fishes. of India)* to him. Day donated some of his fish specimens (about 700) to the Asiatic Society from October 1866 LO June 1873, but his major collection of fishes comprising about 3000 specimens were, however, purchased by the Trustees of the Indian Museum during 1876-79 at a cost of £380. Geoffrey Nevill, who after the foundation of the Indian Museum as a separate institution was its Assistant Secretary and Librarian therein, donated his excellent collection of shells. H. H. Godwin-Austen, a veteran zoologist and geographer, presented his valuable zoological collections from Assam and Burma to the Society.

Collections of the R.I.M.S. *Investigator* etc

The R I.M.S. *Investigator* made biological collections in the Indian and adjacent seas during 1884-1926 and the collections were deposited in the Indian Museum. The *Investigator* collections are of unique importance as we have here specimens of the abyssal fauna of the Indian Seas, the majority of which came from depths varying from 100 to 1900 m. In the year 1898 the Trustees of the Indian Museum published the first of that series of comprehensive monographs dealing with the various groups of Indian marine animals, that has made the name 'Investigator' so famous in zoological literature.

Valuable collections of large rays from the Bay of Bengal, as well as many representatives of the sponges, coelentrates, molluscs and crustaceans characteristic of its shallow waters, were obtained in 1908-09 by the Bengal Fisheries Steamer 'Golden Crown'.

Collections made on certain military and political expeditions

Valuable collections of both the land and freshwater fauna were obtained during several military and political expeditions, notably during:

(a) Two Expeditions to Yunnan, 1868 and 1875

Dr. John Anderson took a prominent part in both expeditions as a .naturalist. The zoological collections formed the basis of extensive research and the results were published in two large volumes under the title 'Anatomical and Zoological Researches : comprising an account of the zoological results of the two expeditions to Western Yunnan in 1868 and 1875; and a monograph of two Cetacean genera, *Plantanista* and *Orcella'*, The fate of a considerable proportion of the collections is still unknown, but those specimens that remain are of great importance and value, including as they do many types and several unique specimens.

(b) Persian Boundary Commission, 1870-72.

The zoological results of this expedition were published by William Blanford in 1876 in the second volume of 'Eastern Persia' (London: Macmillan and Co). With a few exceptions, invertebrates were not collected; the fish are discussed by J. Travis Jenkins in Vol. 7 of *Records.*

(c) The Second Yarkand Mission, 1873-74.

Dr. F. Stoliczka made a very rich collection of vertebrates of all groups, and also a very valuable set of beetles and spiders during this expedition. The different groups were fully worked out by leading scientists of the time, and large numbers of new species were described and the majority of the types were deposited in the Indian Museum; the fate of the spider types is, however, unknown.

(d) The Dafla Expedition, 1874-75

Godwin-Austen's collections from east of Bhutan included numerous examples of rare or almost unknown beetles, lizards, crustaceans and mammals.

(e) Afghan Delimitation Commission, 1885

Dr J. E. T. Aitchinson collected a large number of both vertebrates and invertebrates, on which he published a report in 1887. On this expedition Capt.C. E. Yate obtained a series of mammals which were described by J. Scully in the *Journal of the Asiatic Society.* Capt. Yate's specimens were presented directly to the Indian Museum but of the larger and more general collections, only duplicates were sent to the Indian Museum.

(f) The Pamir Boundary Commission, 1896

The collection from the Russian frontier on the Pamirs was obtained by Lt. Col. A. W. Alcock who served as Surgeon- Naturalist with this Commission. Though small, the collection is valuable chiefly on account of the fishes and the butterflies. Alcock (1898) described his zoological work in his 'Report on the Natural History Results of the Pamir Boundary Commission'.

(g) **The Afghan-Baluch Boundary Commission, 1896**

This expedition, under the command of Sir Henry Mc Mahon, collected several new species of fishes from the Helmand Basin. Most of the specimens were deposited in the Indian Museum.

(h) The Tibet Frontier Commission, 1903-04

On the military expedition to Lhasa in 1903-04, a comparatively small number of duplicates only of zoological specimens were deposited in the Indian Museum. Several of the medical officers, however, who were stationed at Gyantze presented valuable collections. Special mention in this connection may be made of Capt. F. H. Stewart, the results of whose work in Tibet on the aquatic fauna were published in the *Records* in 1911 and 1912.

(i) The Seistan Arbitration Commission, 1903-05.

The above expedition on the Afghan frontier was under the command of Sir Henry Me Mahon who took great personal interest in the specimens obtained.

(j) The Abor Expedition, 1911-12.

Dr. S. W. Kemp's collections from east of Bhutan were of exceptional interest, more specially as regards the lower vertebrates, the earthworms, molluscs, land planarians and other aquatic groups. The unique discovery of this expedition was "*Typhloperipatus williamsoni*" . a new genus and species of that peculiar group the Onychophora, intermediate in several respects between the arthropods and the annelid worms.

(k) Private Donors.

Among the private donors to the Indian Museum, a-considerable number have already been mentioned in reference to the collections of the Asiatic Society, and to those made on certain military and political expeditions. The collections that the Museum owes to private donors are chiefly representatives of localities or districts rather than of special groups of animals, Some of the notable donors whose names may be specially mentioned are Mr. S. E. Peal (a tea planter of Sibsagar, Assam); several of the Hooghly pilots, notably Messrs W. M. Daly, A. J. Milner and J. Barnet, at the mouth of the Ganga R.; Lt. Col. A. R. S. Anderson from the Andaman and Nicobars, particularly the invertebrates; and C. G. Rogers from the hill ranges of Burma.

(l) Acquisitions by Purchase.

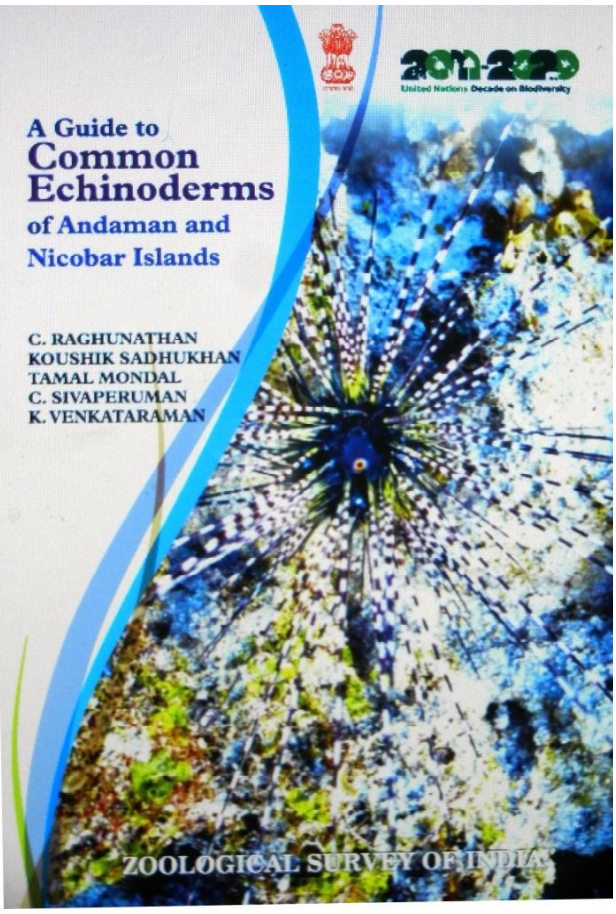
Several valuable collections, such as Francis Day's collection of Indian fishes, Lionel Niceville's collection of butterflies and Dudgeon's collection of moths, etc. were purchased by the Trustees of the Indian Museum.

(m) Field-work of the Staff.

Two main objectives were kept in view during their field work- to obtain material from a survey of the fresh and brackish water fauna of different parts of India, and to elucidate and illustrate the precise distribution of the Indian representatives of several groups, more particularly the Crustacea, Coleoptera, Arachnida, Reptiles and

Batrachians; the birds and mammals were perforce neglected due to inadequate staff. James Wood-Mason, who had taken a very prominent part in the foundation of the biological work of the *R.I.M.S* ***Investigator,*** surveyed the Indian marine and freshwater Crustacea. John Anderson undertook on his own account an expedition to the Mergui Archipelago, the zoological results of which were fully described in two special volumes of the *Journal of the Linnean Society;* the valuable collections he made were sent to the Indian Museum but a certain proportion of it was lost at that time. Frank Fine and Nelson Annandale collected several interesting specimens from the Andamans and in the Gulf of Mannar region. The number and importance of the specimens collected in those groups on which special work has been done in connection with the Museum, had been clearly shown in the papers published in the *Records of the Indian Museum* and a few volumes of the *Journal of the Asiatic Society of Bengal,* besides those of the official *Fauna of British India* edited and published in England:

(n) Collections built up as a result of our Own Surveys



The most important additions are those obtained as a result of our own surveys in various parts of the country, the systematic exchange of specimens with museums throughout the world and also through the generosity of private donors; 966 taxonomic categories of different groups of animals have been described and added to the collections; examples of 2200 species not represented earlier in the collections, were either collected or acquired by exchange. The importance of the collections as biological standards was recognised by the Government of India and, therefore, declared them as the National Zoological Collections *vide* a gazette notification dated 11 th July, 1964*. The National Zoological Collections which till the year 1966 totaled 7,69,578 identified specimens, gradually crossed the one million mark of which about 15,000 specimens are primary types. The Types were segregated in recent years into separate Accession Type-Registers at the instance of Dr. B. K. Tikader. A plan for a ready reference to original accounts of the numerous animals discovered from the Indian subcontinent has been chalked out, something for which the scientists have always felt a great need. A comprehensive scheme has been initiated to computerise our holdings of the Types and the information associated with them.

Few museum administrators or systematists would propose a halt to collection growth. The problems then are how much should collections grow and how can they efficiently be used and maintained?. Much of the ultimate value of collections lies in what we do not know about them. Given such a situation, the specialists educated guess is our best guide as to what and how much to save. Regarding our present level of systematics, there is no doubt that collection size must not remain on a plateau based on present holdings. Expand they must. Surveys shall have to continue for the animals we never catch, it's those we miss that lure us back again. With the increase in collections, it is no longer a case of taking whatever is collected. From February 1989 it is quality rather than quantity that matters. As collection becomes more complete, it is naturally more difficult and expensive to fill the lacunae.

Publications

The Zoological Survey of India inherited two series of publications from the Zoological and

Anthropological Section of the Indian Museum, namely:-

Records of the Indian Museum and **Records of the Zoological Survey of India**

The Records of the Indian Museum served as a vehicle for publishing zoological research articles even before the establishment of the ZSI. At one time, it was the only journal for publishing taxonomic research papers, descriptions of new species, new records, revisionary studies, etc. for scientists of the ZSI. The first issue was published in 1907. After India's independence, the ZSI published 88 issues of the Records of the Indian Museum in 21 volumes. After 1962, the journal was renamed the Records of the Zoological Survey of India.

The Records of the Zoological Survey of India is a quarterly in-house journal now. It is a medium for zoological communications related to taxonomy, faunistics, biology, ecology and populations of all taxa. Since 1947, 168 issues of the Records of the Zoological Survey of India have been published in 67 volumes.

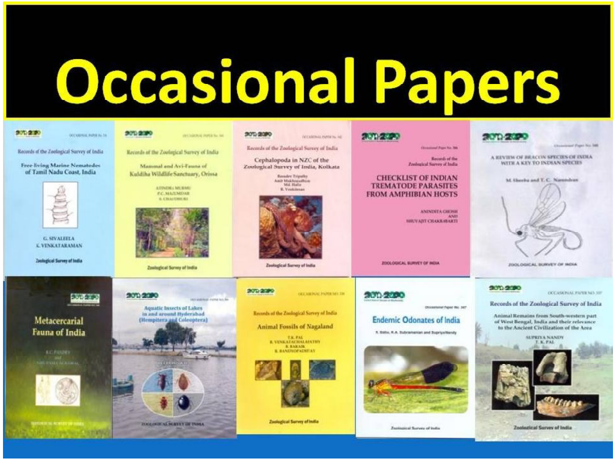
Memoirs of Indian Museum and **Memoirs of the Zoological survey of India**

The Memoirs are for publishing works on the systematics, phylogeny and biogeography of a group of animals or of groups of animals occurring in an ecologically defined area and any other work of a monographic nature. It is an occasional publication, brought out depending upon the availability of material. It was started in 1907, before the establishment of the ZSI. After India's independence, the ZSI has eight issues of the Memoirs of the Indian Museum in two volumes.

After 1968, the name was changed to Memoirs of the Zoological Survey of India. Since 1947, 31 issues of the Memoirs of the Indian Museum/ Memoirs of Zoological Survey of India have been published in eight volumes.

Occasional Papers

This series is used to publish under a separate cover findings related to particular topics and animal groups, district faunas, checklists and other lengthy taxonomic research papers that cannot be accommodated in the Records of the Zoological Survey of India. Publication of this series began in 1976, and so far 335 numbers have been published.



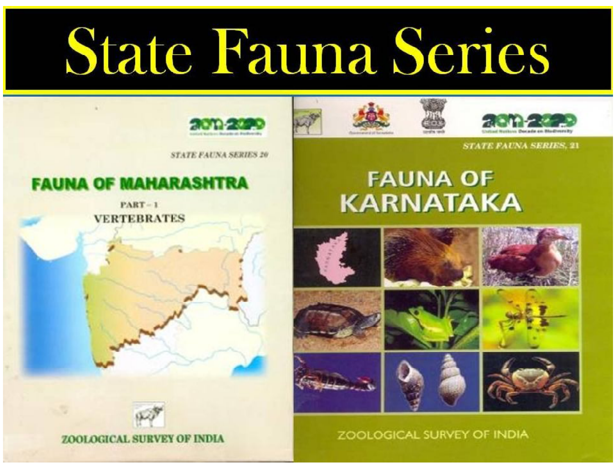
Fauna of British India and **Fauna of India**

Ninety one volumes of '**Fauna of British India**' on different groups were published before independence. This programme was re-oriented in 1975 as 'Fauna of India'. Since then 52 volumes have been published.

Under this Series, a consolidated and up-to-date Taxonomic/systematic account of different groups of animals, based on detailed studies, are undertaken by the Scientists of eminence, who have worked on that group for more than two decades. The fauna volumes provide identification keys and distribution ranges of the species and genera belonging to a particular animal group. These volumes not only provide an inventory of the various taxa of that animal group within Indian region but also their distribution in whole of Asia and the World.

State Fauna Series

ZSI headquarters in collaboration with its 16 Regional Centres located in various parts of the country has undertaken intensive and extensive survey programmes on the faunal resources of various States of India and collected and documented the baseline data. The first of the



series: State Fauna of Orissa was published in 1987. These published documents on fauna have been realised to be highly useful not only to the research workers but also to the state governments to assess/monitor the faunal wealth of their states. The faunal documents also help in EIA works/study as the base line data. The State Fauna series of the 22 States have been published; survey, study and documentation of the fauna of other four states are being completed; and the Survey and faunal inventorying works of three states are in progress.

Conservation Area Series

This series of publication was started to survey, study and document the fauna of reserve forests of our country in order to suggest the conservation measures based on the monitoring and inventorying works. The Fauna of Nanda Devi Biosphere Reserve was the first published in the series in 1987. So far 44 publications have been brought out under this series.

Ecosystem Series

The series was started in the year 1992 to study the different ecosystems of the country viz. Estuarines, Wetlands, Himalaya, Marine, etc. The survey/ exploration, study and documentation of the faunal resources of many more ecosystems are yet to be undertaken under this programme. A total of 23 publications have been published as listed below:

a. Estuarine Ecosystem Series (First Published in 1992); 6 books

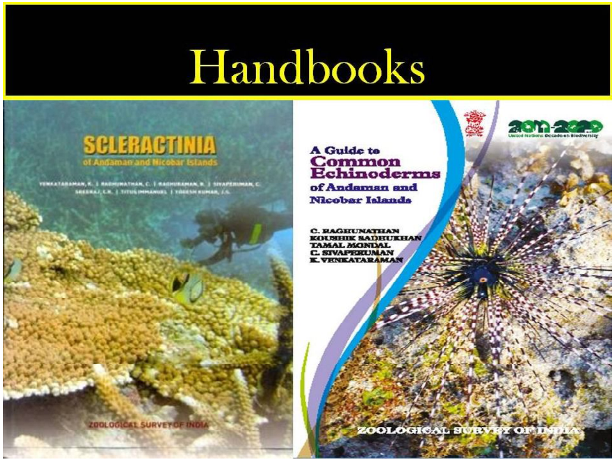
b. Wetland Ecosystem Series (First Published in 1995); 14 books

c. Himalayan Ecosystem Series (First Published in 1995); 2 books

d. Marine Ecosystem Series (First Published in 2007); 1 book

Handbook and Pictorial Guides

The ‘Handbook series’ publications are identification manuals of major groups of animals with keys and illustrations. The handbooks are important tools to help in distinguishing and identifying the species of different animal groups. Pictorial handbooks with colour photographs were also published for common people to generate interest towards fauna of the country. The first handbook on Indian Thysanoptera was published in 1980. So far 48 handbooks have been brought out.



Special Publications

ZSI has been publishing special publications on proceedings of symposia, seminars and workshops, etc., conducted by the Survey, and books of important and valued nature. The publishing of special publications was started with the first book ‘State of Art report – Zoology’ brought out in 1980. 45 publications have so far been published under this series, some of which are as important as the ones like: Faunal resources of India, Red Data Books, Environmental Awareness, Ecosystems of India, Geo Spatial Atlas of Birds of Rajasthan, etc.

Status Survey of Endangered Species

The publication of this series was started with an aim to survey and monitor the status of critically endangered species and threatened species of India. So far 11 documents on status of animals have been published.

Technical Monographs

Transfer of the Survey to the Department of Environment made it necessary for the activities to be more elaborative, with the inclusion of the applied nature of works also, and the results are published under this series. Its publishing was started in the year 1978, and was discontinued in the year 1987 during which 17 monographs were published.

Zoologiana

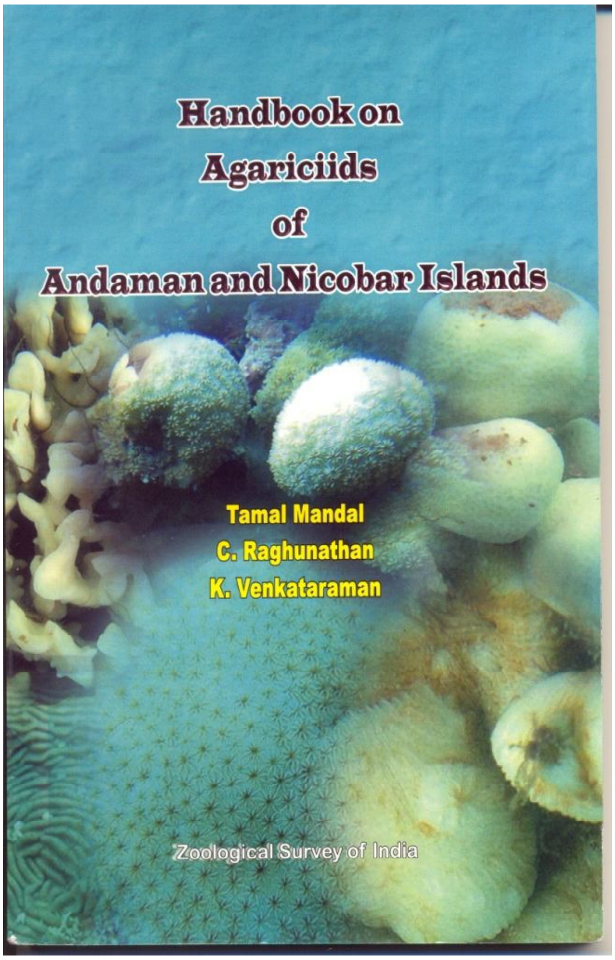
It is a semi-popular journal for publishing accounts of the general nature of faunal resources, conservation of wildlife, etc., on the basis of work done at the Survey. This journal was started in the year 1978 and, after publishing 5 volumes, was discontinued in the year 1990.

Bulletin of Zoological Survey of India

This journal started in the year 1978 as a house journal was meant to cater to the growing diversity in zoological research undertaken in the Survey. The journal provided the researchers opportunities to publish the short-length papers, or communications of the research findings, especially to facilitate the quick and easy publication of new taxa, records and other findings. Till it was discontinued in the year 1987, 8 volumes, each in three parts, were published.

Library

A commodious and well equipped library occupies about 7650 sq ft of floor space on the first floor of the Indian Museum, Calcutta, besides the small libraries maintained by the Survey's regional centres. The library has outstanding collection of literature in taxonomy, ecology, biology, wildlife, marine biology and zoogeography. It also specialises in publications on fisheries, public health and hygiene, forestry and veterinary. The library currently receives nearly BOO serial titles and has a catalogued collection of 85,000 volumes, as well as extensive Reports, a Maps and Charts Collection, and a Rare Book Collection, with numerous accounts and journals of famous voyages of discovery. The initial collection of 12,000 volumes in the library which was transferred to the ZSI from the Indian Museum in 1916, was got together by the energetic Librarian, Mr. C. O. Bateman. Since that date, roughly 1000 volumes have been added every year. The personal library of the late Dr. G. D. Bhalerao was a notable acquisition during the 1950s. The library was completely disorganised and virtually in shatters after the Varuna floods in 1943, but due to the sagacity, diligence and conscientious supervision of Shri Suresh Chandra Roy Choudhury and Shri Samarandu Ghoshal, the library was set in order and the books reconditioned in record time. So sincere and dedicated was Ghoshal Babu to his books that if any reader by chance should happen to drop a book, he would, in a fraction of a second, be by the reader's side with an anxious look.



There is no up-to-date printed catalogue of the books in the library, but a list of the serials available may be found in S. W. Kemp's 'Catalogue of the Scientific Periodicals in the Principal Libraries of Calcutta', S. K. Tandon's 'Catalogue of Scientific Journals in the Library of the Zoological Survey of India, Calcutta' and also in 'National Union Catalogue of Scientific Series' (4 Vols).

The library is at the service of every naturalist. In order to meet the increasing demand for up-to-date informations on taxonomic literature, a beginning has been made to build up an-Information Retrieval Service. Reprographic facilities such as xeroxing, microfilming, etc. are available. In addition, the Survey has launched a major programme to microfilm old and fragile treatises, and many zoological treatises several of which are out of print.

The emergence of computers in the library and bibliographic information processing area has caused a revolutionary change in housekeeping routines and information storage and retrieval functions. A concept of Computer Networking of Science and Technology Libraries of Calcutta (CALIBNET) has recently been initiated at the Headquarter's library for symboitic capabilities of computerised library and information systems, bibliographic databases and networks on sharing of resources amongst libraries, against the background of pecuniary pressure suffered by them from spiralling cost of scientific literature coupled with shrinking library budget.

Directors of Zoological Survey of India

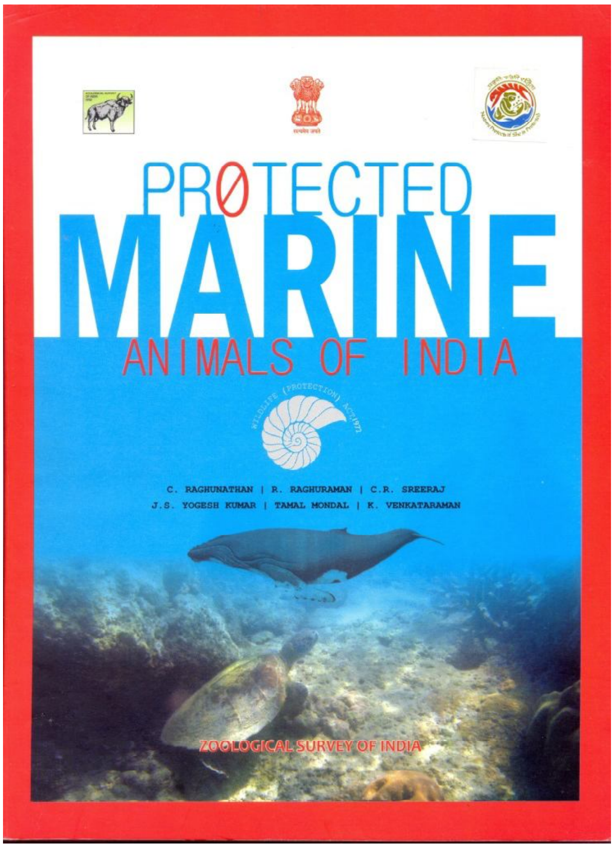
The distinguished occupants of the post of Director, Zoological Survey of India were/are as follows:

1. Dr. T. N. Annandale 1916 - 24
2. Dr. S. W. Kemp 1924
3. Lt. Col. R. B. S. Sewell 1925 - 33
4. Dr. B. Prashad 1933 - 44
5. Dr. B. N. Chopra 1944 - 47
6. Dr. S. L. Hora 1947 - 55
7. Dr. M. L. Roonwal 1956 - 65
8. Dr. A. P. Kapur 1966 - 73
9. Dr. T. N. Ananthakrishnan 1977 - 80
10. Dr. K. K. Tiwari 1980 - 81
11. Dr. B. K. Tikader 1981 - 86
12. Dr. M. S. Jairajpuri 1989 - 1992
13. Dr. A.K. Ghosh 1992 - 1996
14. Dr. J.R.B. Alfred 1996 - 2007
15. Dr. Ramakrishna 2007 - 2010
16. Dr. K. Venkataraman 2010 - 2015

The prestige the Zoological Survey of India now enjoys is surely due overwhelmingly to the sagacity and farsight of these dedicated and gifted men - who were directly responsible for the conduct of its affairs over the years - and those who nurtured it with their pioneering attainment in the field of natural history and with their original scientific contributions. Science has a right to know who and what the zoologist has been and under what circumstances he lived and worked. Biographical sketches of these distinguished scientists are given on the following pages. The sketches drafted here are far from complete, being compiled from available sources and also from information. kindly provided by some of whom we are fortunate in still having amongst us and who continue to foster the growth and development of the Survey.

Vision 2020

The Zoological Survey of India (ZSI) was established in 1916, with a view to explore and identify the faunal resources (faunal diversity) of the country and to document the base line data with regards to taxonomy, distribution, bio-ecology, etc., of the animal groups. During the last 95 years and particularly from the Second Five Year Plan period, the ZSI has grown from a small unit at the Indian Museum, Calcutta, to a premier National Institution with 16 Regional



Centres spread across the country, with its Headquarters at Kolkata. Over the successive plan periods the functions of ZSI have also expanded gradually encompassing areas like the Environmental Impact Assessment with regard to fauna; survey of Conservation Areas; Status Survey of Endangered Species; Computerization of data on faunal resources; Environmental Information System (ENVIS) on faunal diversity, etc. The Organization also has a regular Training and Extension wing for generating public awareness for the conservation of environment and wildlife by conducting exhibitions, training programmes and interacting with different Government and NGO organizations, universities, colleges, schools and the stake holders.

The Zoological Survey of India also acts as a custodian of the National Zoological Collections which comprise more than two million specimens belonging to some 81,000 species including about 10,000 species of our neighboring countries like Myanmar, Pakistan, Bangladesh, Sri Lanka and also of Thailand.

The objectives and functions of ZSI were reviewed in 1987 and redefined in 1991. However, the scope and functions of ZSI have been considerably expanded, particularly in the light of the Convention on Biological Diversity, ratified by Govt. of India in 1994. The revised priorities of work suggested by the department were approved by the Ministry of Environment & Forests, Govt. of India, with the target proposed up to 2000 A. D. which was further reviewed by the Programme Advisory Committee (PAC) during 2001 with new directives. In the light of the above, the objectives and implementation strategies for the Eleventh Five Year Plan are redefined as follows.

A. Primary Objectives

1. Exploring, Surveying, Inventorying and Monitoring of faunal diversity in various states, selected ecosystems and protected areas of India.

2. Taxonomic studies of the faunal components collected.

3. Status survey of Threatened and Endemic species.

4. Preparation of Red Data Book, Fauna of India and Fauna of States.

5. Bio-ecological studies on important communities/species.

6. Preparation of database for the recorded species of the country.

7. Maintenance & Development of National Zoological Collections.

8. Training, Capacity Building and Human Resource Development.

9. Faunal Identification, Advisory services and Library Services.

10. Publication of results including Fauna of India, Fauna of States and fauna of Conservation Areas.

B. Secondary Objectives

1. GIS and Remote Sensing studies on recorded animal diversity as well as on threatened species.

2. Chromosomal Mapping and DNA fingerprinting.

3. Environmental Impact Studies.

4. Maintenance of Musea at Headquarters and Regional Centres.

5. Development of ENVIS and CITES Centers.

6. Research Fellowship, Associateship and Emeritus Scientists Programme.

7. Collaborative research programmes on Biodiversity with other Organizations in India and abroad.

NEW PROGRAMMES

1. Surveying and Inventorying the Marine faunal diversity.
2. Establishment of a new unit of ZSI at Jamnagar, Gujarat, to assess the faunal diversity of Marine Protected Area and Hot Desert ecosystems.
3. Establishment of new unit of ZSI at Gangtok, Sikkim, to assess the faunal diversity of Kanchenjunga Biosphere Reserve, monitor the diversity and distribution of the faunal elements of the Eastern Himalaya which is one of the global Hot Spots of biological diversity, in India.
4. Monitoring the status of selected animals included in the Wildlife Schedules.
5. Development of Taxonomic expertise in the form of Human Resource Development and database.

Strategy

In order to achieve the above objectives, strategies including approach, coverage and manpower deployment have been examined and the appropriate methodology has been evolved. These will be adopted as proposed below:

Surveying, Inventorying and Monitoring of faunal diversity in various states, selected ecosystems and Protected Areas of India.

ü The objectives of the programme are to explore the faunal resources of various States and Union territories of India, selected ecosystems and conservation areas.

ü Nearly 80 % of the freshwater fishes and amphibians have been surveyed and documented, reptiles, birds and mammals have been covered to the maximum extent, Invertebrates need to be investigated from the vast area of the country measuring nearly 32,89,263 km^2.

Vision Statement

Taxonomy towards sustaining biodiversity/faunal diversity.

Mission statement

Our Mission is to contribute towards the judicious conservation of the faunal resources of the nation by conducting explorations, undertaking taxonomic identifications and also documenting the country's vast diversity.

Vision 2020.

Vision 2020 is the proposed action framework of ZSI till 2020.

Goals/Objectives of Vision 2020

1. Strengthening the faunal inventorying of the nation
2. Integration of studies on Invasive Alien fauna of India
3. Development of Regional/national faunal databases
4. Digitisation of Natural History Collections
5. Introduction and integration of cyber taxonomy
6. Integration of DNA finger printing studies on relevant taxa
7. Establishment of GIS cell in the Zoological Survey of India
8. Launching Major Taxonomic Initiatives
9. Capacity Building in Animal Taxonomy in India

Why this Vision document?

Biodiversity is considered as a nations' natural resource and is critical to human sustainability. Taxonomy is the science for documenting biodiversity globally, it is the key science needed to identify a species and to describe an unknown species (Kim and Byrne, 2006). We can only benefit from natural resources if they are known to us and we can conserve and protect only those natural resources that we are aware of. To determine what is being lost, we must have some idea of what is available at any point of time. Maintaining a ledger that lists inventory is a basic responsibility that companies owe to their shareholders. (Sharkey, M.J, 2001). Every nation should have an inventory of its natural resources or biotic assets.

The Zoological Survey of India (ZSI) is the premier taxonomic organization of the country to explore and identify its faunal resources. Vision 2020 is intended to serve as a help guide for ZSI, to attain the goals decided upon for the next 10 years. This framework focuses on 9 different areas of action and is developed to achieve better planning so as to ensure a systematic implementation to achieve targets in time.

This document is developed in accordance with the various legislations that have been enacted and policies and action plans at the National Level and also the recommendations as well as reports of the special task force constituted at the National level, that have direct relevance with the faunal diversity of the country. {The (Wildlife (Protection) Act 1972, Biological Diversity Act

(BDA), 2002, Coastal Regulation Zone Notification 1991, National Forest Policy (NFP) 1988, National Environment Policy (NEP) 2006, National Biodiversity Action Plan (NBAP), 2008, National Action Plan on Climate Change (NAPCC) 2008, India's Fourth National Report to the Convention on Biological Diversity, 4th report 2009, Report of the Task Force on Mountain Ecosystems and also on Grasslands and Deserts by The Planning Commission (Environment and Forests Division) 2006, National Report on Wetlands 2009].

References:

1. Sharkry, M.J. 2001. The All taxa biological Inventory of the Great Smoky Mountains National Park. *Florida Entomologist* 84(4): 556-564.

2. Kim Ke Chung, Loren Æ Byrne B, 2006. . Biodiversity loss and the taxonomic bottleneck: emerging biodiversity science. *Ecological Research* 21: 794–810.

1. Strengthening the Faunal Inventorying of the nation

The schemes and steps in Faunal Inventorying are revised and redefined in accordance with the legislations and national policies dealing on the conservation of natural resources and sustainable development of the country.

Major ecosystems in India are listed and the role of ZSI in conservation of each ecosystem is defined. Standardised survey procedures and methodologies are also included.

1.1 Survey groups and survey units

ZSI has primarily been involved in developing a faunal inventory of the country and the approach has always been an 'All Taxa Faunal Inventory'.

Documentation of the diversity with regard to well known taxa such as Aves and Mammalia among vertebrates and butterflies (Lepidoptera: Rhopalocera) and dragonflies (Odonata) among invertebrates are relatively easily achieved, but is an uphill task in the case of lesser known groups among invertebrates, where the magnitude of the diversity is very high and the taxa are rather poorly studied. The inventorying of the fauna is very much taxon dependant and is achieved through organized repeated sampling and ad hoc collecting.

· Various Ecosystems (Annexure 1) in the country are prioritised and are surveyed by the organisation in part or entire and a faunal inventory of multiple taxa in a region or habitat is brought out, through a series of publications.

· Lesser known taxa as in the case of most of the invertebrates are aimed to be dealt with in detail through Taxonomic studies and the research findings be published through a series of taxonomic monographs

· The survey units chosen are ecosystem based and are geopolitical or conservation areas or other areas of special ecological /geological significance

· The regions once surveyed if needed will be revisited after a gap of 10 years (varying as per the groups) for necessary revalidation of the results

· The taxa dealt are usually in line with the available taxonomic expertise.

· Methodologies and procedures specifically standardized for a taxon are to be employed in a uniform way during survey and sampling.

· Though the organisation uses classical taxonomic procedures for its routine identifications, this is supplemented by standard molecular and ecological techniques, as and when the situation demands.

1.2 Ecosystem based surveys

The faunal wealth of the country is assessed by ZSI by conducting numerous intensive and extensive faunistic surveys, which are usually ecosystem centered. The five major ecosystems of the world (Coastal ecosystem, Forest ecosystem, Freshwater system, Grassland ecosystem and Agroecosystem) account for about 90 percent of the earth's land surface, excluding Greenland and Antarctica (The Pilot Analysis of Global Ecosystems (PAGE- WRI, 2000). ZSI has been surveying the representatives of these ecosystems in India. In addition, the Himalayan ecosystem, the Desert Ecosystem and the Marine ecosystem of the country are also surveyed. Since Wetlands in India include both marine and freshwater habitats, this ecosystem is often dealt separately. In case the area chosen are geographical, limited by political boundaries or in case they are areas of Conservational importance, the survey units within the area are chosen based on the ecosystems already mentioned.

1.3. Major Ecosystems, their survey and the roles of ZSI in their conservation

1.3.1. Forest ecosystems

Forests are terrestrial ecosystems dominated by trees, where the tree canopy covers at least 10 percent of the ground area. Forests contain the greatest assemblages of species found in any terrestrial ecosystem, and the status of biodiversity is, in itself, an indicator of forest condition (PAGE, 2000). Large scale influences by man over the time has led to a decrease in both the spatial extent as well as the biological condition of forests. The deforestation and extinction rates are quite high in the tropical forests, where genetic and species diversity are the highest.

National Forest Policy (NFP, 1988) aims at maintaining a minimum of 33% of India's geographical area under forest and tree cover. Legal protection of forested land is often very much significant for conservation purposes. Currently India has 23.39% of its geographical area under forest and tree cover. In India forests come under 16 major forest types and 251 subtypes. 661 Protected Areas (PA) established under the Wildlife (Protection) Act (WPA) 1972, cover approximately 4.80% of the total geographical area of the country. The topical evergreen forests of the two major biodiversity hotspots in India the Himalaya and the Western Ghats–Srilanka are known centres of faunal richness and endemism.

Legislations and action plans like Biological Diversity Act (BDA), 2002, National Wildlife Action Plan (NWAP) (2002-2016), National Environment Policy (NEP) 2006, National Biodiversity Action Plan (NBAP), 2008 and

National Action Plan on Climate Change (NAPCC), 2008, ensure conservation and sustainable use of biological resources (India's Fourth National Report to the Convention on Biological Diversity, 4th report, 2009).

Role of ZSI in conservation of forests

The faunal components of a forest are totally dependent on its floral counterpart, and are indicative of the latter. Hence the measures of general biological conditions of the forests and the impact due to human modifications can be interpreted to a large extent based on the data on the diversity of faunal species. Developing a standardized baseline inventory of the forest fauna, along with depictions on their abundance status are essential for conservational needs and also to develop estimates on species extinction. The taxonomic strength of ZSI can contribute to

·Develop baseline inventory of faunal diversity of different ecoregion based forest types

·Identify species that can serve as indicators of diversity of other taxa

·Inventorying species based on elevational and topographic parameters

·Periodic monitoring of the population status of threatened/endangered species

·Develop detailed faunal inventory of Conservation Areas

Reference:

http://www.wri.org/publication/pilot-analysis-global-ecosystems-forest-ecosystems, http://pdf.wri.org/page_forests.pdf

1.3.2. Himalayan ecosystem

The Himalayan ecosystem is fragile and diverse. The Indian Himalayan Region (IHR), administratively covers 10 states entirely (i.e., Jammu & Kashmir; Himachal Pradesh; Uttarakhand; Sikkim; Arunachal Pradesh; Nagaland; Manipur; Mizoram; Tripura; Meghalaya) and two states partially (i.e., the hill districts of Assam and West Bengal) and over four Biogeographic zones *viz*., the Indian Trans-Himalaya, the Greater Himalaya, North-east India and parts of Upper Gangetic and entire Brahmaputra flood plains

The Task Force Report on Mountain Ecosystems, by The Planning Commission (Environment and Forests Division) 2006, helps to identify the gap areas in our knowledge regarding faunal diversity of this region. As per the report, data regarding smaller mammals, reptiles, amphibians, and fishes are much scanty, the insect diversity of this region have been largely ignored, with the exception of a few studies of the Himalayan Lepidoptera. Since the system of cultivation in the area is mainly slash and burn, the Jhum system, how the practice affects the faunal elements in the agroecosystem (soil as well as the aerial forms), will be worth exploring.

Recognizing the importance of the Himalayan region as a unique repository of biodiversity, especially the Eastern Himalaya, and also considering the regions' sensitivity to climatic and anthropogenic changes, a 'National Mission for Sustaining the Himalayan Ecosystem' has been constituted in 2010. One of the issues of the mission is to address Biodiversity conservation and protection.

Role of ZSI in conserving Himalayan Ecosystem

As a consequence of climate change, a change in distributional pattern of vegetation, with species in high-elevation ecosystems shifting to higher elevations (Escalator Effect) has already been observed. Since range shift of the faunal components is also very much likely, the distribution of Himalayan fauna (including both vertebrates and invertebrates) needs to be monitored and periodically analysed as a priority study. Long-term studies on faunal elements of Himalayan forests are essential to monitor such changes. Long term monitoring plots need to be assigned for such studies.

· Status survey of the endangered mammals

· Survey, exploration and inventorying of data deficient groups like smaller mammals, reptiles, amphibians, and fishes (vertebrates) and non-lepidopterous insects.

· Monitor the effects of climate change, like range shifts, with regard to distribution of varied faunal elements (vertebrates as well as invertebrates, including butterflies) of the region.

1.3.3. The Grassland and Desert ecosystems

Grasslands and Deserts are the most neglected ecosystems in India, and are often looked at as 'wastelands' on which tree plantation is suggested, or which can easily be diverted for other uses [Report of 'The Task force on Grasslands and Deserts by The Planning Commission (Environment and Forests Division, 2006].

Grasslands are terrestrial ecosystems dominated by herbaceous and shrub vegetation and influenced by fire, grazing, drought and/or freezing temperatures. Of the 136 terrestrial ecoregions identified as outstanding examples of the world's diverse ecosystems, 35 are grasslands, supporting some of the most important grassland biodiversity in the world (PAGE 2000, http://pdf.wri.org/page_grasslands.pdf.). Rann of Kutch flooded grasslands of India and Pakistan is one among them. (http://wwf.panda.org/about_our_earth/ecoregions/ rannofkutch_flooded_grasslands.cfm).

Some of the most threatened species of wildlife are found in the grasslands and deserts (e.g. Great Indian Bustard, Lesser Florican, Bengal Florican, Swamp Francolin, Finn's Weaver, Indian Rhinoceros, Snow Leopard, Nilgiri Tahr, Wild Buffalo, Pygmy Hog, Hispid Hare, Hog Deer and Swamp Deer etc). 57 species of animals and seven habitats/ecosystems belonging to 16 Indian states and 30 protected areas in 11 states are to benefit by granting better protection of Grasslands/Deserts. (Appendix 1, II and III, *Report of the Task Force on Grasslands and Deserts,* 2006).

In India, the dry desert lies mainly in Rajasthan and Gujarat, where as Ladakh in Jammu and Kashmir, Lahul-Spiti in Himachal Pradesh, and a small area of Sikkim comprise the cold desert. Lakes and marshes of this region, are mostly saline, and are important breeding grounds for many species of birds.

Tremendous changes in the avifaunal structure of the Thar Desert are taking place due to the Indira Gandhi Nahar Project (IGNP), aiming to dedesertify and transform desert waste land into agriculturally productive areas. Species never seen earlier are now regularly found near the canal (*Report of the Task Force on Grasslands and Deserts,* 2006) and needs documentation.

The Task force on Grasslands and Deserts (2006), has identified grasslands as a key area of livestock dependency and also vital to poverty alleviation of the rural folks in India. Also acknowledging the importance of grasslands and deserts for biodiversity conservation, it is demanded to set up a Grassland Development and Grazing Policy to ensure the sustainable use of grasslands and biodiversity conservation.

Presence of a huge livestock population of more than 500 million and with dependence of the rural population on it, the grasslands in India are under tremendous pressure. Since modifications from conversion to agriculture and urbanization, as well as fragmentation and the introduction of invasive species have considerably altered the grassland biodiversity, protection, monitoring, and maintenance activities need to be tailored to suit the needs of each area to ensure that each continues to support grassland biodiversity.

Role of ZSI in conservation of Grassland and Dessert ecosystems

The Task force on Grasslands and Deserts by The Planning Commission (Environment and Forests Division), (2006), has identified ZSI as one of the major institutions that can contribute towards the key areas of Research and Development, by generating a 'Basic inventory of Fauna' as well as conducting 'Ecological studies' and contribute towards the conservation, development and better utilization of natural resources of grasslands and desert ecosystems.

·Inventorying and documenting the faunal diversity of different grasslands and deserts of India

·Developing Datasets on exotic species

·Status surveys of threatened /endangered grassland fauna like the Great Indian Bustard *Ardeotis nigriceps* of the Sewan grasslands and the Swamp Francolin *Francolinus gularis*, Bengal Florican *Houbaropsis bengalensis*, and Finn's Weaver *Ploceus megarhynchus* of the terai grasslands in the Gangetic plains.

·Status survey of threatened/ endangered desert fauna like Snow Leopard *Uncia uncia*

·Inventory of Avifauna in Thar Desert

· Monitor the changes in faunal compoition, like the avifaunal structure of the Thar desert due to the Indira Gandhi Nahar Project

Reference:

PAGE, 2000. http://pdf.wri.org/page_grasslands.pdf

1.3.4. Wetland Ecosystem

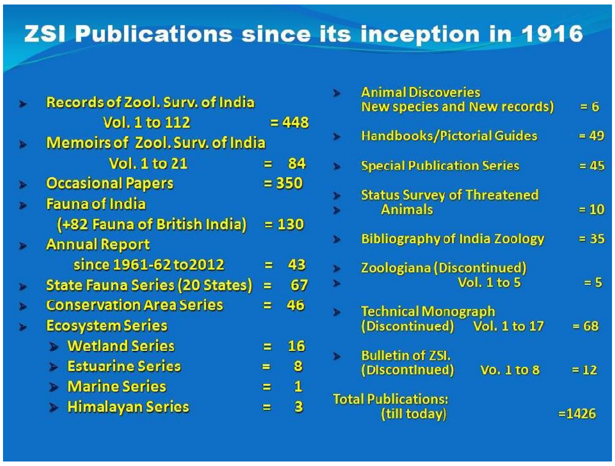
Wetlands, the transitional zones between permanently aquatic and dry terrestrial ecosystems are among the most productive ecosystems. Natural wetlands in India consist of high altitude wetlands in Himalaya, flood plains of the major river systems, saline and temporary wetlands of the arid and semi-arid regions, coastal wetlands such as lagoons, backwaters, estuaries, mangroves, swamps and coral reefs, and so on.

Presences of dense human population in catchments, urbanisation, and various anthropogenic activities have resulted in over exploitation of wetland resources, leading to degradation in their quality and quantity. To prevent the degradation and ensuring the wise use for the benefit of local communities and overall conservation of biodiversity, government of India has been implementing the National Wetlands Conservation Programme (NWCP) in close collaboration with the State/UT Governments since the year 1985-86. Under the programme, 115 wetlands have been identified till now (including the 25 wetlands of international importance under Ramsar Convention) by the Ministry which require urgent conservation and management interventions (National Report on Wetlands, 2009). As of now there is no specific legal framework for wetland conservation, management and their wise use. Draft regulatory framework for conservation and management of wetlands is being finalized to be notified under the Environment (Protection) Act, 1986.

National Forest commission 2006 has demanded the launch of a National Wetland Conservation Act, a National Wetland Biodiversity Register, a National Wetland Inventory and Monitoring Programme and a National Wetland information system for checking the health of the wetlands.

Role of ZSI in wetland conservation

Information regarding the flora and fauna of wetlands is an important component of a wetland inventory that decides the status of the wetland,



whether to be included as of national importance or not. ZSI being a premier taxonomic organisation, can develop need based faunal inventories of selected wetlands on a priority basis to be incorporated into the Wetland information system or it's Management Action Plan (MAP). Since it is very much essential that the data within the inventory remains current, periodic surveys are needed to collect new data, which later can be integrated with those existing.

Baseline information on the biodiversity of water bodies in the form of an inventory of the fauna including birds, fishes, reptiles, mammals and invertebrates is essential to identify the wetlands that are to be designated as Ramsar sites for inclusion in the 'List of Wetlands of International Importance', in preparing the MAPs, in the identification of the IUCN conservation categories like RET species, Endemic and Vulnerable species.

Of the eight Criteria listed for identification of wetlands of national importance under NWCP, the majority are evaluations of the floral/faunal components of the wetlands (National Report on Wetlands 2009). Criteria 2-4 are based on data emanated by assessing species and ecological communities, 5-6 are specific criteria based on water birds and 7-8 on specific criteria based on fish.

The dynamic nature of wetlands leads to periodic drying and inundation varying in frequency and duration over time. Therefore all plants and animals that live in wetlands will not be present in them throughout. Hence seasonal surveys specific to individual wetlands are needed to pool in data on its seasonal faunal components. Such a baseline data is essential in assessing the health of the water body at any point of time.

·Develop baseline information on the faunal diversity of wetlands, that can act as a reference system. The species inventory may include data on various fauna including birds, fishes, reptiles, mammals and also invertebrates

·The inventory needs to segregate the following and that can act as a reference system to yield significant information on the status of the wetland, as well as its faunal components.

♦ the occasional visitors
♦ residents
♦ migrants
♦ forms which totally dependent on the wetland throughout their life
♦ those that use wetlands only for a specific part of their life cycle (for egg laying,as nurseries and as breeding grounds).

· Conduct seasonal surveys specific to individual wetlands for assessing seasonality of faunal components

Data emanating out of periodic faunistic surveys conducted and monitoring at the catchments areas and flood plains of wetlands are essential for ensuring the health of the ecosystem.

1.3.5. Freshwater Ecosystem

Freshwater systems are created by water that enters the terrestrial environment as precipitation and flows both above and below the ground, towards the sea. These systems encompass a wide range of habitats, including rivers, lakes, and wetlands, and the riparian zones associated with them. Their boundaries are constantly changing with the seasonality in the hydrological cycle.

An estimated 12 percent of all animal species live in fresh water (Abramovitz 1996:7), while many others, including humans, depend on fresh water for their survival. More than 20 percent of the world's freshwater fish have become extinct or been threatened or endangered in recent decades. Freshwater species, such as fish, and wetland-dependent birds and amphibians are at high risk of imperilment in many regions of the world. Further, the introduction of alien species has contributed to the extinction and imperilment of native fauna.

At the minimum, key indicator species and the presence or introduction of non-native species and their impacts on native fauna and flora (PAGE, 2000) need to be monitored.

The Western Ghats Rivers and Streams are among the global 200 ecoregions identified by the World Wildlife Fund (WWF) as priorities for conservation, under small river systems.

As per the report of National Bureau of Fish Genetic Resources, Lucknow, (NBFGR, 2010), 120 species of fresh water fishes are threatened in India, 12 species are listed in schedule 1 of the Wildlife protection Act (1972). IUCN lists (IUCN Redlist, 2011) 14 species as Critically Endangered, 69 Endangered and 76 species Vulnerable (total 159).

The National River Conservation Directorate, under the Ministry of Environment and Forests is engaged in implementing the River and Lake Action Plans under the National River Conservation Plan (NRCP) and National Lake Conservation Plan (NLCP) (Annual report 2005-6).

The Government of India and the World Bank signed three agreements, May 2011, (of which 2 deals with biodiversity conservation) for cleaning Ganga River and to Strengthen Rural Livelihoods and Biodiversity Conservation in India.

For sustainable utilization of freshwater fishes, Karnataka State Biodiversity Board (KSBB, 2004) has demanded the creation of a policy and regulatory framework for the protection of fresh-water biodiversity (Karnataka State Biodiversity Strategy and action Plan, as a part of National Biodiversity Strategy and Action Plan – NBSAP, ENVIS Technical Report No. 15**)**

Role of ZSI in Freshwater Ecosystem Conservation

· Develop baseline information on the faunal diversity of water bodies in the form of an inventory of various fauna including birds, fishes, reptiles, mammals and also invertebrates

· Analyse the species population trends with respect to birds and amphibians

· Evaluation of Threatened taxa

· Documentation of the presence of exotic/ Invasive Alien species.

References:

http://www.wri.org/publication/pilot-analysis-global-ecosystems-freshwater-systems, http://pdf.wri.org/page_freshwater.pdf

1.3.6. Marine and Coastal ecosystems

The National Environmental Policy (NEP) 2006 while defining the basic principles of environmental conservation and management, places mangroves among the Entities of Incomparable Value (EIV). NBAP (2008) proposes the need to conserve the stretches of mangroves like those in Sunderbans, as an element of the centrally sponsored scheme, 'Integrated development of wildlife habitats' for protection of wildlife outside PAs.

National Strategy and Action Plan, on the basic tenets of the National Environment Policy, (2006), drafted under the regional initiative, "Mangroves for the Future (MFF)" for coastal ecosystem conservation and livelihood sustainability.

The National Biodiversity Action Plan (2008) is of the view that the information on biodiversity of coastal and marine areas of the country is highly fragmentary and protection of coastal belts and conservation of flora and fauna in those areas are listed among the action points.

Department of Biotechnology, Ministry of Science and Technology under an initiative, the 'Biotechnological Approaches to Biodiversity Conservation', has recommended bioprospecting of marine organisms for development of new products (National Biodiversity Action Plan, 2008).

Analysis of current inventory of coastal and marine biodiversity of India reveals that many groups that are commercially important are the ones that have been extensively inventoried, leaving out several groups, notably the minor phyla grossly understudied (India's Fourth National Report to the Convention on Biological Diversity, 2009) .

Coastal ecosystems, found along continental margins, are regions of remarkable biological productivity and high accessibility to man and are rich assets, vital for human well-being. Total coastline of India is 8,000 km long, spanning 13 maritime States and Union Territories (UTs) including Island UTs. Tidal/ Mud flats, sandy beaches, mangroves, coral reefs, salt marshes, lagoons, estuaries, seagrass beds, aquaculture ponds , Salt pans, Creeks , Rocky coasts and back waters, provides its own distinct bundle of goods and services and faces somewhat different pressures. The resident and migratory bird diversity associated with coastal and marine ecosystems in India is very high.

Coral reefs are the protectors of the coastlines of the maritime states. The coastal populations of India mostly depend on the coral reef ecosystems. Coral reef areas in the country are protected by the Environment (Protection) Act, 1986 and the Coastal Regulation Zone Notification of 1991 issued under the broad Environmental Protection Act as well as the Wildlife (Protection) Act, (WPA) 1972, since all coral reef areas in India are protected areas declared under the Wildlife (Protection) Act 1972.

Role of ZSI in conservation of Marine and Coastal ecosystems

· Providing descriptive information about the distribution and status of marine and coastal fauna

· Faunal diversity assessments in less explored and unexplored coastal zones

· Compilation of baseline data of fauna of coastal ecosystems, listing the keystone species as well the alien invasives.

· Basic inventorying of coastal and marine species by habitat type, fundamental to subsequent research, management, and conservation

· Faunal inventory of Bhitarkanika (Odisha), since govt. of India has recognized this area as a "*Mangrove Genetic Resource Centre*".

Reference:

http://pdf.wri.org/page_coastal.pdf.

1.3.7. Agroecosystems

Agro-ecosystems are defined as "a biological and natural resource system managed by humans for the primary purpose of producing food as well as other socially valuable nonfood goods and environmental services (PAGE, 2000). Twenty to 30 percent of the world's forest areas have been converted to agriculture, resulting in extensive habitat loss / species loss. As per some global estimates, the world population will grow to 7.5 billion by the year 2020 and 9 billion by 2050, which means more pressure on natural ecosystems (DIVERSITAS, 2005-http://www.agrobiodiversity-diversitas.org/documents/Jackson%20et%20al%20Science%20plan%20agroBIODIVERSITY.pdf).

Agricultural expansion is expected to be greatest in developing countries and arid regions, while agricultural area will decline in industrial countries (Millennium Ecosystem Assessment, 2005).

India is primarily an agriculture based country and its economy largely is based on agriculture. (http://www.iasri.res.in/ebook/EB_SMAR/e-book_pdf%20files/Manual%20III/17-Crop%20Estimation.pdf. This sector remains the principal source of livelihood for more than 58% of the population (Department of Agriculture and Cooperation (DAC), Annual report, 2010-11). About 43 % of *India's geographical area* is used for *agricultural activity, while* some Indian states like Punjab and Haryana have even upto 84% of their land area under cultivation. No doubt Agro-ecosystems has gained the status of one of the prominent ecosystems of India.

Increasing agricultural production with limited natural resources in a sustainable manner for ensuring food and nutritional security are one of the major challenges before the Government (Department of Agriculture and Cooperation, Annual report, 2010-11). For sustainability and maintaining productivity, biodiversity remains vital to agroecosystems as much as to natural ecosystems. Biodiversity loss in agricultural landscapes affects not just the production of food, fuel, and fiber, but also a range of ecological services supporting clean water supplies, habitats for wild species, and human health (DIVERSITAS, 2005). Since most of the ecosystem services are rendered by a varied battalion of invertebrate fauna, health of an agroecosystem is largely dependent on the diversity of these components, broadly comprising of the nutrient recycling detritivores, carnivorous/ predatory arthropods and also beneficial insects such as pollinators and natural enemies of pests. Both the above ground and the below ground diversity are crucial for proper ecosystem functioning, for agro-ecosystems in particular (DIVERSITAS, 2005).

Role of ZSI in conservation of Agroecosystems:

ZSI can contribute towards the conservation of Agro-ecosystems by delivering apt taxonomic products aiding the assessment of the impacts of man on the ecosystem structure and function. Faunal diversity of agro-ecosystems is largely crop specific and is influenced by land management practices. A baseline database of taxa encountered in specific agro-ecosystems will prove an aid to interpret such changes in diversity.

·Undertaking baseline inventories of above ground and below ground faunal diversity of different agro-ecosystems region wise/crop wise

·Develop region specific or crop specific taxonomic tools to identify various key functional groups in agro-ecosysetms like pollinators, pests, natural enemies.

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Integration of studies on Invasive Alien fauna of India

Invasive Alien species (IAS) are species whose introduction and or spread outside their natural habitats threaten biological diversity, negatively affecting the food, security, plant, animal and human health of a nation. Biological invasions by non-native species constitute one of the leading threats to natural ecosystems and biodiversity (CBD, 2009).

Presently, there is no exclusive legislation or policy in India to deal with the invasive alien species. The National Biodiversity Action Plan (2008) in its objectives has enumerated ways for the regulation of introduction of invasive alien species and their management.

As per India's 4th National Report to the convention on Biological Diversity (2009), India duly recognizes the importance of regulating introductions and managing Invasive Alien Species and also follows international quarantine. Introduction of a scheme on integrated forest protection to cover IAS, formulation of a set of regulations by Forest Invasive Species Cell, implementation of regulations laid by International maritime Organisation (IMO) in ballast water exchanges in all major ports in India etc. are some of the measures adopted by the government to combat the issue of IAS.

A national strategy is required to assess the full scope of invasive non native species. Accessibility of information regarding invasive species on a global scale can be of some help in tackling the problem. Such databases cater information on

distribution, pathways of introductions and management of species and help in designing ways to limit its spread. The Global Invasive species database (http://www.issg.org/database/welcome/) provide country wise and faunal/floral group-wise information of IAS.

Prevention of introduction, proper surveillance for the invasive, apt control/eradication methods and preventing reintroductions are steps vital for the containment of IAS. Survey methods need to be designed based on specific behaviour or characteristics of the invader. Many of the terrestrial animal invasive can be tracked, on observing the, droppings and feeding damage.

Role of ZSI in combating Invasive Alien Species

Taxonomy is a critical tool for combating the threats from invasive. Delivering all possible taxonomic tools to the best of the capacity within the shortest timeframe possible to end-users is essential while responding threats posed by invasive. Packaging existing information as per the user needs is highly recommended. Since combating invasive are always a priority, generating products and information required confronting invasive are important outputs of taxonomic institutions. Being the premier taxonomic institution of the country, ZSI can offer services as detailed below.

· Undertaking seasonally timed Species specific surveys, site specific or habitat selective surveys

1. For larger mammals, annual or biennial survey by a specialist can detect the presence of any invasive in a given area

2. Group specific/species specific survey methods need to be used for early detection of small mammals, reptiles, and even invertebrates like insects.

3. Invasive species of fresh water and marine fishes and other aquatic invertebrates can be detected during the routine sampling exercises.

·Collection of Data on invasive in a standardized format for incorporation in the National Database

·Preparation of a national database of indigenous as well as non-indigenous species based on habitat/ecosystem.

·Preparation of a database on invasive alien faunal species of India

·Provide a taxonomic kit with regard to the IAS in question, comprising of

•Taxonomic identification tools like field guides, pictorial keys, ID cards, interactive ID tools, or molecular probes.

•Current scientific name of the organism, along with alternate names, common names and synonyms.

•Data regarding current range ecological niche, time of activity associations with other species, potential range (invasive potential)

•Reference collection for comparison of voucher specimens

•Expert support for identification of the species

•Impart training to taxonomists, extension/field staff for surveys and monitoring.

•Details on global geographical distribution of the species, details on associated taxa (like natural enemies and hosts) and their possible pathways of intrusion

•Standardized survey and monitoring techniques

•Information to the public via posters, websites, leaflets featuring illustrations/photograph of the species of concern

References:

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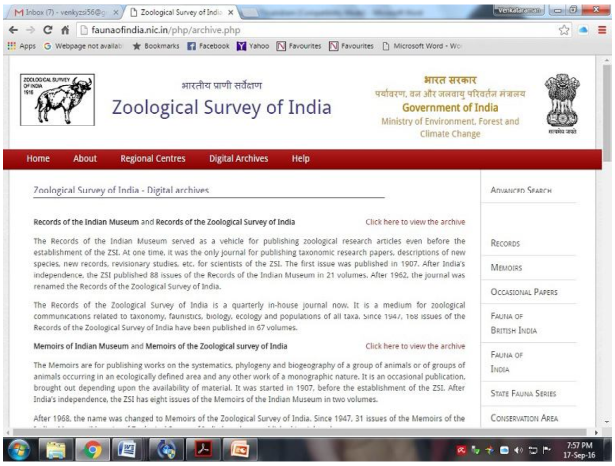


Development of Regional/national faunal databases

India is one among the mega biodiversity countries of the world. The varied ecosystems, topography and climatic factors have contributed towards this richness. The enormous data on the faunal elements of our country accumulated over the time remain scattered in various publications by different institutions and organisations. There is a need to bring together the scientific names of all the land and aquatic *animals* in one authoritative *database*. Making available a standardized, validated and collated data on all the known animal species of India is a challenging endeavour and will be an ongoing task as well.

The objectives:

To develop, launch and maintain a web enabled free and open source searchable database of all animal species known to occur in India, highlighting the magnitude of our faunal diversity and thereby ensuring their protection and conservation at the highest possible level.

·To develop a faunal database, Searchable at least by Family, Genus and Species names, common names and State/district names and also ideally by habitats/ ecosystems in which they occur.

·To develop a working knowledge on the scientific names and also on spatial distribution of animals in India.

·To identify precisely where the gap areas lie, regarding our information as well as the expertise on faunal groups (Animal Groups with feeble representation in the database necessarily reflects our gap areas).

·To identify areas less surveyed and plan future surveys accordingly.

·To develop novel taxonomic expertise and also to strengthen the available ones to deal with less studied animal groups as revealed by the National faunal database.

·To facilitate better identification of areas of conservational significance in relation to the status and distribution of animal species

Proposed Action plan

·Select a few animal groups as a priority, formulate a working group under a Coordinator, set time frames, and work towards the target using systems of international parameters, standards and procedures. The phase on vertebrates to be completed by 2015 and the phase dealing with at least 50 % of the invertebrates to be completed by 2020.

·The work group may ideally be of experts both from inside and outside the organisation. Organise occasional meetings/workshops (once or twice annually for each working group) of the members of the work groups for data validations.

·Well equipped Bioinformatics cells with adequate experts and support staff to be established in selected Centres of ZSI for the proposed database work, by 2012. The work primarily involves extensive literature survey and compilation, data entry, digital imaging of specimens and other computational works. The cell needs to have its own infrastructure including advanced computer systems with accessories and also high quality microscopes for digital imaging.

·Prioritise less surveyed /un-surveyed areas for future field studies in order to supplement the existing data.

(Developed in accordance with Global Biodiversity Information Facility. 2008. *GBIF Training Manual 1: Digitisation of History Collections Data*, version 1.0. Copenhagen: Global Biodiversity Information Facility)

Digitisation of Natural History Collections

Digitising and data basing of biological collections increases the utility of biological data. Digitisation of Natural History Collections is all about extraction of metadata from the museum labels and records, in a uniform standardised format. This includes digital imaging of the specimens too. The use of internationally approved standard soft-wares ensures communication with the datasets by international initiatives such as Global

Biodiversity Information Facility (GBIF), Biodiversity Heritage Library (BHL), Barcode of Life (BOL) and Encyclopaedia of Life (EOL).

The Objectives:

·To digitise the vast Natural History Collections at Headquarters (HQ) and Regional Centres of ZSI, as a searchable database and to develop an updated record of each of the nearly 3 lakhs identified specimens housed in the faunal depositories of ZSI, and also its incorporation into a searchable database.

·To develop 'Primary Type Information System' (PTIS), a web-based database for the primary types in the National Zoological Collections at ZSI HQ and its Regional Centres.

· To identify areas less surveyed and plan future surveys accordingly.

Proposed Action plan

·Digitisation of Natural history collections at ZSI to be achieved using international recognized softwares like SPECIFY®, a versatile collection/ research data management system with provisions for web interface and Distributed Generic Information Retrieval (DiGIR) protocols (to be completed by 2020). The Primary Type Information System to be completed by 2017, in a time frame of 5 years after the launch of the Bioinformatics cell.

·Rest of the points same as under Development of National/Regional Databases

(Developed in accordance with Global Biodiversity Information Facility. 2008. *GBIF Training Manual 1: Digitisation of History Collections Data*, version 1.0. Copenhagen: Global Biodiversity Information Facility)

Introduction and integration of Cyber taxonomy

Taxonomy is the science central to exploring and understanding biodiversity. The demand on this science to cater the increasing need of biodiversity knowledge has resulted in the emergence of Cyber taxonomy. It is an assemblage of electronic taxonomic tools for accelerating species' discoveries and application of taxonomic knowledge in biodiversity studies.

The Objectives

Introduction and intergration of Cyber-taxonomy at ZSI is aimed in dissemination of taxonomic information with regard to Indian fauna at a rapid pace, in a more efficient way.

·The user-friendly internet based interactive taxonomic keys and digital fact sheets on various faunal groups, can cater the needs of a broad spectrum of users than conventional taxonomists, that too at a faster pace, increasing the outreach of taxonomy by manifold.

·To develop Cyber taxonomy at ZSI, to keep pace with the recent trends and advances in the international scenario of taxonomy

·To develop and maintain region wise/habitat wise online interactive taxonomic keys and digital fact sheets on various faunal groups in India.

·Develop digital information systems on key groups like Invasive Alien Species, endemics, threatened and endangered species, groups of economic and ecological significance and also on most commonly encountered taxa under various groups.

Proposed Action plan

· Render Training and exposure to the field of Cyber taxonomy to all practicing taxonomists as well as to the new recruits of the organisation, through annual training programs, by 2016.

·Establish Cyber taxonomy units at selected Centres of ZSI by 2012, to assist the taxonomists in developing digital taxonomy products. The units need to have their own infrastructure including advanced computer systems with accessories and also high quality, advanced microscopes for digital imaging.

(Developed based on La Salle, J., Wheeler Q. D., Jackway, P., Winterton, S., Hobern, D., Lovell, D., 2009. Accelerating taxonomic discovery through automated character extraction *Zootaxa* 2217: 43–55. http://www.mapress.com/zootaxa/2009/f/zt02217p055.pdf accessed on 15/11/2011.).

Establishment of Geographical Information System (GIS) Cell at ZSI

The Geographical Information System and Remote sensing techniques are identified as one of the most important methods for the study of ecosystem and its faunal composition. It is proposed to establish and develop a Cell for G.I.S. and remote sensing for the collection and analysis of data and to supplement it with that collected on ground for bringing out an integrated picture on faunal diversity of various ecosystems. These techniques have proven to be very important tools aiding rapid assessment and survey of flora and fauna.

The objective

The establishment of a GIS Cell in ZSI is aimed to facilitate incorporating GIS and remote sensing techniques in regular faunal surveys of the department, so that the end results of the surveys are more informative and user friendly to the policy makers.

Proposed Action plan

· By 2015, A fully functional GIS Cell need to start contributing to the routine survey results, helping in bringing out an integrated picture on animal diversity of the country.

· Scientists also need to be trained in the use of GIS and Remote sensing gadgets and softwares and integrating data in their taxonomic studies, the training has to be achieved by 2018.

Integration of DNA finger printing studies on relevant taxa

DNA fingerprinting method is emerging as a critical tool in conservation genetics and molecular ecology. Recent advances of molecular techniques like DNA sequencing, minisatellite, microsatellite, and RAPD (random amplified polymorphic DNA) procedures, PCR (polymerase chain reaction) amplification of mitochondrial DNA, nuclear DNA, ribosomal DNA are proven aids for redefining genera, species and subspecies and their phylogenetic relationships.

The objective

To initiate and integrate frontier areas of research like DNA Fingerprinting on faunal groups and taxa of immense conservation / ecological/ economic importance.

Proposed Action plan

By 2017, ZSI need to develop full fledged expertise in DNA finger printing techniques of relevant taxa.

Launching Major Taxonomic Initiatives for Taxonomists in ZSI

· **Provision for taking up detailed taxonomic studies in the case of lesser known taxa**

Revisionary and monographic studies are always considered as major contributions in the field of taxonomy and such works are essential to improve our knowledge and understanding of the lesser known taxa. The taxonomists at ZSI need be permitted to take up such detailed taxonomic investigations on groups which are less studied and underexplored.

· **Provision for short-term funded training in aspects of taxonomy, at institutes of international reputes abroad.**

Established Taxonomists at ZSI, with proven track record should be encouraged to undertake short term visits to reputed international museums and taxonomic institutes abroad, for achieving specialised training or for studying the type specimens, funded by the organisation.

· **'Fauna of India Series'**

Under the ongoing scheme of 'Fauna of India series', provision shall be made for undertaking short term study visits to major international museums, which houses the type specimens related to the study, on departmental funding.

Capacity Building Strategy in Animal Taxonomy

1. Identify taxonomic information and gaps and prioritize capacity building needs.
2. Generate new taxonomic information and regional and national level.
3. Exchange taxonomic information at local, regional, national and global level.
4. Incorporation of taxonomic information into the implementation of various programmes of work at local, regional and national level.

·Organize one national level workshop on animal taxonomy by the end of 2013 to identify priority-areas for taxonomic capacity-building, human capacity and infrastructure needs at national level. Recommendations of this workshop to be included in updated National Biodiversity Strategies and Action Plans (NBSAPs).

·Organize regional training workshops on taxonomy to improve access to and sharing of knowledge, data and information on animal biodiversity. At least two such workshops will be completed by 2014 to facilitate cross sectoral communication and to set the basis for additional workshops until 2020. Improve training in taxonomic skills by holding regional and other workshops for members of the education sector in which they can share experiences and ideas.

·Produce biodiversity identification tools in regional languages (e.g. field guides, multimedia, online tools) such as selected protected areas, threatened species, invasive alien species, and species useful to agriculture such as pollinators, pests etc.

·A review at national and regional level by 2015 of human capacity and infrastructure requirements to maintain and pass-on taxonomic expertise to the next generation, in order to identify and monitor biodiversity, particularly on invasive alien species, under-studied taxa, threatened and socio-economically important species, including indicator species.

·To build and maintain a national information systems and infrastructure on animal biodiversity at international standards to provide free and open-access to the results of biodiversity research and related activities, and to implement national targets by the end of 2015. This information infrastructure will be able to communicate with international initiatives such as Global Biodiversity Information Facility (GBIF), Biodiversity Heritage Library (BHL), Barcode of Life (BOL) and Encyclopaedia of Life (EOL).

·To procure human resources and capital infrastructure to build, modernize, and maintain the National Zoological Collections at ZSI and other animal biodiversity collections held at universities, national institutions etc by 2017.

·By 2020, assess the status of biodiversity at regional and national levels by developing a comprehensive coverage of information on known species at the global level including information on abundance, distribution, functioning and conservation in the ecosystem.
Initiate projects by 2020 to produce an inventory for all species in targeted priority areas such as biodiversity hotspots, protected areas, and community conservation areas and incorporate accurate information on animal biodiversity, regarding conservation and sustainable use, in decision making.

·Between 2018-2020, using appropriate indicators, monitor progress to ensure that national or regional capacity-building action plans and initiatives are in place and can be sustained them beyond 2020.

CRUSTACEN RESEARCH IN INDIA

JAYACHANDRAN K V
DIRECTOR OF RESEARCH
Kerala University of Fisheries & Ocean Studies
E-mail : chandrankvj@gmail.com

My talk is based on

- the experience in engaging graduate, post graduate, doctoral programmes for 35 years
* Analysis of crustacean samples from different parts of the country and outside
- Discussions / interactions with scientists on the subject
*

CRUSTACEANS ARE

- **Most diverse group of organisms on earth**
  - wide range of morphological variations
- **Paired appendages with great complexity**
- **All of them have chitinous exoskeleton**
- **Age group is believed to have evolved**
  early Cambrian or beyond

NUMBER OF CRUSTACEANS

* **52,000 spp. By 2001 (Martin & Davis)**
- **67,000 spp. Wikipedia**
- **54,000 spp. for reef associated peracarids alone – Kensley**

Therefore the exact number is yet to be assessed clearly

SIZE OF CRUSTACEANS

- **94 µm has been reported for *Stygotantulus stocki* (tantulocarids, parasitic on copepods)**
* **4.0 m (12.5 feet) extended leg span for *Macrocheira kaempferi* (Japanese spider crab)**
- **46 cm maximum carapace width for *Pseudocarcinus gigas* (giant crab)**

SIZE OF CRUSTACEANS

- **1.5 mm carapace width for a pinnotherid crab – *Nannotheres moorei***
- **0.76 mm - length for hermit crab *Pygmaeopagurus* sp.**

BIOMASS OF CRUSTACEANS

* Antarctic krill - *Euphausia superba*
  - estimated to be 500 million tons
* By sheer numbers – nauplius larva constitute the highest number – most abundant type of multicellular animal on earth
* > 10 million tons of crustaceans are produced for human consumption
* Copepods form the highest biomass
* Japanese spider crab weighs 20 kg

BODY FORMS IN CRUSTACEA

* Worm like as in Remipedia, Cephalocarida and so on
* Laterally compressed
* Cylindrical
* Anterior part sub-cylindrical and posterior region laterally compressed
* Dorso-ventrally flattened
* Varying body shape - Eupagurids
* and in many other body shape

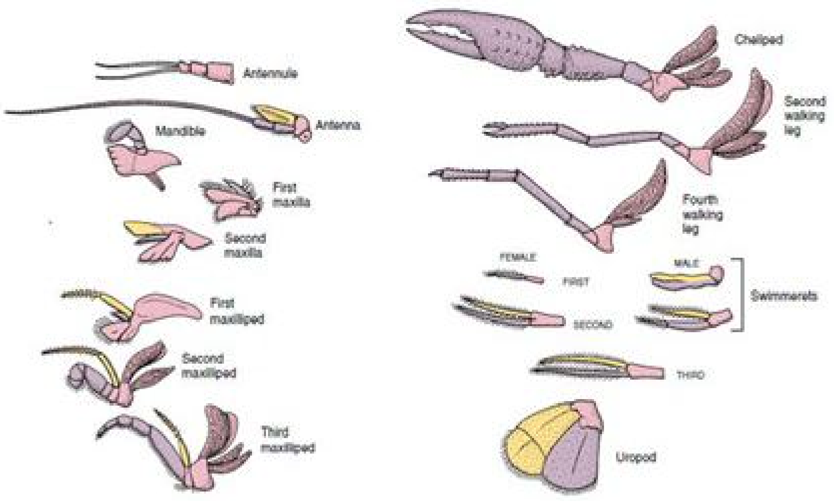
APPENDAGES

* Vary very much in different groups
* Maximum numbers on groups like Notostraca, Decapoda Remipedia and so on
* Limited to Cephalothoracic region
* Both on cephalo-thorax and abdomen in malacostracans and only at cephalo- thoracic region in other crustaceans
* Reduction in the appendages
* Modification according to attachment

DIFFERENT TYPES OF APPENDAGES

* Bi-ramous
* Uni-ramous
* Tri-ramous
* Phyllopodial
* Stenopodial

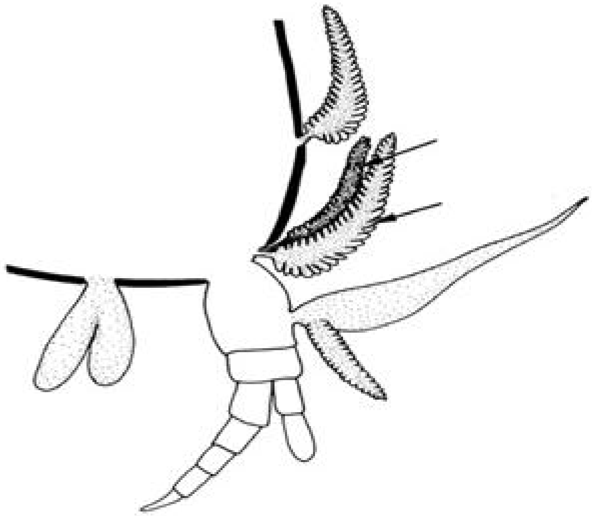
APPENDAGES



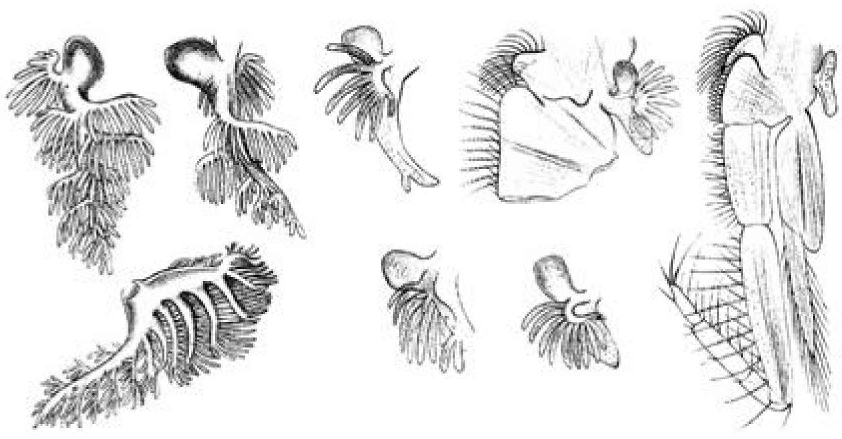
GILLS IN CRUSTACEANS

* **Arthrobranch**
* **Podobranch**
* **Pleurobranch**
* **Dendrobranch**
* **Trichobranch**
* **Phyllobranch**

GILLS IN CRUSTACEANS



COMPLEXITY AMONG PODOBRANCHS IN EUPHAUSIDS



SO MANY OTHER CHARACTERS ARE UNAVOIDABLE FOR TAXONOMIC STUDIES

* Carapace
* Abdomen
* Telson
* Petasma
* Thelycum
* Appendages
* Movable articulation
* Immovable articulation
* Larval characters

HABITAT OF CRUSTACEANS

Inhabit all imaginable habitats

* Intertidal
* Interstitial
* Pelagic
* Column
* Benthic
* Very deep oceans
* Estuaries
* Freshwater
* Hill tops
* Subterranean
* Caves
* Terrestrial
* oil wells
* Parasites
* Hyper saline
* Salt pans

and so on

Evolution wise

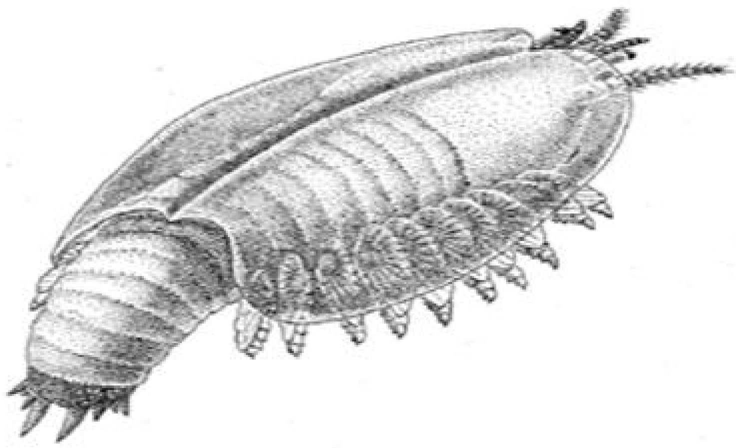
* **First crustacean must have evolved during upper Cambrian period or even beyond that**

* **A beautifully preserved fossil from Upper Cambrian of Sweden – *Rehbachiella* – appears to be an anostracan**

FOSSIL CRUSTACEANS

* **Very vast topic, and I am also not competent to talk on**
* **Earliest fossil is that of anostracan *Rehbachiella kinnekullensis***
* **Living fossil – *Triops cancriformis***
* **Adaptive radiation has been quite evident in this group**

FOSSIL – Canadapsis perfecta – Middle Cambrian – Burgess shale – Courtesy Smithsonian Institution



FOSSIL – Eryma mandelsiohi - Decapod – Jurassic – Bissingen an der, Germany

FOSSIL – Aeger tipularis – from Solnhofen, Germany – Late Jurassic

FOSSIL – Lobster – Germany – Late Jurassic

TRENDS IN CRUSTACEAN TAXONOMY

* Morphological
* Larval stages and embryological stages
* Ecological approach
* Behavioural approach
* Biochemical approach
* Cytological approach
* Molecular approach

NOW

Crustacean classification is the most difficult among all other groups of invertebrate

Let us have an idea about crustacean research in India

Class Branchiopoda

Order	Suborder	Infraorder	Fam.
Anostraca	…….	…..	8
Notostraca			1
Diplostraca	Laevicaudata		1
	Spinicaudata		3
	Cyclastherida		1
	Cladocera	Ctenopoda	2
		Anomorpha	5
		Onychopoda	3
		Haplopoda	1

Class Branchiopoda

Total number of species reported so far

- Anostraca 8 families; 26 genera; 300 spp.
- Notostraca 1 family; 2 genera; 11 spp.
- Dipostraca 15 families; 25 genera; 650 spp
- From India around 75 species have been recorded
- Day, 1880; Tiwari, 1952; Nayar & Nair, 1968;
- Belk & Esparza, 1995; Prasad, 2009; Christopher Rogers, 2013; Sameer & Ghate, 2015
- Research on Branchiopoda need to be intensified

Class Remipedia

Order	Suborder	Infraorder	Fam.
Nectiopoda	…….	…..	3

- Fam. Godzilliidae
- Fam. Speleonectidae
- Fam. Micropacteridae 8 genera 21 species

  No Indian representative

REMIPEDIA

Class Cephalocarida

- Order | Suborder | Infraorder | Fam.
- Brachypoda ……. ….. 2

- Fam. Hutichinsoniellidae
- Fam. Lightiellidae 5 genera 13 species

No Indian representative

CLASS MAXILLOPODA

Subclass	Infraclass	Order	Subord.	Fam.
Thecostraca	Facetotecta			3
	Ascothoracida	Laurida		3
		Dendrogastrida		3
	Cirripedia	Pygophora		2
	(Acrothoracica)	Apygophora		1
		Kentrogonida		3
	(Rhizocephala)	Akentrogonida		9
sup.order		Pedunculata	Heteralepado-morpha	6
			Iblomorpha	1
	(Thoracica)		Lepadomorpha	3
			Scalpellomorpha	4

Class Maxillopoda

Subclass	Order	Suborder	Fam.
Thoracica	Sessilia	Brachylepadomorpha	1
		Verrucomorpha	2
		Balanomorpha	12
Tantulocarida			5
Branchiura	Arguloida		1
Pentastomida	Cephalobaenida		2
	Porocephalida		7
Mystacocarida	Mystacocaridida		1

Class Maxillopoda

Subclass Thecostraca 59 fam; 325 g; 1877 spp.
Infraclass Facetotrecta 1 genus; 13 spp.
Infraclass Ascothoracica 6 fam; 138 spp.
Order Laurida 3 fam; 26 gen; 60 spp.*
Order Dendrogastrida 3 fam; 9 gen; 52 spp.*
Infraclass Cirripedia 41 fam; 33 gen; 2291 spp.*
Suporder Acrothoracica 4 fam; 12 gen; 72 spp
Suporder Rhizocephala 11 fam; 42 gen; 288 spp
Sup.order Thoracica 14 fam; 18 gen; 50 spp.
Order Pedunculata 17 fam; 97 gen; 697 spp.
Order Sessilia 20 fam; 167 gen; 877 spp.

Indian Maxillopoda

Maxillopoda	94 fam; 242 gen; 529 spp		
Thecostraca	11 fam; 20 gen; 52 spp		
Cirripedia	11 fam; 20 gen; 52 spp		
Thoracica	10 fam; 18 gen; 50 spp		
Pedunculata	4 fam; 5 gen; 11 spp		
Sessilia	6 fam; 13 gen; 39 spp		
Archaeobalanidae	5 spp.	Balanidae	21 spp
Chelonibiidae	4 spp.	Iblidae	1 sp
Lepadidae	6 spp	scalpellidae	1 sp
Poecilasmatide	3 spp	Tetraclitidae	4 spp

From India 36 spp from India - Daniel, 1952-1975; Annandale, 1907-1924; Borradaile, 1903

Indian studies are scanty and no current investigations

- Desai et al., 1983; Heiner Fabian et al., 2005; Krishna Pillai, 1986; Tiwari and Vijayalakshmi R. Nair, 2002; Lodh, 1990;. Madhupratap, 1987; Mishra and Panigrahy, 1999; Mishra, 2002; Nair et al., 1999; Patil et al., 2008; Rajan et al., 2008; Baskara Sanjeevi, 2004; Srinivasan and Santhanam, 1991

Subclass Tantulocarida

- 4 families; 23 genera; 33 species
- A recently described subclass and no representative from India

Subclass Branchiura

1 family; 4 genera; 157 species

Argulus 129 species

Dolops 13 species

Chonopeltis 14 species

Dipteropeltis 1 species

Ramakrishna, 1951 reported 5 species of Argulus

Subclass Pentastomida
Subclass Mystacocarida

- **3 orders; 9 fam; 24 genera; 129 spp.**
- **1 order; 1 fam; 2 genera; 13 spp.**
- **No representatives from India**

SUBCLASS COPEPODA

Super Order	Order	Fam.
Gymnoplea	Calanoida	43
Podoplea	Misophrioida	3
	Cyclopoida	15
	Gelyelloida	1
	Mormonilloida	1
	Harpacticoida	54
	Poecilostomatoida	61
	Siphonostomatoida	40
	Monstrilloida	1

Number of species

- 240 fam; 2600 genera; 21,000 spp.
- From India
- East coast - 23 fam; 106 spp
- West coast – 31 fam; 179 spp.
- Kasturirangan, 1963 listed 105 species
- 17 sand dwelling harpacticoids under 5 families
- Pillai 1945- 1985; Ummerkutty, 1961-1966; Krishnaswamy, 1957-1960; Saraswathy, 1964; Farran, 1913; Johnson, 1939; Sewell, 1912- 1949;
- Madhupratap & Haridas, 1992
- Recent study by Resmi & Jayachandran, 2014

CLASS OSTRACODA

Subclass	Order	Suborder	Fam.
Myodocopa	Myodocopa	Myodocopina	5
	Halocyprida	Cladocopina	1
		Halocypridina	2
Podocopa	Platycopida	Bairdiocopina	2
		Cytherocopina	23
		Darwinulocopina	1
		Cypridocopina	6
		Sigilliocopina	1

Number of species

- 43 families; 13,000 extant species
- Indian species
- 2 superfamilies; 5 families; 39 genera; 152 spp.
- Jain, 1980 reported 306 marine ostracods
- **McKenzie, 1971; Baird, 1859; Gurney, 1907; Klie, 1927;Arora, 1931; Hartman, 1964; Venkataraman, 1999; Patil & Talmale, 2005-2012; George et al., 1975; George & Nair, 1980; Karuthapandi et al., 2014.**
- **Studies and scanty and no continuity of research**

CLASS MALACOSTRACA

Subclass	Sup.order	Order	Sub Ord.	Fam
Phyllocarida		Leptostraca		3
Hoplocarida		Stomatopoda	Unipeltata	17
Eumalacostraca	Syncarida	Bathynellacea		2
		Anaspidacea		4
	Peracarida	Spelaeogriphacea		1
		Thermosbaenacea		4
		Lophogastrida		2
		Mysida		4
		Mictacea		2
		Amphipoda	Gammaridea	124
			Caprellidea	6
			Hyperiidea	21

CLASS MALACOSTRACA

Subclass	Sup.order	Order	Sub Ord.	Fam
Peracarida	Spelaeogriphacea	Isopoda	Ingolfiellidea	1
			Phreatoicidea	3
			Anthuridea	6
			Microcerberidea	2
			Flabellifera	18
			Asellota	28
			Calabozoida	1
			Valvifera	11
			Epicaridea	11
			Oniscoidea	38
		(Infra order	Tylomorpha -1)	
			Ligiamorpha -32)	

CLASS MALACOSTRACA

Sup.order	Order	Sub Ord.	Infraorder	Fam
	Tanaidacea	Tanaidomorpha		8
		Neotanaidomorpha		1
		Apseudomorpha		12
	Cumacea			8
Eucarida	Euphausiacea			2
	Amphionidacea			1
	Decapoda	Dendrobranchiata		7
		Pleocyemata	Stenopodidea	1
			Caridea	36
			Astacidea	7
			Thalassinidea	11
			Palinura	4
			Anomura 13; Brachyura	71

Sub class Phyllocarida

- 1 order; 3 families; 10 genera; 42 spp.
- No species reported from India
- Nebalia dahli reported from Pakistan

Sub Class Hoplocarida

- 1 order; 1 suborder; 7 superfamilies;
  17 families; 450 species

From India reports are available on 8 famiies;
20 genera; 58 species

Eurysquillidae 1,1; Gonodactylidae 1, 13
Lysiosquillidae 1, 3; Nannosquillidae 2, 2
Protosquillidae 1,1; Pseudosquillidae 1, 1
Squillidae 12, 36; Tetrasquillidae 1,2

Kemp, 1913 – 1915; Shanbhougue, 1975;
Manning, 1968 – 1978; Ghosh, 1995;
Rath & Mishra, 2012

Order Bathynellacea & Anaspidacea

- Bathynellacea 216 spp. 66 genera
- Parabathynellidae 128 spp. 39 genera
- Bathynellidae 91 spp. 27 genera
- 240 spp. 78 genera
- Ranga Reddy (2014) 16 species of reported from India

- No report of Anaspidacea from India
-

Orders Spelaeogriphacea Thermosbaenaecea Lophogastrida

- Spelaeogriphacea - 3 species
- Thermosbaenaecea – 4 fam; 7 gen; 34 spp.

Lophogastrida - 4 fam; 10 gen; 58 spp.

No Indian reports.

For Lophogastrids there is possibility of Indian occurrence

No taxonomic group to study this

Orders Mysida & Mictacea

- **Mysida – 4 fam.;180 gen.; 1046 spp.**
- **Fam. Mysida : 10 subfam; 172 g; 1000 spp**
- **Fam. Petalophthalmidae : 6 gen; 32 spp**
- **Fam. Lepidomysidae : 1 gen.; 9 spp.**
- **Fam. Stygiomysidae : 1 gen; 7 spp.**
- **Mysidae enjoys discontinuous distribution**
- **Pillai, 1961-1973; Panampunnayil, 1977-2002;**
- **Biju & Panampunnayil, 2009- 2011**
- **Only scanty studies from India (21 g; 27 spp)**

Order Amphipoda

- Gammaridea 125 fam.; 1000 g; 7900 spp
- Caprellidea 8 fam.;
- Hyperidea 21 families; 233 spp
- Infolfiellidea 2 families; 40 spp
- freshwater Gammaridea 10 gen; 17 spp.
- 166 spp. from India
- Sivaprakasam, 1968-1969; Rabindranath, 1969-1975; Rao, 1969; Sasidharan, 1982-1984; Tembe & Despande, 1964

Order Isopoda

- Suborder Phreatoicidea 3 families
- Indian species - Chopra & Tiwari, 1950;
- Tiwari, 1955 a, b
- Suborder Anthuridea : 6 fam; 57 gen; 500sp
- Suborder Microcerberidea 2 fam; 8 g;46sp
- Indian species
- Suborder Flabellifera 18 fam; 3000 spp
- Pillai 1954, 1964; Panikkar & Aiyar, 1937;
- Ravichandran, 1999-2009; Tiwari, 1953; Biju & Bruce, 2011

Order Isopoda

- Suborder Asellota 2200 spp.
- Indian examples Joshi & Bal, 1959; Kumari & Shyamasundari, 1984; Pillai, 1954
- There are Indian examples from Cymathoidea, Anthuroidea, Valvifera, Sphaeromatidea (9 families)
- Under Oniscidae 12 fam., 68 spp from India
- Srivastava et al., 2006; Nair et al., 1999
- Epicaridea 11 fam; 216 gen; 704 spp
- Pillai, 1966; Regina Jasmine & Jayachandran, 2006

Orders Tanaidacea & Cumacea

- Tanaidacea 36 families; 940 spp
- From India only work available are : Balasubramanyan, 1962; Kimlarsen et al., 2013
- Cumacea 8 fam; 140 g; 1500 spp
- From India the work of Kurian, 1992 alone
  - Is available

Indian species under Eucarida

- Dendrobrachiata 41 g; 155 spp
- Penaeoidea 34, 135
- Aristeidae 7, 14
- Benthesicymidae 4, 12
- Penaeidae 17, 85
- Sicyonidae 1, 4
- Solenoceridae 5, 20
- Sergestoidea 7, 20
- Luciferidae 1, 7
- Sergestidae 6, 13

Indian species under Eucarida

- Pleoceymata 87, 209
- Axiidea 4, 5 Axiidae 3, 4
- Stenopodidea 5, 5
- Callianasidea 1,1 Spongicolidae 3, 3
- Stenopodidae 2, 2
- Caridea 78, 199

Caridea

- Alpheoidea 15, 42
- Alpheidae 4, 23 Hippolytidae 10, 17
- Ogyrididae 1, 1

- Brasilioidea 1,1
- Disciadidae 1, 1

Caridea

- Crangonoidea 7, 28
- Crangonidae 6,18 Glyphocrangonidae 1, 10
- Oplophoroidea 7 , 13
- Acanthephyridae 6, 10 Oplophoridae 1, 3
- Pasiphaeoidea 5, 11
- Nematocarcinoidea 3, 5
- Namatocarcinidae 1, 3
- Rhynchocinetidae 2,2

Caridea

- Pandalidoidea 11, 31
- Pandalidae 9, 27 Thalassocardidae 2, 4
- Palaemonoidea 26, 64
- Gnathophyllidae 1,1 Hymenoceridae 1,1
- Palaemonidae 24, 120
- Processoidea 2,3
- Psalidopodoidea 1,1
- Brachyura, Palinura are covered by other
- experts

In general

- Research on Crustaceans is still in its infant stage
- One of the aims of the present seminar and workshop is to consolidate the crustacean research in India and to attract attention of investigators to deeply involve in the studies of this precious group

Challenges

- Real experts in crustacean taxonomy is meagre
- Major groups alone were attempted in taxonomic studies
- Classic taxonomy and molecular taxonomy are to to be sensibly interpreted
- Biodiversity utilization has not be attempted seriously
- Proper documentation is highly essential
- Species introductions are to be cautiously done

STENOPODIDAE

CARIDEA

Collecting freshwater decapod crustaceans

D.C.J. Yeo, S. De Grave & P.K.L. Ng

Right person, right place, right time:

- Importance of:
  - Training, Experience
    - Search image, Instincts
    - Juveniles...or small species
    - Knowledge of biology/behaviour of target species, habitat, etc. Clues from:
      - Literature
      - Morphology
      - Local knowledge
  - Thoroughness, Persistence
  - ...LUCK

Wet habitats

- Rivers, streams, creeks,
  - Main channel (e.g., *Johora tiomanensis* – at night)
  - Submerged river/stream banks (e.g., *Potamalpheops amnicus*)
  - Semi-terrestrial riparian zone (e.g., *Phricotelphusa limula*)
  - Waterfalls, cataracts, crevices (e.g., *Balssiathelphusa natunaensis*)
  - Rocks, boulders (e.g., *Johora tiomanensis*)
  - Aquatic plants (submerged/emergent/floating), leaf litter, woody debris, root mats (e.g., *Balssiathelphusa natunaensis*)
  - Caves (e.g., *Erebusa calobates, Stygothelphusa* spp.)

Wet habitats

- Lakes, ponds, pools
  - Open water (e.g., *Orconectes rusticus, Nautilothelphusa zimmeri*)
  - Shoreline/Littoral zone (e.g., *Parathelphusa pantherina*)
  - Rocks, boulders (e.g., *Isolapotamon bauense*)
  - Aquatic plants (submerged/emergent/floating), leaf litter, woody debris, root mats (e.g., *Inlethelphusa acanthica*)
  - Mud wallows of rhinoceros (*Thelphusula dicerophilus*)

Wet habitats

- Swamps (e.g., *Macrobrachium oxyphilus, Parathelphusa reticulata*)
- Rice fields (e.g., *Sayamia, Esanthelphusa, Somanniathelphusa*)
  - Open water (e.g., *Nautilothelphusa zimmeri*)
  - Bunds (e.g., *Malayopotamon granulatum*)
  - Aquatic plants (submerged/emergent/floating), leaf litter, woody debris, root mats (e.g., *Limnopilos sumatrana*)

Wet habitats

- Mud flats – burrows, under debris (e.g., *Potamalpheops tigger*)
- Phytotelms - aquatic microhabitats in/on plants
  - Tree holes (e.g. the potamonautid *Globonautes macropus* and the sesarmid *Labuanium* spp.)
  - Leaf axils - palms (e.g., *Labuanium politum*; Sesarmidae), bromeliads (e.g. *Sesarma jarvisi* and *Metopaulias depressus*; Sesarmidae)
  - Pitcher plants (e.g., *Geosesarma malayanum*)
- Anchialine, but strictly-speaking, not a freshwater habitat
- (e.g., *Orcovita* spp.)

Dry habitats

- Dry river beds – in burrows, under rocks (e.g., *Larnaudia larnaudii*)
- Forest floor
  - Burrows (e.g., *Pudaengon, Thaipotamon*)
  - Fallen/rotting logs and other debris (e.g., *Geosesarma*)
  - Leaf litter (e.g., *Cardisoma carnifex, Johora grallator*)
- Plants
  - Trees (e.g, arboreal species *Arachnothelphusa* and *Labuanium*)
  - Riparian vegetation (e.g, *Labuanium/Scandarma*)
  - Screw pines (*Pandanus*) (e.g., the sesarmid *Scandarma lintou*)
- Limestone cliff/karst areas – crevices, rocks (e.g., *Discoplax, Gecarcoidea, Gubernatoriana*)

Other "habitats"

- Markets
- Aquarium/ornamental trade
  - Retail
  - Wholesale/suppliers

Methods
- what, how, pros and cons

- Hand-catching
- Snorkeling and SCUBA
- Traps
  - Funnel (pot, bottle, bubus) traps
  - Fyke nets
  - Small mammal traps
  - Pitfall traps
- Surrogate habitats, colonisers
- Electrofishing
  - Backpack
  - Boat
- Nets
  - Gill nets
  - Seine nets
  - Cast nets
  - Lift nets (large), bento traps (small)
  - Push nets (tray nets)
  - Hand nets
- Hook and line
- Night collection
- Local collectors

Containment of live decapods (until killing, preservation)

- Containers, bags, and pockets
- Aggression – crowding, solitary confinement
- Keeping cool, keeping clean

Safety first...

- Respect the habitat, assess the risks, know your limits

- Respect the animals
  - Handling/holding the animals
  - The tyranny of testosterone

Preservation and storage

S. De Grave, P.K.L. Ng & D.C.J. Yeo

What happens after you collect a specimen…

- Transporting specimens
- Labels
- Colour photography
- Anesthetizing small specimens
- Anesthetizing large specimens
- Preserving for DNA
- Short term storage
- Long term storage

Transporting shrimps and crabs

DEMONSTRATION 1

Keep specimens cool...

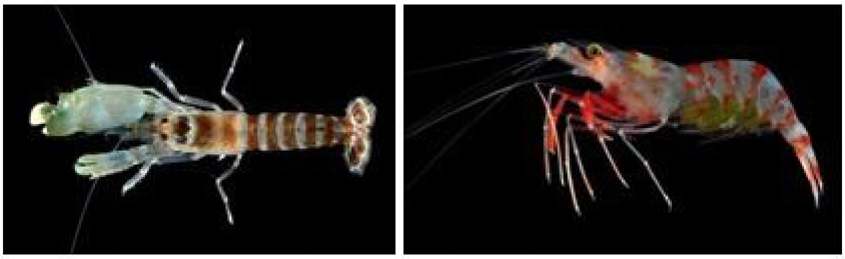
LABELS

Should be:

- written and inserted inside vials or bags as soon as possible
- indestructible fabric and fade proof ink or pencil
- travels with specimen, always

Never:

- Write on outside of bag or vial
- Mix specimens and try separate later



COLOUR PHOTOGRAPHY

Lab setup...

Can be done in the field...

Anesthetizing small shrimps and crabs

DEMONSTRATION 2

Anesthetizing large shrimps and crabs

DEMONSTRATION 3

PRESERVING FOR DNA

- For best results, tissue pluck (e.g. pleopod, leg) before death and preserve separately in lab grade 95% ethanol or higher
- However, common markers (e.g. COI, 16S, H3) amplify well from specimens in good quality 75% ethanol
- Avoid non lab grade alcohol
- Commercial preparations (e.g. RNALater) work well, but poor longer term preservation

SHORT TERM STORAGE

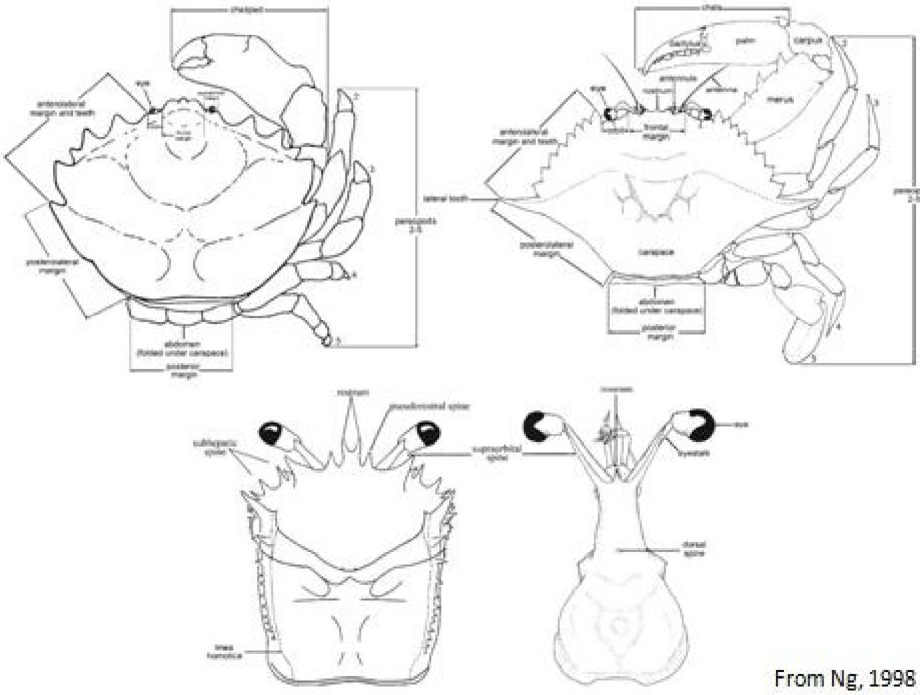
LONG TERM STORAGE

Crab and shrimp morphology and terminology

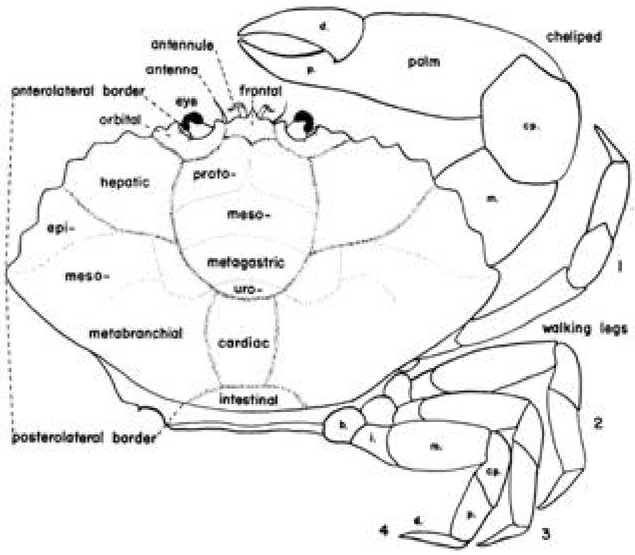
P.K.L. Ng, S. De Grave & D.C.J. Yeo

P.K.L. Ng

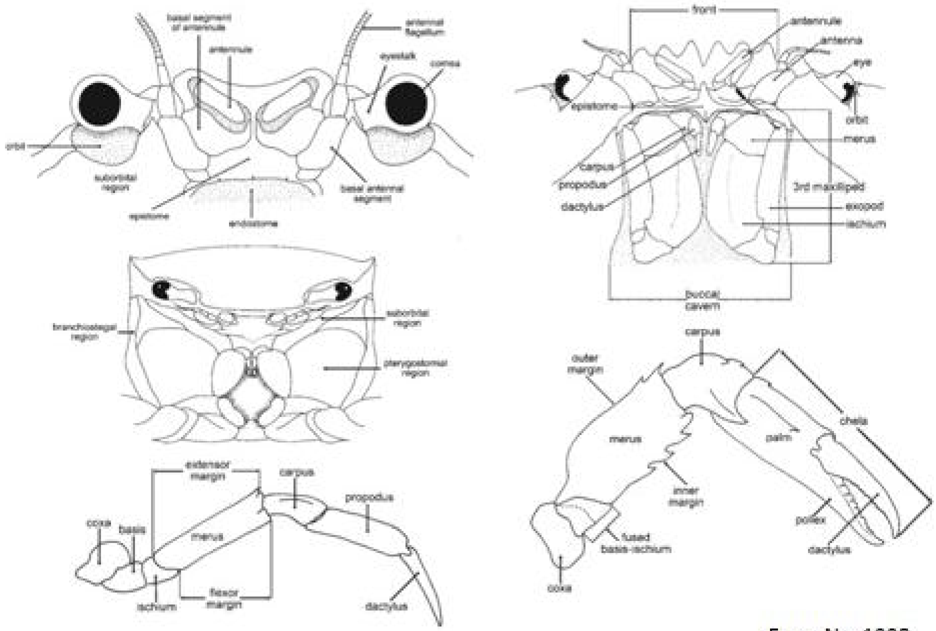
MARINE CRABS



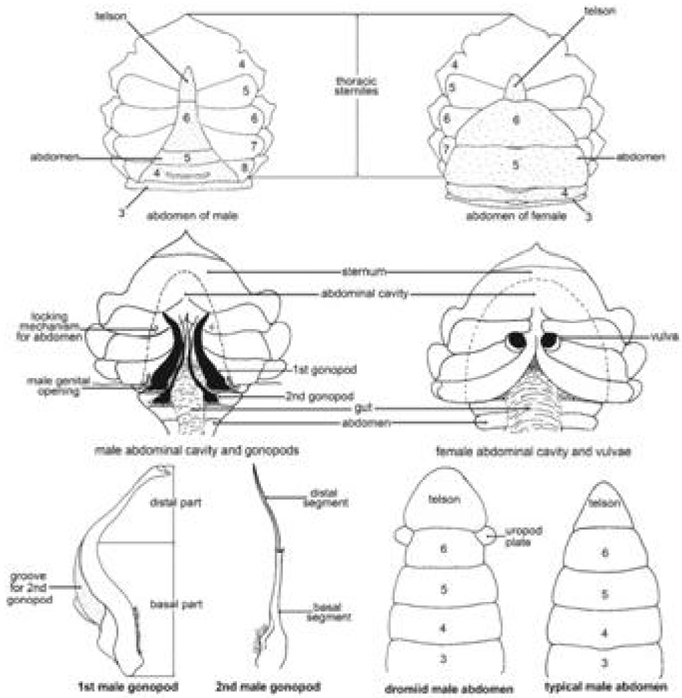
From Ng, 1998



Adapted from Williams, 1984



From Ng, 1998

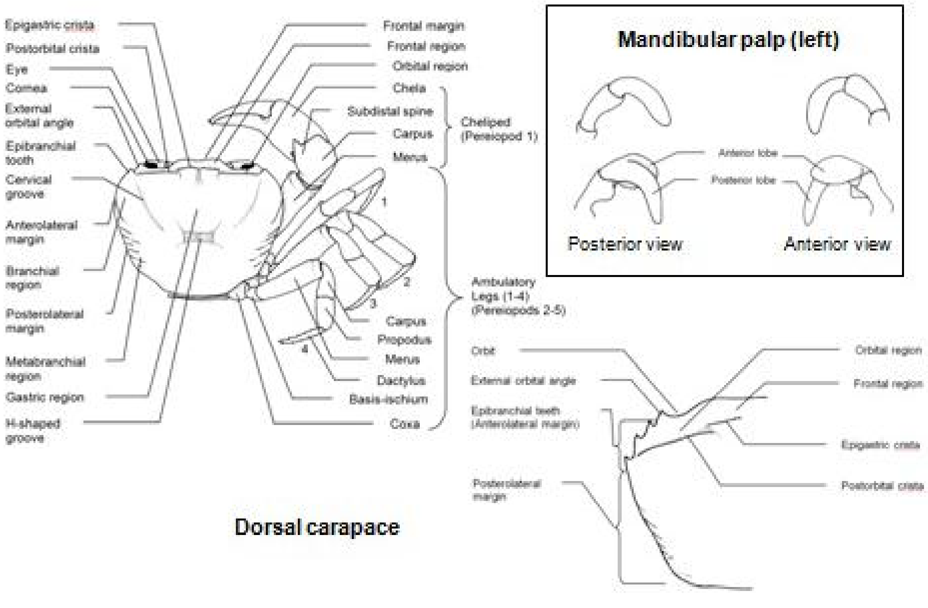


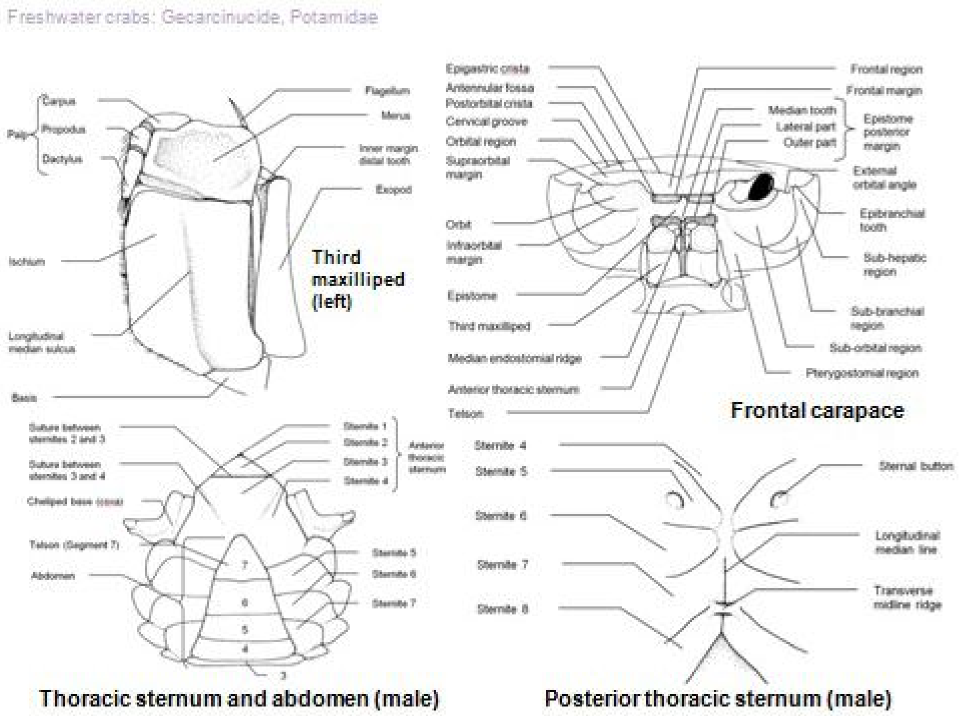
From Ng, 1998

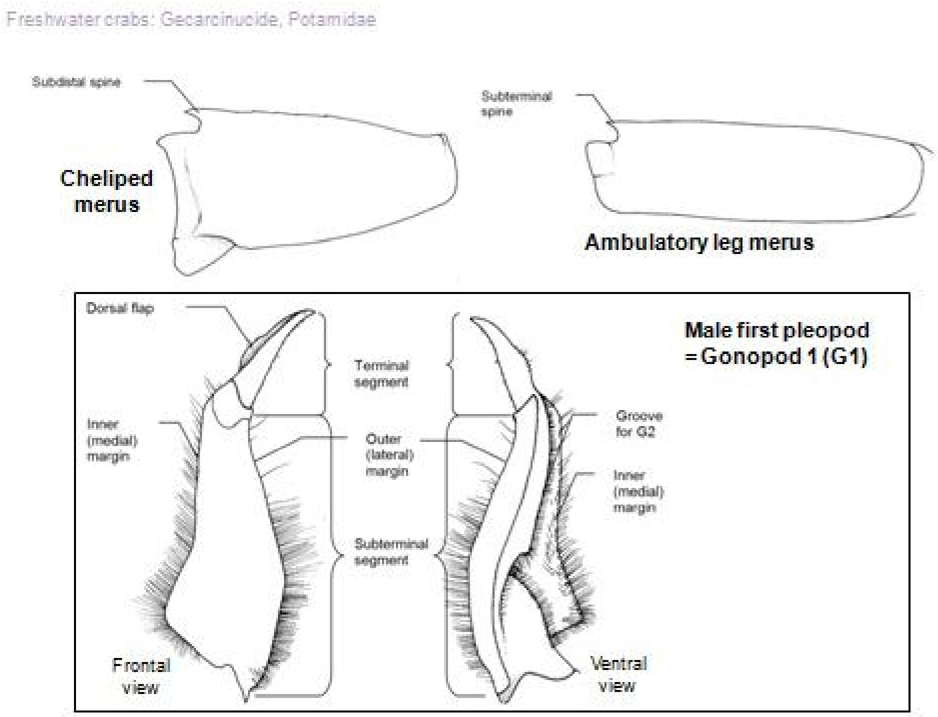
FRESHWATER CRABS
- GECARCINUCIDAE
- POTAMIDAE

DCJ Yeo

Freshwater crabs: Gecarcinucide, Potamidae

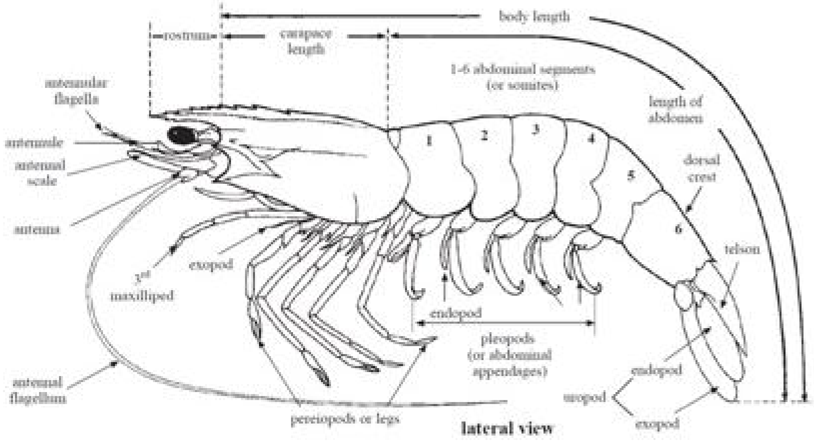



Freshwater crabs: Gecarcinucide, Potamidae
Palp
Carpus
Propodus
Dactylus
Ischium
Longitudinal median sulcus
Basis
Flagellum
Merus
Inner margin distal tooth
Exopod
Third maxilliped (left)
Epigastric crista
Antennular fossa
Postorbital crista
Cervical groove
Orbital region
Supraorbital margin
Orbit
Infraorbital margin
Epistome
Third maxilliped
Median endostomial ridge
Anterior thoracic sternum
Telson
Frontal region
Frontal margin
Median tooth
Lateral part
Outer part
Epistome posterior margin
External orbital angle
Epibranchial tooth
Sub-hepatic region
Sub-branchial region
Sub-orbital region
Pterygostomial region
Frontal carapace
Suture between sternites 2 and 3
Suture between sternites 3 and 4
Cheliped base (coxa)
Telson (Segment 7)
Abdomen
Sternite 1
Sternite 2
Sternite 3
Sternite 4
Anterior thoracic sternum
Sternite 5
Sternite 6
Sternite 7
7
6
5
4
3
Thoracic sternum and abdomen (male)
Sternite 4
Sternite 5
Sternite 6
Sternite 7
Sternite 8
Sternal button
Longitudinal median line
Transverse midline ridge
Posterior thoracic sternum (male)

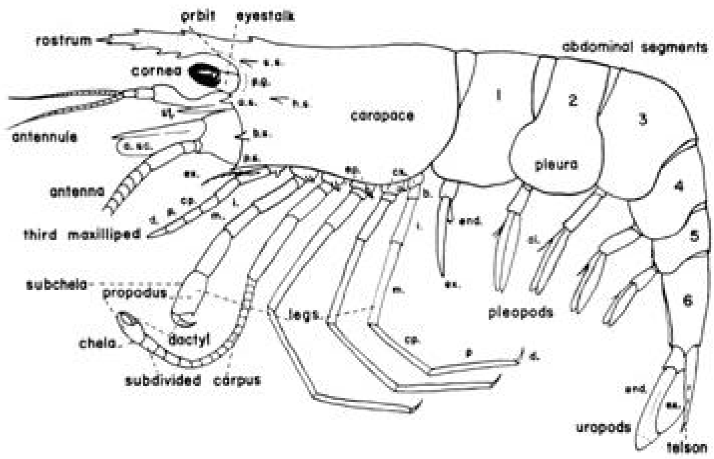

Freshwater crabs: Gecarcinucide, Potamidae
Subdistal spine
Cheliped merus
Subterminal spine
Ambulatory leg merus
Dorsal flap
Inner (medial) margin
Terminal segment
Outer (lateral) margin
Subterminal segment
Groove for G2
Inner (medial) margin
Male first pleopod = Gonopod 1 (G1)
Frontal view
Ventral view

S. De Grave

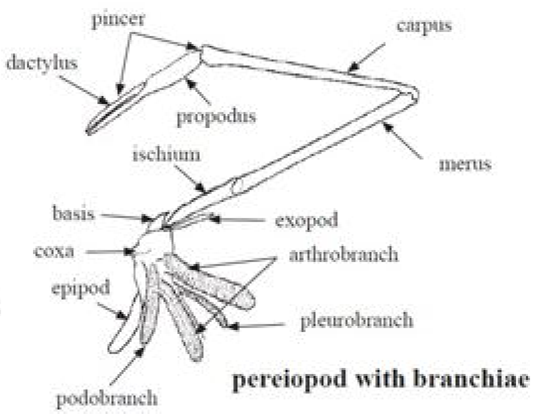
SHRIMPS



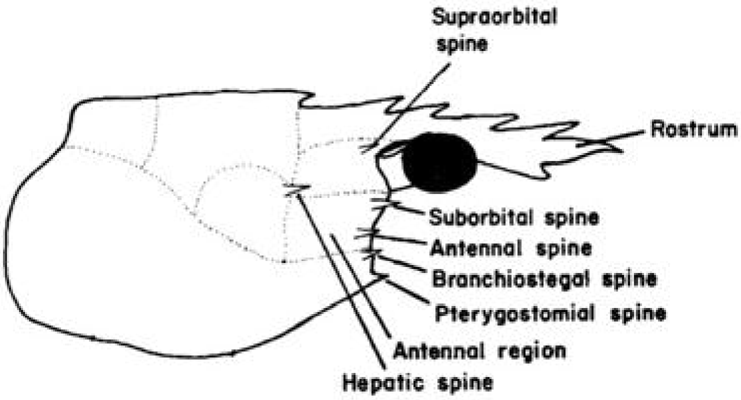
From Chan, 1988



Adapted from Williams, 1984

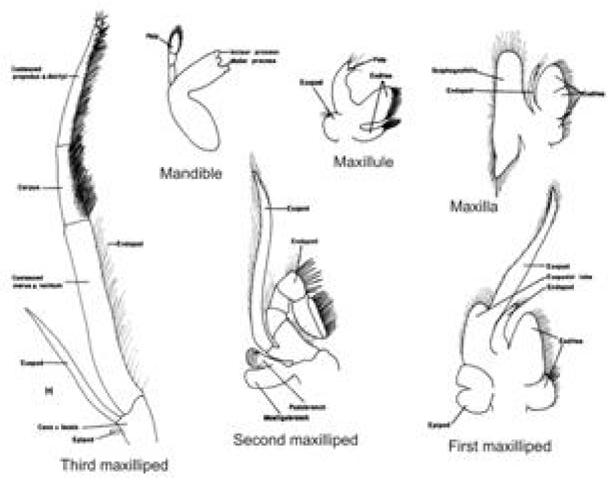


From Chan, 1988



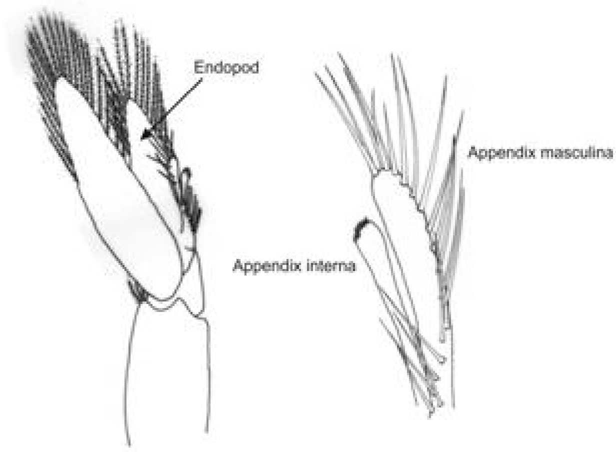
Note that in current terminology,
these are often referred to as teeth, not spines

Adapted from McLaughlin, 1980



Adapted from McLaughlin, 1980

Second pleopod of males



Appendix masculina is lacking in females

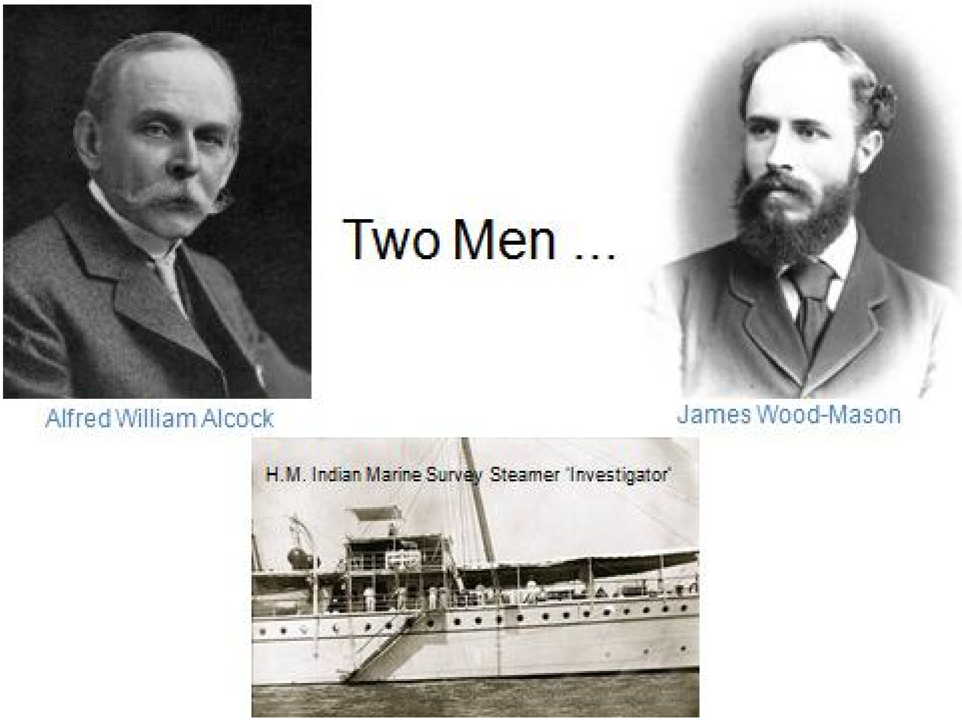
MARINE CRABS OF INDIA
&
THE INDIAN OCEAN

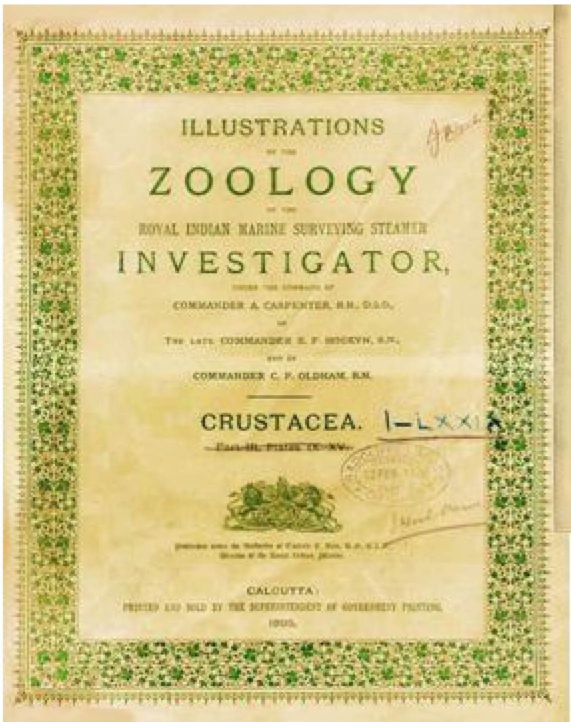
Philyra malefactrix (Kemp, 1915)

LEGACIES

Herbst, J. F.W., 1782–1804. *Versuch einer Naturgeschichte der Krabben und Krebse nebst einer systematischen Beschreibung ihrer verschieden Arten.* Gottlieb August Lange, Berlin & Stralsund.


Zool. Mus. Berlin.
Herbst
2169
Calappa gallus (Herbst, 1803)


Two Men ...
Alfred William Alcock
James Wood-Mason
H.M. Indian Marine Survey Steamer 'Investigator'



ILLUSTRATIONS

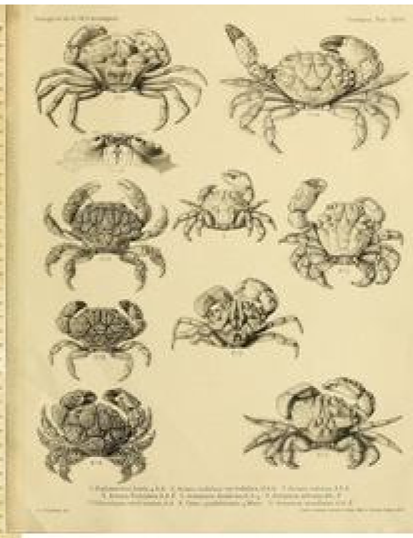
ZOOLOGY

ROYAL INDIAN MARINE SURVEYING STEAMER

INVESTIGATOR,

CRUSTACEA. I–LXXI

CALCUTTA



Foundation of Indo-West Pacific Carcinology

Monograph

ZOOTAXA

ZOOTAXA

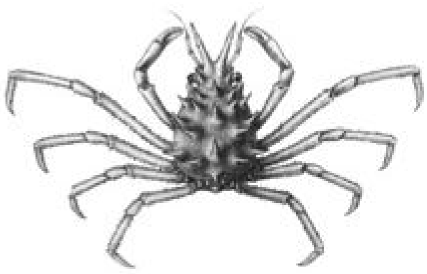
3757

On two reports associated with James Wood-Mason and Alfred William Alcock published by the Indian Museum and the Indian Marine Survey between 1890 and 1891: implications for malacostracan nomenclature

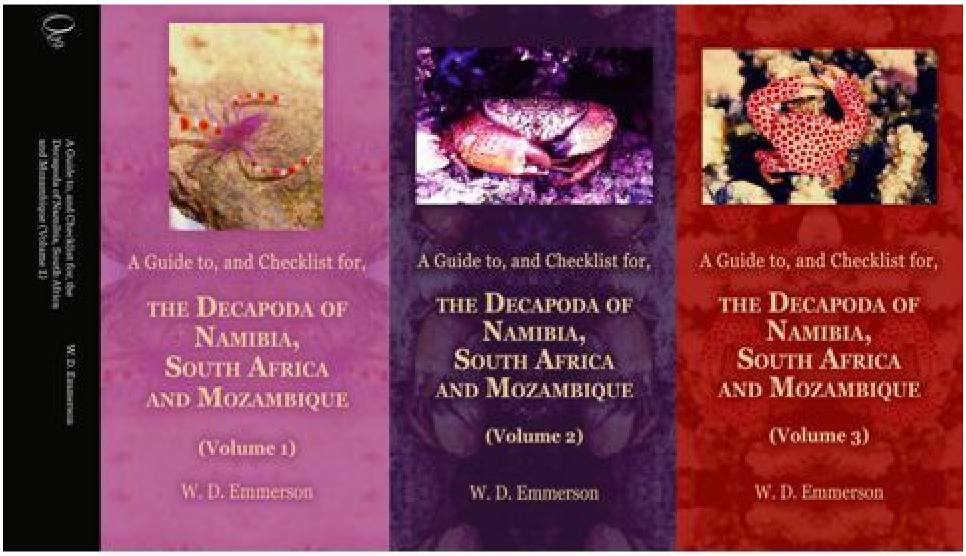
RONY HUYS, MARTYN E. Y. LOW, SAMMY DE GRAVE, PETER K. L. NG & PAUL F. CLARK

Magnolia Press
Auckland, New Zealand

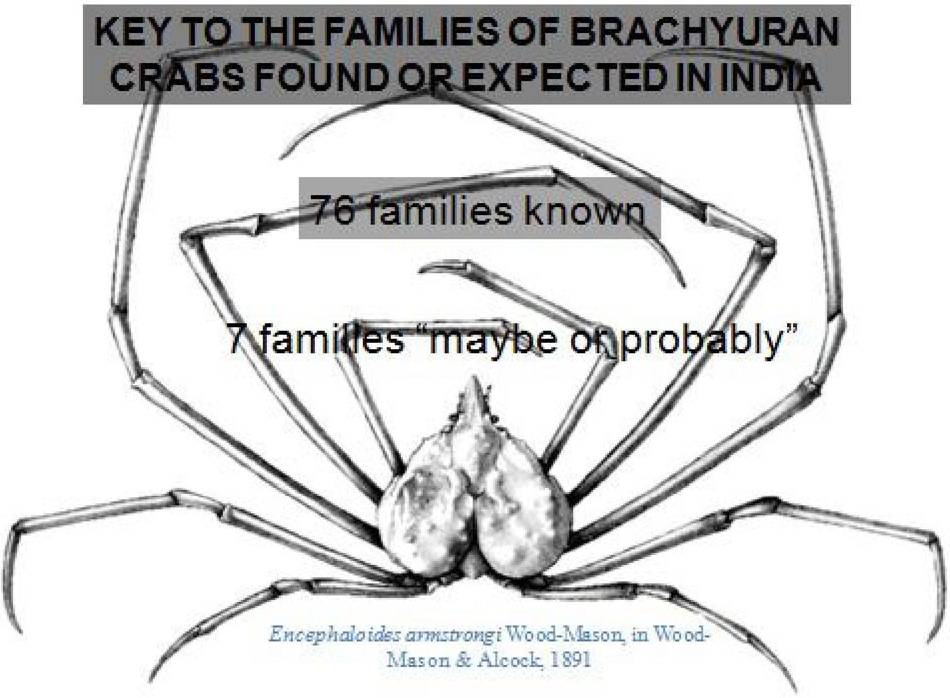
Too many types and names from Alcock and Wood-Mason ....

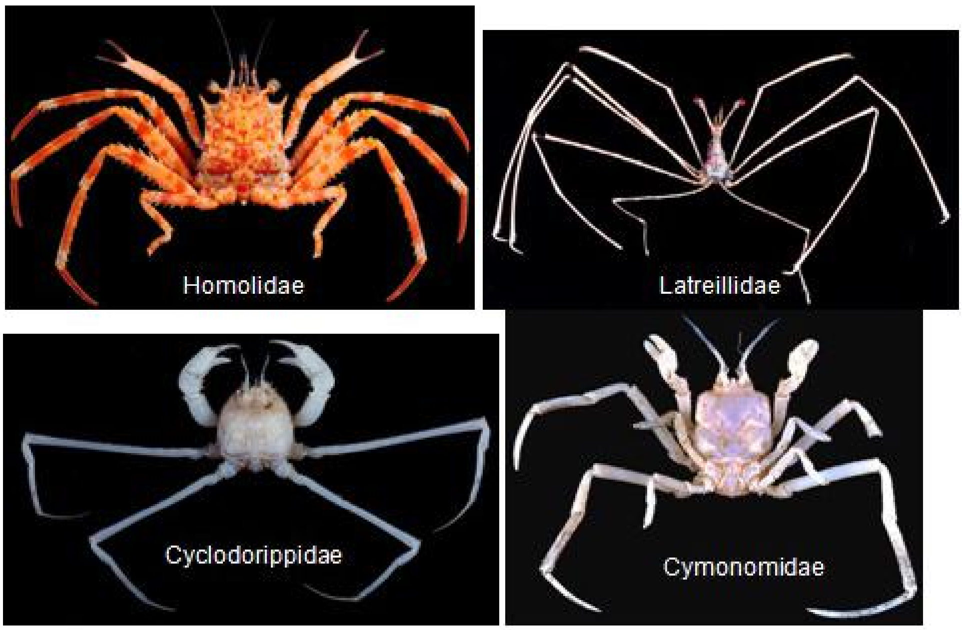


Anamathia livermorii Wood-Mason, in Wood-Mason & Alcock, 1891

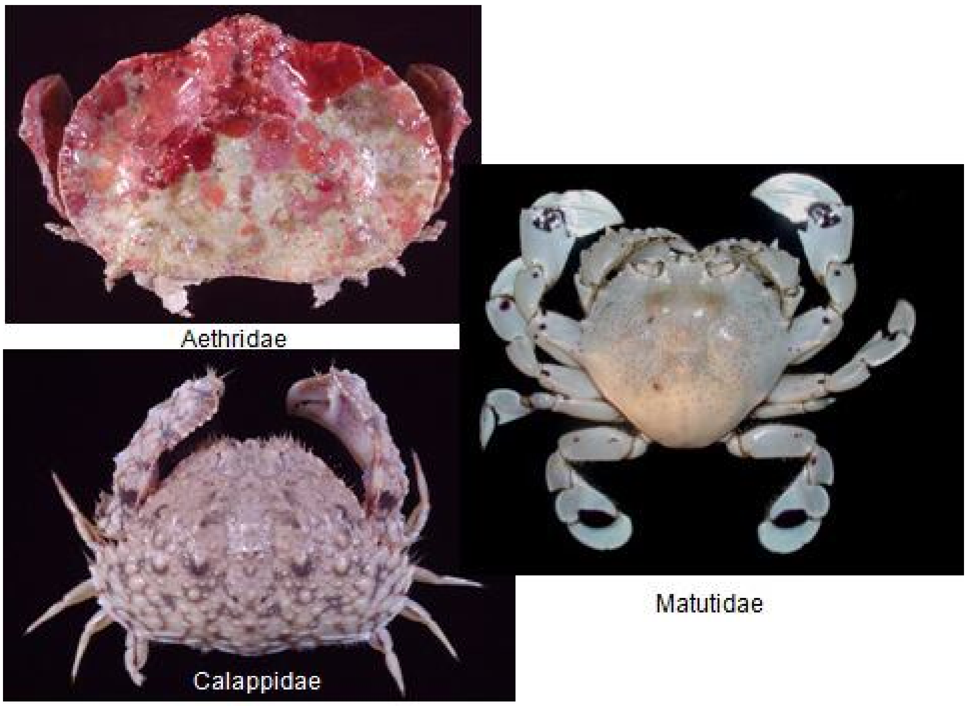


Newest Resource: Emmerson 2016!

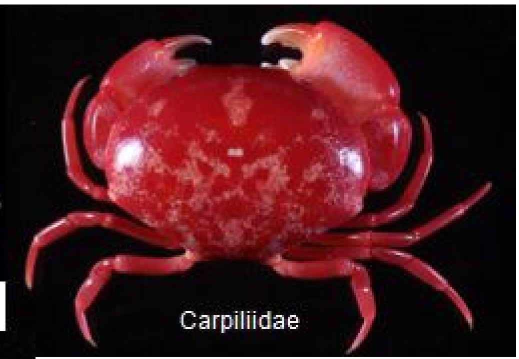

KEY TO THE FAMILIES OF BRACHYURAN CRABS FOUND OR EXPECTED IN INDIA
76 families known
7 families "maybe or probably"
Encephaloides armstrongi Wood-Mason, in Wood-Mason & Alcock, 1891


Homolidae
Latreillidae
Cyclodorippidae
Cymonomidae


Dromiidae
Dynomenidae
Homolodromiidae
Raninidae
Lyreididae


Aethridae
Matutidae
Calappidae

Cancridae



Carpiliidae

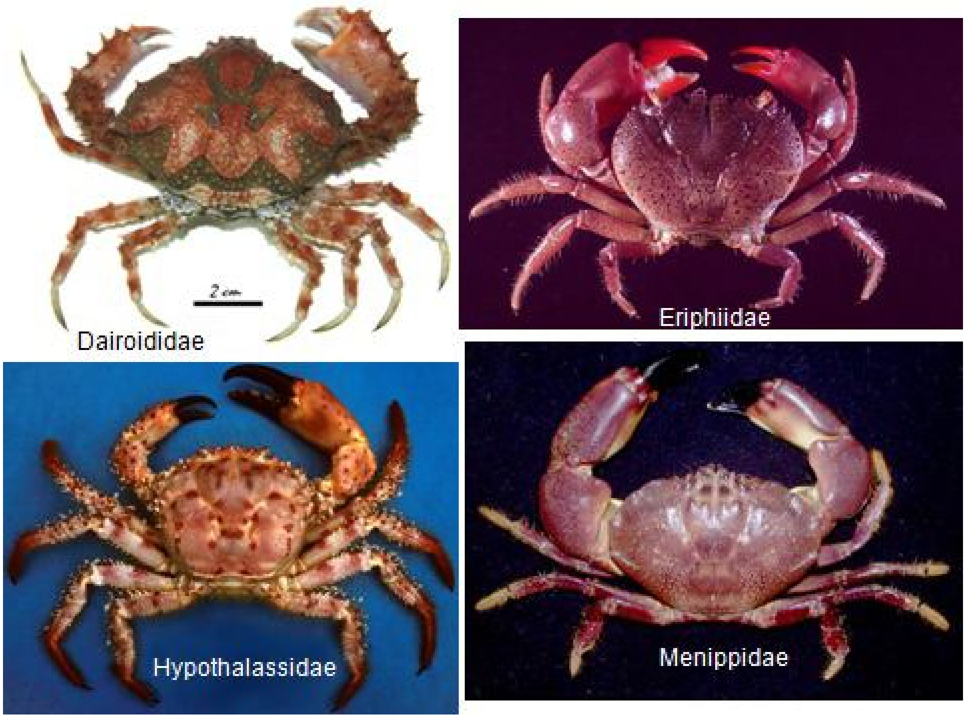
Dairidae

Dacryopilumnidae

Dorippidae

Ethusidae

Corystidae


Dairoididae
Eriphiidae
Hypothalassidae
Menippidae


Oziidae
Gecarcinucidae
Acidopsidae
Chasmocarcinidae

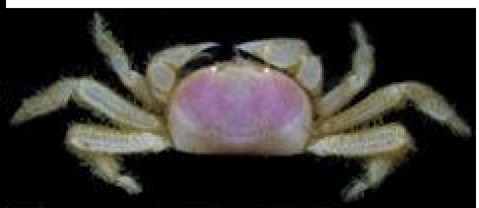
Goneplacidae

Euryplacidae

Mathidellidae

Progeryonidae

Scalopidiidae



Hexapodidae

Hymenosomatidae


Leucosiidae


Iphiculiidae


Palicidae


Crossotonotidae


Epialtidae


Oregoniidae


Inachidae


Majidae

Parthenopidae

Pilumnidae

Galenidae

Tanaochelidae

Brusiniidae

Geryonidae

Polybiidae

Ovalipidae

Portunidae

Potamidae

Pseudoziidae

Planopilumnidae

Christmaplacidae

Retroplumidae


Trapeziidae


Trichopeltarionidae


Linnaeoxanthidae


Xanthidae


Cryptochiridae


Gecarcinidae

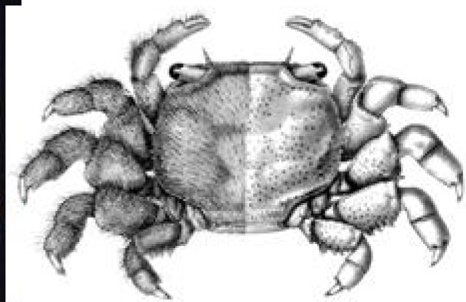

Grapsidae


Percnidae


Plagusiidae


Sesarmidae


Varunidae


Camptandriidae

Dotillidae

Macrophthalmidae

Mictyridae

Ocypodidae

Xenophthalmidae

Aphanodactylidae

Pinnotheridae

Recent new marine taxa ...

Moloha tumida Ng & Kumar, 2015


Neorhynchoplax patnahi Ng, Nesemann & Sharma, 2011


So what are some of the more interesting developments ?
Discoplax magna Ng & Shih, 2014

Austruca occidentalis (Naderloo, Schubart & Shih, 2016)

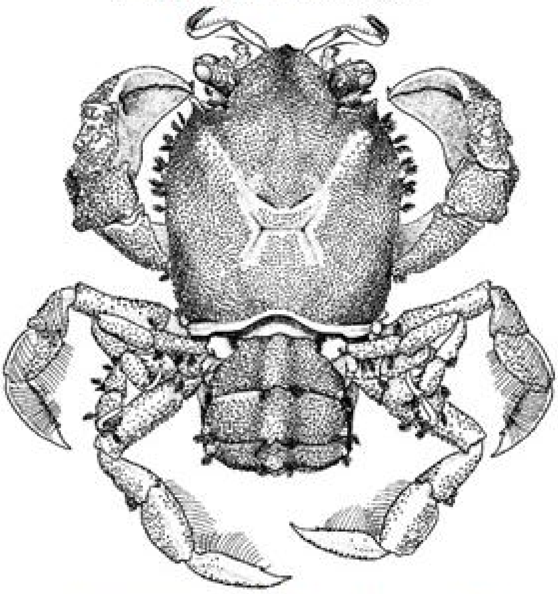
Labuanium vitatum Ng & Davie, 2011

Pinnotherids, *Afropinnotheres ratanakara* Ng & Kumar, 2015, and *Arcotheres* nsp

MISSING FAMILIES ?

MISSING FAMILIES ?

PHYLLOTYMOLIDAE



Lonchodactylus messingi Tavares & Lemaitre, 1996

BYTHOGRAEIDAE

Gandalfus yunohana (Takeda, Hashimoto & Ohta, 2000)

CONLEYIDAE

Conleyus defodio Ng & Ng, 2003

VULTOCINIDAE

Vultocinus anfractus Ng & Manuel-Santos, 2007

PILUMNOIDIDAE

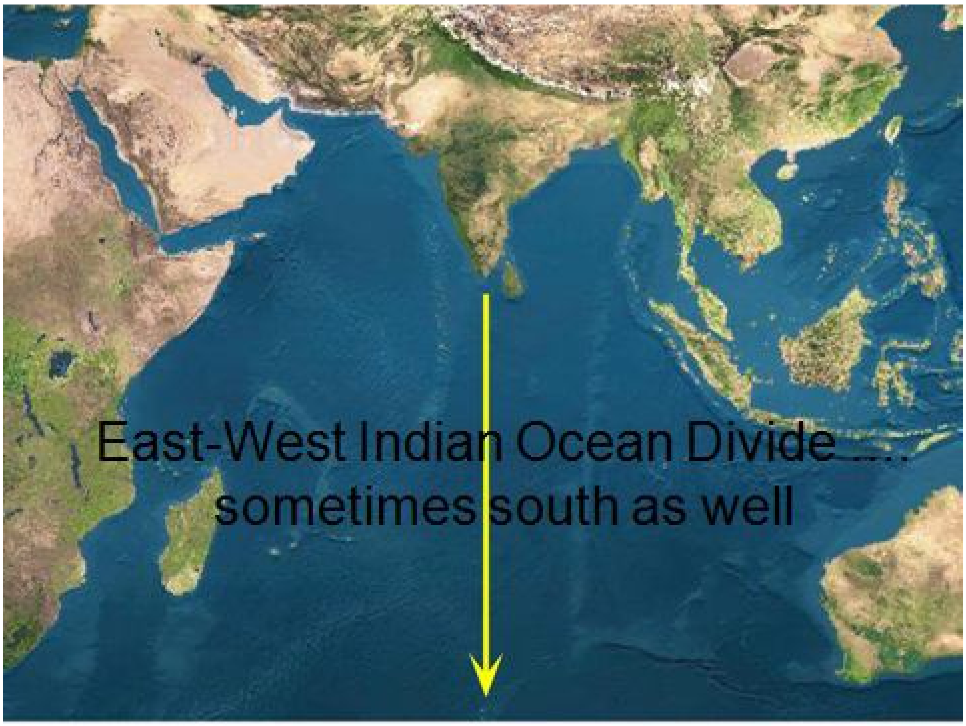
Pilumnoides rubus Guinot & Macpherson, 1987

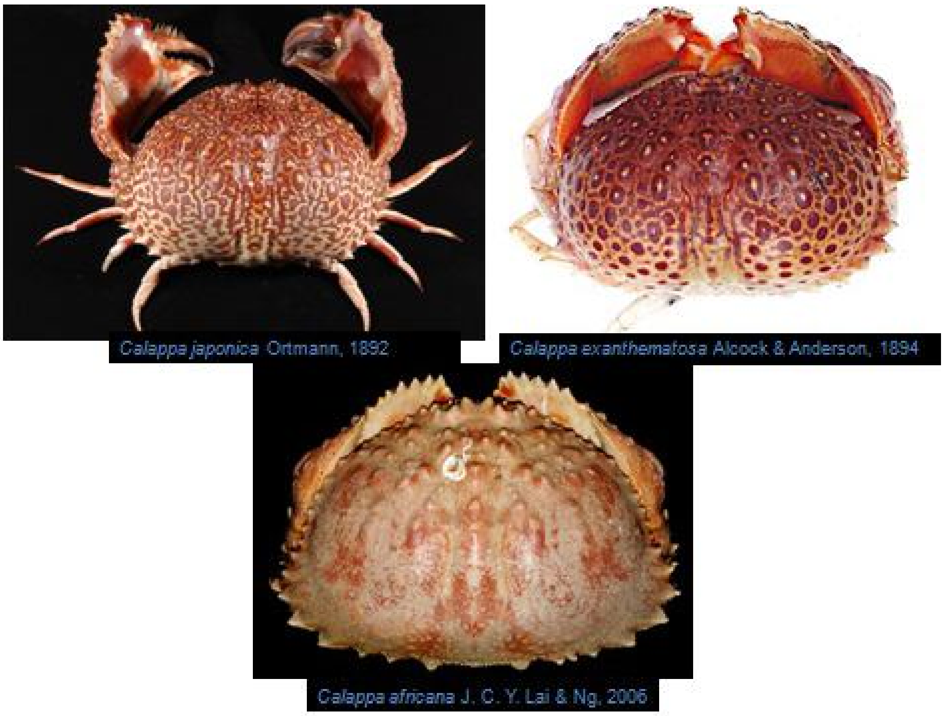
XENOGRAPSIDAE

MARINE ANIMALS ARE NOT
AS WIDESPREAD AS WE THINK …

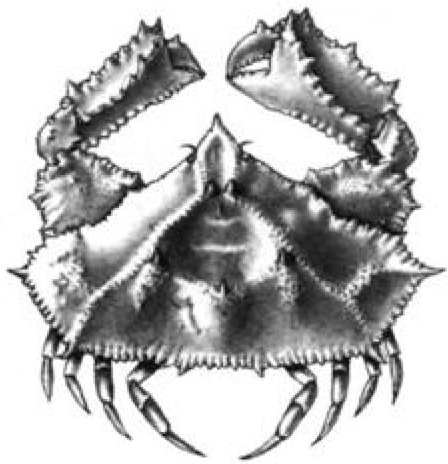

Indian Ocean Divide


Calappa philargius (Linnaeus, 1758)
Calappa bilineata Ng, J. C. Y. Lai & Aungtonya, 2002
Calappa lophos (Herbst, 1782)
Calappa guerini Brito Capello, 1870


East-West Indian Ocean Divide ….
sometimes south as well


Calappa japonica Ortmann, 1892
Calappa exanthematosa Alcock & Anderson, 1894
Calappa africana J. C. Y. Lai & Ng, 2006

Still VERY much in a discovery phase!



Cryptopodia angulata cippifer Alcock, 1895

SUMMARY

39 superfamilies, 103 families, 113 subfamilies, 1423 genera (with 419 synonyms), and 7344 species (with 2092 synonyms)

LIST OF EXTANT BRACHYURAN SUPERFAMILIES,

FAMILIES AND SUBFAMILIES

Infraorder Brachyura Latreille, 1802

Section Podotremata Guinot, 1977

CYCLODORIPPOIDEA Ortmann, 1892

Cyclodorippidae Ortmann, 1892

Cyclodorippinae Ortmann, 1892

= Cyclodorippidae Ortmann, 1892

= Tymolinae Alcock, 1896

Xeinostomatinae Tavares, 1992

= Xeinostomatinae Tavares, 1992 [recte Xeinostominae]

Cymonomidae Bouvier, 1898

= Cymonomae Bouvier, 1898

Phyllotymolinidae Tavares, 1998

= Phyllotymolinidae Tavares, 1998

DROMIOIDEA De Haan, 1833

Dromiidae De Haan, 1833

Dromiinae De Haan, 1833

= Dromiacea De Haan, 1833

= Conchoecetini Števčić, 2005

= Stebbingdromiini Števčić, 2005

Hypoconchinae Guinot & Tavares, 2003

= Hypoconchinae Guinot & Tavares, 2003

Sphaerodromiinae Guinot & Tavares, 2003

= Sphaerodromiinae Guinot & Tavares, 2003

= Frodromiini Števčić, 2005

Dynomenidae Ortmann, 1892

Acanthodromiinae Guinot, 2008

= Acanthodromiinae Guinot, 2008

Dynomeninae Ortmann, 1892

= Dynomenidae Ortmann, 1892

Metadynomeninae Guinot, 2008

= Metadynomeninae Guinot, 2008

Paradynomeninae Guinot, 2008

= Paradynomeninae Guinot, 2008

HOMOLODROMIOIDEA Alcock, 1899

Homolodromiidae Alcock, 1899

= Homolodromidae Alcock, 1899

HOMOLOIDEA De Haan, 1839

Homolidae De Haan, 1839

= Homolidea De Haan, 1839

= Thelxiopeidae Rathbun, 1937

= Latreillopsini Števčić, 2011 [recte Latreilliopsini]

Latreilliidae Stimpson, 1858

= Latreillidea Stimpson, 1858

Poupiniidae Guinot, 1993

= Poupiniidae Guinot, 1993

RANINOIDEA De Haan, 1839

Lyreididae Guinot, 1993

= Lyreidinae Guinot, 1993

Raninidae De Haan, 1839

Cyrtorhininae Guinot, 1993

= Cyrtorhininae Guinot, 1993 [recte Cyrtorhinae]

Notopodinae Serène & Umali, 1972

= Notopodinae Serène & Umali, 1972 [recte Notopinae]

= Cosmonotini Števčić, 2005

Ranininae De Haan, 1839

= Notopterygia Latreille, 1831

= Raninoidea De Haan, 1839

= Gymnopleura Bourne, 1922

Raninoidinae Lörenthey & Beurlen, 1929

= Raninoidinae Lörenthey & Beurlen, 1929

= Raninellidae Beurlen, 1930

Symethinae Goeke, 1981

= Symethidae Goeke, 1981

Section Eubrachyura Saint Laurent, 1980

Subsection Heterotremata Guinot, 1977

AETHROIDEA Dana, 1851

Aethridae Dana, 1851

= Oethrinae Dana, 1851

= Hepatinae Stimpson, 1871

BELLIOIDEA Dana, 1852

Belliidae Dana, 1852

Belliinae Dana, 1852

= Cyclinea Dana, 1851

= Belliidea Dana, 1852

= Acanthocyclidae Dana, 1852

= Corystoidini Števčić, 2005

Heteroziinae Števčić, 2005

= Heteroziidae Števčić, 2005

BYTHOGRAEOIDEA Williams, 1980

Bythograeidae Williams, 1980

= Bythograeidae Williams, 1980

CALAPPOIDEA De Haan, 1833

Calappidae De Haan, 1833

= Calappidea De Haan, 1833

Matutidae De Haan, 1835

= Matutoidea De Haan, 1835

CANCROIDEA Latreille, 1802

Atelecyclidae Ortmann, 1893

= Chlorodinae Dana, 1851 (suppressed by ICZN, pending)

= Atelecyclidae Ortmann, 1893

Cancridae Latreille, 1802

= Cancridae Latreille, 1802

= Trichoceridae Dana, 1852

CARPILIOIDEA Ortmann, 1893

Carpiliidae Ortmann, 1893

= Carpilidés A. Milne-Edwards, 1862 (not in Latin, unavailable name)

= Carpiliinae Ortmann, 1893

CHEIRAGONOIDEA Ortmann, 1893

Cheiragonidae Ortmann, 1893

= Cheiragonidae Ortmann, 1893

= Telmessidae Guinot, 1977

CORYSTOIDEA Samouelle, 1819

Corystidae Samouelle, 1819

= Corystidae Samouelle, 1819

= Euryalidae Rathbun, 1930

DAIROIDEA Serène, 1965

Dacryopilumnidae Serène, 1984

= Dacryopilumninae Serène, 1984

Dairidae Ng & Rodríguez, 1986

= Dairoida Serène, 1965 (unavailable name)

= Dairidae Ng & Rodríguez, 1986

DORIPPOIDEA MacLeay, 1838

Dorippidae MacLeay, 1838

= Dorippina MacLeay, 1838

Ethusidae Guinot, 1977

= Ethusinae Guinot, 1977

ERIPHIOIDEA MacLeay, 1838

Dairoididae Števčić, 2005

= Dairoididae Števčić, in Martin & Davie, 2001 [recte Dairodidae] (nomen nudum)

= Dairoididae Števčić, 2005

Eriphiidae MacLeay, 1838

= Eriphidae MacLeay, 1838

= Garthopilumnidae Števčić, 2005 (nomen nudum)

= Garthopilumnidae Števčić, 2011

Hypothalassiidae Karasawa & Schweitzer, 2006

= Hypothalassiidae Karasawa & Schweitzer, 2006

Menippidae Ortmann, 1893

= Menippidae Ortmann, 1893

= Myomenippinae Ortmann, 1893

= Ruppellioida Alcock, 1898

Oziidae Dana, 1851

= Oziinae Dana, 1851

Platyxanthidae Guinot, 1977

= Platyxanthidae Guinot, 1977

GECARCINUCOIDEA Rathbun, 1904

Gecarcinucidae Rathbun, 1904

= Gecarcinucinae Rathbun, 1904

= Parathelphusinae Alcock, 1910

= Somanniathelphusinae Bott, 1968

= Spiralothelphusinae Bott, 1968

= Ceylonthelphusinae Bott, 1969

= Liotelphusinae Bott, 1969

= Sundathelphusidae Bott, 1969

= Nautilothelphusini Števčić, 2005

GONEPLACOIDEA MacLeay, 1838

Acidopsidae Števčić, 2005

= Acidopsinae Števčić, 2005

= Acidopsidae Števčić, in Martin & Davis, 2001 [recte Acidopidae] (nomen nudum)

= Acidopsidae Števčić, 2005 [recte Acidopidae]

= Parapilumnidae Števčić, 2005

= Raouliinae Števčić, 2005

= Raouliidae Števčić, 2005

= Typhlocarcinodidae Števčić, 2005

= Caecopilumnidae Števčić, 2011

Chasmocarcinidae Serène, 1964

Chasmocarcininae Serène, 1964

= Chasmocarcininae Serène, 1964

Megaesthesiinae Števčić, 2005

= Megaesthesiinae Števčić, 2005

Trogloplacinae Guinot, 1986

= Trogloplacinae Guinot, 1986

Conleyidae Števčić, 2005

= Conleyidae Števčić, 2005

Euryplacidae Stimpson, 1871

= Euryplacinae Stimpson, 1871

= Systroplacini Števčić, 2013

Goneplacidae MacLeay, 1838

Bathyplacinae Števčić, 2005

= Bathyplacinae Števčić, 2005

Goneplacinae MacLeay, 1838

= Gonoplacinae MacLeay, 1838 [sic]

= Goneplacidae MacLeay, 1838

= Carcinoplacinae H. Milne Edwards, 1852

= Notonycidae Števčić, 2005

= Psopheticini Števčić, 2005

= Michaeliinae Števčić, 2011

Microgoneplacinae Števčić, 2011

= Microgoneplacini Števčić, 2011 [recte Microgeneplacini]

Neommatocarcininae Števčić, 2011

= Neommatocarcinidae Števčić, 2011

Paragoneplacinae Števčić, 2011

= Paragoneplacini Števčić, 2011

Litocheiridae Kinahan, 1856

= Litocheiridae Kinahan, 1856

= Litocheiridae Števčić, 2005

Mathildellidae Karasawa & Kato, 2003

= Mathildellinae Karasawa & Kato, 2003

= Intesiini Števčić, 2005

= Platypilumninae Števčić, 2005

Progeryonidae Števčić, 2005

= Paragalenini Števčić, 2005

= Progeryonini Števčić, 2005

= Rhadinoplacinae Števčić, 2011

Scalopidiidae Števčić, 2005

= Scalopidiidae Števčić, 2005

Sotoplacidae Castro, Guinot & Ng, 2010

= Sotoplacidae Castro, Guinot & Ng, 2010

Vultocinidae Ng & Manuel-Santos, 2007

= Vultocinidae Ng & Manuel-Santos, 2007

HEXAPODOIDEA Miers, 1886

Hexapodidae Miers, 1886

= Hexapodinae Miers, 1886

HYMENOSOMATOIDEA MacLeay, 1838

Hymenosomatidae MacLeay, 1838

Hymenosomatinae MacLeay, 1838

= Hymenosomidae MacLeay, 1838

= Hymenicinae Dana, 1851

Odiomarinae Guinot, 2011

= Odiomarinae Guinot, 2011

LEUCOSIOIDEA Samouelle, 1819

Iphiculidae Alcock, 1896

= Iphiculoida Alcock, 1896

Leucosiidae Samouelle, 1819

Ebaliinae Stimpson, 1871

= Ebaliinae Stimpson, 1871

= Iliinae Stimpson, 1871

= Myrodinae Miers, 1886

= Oreophorinae Miers, 1886

= Myroida Alcock, 1896

= Nucioida Alcock, 1896

= Nursilioida Alcock, 1896

= Philyrinae Rathbun, 1937

= Arcaniini Števčić, 2005

= Ixini Števčić, 2005

= Pariliini Števčić, 2005

= Persephonini Števčić, 2005

= Randalliini Števčić, 2005

= Ihleini Števčić, 2011

= Coralliocryptini Števčić, 2013

Cryptocneminae Stimpson, 1907

= Cryptocnemidae Stimpson, 1907

= Leuciscini Števčić, 2005

= Lissomorphini Števčić, 2005

= Onychomorphini Števčić, 2005

Leucosiinae Samouelle, 1819

= Leucosiadae Samouelle, 1819

MAJOIDEA Samouelle, 1819

Epialtidae MacLeay, 1838

Epialtinae MacLeay, 1838

= Epialtidae MacLeay, 1838

= Huenidae MacLeay, 1838

= Menaethinae Dana, 1851

= Acanthonychinae Stimpson, 1871

= Alcockiini Števčić, 2005

Pisinae Dana, 1851

= Amathinae Dana, 1851

= Chorininae Dana, 1851

= Libiniinae Dana, 1851 [recte Libininae]

= Pisinae Dana, 1851

= Periceridae Dana, 1851

= Pyrinae Dana, 1851

= Stenociopinae Dana, 1851

= Leptopisinae Stimpson, 1871 [recte Leptopinae]

= Cyphocarcininae Neumann, 1878

= Ixioninae Neumann, 1878

= Lissoida Alcock, 1895

= Blastidae Stebbing, 1902

= Hyasteniinae Balss, 1929

= Macrocoelominae Balss, 1929

= Coelocerini Števčić, 2005

Pliosomatinae Števčić, 1994

= Pliosomatinae Števčić, 1994 [recte Pliosominae]

Tychinae Dana, 1851

= Tychiidae Dana, 1851 [recte Tychidae]

= Criocarcininae Dana, 1851

= Othoninae Dana, 1851

= Picrocerinae Neumann, 1878

= Ophthalmiinae Balss, 1929

Inachidae MacLeay, 1838

Eucinetopinae Števčić, 2005

= Eucinetopini Števčić, 2005

Inachinae MacLeay, 1838

= Macropodiadae Samouelle, 1819 (pre-occupied name)

= Eurypodiidae MacLeay, 1838 [recte Eurypodidae]

= Inachidae MacLeay, 1838

= Leptopodidae Bell, 1844 [recte Leptopodiadae]

= Achaeinae Dana, 1851

= Camposcinae Dana, 1851

= Macrocheirinae Dana, 1851

= Oncininea Dana, 1852

= Oncinopodidae Stimpson, 1858 [recte Oncinopidae]

= Anomalopodinae Stimpson, 1871 [recte Anomalopinae]

= Microrhynchinae Miers, 1879

= Chorinachini Števčić, 2005

= Encephaloidini Števčić, 2005

= Ephippiini Števčić, 2005

= Eucinetopini Števčić, 2005

= Grypachaeini Števčić, 2005

= Sunipeini Števčić, 2005

= Trichoplatini Števčić, 2005

Podochelinae Neumann, 1878

= Podochelinae Neumann, 1878

Inachoididae Dana, 1851

Inachoidinae Dana, 1851

= Inachoidinae Dana, 1851

= Salacinae Dana, 1851

= Collodinae Stimpson, 1871

Stenorhynchinae Dana, 1851

= Stenorhynchinae Dana, 1851

Majidae Samouelle, 1819

Eurynolambrinae Števčić, 1994

= Eurynolambrinae Števčić, 1994

Majinae Samouelle, 1819

= Majinae Samouelle, 1819

= Maiadae Samouelle, 1819

= Cyclacinae Dana, 1851

= Micippinae Dana, 1851

= Paramicippinae Dana, 1851

= Prionorhynchinae Dana, 1851

= Naxiinae Stimpson, 1871

= Eurynominae Neumann, 1878

= Schizophrysinae Miers, 1879

= Mamaiidae Stebbing, 1905

Planoterginae Števčić, 1991

= Planoterginae Števčić, 1991

Mithracidae MacLeay, 1838

= Mithracidae MacLeay, 1838

= Thoini Števčić, 1994

Oregoniidae Garth, 1958

Oregoniinae Garth, 1958

= Oregoniinae Garth, 1958

= Macroregoniini Števčić, 2005

Pleistacanthinae Števčić, 2005

= Pleistacanthini Števčić, 2005

ORITHYIOIDEA Dana, 1852

Orithyiidae Dana, 1852

= Orithyiinae Dana, 1852

PALICOIDEA Bouvier, 1898

Crossotonotidae Moosa & Serène, 1981

= Crossotonotinae Moosa & Serène, 1981

Palicidae Bouvier, 1898

= Cymopoliidae Faxon, 1895 (pre-occupied name)

= Palicés Bouvier, 1897 (not in Latin, unavailable name)

= Palici Bouvier, 1898a

= Palicae Bouvier, 1898b

= Palicidae Rathbun, 1898

PARTHENOPOIDEA MacLeay, 1838

Parthenopidae MacLeay, 1838

Daldorfiinae Ng & Rodríguez, 1986

= Daldorfiidae Ng & Rodríguez, 1986 [recte Daldorfidae]

Parthenopinae MacLeay, 1838

= Parthenopidae MacLeay, 1838

= Cryptopodiinae Stimpson, 1871

= Lambrinae Neumann, 1878

= Mimilambridae Williams, 1979

= Lambrachaeini Števčić, 1994

PILUMNOIDEA Samouelle, 1819

Galenidae Alcock, 1898

Dentoxanthinae Števčić, 2005

= Dentoxanthinae Števčić, 2005

Galeninae Alcock, 1898

= Galenidés A. Milne-Edwards, 1862 (not in Latin, unavailable name)

= Galenoida Alcock, 1898

Halimedinae Alcock, 1898

= Halimedoida Alcock, 1898

Parapanopinae Števčić, 2005

= Parapanopini Števčić, 2005

Pilumnidae Samouelle, 1819

Calmaniinae Števčić, 1991

= Calmaniini Števčić, 1991

Eumedoninae Dana, 1852

= Eumedonidae Dana, 1852

= Ceratocarcininae Števčić, Gore & Castro, 1988

= Hapalonotinae Števčić, 2005

= Rhabdonotini Števčić, 2011

Pilumninae Samouelle, 1819

= Pilumnidae Samouelle, 1819

= Actumninae Dana, 1851

= Heteropanopioida Alcock, 1898

= Heteropilumninae Serène, 1984

= Bathypilumnini Števčić, 2005

= Danielini Števčić, 2005

= Priapilumnini Števčić, 2005

Rhizopinae Stimpson, 1858

= Rhizopidae Stimpson, 1858

= Typhlocarcinopinae Rathbun, 1909 [recte Typhlocarcinopsinae]

= Itampolinae Števčić, 2005

= Peleianinae Števčić, 2005

Xenophthalmodinae Števčić, 2005

= Xenophthalmodinae Števčić, 2005

Tanaochelidae Ng & Clark, 2000

= Tanaochelinae Ng & Clark, 2000

PORTUNOIDEA Rafinesque, 1815

Brusiniidae Števčić, 1991

= Brusiniini Števčić, 1991

Carcinidae MacLeay, 1838

Carcininae MacLeay, 1838

= Carcinidae MacLeay, 1838

= Megalopidae Haworth, 1825

Platyonichinae Dana, 1851

= Platyonichidae Dana, 1851 [recte Platyonychidae]

= Platyonichidae Ortmann, 1893 [recte Platyonychidae]

= Portumninae Ortmann, 1899

= Xaividae Berg, 1900

Geryonidae Colosi, 1923

Geryoninae Colosi, 1923

= Geryonidae Colosi, 1923

Benthochasconinae Spiridonov, Neretina & Schepetov, 2014

= Benthochasconinae Spiridonov, Neretina & Schepetov, 2014

Ovalipidae Spiridonov, Neretina & Schepetov, 2014

= Ovalipidae Spiridonov, Neretina & Schepetov, 2014

Pirimelidae Alcock, 1899

= Pirimelinae Alcock, 1899

Polybiidae Ortmann, 1893

= Polybiinae Ortmann, 1893

= Liocarcininae Rathbun, 1930

= Macropipinae Stephenson & Campbell, 1960

Portunidae Rafinesque, 1815

Caphyrinae Paul'son, 1875

= Caphyrinae Paul'son, 1875

= Lissocarcinidae Ortmann, 1893

= Coelocarcinini Števčić, 2005

Carupinae Paul'son, 1875

= Carupinae Paul'son, 1875

= Catoptrinae Borradaile, 1903

= Goniocaphyrinae Borradaile, 1900

= Pelini Števčić, 2011

= Richerellini Števčić, 2011

= Kumini Števčić, 2013

Lupocyclinae Alcock, 1899

= Lupocycloida Alcock, 1899

Podophthalminae Dana, 1851

= Podophthalmidae Dana, 1851

Portuninae Rafinesque, 1815

= Portunidia Rafinesque, 1815

= Arenaeinae Dana, 1851

= Lupinae Dana, 1851

= Neptuniden Nauck, 1880 (not in Latin, unavailable name)

= Atoportunini Števčić, 2005

Thalamitinae Paul'son, 1875

= Thalamitinae Paul'son, 1875

Thiidae Dana, 1852

Nautilocorystinae Ortmann, 1893

= Nautilocorystidae Ortmann, 1893

Thiinae Dana, 1852

= Thiidae Dana, 1852

POTAMOIDEA Ortmann, 1896

Potamidae Ortmann, 1896

Potaminae Ortmann, 1896

= Thelphusidae MacLeay, 1838 (priority suppressed, ICZN ruling)

= Potamoninae Ortmann, 1896

= Potamidae Ortmann, 1896 (spelling changed, ICZN ruling)

Potamiscinae Bott, 1970

= Potamiscinae Bott, 1970

= Sinopotamidae Bott, 1970

= Isolapotamidae Bott, 1970

= Malayopotamini Števčić, 2011

Potamonautidae Bott, 1970

Deckeniinae Ortmann, 1897

= Deckenini Ortmann, 1897

= Seychellinae Števčić, 2005

Hydrothelphusinae Colosi, 1920

= Hydrothelphusini Colosi, 1920

= Hydrothelphusini Bott, 1955

= Globonautinae Bott, 1969

Potamonautinae Bott, 1970

= Platythelphusinae Colosi, 1920

= Potamonautinae Bott, 1970

PSEUDOTHELPHUSOIDEA Ortmann, 1893

Pseudothelphusidae Ortmann, 1893

Epilobocerinae Smalley, 1964

= Epilobocerinae Smalley, 1964

Pseudothelphusinae Ortmann, 1893

= Bosciacaea H. Milne Edwards, 1853 (name not available)

= Bosciadae Stimpson, 1858 (name not available)

= Pseudothelphusidae Ortmann, 1893

= Potamocarcinini Ortmann, 1897

= Kingsleyini Bott, 1970

= Guinotini Pretzmann, 1971

= Hypolobocerini Pretzmann, 1971

= Strengerianini Rodríguez, 1982

PSEUDOZIOIDEA Alcock, 1898

Christmaplacidae Naruse & Ng, 2014

= Christmaplacidae Naruse & Ng, 2014

Pilumnoididae Guinot & Macpherson, 1987

= Pilumnoidinae Guinot & Macpherson, 1987

Planopilumnidae Serène, 1984

= Planopilumninae Serène, 1984

= Flindersoplacidae Števčić, 2005

= Platycheloniini Števčić, 2005

= Haemocinidae Števčić, 2011

Pseudoziidae Alcock, 1898

= Pseudozioida Alcock, 1898

RETROPLUMOIDEA Gill, 1894

Retroplumidae Gill, 1894

= Retroplumidae Gill, 1894

= Ptenoplacidae Alcock, 1899

TRAPEZIOIDEA Miers, 1886

Domeciidae Ortmann, 1893

= Domoeciinae Ortmann, 1893

Tetraliidae Castro, Ng & Ahyong, 2004

= Tetraliinae Števčić, 2005

Trapeziidae Miers, 1886

Calocarcininae Števčić, 2005

= Calocarcinini Števčić, 2005

= Sphaenomeridini Števčić, 2005 [sic]

= Philippicarcinini Števčić, 2011

Quadrellinae Števčić, 2005

= Quadrellini Števčić, 2005

Trapeziinae Miers, 1886

= Trapeziidae Miers, 1886

TRICHODACTYLOIDEA H. Milne Edwards, 1853

Trichodactylidae H. Milne Edwards, 1853

Dilocarcininae Pretzmann, 1978

= Dilocarcini Pretzmann, 1978

= Holthuisiini Pretzmann, 1978

= Valdiviini Pretzmann, 1978

Trichodactylinae H. Milne Edwards, 1853

= Trichodactylacea H. Milne Edwards, 1853

TRICHOPELTARIOIDEA Tavares & Cleva, 2010

Trichopeltariidae Tavares & Cleva, 2010

XANTHOIDEA MacLeay, 1838

Linnaeoxanthidae Števčić, 2005

= Melybiidae Števčić, in Martin & Davis, 2001 (nomen nudum)

= Linnaeoxanthinae Števčić, 2005

= Melybiidae Števčić, 2005

Panopeidae Ortmann, 1893

= Eucratopsinae Stimpson, 1871

= Prionoplacidae Alcock, 1900

= Chasmophorinae Števčić, 2005

= Cycloplacinae Števčić, 2005

= Malacoplacini Števčić, 2005

= Panopaeinae Ortmann, 1893

Pseudorhombilidae Alcock, 1900

= Pseudorhombilinae Alcock, 1900

= Speocarcinidae Števčić, in Martin & Davis, 2001 (nomen nudum)

= Eucratodinae Števčić, 2005

= Euphrosynoplacini Števčić, 2005

= Chacellini Števčić, 2005

= Bathyrhombilini Števčić, 2005

= Lophoxanthini Števčić, 2005

= Micropanopeini Števčić, 2005

= Perunorhombilini Števčić, 2005

= Robertsellini Števčić, 2005

= Speocarcinidae Števčić, 2005

= Tetraxanthinae Števčić, 2005

= Trapezioplacinae Števčić, 2005

= Krunorhombilini Števčić, 2011

= Scopoliini Števčić, 2011

= Thalassoplacini Števčić, 2005

Xanthidae MacLeay, 1838

Actaeinae Alcock, 1898

= Actaeinae Alcock, 1898

Antrocarcininae Ng & D. G. B. Chia, 1994

= Antrocarcininae Ng & D. G. B. Chia, 1994

Chlorodiellinae Ng & Holthuis, 2007

= Chlorodiellinae Ng & Holthuis, 2007

Cymoinae Alcock, 1898

= Cymoida Alcock, 1898

Etisinae Ortmann, 1893

= Etisinae Ortmann, 1893

Euxanthinae Alcock, 1898

= Euxanthoida Alcock, 1898

= Ladomedaeidae Števčić, 2005

= Pilomedaeini Števčić, 2013

Garthiellinae Mendoza & Manuel-Santos, 2012

= Garthiellinae Mendoza & Manuel-Santos, 2012

Glyptoxanthinae Mendoza & Guinot, 2011

= Glyptoxanthinae Mendoza & Guinot, 2011

Kraussiinae Ng, 1993

= Kraussiinae Ng, 1993

Liomerinae Sakai, 1976

= Liomeroida Sakai, 1976

Polydectinae Dana, 1851

= Polydectinae Dana, 1851

= Melioida Alcock, 1898

= Lybioida Serène, 1965

Xanthinae MacLeay, 1838

= Xanthidae MacLeay, 1838

= Xanthodioida Alcock, 1898

= Liagoridés A. Milne-Edwards, 1862 (not in Latin, unavailable name)

= Coralliopinae Števčić, 2005

= Gonopanopeini Števčić, 2005

= Liagorini Števčić, 2005

= Megametopinae Števčić, 2005

= Paraxanthini Števčić, 2005

= Orphnoxanthini Števčić, 2005

= Camilohelleriini Števčić, 2011

= Nanocassiopini Števčić, 2013

Zalasiinae Serène, 1968

= Zalasiinae Serène, 1968

= Trichidea De Haan, 1839

= Banareiini Števčić, 2005

Zosiminae Alcock, 1898

= Zozymoida Alcock, 1898

Subsection Thoracotremata Guinot, 1977

CRYPTOCHIROIDEA Paul'son, 1875

Cryptochiridae Paul'son, 1875

= Cryptochiridae Paul'son, 1875

= Lithoscaptidae Richters, 1880

= Hapalocarcinidae Calman, 1900

GRAPSOIDEA MacLeay, 1838

Gecarcinidae MacLeay, 1838

= Gécarciniens H. Milne Edwards, 1837 (not in Latin, unavailable name)

= Gecarcinidae MacLeay, 1838

= Geocarcinidae Miers, 1886

= Cardisomaceen Nauck, 1880 (not in Latin, unavailable name)

= Cardisominae Ehrardt, 1968 (nomen nudum)

Glyptograpsidae Schubart, Cuesta & Felder, 2002

= Glyptograpsidae Schubart, Cuesta & Felder, in Martin & Davis, 2001 (nomen nudum)

= Glyptograpsidae Schubart, Cuesta & Felder, 2002

Grapsidae MacLeay, 1838

= Grapsidae MacLeay, 1838

= Goniopsinae Kossmann, 1877

= Leptograpsinae Kossmann, 1877

Percnidae Števčić, 2005

= Percnini Števčić, 2005

Plagusiidae Dana, 1851

= Plagusiinae Dana, 1851

= Euchirograpsini Števčić, 2005

= Davusiini Števčić, 2011

Sesarmidae Dana, 1851

= Sesarminae Dana, 1851

= Aratini Števčić, 2005

Varunidae H. Milne Edwards, 1853

Asthenognathinae Stimpson, 1858

= Asthenognathidae Stimpson, 1858

Cyclograpsinae H. Milne Edwards, 1853

= Cyclograpsacea H. Milne Edwards, 1853

= Helicinae Kossmann, 1877 (pre-occupied name)

= Paragrapsini Števčić, 2005

= Heliceinae Sakai, Türkay & Yang, 2006

Gaeticinae Davie & Ng, 2007

= Gaeticinae Davie & Ng, 2007

= Brankocleistostomidae Števčić, 2011

= Gopkittisakini Števčić, 2011

Thalassograpsinae Davie & Ng, 2007

= Thalassograpsinae Davie & Ng, 2007

Varuninae H. Milne Edwards, 1853

= Varunacea H. Milne Edwards, 1853

= Pseudograpsinae Kossmann, 1877

= Varuninae Alcock, 1900

Xenograpsidae N. K. Ng, Davie, Schubart & Ng, 2007

= Xenograpsidae N. K. Ng, Davie, Schubart & Ng, 2007

OCYPODOIDEA Rafinesque, 1815

Camptandriidae Stimpson, 1858

= Camptandriidae Stimpson, 1858

= Cleistotomatini Pretzmann, 1977

Dotillidae Stimpson, 1858

Dotillinae Stimpson, 1858

= Dotinae Dana, 1851

= Scopimeridae Alcock, 1900

= Lazarocleistostomidae Števčić, 2011

Sheniinae Ng, Clark & Cuesta, 2010

= Sheniinae Ng, Clark & Cuesta, 2010

Heloeciidae H. Milne Edwards, 1852

= Heloeciacaea H. Milne Edwards, 1852

= Heloeciinae Türkay, 1983

Macrophthalmidae Dana, 1851

Ilyograpsinae Števčić, 2005

= Ilyograpsini Števčić, 2005

Macrophthalminae Dana, 1851

= Macrophthalmidae Dana, 1851

Tritodynamiinae Števčić, 2005

= Tritodynamiini Števčić, 2005

Mictyridae Dana, 1851

= Mictyridae Dana, 1851 [recte Myctiridae]

Ocypodidae Rafinesque, 1815

Gelasiminae Miers, 1886

= Gelasimiden Nauck, 1880 (not in Latin, unavailable name)

= Gelasimidae Miers, 1886

Ocypodinae Rafinesque, 1815

= Ocypodia Rafinesque, 1815

= Ucainae Dana, 1851

= Ucini Pretzmann, 1983

Ucidinae Števčić, 2005

= Ucidinae Števčić, 2005

Xenophthalmidae Stimpson, 1858

Anomalifrontinae Rathbun, 1931

= Anomalifrontinae Rathbun, 1931

Xenophthalmidae Stimpson, 1858

= Xenophthalmidae Stimpson, 1858

PINNOTHEROIDEA De Haan, 1833

Aphanodactylidae Ahyong & Ng, 2009

= Aphanodactylidae Ahyong & Ng, 2009

= Gustavini Števčić, 2011

Pinnotheridae De Haan, 1833

Pinnothereliinae Alcock, 1900 ?

= Pinnothereliinae Alcock, 1900

Pinnixinae Števčić, 2005

= Alarconiini Števčić, 2005

= Glassellini Števčić, 2005

= Pinnixini Števčić, 2005

Pinnotherinae De Haan, 1833

= Pinnotheridea De Haan, 1833

= Dissodactylidae Smith, 1870

= Parapinnixini Števčić, 2005

Pinnixulalinae Palacios Theil, Cuesta & Felder, 2016

= Pinnixulalinae Palacios Theil, Cuesta & Felder, 2016

KEY TO THE FAMILIES OF BRACHYURAN CRABS FOUND OR EXPECTED IN INDIA

1 Male and female genital openings coxal (on ambulatory leg 5) 2
– Male genital openings coxal, coxo-sternal or sternal; female genital openings sternal... 12

2 Basal segment of eyestalk much longer than terminal article, from dorsal view, eyestalk appears to be 2-segmented
Latreilliidae
– Basal segment of eyestalk much shorter than terminal article, from dorsal view, eyestalk appears to be unsegmented 3

3 Fourth (last) last pair of ambulatory legs distinctly subchelate to chelate or strongly reduced to just 3 articles, inserted obliquely on carapace and directed upwards 4
– Fourth (last) last pair of ambulatory legs normal in structure or reduced in size but not subchelate or chelate and never reduced to just 3 articles, inserted laterally on carapace and directed laterally ... 10

4 Merus of third maxilliped distinctly triangular in shape 5
– Merus of third maxilliped quadrate to subquadrate, never clearly triangular in shape... 7

5 Third maxilliped with palp (dactylus, propodus and carpus) inserted on inner surface of merus, not visible when flexed; exopod without flagellum .... **Cyclodorippidae**
– Third maxilliped with palp (dactylus, propodus and carpus) inserted on inner margin of merus, distinctly visible even when flexed; exopod with distinct flagellum 6

6 No orbits visible; eye peduncle fused to carapace, no distinct cornea .. **Cymonomidae**
– Orbits and eyes normal, well developed; eye peduncle mobile with distinct cornea ..
Phyllotymolidae [not yet known from Indian Ocean]

7 Carapace longitudinally rectangular, dorsal surface glabrous or with scattered stiff setae. Only fourth pair of ambulatory legs with dactylus and propodus subchelate to chelate ..
Homolidae
– Carapace longitudinally ovate, circular or hexagonal, dorsal surface usually with dense, soft setae. Both third and fourth ambulatory legs with dactylus and propodus subchelate to chelate; carries sponges and other marine organisms when alive .. 8

8 Carapace circular to hexagonal. A small platelet-like structure usually intercalated between edges of pleonal somite 6 and telson; crab carries sponges, tunicates, and bivalve shells
Dromiidae
– Carapace longitudinally ovate. No platelet-like structure intercalated between edges of pleonal somite 6 and telson; crab believed to carry sponges or related objects..
Homolodromiidae

9 Carapace longitudinally subrectangular. Ambulatory legs very long, slender; dorsal surface of carapace and pereopods densely covered with stiff setae ..
Poupiniidae [not yet known from Indian Ocean]
– Carapace longitudinally or transversely rectangular to ovate. Ambulatory legs relatively short, stouter; dorsal surface of carapace and pereopods usually smooth, covered with dense stiff setae in only some taxa..10

10 Merus of third maxilliped quadrate to transversely rectangular, never distinctly triangular in shape. Carapace ovate to transversely ovate. Thoracic sternum relatively broad. Fingers of chela not prominently bent. A small platelet-like structure always intercalated present between edges of pleonal somite 6 and telson. Fourth ambulatory leg strongly reduced, present only as a short appendage; not a burrower; no known carrying behaviour .... **Dynomenidae**

– Merus of third maxilliped distinctly triangular in shape. Carapace longitudinally ovate; thoracic sternum very narrow. Thoracic sternites 5 to 7 very narrow. Fingers of chela strongly bent. Pleonal somite 6 and telson normal without intercalated plate. Fourth ambulatory leg reduced but still clearly discernible as leg; usually burrows into soft substrates; does not carry objects... 11

11 Anterolateral edges of pleonal somite 6 with distinct projection used to lock pleon to thoracic sternum ... **Lyreididae**

– Anterolateral edges of pleonal somite 6 rounded, without projection for locking pleon to thoracic sternum …. **Raninidae**

12 Male genital openings clearly coxal or coxosternal, with penis protruding directly from coxa of ambulatory leg 5 13

– Male genital openings clearly sternal … 69

13 Only 3 pairs of ambulatory legs visible, fourth pair lost, not visible... **Hexapodidae**

– Adults with 4 pairs of ambulatory legs ... 13

14 Merus of third maxilliped distinctly triangular in shape ... 15

– Merus of third maxilliped quadrate to subquadrate, never clearly triangular in shape ... 21

15 Last two pairs of ambulatory legs distinctly chelate, inserted obliquely on carapace and directed upwards ... 16

– Last two pairs of ambulatory legs distinctly normal, inserted laterally on carapace ...17

16 Afferent branchial openings narrow, elongated. Male pleon triangular. Male gonopores coxal to coxo-sternal in condition ... **Dorippidae**

– Afferent branchial openings oval or circular. Male pleon narrow, with nearly parallel sides. Male gonopores only exhibits coxo-sternal in condition ... **Ethusidae**

17 Opening for afferent respiratory current at base of chela, no canal present along sides of buccal cavern even when third maxillipeds pushed aside ... 18

– Opening for afferent respiratory current below frontal margin or orbits, adjacent to endostome, with distinct canal present along sides of buccal cavern when third maxillipeds pushed aside ... 19

18 Female pleon with all somites freely articulating, not forming brood-chamber with thoracic sternum, egg-mass protruding from sides of pleon when ovigerous ... **Iphiculidae**

– Female pleon with most somites fused, forming brood-chamber with thoracic sternum, egg-mass not visible when ovigerous .... **Leucosiidae**

19 Afferent respiratory opening separated by the third maxilliped and not continuous with each other .... **Aethridae**

– Both afferent respiratory opening directly under the middle portion of the frontal margin, not separated by any of the mouthparts 20

20 Sides of carapace may be expanded to form a clypeiform process. Right chela (rarely left) with specialized cutting tooth, the fingers of other chela long, forceps-like. Propodus and dactylus of ambulatory legs never paddle-like .... **Calappidae**

– Sides of carapace never expanded to form a clypeiform process. Chelae symmetrical, fingers never with specialized cutting tooth. Propodus and dactylus of first to fourth ambulatory legs paddle-like .... **Matutidae**

21 Fourth ambulatory leg strongly reduced compared to other legs, appears rudimentary or vestigial 22

– Fourth ambulatory leg subequal to other legs, or if smaller, is functional and not greatly reduced in size compared to third leg 24

22 Carapace quadrate, smooth, may have dorsal transverse ridges, anterolateral margin entire. Last ambulatory leg setose to strongly setose and appearing feather-like … **Retroplumidae**

– Carapace quadrate to ovate, dorsal surface rugose to strongly rugose and granulate, never with dorsal transverse ridges; anterolateral margin with teeth and spines. Last ambulatory leg simple, filamentous, not setose 23

23 Somites 1 and 2 of male and female pleons compressed dorsoventrally, very narrow in comparison to the remaining 4 pleonal somites .... **Palicidae**

– Somites 1 and 2 of male and female pleons wide, not compressed dorsoventrally .... **Crossotonotidae**

24 Carapace transversely ovate, wider than long; anterolateral margins convex. Wholly freshwater group, eggs large developing directly into juvenile crabs, females brooding young for short period 25

– Carapace transversely ovate to quadrate or longer than broad. Completely marine groups, eggs almost always developing into planktonic zoeae, rarely as megalopa, females do not usually brood young 26

25 Mandibular palp with 3 articles and terminal article usually with single lobe. Male pleon triangular in shape .... **Potamidae**

– Mandibular palp with 2 articles, terminal article bilobed. Male pleon usually distinctly T-shaped, sometimes vaguely triangular .... **Gecarcinucidae**

26 Carapace usually pyriform, usually longer than broad, sometimes quadrate; carapace, chelipeds and ambulatory legs usually with hooked setae (sometimes very dense) that cling on to debris and objects, used in camouflage 27

– Carapace usually broader than long; carapace, chelipeds and ambulatory legs without hooked setae (if present are simple) 29

27 Basal antennal segment broad, at most twice as long as broad. Orbits present, formed by supraorbital eave, adjacent spines and a postorbital spine or lobe .... **Majidae**

– Basal antennal segment slender, at most twice as long as broad. Orbits absent or with narrow, weakly developed supraorbital eave and small postorbital lobe 28

28 Orbits with narrow, weakly developed supraorbital eave partially overhanging eyes; with or without small postorbital lobe .... **Epialtidae**

– Orbits absent, eyes unprotected though orbital margin usually with several small spines and postorbital spine .... **Inachidae** and **Oregoniidae**

29 Fossae (sockets) for antennules quadrate to longer than broad, antennules fold longitudinally or almost so 30

– Fossae for antennules broader than long, antennules fold transversely or obliquely.... 33

30 Carapace poorly calcified; pyriform, subpyriform, triangular, circular, or subcircular; orbits absent .... **Hymenosomatidae**

– Carapace strongly calcified, longitudinally and transversely ovate, hexagonal, circular, or subcircular; orbits complete 31

31 Antennal flagellum slightly setose to glabrous .... **Cancridae**

– Antennal flagellum distinctly setose 32

32 Antennae very long, longer than or as long as carapace length, strongly setose. Chelipeds homochelous .... **Corystidae**

– Antennae short, much shorter than carapace length, not strongly setose. Chelipeds slightly to strongly heterochelous .... **Trichopeltariidae**

33 Carapace triangular or hexagonal; front triangular, forked or spiniform. Chelipeds triangular in cross-section, usually very long 34

– Carapace shape not as above; front usually truncate or multidentate. Chelipeds usually oval to circular in cross-section, usually not prominently elongated 35

34 Press-button on sterno-pleonal cavity that retains male pleon consists of a rounded tubercle on posterior edge of sternite 5. Male pleon relatively broad .... **Dairoididae**

– Press-button on sterno-pleonal cavity consists of a low peg-like tubercle on anterior edge of sternite 5. Male pleon relatively slender .... **Parthenopidae**

35 Last pair of ambulatory legs with dactylus flattened, paddle-like (with exception of a few mud-dwelling and obligate coral-symbionts)............................... 36

– Last pair of ambulatory legs with normal dactylus, not paddle-like 39

36 Carapace distinctly longer than broad. Ambulatory legs short **Brusiniidae**

– Carapace rounded or distinctly broader than long. Ambulatory legs normal length or elongated 37

37 Carapace prominently wider than long; front relatively wide .... **Portunidae**

– Carapace rounded to slightly wider than long; front relatively narrower 38

38 Dactylus of last ambulatory leg ovate **Ovalipidae**

– Dactylus of last ambulatory leg lanceolate **Polybiidae**

39 Cross-section of dactylus of ambulatory leg T-shaped .... **Geryonidae**

– Cross-section of dactylus of ambulatory leg not T-shaped, usually quadrate to ovate.... 40

40 Orbits almost non-existent, area demarcated by margins of carapace but no obvious concavity for orbit; eyes very reduced, cornea unpigmented. Deep sea family, often associated with hydrothermal vents **Bythograeidae** [not yet known from Indian Ocean]

– Orbits clearly demarcated as concavity for normally well developed eyes with distinctly pigmented corneas. Shallow water to deep sea 41

41 All male pleonal somites (including telson) freely articulating 42

– Male pleonal somites 3 and 4, or 3–5 fused, immovable, even if some or all the sutures are visible 60

42 Carapace with frontal margin and anterior part much wider than posterior part, antero- and posterolateral margins not well demarcated, converging sharply to very short posterior margin; frontal region very wide, eyes positioned at edge of carapace and demarcates broadest part of carapace 43

– Carapace quadrate to ovate; frontal margin normal, occupying part of frontal region; eyes not place at the edge of carapace, widest part of carapace usually at junction of well demarcated antero- and posterolateral margins 44

43 Carapace superficially transversely ovate, appears trapezoidally subglobose, dorsally very convex; frontal margin not clearly discernible with entire surface very convex. G2 much longer than G1, with distal segment looping; free living or in holes in dead corals.......**Dacryopilumnidae**

– Carapace distinctly trapezoidal, dorsal surfaces almost flat; frontal margin sharply defined. G2 about half length of G1; obligate symbionts on zooxanthellate scleratinian acroporid corals.............**Tetraliidae**

44 G1 very slender, usually S-shaped, distal part never with large spines or complex folds; G2 less than 0.25 G1 length, very small, sigmoidal, comma-shaped 45

– G1 otherwise; G2 about between 0.3–0.7 times G1 length 47

45 At least one cheliped long and slender, at least twice length of carapace; tips of chelipeds spoon-tipped .... **Tanaochelidae**

– Chelipeds about same length as carapace; tips of chelipeds not spoon-tipped, sharp 46

46 Carapace usually densely pubescent. Male pleon triangular, with somites 5, 6 and telson trapezoidal to triangular; G1 S-shaped........... **Pilumnidae**

– Carapace usually glabrous or sparely pubescent. Male pleon distinctly T-shaped, with somites 5, 6 and telson slender, elongate; G1 long, straight to almost straight, tip may be fluted **Galenidae**

47 Carapace squarish, dorsal regions well demarcated by prominent clumps of granules; entire surface of carapace and pereopods densely covered with thick short setae which obscures surface and margins. Male thoracic episternite 7 with posterior angle prominently prolonged posteriorly to form long spur which just touches coxa of last ambulatory leg **Vultocinidae** [not yet known from Indian Ocean]

– Carapace transversely rectangular to ovate; surface of carapace not as above. Male thoracic episternite 7 not as above....... 48

48 Male pleon distinctly T-shaped, male pleonal somites very narrow. G1 very slender medially and distally, almost straight; G2 about one-third length of G1 .... **Euryplacidae**

– Male pleon triangular, male pleonal somites trapezoidal to triangular. G1 relatively stout and straight or gently curved; G2 0.25 times length to longer than G1 49

49 Carapace distinctly trapezoidal with prominent lateral spine along median part of lateral margin. G1 with median part paddle-like, margins with short spines; G2 with tip of distal segment expanded .... **Goneplacidae** [part: *Microgoneplax*]

– Carapace not trapezoidal, lateral margin not as above. G1 tubular; G2 with tip of distal segment sharp to truncate, never expanded.................. 50

50 G2 about 0.3–0.5 times G1 length............ 51
– G2 usually subequal in length or longer than G1............... 55

51 Carapace subcircular. Male thoracic sternite 3 distinctly wider than sternite 4 ...... **Pilumnoididae** [not yet known from Indian Ocean]
– Carapace usually transversely subtrapezoidal to subrectangular (rarely ovate) or subovate. Male thoracic sternite 3 distinctly less wide than sternite 4 52

52 Eyes and ocular peduncle prominently reduced. Antennules very long, second and third articles elongated, not able to retract into antennular fossa. Ambulatory legs very long ..... **Christmaplacidae**
– Eyes and ocular peduncle prominently normal. Antennules short, second and third articles short, retracts into antennular fossa. Ambulatory legs relatively shorter 53

53 Carapace transversely ovate or almost so; posterolateral margins strongly converging to posterior carapace margin; dorsal carapace surfaces almost smooth, never setose ... **Pseudoziidae**
– Carapace usually transversely subtrapezoidal to subrectangular (rarely ovate) or subcircular; posterolateral margins gently converging to posterior carapace margin; dorsal carapace surfaces smooth to ornamented, densely setose and/or eroded 54

54 Dorsal surface of carapace relatively smooth. G1 prominently sinuous ... **Conleyidae** [not yet known from Indian Ocean]
– Dorsal surface of carapace often ornamented, densely setose and/or eroded; G1 straight to gently sinuous **Planopilumnidae**

55 Male pleon distinctly triangular, with lateral margins of somites 3–6 distinctly converging towards telson; pleonal somite 3 about 2 times telson width 56
– Male pleon subrectangular, with lateral margins of somites 3–6 gradually converging towards telson; pleonal somite 3 about 2 times telson width 57

56 Male thoracic sternite 7 transversely very narrow. G1 tapering to relatively sharp tip; G2 very long, distal segment as long or longer than basal segment .... **Progeryonidae**
– Male thoracic sternite 7 transversely broad. G1 with tip usually open to flared; G2 long, with distal segment of varying lengths .... **Goneplacidae**

57 G1 reaching to edge of thoracic sternite 4 .... **Menippidae**
– G1 reaching to edge of thoracic sternite 5 58

58 Carapace usually transversely ovate, with frontal regions relatively narrower; surfaces usually smooth or covered with flattened granules, sometimes appearing eroded; or carapace more quadrate and very setose, with setae obscuring margins. Larger chela usually with distinct cutting tooth .... **Oziidae**
– Carapace quadrate, with frontal regions relatively broad; surfaces usually granular to spinose, never strongly setose, margins never obscured by setae. Larger chela usually with indistinct cutting/crushing tooth or molariform crushing teeth 59

59 Carapace rugose to smooth, margins may be spinular but surfaces of carapace, chelipeds and ambulatory legs are never prominently spinose. Larger chela with distinct molariform crushing teeth. G2 with terminal part of distal segment gradually tapering to sharp tip; intertidal crabs .... **Eriphiidae**

– Carapace, chelipeds and ambulatory legs covered with numerous sharp spines all over dorsal and lateral surfaces. Larger chela with indistinct cutting/crushing tooth. G2 with terminal part of distal segment of G2 suddenly becoming very slender along terminal section subtidal to deep-water crabs ....**Hypothalassiidae**

60 Male pleonal somites 3 and 4 fused 61

– Male pleonal somites 3-5 fused although sutures may be visible 62

61 Carapace ovate, dorsally prominently convex; anterolateral margin entire with only 1 rounded lateral tooth present. Male pleon relatively broad. G2 very long, over 1.5 times G1 length, distal segment looping .... **Carpiliidae**

– Carapace quadrate to transversely subrectangular, dorsally gently convex to almost flat; anterolatelal margins usually dentate or lobate. Male pleon triangular. G2 as long as G1, distal segment as long as subdistal segment or shorter .... **Mathildellidae**

62 Carapace prominently trapezoidal with external orbital tooth strongly expanded laterally to form sharp angle............ **Goneplacidae** [part: *Neommatocarcinus*]

– Carapace otherwise 63

63 Penis either exposed or sheathed under a calcified structure between thoracic sternites 7 and 8 64

– Penis never exposed or sheathed between thoracic sternites 7 and 8 65

64 Penis exposed between thoracic sternites 7 and 8, not sheathed under any structure. Carapace about twice as broad than long, male pleonal somite 3 about 0.2 times carapace width **Scalopidiidae**

– Penis sheathed underneath a calcified structure between thoracic sternites 7 and 8. Carapace width about same as length, male pleonal somite 3 about 0.3 times carapace width **Chasmocarcinidae**

65 G2 slender less than 0.3 times G1 length 66

– G1 moderately stout; G2 longer than 0.3 times G1 length 67

66 Eyes usually small in adults. Third maxillipeds adjoining when closed, leaving almost no gape when closed. Chelipeds relatively shorter, longer in adult males, meri and carpi sometimes spinose, with only one chela; only one chela of adult male chela swollen or enlarged; molariform structure on proximal part of cutting edge of propodal finger, when present, always on only one chela. Relatively shorter ambulatory leg, merus sometimes spinose dorsal margin...................**Xanthidae**

– Eyes large in adults. Third maxillipeds widely separated from each other, leaving prominent gape when closed. Chelipeds long in both sexes, with spinose meri and carpi; both chelae flattened; propodal finger of both chela of both sexes with prominent molariform structure on proximal part of cutting edge. Relatively long ambulatory leg, merus with spinose dorsal margin .... **Linnaeoxanthidae**

67 Carapace surface with numerous mushroom-shaped tubercles, fusing with each other along edges; tufts of setae at edges of some of fused tubercles. G2 1.5 times length of G1; free-living species .... **Dairidae**

– Carapace surface smooth, gently rugose or with granules or small spines, never large tubercles, glabrous or almost so. G2 half to subequal in length to G1 68

68 Carapace rounded, dorsal surface covered with small granules and spines; anterolateral regions lined with numerous spines and granules. Propodus of chelipeds with prominent round or pointed tubercles along other surface; merus short, with a row of teeth along anterior margin. Associated with scleractinian coral. .... **Domeciidae**

– Carapace trapezoidal or transversely ovate, dorsal surface smooth or faintly rugose at best; anterolateral margin usually entire or with low teeth, never spines. Propodus of cheliped smooth, without tubercles along other surface; merus long to very long, always having a third or more of the length a row of conspicuous teeth along anterior margin. Associated with scleractinian coral or deep sea soft coral. .... **Trapeziidae**

69 Carapace poorly calcified; typically parasitic or commensal on molluscs, echinoderms or corals 70

– Carapace well calcified; usually quadrate or transversely ovate; segments of third maxillipeds normal; free living 72

70 Carapace pyriform, subpyriform, triangular, circular, or subcircular. Fossae (sockets) for antennulae quadrate to longer than broad, antennules fold longitudinally or almost so. Male and female adults parasitic in scleractinian corals, forming galls .... **Cryptochiridae**

– Carapace transversely ovate, quadrate or rounded, never pyriform or subpyriform. Fossae for antennules broader than long, antennules fold transversely or obliquely. Adults free living or are parasites or commensals in molluscs, various phyla of worms, echinoderms or other crustaceans, never with scleractinian corals 71

71 Third maxilliped with normal third maxillipeds, dactylus inserted distally on tip of propodus. Associated with terebellid worms .... **Aphanodactylidae**

– Third maxilliped with dactylus inserted distally at or near base of propodus; dactylus may be absent or strongly reduced. Associated with some worms, molluscs and echinoderms .... **Pinnotheridae**

72 Distinct rhomboidal gap between closed third maxillipeds; mandibles usually visible when mouthparts closed 73

– No distinct rhomboidal gap between closed third maxillipeds, if present very small; mandibles not visible when mouthparts closed 75

73 Carapace distinctly ovate; suborbital crest straight without any granules; pterygostomial region with very thick, soft setae. Ambulatory legs with strong fixed chitinous spines on dactyli **Gercarcinidae**

– Carapace subquadrangular to quadrangular; suborbital crest with small granules; pterygostomial region glabrous to moderately setose. Ambulatory legs unarmed or with small chitinous spines on dactlyi. 74

74 Merus and ischium of third maxilliped without setose oblique ridge. Pterygostomial region sparingly setose, without pattern of reticulated setae **Grapsidae**

– Merus and ischium of third maxilliped with distinct oblique setose ridge. Pterygostomial region densely setose, setae arranged as reticulate pattern **Sesarmidae**

75 Front simple, triangular, narrow to very narrow compared to carapace width 76
– Front truncate, multilobate or multidentate, relatively broad compared to transverse carapace 80

76 Carapace rounded, globose; orbits absent; eyes relatively short 77
– Carapace quadrate; orbits long; eyes relatively long 79

77 Chelipeds relatively stout, almost covering entire face when closed against frontal region; eyestalk absent ....**Mictyridae**
– Chelipeds relatively small, not covering entire face when closed against frontal region; eyestalk short but present..................78

78 Carapace wider than long; orbits longitudinally slit-like. Eyestalk very short........... **Xenophthalmidae**
– Carapace round or almost so; orbits transversely ovate. Eyestalk relatively long .... **Dotillidae**

79 Cheliped strongly heterochelous in males (as in *Uca*) or subequal in both sexes (*Ocypode*); dactylar finger with row of teeth along cutting edge, never distinct median or submedian truncate tooth .... **Ocypodidae**
– Cheliped equal in size; dactylar finger usually with a distinct truncate tooth medially or submedially along cutting edge .... **Macrophthalmidae**

80 Male pleonal somites 2 and 3 fused, or if suture visible, somites are immovable. G1s strongly bent, forming U-shape .... **Camptandriidae**
– Male pleonal somites 2 and 3 always movable, never fused. G1s straight; aquatic to semiterrestrial crabs 81

81 Carapace distinctly subcircular to quadrate in shape, usually longer than wide; frontal margin with deep cleft to receive antennules. Male pleon with somites 3–5 or 3–6 fused 82
– Carapace ovate to quadrangular in shape, usually wider than long; frontal margin without cleft to receive antennules. Male pleon with 7 free somites and telson 83

82 Carapace with dorsal surface distinctly convex. Merus of third maxilliped as wide as ischium. Male pleon with somites 3–6 fused **Plagusiidae**
– Carapace with dorsal surface almost flat. Merus of third maxilliped much narrower and smaller than ischium. Male pleon with somites 3–5 fused **Percnidae**

83 Orbit of eyes totally closed. Third maxillipeds closed with almost no gape, with faint sulci on merus and ischium respectively. Subtidal crabs associated with hydrothermal vents **Xenograpsidae** [not yet known from Indian Ocean]
– Orbit of eyes with lateral opening. Third maxillipeds closed with a small gape, with distinct sulci on merus and ischium respectively. Intertidal and subtidal crabs, many freshwater as adults **Varunidae**

Indian Ocean marine Caridea:
an overview

S. De Grave

Families known from Indian waters

Shallow water families (primarily):

- Palaemonidae (24 G, 54 S)
- Alpheidae (4 G, 23 S)
- Hippolytidae (6 G, 12 S)
- Crangonidae (6 G, 18 S)
- Lysmatidae (2 G, 4 S)
- Thoridae (2 G, 3 S)
- Rhynchocinetidae (2 G-S)
- Ogyrididae (1 G-S)
- Disciadidae (1 G-S
- Processidae (2 G, 3 S)

Samuel *et al.*, 2016

Deep water families (primarily):

- Pandalidae (9 G, 27 S)
- Pasiphaeidae (5 G, 11 S)
- Glyphocrangonidae (1 G, 10 S)
- Acanthephyridae (6 G, 10 S)
- Thalassocarididae (2 G, 4 S)
- Nematocarcinidae (1 G, 3 S)
- Oplophoridae (1 G, 3 S)
- Psalidopodidae (1 G-S)

Some families (e.g Stylodactylidae, Anchistioididae are overlooked)

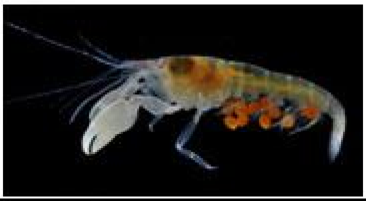
SHALLOW WATER FAMILIES

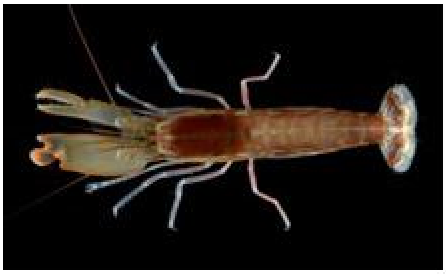
Palaemonidae

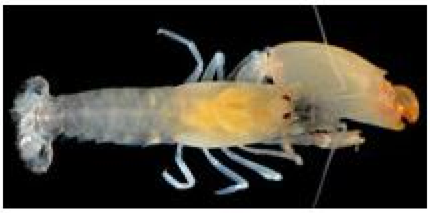
Anchistioididae

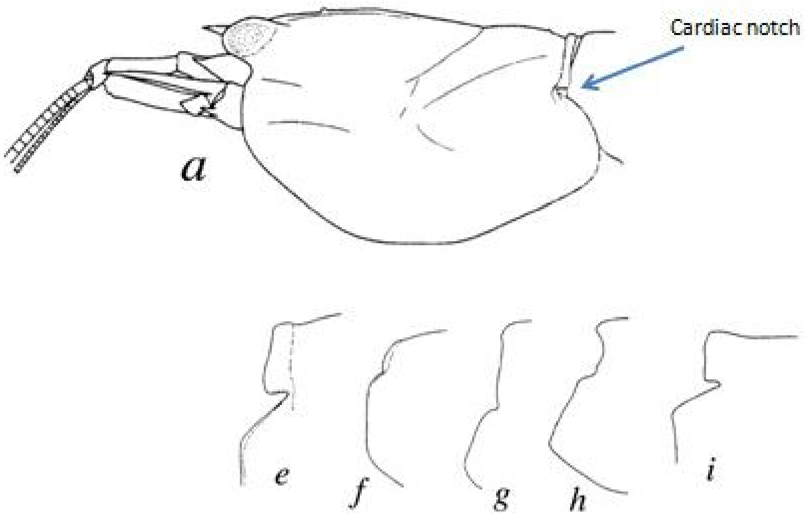
Single genus, sponge dwelling
Very "pontoniinid" like

Alpheidae









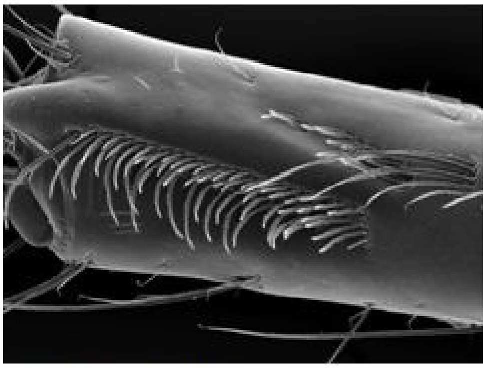
Hippolytidae

Thoridae


...also in deep water

Lysmatidae

Carpo-propodal brush on first pereiopod



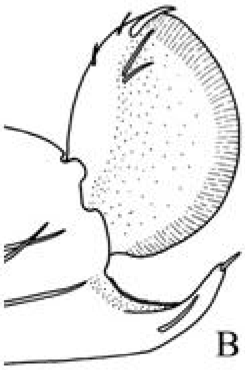
Lysmata seticaudata

Hippolyte varians

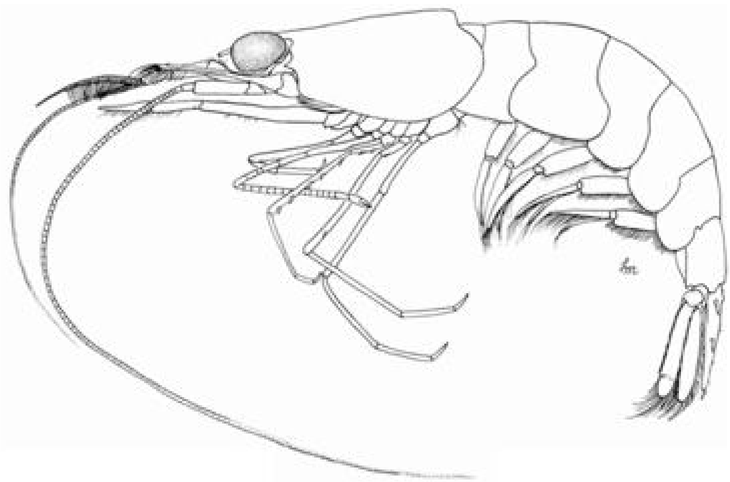
Rhynchocinetidae

Hinged rostrum

Disciadidae



Processidae



DEEP WATER FAMILIES

Pandalidae

Stylodactylidae

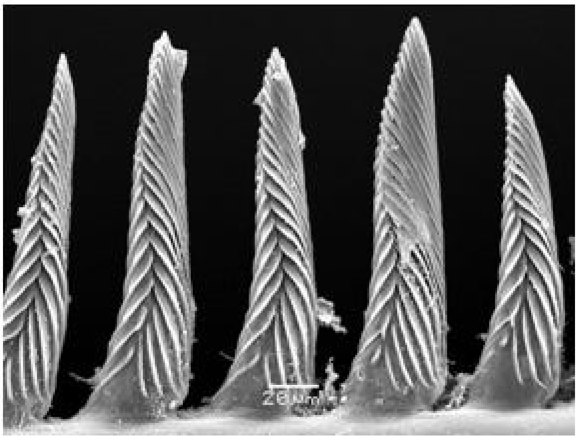
Neostylodactylus

Small, benthic species
Shallow water

Pasiphaeidae

Leptochela

Small, benthic species
Shallow water

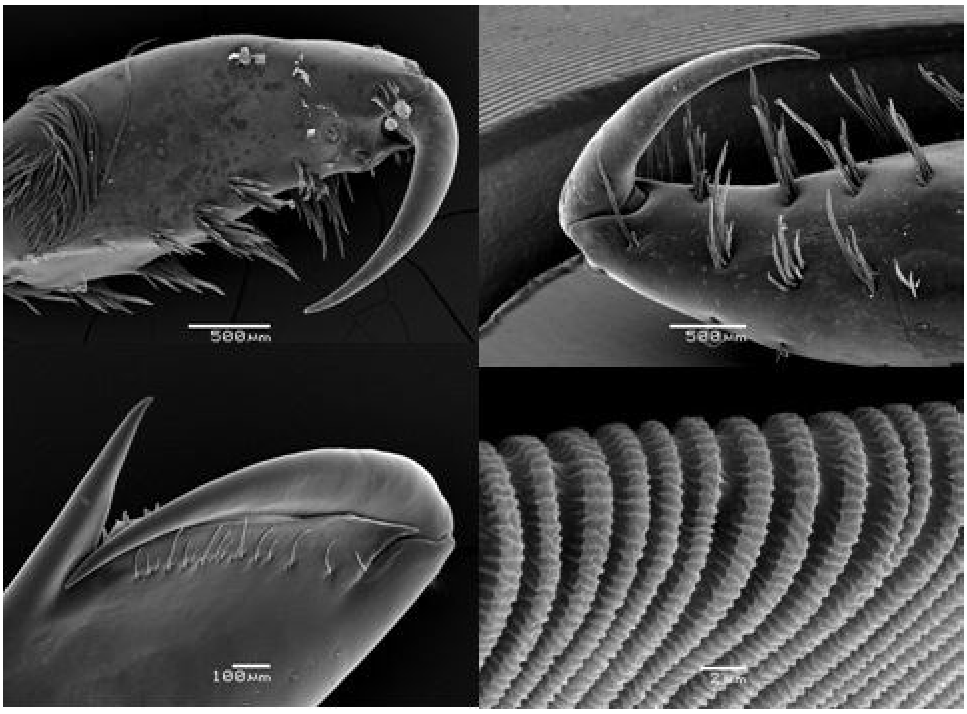


Glyphocrangonidae

Crangonidae

Philocheras

Small, benthic species
Shallow water



Acanthephyridae

Oplophoridae

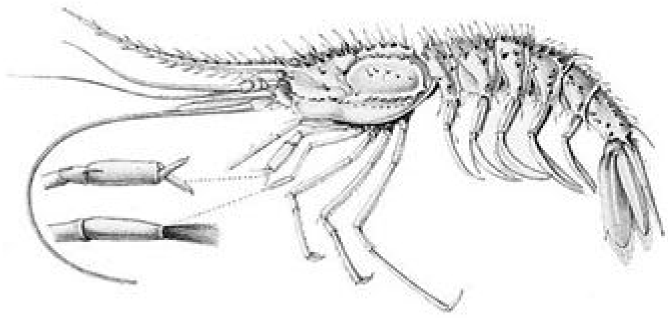
Acanthephyridae
- Deeper water
- No cuticular photophores
- Soft integument
- Well developed molar

Oplophoridae
- Shallower water
- Cuticular photophores
- Hard integument
- Larger eyes

Thalassocarididae

Nematocarcinidae

Psalidopodidae



Single genus
Chelae and spinose body very characteristic

Shallow water:
- Barbouriidae
- Merguidae

Deep water:
- Alvinocarididae
- Bathypalaemonellidae
- Eugonatonotidae

PROBABLY OCCUR IN INDIAN WATERS

Barbouriidae

Parhippolyte misticia
Deep in sea caves

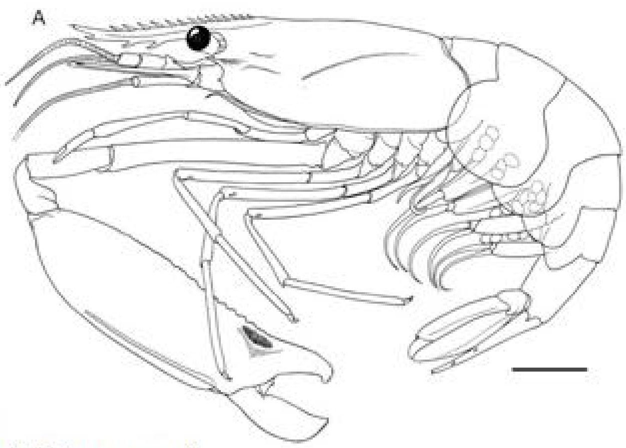
Merguiidae

Single genus
Semi terrestrial

Alvinocarididae

Associated with vents and seeps

Bathypalaemonellidae



Very rare
Characteristic P2 (very unequal)

Eugonatonotidae

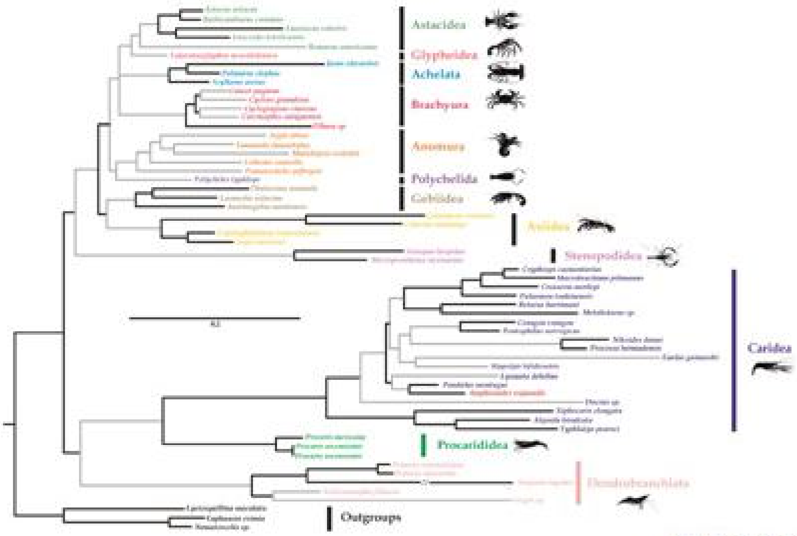
Single species in IWP
Characteristic body shape

Four "shrimp-like" taxa

S. De Grave

"Shrimps" are not monophyletic:

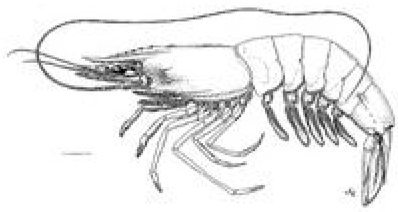
- Suborder Dendrobranchi
- Infraorder Procaridid
- Infraorder Caridea
- Infraorder Stenopodi



De Grave et al., 2015a

Suborder Dendrobranchiata

- Seven families
- Around 70 genera and 540 species



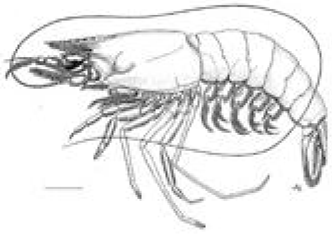
- First three pereiopods chelate
- Large copulatory organs on first pleopod of males (petasma) and females (thelycum)

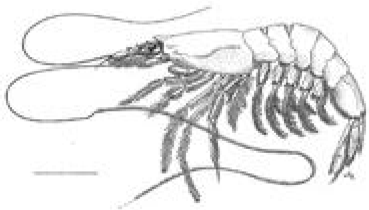
Penaeoidea

- Pereiopods well developed
- Hard integument
- Mainly benthic

Sergestoidea

- Rostrum and last two pereiopods reduced or absent
- Soft integument, small bodied
- Pelagic





Indian biodiversity of Penaeoidea

- Aristeidae (7 G, 14 S)
- Benthesicymidae (4 G, 12 S)
- Penaeidae (17 G, 85 S)
- Sicyoniidae (1 G, 4 S)
- Soleoceridae (5 G, 20 S)

Data from Samuel et al., 2016

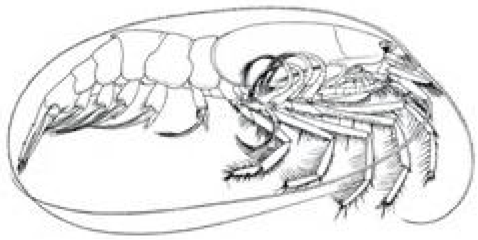
Indian biodiversity of Sergestoidea

- Luciferidae (1 G, 7 S)
- Sergestidae (6 G, 13 S)

Data from Samuel et al., 2016

Infraorder Procarididea

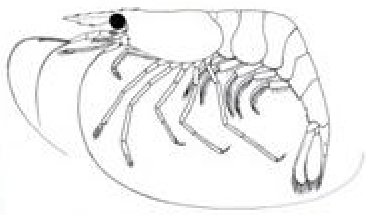
- One family
- Two genera, six species



- Third maxilliped with 7 segments
- All pereiopods non-chelate

Infraorder Caridea

- 40+ families
- Around 400 genera and 3700-4000 species



- Third pereiopod non-chelate
- Second pleuron pear-shaped

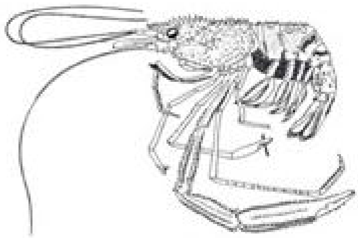
Indian biodiversity of Caridea

- Alpheidae (4 G, 23 S)
- Hippolytidae (6 G, 12 S)
- Ogyrididae (1 G-S)
- Disciadidae (1 G-S
- Crangonidae (6 G, 18 S)
- Glyphocrangonidae (1G, 10 S)
- Nematocarcinidae (1 G, 3 S)
- Rhynchocinetidae (2 G-S)
- Oplophoridae (1 G, 3 S)
- Acanthephyridae (6 G, 10 S)
- Palaemonidae (24 G, 54 S)
- Pandalidae (9 G, 27 S)
- Thalassocarididae (2 G, 4 S)
- Pasiphaeidae (5 G, 11 S)
- Processidae (2 G, 3 S)
- Psalidopodidae (1 G-S)
- Lysmatidae (2 G, 4 S)
- Thoridae (2 G, 3 S)

Data from Samuel et al., 2016.
Families updated to De Grave et al., 2014, 2015b

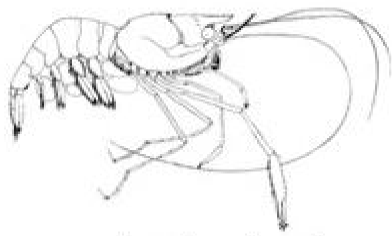
Infraorder Stenopodidea

- Three families
- About 12 genera and 75-80 species



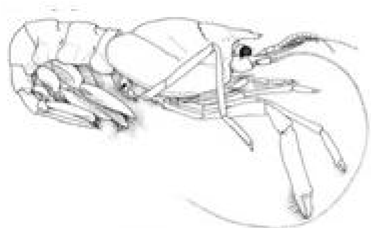
- Third pereiopod enlarged
- First 3 pereiopods chelate

Stenopodidae



- Uropod with 2 dorsal ridges
- Telson ending in two spines

Spongicolidae



- Uropod (usually) with one dorsal ridge
- Telson ending in 3-5 spines

Third family, Macromaxillocarididae, Bahamas only

Indian biodiversity of Stenopodidea

- Stenopodidae (2 G-S)
- Spongicolidae (3 G-S)

Data from Samuel et al., 2016

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KEY TO THE FAMILIES OF CARIDEAN SHRIMPS FOUND OR EXPECTED IN INDIA

1. First pair of pereiopods chelate or simple…………………………………………….2

– First pair of preriopods subchelate or prehensile…………………………………..3

2. First and second pereiopods similar, with long slender fingers; fingers pectinate…………………………………………………………..…..**Pasiphaeidae**

– First and second pereiopods often dissimilar, if not, then not pectinate…….……….4

3. Carpus of second pereiopod multi-articulate; first pereiopod prehensile……………………………………….…..……..…..**Glyphocrangonidae**

– Carpus of second pereiopod not divided; first pereiopod subchelate….…**Crangonidae**

4. Carpus of second pereiopods entire, not subdivided; first pereiopod always with well-developed chela…………………………………………………………………..5

– Carpus of second pereiopod usually subdivided into two or more segments; if not, then first pair of pereiopods non-chelate…………………………………………..17

5. Pereiopods 1 and 2 similar, fingers long and slender, chopstick-like; last two segments of second maxilliped implanted side by side at end of penultimate segment; ……………………………………………………………………...**Stylodactylidae**

– Pereiopods 1 and 2 with fingers notchopstick-like; last segment of second maxilliped attached to penultimate, not touching antepenultimate………………………………..6

6. First pereiopods with both fingers of chela movable………………….**Psalidopodidae**

– Chela of first pereiopod with only one movable finger………………………………..7

7. Epipods present on pereiopods, terminating in a naked appendix which extends into the branchial chamber; first and second pereiopods similar; exopods of pereiopods well-developed, long……………………………………………………………..8

– Epipods of the pereiopods, if present, not terminating in naked appendix; first and second pereiopods often dissimilar in size or form; exopods, if present, shorter……..9

11. Pereiopods without epipods; eyes white or without pigment………..**Alvinocarididae**

– Pereiopods with epipods on at least the three anterioir pairs of pereiopods; eyes usually black or dark brown………………………………………………………….12

12. Second pereiopod with dactylus disc-shaped……………………………..**Disciadidae**

– Second pereiopod with dactylus not disc-shaped…………………………………….…13

13. Rostrum finely dentate; anterior two pairs of pereiopods slender; fingers of chelipeds not bearing conspicuous spines; posterior pereiopods extremely long (usually broken)……………………………………………………………..…**Nematocarcinidae**

– Rostrum grossly dentate; fingers of cheliped with well-developed spines; posterior pereiopods not significantly longer than anterior ones……………………………....14

14. Rostrum moveable, incompletely fused with carapace; pereiopods without exopods………………………………………………………......**Rhynchocinetidae**

– Rostrum immovable; all pereiopods with exopods………………….**Eugonatonotidae**

15. Second pereiopods very unequal; larger cheliped with claw near equal in size to carapace; rostrum long, dentate……………………………….….**Bathypalaemonellidae**

– Second pereiopods equal or unequal; if larger cheliped near equal to carapace, then rostrum short, often edentate…………………………………………………………16

16. First maxilliped with exopodal lash vestigial; molar process of mandible flared distally…………………………………………………………………..**Anchistioidae**

– First maxilliped with exopodal lash fully developed; molar process of mandible not flared distally……………………………………………………….....**Palaemonidae**

17. Right first pereiopod chelate, left usually simple………………………….**Processidae**

– Both first pereiopods either chelate or simple……………………………………..…18

18. First pair of pereiopods distinctly chelate…………………………………………....19

– First pair of pereiopods with chela small, rudimentary or absent…………………....25

– Posterolateral extension of uropod normal…………………………………………...24

24. Flagellum of antennule stout, club shaped……………………….....………..**Thoridae**

– Flagellum of antennule more elongated……………………**Hippolytidae/Lysmatidae**

25. Second pereiopod undivided or with single articulation; first pleopod of male with enlarged endopod, petasma-like…………………………………....**Thalassocarididae**

– Second pereiopod with carpus comprised of more than two segments; first pereiopod simple, without chela……………………………………………………....**Pandalidae**

FRESH WATER PRAWN RESOURCES OF THE GENUS *MA CROBRACHIUM* BATE,1868 (DECAPODA: PALAEMONIDAE)OF INDIA, WITH A KEY FOR THEIR FIELD IDENTIFICATON

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1.	Merus distinctly shorter than carpus 2
-	Merus about as long as or longer than carpus..36
2.	Rostrum with distinct elevated basal crest 3
-	Rostrum without distinct elevated basal crest 9
3.	Rostrum long and distally curved upwards; lower margin of rostrum with 8-14 teeth. Tip of telson reaching beyond longer posterior spines 4
-	Rostrum generally straight, lower margin with 4-7 teeth. Tip of telson overreached by longer posterior spines 5
4.	Chela distinctly longer than carpus ....*rosenbergii*
-	Chela as long as or shorter than carpus ....*villosimanus*
5.	Proximal rostrum slightly elevated, with 5-9 teeth. Fingers of second chela shorter than palm ....*lamarrei*
-	Proximal rostrum elevated, with 9-10 teeth. Fingers of second chela longer than palm 6
6.	Rostrum with 3 post-orbital teeth on carapace 7
-	Rostrum with 2 post-orbital teeth on carapace 8
7.	Carapace smooth (large species) ....*malcolmsonii*
-	Carapace rough (large species) ....*josephi*
8.	Proximal part of rostrum highly elevated, rostral formula 10-12 / 4-5, 2nd chelate leg with carpus and merus longer than palm ....*gangeticum*
-	Proximal part of rostrum less elevated than *M. gangeticum*, rostral formula 12-13 / 5-7, 2nd chelate leg with merus and carpus shorter than palm ....*birmanicum*
9.	Fingers of large chela of adult male with numerous teeth along cutting edges 10
-	Fingers of large chela of adult male at most with 1 or 2 teeth in proximal part of cutting edges, rest of the cutting edges entire 11
10	Palm of larger 2nd leg of adult male cylindrical and fingers equal, generally with more than 10 denticles on cutting edges ....*australe*
-	Palm of larger 2nd leg of adult male compressed and fingers unequal, with 5-7 prominent denticles on cutting edges ....*indicum*
11	4-6 teeth of dorsal margin of rostrum behind orbit 12
-	1-3 teeth of dorsal margin of rostrum behind orbit 13
12	Medium sized species; 2nd cheliped strong, stout and spinulose; palm subcylindrical; fingers slightly curved, with gap when closed ....*aemulum*
-	Small species; 2nd cheliped slender, without spinules; palm subcylindrical; fingers slender, without gap when closed ....*nobilii*
13	Second cheliped of adult male smooth, without tubercles or spinules; fingers without or with with 1-4 small denticles on proximal cutting edges 14
-	Second cheliped of adult male with many distinct tubercles; fingers with 1 or 2 distinct denticles on proximal cutting edges 23
14	Rostrum slender. Fingers of 2nd cheliped with or without 1 or 2 microscopic denticles in the proximal part of cutting edges 15
-	Rostrum broad, lanceolate. Fingers of 2nd cheliped with 3-4 very small denticles in proximal part of cutting edges ....*elatum*
15	Carpus of 2nd leg of adult male shorter than chela 16
-	Carpus of 2nd leg of adult male much longer than chela 17

16	Lower margin of the rostrum with 5-8 teeth .... *naso*
-	Lower margin of the rostrum with 2-5 teeth 19
17	Appendix masculina of 2^{nd} pleopod extends as far as the tip of endopod 18
-	Appendix masculina of 2^{nd} pleopod extends beyond half of endopod ...... *canarae*
18	Lower rostrum with 6-9 teeth; fingers of 2^{nd} chela subequal to palm ....*lamarrei lamarrei*
-	Lower rostrum with 4-6 teeth; fingers of 2^{nd} chela unequal to palm ....*lamarrei lamarroides*
19	Carpus of 2^{nd} chela as long as chela ....*peguense*
-	Carpus of 2^{nd} chela distinctly longer than chela 20
20	Uropodal exopod without accessory spine ....*kistnense*
-	Uropodal exopod with accessory spine 21
21	Convex rostrum with 12-15 teeth; carpus equal to chela ....*banjarae*
-	Nearly straight rostrum with 5-10 teeth; chela shorter than carpus 22
22	Posterior tip of telson with 2 pairs of plumose setae in between movable spines ....*sankolli*
-	Posterior tip of telson with 2 pairs of plumose setae and a few short setae (submarginal) in between movable spines ....*unikarnatakae*
23	Carpus of 2^{nd} chelate leg of adult male longer than chela 24
-	Carpus of 2^{nd} chelate leg of adult male shorter than chela 27
24	Small species, up to 40 mm long. Chela of 2^{nd} chelate leg of adult male with tubercles along each side of cutting edge ....*tiwarii*
-	Large species. Chela of 2^{nd} chelate leg of adult male without tubercles along each side of cutting edge 25
25	Rostrum with 9-11 teeth on the dorsal side (3 post-orbital) ....*idae*
-	Rostrum with 12-15 teeth on the dorsal side (2 post-orbital) 26
26	Rostrum extending as far as tip of antennal scale or behind; 2^{nd} leg prominently tuberculate; movable finger entirely hairy but immovable finger with hairs along cutting edge ....*idella idella*
-	Rostrum extends slightly beyond antennal scale; 2^{nd} leg weakly tuberculate; fingers without hairs ....*idella georgi*
27	Fingers of large chela of adult male with tubercles along both sides of cutting edges; all podomeres pubescent ....*rude*
-	Fingers of large chela of adult male without row of tubercles along both sides of cutting edges 28
28	Fingers of the 2^{nd} chelate leg of adult male naked or with row of short hairs only along each side of cutting edges 29
-	Fingers of 2^{nd} chelate leg of adult male covered with stiff or velvety hairs throughout surface or only along cutting edges 32
29	Fingers with longitudinal grooves containing soft felt-like pubescence 31
-	Fingers without longitudinal grooves covered with soft felt-like pubescence 30
30	Rostrum not reaching tip of squama; lower margin with 3-5 teeth...... ***andamanicum***
-	Rostrum reaches tip of squama; lower margin with 5 teeth .... ***novaehollandiae***
31	Rostrum short, extending as far as antennular peduncle; rostral formula: 6-8/2-4, with 2 teeth post-orbital. distal upper margin with wide edentate part .....*siwalikense*

32	Lower margin of rostrum with 3-6 teeth (rarely 7) 33
-	Lower margin of rostrum with 2 or 3 teeth (rarely more than 3) 35
33	Rostrum straight, upper margin with 8-12 teeth, of which 2-4 post-orbital, lower margin with 3-6 teeth 34
-	Rostrum curved upwards, upper margin with 9-12 teeth, of which 3 post-orbital, lower margin with 5-6 (rarely 4 or 7). Both fingers of 2nd chelate leg entirely pubescent .... ***equidens***
34	Rostral formula 8-12/3-4, of which 2 teeth post-orbital; fingers of 2nd leg of adult male slender and non hirsute ....***divakarani***
-	Rostral formula 9-12/ 4-5 (rarely 3), of which 4 teeth post-orbital; fingers of 2nd leg of adult male strong and hirsute ....***sulcatus***
35	Rostrum directed forwards; rostral formula: 6-11/2-6; carpus of 2nd chelate leg shorter than chela ....***.nipponense***
-	Rostrum lanceolate; rostral formula: 6-9/ 1-2; carpus of 2nd chelate leg as long as or slightly longer than chela .... ***veliense***
36	Fifth legs conspicuously longer than 4th. Rostrum short and high, with many dorsal teeth; 2nd legs of adult male smooth .... ***mirabile***
-	Fifth legs about same length as 4th 37
37	Second pereiopod of adult male very unequal 39
-	Second pereiopod of audlt male subequal (rarely equal)..................................40
38	Rostral formula: 6-8/3-5 with 2 post-orbital teeth ....***hendersodayanum***
-	Rostral formula: 8-9/4=7 with 2 post-orbital teeth ....***..dayanum***
39	Second chelate leg spinulose, without pubescence on palm; cutting edges of fingers with prominent denticle at middle and 4 small denticles proximally ....***johnsonii***
-	Second chelate leg spinulose, teeth on cutting edges of fingers of adult male large, tooth anterior to dactyl placed in or slightly before middle of fingers .....***javanicum***
40	Rostrum rather slender, reaching beyond antennular peduncle 42
-	Rostrum short and high, not reaching beyond antennular peduncle 41
41	Rostrum convex, general rostral formula : 10-12/2-3 (3 to 4 teeth post-orbital) ....***altifrons altifrons***
-	Rostrum less convex, general rostral formula : 7-9/ 2 (2 post-ortbial) ....***altifrons ranjhai***
42	Mandibular palp 2-jointed, eyes with cornea strongly reduced, much narrower than eye stalk .... ***cavernicola***
-	Mandibular palp 3-jointed, eyes with cornea well developed, distinctly broader than eye stalk 43
43	Both dactyl and fixed finger of large chela of adult male with only 1 or 2 large teeth on cutting edge 45
-	Between one or two large teeth and proximal part of both fingers of adult male, several smaller teeth occur which sometimes attain size of large teeth 44
44	Carpus and palm covered with tufts of velvety hairs and without spinules ....***hirsutimanus***
-	Carpus and palm not covered with tufts of velvety hiars but with spinules ....***latimanus***
45	Fingers of large chela of adult male with numeous longitudinal grooves, which are

CHECKLIST OF CRABS OF PARANGIPETTAI COAST, INDIA

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Introduction

Of all the Crustacea, one of the best known and most intensely studied groups is the true crabs of the infraorder Brachyura. (Ng, 2002).The Brachyuran crabs forming the last suborder of the Decapoda from the phylum Arthropoda are the unique 'side-walkers' having colourful exoskeleton and a pair of massive chela. These fairly recently formed Brachyurans are undergoing vast adaptive radiations to suit its different life style and found distributed in various environments like marine, estuarine, mangrove, backwaters and intertidal regions.

Mangrove ecosystem covers less than one percent (1%) of the Earth's surface, but is ecologically, physically and econocally important (Senger, 2002). This habitat may produce upto 20 tones of biomass per year (Ong, 1984). It is recognized worldwide as important for sustaining coastal geomorphology and as habitat for permanent and transient faunal species (Tomlinson, 1986).

Crabs are always the chosen test animals since their tolerance is very wide. They are the scavengers of their habitat and play adominant role in food web. The burrowing members of the above family help the intertidal area. Besides their association with other organisms like algae, seaweed, anemones, barnacles, bivalves and holothurians make the carcinological studies more lively (Alcock, 1986)

Similarly most of the Brachyuran crabs are economically important. They fill the local protein demand and the medicinal value of crabs are much discussed. A few of them are labeled as 'pests' causing damage to coastal plants and culture ponds. However in future even economically not useful smaller intertidal crabs could presumably be used in the preparation of high energy content artificial food pellets at cheaper coast for the cultivation of edible varieties of sea food.Studies relating to taxonomy and systematic of Indian crabs are limited, through numerous studies are being carried out in the other areas of science.(Sethuramalingam, 1983).

Discontinuous distribution, allometric growth pattern resulting in dynamic morphology, polymorphism and sxual dimorphism add confusions. Moreover, the greater degree of adaptation of these brachyuran crabs to different environment and the resulting individual variability or clonical variations with species and population render the taxonomic works more difficult.

Similarity many families like Portunidae are comprised of large number of species possibly based on minor characters like the presence or absence of transverse ridges or the numbers, structure, orientation and arrangement of spines and spinules either in cephalothorax or in appendages. (Stephenson, 1957) All these characters are obviously subjected to growth variations also. Especially the spines and spinules which are sharp in juveniles may usually become worn-out after the terminal moult causing problem in their distinctness.

So along with the morphological characters like the carapace shape, lateral and frontal spines, a detailed study of the structure of third maxilliped, the structure and juxta-position of gonopods in males or the nature of gonopores in females coupled with the studies of the fourth arthrophragm is found to be helful in brachyuran taxonomy. Based on these details the checklist is prepared for the crabs distributed in Bay of Bengal along Parangipettai coast.

Checklist of Crabs of Parangipettai

Family	**:**	**Dromidae**
		Lauridromiadehaani(Rathbun, 1923)
	:	*Dromidiopsisaustraliensis* (Haswell, 1882)
Family	**:**	**Dorippidae**
		Dorippoidesfacchino(Herbst, 1785)
Family	**:**	**Leucosidae**
	:	*Seulociapubescens* (Miers, 1877)
	:	*Philyrascabriuscula* (Fabricius, 1798)
	:	*Philyraglobus* (Fabricius, 1775)
	:	*Philyracorallicola*Alcock, 1896
	:	*Aloxrugosum* (Stimpson, 1858)
	:	*Arcaniagracilis* Henderson, 1893
	:	*Ixa cylindrus* (Fabricius, 1777)
Family	**:**	**Calappidae**
Subfamily	:	Calappinae
	:	*Calappalophos* (Herbst, 1782)
Subfamily	:	Matutinae
	:	*Ashtoretlunaris* (Forskal, 1775)
	:	*Matutaplanipes* Fabricius, 1798
Family	**:**	**Majidae**
Subfamily	:	Pisinae
	:	*Doclearissoni* Leach, 1815
	:	*Docleaovis* (Fabricius, 1787)
Family	**:**	**Parthenopidae**
	:	*Parthenope* weber, 1795
Family	**:**	**Portunidae**
Subfamily	:	Portuninae

Scylla serrata(Forskal, 1775)

Scylla olivacea(Herbst, 1796)

Portunus (Portunus) sanguinolentus(Herbst, 1783)

Portunus (Portunus) pelagicus (Linnaeus, 1758)

Portunus (Portunus) reticulatus(Herbst, 1799)

Portunus (Monomia) whitei

Portunus gracilimanus (Stimpson, 1858)

Portunus (Monomia) gladiator Fabricius, 1798

Portunus (Monomia) argentatus glareosus (Alcock, 1899)

Portunus (Xiphonectes) hastatoides Fabricius, 1798

Portunus spinipes (Miers, 1886)

Subfamily : Thalamitinae (Paul'son, 1875)

Charybdis (Charybdis)lucifera(Fabricius, 1798)

Charybdis (Charybdis)hellerii(A. Milne-Edwards, 1867)

Charybdis amboinensis Leene, 1938

Charybdis (Charybdis) feriata(Linnaeus, 1758)

Charybdis miles (De Haan, 1835)

Charybdis affinis Dana, 1852

Charybdis callianassa (Herbst, 1789)

Charybdis variegata (Fabricius, 1798)

Charybdis natator (Herbst, 1794)

Charybdis (Charybdis)granulata(De Haan, 1833)

Charybdis edwardsi Leene&Buitendijk, 1949

Charybdis truncata (Fabricius, 1798)

Charybdis hoplites (Wood-Mason, 1877)

Thalamitacrenata(Ruppell, 1830)

Thalamitachaptalii(Audouin, 1826)

Subfamily	:	Podophthalminae (Dana, 1851)
		Podophthalmus vigil (Fabricius, 1798)
Family	**:**	**Xanthidae**
Subfamily	:	Xanthinae
		Liagorerubromaculata (De Haan, 1835)
		Macromedaeuscrassimanus(A.Milne-Edwards, 1867)
		Demaniabaccalipes (Alcock, 1898)
		Halimedeochtodes (Herbst, 1783)
Family	**:**	**Galenidae**
Subfamily	:	Galininae
		Galenebispinosa(Herbst, 1783)
Family	**:**	**Pilumnidae (Samouelle, 1819)**
Subfamily	:	Pilumninae (Samouelle, 1819)
		Benthopanopeindica(De Man, 1887)
Family	**:**	**Goneplacidae**
		Heteropilumnusangustifrons (Alcock, 1900)
		Litocheiraintegra(Meirs)
Family	**:**	**Pinnotheridae**
Subfamily	:	Pinnotherinae
		Acrotheressinensis(Shen, 1932)
Family	**:**	**Ocypodidae**
Subfamily	:	Ocypodinae
		Ocypodeplatytarsis(H. Milne Edwards, 1852)
		Ocypodemacrocera(H. Milne Edwards, 1852)
Subfamily	:	Ucinae
		Uca (Austruca) lactea(De Haan, 1835)
		Uca (Paraleptuca) triangularis(A. Milne Edwards, 1873)
Family	**:**	**Macrophthalmidae**

Subfamily	:	Macrophthalminae
		Macrophthalmusdepressus(Ruppell, 1830)
		Macrophthalmuserato(De Man, 1888)
Family	**:**	**Dotillidae**
		Dotillaclepsydrodactyla (Alcock, 1900)
		Dotillamyctiroides(H. Milne Edwards, 1852)
Family	**:**	**Grapsidae**
Subfamily	:	Grapsinae
		Grapsusalbolineatus(Latreille, in Milbert, 1812)
		Grapsustenuicrustatus(Herbst, 1783)
		Metopograpsusmaculatus(H. Milne Edwards, 1853)
		Metopograpsusmessor(Forskal, 1775)
Family	**:**	**Varunidae**
Subfamily	:	Varuninae
		Ptychognathusaltimanus(Rathbun, 1914)
		Pseudograpsus intermedius (Chappgar, 1955)
Family	**:**	**Sesarmidae (Dana, 1851)**
		Episesarmamederi(H. Milne- Edwards, 1853)
		Muradiumtetragonum(Fabricius, 1798)
		Nanosesarmaminutum(De Man, 1887)
		Nanosesarmabatavicum(Moreira, 1903)
		Nanosesarmaandersonii(De Man, 1895)
		Parasesarmaplicatum(Latreille, 1806)
		Selatiumbrockii(De Man, 1887)
Family	**:**	**Plagusiidae**
Subfamily	:	Palgusiinae
		Plagusiatuberculata(Lamarck, 1818)
		Plagusiadentipes(De Haan, 1835)

Family : Gecarcinidae

CardisomaCarnifex(Herbst, 1796)

References

1. Alcock, A., 1968. Materials for acarcinological fauna of India.Verlag Von J. Cramer, New York.

2. Ong, J.E., 1984. Mangrove outwelling? In: Ong, J.E. aand W.K. Gong (eds), Productivity of the mangrove Ecosystem : Management Implications. UniversitiSains Malaysia, Penang, 30-36

3. Peter, K. L. Ng, D. Guinot and P.J.F. Davie, 2008. SystemaBrachyurorum; Part I. An annotated checklist of extant brachyuran crabs of the world. The Raffles Bulletin of Zoology., 17: 1-286

4. Sethuramalingam, S., 1983. Studies on Brachyuran crabs from Vellar estuary-kille back waters complex of Portonvov coast.Ph.D. Thesis, Annamalai University.

5. Stephenson, W. and B. Campbell, 1957. The Australian Portunids (Crustace: Portunidae). 11.genus Charybdis. Aust. J. mar.Freshw. Res., 10: 84-124

6. Saengar, P., 2002. Mangrove ecology, silviculture and conservation. Kluwer Academic Publisher, Dordrecht.

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Modern Taxonomy ...
and the Status of Global Crab Systematics

Peter K. L. Ng

WHY BOTHER?

Who cares what name an animal is anyway?

So what if we do not know what a species is?

Who cares if it is new?

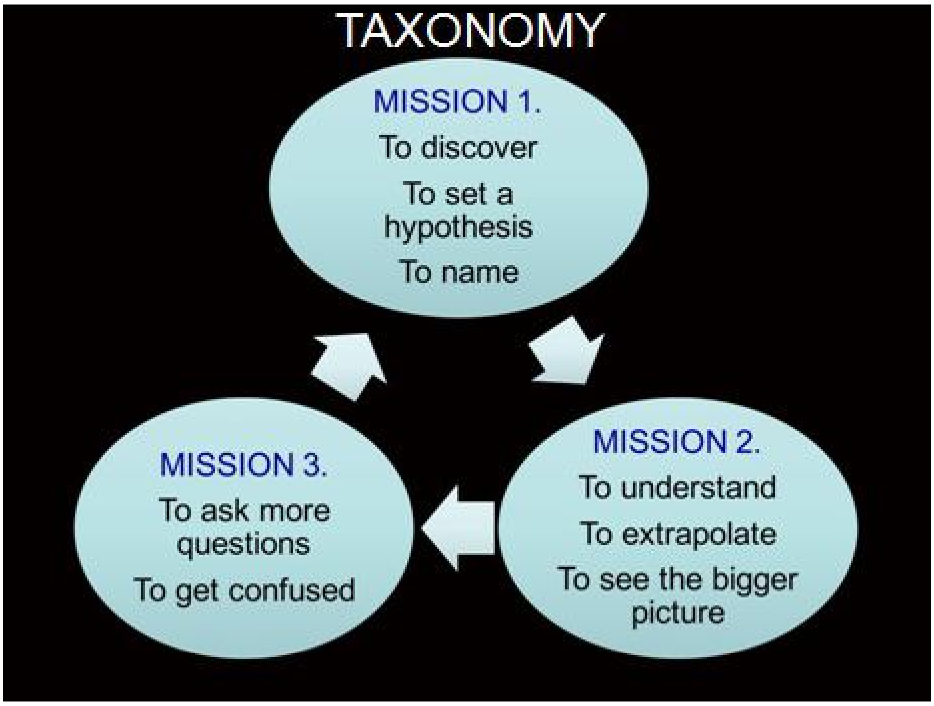
Why do we need to know?

How is Taxonomy a Science?

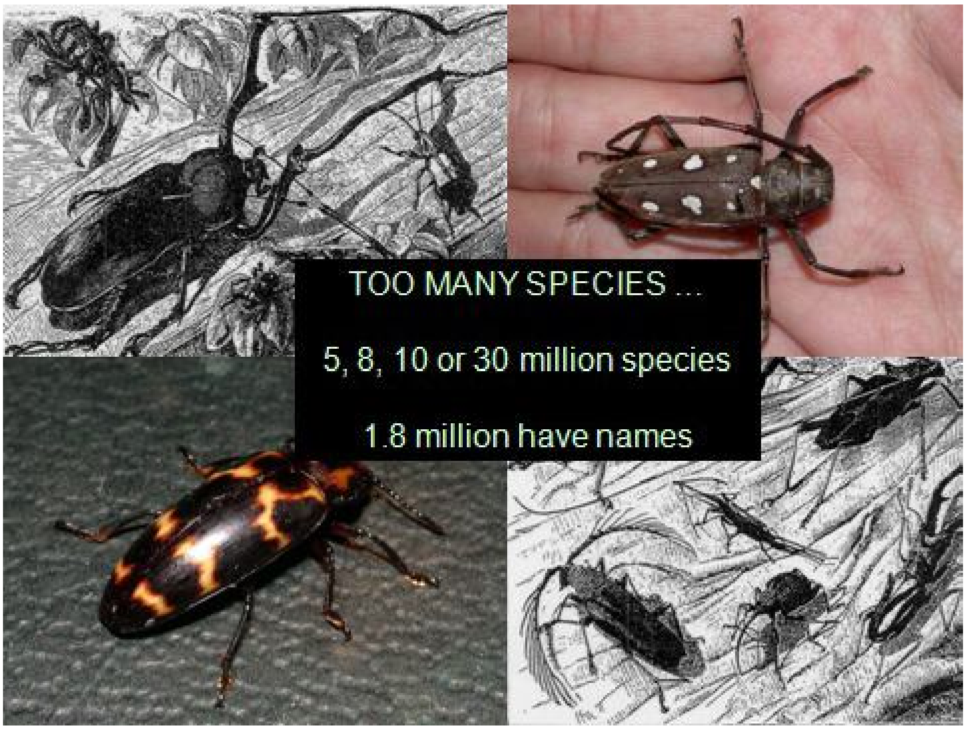
How does it help the economy?

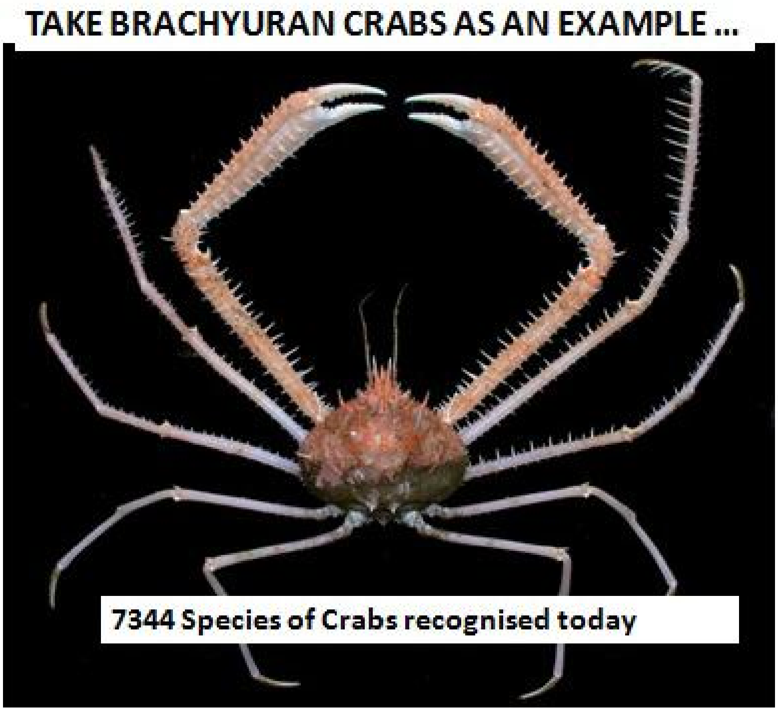
LET US GET STARTED THEN

Oxypleurodon sanctaeclausi Richer de Forges & Ng, 2009



And to be
a bit crazy


TOO MANY SPECIES ...
5, 8, 10 or 30 million species
1.8 million have names


TAKE BRACHYURAN CRABS AS AN EXAMPLE ...
7344 Species of Crabs recognised today

Macrobrachium rosenbergii **or**
Macrobrachium dacqueti **?**

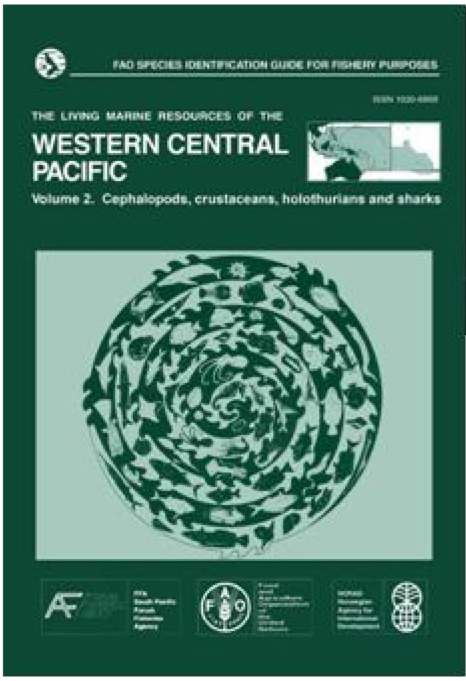
Names provide stability and usability

Johora singaporensis (Ng, 1987)

Amphidromus atricallosus temasek Tan & Chan & Panha, 2011

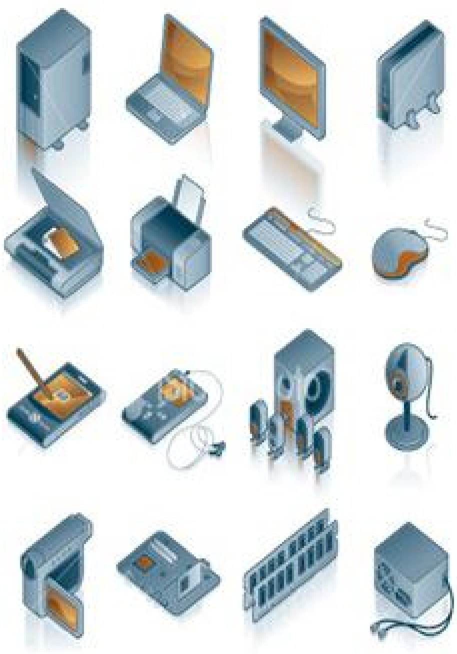
Names have legal value – Protecting and managing species

You cannot conserve what you do not know



Scylla serrata or whatever ...

Names have consequences ...



POWER OF A NEW CENTURY

Ease of international travel

Ease of international communication

Powerful and cheap new imaging tools that allow to see and record better than ever before.

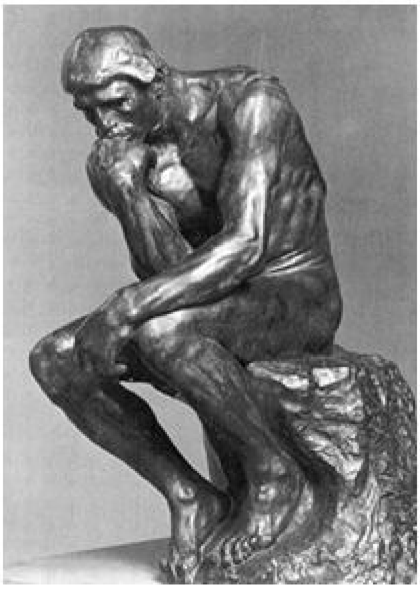
New typing and drawing tools

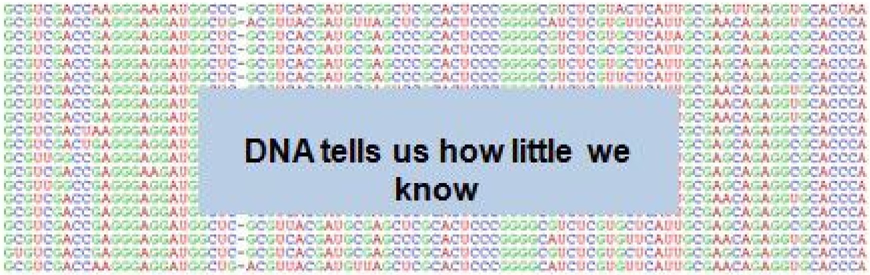
New technologies for genetics

Information technology through the World Wide Web etc.

Digital publishing

And NO END OF NEW HEADACHES ....

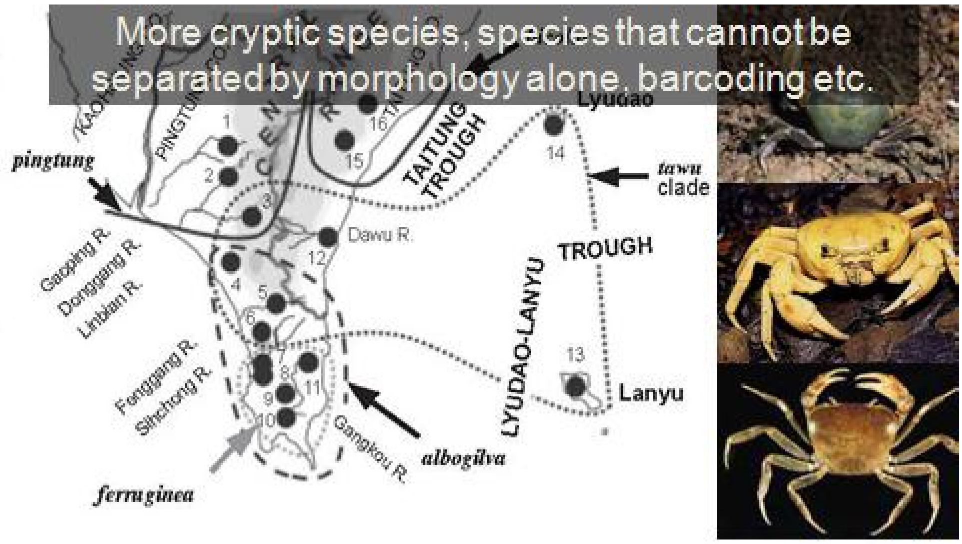




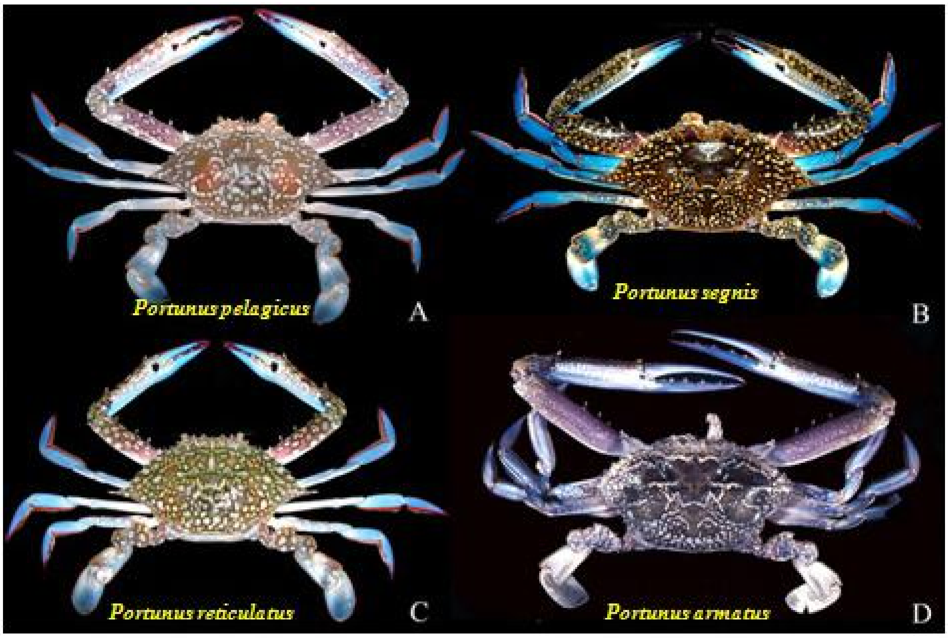
Perspectives …

Named 11 genera, 103 species

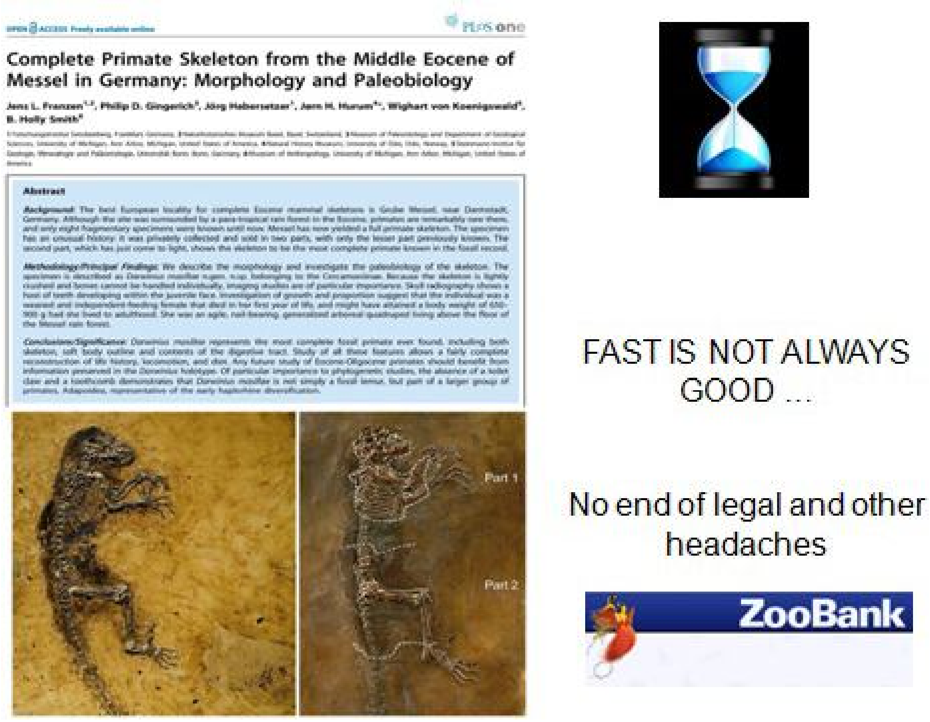
People complain he – I – we – are "splitters"

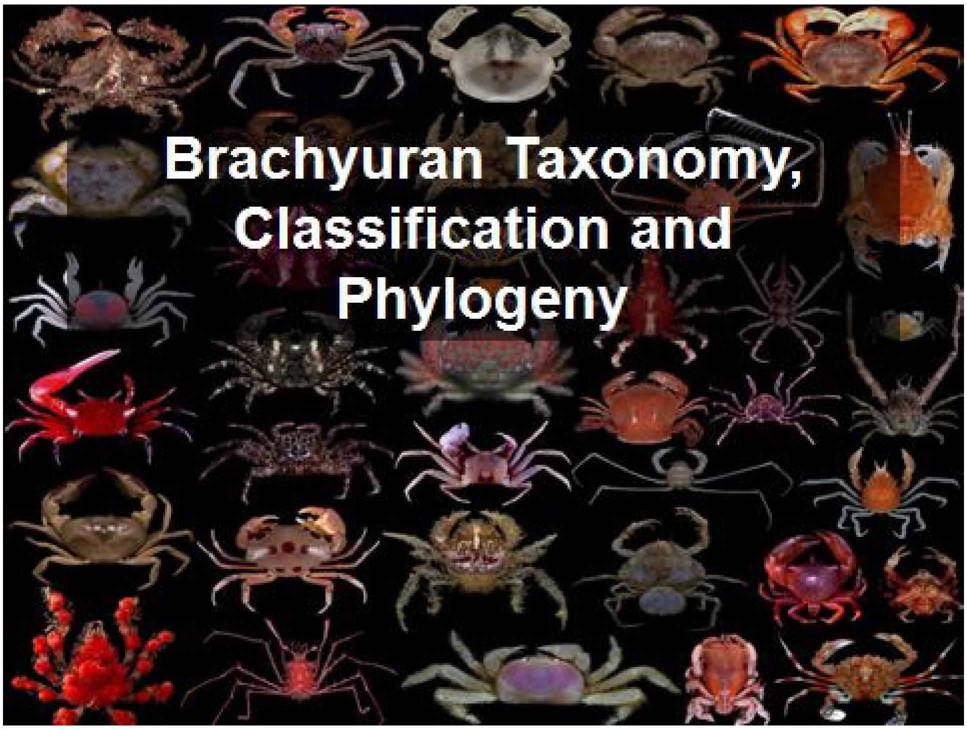


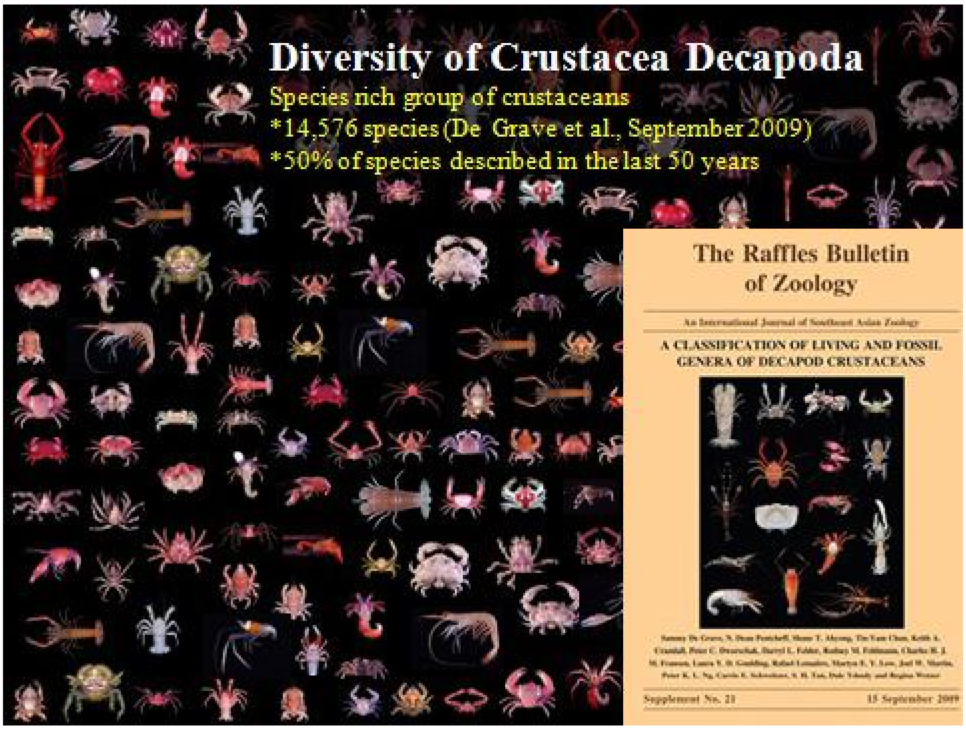
But the data coming in says we have not split enough!

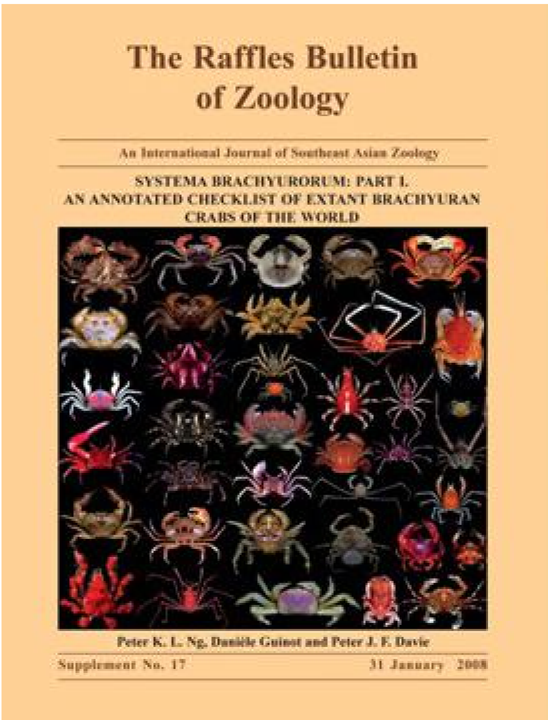


Cryptic species: Lai et al. (2011) ..... four species – Indo-West Pacific!

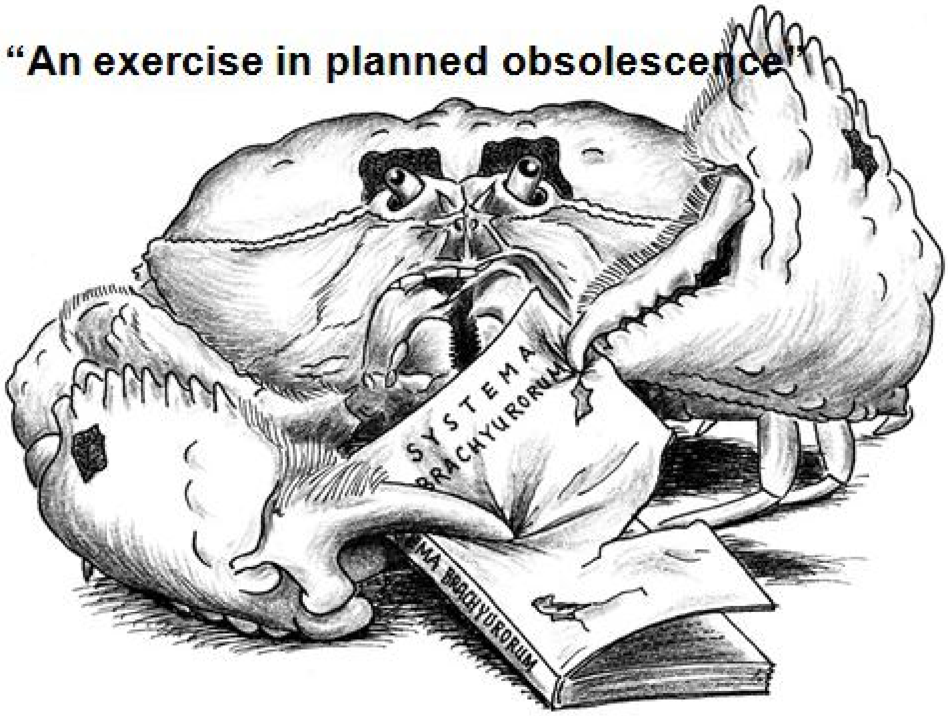

Complete Primate Skeleton from the Middle Eocene of Messel in Germany: Morphology and Paleobiology
Abstract
Part 1
Part 2
FAST IS NOT ALWAYS GOOD ...
No end of legal and other headaches
ZooBank


Brachyuran Taxonomy, Classification and Phylogeny



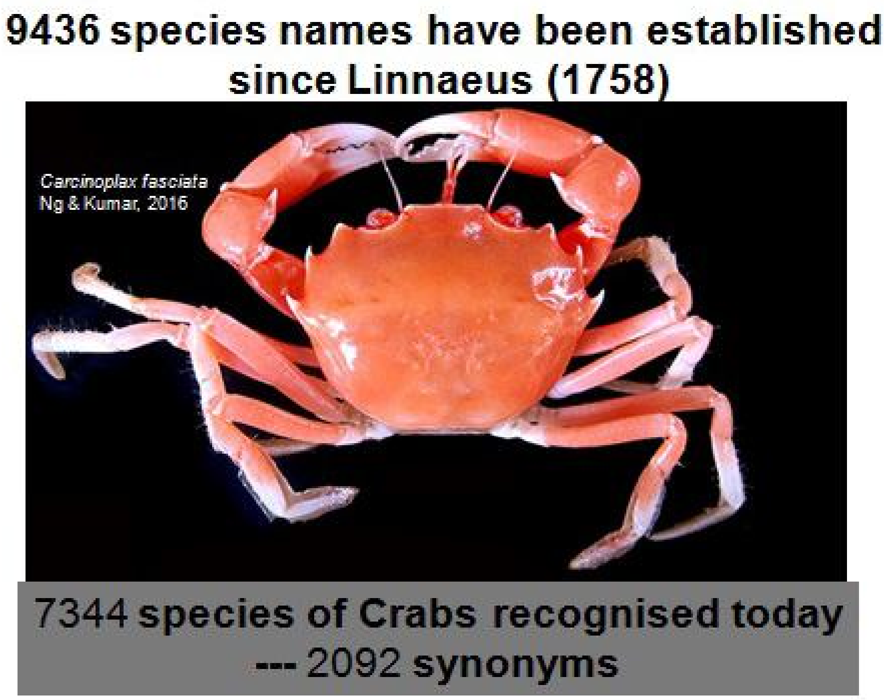


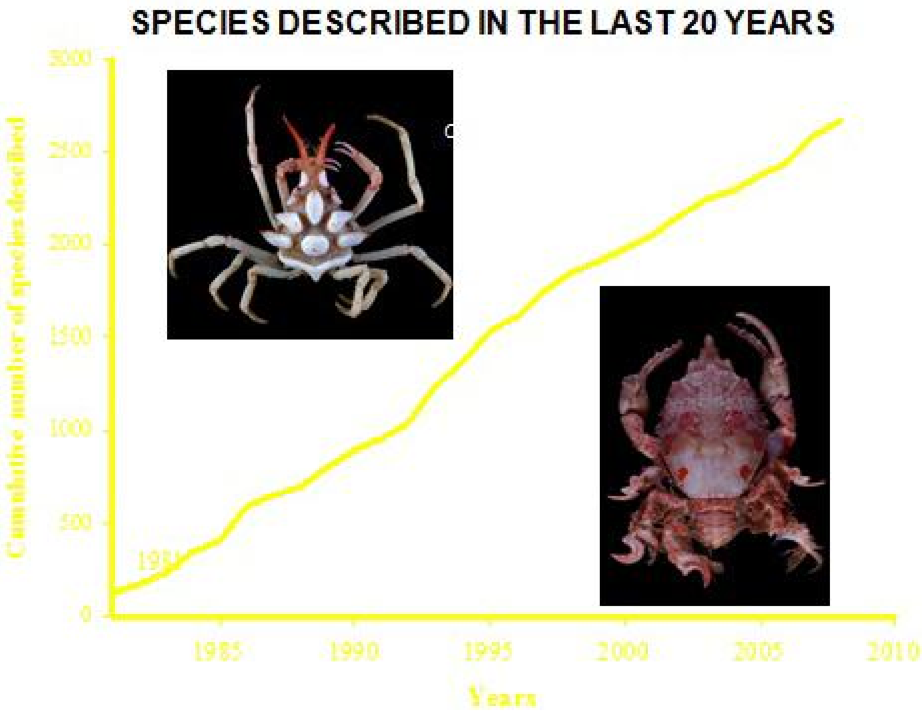
Systema Brachyuorum


"An exercise in planned obsolescence"
SYSTEMA BRACHYURORUM


Dacryopilumnus rathbunae
SO WHAT HAS CHANGED ???


103 family names recognised in 39 superfamilies
Gecarcoidea humei
(Wood-Mason, 1874)
1423 generic and subgeneric names now recognised
with 419 synonyms


9436 species names have been established
since Linnaeus (1758)
Carcinoplax fasciata
Ng & Kumar, 2016
7344 species of Crabs recognised today
--- 2092 synonyms



Chace (1951) records 4428 species

Chace, F. A., Jr., 1951. The number of species of decapod and stomatopod Crustacea. *Journal of the Washington Academy of Sciences*, **41**(11): 369–372.

Ng et al. (2008) records 6793 species

NOW – 7344 species –

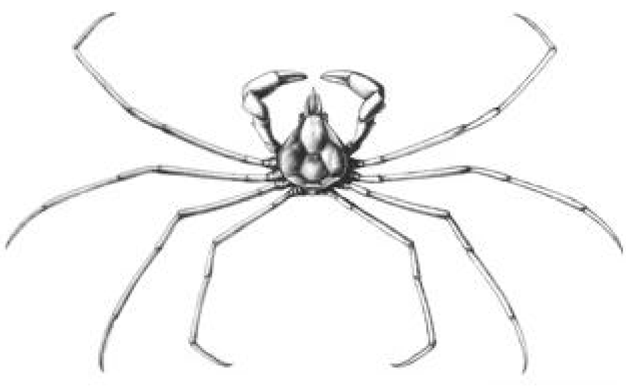
a 65% increase in 65 years

Rate of Discovery ?

Year	Genera	Species
2008	10	60
2009	25	61
2010	20	40

About 80 new species and genera annually

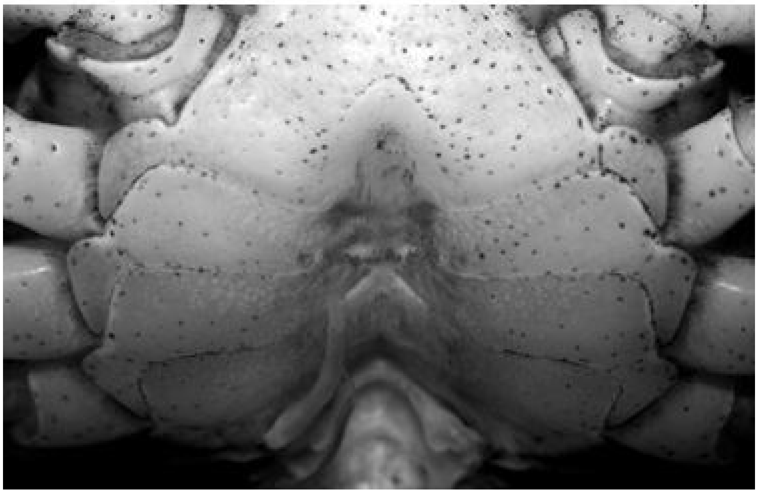
A RAPIDLY EVOLVING SCIENCE



Characters States Change ...

Carapace shapes
Mouthparts
Legs

Thoracic sternum
Male and female genital openings
Gonopods



Available online at www.sciencedirect.com

ScienceDirect

Zoologischer Anzeiger

ELSEVIER

Xanthidae MacLeay, 1838 (Decapoda: Brachyura: Xanthoidea) systematics: A multi-gene approach with support from adult and zoeal morphology

Joelle C.Y. Lai[a,*], Jose Christopher E. Mendoza[a], Danièle Guinot[b], Paul F. Clark[c], Peter K.L. Ng[a]

Abstract

1. Introduction

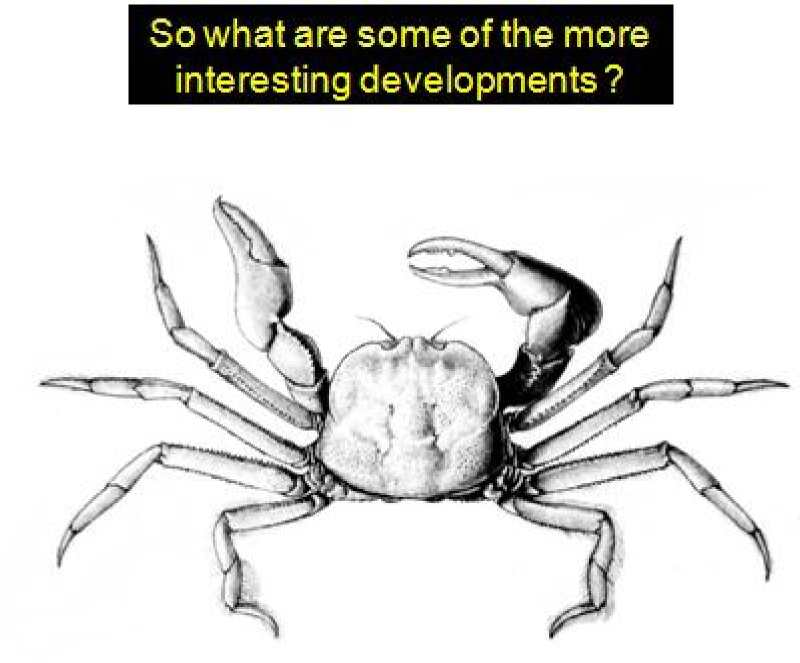
THE CARAPACE LIES

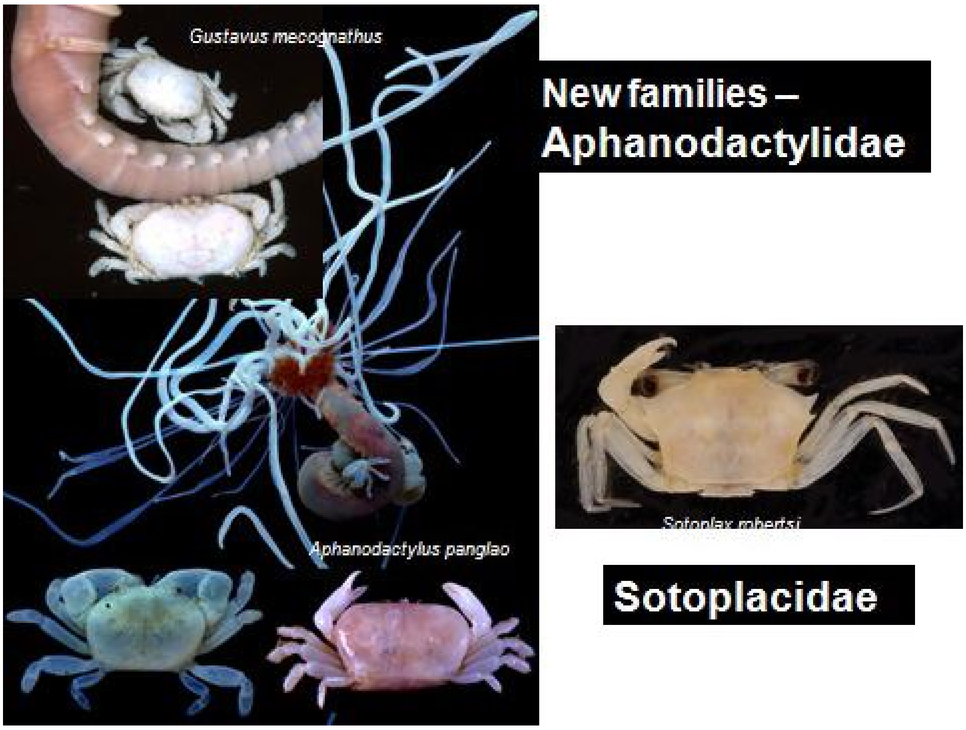
Character Values Change ...

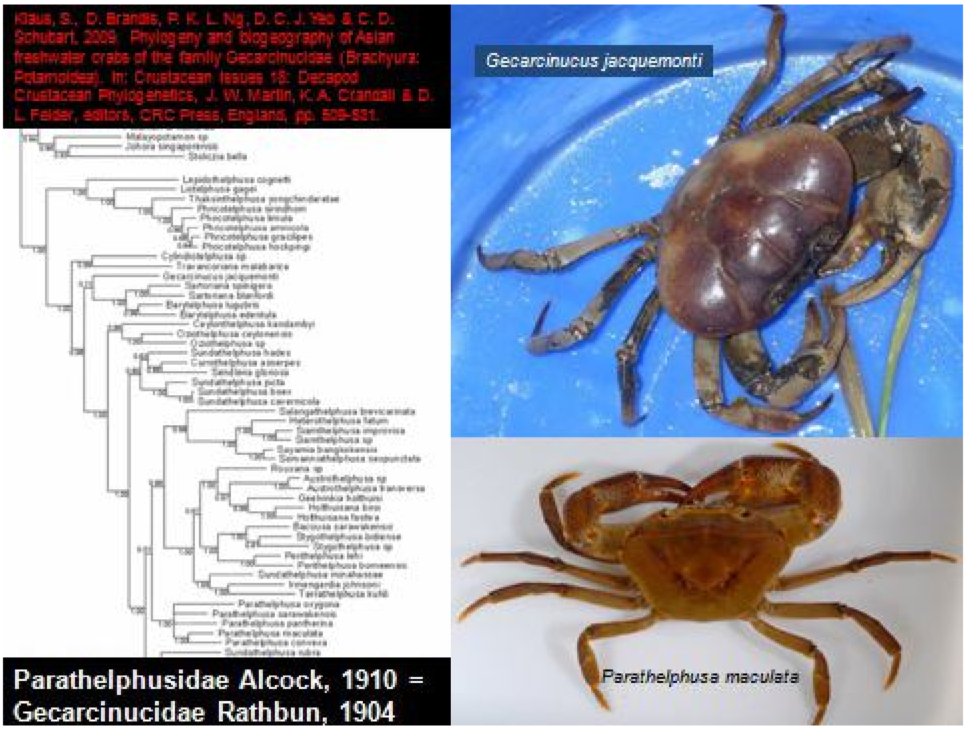
The use of character suites

The use of DNA as a tool

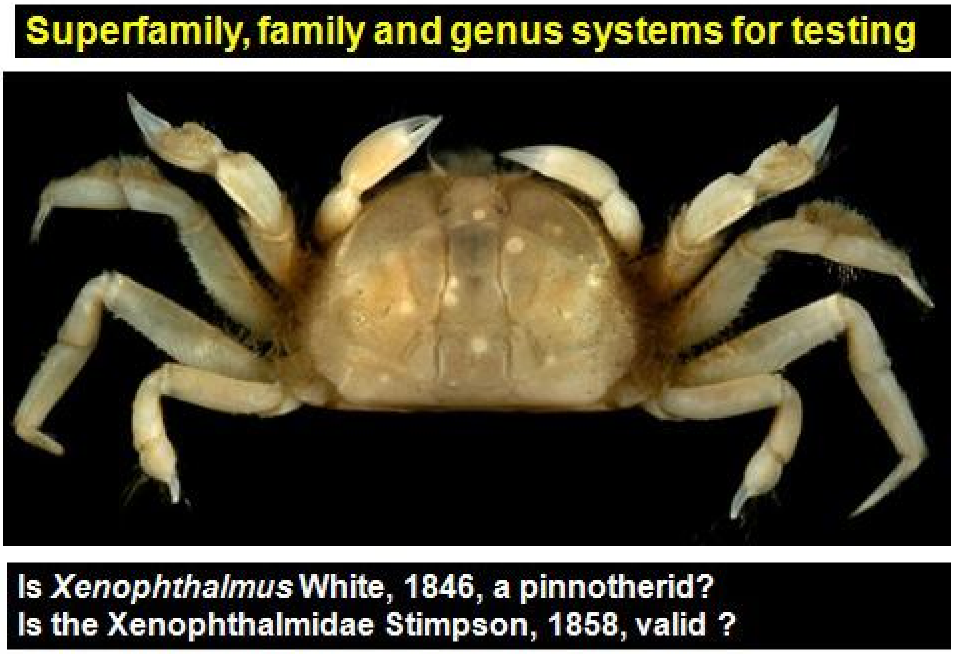
CHASING TYPES


So what are some of the more
interesting developments ?


Gustavus mecognathus
New families –
Aphanodactylidae
Aphanodactylus panglao
Sotoplax robertsi
Sotoplacidae



Klaus, S., D. Brandis, P. K. L. Ng, D. C. J. Yeo & C. D. Schubart, 2009. Phylogeny and biogeography of Asian freshwater crabs of the family Gecarcinucidae (Brachyura: Potamoidea). In: Crustacean Issues 18: Decapod Crustacean Phylogenetics, J. W. Martin, K. A. Crandall & D. L. Felder, editors, CRC Press, England, pp. 509-531.
Gecarcinucus jacquemonti
Parathelphusa maculata
Parathelphusidae Alcock, 1910 = Gecarcinucidae Rathbun, 1904



Superfamily, family and genus systems for testing
Is *Xenophthalmus* White, 1846, a pinnotherid?
Is the Xenophthalmidae Stimpson, 1858, valid ?

Percnidae Števčić, 2005

Schubart, C. D. & J. A. Cuesta, 2010. Phylogenetic relationships of the Plagusiidae Dana, 1851 (Brachyura), with description of a new genus and recognition of Percnidae Števčić, 2005, as an independent family. *Crustaceana Monographs*, **11**: 279–299.

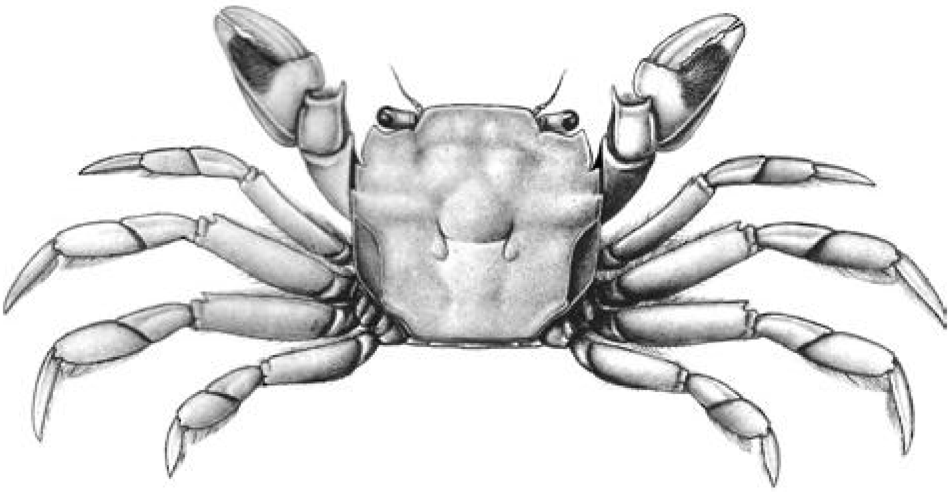
The testing of hypotheses --- the situation with Ocypodoidea, Grapsoidea, Pinnotheroidea etc.

The new Ocypodoidea, and the dissolution of "*Uca*"

ONE Majoidea but how many families and subfamilies etc. ?

The Integrity of the Xanthoidea and Eriphioidea ?

Interesting Times Ahead –
and Opportunities Galore !



A brief guide to nomenclature and ICZN rules

P.K.L. Ng & S. De Grave

Nomina si nescis, perit et cognitio rerum

WHAT IS IN A NAME? **Linnaeus, 1758**

Why do names change

- Increased taxonomic or systematic understanding
- New discoveries
- New techniques and tools
- Changes in species concepts
- Correct application of ICZN rules
- Corrections of errors in spelling
- New synonyms and forgotten names
- Clarification of publication dates

Why a Code?

Changes are governed by the ICZN (1999) Code of Nomenclature

The objects of the Code are *to promote* ***stability*** *and* ***universability*** *in the scientific names of animals and to ensure that the name of each taxon is unique and distinct.*

All its provisions and recommendations are subservient to those ends and none restricts the freedom of taxonomic thought or actions"

Why a Code?

Changes are governed by the International Code of Zoological Nomenclature, i.e., the Code (ICZN, 1999)[1,2]

"The objects of the Code are *to promote **stability** and **universability** in the scientific names of animals and to ensure that the name of each taxon is unique and distinct.*

All its provisions and recommendations are subservient to those ends and none restricts the freedom of taxonomic thought or actions"

---

[1]ICZN 1999. International Code of Zoological Nomenclature. Fourth Edition. The International Trust for Zoological Nomenclature, London, UK. 306 pp.

[2]ICZN = International Commission on Zoological Nomenclature, which is the author of the code

Linnaean system

- Starting point = Linnaeus, 10th ed. (1758)
- Binominal species names, uninominal at higher level, trinominal at lower levels
- Based on the Latin alphabet
- Based on the rules of Latin grammar
- Hierarchical in nature
- Standard point of reference

- Data management system as service for other disciplines

MAIN PRINCIPLES

Main Principles

- Principle of Binominal Nomenclature (species names)
- Principle of Typification (identity determined by type)
- Principle of Synonymy (one taxon = one name)
- Principle of Homonymy (one name = one taxon)
- Principle of Priority (oldest rules - usually)

PRINCIPLE OF BINOMINAL NOMENCLATURE

Each species has a UNIQUE paired name combination

Genus epithet:	Species epithet:
Homo	*sapiens*
Pongo	*pygmaeus*
Pan	*troglodytes*
Betta	*picta*

Genus name and **specific epithet** together form the **species name**

Sometimes authority is added, e. g. *Homo sapiens* L., 1758
Only Linnaeus can be abbreviated in zoological nomenclature

Recommendation no. 1

Avoid too many authors on the byline – especially if its the taxonomic authority, i.e. in new names.

Avoid "in" descriptions as far as possible

Example:

Dai, A. Y., G. X. Chen, Y. Z. Song, P. F. Fan, Y. G. Lin & Y. Q. Zeng, 1979. On new species of freshwater crabs harbouring metacercariae of lung flukes. *Acta Zootax. Sinica*, **4**(2): 122-131.

To cite: *Sinopotamon anhuiense* Dai and Fan in Dai, Chen, Song, Fan, Lin & Zeng, 1979, is very tedious and librarians/databases find this difficult to impossible to track.

Understanding scientific names

- Derivation and formation of name, i.e. etymology
- Gender agreement
- Descriptiveness and appropriateness
- Length, usage and mnemonic value
- Ethics and honour

Species names can be:

- Descriptive (e.g. *quadridentata*, *sexpunctata*, *striata*, *rubra*, *villosum*)
- Symbolic (e.g. *toxica*, *styx*, *posidon*, *ferox*, *pokipoki*)
- Relate to provenance (e.g. *malayensis*, *sinensis*, *americanus*, *novaehollandiae*, *sandwichensis*)
- Relate to habitat (e.g. *gua*, *terrestris*, *bathyalis*, *corallinus*, *nepenthicola*)
- Honourific (e.g. *johnsoni*, *keelini*, *jonesi*, *jonesae*, *geoffroyorum*, *rincewindi*) [-*i* if male, -*ae* if female, -*orum* if plural]

Derivation of species names

- After descriptive features: adjective or participle
- After other species: adjective or noun in apposition
- After people (real or fictional): noun in genitive case
- After places: adjective

- Adjectives or participle need to agree in gender with genus name !!
- But nouns always stay as is
- Can be difficult to determine the exact derivation if not specified and thus the potential need to change spelling

Recommendation no. 2

Always specify and/or explain the etymology

Example: Anker, A. (2012). Revision of the western Atlantic members of the *Alpheus armillatus* H. Milne Edwards, 1837 species complex (Decapoda, Alpheidae), with descriptions of seven new species. *Zootaxa,* 3386, 1-109.

Alpheus amarillo sp. nov.

Etymology. From the Spanish word amarillo (yellow), referring to the bright yellow body colour of living shrimps; used as a noun in apposition.

Will not change ending if moved to another genus.

Good names and bad names

- Good names are short and euphonious or aid in identification: for example the crabs *Paratymolus po* and *Scylla serrata;* and the fish *Betta pi*

- Bad names are long or difficult to spell or confuse or mislead, for example:

- the Lake Baikal amphipod, *Echinosiezengowitzparagammarus siebenkotzenkarella* ----- too long and hard to pronouce
- or the pantropical shrimp genus *Bermudacaris* ----- misleading and confusing

Recommendation no. 3

Avoid silliness:

Example: *Carthwrightia carthwrighti* Cartwright, 1967

Genus described by Islas (1958) and named for Oscar Cartwright, a renowned beetle taxonomist,

Species described in 1967 by Oscar Cartwright and named after his brother, Raymond.

But sense of humour is allowed: *Pieza rhea* Evenhuis, 2002; *Apopyllus now* Platnick & Shadab, 1984

Gender agreement

Examples:

Basionym: *Carpilodes lophopus* Alcock, 1898 --- genus and species both masculine

Current name: *Actiomera lophopa* (Alcock, 1898) --- genus and species both feminine

Basionym: *Actaea cavernosa* A. Milne-Edwards, 1878 --- genus and species both feminine

Current name: *Glyptoxanthus cavernosus* (A. Milne-Edwards, 1878) --- genus and species both masculine

Basionym: *Cancer armadillus* Herbst, 1790 --- genus masculine, species noun

Current name: *Demania armadillus* (Herbst, 1790) --- genus feminine, species name not changed

NB. Remember – the gender of the species ALWAYS follows the genus. Not the subgenus!

Difficulties

Not always clear what gender of genus is:

- The crab genus *Parasesarma* has a typical "feminine" –*a* ending, but is actually neuter, so *Parasesarma plicatum* is the correct name for the Indian mangrove crab
- The fish genus *Oxyeleotris* sounds masculine, but is actually feminine, so *O. marmorata* is the correct name for the giant goby or marbled gudgeon

When unsure – check good dictionaries, e.g.
Brown, Roland Wilbur, 1954. Composition of Scientific Words. U. S. National Museum, Washington D.C., 882 pp.

Or ask a priest or Latin scholar!

PRINCIPLE OF TYPIFICATION

Principle of typification

Each taxonomic grouping or taxon must have clearly defined representatives, i.e. types, designated in order to be valid:

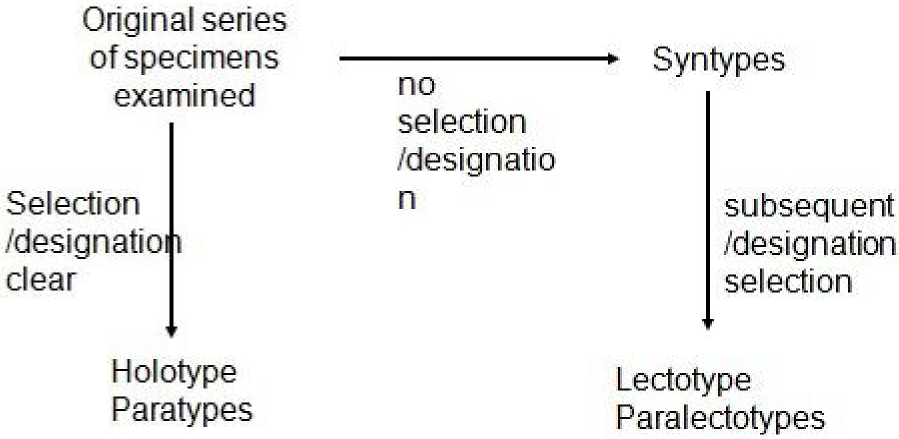
- Species + subspecies must have type specimen(s)
- Genus + subgenus must have type species
- Family + subfamily must have type genus

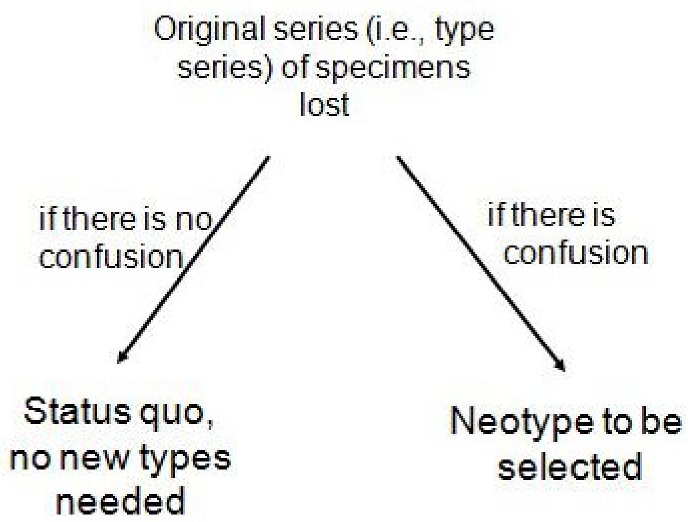
Categories of type specimens

Name bearing
- Holotype
- Syntype
- Lectotype
- Neotype

Non name bearing
- Paratype /allotype
- Paralectotype

Original description





What can be a type specimen?

- A whole animal;
- Any part of an animal, even a single tooth or feather or even blood sample;
- A fossil fragment (no matter how fragmented!);
- A DNA sequence;
- A living specimen;

- Note iconotypes: drawings/photographs of the supposed type specimen!

PRINCIPLE OF SYNONYMY

Principle of Synonymy

One name to rule them all...

Example 1

Accepted name: *Crangon crangon* (Linnaeus, 1758)

= *Crangon vulgaris* Fabricius, 1798:
= *Crangon Rubro punctatus* Risso, 1816
= *Cancer schillinus* Nardo, 1847
= *Crangon maculosus* Rathke, 1837
= *Crangon maculosus* forma *typica* Czerniavsky, 1884
= *Crangon maculosus* forma *brevirostris* Czerniavsky, 1884
= *Crangon maculosus* var. *suchumica* Czerniavsky, 1884
= *Steiracrangon orientalis* var. *longicauda* forma *intermedia* Czerniavsky, 1884
= *Steiracrangon orientalis* var. *brevicauda* Czerniavsky, 1884
= *Crangon crangon typicus* Doflein, 1900
= *Crangon crangon* forma *mediterranea* Bražnikov, 1907
= *Crangon crangon* forma *typica* Bražnikov, 1907

Principle of Synonymy

Example 2:

Demanietta merguensis **(Bott, 1966)**

Telphusa stoliczkana – De Man, 1887: 94 (not *Telphusa stoliczkana* Wood-Mason, 1871).

Potamon (Potamonautes) stoliczkana – De Man, 1898b: 425 (part), Pl. 6 fig. 10b, c (not *Telphusa stoliczkana* Wood-Mason, 1871).

Potamon (Potamon) thagatensis Rathbun, 1904: 296 (part).

Potamon (Potamon) thagatense – Alcock, 1910b: 54, Fig. 47; Kemp, 1923a: 16 (not *Potamon (Potamon) thagatensis* Rathbun, 1904).

Potamonautes thagatensis – Balss, 1937: 167, Fig. 30; Pretzmann, 1963: 367, Pl. 9 fig. 10 (not *Potamon (Potamon) thagatensis* Rathbun, 1904).

Potamiscus (Demanietta) tenasserimensis merguensis Bott, 1966: 488, Fig. 23, Pl. 18 fig. 6.

Ranguna (Demanietta) tenasserimensis merguensis – Bott, 1970b: 174, Pl. 39 fig. 47, Pl. 49 fig. 43; Chuensri, 1974b: 26.

Demanietta merguensis – Ng and Naiyanetr, 1993: 31; Yeo and Ng, 1999a: 640; Yeo et al., 1999: 539, Figs. 3A-D, 6E, 8C.

PRINCIPLE OF HOMONYMY

Principle of Homonymy

Examples:

The name *Calmania* Bouvier, 1909, is invalid as it is a junior homonym of *Calmania* Laurie, 1906 (Crustacea Brachyura) and *Calmania* Nobili, 1907 (which is in turn a junior subjective synonym of *Brachycarpus* Spence Bate, 1888)

The name *Corniger* Borradaile, 1915, is invalid as it is a junior homonym of *Corniger* Agassiz, 1831 (Pisces) and *Corniger* Boehm, 1879 (Pycnogonida)

The name *Orientalia* Dang, 1975, is a junior homonym of *Orientalia* Radoman, 1972 (Mollusca: Gastropoda), with *Hainanpotamon* Dai, 1995, the first available replacement name

PRINCIPLE OF PRIORITY

Principle of Priority

- Oldest available name for a species normally has priority:

Metasesarma obesum (Dana, 1851) over *M. rousseauxi* H. Milne Edwards, 1853

- There are exceptions….nomen oblitum/nomen protectum concept or by ICZN Direction

- Date of publication must be verifiable, but can be the last day of a given month or even last day of year if no other information

- Principle of Priority applies at all hierarchical levels

NITTY-GRITTY RULES

Criteria of publication

- Must be issued for public and permanent scientific record
- Must be obtainable free or by purchase
- Must be produced so as to be simultaneously obtainable, i.e. several copies.

- Before 1986, must be printed on paper
- Between 1985 and 2000 various media allowed, but strict rules
- After 1999, if not printed then generally available in at least 5 libraries
- After 2011, electronic publication allowed under strict conditions

Criteria of availability

For new species names to be valid, they must:

- be published
- Mandatory usage of Latin alphabet
- Be binominal
- Cannot be used as a junior synonym

- Cannot be infrasubspecific (if after 1961)
- Cannot be conditional (if after 1961)

Some details..

- Names published before 1931 must be accompanied by description or an indication
- Names published after 1930 must be accompanied by description in words or an indication
- Family level names published after 1930 must have a stem-genus name
- Genus level names published after 1930 must have type species indicated

More details...

Names published after 1999 must:

- be explicitly stated to be new
- must be defined and differentiated

- Family level names must have type genus stated
- Genus level names must have type species stated
- Species level names must have type specimen indicated

And more...

Electronic publication of names allowed after 2011, but must:

- be registered in Zoobank before publication,
- the work itself must state date of publication,
- gives evidence that registration has occurred,
- and states the electronic archive in which copies are deposited.

In post 2011 world, very messy: fully electronic publications, ZOOBANK, registration, LSID numbers, preprints, early publication etc.

Motto: Be careful – VERY careful

SOME CONVENTIONS AND DEFINITIONS…

Endings for suprageneric taxa

- -inae for subfamily
- -idae for family
- -0idea for super family
- Above superfamilies, there are no rules (problems – cannot keep everyone happy …)

- Vernacular usage example:

  Subfamily – sesarmine

  Family – sesarmid

  Superfamily – xanthoid

NB. Use of lower case when these names are use as adjectives rather than nouns, e.g., either "these are crabs of the Sesarmidae" or "these are sesarmid crabs"

Nomen definitions.

Nomen nudum: A name which is not validly published according to ICZN rules

Nomen dubium: Name of unknown or doubtfull application, e.g. poor description, no known type or no known type location

Nomen novum: replacement name

Nomen oblitum: A name which does not take precedence over a junior synonym

Nomen protectum: A name given precedence over an unused senior synonym

Correct usage of parenthesis.....

Basionym: *Potamon* (*Potamiscus*) *tumidum* Alcock, 1909

Subgenus not recognised: *Potamon tumidum* Alcock, 1909

Subgenus elevated: *Potamiscus tumidus* (Alcock, 1909)

Genus split up and species moved: *Ranguna tumida* (Alcock, 1909)

Correct usage of subgeneric authorities…

Basionym: *Actaea* De Haan, 1833

Split into several subgenera:
Actaea (*Actaea*) De Haan, 1833 (nominotypical subgenus)
Actaea (*Paractaea*) Guinot, 1966
Actaea (*Novactaea*) Guinot, 1967

Now considered to be genera:
Actaea De Haan, 1833
Paractaea Guinot, 1966
Novactaea Guinot, 1967

SOME ISSUES…

Subspecies…

- Subjective decisions
- Often not supported by proper data
- Personal viewpoint rather than "proper" science

- Bear in mind taxonomic usage, e.g. IUCN does not use subspecies for Red Listing

What of levels below subspecies?

For example:

Pseudodon (*Parapseudodon*) *vondembuschianus cambodiensis* var. *vermaculatus* (Bouvier, 1923)

or

Potamon (*Telphusa*) *fluviatilis fluviatilis* Natio *tarantium* Pretzmann, 1983

Tricky…

- Depends on when described, how described etc.
- Some are valid, some not (seek expert advice based on ICZN rules!)
- If after 1999, then no validity for infrasubspecific taxa

In case of "tricky" problems

See if Commissioners can help,
then call in the Commission via an application (http://iczn.org/content/guidelines-case-preparation), but unlike Ghostbusters, just do not always expect a decision in your life time – it has heaps of "cold cases"

And remember...

Nomenclatural Rules are there to help scientists communicate their science.

For all scientists, across all continents, all countries, all cultures, all races, all languages, and across time.

There are rules. There are recommendations. And there must be a lot of common sense!

Publish or perish: thoughts on the publication process

S. De Grave & P.K.L.Ng

Journals with exclusive Crustacea content

- ***Crustaceana*** (http://www.brill.com/crustaceana), online submission system, editing charges, print + pdf, broad scope incl. taxonomy and short notes.
- ***Journal of Crustacean Biology*** (http://www.brill.com/journal-crustacean-biology; soon to move to OUP), online submission system, page charges for non-Society members, print + pdf, broad scope, no taxonomy.
- ***Nauplius*** (http://www.scielo.br/revistas/nau/iaboutj.htm), online submission, free to publish, e-only, broad scope, main focus is Americas
- ***Crustacean Research*** (http://crustacean-research.webnode.jp/), online submission, free to publish, e-only, broad scope, main focus is Asia

Journals with major Crustacea content

- ***Zootaxa*** (http://www.mapress.com/j/zt/), email submission system, free to publish, print + pdf, taxonomy and systematics only
- ***Zookeys*** (http://zookeys.pensoft.net/), online submission system, page charges (but can be waived), e-only, taxonomy and systematics only
- ***Raffles Bulletin of Zoology*** (http://lkcnhm.nus.edu.sg/nus/index.php/nhmpublications/rbz), email submission system, free to publish, e-only, broad scope, but usually taxonomy or ecology, South East Asia focus

- Many more: Marine Biodiversity, Marine Biology Research, JMBA, Hydrobiologia, Checklist, PeerJ,...

AN AUTHOR'S VIEWPOINT

Initial decisions

- What to publish? Whatever is worthwhile, short notes or longer papers?
- Where to send? Local, regional and international journals?
- Check MS fits scope of journal
- Is usage of colour justified
- What are the fees and who will pay?
- Consider ethical issues

Common problems

- Material should not be deposited in private collection
- Quality of figures
- Number and size of figures
- Know the journal style

Common problems in taxonomic papers

- Lack of knowledge of nomenclature or ICZN rules
- Lack of knowledge about types
- Lack of knowledge about convention in writing taxonomic papers
- Limited literature access

- For new taxa, derive name properly
- State etymology and gender of name (if required)

How to cite synonymies

Demania armadillus (Linnaeus, 1758)

Cancer armadillus Linnaeus, 1758: 23.
Xantho armadillum – H. Milne Edwards, 1837: 214.
Xantho armadillus – Balss, 1938: 23, pl. 1.
Xantho (*Demania*) *indicum* Chopra, 1939: 56, fig. 2.
Demania indica – Deb, 1987: 11.
Demania bangladeshensis Huda & Qanu, 1992: 12, pl. 2a.
Demania armadillus – Ng & Holthuis, 1997: 77, fig. 1.

Submission process

- Follow instructions carefully
- Add a formal submission letter, ask for acknowledgement if need be
- Pick potential reviewers carefully
- Select a corresponding author

Review process

- Mandatory for good journals, but number and depth varies
- Suggestions are recommendations, but within reason should be followed
- Comments should be constructive, not personal

- Never argue with an editor, their decision is final

AN EDITOR'S VIEWPOINT

Submission dos and dont's

- Check fit of MS to journal scope
- Avoid known holiday periods when doing a submission
- If submission system is online, use it, do not email submission!
- Format correctly for the journal, use an example
- Language should not distract from content, but does not have to be perfect English
- Reviewers need to focus on science and content, not copy edit, correct language
- An all author agreement should be included in initial submission
- Be consistent throughout
- Quality and format of figures is important, especially graphs
- Pay particular attention to tables

- Avoid plagiarism, no matter how small
- Cite correctly and in context
- All journals use different workflows, e.g Zookeys, RBZ, Checklist
- Reviewing and editing takes time !

- After revision, send in a track changes file and a clean version
- Always have a point by point rebuttal of review comments, incl. annotated pdf comments

- Check proofs properly, MS is no longer under control of editor
- At proof stage no large changes can be made

NOMENCLATORIAL ISSUES

Nomenclatorial acts

- Not just new species descriptions
- Editors not always well versed
- E-only publication problems
- Zoobank
- Online First problems
- Version of record definition

Resources for Decapoda

P.K.L. Ng, D.C.J. Yeo & S. De Grave

Internet resources for Decapoda

- World Register of Marine Species, http://www.marinespecies.org/index.php
- AToL Decapoda, http://decapoda.nhm.org/
- Biodiversity Heritage Library, http://www.biodiversitylibrary.org/
- Gallica, http://gallica.bnf.fr/
- IUCN Red List, http://www.iucnredlist.org/
- Crusta, http://crustiesfroverseas.free.fr/index.php
- Marine Species Identification Portal, http://species-identification.org/index.php
- ARKive, http://www.arkive.org
- Australian Faunal Directory, http://www.environment.gov.au/biodiversity/abrs/online-resources/fauna/
- Marine lobsters of the World, http://wbd.etibioinformatics.nl/bis/lobsters.php?menuentry=inleiding
- Crabs of Japan, http://species-identification.org/species.php?species_group=crabs_of_japan&menuentry=inleiding
- Delta keys to Primitive Crab Identification, http://researchdata.museum.vic.gov.au/crustacea/primitive_crabs/delta/deltakey.htm
- Crustacea.net, http://www.crustacea.net/index.htm
- FAO Species Identification Guide for Fishery Purposes: The Living Marine Resources of the Western Central Pacific, Volume 2: Cephalopods, crustaceans, holothurians and shark http://www.fao.org/docrep/009/w7192e/w7192e00.htm

SHRIMPS

(Caridea, Dendrobranchiata, Stenopodidae)

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