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AN ILLUSTRATED KEY TO THE MALACOSTRACA (CRUSTACEA) OF THE NORTHERN ARABIAN SEA

Part 1: INTRODUCTION

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ABSTRACT: The key deals with the Malacostraca from the northern Arabian Sea (22°09'N to 10°N and 50°E to 76°E). It is compiled from the specimens available to us and those which are in the literature. An introduction to the class Malacostraca and key to the identification of subclasses, superorders and orders is given. All the key characters are illustrated. Original references with later changes are mentioned.

The key will be published in parts not necessarily in chronological order.

KEY WORDS: Malacostraca - Arabian Sea - Orders - Keys.

INTRODUCTION

The origin of this work can be traced back to the prepartition era and the early efforts of carcinologists who reported on the marine Crustacea of the northern Arabian Sea and adjacent oceanic zones. We owe indebtedness to many previous workers like Alcock (1896-1901) and Henderson (1893) who had also contributed to the list of species which the fauna now embodies. With the creation of Pakistan carcinological studies were undertaken specially by the students and scientists working at the Zoology Department, University of Karachi. The progress was initially slow and restricted mostly to the description of species that could by obtained during random collections. However, several scientists got interested in the commercially important crustaceans and the work gained momentum.

The systematic studies on organisms were encouraged by the specialists world around and as a result the Marine Reference Collection and Resource Centre (MRC) came into being. The reference library built up by exchange or donation basis from the areas adjacent to Pakistan led to the idea that our part of sea eventually may have the genera and species not yet been recorded. Further, inspired by the work of Lovett (1981) a compiled guide was thus planned to accommodate all the malacostracan species recorded up to now from coasts, open sea or perhaps the deep sea. In all 735 species are treated in the key. Substantial part of this compilation was carefully scrutinized and improved by specialists in the world, some of them contributed additional information in the portion read by them. Their illustrations are used in the key with due permission.

The present work is based on published papers, theses (unpublished) as well as the unidentified collections housed in the MRC or some other institutions. Species reported in the literature but not available for study have been included as such since

they are likely to turn up in future or may prove to have been extinct or migrated from the region.

The work is heavily based on fresh collections made regularly by the staff of the Centre. Each collection is sorted, identified, illustrated and catalogued. New records or new species encountered are simultaneously prepared for publication in local or foreign journals.

The work done so far is found only in publications that are not commonly available and several are now out of print. There appears to be a great need for such type of work both at home and abroad. The study aimed firstly, to bring together in a central reference, all the current taxonomic works on the Malacostraca of the northern Arabian Sea dealing with intertidal as well as offshore representatives and secondly to produce a guide that could readily be used by the students, biologists and informed amateurs. This is an attempt to pull together under one cover the published information on the subject and the region in question. For researchers this key may open up a field for investigations and would give an idea as to the avenues in which further investigations can be directed.

The present investigation began with the idea first to compile a list of known species of malacostracans from the northern Arabian Sea and coasts bounding it and then prepare keys for the identification of different malacostracan groups. It soon became apparent that systematic problems within the taxa pose insurmountable obstacles to the accomplishment of the proposed study. The search of references was a time consuming job, to obtain access was even more difficult task particularly from the west coast of India. The late arrival of some of the literature sought forced us to not to include those species, for the time being, in the already constructed key as inclusion of one species sometime disturbs the entire pattern. To overcome this problem name of such species are given in the end of that group under the heading "Not treated".

The class Malacostraca, includes crabs, lobsters, crayfish, shrimps and pill bugs. Over 18,000 malacostracan species, accounting for about two-third of all known crustacean species, have been described in the world. The malacostracans have considerable economic importance. They provide more human food than all other invertebrate groups together. Small members of the class are a welcome part of the diet of many commercially valuable fishes. Malacostracans are generally large-sized crustaceans, however, there is a considerable size variation. The smallest malacostracans are less than a millimeter long (Barth & Broshears, 1982) while an American lobster can extend 60cm and the world's largest living arthropod, the Japanese spider crab *Macrocheira kaempferi*, can measure 366cm in its chela span.

The traditional systematics of the class Crustacea which was originated by Latreille (1806) divide it into the Entomostraca and Malacostraca, as known to all carcinologists. After that it had been clearly demonstrated that the Crustacea was more than a class and all the subclasses, including the subclass Malacostraca, begin to be considered as independent classes (Manton, 1977; Bowman & Abele, 1982; Scharm, 1982). In the present existing situation western authors like McLaughlin (1980) accept, with some changes, Crustacea as more than a class while Soviet carcinologists like Zarenkov (1982) accept a single class Crustacea with many subclasses. In 1988 again a Soviet taxonomist, Starobogatov proposed to divide the Crustacea as 4 independent classes, instead of 10 to 12 and agreed with Bowman & Abele (1982) in considering the Crustacea a supraclass (=superclass of Bowman & Abele, 1982). The crustaceans

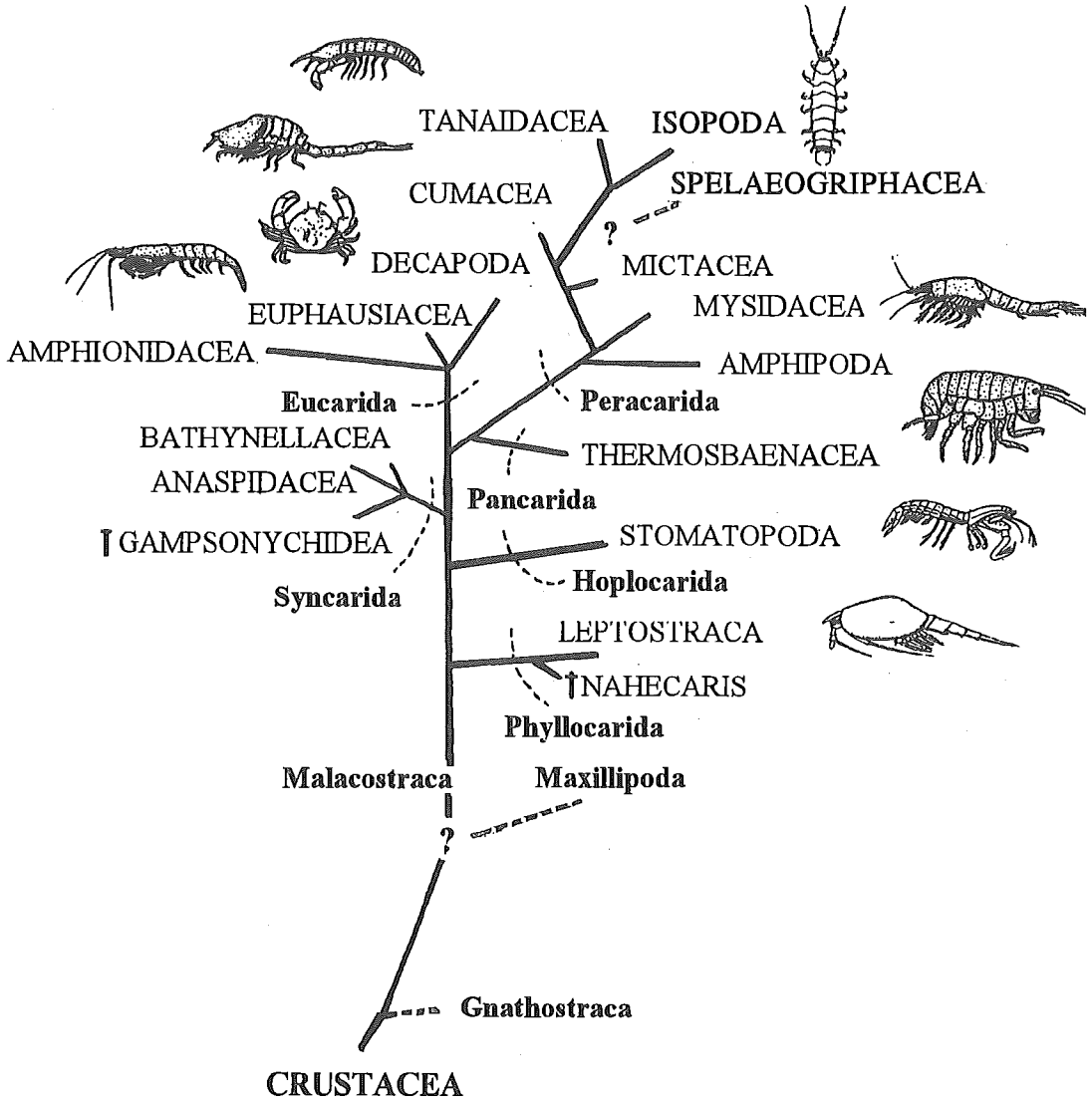

Fig.1. Dendogram of the Malacostraca showing the possible relations of its orders to each other. (modified from various authors)

have been divided into 6 classes by Bowman & Abele (1982). A dendrogram is prepared showing evolutionary trend in the Malacostraca (Fig.1).

It may be pointed out that Bowman & Abele (1982) divided the class Malacostraca into 3 subclasses. Their classification is basically similar to that of Moore & McCormich (1969) but incorporating recent changes in the classification of certain taxa, for example in the unsettled classification of Decapoda, they have followed Glaessner (1969), Guinot (1977) and De Saint Laurent (1980 a,b). Later works by Abele & Felgenhauer (1986) have resulted in confirmation of the fundamental division of the decapods into two suborders i.e. Dendrobranchiata and Pleocyemata. Kim & Abele (1990) used nucleotide sequences in a phylogenetic study of selected decapods and provided molecular evidence in support of this division. Status of orders Cumacea

and Tanaidacea are reviewed by Meglitsch & Schram (1991), they have put Cumacea and Tanaidacea as suborders of order Hemicaridea and orders Isopoda and Amphipoda under order Edriophthalma. The superorder Syncarida has been given the status of order and the two suborders Mysida and Lophogastrida of the order Mysidacea are ranked as orders. The order Decapoda has been divided into four suborders by these authors, they are Dendrobranchiata, Eukyphida, Euzygida and Reptantia. The scheme given by Bowman & Abele (1980) is followed here.

The principal objective of the key is to contribute to the faunistic knowledge of the marine area, up to now little studied inspite of its oceanographic and fishery importance. According to Bacescu (1978) the calcareous and glauconiticous muddy bottoms of this area are ideal medium for generating special types of crustaceans, thus proving the Indian Ocean an important speciation centre.

The present easy-to-follow illustrated key includes the extant and adult malacostracans, free living and the parasitic ones collected and reported from the northern part of the Arabian Sea, its coastal boundaries as well as its islands of Laccadive, Scotra and Kuria Muria (Fig.2), from shores and inshores waters as well as pelagic and planktonic. Oceanographically the southern limit of the Arabian Sea could be fixed at 10^{o} north latitude (Rao, 1979). This is strictly followed in the key. Briggs (1974:19)

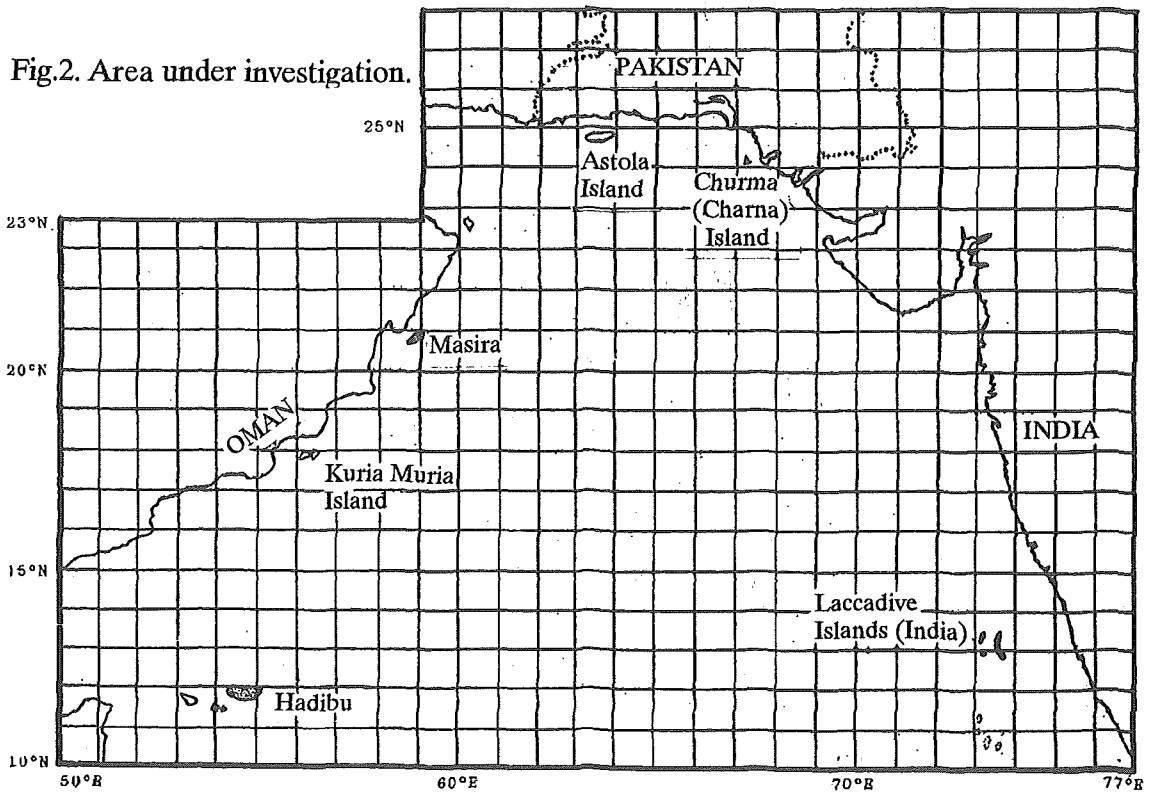

Fig.2. Area under investigation.

indication that there is presence of a zoogeographic "north-eastern boundary" in the northern Arabian Sea, "tentatively considered to occur at the entrance to the Persian Gulf (the Gulf of Oman)", is accepted here and we have refrained from including the species occurring in the Gulfs for the time being. At the end a chapter on collection and preservation methods for all the mlacostracan orders is added.

The key is prepared as dichotomous couplets, where necessary a triplet had to be constructed. The couplet leads to a number indicated on the right margin which heads a new set of alternatives. The progression from one couplet to the next must be followed strictly. Eventually the choices lead to a specific name of the species and its original authors with a reference of the first discoverer in the area studied and if necessary a second reference. A few references of the earliest record are still retained, some for purely historic interest, some to signalise the persistence of certain species over a long period. Before the species names the user can key out higher categories such as suborders, infraorders, superfamilies, families, subfamilies, genera and subgenera, sometimes a key to the determination of sex is also given. If an order is represented by a single family and single species, it is keyed out then and there and the order is not dealt separately, otherwise for each order its key to the species is given as a separate part. Since the number of species in the order Decapoda came out to be more than anticipated and the numbers of couplet were reached to three digits the infraorders of the order Decapoda are therefore keyed out in Roman numbers, and each infraorder starts with a new number. With each order selected Pakistani as well as supplemental references, from the Arabian Sea, are also provided.

The key borrows heavily from the past but reconstructing should make it more usable than the older keys. At many places the key has been prepared by fabricating pieces of keys of several authors for specimens collected in a number of different regions, the fabricated piece is modified according to the format followed. The keys are updated by incorporating recent changes in nomenclature and reference to the change is also mentioned.

Status and validity of some species is uncertain or disputed as several species have been described from the area without any illustrations, the type repository is also not known. They are, however, treated in the key as such for the time being. Such records, however, are not believed to be authenticated whether old or recent.

If the reader is not able to get anywhere using the key, the tactic of matching the specimen with the given illustrations can always be resorted. Therefore accompanying each species are one or more illustrations of the whole specimen or enlargement of the various key characters. Where an organism is illustrated in lateral view, only the appendages from one side have been drawn, in the case of a dorsal view the appendages of both sides are given. Many of the illustrations have been adapted from those of other authors, modified for the sake of uniformity of style; taken from published and unpublished works. The source of diagram is also given. Whenever practicable drawings were made of specimens from Pakistan. The use of the key encourages to learn the basic terminology by studying carefully the schematic diagrams and the section of the technical terms given in the glossary which are applied similarly to all species within an order. The glossary of the technical terms is included at the end so that the keys are usable by non-specialists and specialists alike. The literature cited does not include the references to the authorships of the taxa. The material housed in MRC is marked with an asterisk (*). The abbreviations used through the text are as

follows.

Abd. abdomen; Ant_1. antennule; Ant_2. antenna; P. pereiopod; Plp. pleopod; Mxp. maxilliped; Max_1. maxillula; Max_2. maxilla.

To make a key of this scope entirely complete, involves ransacking a big mass of literature, which we lack. Anyhow important sets of series, books, catalogues and reports have been scanned to make the work as complete as possible. Still some lacunae in the information are expected.

DEFINITION:

Distinctly segmented crustaceans (Fig.3), body clearly divided into head, thorax and abdomen; telson constituting postsegmental region. Fixed number of somites, typically 20, rarely 21, head constitutes 6 somites, thorax 8 and abdomen 6 or 7. Segments with appendages except 1st, when 7 abdominal somites are present also the last. Appendages variously modified for feeding, locomotion, reproduction, respiration etc., rarely reduced or lacking. Posterior margin of head commonly fuses with one or more thoracic somites to form cephalothoracic carapace. Typically without furcal rami. Mostly with paired compound eyes, may be sessile or stalked. Antennule often biramous. Mandible with or without palp; when present palp always uniramous. Female gonopore on 6th male gonopore on 8th thoracic somite.

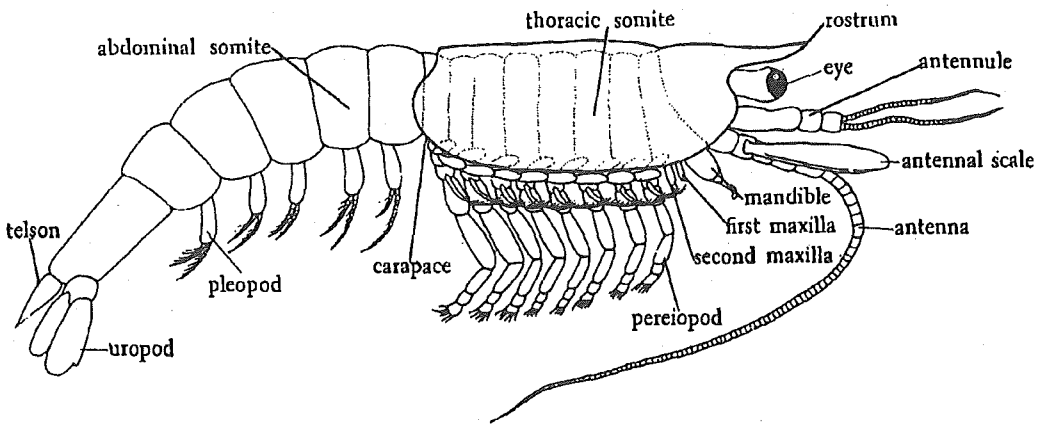

Fig.3. A generalized malacostracan.
(taken from Meglitsch, 1972)

KEY TO THE SUBCLASSES, SUPERORDERS AND ORDERS OF THE NORTHERN ARABIAN SEA MALACOSTRACA

1. Abdomen of 7-somites, last without appendages. Telson with a pair of movable articulated furcal rami. Carapace with adductor muscle. Thoracic limbs similar, somewhat foliaceous;protopod 3-segmented...Subclass Phyllocarida Packard,1879

Carapace bivalve, compressed, covering (but not fused to) all thoracic somites and part of abdomen. Rostrum movable. With only 1 order.....
.....**Order Leptostraca Claus, 1880**

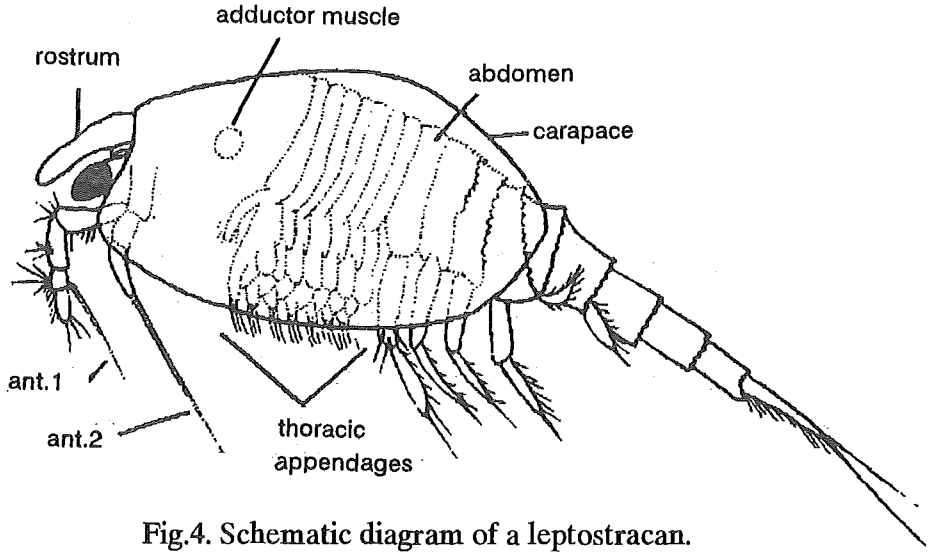

Fig.4. Schematic diagram of a leptostracan.
(after Day, 1974)

Live under loose stones on rocky shores, may be mud-dwelling, algae-inhabiting, or at be bathypelagic, detritus feeders; some species are pollution indicators..
.....**Family Nebaliidae Baird, 1850**

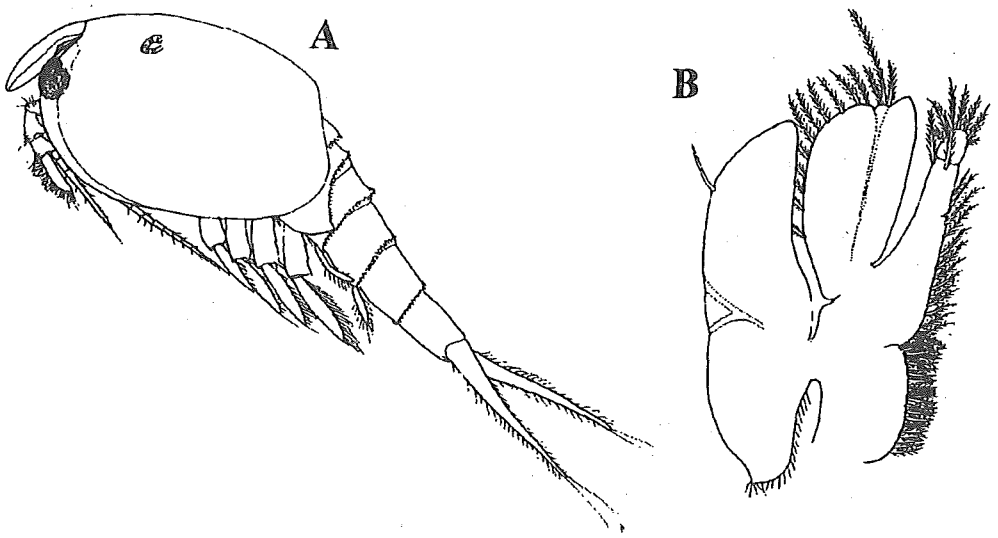

Fig.5. *Nebalia dahli* Kazmi & Tirmizi. A,animal in lateral view;B,first thoracopod.
(after Kazmi & Tirmizi, 1989)

A single species: *Nebalia dahli* Kazmi & Tirmizi, 1989.
Reference in Pakistan: Kazmi & Tirmizi, 1989;1992.
Supplemental Reference: Pillai, 1959.

Abdomen of 6-somites (may be reduced). Telson without furcal rami. Carapace without adductor muscle. Thoracic limbs mostly pediform, posterior thoracic limbs with 3-segmented protopods.....Subclass Hoplocarida Calman, 1904

Second thoracic appendage enlarged and folded on itself to form a large raptorial claw as in praying mantis. Female without brood pouch. With only 1 order.....Order Stomatopoda Latreille, 1817

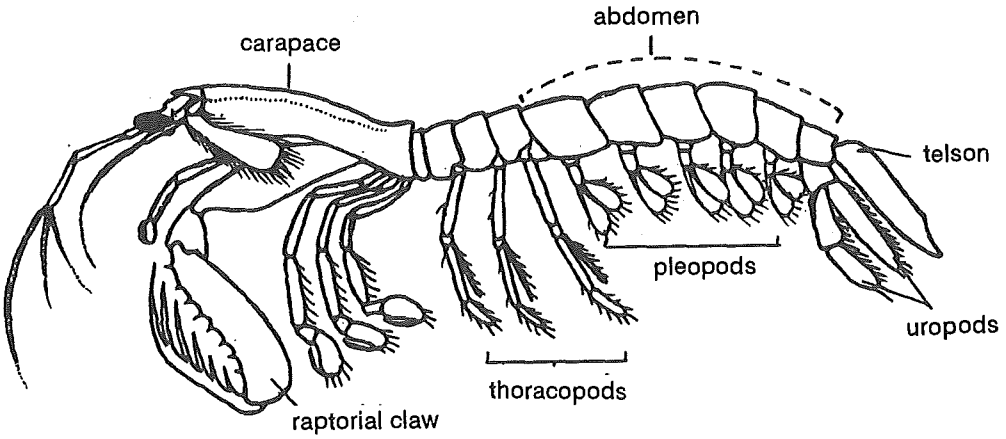

Fig.6. Schematic diagram of a stomatopod
(after Tirmizi & Manning, 1968)

Mantis shrimps, split thumbs, marine or brackish water, live in burrows preferring reefs, some species usually aggressive. Some species actively forage in daytime; others rarely leave the burrow, all appear to be predators.

References in Pakistan: Tirmizi & Manning, 1968;Tirmizi & Kazmi, 1980,1981.
Supplemental References: Manning, 1978; Manning & Bruce, 1989.

Abdomen 6-segmented (may be reduced). Telson without movable furcal rami. Carapace without adductor muscle. Thoracic limbs mostly pediform; protopods 2-segmented.....Subclass Eumalacostraca Grobben, 1892

Four superorders: Syncarida, Pancarida, Peracarida and Eucarida; only the last two occur in the northern Arabian Sea.....2

Carapace does not fuse with more than 4 thoracic somites. Oostegites present.....
.....Superorder Peracarida Calman, 1904

Six orders: Amphipoda, Isopoda, Tanaidacea, Cumacea and Mysidacea (all

except Mictacea occur in the area studied).....3

- Carapace fused with all the thoracic somites. Oostegites absent..... .....Superorder Eucarida Calman, 1904

Three orders: Euphausiacea, Decapoda and Amphionidacea, first two occur in the northern Arabian Sea.....6

3. Carapace essentially lacking, leaving thoracic somites exposed. Uropods variable 4

Carapace present, covering some or all thoracic somites. Uropods always terminal and elongated.....5

4. Body laterally compressed, slightly arched. Thorax of 7 somites (peraeon), each segment bearing a pair of uniramous appendages, coxae bearing side-plates. Appendages on 1st thoracic somite modified as maxillipeds, those on thoracic somites 2 and 3 often subchelate, modified for grasping (gnathopods). Abdomen 6-segmented (pleon); abdominal somites 1-3 with large pleopods, last 3 somites bear uropods, pleotelson absent. Gills at the inner base of pereiopods..... .....Order Amphipoda Latreille, 1816

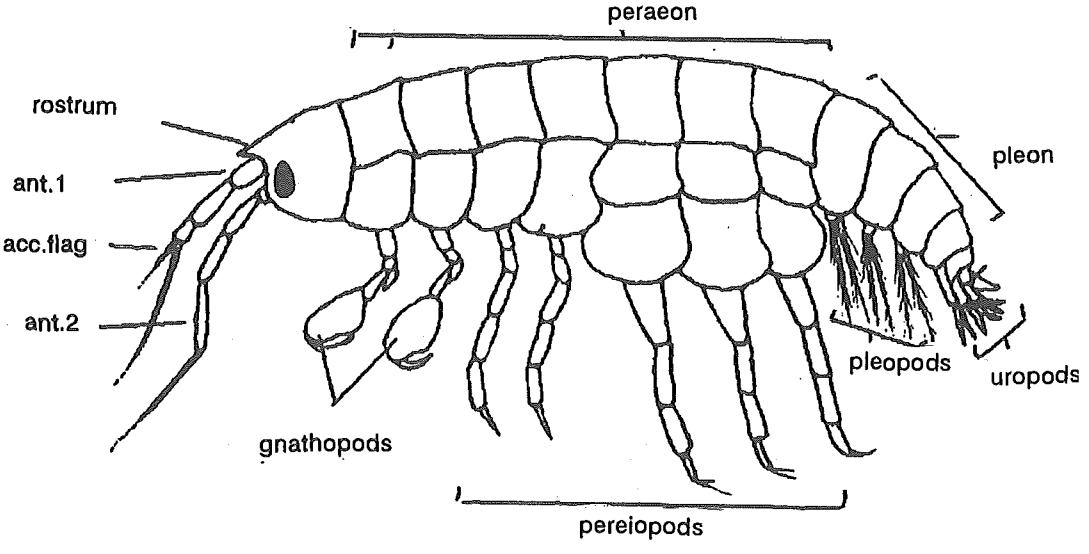

Fig.7. Schematic diagram of an amphipod.

Beachfleas, sandhoppers, skeleton shrimps. Most abundant group of marine animals inhabiting rocky and sandy bottoms, side-swimmers, body colour cryptic; commensas; highly modified as scavengers, filter feeders, detritus feeders.

References in Pakistan: Ahmed, 1976; Javed, 1983.
Supplemental References: Pillai, 1966; Nair, 1973.

Body cylinderical or depressed dorsoventrally. Thorax of 7 somites (peraeon), each somite bearing a pair of uniramous appendages, coxae bearing side plates; 1st pair of thoracic appendages not modified as maxillipeds, often subchelate, remaining thoracic appendages similar in structure. Abdomen of 6 somites (pleon), 6th somite and often preceding ones fused to telson forming pleotelson. Pleon bears 5 pairs of pleopods and 1 pair of uropods. Gills on pleopods.....
.....Order Isopoda Latreille, 1816

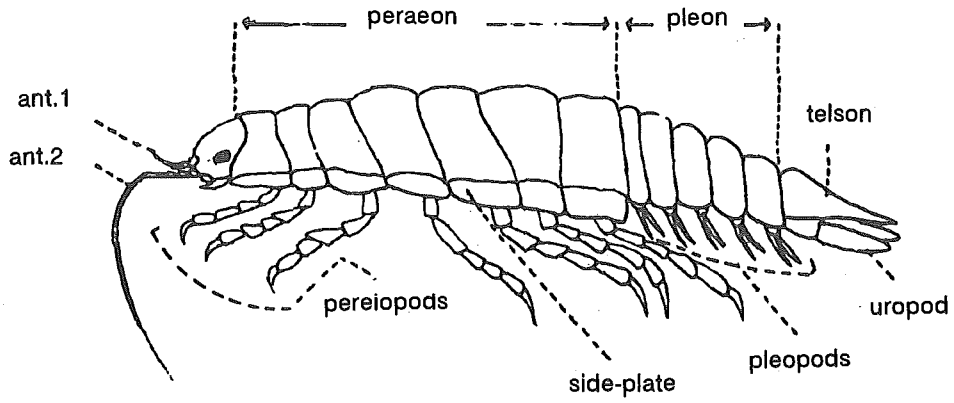

Fig.8. Schematic diagram of an isopod.
(after Day, 1974)

Sowbugs, whalelice, fishlice, pillbugs, occuring at all depths, gripping to rocks and weeds, some live in burrows; herbivorous, omnivorous, scavengers or parasitic.

References in Pakistan: Javed & *et al,* 1987,1988,1989.
Supplemental References: Pillai, 1966; Kensley, 1980; Negoescu, 1980.

5. Carapace tiny, containing small gill chambers fused to 2 anterior thoracic somites. Abdomen short, somites crowded. Eyes absent or present on short,

immovable stalks. Antennae usually with a small scale. Exopod on thoracic legs reduced or missing. One maxilliped, with epipod creating respiratory currents. Telson fused to last abdominal somite. Uropods filiform.....
.....Order Tanaidacea Hansen, 1895

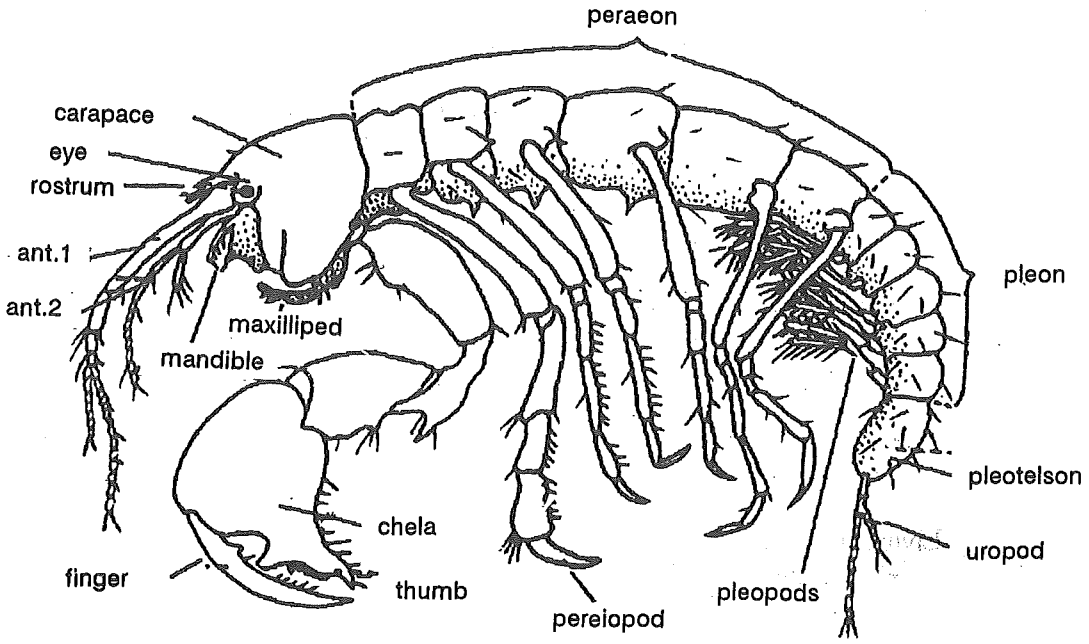

Fig.9. Schematic diagram of a tanaid
(after Day, 1974)

Small, swim occasionally, in general scurry over soft substrates where they can bury rapidly, may hide, among plants or sedentary animals, some spin mucus tubes in the sediment; never occur in large numbers; filter feeders, detritus feeders, also ingest small invertebrates. Sex reversal in some species.

References in Pakistan: Kazmi & Siddiqui, 1992.

Supplemental References: Bacescu, 1978; 1980.

Carapace inflated, covering the first 3 to 4 thoracic somites and a slender abdomen; eyes sessile, when present; antennae without exopods, vestigial in fe males; 3 pairs of maxillipeds, the most anterior with a gill-bearing exopod; natatory setae on some thoracic legs; thoracic legs raptorial or prehensile; 2 to 5 pleopods in males, usually missing in females, uropods filiform, not forming a tail fan.....Order Cumacea Kroyer, 1846

Female. Second antenna rudimentary; pleopod absent.

Male, adult. Second antenna developed, with long flagellum; Pleopods present except in Nannastacidae. More thoracic exopods except in Bodotriidae. Shape and sculpturing of carapace frequently different from female. Immature male resembles female but second antenna shows increasing segmentation with age.

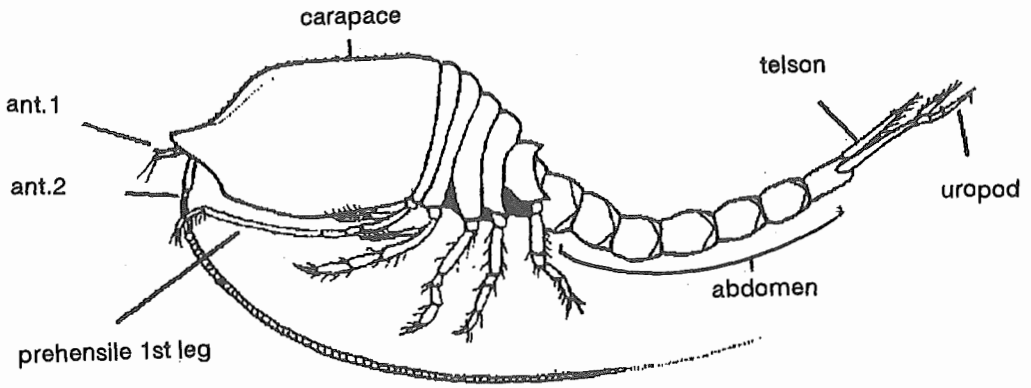

Fig.10. Schematic diagram of a cumacean.
(after Day, 1974)

Living in sandy-mud, feed on organic detritus, may be filter feeders or predaceous, rise at night, caught in plankton nets in shallow coastal waters.

References in Pakistan: Khan & Khan, 1975.
Supplemental References: Kurian, 1973.

Carapace transparent covering most of the thorax; eyes stalked or absent; 1st thoracic and sometimes the 2nd thoracic appendages modified as maxillipeds; remaining thoracic appendages with natatory setae; pleopods often reduced; uropods on last abdominal somite which, with the telson, form a tail-fan.....
.....**Order Mysidacea Boas, 1883**

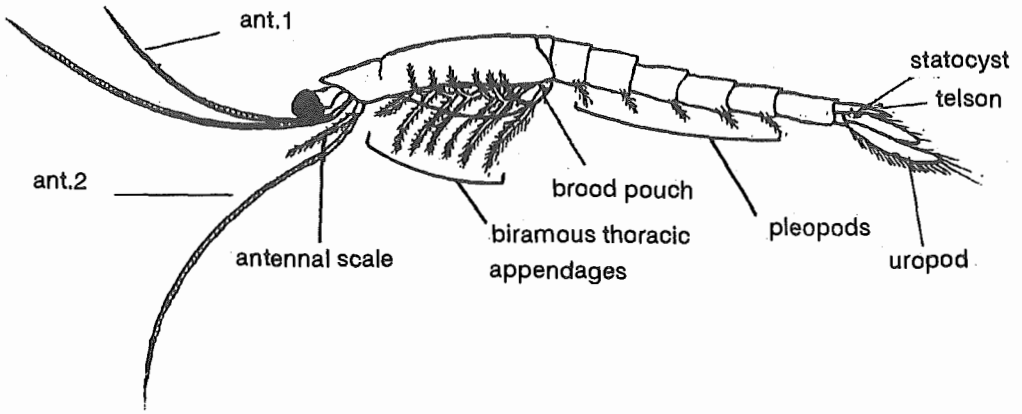

Fig.11. Schematic diagram of a mysidacean.
(after Day, 1974)

Opposum shrimps, live among weeds and mud, detritus feeders, scavengers as well, many mysids shoal, swarm, and school. A number of species perform diurnal vertical migration.

References in Pakistan: Rafi, 1988 (thesis); Kazmi *et al.*, 1992
Supplemental References: Pillai, 1965.

6. Maxillae with large exopods (scaphognathites). With 3 pairs of maxillipeds. Pereiopods uniramous. Usually with a statocyst in base of antennule..... .....Order Decapoda Latreille, 1803

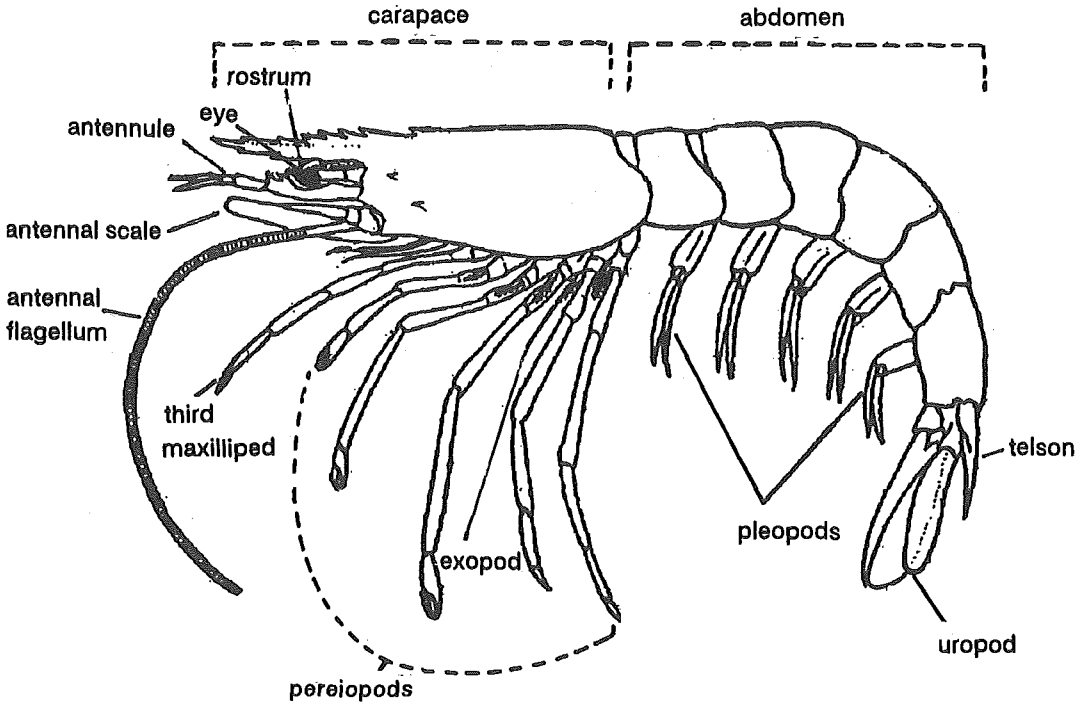

Fig.12. Schematic diagram of a generalized decapod.
(after Kunju, 1978)

Crabs, prawns, lobsters, lobsteretts, ghost shrimps; appearance diversified, complex behaviour displayed by some species, such as precopulatory courtship, invitation of fishes for cleaning etc. Most species omnivorous feeders, many species plankton or detritus feeders.

References in Pakistan: Tirmizi, 1962, 1967, 1968, 1972, 1974. Tirmizi & Javed, 1976. Tirmizi & Kazmi, 1969, 1980, 1981, 1984. Tirmizi, Siddiqui & Yaqoob, 1981, 1988. Tirmizi & Ghani, 1978, 1982, 1986, 1988. Tirmizi & Aziz, 1988. Kazmi *et al.*, 1990, 1991.
Supplemental References: Chhapgar, 1955, 1957, Kunju, 1966, Hogarth, 1989, Holthuis, 1986.

Small exopods on maxillae. No maxillipeds. Pereiopods with exopods. No statocyst.....Order Euphausiacea Dana, 1852

Krill, mostly filter feeders, only a few are predators. Many euphausids live in enormous swarms, undergo vertical migration, approaching the surface at night time. Luminescence due to photophores. Economically important.

References in Pakistan: Khan, 1986; Fatima 1983
Supplemental References: Brinton, 1975.

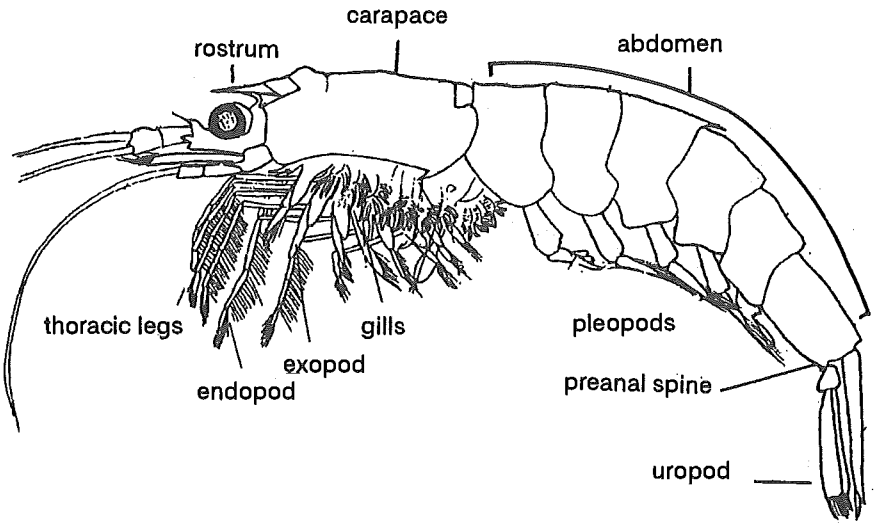

Fig.13. Schematic diagram of a euphausiid.
(after Brinton, 1975)

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REFERENCES

Abele, L.G. and B.E. Felgenhauer. 1986. Phylogenetic and phenetic relationships among the lower Decapoda. *Journal of Crustacean Biology* 6: 385-400.

Ahmed, J. 1976. On some amphipods of Karachi coast. *Record Zoological Survey of Pakistan* 8: 27-36, figs.1-12.

Alcock, A. 1895. Materials for a carcinological fauna of India. No.1. The Brachyura Oxyrhyncha. *Reprinted from Journal of Asiatic Society,* Bengal, LXIV(II) No.2:157-291, pl.III-V.

Alcock, A. 1896. Materials for a carcinological fauna of India. No.2. The Brachyura Oxystomata. *Reprinted from Journal of Asiatic Society,* Bengal, LXV(II) No.2:134-296, pl.VI-VIII.

Alcock, A. 1899. Materials for a carcinological fauna of India. No.5 The Brachyura, Primigenia or Dromiacea. *Reprinted from Journal of Asiatic Society,* Bengal, LXVIII(II) No.3:123-169.

Alcock, A. 1900. Materials for a carcinological fauna of India. No.6. The Brachyura Catometopa or Grapsoidea. *Reprinted from Journal of Asiatic Society,* Bengal, Calcutta. LXIX(II) No.3:279-456.

Alcock, A. 1901. Catalogue of the Indian Decapod Crustacea in the collection of the Indian Museum. *Part I. Brachyura, Primigenia. Fasc.* 1. Introduction and Dromides or Dromiacea. Calcutta: 1-80.

Bacescu, M. 1978. Contribution to the knowledge of Monokonophora (Crustacea: *Tanaidacea*) from the NW of the Indian Ocean. *Memoir Sect. Sti. Academy,* Romania. Ser IV.I:197-220.

Bacescu, M. 1980. Contributions to the knowledge of some Kalliapseudidae (Crustacea, *Tanaidacea*) from the NW of the Indian Ocean. *Travaux du Muzeul de Istorie naturala <<Grigore Antipa>>*, Vol.XXII:359-379.

Barth, H.W., R.E. Broshears. 1982. Arthropod diversity: The Crustaceans. *In: The Invertebrate World.* Holt-Saunders. Pp.1-646.

Bowman, T.E. and L.G. Abele. 1982. Classification of the recent Crustacea. *The biology of Crustacea* vol.1, Academic Press Inc.: 1-27.

Briggs, J.C. 1974. *Marine Zoogeography.* McGraw Hill Book Company. Pp.1-475.

Brinton, E. 1975. Euphausiids of southeast Asian Waters. *Naga Report* 4(5):1-287.

Chhapgar, B.F. 1955. Sea species of Crabs. *Zoological Survey of India*:257.

Chhapgar, B.F. 1957. On the marine crabs (Decapoda:Brachyura) of Bombay State. I & II. *Journal Bombay Natural History* 54(2):399-439.

Day, J.H. 1974. *A guide to marine life on south African shores.* A.A. Balkema. Pp.1-300.

De Saint-Laurent, M. 1980a. Sur la classification et la phylogenie des Crustaces Decapodes Brachyoures. I. Podotremata Guinot, 1977, et Eubrachyura sect. nov. *Comptes Rendus Hebdomadaires des Seances Academie des Sciences* Ser. D. 290: 1265-1268.

De Saint-Laurent, M. 1980b. Sur la classification et la phylogenie des Crustaces Decapodes Brachyoures. II. Heterotremata et Thoracotrmata Guinot, 1977. *Comptes Rendus Hebdomadaires des Seances Academie des Sciences* Ser. D. 290: 1317-1320.

Fatima, M. 1983. Occurrence and relative abundance of Euphausiids from the northern Arabian Sea. *Karachi University Journal of Science* 11(2):207-213.

Glaessner, M.F. 1969. Decapoda. In "Treatise on Ibvertebrate Paleonotolgoy" (R.C. Moore, ed.), Part R, Arthropoda 4, Vol.II, pp.R400-R533. *Geol. Soc. Am., Boulder, Colorado, and the Univ. of Kansas Press, Lawrence.*

Guinot, D. 1977. Propositions pour une nouvelle classification des Crustaces Decapodes Brachyoures. *Comptes Rendus Hebdomadaires des Seances Academie des Sciences*, Ser. D. 285: 1049-1052.

Henderson, J.R. 1893. A contribution to Indian carcinology. *Transactions Linnean Society, London, Zoology* 5: 325-458.

Hogarth, P.J. 1989. The marine crustacea of Dhofar, Southern Oman. *The Journal of Oman Studies* 10: 99-129.

Holthuis, L.B. 1986. Some Pontoniinae (Crustacea: Decapoda: Palaemonidae) from Southern Oman. *Zoologische Mededelingen* 60/17: 263-272.

Javed, W. 1983. A description of *Cymadusa filosa* Savigny, 1816 (Gammaridea, Amphipoda) and its occurrence in the northern Arabian Sea. *Biologia* 29: 177-183.

Javed, W. and R. Ahmed. 1987. On the occurrence of *Paradella dianae* (Menzies, 1962), a genus and species of Sphaeromatidae (Isopoda, Flabellifera) in the Arabian Sea. *Crustaceana* 53(2):215-217.

Javed, W. and R. Ahmed. 1988. Two new species of the genus *Dynamenella* from the Northern Arabian

Sea (Isopoda). *Crustaceana* 55(3):234-241.

Javed, W. and R. Yasmeen. 1989. *Atarbolana setosa*, a new cirolanid Isopod from the Northern Arabian Sea. *Crustaceana* 56(1): 78-82.

Kazmi, Q.B. & M.A. Kazmi. 1973. Fresh record of *Processa edulis carassipes* Nouvel & Holthuis (Caridea, Processidae) from the Indian Ocean. *Journal of Science Faculty, University of Karachi* 3: 51-54.

Kazmi, Q.B. & F.A. Siddiqui. 1992. Note on an anomolous tanaid: *Leptochelia* sp. (Crustacea, Tanaidacea) collected from Manora channel (northern Arabian Sea). *Pakistan Journal of Marine Sciences* 1:65-67.

Kazmi, Q.B. & N.M. Tirmizi. 1989. A new species of *Nebalia* from Pakistan (Leptostraca). *Crustaceana* 56: 293-298.

Kazmi, Q.B. & N.M. Tirmizi. 1990. Report of three leucosids from Pakistan (Decapoda: Brachyura: Leucosiidae). *Crustaceana* 58(1): 17-26, figs.3.

Kazmi, Q.B. & N.M. Tirmizi. 1992. Note on additional material of *Nebalia dahli* Kazmi & Tirmizi, 1989 (Leptostraca: Crustacea) from Karachi (northern Arabian Sea). *Pakistan Journal of Marine Sciences* 1(2): 141-142.

Kazmi, Q.B., N.M. Tirmizi & N. Ghani. 1992. New records of four species of mysids (Crustacea) from coastal waters of the northern Arabian Sea. *Raffles Bulletin of Zoology* 40(1): 27-32.

Kazmi, Q.B., N.M. Tirmizi and M.A. Kazmi. 1991. Contribution to the knowledge of *Synalpheus thai* Banner & Banner (Decapoda, Caridea, Alpheidae) from the Arabian Sea. *Crustaceana* 60:322-324.

Kensley, B. 1980. Anthuridean Isopod Crustaceans from the International Indian Ocean Expedition, 1960-65, in the Smithsonian Collections. *Smithsonian Contributions to Zoology*, 304 :1-37.

Khan, M.A. and M.F. Khan. 1975. Cumacea from Manora channel. *Agriculture Pakistan*, Vol.XXVI, No.4 :533-538

Kim, W. & L.B. Abele. 1990. Molecular phylogeny of selected decapod crustaceans based on 185 RNA nucleotide sequences. *Journal of Crustacean Biology* 10(1): 1-9.

Kunju, M.M. 1966. Observations on the prawn fishery of Mahrashtra coast. In: *Proceedings Symposium on Crustaceans* II: 1392-1397.

Kunju, M.M. 1978. Taxonomy and distribution of cultivable prawn. Central Marine Fisheries Research Institute. Special Publication 3. Pp.1-128.

Kurian, C.V. 1973. Cumacean of the Indian Ocean. *The Biology of the Indian Ocean 3*, Springer-Verlag, New York: 329-330.

Lovette, D.L. 1981. A guide to the shrimps, prawns, lobsters and crabs of Malaysia and Singapore. Faculty of Fisheries. *Marine Sciences Pertanian Malaysia*. Occasional Publications 2:1-155.

Manning, R.B. 1978. Further observations on *Oratosquilla*, with accounts of two new genera and nine new species (Crustacea: Stomatopoda: Squillidae). *Smithsonian Contributions to Zoology* 272: 1-44.

Manning, R.B. and A.J. Bruce. 1984. *Erythrosquilla megalops*, A remarkable new stomatopod from the western Indian Ocean. *Journal of Crustacean Biology* 4: 329-332.

Manton, S.M. 1977. *"Arthropoda: Habits, Functional Morphology and Evolution"*. Oxford University Press (Clarendon), London and New York.

McLaughlin, P.A. 1980. *Comparative morphology of recent Crustacea.* W.H. Freeman and Company, San Francisco. Pp.1-177.

Meglitsch, P.A. 1972. *Invertebrate Zoology.* Oxford University Press. Second Edition. Pp.1-834.

Meglitsch, P.A. & F.R. Schram. 1991. *Invertebrate Zoology.* Oxford University Press. Pp.1-623.

Moore, R.C. and L. McCormick. 1969. General features of Crustacea. In "Treatise on invertebrate Paleontology" (R.C. Moore, Ed.), Part R. *Arthropoda* 4, Vol.1, pp.R57-R120. Geol. Soc. Am., Boulder, Colorado and University of Kansas Press, Lawrence.

Nair, K.K. 1973. Distribution and abundance of planktonic amphipods in the Indian Ocean. In. Bernt

Zeitzschel, ed. *The Biology of Indian Ocean, New York.* Springer-Verlag :349-356.

Negosecu, I. 1980. Littoral Anthuridean Isopods (Isopoda, Anthuridea) from the North-Western Indian Ocean. *Extrait des < <Travaux du Museum d'Histoire naturelle Grigore Antipa> >*, Vol.XXII :401-420.

Pillai, N.K. 1959. On the occurrence of *Nebalia longicornis* in Indian waters. *Journal Bombay natural History Society* 56: 351-353.

Pillai, N.K. 1965. A review of the work on the shallow water Mysidacea of the Indian wates. Proceeding of Symposium on Crustaceans. *Marine Biological Association of India* 5: 1681-1728.

Pillai, N.K. 1966a. Pelagic amphipods in the collections of the Central Marine Fisheries Research Institute, India Part I. Family Oxycephalidae. Proceedings Symposium on Crustacea, Part I. *Marine Biological Association of India.* Pp.169-204.

Pillai, N.K. 1966b. Littoral and parasitic isopods from Kerala: Family Anthuridae I. *Journal of the Bombay Natural History Society* 63: 152-161.

Rafi, S. 1988. *Taxonomy and distribution of mysids in the northern Arabian Sea,* (Unpublished). Pp.1-176.

Rao, K. 1969. The legal regime of the sea bed and the ocean flour, 9. *Indian Journal of International Law*:1.

Schram, F.R. 1982. The fossil record and evolution of crustacean. In: D.E. Bliss (ed.): *The Biology of Crustacea* Vol.1, Academic Press :93-147.

Starobogatov, Ya. I. 1988. Systematics of Crustacea (translated by M.J. Grygier). *Journal of Crustacean Biology* 8: 300-311.

Tirmizi, N.M. 1962. A new record for *Metapenaeus stebbingi* Nobili from Pakistan. *Crustaceana* 4: 103-106.

Tirmizi, N.M. 1967. On the occurrence of *Callianassa (Callichirus) audax* De Man off West Pakistan (Decapoda, Thalassinidea). *Crustaceana* 13(2): 151-154, figs.1-2.

Tirmizi, N.M. 1968. *Parapenaeopsis hardwickii* (Miers) from the Arabian Sea. (Decapoda, Penaeidea). *Crustaceana* 15(2): 137-140. Figs.1-2.

Tirmizi, N.M. 1972. An illustrated key to the identification of northern Arabian Sea penaeids. *Pakistan Journal of Zoology* 4(2): 185-211, figs.1-21.

Tirmizi, N.M. 1974. A description of *Callianassa martensi* Miers, 1884 (Decapoda, Thalassinidea) and its occurrence in the northern Arabian Sea. *Crustaceana* 26(3): 286-292, figs.1-4.

Tirmizi, N.M. & N. Aziz. 1988. Rediscovery of *Sergestes verpus* Burkenroad, 1940 (Sergestidae, Crustacea), from the Indian Ocean with description of the female. *Journal of Natural History* 22: 199-207.

Tirmizi, N.M. & N. Ghani. 1978. *Upogebia quddusiae* n.sp. from Pakistan (Decapoda, & Thalassinidea). *Crustaceana* 35: 134-138.

Tirmizi, N.M. & N. Ghani. 1982. New distributional records for three species of *Acetes* (Decapoda, Sergestidae). *Crustaceana* 42: 44-53.

Tirmizi, N.M. & N. Ghani. 1986. Range extension of a rare pilumnid crab into the northern Arabian Sea. *Crustaceana* 51: 293-295.

Tirmizi, N.M. & N. Ghani. 1988. The rediscovery of *Macrophthalmus laevis* A. Milne Edwards, 1867 in the Arabian Sea (Decapoda: Brachyura). *Crustaceana* 55: 253-256.

Tirmizi, N.M. & W. Javed. 1976. A new species of *Munida* from the Indian Ocean with a redescription of a syntype of *Munida spinulifera* Miers, 1884, (Decapoda, Galatheidae). *Crustaceana* 31(1): 81-89, figs.4.

Tirmizi, N.M. and M.A. Kazmi. 1969. The occurrence of *Alpheus inopinatus* Holthuis & Gottlieb, 1958, in the Arabian Sea (Decapoda, Alpheidae). *Crustaceana* 16: 99-100.

Tirmizi, N.M. and Q.B. Kazmi. 1980. A new species of *Mesacturoides* from Karachi waters with notes on its first larva (Stomatopoda: Gonodactylidae). *Crustaceana* 38: 61-66.

Tirmizi, N.M. and Q.B. Kazmi. 1981. An illustrated key to the identification of northern Arabian Sea stomatopods. *Paksitan Journal of Zoology* 13(1 & 2): 237-260, figs.

Tirmizi, N.M. and Q.B. Kazmi. 1984. A northern record for *Hipplyte ventricosa* H. Milne-Edwards, 1837 with a note on *Palaemon pacificus* (Stimpson, 1860) (Decapoda: Caridea). *Crustaceana* 46: 313-317.

Tirmizi, N.M. and R.B. Manning. 1968. Stomatopod Crustacea from West Pakistan. *Proceeding U.S. National Museum*. 125(3666):1-48, figs.1-17.

Tirmizi, N.M. and R. Serene. 1971. The rediscovery of two species of crabs (Decapoda, Brachyura) with observations on three other species from Pakistan. *Crustaceana* 21(1): 21-32, figs.1-4, pl.2.

Tirmizi, N.M. and F.A. Siddiqui. 1982. *The marine fauna of Pakistan: 1.* Hermit crabs (Crustacea, Anomura). University Grants Commission: 1-103.

Tirmizi, N.M., M.M. Yaqoob and F.A. Siddiqui. 1982. *The marine fauna of Pakistan 3.* Porcellanid crabs (Crustacea, Anomura). Centre of Excellence in Marine Biology, Publication 5. Pp.1-116.

Zarenkov, N.A. 1982. Chlenistonogiye: obshchiye svedeniya, rakoobrazniye. Bol'shoy praktikum po zoologii bespozvonochnykh (materialy k lektsiyam), ch. [Arthropoda: general review, Crustacea. *Grand curriculum on the zoology of invertebrates (Iecture materials), part.1]*, pp. 1-194.-Izdatel'stvo Moskovskogo Universiteta, Moscow. [In Russian].