



Taxonomy, Systematics, and Host Associations of Parasitic Copepods Infecting Marine Fishes of the Bay of Bengal off Visakhapatnam, Andhra Pradesh, India

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Abstract:

The taxonomy and systematics of parasitic copepods remain essential for understanding host–parasite relationships, biodiversity, parasite evolution, and biogeographical distribution. Integrative taxonomic approaches combining detailed morphological investigations with molecular phylogenetic analyses have significantly improved species delimitation and clarified evolutionary relationships within several copepod lineages. Nevertheless, many regions of the Indo-Pacific, including the Bay of Bengal along the east coast of India, remain inadequately explored, and numerous copepod taxa associated with marine fishes are yet to be documented.

The Visakhapatnam coast, situated along the western Bay of Bengal, supports a rich diversity of marine fishes that provide suitable hosts for numerous parasitic copepods. Despite its ecological and fisheries importance, comprehensive taxonomic investigations of parasitic copepods from this region remain limited. Therefore, systematic studies integrating classical morphology with contemporary taxonomic concepts are essential for documenting copepod diversity, host associations, geographical distribution, and their potential impact on marine fish health and fisheries resources.

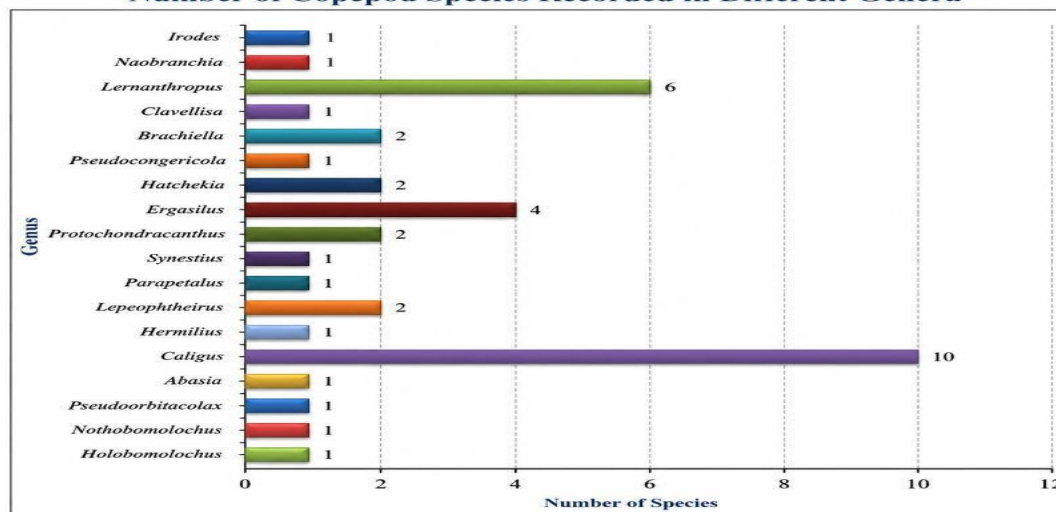
Key words: Copepods, Classical morphology, Geographical distribution, Bay of Bengal, Molecular phylogenetic analyses, Visakhapatnam

Introduction

A good amount of work is available in India but not upto mark. Now-a-days systematic studies of copepod parasites gained importance and research on these lines is intensifying. Fish parasites, pathology and host parasite interactions are of interesting areas of research for parasitologists. Parasitic copepods are common on cultured and wild marine fish and there is a substantive literature describing their Taxonomy, life cycles and host ranges. Many of these species long been recognized to have the potential to affect the growth, fecundity and survival of wild hosts (White 1940, Kabata1958, Hewitt 1971, Neilson et al 1987, Albrecht, W. S. (2014).

Cressey (1991) worked with on parasitic copepods from the Gulf of Maxico and Caribbean Sea and revised the circum global genus *Caligus*. Most of the collections reported were collected from the west coast of Florida and Carrie Bow Cay, Belize, Bunkley- Williams and Williams (1994,1996), reported *Caligus iritans* in *L. griseus* from Cabo Rojo, Puerto Rico, and made additional host records for the Caribbean. Williams and Bunkley- Williams (1996) reported *Caligus bonito* on *Lutjanus griseus* and *Lutjanus jocu* from Puerto Rico.

Number of Copepod Species Recorded in Different Genera



Materials and Methods: Collection

Copepod Parasites are ecto and endoparasites of both elasmobranch and teleost fishes. Copepods are parasitic on almost every kind of surface-living and shallow-water fish. They are Comparatively few in mid- water fishes and very rare in deep-fishes. This is because of the possibility of infection by the free-swimming larvae is greatest in the shallow sunlit waters.



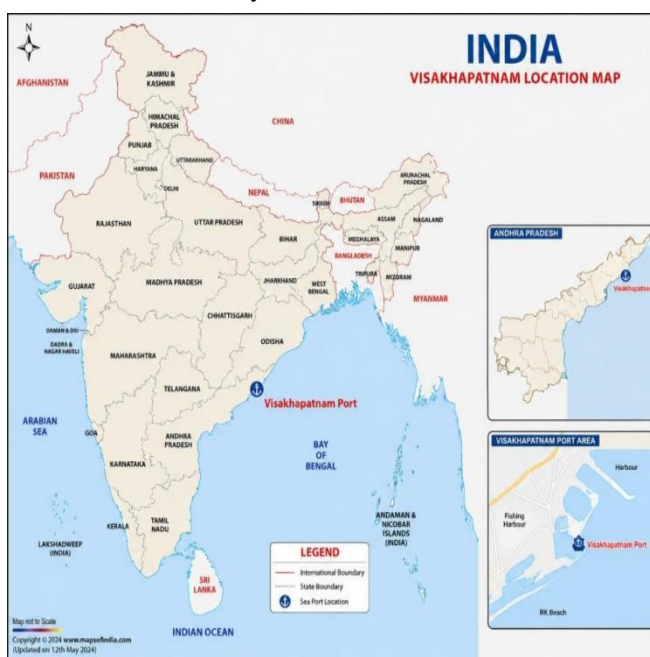
Rastrelliger sp. Examined for copepod parasites

Euthynnus sp. examined for copepod parasites

In the present study fishes were obtained from offshore fishing station, local fish market and Visakhapatnam port. The present study was concentrated mainly on the most valuable marine food fishes, belong to the family Scombridae, like Scomberomorus, Euthynnus, Rastralliger, Sardinella. Some other fishes like Saurida tumbil, Caranx chysophrys, Caranx sausum, Mugil cephalus, Trachinocephalus myops, (Bloch and Schneider) Trichiurus lepturus, Muraenesox talabonoides(Bleeker), Priacanthus hamrur(porskal), Johnius aneus (Bloch) were also ex amined for the parasites.

Copepod parasites inhabit various regions of the body of the fishes. They were collected from gill chamber-quite often present in good numbers on the inner surface of the opercle and gill rachers, nasal cavities, spiracles, cavities of eye-balls, fins, body surface. But Lernaecocerids remain deeply buried in the body of the host with the help of the bulla. The bulla has taxonomic valve and should be kept intact. Bomolochids and taeniocanthids are comparatively small and have to be carefully searched for. The opaque egg sacs reveal the presence of females but males are quite invisible because of their transparency.

Flushing the opercular chamber by squirting water with a dropper would wash out the and dirt can be easily picked up. Bomolochids are known to live in the nasal cavities and the cavities of eye-balls and adipose eye-lids of fishes. They were removed carefully with the help of a brush and fine needles, forceps micro pippets can be used and placed in saline solution. All this work can be done at in the field and large fish cannot be taken to the laboratory and gills, fins, head region can be taken. Gill filaments were carefully teased and the contents were examined under a binocular microscope.\



showing Study Area - Visakhapatnam



Visakhapatnam -off shore fishing station

Lernanthropus occurs firmly attached to the host. As they can be seen with the naked eye they were removed very carefully from the gills. Most of the parasites covered with mucous. Mucous was washed out with the help of pipette by flushing with saline solution. As the parasites are slightly opaque, it is difficult to examine the parasite, so cleaning is necessary

***Scomberomorus* sp. Examined for copepod parasites**



Caligids are very common on the body surface, inner surface of the opercle, on the gill arches and in the buccal cavity of all kinds of fishes. Parasites will remain even after the death of the host. But those on the body surface may drop off or get rubbed off while the hosts are handled. If possible, fishes should be examined soon after they are caught.

Preservation & Examination

Copepod parasites covered by mucus secreted by the host and all sorts of dirt. If the parasites are transferred directly to the preservative, the mucus would harden and stick on the parasite making its subsequent study difficult and very small specimens preserved like this may become useless.

After cleaning, the collected parasites were preserved in 80% ethanol or 10% formalin. Specimens were soaked with lactophenol or lactic acid for a half, to a whole day, lactic acid is being a good clearing fluid and it is not volatile, temporary mounts can be left over for subsequent examination. The only defect of lactic acid is that it destroys the internal tissues (Zhou C and Carotenuto Y, 2018).

As lactic acid mixes with formalin, after examining the parasites can be transferred again into formalin, then dissected and examined using the wooden slide method of Humes and Gooding (1964). For identification, one parasite, from each group has been dissected with zero-point needles and appendages were removed from it and diagrams were drawn with help of camera lucida. Scale given for one appendage is same to all appendages of the same species. Dorso- ventrally flattened copepods like *Caligus* can be adequately studied without dissecting.

Collection of Copepod parasites by dissecting the fish:

Morphology:

Copepods are abundant everywhere in the sunlit waters of the marine habitat.

Copepods (pron.: koupi'pɒd; meaning "oar-feet") since copepoda having a pair of swimming legs on the same somite that are moved together, like the oars of a sculling shell. They act as connecting link between the autotrophic organisms and the carnivores. Recent studies have revealed that copepods live in association with almost every group of metazoans. The subclass of Copepoda under the class Crustacean consists of 10 orders, of these Copepods parasitic on fishes belong to Cyclopoida, Caligoida and Lernaepodoida. Cyclopoids are least modified and lernaepodoids most modified. Caligoids occupy an intermediate position. Cyclopoids generally have a fully segmented body demarcated into a broad

fore- body and a narrow hind-body.

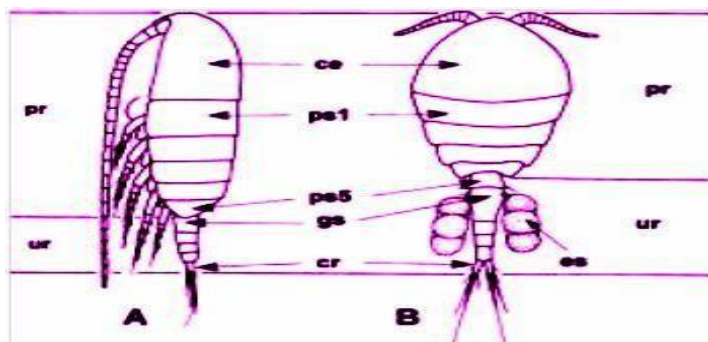


Figure Body plans in the Copepoda. A. Gymnoplean plan, showing division between prosome and urosome located posterior to the fifth leg-bearing somite. B. Podoplean plan, showing division between prosome and urosome located anterior to the fifth leg-bearing somite. Abbreviations: ce, cephalosome; cr, caudal rami; es, egg sac; gs, genital double-somite; pr, prosome; ps1–5, pedigrees somites 1 to 5; ur, urosome



Dissection of gills.



Gill infestation with copepods.



Fish Healthy

Observation and Identifications:

Caligus omissus, n.sp. Cressy and Cressy, 1980

Host: *Zonichthys nigrofasciata* (Rüppell, 1829)

Location: Body surface

Locality: Visakhapatnam Fishing Harbour, East Coast of Bay of Bengal, Visakhapatnam, India.

21 females were collected from about 65 fish examined

Family: Euryphoridae Subfamily: Tuxophorinae Genus: *Tuxophorus* Wilson. *Tuxophorus zonichthin* sp

Description:

Two females and only one male were collected from the body surface of *Zonichthya nigrofasciata* at Visakhapatnam coast.

Female:

Carapace ovate, rounded in front, with a short incision at the centre of anterior margin, and longer than broad with narrow posterior sinuses. The frontal plate distinct with lunules. Postero-median lobe slightly projecting beyond the lateral lobes. The membranous flange of the carapace is broad. Free thoracic segment with dorsal plates above, which have rounded lateral margins, and extend to the same width as the median lobe of carapace and overlap the bases of fourth pair of legs. The genital segment is narrow anteriorly and wide posteriorly. The fifth pair of legs arise from the postero-lateral parts of genital segment and reaches to the tip of abdomen. Abdomen clearly one segmented, as long as broad. Caudal rami longer than broad.

First antenna two segmented. Basal segment stout and broad with several plumose setae at its margin. Terminal segment stout and stumpy tipped with several setae. Second antenna has an adhesion pad on its basal segment which is very broad. The terminal segment is claw like with the spine setae. First maxilla in the form of triangular plate with flange. Second maxilla has a flange at its posterior border and its pulp with three spine setae of which the middle one is large.

First maxilliped long, two segmented. Basal segment stout. Terminal joint slender with two unequal curved distal spines, and in addition an outer lobe at the middle. Second maxilliped with a strong blunt process at its basal segment. The terminal claw long and curved with a spine on its inner side. Sternal fork with broad base and its branches are bifurcated. Basal segment of first leg with a plumose seta at its antero-distal corner. It has vestigial endopod at its posterior side. The

first segment of exopod has a spine at its antero-distal corner and with plumose posterior surface. The terminal segment with three plumose setae on its posterior margin and has four claws. First one stout without any accessory spine, whereas the remaining claws with accessory spines. All claws are plain without any armature.

The exopod of second leg with two strong winged claws and one very small winged claw. The first and second segment of endopod with several small spine setae. The claw on the third leg broad with outer flange. The spines arming the exopod are normal but the third spine on terminal segment of exopod is clearly bent to a side towards the setae. Fourth leg four segmented basal segment stout and is longer than three segments combined. The claws are very stout almost all subequal without any armature. Fifth leg represented in the form of a chitinous elongated process reaching the tip of the abdomen. It is broadest at the base and steadily narrows, and ends with two stout and subequal spines and carry two setae on either side. There is a seta arising from dorso-medial portion of the leg.

Total length of female: 4.00 mm.

Male:

Carapace is same as that of female but the remaining part is very small when compared with that of female. Two thirds of the body occupied by the carapace. One third by the genital segment and abdomen. The transverse dorsal rib is placed somewhat far back so that the cephalic area is larger than thoracic. The genital segment is broad anteriorly and narrow posteriorly. On either side it gives off two finger like projections which face downwards and carry fifth and sixth pairs of legs respectively.

Abdomen broader than long, caudal rami longer than broad. Due to insufficient number, a more detailed description could not be furnished.

Total length of male: 3.24 mm.

Fig. TUXOPHORUS ZONICHTHI (Female)

40I Maxilliped -2 40J Leg - 3

40K Sternal fork 40L Leg - 5

40M Leg - 4

40N T.zonichthi (male)

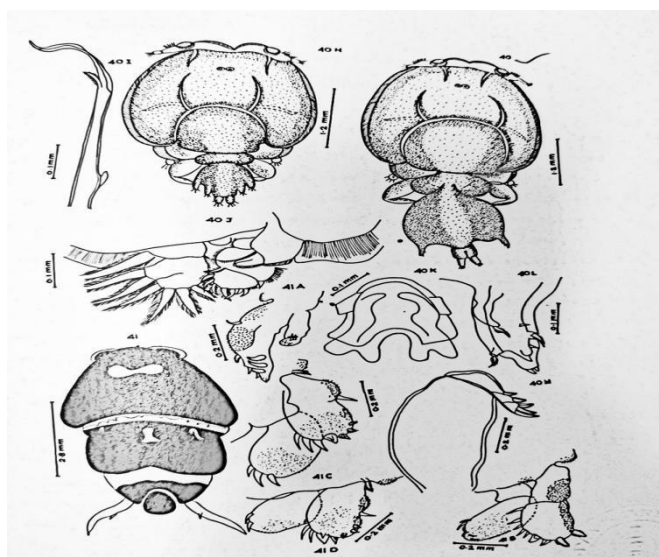
Fig. . PANDARUS NIGER (Female)

41A Leg - 1

41B Leg -2

41C Leg - 3

41D Leg - 4



Discussion:

The genus was first erected by Wilson (1908a). T. caligodes as a type species collected from the surface of Tylosurus marinus, Rachycentron canadus, etc. The following are the subsequent species.

T. wilsoni Kirtisinghe, (1937b)

T. cybii (Solandri) Nunes-Ruivo (1956)

T. tylosuri Rangnekar (1956)

T. cervicornis Heegaard (1962)

The present species closely resembles *T. wilsoni* and *T. caligodes* in general shape of body. It differs from the remaining three in having bifurcated branches of sternal fork. The dorsal plates are nearer to *T. caligodes* than to *T. wilsoni*. But in *T. caligodes* the abdomen is clearly two segmented as mentioned by Rangnekar (1963) WoRMS (2024). and Pillai (1961). But in the present species the abdomen is one segmented as mentioned by Pillai in *T. wilsoni*. According to the description given by Pillai (1961) the dorsal plates are produced backwards in *T. wilsoni* but not in *T. zonichthi*. The third spine on the terminal segment of exopod of third leg is bent to a side in the present species. This condition is not found in

any previously described species. The claws on the fourth leg blunt in the present species whereas they are somewhat pointed in *T. wilsoni* as well as *T. caligodes*. The present species is more nearer to *T. wilsoni* in having fifth pair of legs in the form of chitinous process. In *T. wilsoni* the fifth pair of legs extend beyond the tip of anal laminae, but in the present species they are reaching only the tip of the abdomen. They also differ in its armature from *T. wilsoni*.

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