Parasitic copepods in Carangid fishes from Manginapudi Coastal Waters Machilipatnam, A.P, India

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Abstract

Carangid**,** any fish of the family Carangidae (order Perciformes), which contains more than 200 species of marine fishes, including such well-known forms as the jacks and pompanos. Carangids are swift, predatory, usually silvery fishes found throughout the world in warm and tropical regions. They are primarily marine, but some live in brackish water or may invade fresh water.

The members of the family vary greatly in form, from elongated and streamlined to very deep-bodied and thin from side to side. In general, however, they bear the following features in common: two dorsal fins, the first of which may be reduced to a few small spines; anal and second dorsal fins usually high in front; first two anal spines separated from the third; pectoral fins slim and often sickle-shaped; tail base very slender; tail strong, either forked or crescent-shaped; scales small; and a lateral line (a series of small sense organs along the sides of the body) often partly or wholly covered with large, hard, keeled scales (scutes).

In the present study, 68 fishes were infested out of 544 specimens examined from six different species of Carangid fishes which were collected from Manginapudi coastal waters. Eight species of parasitic copepods were found on gill filaments, body surface and nasal capsule regions. The maximum prevalence was recorded in *Carangoides malabaricus* (22.5 %) and minimum was noticed in (2.4 %) *Selaroides leptolepis*. The intensity of infection ranged from 1 to 1.2. Thus, considerable variation in the respiratory area was observed owing to the attachment of parasites in the infected fishes. *Caligus sp. and C. epidemicus* parasites were attached to body surface and only one *Sphyriid sp*. parasites were found in nasal capsule region. It is very difficult to estimate the actual harm to fish caused by the presence of parasites; if this is uneasy in cultured fish, it is almost impossible in feral fish populations. It should also be emphasized that the presence of a parasite does not necessarily imply manifestation of a disease. In aquaculture, some parasites are able to reproduce rapidly and heavily infect a large proportion of fish which may lead to diseases with significant economic consequences.

Keywords

Carangoides, Copepod parasites, Mode of attachment, Respiratory surface area, Gill rack count, Manginapudi

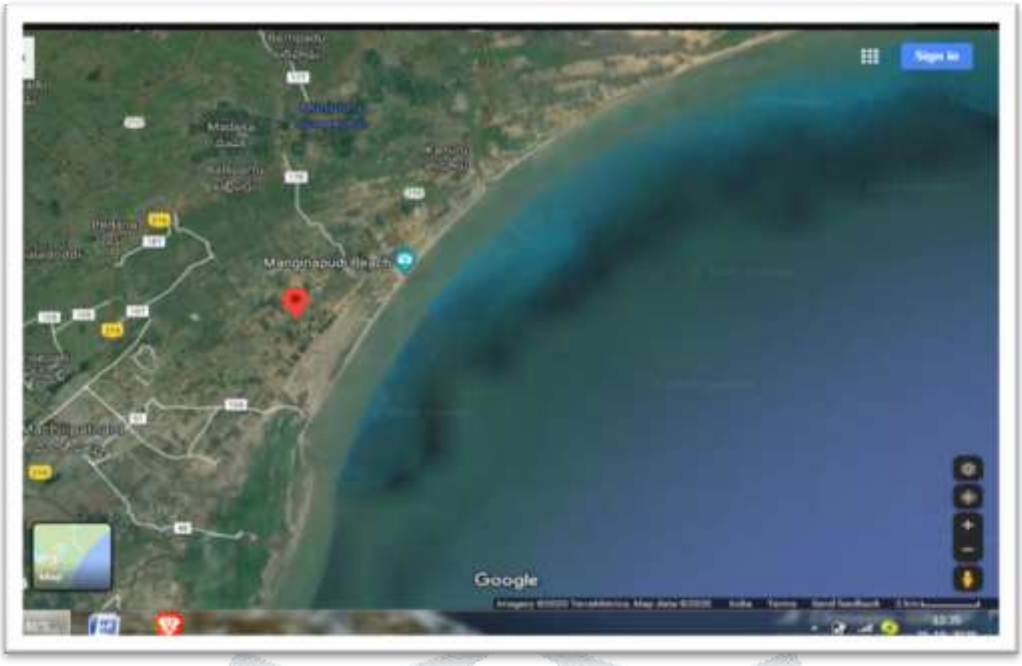
Introduction

Many of the carangids are small, but some grow to a large size. The greater amberjack (*Seriola dumerili*), for example, reaches a length and weight of about 1.8 m (6 feet) and 70 kg (150 pounds). The members of the family are known by various common names. There are the moonfish, pompano, pilot fish, runner, jack (*qq.v.*), and others. One of the most unusual-looking carangids is the lookdown (*Selene vomer*), with an exceptionally thin body and high "forehead." The first rays of the second dorsal fin extend into filaments that reach to the tail. Many of these fishes are valued for food or sport. Certain species, however, such as the greater amberjack and several jacks, may at times carry a toxic substance in their flesh and, when eaten, cause ciguatera, a form of poisoning.

Carangoides malabaricus

The diversity of parasitic copepods reported from deep mesopelagic and bathypelagic fish hosts is extremely low. Parasitic copepods are commonly found in cultured and wild marine fishes. In the aquaculture industry throughout the world, these parasitic copepods, particularly the family Caligidae, are important as pathogens causing heavy mortality or acting as disease inducers, by creating a portal for entry of bacterial or other pathogens (Johnson et al. 2004).

The gills are a favourite site for the attachment of several parasitic copepods. They damage the gills by feeding on the delicate tissue of the gill lamellae or on the blood circulating within the lamellae, leading to a loss of respiratory surface area (Lester and Hayward 2006). There is extensive gill damage and severe haemorrhage, with inflammation and exsanguinations associated with the attachment and feeding of the copepod (Lester and Hayward 2006). This, nowadays, has become a major problem in identification and treatment of parasites and diseases in the rapidly developing mariculture industry (Roza et al. 2002). More recently (Anil et al. 2019) recorded 16 species of parasitic copepods from the gill region of Sea bass in Manginapudi estuarine waters. But there is no detailed study on the infestation of copepod parasites in Carangid fishes of Manginapudi waters. The present study is the investigation on occurrence and infestation of copepod from Carangid species from Manginapudi coast.



Manginapudi Coast Coordinates: (16°13'34.3"N 81°12'15.8"E)

Materials and methods

During a routine observation of the Carangid fishery in the Manginapudi (16°13'34.3"N 81°12'15.8"E) an interesting incidence of parasitisation in Carangid fishes was observed. Fishes were thoroughly checked for parasitic infection in the body surface, fins, head, gill filaments, oral cavities and other tissue also examined. Each fish was examined microscopically for the presence of parasitic crustaceans based on a method described by (Kabata 1985; Anil et al. 2019). The collection and preservation methodology for crustacean parasites was followed by Pritchard and Kruse (1982). Copepod identification was based on morphological features according to Yamaguti (1963), Kabata (1979), Pillai (1985), Sirikanchana (2003), Ho and Kim (2004). Prevalence and mean intensity of each parasitic species were determined as in Margolis et al. (1982).

Respiratory surface area

The influence of infestation in respiratory surface area of the gill arch of infected and uninfected fish were carefully dissected out and blotted to remove the moisture. The imprint drawing of each gill arch on millimeter graph was used to calculate the surface area of the gill arch. The surface area of each tracing was determined by counting the number of small squares and the total area was obtained. The value was taken and doubled to consider the total functioning of the gill arch. The total surface area of the gill arch of both infected and uninfected fish was compared and then area was considered as reduction of respiratory area due to infestation.

Gill rack count

The average gill rack count of the 1st, 2nd and 3rd gill arch of infested fishes were taken. The data collected were tabulated and variation in the gill raker count as a function of infestation was recounted Results

Infestation of fishes

In the present study, 68 fishes were infested out of 544 specimens examined from six different species of Carangid fishes which were collected from Manganapudi coastal waters (Table 1). Eight species of parasitic copepods were found on gill filaments, body surface and nasal capsule regions. These eight species belong to three genera Bomolochidae, Caligidae and Sphyriidae. Caligus sp. (26) was found in highest number followed by *C. epidemicus* (17), *Holobomolochus chilensis* (13), *Parabomolochusbellones* (10) and *Bomolochus sp.* (8) which infested 23, 16,11, 7, 8 species of Carangid fishes respectively (Table 2). While *Nothobomolochus sp.*, *P. cuneatus and Sphyriid sp.*were found in minimum (1) of Carangid fishes. The prev- alence and intensity of copepod parasites on Carangid fishes are presented in Table 3. Maximum prevalence was recorded in *C. malabaricus* (22.5 %) and minimum of (2.4) was noticed in *Selaroides leptolepis* (Fig. 1).

Mode of attachment of parasitic copepods

The distribution of copepod parasites in different species of Carangid fishes was reported. Maximum infection was recorded in *C. malabaricus* in the gill region and mini- mum was recorded in *Carangoides sp.* (gill region) and *S. leptolepis* in the nasal capsule Respiratory surface

Variation in the respiratory surface area of fish owing to the infestation of copepod parasites (*Caligus sp.*, *C. epidemi- cus*, *Bomolochus sp.*, *H. chilensis*, *P. bellones*, *P.cuneatus*, *N. sp. and Sphyriid sp*.) were studied (Fig. 2). Detailed study of respiratory surface area due to the infestation of copepods in Carangid fishes was carried out (Table 4). The maximum numbers of copepods (38) was noticed in the first gill arch and minimum numbers of copepods (5) was found in the fourth gill arch and 16 numbers of copepods were found in the second gill arch and seven numbers of copepods were found in the third gill arch. Thus, considerable variation in the respiratory area was observed owing to the attachment of parasites in the infected fishes. *Caligus sp. and C. epidemicus* parasites were attached body surface (10) and only one *Sphyriid sp*. parasites were found in nasal capsule region.

The infested fish had extremely pale gills, indicating the gill rakers were seriously lost, apical damage and out off gill lamellae were deployed. Some secondary gill lamellae were fused or thickened. Gill lamellae of the first and second arches of gill were found to be eroded due to parasites and the damage was found to be concentrated towards posterior position. Several damage have observed in the host of fishes, gill damage was major effect when a large section of filaments was destroyed and gill arch broken.

Discussion

Caligus fortis was first reported by Kabata (1965) from the nostrils of a yellow spotted trevally *C. fulvoguttatus* (Forsskal) reported as *C. emburyi* (Whitley) by Kabata (1965) caught off Green Island, Queensland. It was sub- sequently found in the nasal cavities of an unidentified jack (*Caranx* sp.) collected from Trivandrum, India by Prabha and Pillai (1986).

Table.1 Parasitic copepods in Carangid fishes

S.No	Name of the Host	No of Fishes Infested	Copepods	No of parasites Collected
1	*Carangoides malabaricus*	23	*Caligus sp.*	26
		5		5
		7		10
		1		1
2	*Alepes sp.*	8	*Bomolochus sp.*	8
3	*Gnathanodon speciosus*	11	*Holobomolochus chilensis*	13
4	*Carangoides sp*	1	*Nothobomolochus sp.*	1
5	*Selaroides leptolepis*	1	*Sphyriid sp.*	1
6	*Parastromateus niger*	11	*Caligus epidemicus*	12

Table.2 Attachment site of parasite in carangid fishes

S.No	Host	Parasites	Site of attachment
1	*Carangoides malabaricus*	*Caligus sp.*	Gill, body surface
		Caligus epidemicus	Gill, body surface
		Parabomolochus bellones	Gill
		Parabomolochus cuneatus	Gill
2	*Alepes sp.*	*Bomolochus sp.*	Gill
3	*Gnathanodon speciosus*	*Holobomolochus chilensis*	Gill
4	*Carangoides sp*	*Nothobomolochus sp.*	Gill
5	*Selaroides leptolepis*	*Sphyriid sp.*	Nasal capsule
	Parastromateus niger	*Caligus epidemicus*	Gill, body surface


Carangoides malabaricus
(Bloch & Schneider 1801)


Alepes sp.


Carangoides sp


Selaroides leptolepis


Parastromateus niger


Gnathanodon speciosus

Table.3 Occurrence of Copepod parasites in carangid fishes

S.No	Name of the Host	No of Fish examined	No of Fish Infected	No of Parasites (%)	Prevalence (%)	Mean Intensity
1	*Carangoides malabaricus*	160	36	42	22.5	1.2
2	Alepes sp.	94	8	8	8.5	1
3	Gnathanodon speciosus	124	11	13	8.9	1.2
4	*Carangoides* sp	36	1	1	2.8	1
5	Selaroides leptolepis	42	1	1	2.4	1
6	Parastromateus niger	88	11	12	12.5	1.1
	Total	544	68	77	12.5	1.1

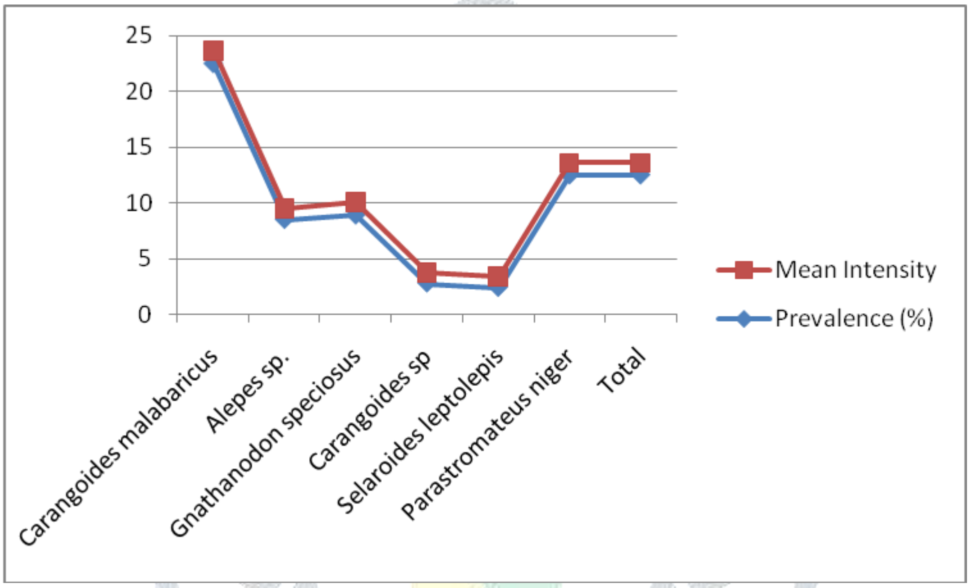


Fig. 1 Prevalence and mean intensity of copepod parasites in carangid fishes

In this study, *Sphyriid sp.* was found in the Nasal capsule of *S. leptolepis*. *Caligus robustus* was circum-global in distribution, occurring on the carangid fishes in the tropical and sub- tropical oceans (Cressey 1991). However, it seems to be rare off Taiwan. *C. robustus* has a broader distribution than *C. fortis*. It has been reported from off Sri Lanka by Bassett-Smith (1898) and Kirtisinghe (1964), from Jamaica by Wilson (1913), from off Mauritania by Brian (1924), from the Gulf of Mexico by Bere (1936) and Causey (1953), from off India by Pillai (1985), and from off Borneo, the Celebes and the Philippines by Cressey (1991). The present study has reported the infestation of parasitic copepods on gills and Nasal capsule of Carangid fishes from Manginapudi coastal environments. Parasitic copepods especially *C. epidemicus* having a broader distribution than *Caligus spp*. were reported in the Manginapudi waters. According to Boxshall and Halsey (2004), Caligid, Ergasilid, and Lernanthropid copepods are known as common parasites of shallow water fish. Copepods of the family Ergasilidae are mostly known as freshwater parasites, and only few species are known from the brackish water or marine environment (Boxshall and Halsey 2004). The other collected copepod families (Bomolochidae, Caligidae, Lernanthropidae, Lernaeopodidae, Pennellidae, Siphonostomatoida and Tetraodontidae,) are mainly or exclusively known as marine fish parasites (Hallett and Roubal 1995; Boxshall and Halsey 2004; El-Rashidy and Boxshall 2012; Ho and Lin 2012; Ozak et al. 2012) *Sinergasilus polycolpus* and *Sinergasilus major* are over distributed on their respective hosts. Other parasitic copepods, such as Caligid copepods (Hallett and Roubal 1995) have been reported to be over disposed in their host populations. In this study, *C. epidemicus* were found in maximum number of

C.malabaricus and *P.niger* fishes. Three species of parasitic copepods, one each from the Siphonostomatoid families Lernanthropidae and Lernaeopodidae and one from the Cyclopoid family Bomolochidae, are redescribed based on material collected from the gills of four fish species belonging to the family Clupeidae caught from coastal waters off Alexandria, Egypt (El-Rashidy and Boxshall 2010).

Caligidae currently accommodates 33 genera, 445 species, more than 75 % are members of Caligus (239 spp.) and Lepeophtheirus (107 spp.) (Ho 2000). Caligus spp. is dominant on marine teleost fishes (Kabata 1979). In the present study, Caligidae has been found on body and gills of Carangid fishes. Many fish genera in this study had same parasites as found in India (Pillai 1985). Many factors have been suggested to influence the aggregation of parasite burdens (Quinnell et al. 1995). However, host resistance and behaviour are considered as important in generating variable parasite burdens (Tanguay and Scott 1992), and host susceptibility is proposed to explain the higher infection levels of *E. briani* in bream *Abramis brama* and tench *Tinca tinca* (Alston and Lewis 1994). *C.malabaricus* was infested with 4 copepod species and showed the highest percentage parasitic infestation followed by other Carangid species of parasitic infestation, respectively.



C. epidemicus *Caligus* sp *Bomolochus* sp.



Nothobomolochus sp. *P. cuneatus* *Sphyriid sp.*


H. chilensis *P. bellones*

Within the present study two species of Caligidae copepods were recorded from Manginapudi; five of them belonging to Bomolochidae and one species probably represents a Sphyriidae genus. Yuniar et al. (2007)

reported *Mugil cephalus*, *Scatophagus argus*, *Eleutheronema tetradactylum*, and *Johnius coitor* had a species-rich copepod fauna. Six parasitic copepods were recorded from *M. cephalus*. Even though this fish species has a wide distribution and has been well studied for copepod para- sites (e.g., Paperna and Overstreet 1981; El-Rashidy and Boxshall 1999), several copepods from the study repre- sent new host records. Parasitic copepod *Pseudocycnus appendiculatus* at their gill filaments and this report doc- uments a new record of the Andaman Sea, Thailand Purivirojkul et al. 2011). Six species of copepods belonging to the Lernanthropidae were found parasitic on the gill filaments of six species of marine fishes of Taiwan (Ho et al. 2011). A new species of *Ergasilus boleophthalmi* parasitic on the gills of two gobiid fishes *Boleophthalmus dussumieri* and *Bathygobius fuscus* from Shatt Al-Basrah Canal, Iraq, was described (Thamir et al. 2011). In the present study eight species of parasitic copepods were recorded from Carangid fishes.

A parasitic copepods study of Algerian teleost fish, report 25 copepod species belonging to eight families harvested from the gills of 14 fish species (Boualleg et al. 2011).*C. elongatus* has been recorded from more than 100 host species, both teleosts and even elasmobranchs, belonging to 47 families (Williams and Williams 1996). Yuniar et al. (2007) reported, seven out of eight fish species were infested with *Caligus spp*. The results of the present study also agree with the earlier works. In the present study it is reported that eight out of six fish species were infested belonging to three genera of copepods. According to Moller and Anders (1986), pranzia stages were recorded to infest a high number of different fish species. Most copepods from Segara Ana- kan were host-specific, with 19 species infesting only a single host fish species (Yuniar et al. 2007). The present study result also shows that *C. epidermicus* have the char- acter of broad host specificity. It infects two different Carangid fish species but the host specificity of *Bomolochus sp., H. chilensis, Nothobomolochus sp. and Sphyriid sp.* was very narrow. Both the species are found to infest only the host fishes of *Alepes sp., Gnathanodon speciosus, Caligus sp. and S. leptolepis.* Host parasite relation is the outcome of the interaction of three factors: the host, the parasite and the environment (Moller 1985).

Prevalence and intensity of parasitic copepods on fish can vary with habitat, season, and host size (Hudson et al. 1994). The prevalence of infection in Saginaw Bay was not as high as in the Alabama ponds, where 100 % of the fishes were infected (Hayden and Rogers 1998). Mugridge et al. (1982) found 50–250 parasites/fish in British ponds and suggested that the reduced growth rate of roach may be caused by *Neoergasilus japonicus*. Ponyi and Molnar (1969) noted severe infections of N. japonicus in Hungary but provided no details on the intensity or effects. Effects of a parasitic copepod on the larval growth of the Chilean triplefin *H. chilensis* (Tripterygiidae) based on the micro- structure of the sagittal otoliths (Palacios-Fuentes et al. 2012). There are reports that the low prevalence of *L. branchialis* in offshore areas might be attributed to the fact that infected fish remain close to shore (Sproston and Hartley 1941; Kabata 1958). In this study it is reported that the prevalence was maximum in *C. malabaricus* and minimum was noticed in *S. leptolepis* and mean intensity of parasitic copepods on fish vary from 1 to 1.2.

First gill arch preference has been previously reported for microcotylids (El Hafidi et al. 1998), as well as nao- branchiids (Roubal, 1999), and it is known that abiotic factors affect the abundance of some monogeneans and copepods (Barker and Cone, 2000). Although less oxy- genated and less ventilated than the posterior arches (Hughes and Morgan 1973), gill arch I is where the current flow is minimal (Paling, 1967) and thus, where monogeneans may be the least precariously attached as suggested by El Hafidi et al. (1998). The parasitic copepod *Haemoba- phes diceraus* was found localized on the isthmus of two specimens of the walleye pollock *Theragra chalcogramma*. In both cases, the parasite directly penetrated the heart, without entering the blood vessels (Yu and Poltev 2010). In the present case, maximum reduction in respiratory surface area was noticed in the first gill compared to other gill arches. The explanation should be considered with caution, since specimens of *Meta microcotyla macracantha* can secure them by coiling around gill filaments (Baker et al. 2005). Further, some other microcotylids do not exhibit such a preference for the first arch (Lyndon and Vidal-Martinez 1994; Geets et al. 1997). A preference for gill arch I among naobranchiids has neither been investigated nor explained in previous studies. Kabata (1988) reported the adult nao- branchiids display a secure mode of attachment, by firmly embracing the individual gill filaments using their modified second maxillae, it is not excluded that larvae are precari- ously attached when they first settle on the gills. In the present investigation highest number of copepods was attached in gill filament. These parasitic copepods with neutral interactions have occurred in the first two arches and have decreased in the third and fourth gill arches.

Fish parasites are an integral part of water ecosystem and they are common in natural and cultured populations of fish. In natural conditions, most parasites do not tend to severely injure their hosts and cause mortalities which affect the population size at detectable levels. It is very difficult to estimate the actual harm to fish caused by the presence of parasites; if this is uneasy in cultured fish, it is almost impossible in feral fish populations. It should also be emphasized that the presence of a parasite does not necessarily imply manifestation of a disease. Diseases caused by parasites are much more frequently manifested in cultured fish, which suffer from artificial conditions and numerous stress factors that influence their ability to effectively protect themselves against parasitic infections. In aquaculture, some parasites are able to reproduce rapidly and heavily infect a large proportion of fish which may lead to diseases with significant economic consequences.

References

Alston S, Lewis JW (1994) The ergasilid parasites Copepoda: Poecilostomatoida of British freshwater fish. In: Pike AW, Lewis JW (eds) Parasitic diseases of fish. Samara Publishing, Dyfed, pp 171–188

Baker TG, Viricel A, Meraziz L, de Buron I (2005) Size variation of adultpolyopisthocotylid Metamicrocotyla macracantha (Mono- genea) in relation to host size. Comp Parasitol 72(2):179–182

Barker DE, Cone DK (2000) Occurrence of Ergasilus celestis (Copepoda) and Pseudodactylogyrus anguillae wild eels (Angu- illa rostrata) in relation to stream flow, pH and temperature and recommendations for controlling their transmission among captive eels. Aquaculture 187(3–4):261–274

Bassett-Smith PW (1898) Some new or rare parasitic copepods found on fish in the Indo-Tropic Region. Ann Mag Nat Hist 7(1):357–372 Bere R (1936) Parasitic copepods from Gulf of Mexico fish. Amer Mid Natu 17:577–625

Boualleg C, Kaouachi N, Seridi M, Ternango S, Bensouilah MA (2011) Copepod parasites of gills of 14 teleost fish species caught in the Gulf of Annaba (Algeria). Afri J Microbiol Res 5(25):4253–4259

Boxshall GA, Halsey SH (2004) An introduction to Copepod diversity. Roy Society, London, pp 1–966

Brian A (1924) Parasitologia Mauritanica, mate0rieux pour la faune parasitologiqueen Mauritanie Arthropoda (1er partie), Copep- oda. Bulletin du Comite0 d'E0 tudes Historiques et Scientifiques de l'Afrique Occidental Francaise 9:364–427

Causey D (1953) Parasitic Copepoda of texas coastal fishes. Publ Inst Mar Sci Univ Texas 3:6–16

Cressey RF (1991) Parasitic copepods from the Gulf of Mexico and Caribbean sea, III: Caligus. Smith Contri Zoo 497:1–53

El Hafidi F, Berrada-Rkhami O, Benazzou T, Gabrion C (1998) Microhabitat distribution and coexistence of Microcotylidae (Monogenea) on the gills of the striped mullet Mugil cephalus: chance of competition. Parasitol Res 84:315–320

El-Rashidy H, Boxshall GA (1999) Ergasilid copepods (Poecilosto- matoida) from the gills of primitive Mugilidae (grey mullets). Syst Parasitol 42:161–186

El-Rashidy H, Boxshall GA (2010) Parasitic copepods on immigrant and native clupeid fishes caught in Egyptian coastal waters off Alexandria. Syst Parasitol 76(1):19–38

El-Rashidy H, Boxshall GA (2012) A new Copepod (Siphonosto- matoida: Lernanthropidae) parasitic on a Red Sea immigrant dragonet (Actinopterygii: Callionymidae), with a review of records of parasitic copepods from dragonets. Syst Parasitol 81(2):87–96

Geets A, Coene H, Ollevier F (1997) Ectoparasites of the white spotted rabbitfish, Siganus sutor (Valenciennes, 1835) off the Kenyan Coast: distribution within the host population and site selection on the gills. Parasitology 115:69–79

Hallett SL, Roubal FR (1995) Experiments on the infection dynamics of Caligus epidermicus Copepoda: Caligidae on the small marine fish Ambassis marianus gunther. J Fish Dis 18:59–66

Hayden KJ, Rogers WA (1998) Neoergasilus japonicus (Poe-cilost- omatoida: Ergasilidae), a parasitic copepod new to North America. J Parasitol 84:88–93

Ho JS (2000) The major problem of cage aquaculture in Asia relating to sea lice. In: Liao I, Lin C (eds) Cage aquaculture in Asia. Proceeding of the First International Symposium on Cage Aquaculture in Asia, Asian FisheriesSociety, Manila and World Aquaculture Society, SoutheastAsian chapter, Bangkok, pp 13–19

Ho JS, Kim IH (2004) Lernanthropid copepods (Siphonostomatoida) parasitic on fishes of the Gulf of Thailand. Syst Parasitol 58:17–21

Ho JS, Lin CH (2012) Cirracanthus longus sp. nov. (Taeniacanthi- dae), a Copepod parasitic on seabats (Ogcocephalidae: Halieu- taea) from Taiwan, with a key to 23 Taeniacanthid species known from Taiwan. Zool Stud 51(4):548–555

Ho JS, Liu WC, Lin CL (2011) Six species of the Lernanthropidae (Crustacea: Copepoda) parasitic on marine fishes of Taiwan, with a key to 18 species of the family known from Taiwan. Zool Stud 50(5):611–635

Hudson PL, Bowenii CA, Stedman RM (1994) New records of Ergasilus (Copepoda: Ergasilidae) in the Laurentian great lakes, including a lakewide review of records and host associations. Can Journ Zoo 72:1002–1009

Hughes G, Morgan M (1973) The structure of fish gills in relation to their respiratory function. Biol Rev 48:419–475

Johnson SC, Treasurer JW, Bravo S, Nagasawa K, Kabata Z (2004) A review of the impact of parasitic copepods in marine aquacul- ture. Zool Stud 43:229–243

Jones SR, Prosperi-Porta G, Kim E (2012) The diversity of microsporidia in parasitic copepods (Caligidae: Siphonostomato- ida) in the Northeast Pacific Ocean with description of Facil- ispora margolisi n. g., n. sp. and a new family Facilisporidae n. fam. J Eukaryot Microbiol 59(3):206–217

Kabata Z (1958) Lernaeocera obtusa n. sp.: its bi-ology and its effects on the haddock marine research. Dept Agric Fish 3:1–26

Kabata Z (1965) Copepoda parasitic on Australian fishes. IV. Genus Caligus (Caligidae). Ann Mag Nat Hist 13(8):109–126

Kabata Z (1979) Parasitic copepods of British fishes. Ray Society, London, pp 1–468

Kabata Z (1985) Parasites and disease of fish cultured in tropics. Taylor and Francis, UK, USA, pp 242–246

Kabata Z (1988) Copepoda and Brachiura. In: Guide to the Parasites of Fishes of Canada. Part II-Crustacea, L. Margolis and Z. Kabata (Eds.). Fish Aqu Sci 101:3–127

Kirtisinghe P (1964) A review of the parasitic copepods of fish recorded from ceylon with descriptions of additional forms. Bull. Fish Res Sta Ceylon 17:45–132

Lester RJG, Hayward CJ (2006) Phylum Arthropoda. In: Woo PTK (ed) Fish diseases and disorders vol 1: Protozoan and Metazoan infections, 2nd edition. CAB international, London, pp 466–565

Lyndon AR, Vidal-Martinez VM (1994) The microhabitat and morphology of Grubea cochlear on the gills of mackerel fromLyme Bay, southern England. J Mar Biol Ass UK 74:731–734

Margolis L, Esch G, Holmes JC, Kuris AM, Schad GA (1982) The useof ecological terms in parasitology. J Parasitol 68(1):131–133 Moller H (1985) Fish disease in coastal waters: indicator of marine pollution. Ani Res Dev 22:106–115

Moller H, Anders K (1986) Diseases and parasites of marine fishes. Verlag Moller, German Federal Republic, p 365

Mugridge RER, Stallybrass HG, Hollman A (1982) Neoergasilus japonicus (Crustacea: Ergasilidae). a parasitic copepod new to Britain. J. Zoo London 197:551–557

Ozak AA, Demirkale I, Yanar A (2012) First record of two species of parasitic copepods on immigrant Pufferfishes (Tetraodontifor- mes: Tetraodontidae) caught in the Eastern Mediterranean Sea. Turk J Fish Aquat Sci 12:1–2. doi:10.4194/1303-2712-v12_3_17 Palacios-Fuentes P, Landaeta MF, Mun˜oz G, Plaza G, Ojeda FP (2012)

The effects of a parasitic copepod on the recent larval growth of a fish inhabiting rocky coasts. Parasitol Res 111(4):1661–1671

Paling ER (1967) A method of estimating the relative volume of water flowing over thedifferent gills of freshwater fish. J Exp Biol 48:533–544

Paperna I, Overstreet RM (1981) Parasites and diseases of mullets (Mugilidae). Aquaculture of grey mullets. In: Oren OH (eds) International biological programm 26. Cambridge University Press, USA, pp 411–493

Pillai NK (1985) The fauna of India: Copepod parasites of marine fishes. Zoo Sur India p 900

Ponyi M, Molnar K (1969) Studies on the parasite fauna of fish in Hungary, part 5. Parasitic copepods Parasitol Hung 2(2):137–148

Prabha C, Pillai NK (1986) Additions to the copepods parasitic on the marine fishes of India. 4. on twenty-six species of Caligidae. Rec Zoo Sur India 79:1–139

Pritchard MH, Kruse OW (1982) The collection and preservation of animal parasites. University of Nebraska Press, USA, p 318 Purivirojkul W, Chaidee P, Thapanand-Chaidee T (2011) New record of Pseudocycnus appendiculatus Heller, 1868 parasites of yellowfin tuna Thunnus albacares (Bonnaterre, 1788) in the Andaman Sea, Thailand. Walailak J Sci & Tech 8(1):81–85

Quinnell RJ, Graffen A, Woolhouse EJ (1995) Changes in parasite aggregation with age: a discrete infection model. Parasitology 111:635–644

Rameshkumar G, Ravichandran S (2013) Lernaeenicus sprattae (Crustacea: Copepoda) on Hemiramphus far. Mid East J Sci Res 13(2):183–186

Ravichandran S, Ajith Kumar TT, Ronald Ross P, Muthulingam M (2007) Histopathology of the infestation of parasitic isopod Joryma tartoor of the host fish Parastromates niger. Res J Parsitol 2(1):68–71

Roubal F (1999) Extent of gill pathology in the toadfish Tetractenos hamiltoni caused by Naobranchia variabilis (Copepoda: Nao- branchiidae). Dis Aqu Org 35:203–211

Roza D, Johnny F, Kawahara S, Hanafi A (2002) Penyakit pada budidaya ikan kerapu dan upaya penanggulangannya. Kumpulan Makalah Seminar PengembanganTeknologi Budidaya Kerapu, Balai Budidaya Laut Lampung p, pp 75–86

Sirikanchana P (2003) Parasites of aquatic animals. Sky Word Advertising Ltd, Bangkok 270

Sproston NG, Hartley PHT (1941) The ecology of some parasitic copepods of gadoids and other fishes. J Mar Biol Ass UK 25:361–392 Tanguay GV, Scott ME (1992) Factors generating aggregation of Eligmosomoides polygyrus Nematoda in laboratory mice. Parasitology 104:519–529

Thamir K, Adday, Atheer H, Ali (2011) Ergasilus boleophthalmi sp.n. (Copepoda: Ergasilidae) parasitic on gobiid fishes from Shatt Al-Basrah Canal, South of Iraq. Wiadomooeci Parazytologiczne 57(3):137–142

Vinoth R, Ajith Kumar TT, Ravichandran S, Gopi M, Rameshkumar G (2010) Infestation of Copepod parasites in the food fishes of Vellar estuary, Southeast coast of India. Act Parasitol Glob 1(1):1–5

Williams EH Jr, Williams LB (1996) Parasites off shore, big game sport fishes of Puerto Rico and the Western North Atlantic. Puerto Rico Department of Natural and Environmental Resources/Department of Biology, University of Puerto Rico, San Juan, Puerto Rico/Mayaguez, Puerto Rico, p 384

Wilson CB (1913) Crustacean parasites of West Indian fishes and land crabs, with descriptions of new genera and species. Proc Unit States Nat Mus 44:189–277

Yamaguti S (1963) Parasitic Copepoda and Branchiura of fishes. Interscience publishers, A Division of John Wiley & Sons, New York, p 1104

Yu N, Poltev (2010) An unusual localization of the parasitic Copepod Haemobaphes diceraus Wilson, 1917 (Copepoda: Pennellidae) on the walleye pollock Theragra chalcogramma. Rus J Mar Biol 36(2):154–156

Yuniar A, Palm HW, Walter T (2007) Crustacean fish parasites from Segara Anakan Lagoon, Java, Indonesia. Parasit Res 100: 1193–1204