Journal of Aquatic Biology & Fisheries | 2021 | **9** | pp. 171-177

ISSN 2321–340X

Metazoan Parasites of Red Cornet Fish *Fistularia petimba* (Lacepede, 1803) from Kerala, Southwest Coast of India

Prasad, B.O.

Department of Zoology, Sree Narayana College,
Kannur, 670007, Kerala, India
Email: prasadaqb@gmail.com

Abstract

Parasitic infections of red cornet fish (*Fistularia petimba*) were investigated from fish landing centres of southern Kerala coast, India. The helminth community consisted of five species of Digenea, *Allolepidapedon fistulariae*, *Stephanostomum adinterruptum*, *S. fistulariae*, *Bucephalus* sp. 1 and *Bucephalus* sp. 2; one each from Nematoda, *Hysterothylacium* sp., Copepoda, *Caligus tenuicauda* and Isopoda, *Cymothoa* sp. The overall prevalence of infection was 72.7%, registering higher among males (90%) than females (67.6%). The mean intensity of infection was higher among females. The most prevalent species were *A. fistulariae* and *S. fistulariae*. Among the five digenetic trematodes, *A. fistulariae*, *S. adinterruptum* and *S. fistulariae* were reported for the first time off the southwest coast of India. *F. petimba* is a new host record for the metacercarea of the digenetic trematode *Bucephalus* spp.

Keywords: *Fistularia petimba*, Metazoan parasites, Prevalence, Mean Intensity

1. Introduction

Cornet fishes or flutemouths are elongated fishes of the family Fistulariidae under the order Syngnathiformes. The family consists of a single genus *Fistularia*, with four species (*Fistularia commersonii*., *F. corneta*., *F. petimba*., *F. tabacaria*). The red cornet fish, *Fistularia petimba* Lacepede, 1803, is perhaps the most widespread species, distributed along the Atlantic, Indian, and Western Pacific oceans, including Hawaii, usually occurs at a depth range of 10-200m. Adults are exclusively marine, crepuscular, slow movers over soft substrates of the sublittoral zone, while juveniles share estuarine habitats. They can reach up to 2 m in length; but rarely exceeds 1m (Froese and Pauly, 2018). The long tubular snout is very efficient in sucking small fish and shrimps as major food sources. The species constitute subsistence fisheries along with their distribution range.

Only scattered information is available on the metazoan parasite assemblage of red cornet fish and their close kins along their distribution range. Among these, parasitic reports exclusively on *F. petimba* are those of Yamaguti (1970), Dyer *et al*. (1988), Bray and Cribb (2003), Madhavi and Bray (2018) on Digenea; Hasegawa *et al*. (1991), Miguel (2019) on Nematoda; Amin *et al*. (2019) on Acanthocephala; Ho *et al*. (2008) on Copepoda; Williams *et al*. (2000), Rameshkumar *et al*. (2014) and Aneesh *et al*. (2020) on Isopoda. The present study forms the first comprehensive report on the occurrence and nature infection of metazoan parasites in *Fistularia petimba* off the south-west coast of India.

2. Materials and Methods

A total of 44 specimens of *Fistularia petimba* were collected from Neendakara and Sakthikulangara regions of the Arabian Sea (8° 56' 19.18'' N. 76° 32' 25.19'' E). The fishes were packed in ice, and brought to the laboratory of Department of Aquatic Biology and Fisheries, University of Kerala, Thiruvananthapuram, for parasitological examination. The fishes were weighed, measured and examined carefully for the presence of metazoan parasites. Sex of the fishes was noted during the parasitological examination. Each body part was examined using a hand lens and later under a stereo dissecting microscope (SDM – Olympus Stereozoom SZ-ST). Skin scrapings from various parts of the body were also examined under a high power transmission light microscope (TLM – Olympus TRM BX50) for the ectoparasites. Later, the fishes were dissected, gills, all the internal organs and muscle samples were examined in separate petri dishes in 8% saline. Parasites encountered were cleaned in tap water and preserved either in 10% neutral buffered formalin (NBF) or 70% alcohol with glycerine, depending upon the types of parasites. Digeneans were cleaned and fixed in 5% NBF. Representatives of each species of trematodes were stained in Gower's carmine and permanent mounts were prepared. Sufficiently stained materials were dehydrated in alcohol series, cleared in phenol-xylol and xylol and mounted in Dibutylphthalate Polystyrene Xylene (DPX). Copepods were dissected in 50% aqueous lactic acid by adopting the wooden slide method (Humes and Gooding, 1964). Camera Lucida sketches were made, and measurements were taken by using a calibrated ocular micrometer. Parasite identification was done following the standard literature and original descriptions (Yamaguti, 1961, 1975; Gibson *et al*., 2002; Jones *et al*., 2005; Bray *et al*., 2008; Anderson *et al*., 2009; Gibbons, 2010). All parasite species identified to the lowest possible taxon were evaluated through WoRMS (2021). The identification of host fish was based on Fish Base (Froese and Pauly, 2018) and WoRMS (2021). Data on the nature of infection were analysed following Bush *et al*. (1997).

Received on: 27-01-2021; Revised on: 31-07-2021; Accepted on: 31-07-2021

3. Results and Discussion

3.1. Systematic account of parasites collected

3.1.1. Digenea (Adults)

Order Plagiorhiida
Superfamily Lepocreadioidea
Family Lepocreadiidae
Genus *Allolepidapedon*

3.1.1.1 *Allolepidapedon fistulariae* Yamaguti, 1940 (Fig. 1)

Material: 39 specimens from *Fistularia petimba*

Location: Intestine

Measurements: Length, 4.860; width, 0.30; oral sucker, 0.1 × 0.21; ventral sucker, 0.17 × 0.16; prepharynx, 0.81; pharynx, 0.17 × 0.08; oesophagus, 0.03; anterior testis, 0.36 × 0.16; posterior testis, 0.37 × 0.16; ovary, 0.14 × 0.11

Remarks

Allolepidapedon fistulariae is characterized by a very long excretory vesicle, a marginal genital pore and a smaller sucker ratio. The present material conforms to the original description by Yamaguti (1940) except for the epithelial spines of the body reach only up to the level of anterior testes, unlike reported by Yamaguti (1940) in the original description, where they reach up to the posterior end of the body. Dyer et al. (1988) also reported *A. fistulariae* from *Fistularia petimba* off Okinawa coast, Japan. Nahhas et al. (2004), while describing a new species, *Stephanostomum fijiensis*, synonymized *A. petimba* with *A. fistulariae*. From the Mediterranean Sea, Pais et al. (2007) reported *A. fistulariae* for the first time from *F. commersonii*, followed by reports of Merella *et al*. (2010), Merella *et al*. (2015) and Bray *et al*. (2016). The parasite has also been reported from cornet fishes off the Italian coast (Marchini *et al*., 2013; Servello *et al*., 2019) and the western coast of Libya (Salem, 2017). The present report extends the distribution of the worm to Indian waters.

Superfamily Brachycladioidea
Family Acanthocolpidae
Genus *Stephanostomum*

3.1.1.2. *Stephanostomum adinterruptum* Hafeezullah, 1971 (Fig. 2)

Material: 8 specimens from *Fistularia petimba*.

Location: Intestine

Measurements: Length, 3.348; width, 0.342; oral sucker, 0.081 × 0.153; ventral sucker, 0.153 × 0.153; prepharynx, 0.585; pharynx, 0.153 × 0.081; oesophagus, 0.027; anterior testis, 0.297 × 0.234; posterior testis, 0.351 × 0.252; ovary, 0.207 × 0.198.

Remarks

In the original description of *Stephanostomum adinterruptum*, Hafeezullah (1971) described the relatively short post-testicular region, unarmed cirrus, ejaculatory duct and metraterm and the shorter eggs. But according to Madhavi (1976), both cirrus and ejaculatory duct are spined, which were seen only in fresh specimens. The present material agrees with the description of Hafeezullah (1971) except having longer and armed cirrus and more posteriorly extended cirrus sac; and also confirms spines in two complete circles.

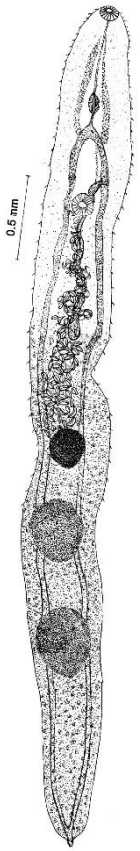

Fig. 1. *Allolepidapedon fistulariae*

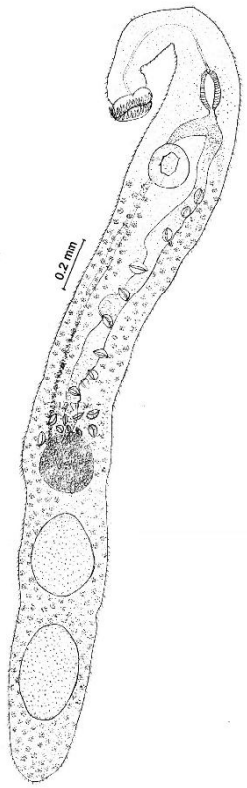

Fig. 2. *Stephanostomum adinterruptum*

The reports on this species from *Fistularia villosa* off Visakhapatanam coast are of Hafeezullah (1971), Madhavi (1976) and Madhavi and Bray (2018). In the present study, *S. adinterruptum* is reported for the first time from *F. petimba* and from the southwest coast of India.

3.1.1.3. *Stephanostomum fistulariae* Yamaguti, 1940 (Fig. 3)

Material: 39 specimens from *Fistularia petimba*

Location: Intestine

Measurements: Length, 4.860; width, 0.30; oral sucker, 0.1 × 0.21; ventral sucker, 0.17 × 0.16; prepharynx, 0.81; pharynx, 0.17 × 0.08; oesophagus, 0.03; anterior testis, 0.36 × 0.16; posterior testis, 0.37 × 0.16; ovary, 0.14 × 0.11

Remarks

The most striking characters of *Stephanostomum fistulariae* are the small sucker width ratio, position of the ovary and a shorter cirrus sac. These features make *S. fistulariae* distinct from the closely related *S. adinterruptum*. The present material agrees well with the original description of the species by Yamaguti (1940) from *F. petimba* off Japan. Another report on *Stephanostomum fistulariae* is that of Arthur and Te (2006) from *F. petimba* off Viet Nam coast. The present one is the first report of *S. fistulariae* off the southwest coast of India.

Superfamily Bucephaloidea
Family Bucephalidae
Genus *Bucephalus*

3.1.1.4. *Bucephalus* sp. 1 (Fig. 4)

Material: 1 specimen from *Fistularia petimba*

Location: Intestine

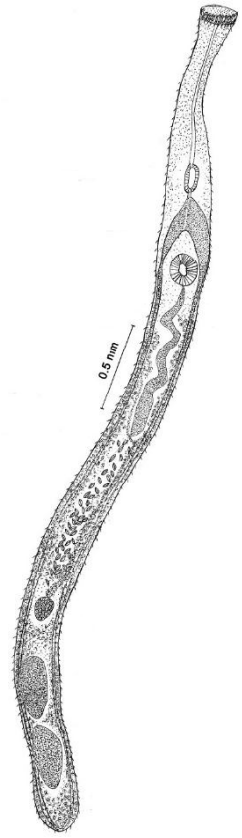

Fig. 3. *Stephanostomum fistulariae*

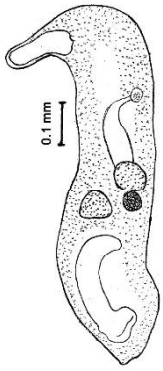

Fig. 4. *Bucephalus* sp. 1

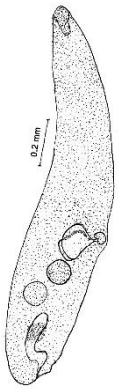

Fig. 5. *Bucephalus* sp. 2

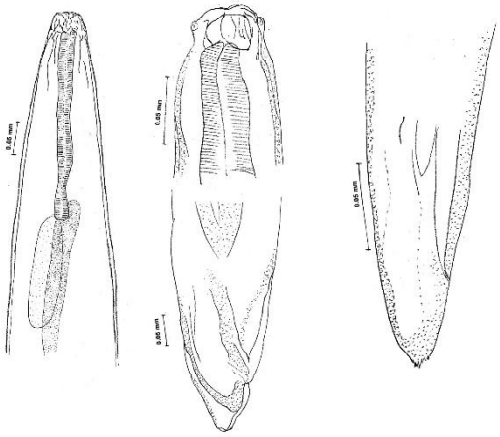

Fig. 6. *Hysterothylacium* sp.

Description: Body elongate, tapering anteriorly. Small, funnel-shaped rhynchus at the anterior end, not prominent. Gut well developed. Testes two, round, separated from each other, post-equatorial. Cirrus sac elongated. The genital pore opens at the posterior end.

Measurements: Length, 1.458; width, 0.306; rhynchus, 0.162 × 0.063; anterior testis, 0.09 × 0.09; posterior testis, 0.099 × 0.099.

3.1.1.5. *Bucephalus* sp. 2 (Fig. 5)

Material: 1 specimen from *Fistularia petimba*

Location: Gills

Description: More or less similar to species 1; but smaller in size.

Measurements: Length, 0.954; width, 0.198; rhynchus, 0.144 × 0.054; testis, 0.063 × 0.072; ovary, 0.045 × 0.045.

Remarks

According to Spakulova et al. (2002), fairly a good number of *Bucephalus* species have rhynchus surrounded by seven tentacles with two projections. Besides this, the number of papillae at the base of tentacles is also of taxonomic significance. Since only a single material of immature stage was available, a detailed study was not attempted. However, the present report extends the first record of the Genus *Bucephalus* from *Fistularia petimba*.

3.1.2. Nematoda (Larval stages)

Phylum	Nematoda
Class	Chromadorea
Order	Rhabditida
Family	Raphidascarididae
Subfamily	Raphidascaridinae
Genus	*Hysterothylacium*

***Hysterothylacium* sp.** (Fig. 6)

Material: 94 from *Fistularia petimba*

Location: Intestine

Remarks

The Anisakid genus *Hysterothylacium* Ward and Magath, 1917 was revised by Deardorff and Overstreet (1981). They established that most species that mature in fish are species of *Hysterothylacium*, which is a common genus reported as a larval parasite among marine fishes (Anderson, 2000; Klimpel and Palm, 2001; Pantoja *et al*., 2016). More than 55 species of this genus are described from the intestine of marine fishes (Bijukumar, 1995). Reports on *Hysterothylacium* from the cornet fishes are of Deardorff *et al*. (1982) and Bao *et al*. (2019) (*Hysterothylacium fortalezae* and *H. deardorffoverstreetorum*) off Hawaii coast and Rio de Janeiro, Brazil, respectively.

3.1.3. Copepoda

Class	Hexanauplia
Subclass	Copepoda
Order	Siphonostomatoida
Family	Caligidae
Genus	*Caligus*

***Caligus tenuicauda* Shiino, 1964** (Fig. 7)

Material: 40 specimens from *Fistularia petimba*

Location: Gills, mouth

Measurements: Body length, 3.978 (3.871-4.110); cephalothorax, 1.294 × 1.170 (1.171-1.302) × (1.159-1.177); trunk length, 1.404 (1.391- 1.409); trunk width, 0.998 (0.881-1.105); abdomen length, 0.982 (0.877-1.003).

Fig. 7. *Caligus tenuicauda*

Fig. 7a. Maxilliped

Fig. 7b. Antennule

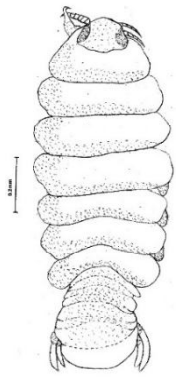

Fig. 8. *Cymothoa* sp.

Remarks

The species can be easily identified as a typical caligid structure, with a very small flabellum and an elongated abdomen. The fourth leg stouter, and the distal exopod segment of the first leg is devoid of plumose setae. The sternal fork with nearly parallel and apically rounded rami. Pillai (1961) described *Pseudocaligus fistularia* (junior secondary hononym), but without a description of the second maxilla, which was later described by Prabha Ramakrishnan (1980). The second maxilla of the present material agrees with the original description of Prabha Ramakrishnan (1980). In the present material, the subchela of maxilliped (Fig. 7a) is more curved than that illustrated by Pillai (1961). Prabha Ramakrishnan (1980) described a short spine at the inner distal corner of antennules, which was lacking in the present material (Fig. 7b).

Pseudocaligus tenuicauda was first reported by Shiino (1964) from Japan. Later on, *Pseudocaligus tenuicauda* was placed as the synonymy of *P. fistulariae* by Pillai (1985). Kabata (1965) agrees the validity of using the setae of the fourth leg as a generic level character for the genera *Pseudocaligus* and *Pseudolepeophtheirus* Markevich, 1940; and also considered *Pseudocaligus* and *Pseudolepeophtheirus* to be synonymised with their respective related genera, *Caligus* and *Lepeophtheirus* von Nordmann, 1832. Accordingly, Dojiri and Ho (2013) formally recognised *Pseudocaligus* as a junior synonym of *Caligus* (Ozak *et al.*, 2013; Freeman *et al*., 2013), which agrees with the findings of Ben Hassine (1983) too. Ultimately, the new combination *Caligus tenuicauda* (Shiino, 1964) thus becomes the valid name for the junior secondary homonym *Pseudocaligus fistularia* (Pillai, 1961).

3.1.4. Isopoda

Class Malacostraca
Order Isopoda
Family Cymothoidae
Genus *Cymothoa*

***Cymothoa* sp.** (Fig. 8)

Material: 1 specimen from *Fistularia petimba*

Location: Mouth

Measurements: Total length, 1.264; width, 0.496

Remarks

Cymothoid isopods are mostly ectoparasites of fish. These protandrous hermaphrodites attach mostly around the head region of the fish. The present specimen was collected from the mouth of *Fistularia petimba*. Several reports are there on the infestation of *Cymothoa bychowski*, particularly from Cornet fishes off Indian water (Aneesh *et al*., 2020), off Australia (Avdeev, 1979; Martin *et al*., 2016), north of NCS Beach, Guam (Williams *et al*., 2000) and Agatti Island, Lakshadweep (Rameshkumar *et al*., 2014). Since only one material was available, detailed study was not attempted.

3.2. Overall nature of infection

Of the total 44 fishes examined, 32 were infected (prevalence = 72.7%). Prevalence of infection was noticeably higher in males (90.0%) than in females (67.6%). The mean intensity of infection was 7.0; with infected females registering mean intensity almost twice (11.0) as high as males (5.4) (Table 1).

Altogether 8 species of parasites were collected from the infected fishes, which comprised five species of Digenea, one each of Nematoda, Copepoda and Isopoda. Of these, digenetic trematode, *Allolepidapedon fistulariae* is reported for the first time from Indian waters. *Stephanostomum adinterruptum* and *S. fistulariae* were reported for the first time off the southwest coast of India. Genus *Bucephalus* forms the first record from *Fistularia petimba*.

The results of the analyses of prevalence and mean intensity of each infection are presented in Table 2. The digenean, *A. fistulariae*, was the most prevalent parasite (prevalence - 22.7%). The lowest prevalence was noted for three parasites, *Bucephalus* sp.1, *Bucephalus* sp.2 and *Cymothoa* sp. (2.3%). The highest mean intensity was registered for *Hysterthylacium* sp. Larva (11.8) and the lowest for *Bucephalus* sp.1, *Bucephalus* sp.2 and *Cymothoa* sp. (1.0). Of the 223 parasites collected, the maximum representation was by *Hysterthylacium* sp. larva, followed by *Caligus tenuicauda*.

Table 1. Nature of metazoan parasitic infection in *Fistularia petimba*

	Male	Female	Total
Number of fish examined	34	10	44
Number of fish infected	23	9	32
Prevalence of infection (%)	90	67.6	72.7
Number of parasites collected	124	99	223
Mean Intensity of infection	5.4	11	7
Maximum number of parasites in an infected fish	29	35	

4. Conclusion

The parasite fauna of *Fistularia petimba* was low in species diversity. Among the eight species of parasites encountered, six were helminths. Nevertheless, nematode, copepod and isopod were represented by only one species each. A total of 223 parasites belonging to digenea (*Allolepidapedon fistulariae*, *Stephanostomum adinterruptum*, *S. fistulariae*, *Bucephalus* sp.1, *Bucephalus* sp.2), nematode (*Hysterthylacium* sp.), copepod (*Caligus tenuicauda*) and isopod (*Cymothoa* sp.) were collected. This low species diversity of these groups suggests that their definitive and intermediate hosts (if any) are scarce in the particular environment.

Among the digenetic trematodes, the present reports of *Allolepidapedon fistulariae*, *Stephanostomum adinterruptum*, *S. fistulariae*, *Bucephalus* sp. extends the distribution of these worms to the southwest coast of India. *Stephanostomum adinterruptum* and *Bucephalus* sp. are reported for the first time from red cornet fish, *Fistularia petimba*.

Acknowledgements

The author place deepest gratitude to Dr. S. Radhakrishnan, Assistant Professor, Department of Aquatic Biology and Fisheries, University of Kerala, for suggesting the topic, sincere guidance and valuable suggestions. The author gratefully acknowledge the help and assistance received for identifying the trematodes from Prof. (Dr.). R. Madhavi, (Rtd.) and Prof. (Dr.). U. Shameem, Department of Zoology, Andhra University, Visakhapatnam. Thanks are also due to Dr. B. Santhosh, Principal Scientist, CMFRI Vizhinjam Centre, Thiruvananthapuram for identifying nematodes as well as copepods.

Table 2. Prevalence, mean intensity and number of various metazoan parasites from male and female *Fistularia petimba*

Parasite	Prevalence (%)			Mean intensity			Number of parasites from		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Digenea									
Allolepidapedon fistulariae	23.5	20	22.7	3.3	6.5	3.9	26	13	39
Stephanostomum adinterruptum	0	20	4.5	0	4	4	0	8	8
Stephanostomum fistulariae	14.7	40	20.5	1	8.5	4.3	5	34	39
Bucephalus sp.1 metacercaria	0	10	2.3	0	1	1	0	1	1
Bucephalus sp. 2 metacercaria	0	10	2.3	0	1	1	0	1	1
Nematoda									
Hysterthylacium sp. larva	14.7	30	18.2	11.6	12	11.8	58	36	94
Copepoda									
Caligus tenuicauda	14.7	20	15.9	6.8	3	5.7	34	6	40
Isopoda									
Cymothoa sp.	2.9	0	2.3	1	0	1	1	0	1

5. References

Amin, O.M., Heckmann, R.A, Van Ha, N. 2019. Descriptions of two new acanthocephalans (Rhadinorhynchidae) from marine fish off the Pacific coast of Vietnam. *Syst Parasitol*., 96(1):117-129; doi: 10.1007/s11230-018-9833-x.

Anderson, R.C. 2000. *Nematode parasites of vertebrates: their development and transmission*. CAB Publishing, New York, 650pp.

Anderson, R.C., Chabaud, A.G., Willmott, S. 2009. *Keys to the nematode parasites of vertebrates*. Archival volume. CAB International, Wallingford.

Aneesh, P.T., Hadfield, K.A., Smit, N.J. and Bijukumar, A. 2020. A new genus and species of fish parasitic Cymothoid Isopod (Crustacea) from Indian waters, with a key to the branchial-attaching Cymothoid genera. *Mar. Biol. Res*. 16:565-584; doi: 10.1080/17451000.2020.1851032.

Arthur, J.R. and Te, B.Q. 2006. Checklist of the parasites of fishes of Viet Nam. FAO Fisheries Technical Paper 369(2):1-133.

Avdeev, V.V. 1979. New species of the genus *Cymothoa* (Isopoda, Cymothoidae) from the Indian Ocean. *Parazitologiya* (Leningr.) 13:223-234.

Bao, M., Pierce, G.J., Strachan, N.J.C., Pascual, S., González- Muñoz, M. and Levsen, A. 2019. Human health, legislative and socioeconomic issues caused by the fish-borne zoonotic parasite *Anisakis*: Challenges in risk assessment. *Trends Food Sci. Technol*. 298- 310; doi.org/10.1016/j.tifs.2019.02.013.

Ben Hassine, O.K. 1983. Les copépodes parasites de poissons Mugilidae en Méditerranée occidentale (côtes Francaises et Tunisiennes). Morphologie, Bio-écologie, Cycles évolutifs. Dissertation, Université des Sciences et Techniques du Languedoc.

Bijukumar, A, 1995. Studies on the Metazoan Parasites Associated with the Flatfishes (Order Pleuronectiformes) of the Coast of Kerala. Ph. D. Thesis, Univ. Kerala, India

Bray, R.A. and Cribb, T.H. 2003. Species of *Stephanostomum* Looss, 1899 (Digenea: Acanthocolpidae) from fishes of Australian and South Pacific waters, including five new species. *Syst. Parasitol*. 55:159–197; doi: 10.1023/a:1024655818783.

Bray, R.A., Diaz, P.E. and Cribb, T.H. 2016. Knowledge of marine fish trematodes of Atlantic and Eastern Pacific Oceans. *Syst. Parasitol*. 93(3):223–235; doi.org/10.1007/s11230-016-9629-9.

Bray, R.A., Gibson, D.I. and Jones, A. 2008. *Keys to the Trematoda. Vol. 3*. CABI Publishing and The Natural History Museum, London, U.K.

Bush, A.O., Lafferty, K.D., Lotz, J.M. and Shostak, A.W. 1997. Parasitology meets ecology on its own terms: Margolis *et al*. revisited. *J. Parasitol*. 83:575–583; doi.org/10.2307/3284227.

Deardorff, T.L., Kliks, M.M., Rosenfeld, M.E., Rychlinski, R.A. and Desowitz, R.S. 1982. Larval ascaridoid nematodes from fishes near the Hawaiian Islands, with comments on pathogenicity experiments. *Pac. Sci*. 36(2):187-201; http://hdl.handle.net/10125/419.

Deardorff, T.L. and Overstreet, R.M. 1981. Larval *Hysterothylacium* (= Thynn-ascaris) (Nematoda: Anisakidae) from fishes and invertebrates in the Gulf of Mexico. *Proc. Helminthol. Soc. Wash*. 48:113-126.

Dojiri, M. and Ho, J.S. 2013. Systematics of the Caligidae, copepods parasitic on marine fishes. Koninklijke Brill NV, Leiden. 10.1163/9789004204256.

Dyer, W.G., Williams, E.H. and Williams, L.B. 1988. Digenetic trematodes of marine fishes of Okinawa, Japan. *J. Parasitol*. 74:638-645; doi.org/10.2307/3282183.

Freeman, M.A., Anshary, H. and Ogawa, K. 2013. Multiple gene analyses of caligid copepods indicate that the reduction of a thoracic appendage in *Pseudocaligus* represents convergent evolution. *Parasites Vectors*. 6(1):336; doi.org/10.1186/1756-3305-6-336.

Froese, R. and Pauly, D. (eds) 2018. Fishbase, world wide web electronic publication. http://www.fishbase.org. Accessed 27 March 2021.

Gibbons, L.M. 2010. *Keys to the Nematode Parasites of Vertebrates*. Supplementary Volume. CAB International. Wallingford, UK. 416pp.

Gibson, D.I., Jones, A. and Bray, R.A. 2002. *Keys to the Trematoda. Vol. 1*. CABI Publishing and The Natural History Museum U.K.

Hafeezullah, M. 1971. On some new and known digenean trematodes from marine fishes of India. *J. Helminthol*. 45:73-88.

Hasegawa, H., Williams, E.H. and Williams, B.L. 1991. Nematode parasites from marine fishes of Okinawa, Japan. *J. Helminthol. Soc. Wash*. 58:186–197.

Ho, J.S., Chang, W.C. and Lin, C.L. 2008. Three species of caligid copepods (Siphonostomatoida) parasitic on marine fishes collected off Tai-dong, Taiwan. *J. Fish. Soc. Taiwan*. 35:223–237.

Humes, A.G. and Gooding, R.U. 1964. A method for studying the external anatomy of copepods. *Crustaceana*. 6:238-240; doi.org/10.1163/156854064X00650.

Jones, A., Bray, R.A. and Gibson, D.I. 2005. *Keys to the Trematoda. Vol. 2*. CABI Publishing and The Natural History Museum, London, U.K.

Kabata, Z. 1965. Copepoda parasitic on Australian fishes. IV. Genus *Caligus* (Caligidae). *Ann. Mag. Nat. Hist. Ser*. 13(8):109–126; doi.org/10.1080/00222936508651546.

Klimpel, S. and Palm, H.W. 2001. Anisakid nematode (Ascaridoidea) life cycles and distribution. Increasing zoonotic potential in the time of climate change? *Parasitol. Res*. 2:201–222; doi:10.1007/978-3-642-21396-0_11.

Madhavi, R. and Bray, R. 2018. *Digenetic trematodes of Indian marine fishes*. Springer. doi:10.1007/978-94-024-1535-3.

Madhavi, R, 1976. Digenetic trematodes from marine fishes of Waltair Coast, Bay of Bengal. Family Acanthocolpidae. *Riv. Parassit*. 37:115-128.

Marchini, A., Ferrario, J. and Occhipinti-Ambrogi, A. 2013. Recent additions to the alien marine biota along Italian coasts. *Rapp. Comm. Int. Mer. Me´dit*. 40:887.

Martin, M.B., Bruce, N.L. and Nowak, B.F. 2016. Review of the fish-parasitic genus *Cymothoa* Fabricius, 1793 (Crustacea: Isopoda: Cymothoidae) from Australia. *Zootaxa*. doi.org/10.11646/zootaxa.4119.1.1.

Merella, P., Pais, A., Follesa, M.C., Farjallah, S., Gagliardi, F., Mele, S., Piras, M.C. and Garippa, G. 2015. Parasites of the lessepsian sprinter *Fistularia commersonii* (Osteichthyes: Fistulariidae): an update after 15 years since its arrival in the Mediterranean Sea. IX International Symposium on Fish Parasites, Valencia (Spain), August 31 2015–September 05 2015, p 87.

Merella, P., Casu, M., Garippa, G., Pais, A. and Crame, A. 2010. Lessepsian fish migration: Genetic bottlenecks and parasitological evidence. *J. Biogeo*. 37(5):978-980; doi:10.1111/j.1365-2699.2010.02272.x.

Miguel, S.H.G. 2019. Hygienic-sanitary importance of nematoides of the Raphidascaridadae family and cestoids of the order Trypanorhyncha parasites of *Fistularia petimba* Lacepède, 1803, commercialized in the municipality of Cabo Frio, Brazilian State of Rio de Janeiro. Dissertation, Federal Fluminense University.

Nahhas, F.M., Nasser, H. and Tam, J. 2004. Digenetic trematodes of marine fishes from Suva, Fiji. Families: Acanthocolpidae, Lepocreadiidae, Bivesiculidae, Zoogonidae, Monorchiidae and description of a new species. *Riv. Parassitol*. 21:33-48.

Özak, A.A., Demirkale, I., Boxshall, G.A. and Etyemez, M. 2013. Parasitic copepods of the common sole, *Solea solea* (L.), from the Eastern Mediterranean coast of Turkey. *Syst. Parasitol*. 86(2):173-85; doi: 10.1007/s11230-013-9441-8.

Pais, A., Merella, P., Follesa, M.C. and Garippa, G. 2007. Westward range expansion of the Lessepsian migrant *Fistularia commersonii* (Fistulariidae) in the Mediterranean Sea, with notes on its parasites. *J. Fish. Biol*. 70:269-277; doi.org/10.1111/j.1095-8649.2006.01302.x.

Pantoja, C.S., Pereira, F.B., Santos, C.P. and Luque, J.L. 2016 Morphology and molecular characterization hold hands: clarifying the taxonomy of *Hysterothylacium* (Nematoda: Anisakidae) larval forms. *Parasitol. Res*. 115(11):4353-4364; doi: 10.1007/s00436-016-5221-0.

Pillai, N.K. 1985. *The fauna of India. Copepod parasites of marine fishes*. Zoological Society of India, Calcutta.

Pillai, N.K. 1961. Copepods parasitic on South Indian fishes. Pt. 1. Caligidae. *Bull. Cent. Res. Inst. Univ. Kerala*. 8:87-130.

Prabha Ramakrishnan. 1980. Revision of the Caligidae (Copepoda) with special reference to the Indian fauna. Dissertation, University of Kerala, India.

Rameshkumar, G., Ravichandran, S. and Sivasubramanian, K. 2014. A new record of parasitic isopod for the Indian fauna (*Mothocya karobran* Bruce, 1986) from *Strongylura strongylura* in the Pazhayar region, Southeast coast of India. *J. Parasit. Dis.* 38(3):328–330; doi.org/10.1007/s12639-013-0268-7.

Salem, O. 2017. Parasites of invasive fishes and their impact on the western coast of Libya. Dissertation, Tripoli University, Libya.

Servello, G., Andaloro, F., Azzurro, E., Castriota, L., Catra, M., Chiarore, A., Crocetta, F., D'Alessandro, M., Denitto, F., Froglia, C., Gravili, C., Langer, M.R., Brutto, S.L., Mastrototaro, S., Petrocelli, A., Pipitone, C., Piraino, S., Relini, G., Serio, D., Xentidis, N.J. and Zenetos, A. 2019. Marine alien species in Italy: A contribution to the implementation of descriptor D2 of the marine strategy framework directive. 20(1):1-48; doi.org/10.12681/mms.18711.

Shiino, S.M. 1964. Results of Amami Expedition. 6. Parasitic Copepoda. Reports of the Faculty of Fisheries, Prefectural University of Mie 5(1):243-255.

Spakulova, M., Macko, J.K., Berrilli, F. and Dezfuli, B.S. 2002. Description of *Bucephalus anguillae* n. sp. (Trematoda: Bucephalidae), a parasite of the eel, *Anguilla anguilla* (Anguillidae) from a Brackishwater lagoon of the Adriatic Sea. *J. Parasitol.* 88:382-387; doi.org/10.1645/0022-3395(2002)088[0382:DOBANS]2.0.CO;2.

Williams, E.H., Williams, L.B. and Pitlik, T. 2000. Three new records for Micronesia of cymothoid isopods (Crustacea) parasitic on fishes. *Pacific Sci.* 54:157-158.

WoRMS Editorial Board. 2021. World Register of Marine Species. Available from http://www.marinespecies.org. Accessed 9 April 2021.

Yamaguti, S. 1940. Studies on the helminth fauna of Japan. Part 31. Trematodes of fishes. VII. *Jap. J. Zool.* 9:35-108.

Yamaguti, S. 1961. *Systema Helminthum. Vol. 3*. In: The Nematodes of Vertebrate, Interscience Publishers, New York, 679 pp.

Yamaguti, S. 1970. *Digenetic trematodes of Hawaiian fishes.* Keigaku Publishing Co. Ltd. Tokyo Japan.

Yamaguti, S. 1975. *A Synoptical Review of Life Histories of Digenetic Trematodes of Vertebrates*. Keigaku Publishing Company, Tokyo, 590 pp.