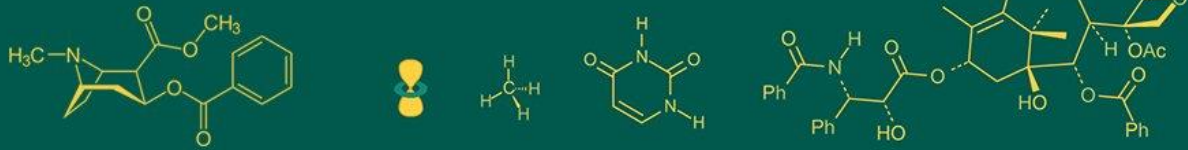


## International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693  
 ISSN Online: 2617-4707  
 IJABR 2024; SP-8(6): 187-193  
[www.biochemjournal.com](http://www.biochemjournal.com)  
 Received: 09-04-2024  
 Accepted: 14-05-2024

**Sugumar Ramkumar**  
 Senior Scientist, ICAR-CMFRI  
 Mumbai Regional Station,  
 Mumbai, Maharashtra, India.

**Mahendra Pandit Sonawane**  
 Technician, Ratnagiri field  
 centre of ICAR-CMFRI  
 Mumbai Regional Station,  
 Mumbai, Maharashtra, India.

**Vaibhav Dinkar Mhatre**  
 Technical officer, ICAR-  
 CMFRI Mumbai Regional  
 Station, Mumbai,  
 Maharashtra, India.

**Punam Ashok Khandagale**  
 Technical officer, ICAR-  
 CMFRI Mumbai Regional  
 Station, Mumbai,  
 Maharashtra, India.

**Lakshmanan Ranjith**  
 Senior Scientist, ICAR-CMFRI  
 Tuticorin Regional Station,  
 Tuticorin, Tamil Nadu, India.

**Vaibhav Milan Tawde**  
 Multi-Tasking Staff, ICAR-  
 CMFRI Mumbai Regional  
 Station, Mumbai,  
 Maharashtra, India

**Corresponding Author:**  
**Sugumar Ramkumar**  
 Senior Scientist, ICAR-CMFRI  
 Mumbai Regional Station,  
 Mumbai, Maharashtra, India

## Parasitism of *Pennella instructa* on indo-pacific sailfish *Istiophorus platypterus* and its commensality relation with goose barnacle, *Conchoderma virgatum* along Eastern Arabian Sea

**Sugumar Ramkumar, Mahendra Pandit Sonawane, Vaibhav Dinkar Mhatre, Punam Ashok Khandagale, Lakshmanan Ranjith and Vaibhav Milan Tawde**

DOI: <https://doi.org/10.33545/26174693.2024.v8.i6Sc.1287>

### Abstract

This study reports a parasite infection of *Pennella instructa* Wilson C.B., 1917, on Indo-Pacific Sailfish *Istiophorus platypterus* (Shaw, 1792) in a commercial fishing area off the Ratnagiri coast in the eastern Arabian Sea. It confirms the presence of the Epizoic cirripede, *Conchoderma virgatum* Spengler, 1789, on *P. instructa* as commensality attachment. It also confirms that *P. instructa* and *C. virgatum* have expanded their range to the North Eastern Arabian Sea.

**Keywords:** Copepodid, Marine parasite, Istiophoridae, Xiphidiidae, India

### Introduction

Global reports of *Pennella* (Copepoda: Siphonostomatoida: Pennellidae) infestations include pelagic fishes, cephalopods, marine mammals, and sea turtles, Kabata, 1979 & 1984 [27, 28]; Pascual *et al.*, 1997 [42]; Morales-Serna *et al.*, 2012 [32]; Nina *et al.*, 2002 [39]. This parasite infestation primarily affects the muscle tissue of the host, without infiltrating internal organs during its copepodid life stage, also known as a mesoparasitic life stage. The genus *Pennella* life cycle stages include two naupliar stages, followed by a copepodid stage, then a chalimus stage, and finally an adult stage. *Pennella*'s inseminated females use fish and marine mammals as their second host to produce fertile eggs, which they then release into the water (Garcia *et al.*, 2010; Mugetti *et al.*, 2021) [18, 33].

*Conchoderma virgatum*, an Epibionts pelagic bio fouling organism, attaches itself to a variety of marine species, including sea snakes, sharks (Beckett, 1968) [3], fish (Nagasawa *et al.*, 2020; Mesaglio *et al.*, 2022) [36, 31], penguins (Nascimento *et al.*, 2010) [37], whales Minke whale (Lafsdóttir & Shinn, 2013) [41], sea turtles (Angulo-Lozano *et al.*, 2007) [1], and whale barnacles (*Coronula* spp.). It prefers hard substrates or body structures, rough skin, carapace ridges, or epidermal abrasions for attachment, Eckert & Eckert, 1987 [11]; Beckett, 1968 [3]; Félix *et al.*, 2006 [14].

*Pennella* spp. globally host species of the family Istiophoridae (Marlins, Spearfish, and Sailfish), such as *Istiophorus platypterus* (Causey, 1960) [6]; *Kajikia albida*, *K. audax* (Hernandez-Trujillo, 2014) [21]; *Tetrapturus angustirostris* (Ho and Nagasawa, 2001); *Makaira mazara* (Ho and Nagasawa, 2001) [22]; and Xiphidae (Swordfish) such as *Xiphias gladius*, Hogans *et al.*, 1985 [25]; Castro-Pampillon *et al.*, 2002 [5]; Tanrikul and Akyol, 2011 [46].

*P. instructa* was infested with *I. platypterus* collected from India's south-east and south-west coasts (Devaraj and Bennet, 1972) [10]. Varghese *et al.*, (2009) [50] have reported *P. instructa* parasitic on *I. platypterus* from the north-west coast of India. Daniel and Premkumar (1967) [9] reported the occurrence of *Conchoderma virgatum* on *Pennella* sp., parasitic on *Cypsilurus speculiger*. However, Natarajan and Nair (1970) [38] reported an incident of *C. virgatum* attachment on a copepod parasite, *Lernaenicus hemiramphi* Kirtisinghe.

Fernando and Ramamoorthy (1974) discovered *C. virgatum* barnacle parasitism on a scyphozoan medusa, *Rhopilema* sp., in their umbrella region on the Tranquebar coast of the Bengala Gulf in Tamil Nadu. Lazarus and Sreenivasan (1980) reported the presence of *C. virgatum* on *Pennella diodontis* Oken. Pradeep *et al.*, (2016)<sup>[43]</sup> documented a parasitic infestation of *P. instructa* on *I. platypterus* in the Andaman Sea, with *C. virgatum* attached.

## Materials and Methods

Twenty specimens of Indo-Pacific Sailfish *I. platypterus* were examined from January to December 2023 from the fish landings of Harne, Anandwadi, Mirkarwada, and Sakri Nate fish landing centres on the Ratnagiri coast of Maharashtra, Eastern Arabian Sea. At the fishing landing centers in Harne, Anandwadi, and Sakri Nate-Mirkarwada, fishermen catch sailfish using hook and line, drift gillnet, and purse seine, respectively. Single-day fishing involves hook and line and drift gillnet, whereas multiday fishing uses purse seine (3-4 days). The Harne Fish landing centre practices hook-and-line fishing at a depth of 35 to 60 metres west of the Harne coast. The Anandwadi fish landing centre conducts drift gillnet fishing at a depth of 40 to 50 meters west of the coast. To the west and southwest of their shore, Sakri Nate and Mirkarwada purse seiners practice fishing at depths of 30 to 60 metres. Hook-and-line and drift gillnet fishing methods, which primarily target seer fish, incidentally take sailfish as by catch. Similarly, purse seine fishing targets Indian mackerel and oil sardines, capturing sailfish as by catch. Observed specimens of *P. instructa* and *C. virgatum*, preserved them in 5% formalin, and brought 10 specimens of *P. instructa* and *C. virgatum* to the laboratory for further analysis. Identifications and morphometric measurements of the specimens (copepod and barnacle) were done by following the studies of Danial and Premkumar (1967)<sup>[9]</sup>, Yamaguti (1963)<sup>[52]</sup>, Devaraj and Bennet (1972)<sup>[10]</sup>, Hastings (1972)<sup>[20]</sup>, Kabata (1979)<sup>[27]</sup>, Kabata (1984)<sup>[28]</sup>, Hogans (1986)<sup>[24]</sup>, Nagasawa *et al.* (2020)<sup>[36]</sup>, and Nascimento *et al.* (2010)<sup>[37]</sup>.

## Results

The copepod parasite *Pennella instructa* is visible in various parts of the sailfish's body, mostly in the ventral area. The dorsal side of the body and the caudal peduncle area exhibit some infections. Out of the 20 sailfish specimens, we found 23 specimens of the *P. instructa* copepod parasite and 14 specimens of *Conchoderma virgatum* adhering to *P. instructa*. Between January and December 2023, we found copepod parasites with associated barnacles (*C. virgatum*) infesting sailfish landings from Harne and Anandwadi fish landing centres. On the other hand, the Mirkarwada and Sakri Nate fish landing centres reported sailfish that had copepod parasite infections but no *Conchoderma* barnacle attachment. The year 2023 also revealed that these landing centres had year-round copepod parasite infections in their sailfish landings.

On the Harne Coast, hook-and-line fishing caught 15% of the sailfish with parasitic *P. instructa* infestations. Drift gillnet fishing at Anandwadi fish landings reported 19% of the sailfish caught with *P. instructa* infestation. The fish landings from the Sakri Nate purse seine revealed that 5% of the sailfish catch had *P. instructa* parasitism. Mirkarwada purse seine accounted for 8% of sailfish landings with *P. instructa* infections. On sailfish landings in Harne and

Anandwadi, *C. virgatum*'s commensality attachment to *P. instructa* was estimated at 4% and 7%, respectively.

## *Pennella instructa* Wilson C.B., 1917

*P. instructa* is a hematophagous marine copepod parasite from the family Pennellidae. In the current study, the total length of *P. instructa* ranged from 38 mm to 114.02 mm. In the majority of cases, thick fibrous cysts form in the host's flesh in the infection area. The parasite had a bulbous cephalosome with two long, unbranched horns on each side that extended posteriorly and parallel to the neck. The horns serve to secure the host. The cephalosome's flat anterior section is partially covered by papillae. The cephalosome and neck are yellow-coloured. The trunk is dark brownish in hue and connects the neck to the abdomen. The abdomen ends with feather-like structures known as plumules. The abdomen bears extended egg strings (Figure 1). The egg strings were yellow-coloured. Morphometric measurements of 10 specimens of *P. instructa* in this study are shown in Table 1. The photo of *P. instructa* and its infestation on *I. platypterus* is shown in Figures 2 and 3, respectively.

## *Conchoderma virgatum* Spengler, 1789

*Conchoderma virgatum*, the striped goose barnacle, of family Lepadidae, subclass Cirripedia was found adherent to *P. instructa*'s trunk in the present study. The total number of barnacle associations per parasite ranged from two to fourteen (Figure 4). The body (capitulum) and base stem (peduncle) meld closely. The capitulum has brown striations on a white background. The parasite attaches itself to the host using an extremely sticky, cement-like material. The barnacle's overall length ranges from 15 mm to 27.5 mm. *P. instructa* showed no obvious consequences of infestation other than attachment site inflammation by *C. virgatum*. The photo of *C. virgatum* attachment on *P. instructa* is shown in Figures 3 and 4.

## Seasonal variation

The parasite *P. instructa* infests *Istiophorus platypterus* year-round. From April to September, only large *P. instructa* parasites (over 90 mm) appeared on sailfish. Between October and December, *P. instructa*, with smaller sizes ranging from 38 mm to 78.9 mm, began to attach to sailfish in a mixed population of both small and large sizes. From February to April, *P. instructa* attachment on *I. platypterus* increases in intensity (6 to 14 numbers per sailfish), peaking in April (10 to 14 numbers per sailfish). After that, the density of *P. instructa* attachment on *I. platypterus* decreased until January (3 to 5 numbers per sailfish). We observed *C. virgatum* attachment on *P. instructa* from February to September 2023, with an increase in its intensity during April and May range from 3 to 14 numbers per parasite. However, there was a complete absence of *C. virgatum* attachment from October 2023 to January 2024.

## Discussions

Fish infections by *Pennella* sp. or spp. vary across time; in 1983, the highest infection rate in the western North Pacific was over 30%; after 1985, it dropped to less than 1% (Nagasawa *et al.* 1988; Yamaguchi and Honma 1992)<sup>[35, 51]</sup>. A *Pennella* pandemic struck in 2012, almost thirty years later, and the infection rates remained somewhat high until 2017 (Suyama *et al.*, 2019)<sup>[45]</sup>.

In the North Pacific, parasitism was relatively prevalent from May to August (pre-fishing season: May to July; fishing season: August to December), but it never exceeded 10% after September between 2012 and 2015 (Suyama S *et al.*, 2019) [45]. This highlights the importance of monitoring whether such a crisis has originated or is occurring in the waters of the Arabian Sea in Maharashtra in the coming years. Our study shows that the highest incidence of *P. instructa* on sailfish occurs between April and September. Additionally, we observed that *C. virgatum* attachment to *P. instructa* was highest during the months of April and September. The Maharashtra Coast has a lean fishing season from January to May, followed by a peak fishing season from August to November. During the lean fishing season, the occurrence of large size *Pennella* species parasitism was more prevalent. *Penella* significantly increases the prevalence of subcutaneous parasite infestations (Speare 1995) [44]. In this investigation, we observed the implanting of the sampled specimen of *P. instructa* in the subcutaneous tissue of *I. platyterus*. Numerous authors have documented the high specificity of *Pennella* spp. with regard to their host spectrum. For instance, studies have demonstrated that *Pennella balaenoptera* can infect marine mammals such as whales-fin whale, dolphins, porpoises, and pinnipeds (Cicek *et al.*, 2007; Fraija-Fernandez *et al.*, 2018; Marcer *et al.*, 2019; Hogans *et al.*, 1985) [7, 17, 30, 25]. Researchers have found similar reports of *Pennella filosa* infestations in dolphinfish (*Coryphaena hippurus*), Indo-Pacific sailfish (*Istiophorus platyterus*), striped marlin (*Kajikia audax*), blue marlin (*Makaira nigricans*), ocean sunfish (*Mola mola*), Atlantic bluefin tuna (*Thunnus thynnus*), albacore (*T. alalunga*), and swordfish (*Xiphias gladius*). Several Indian coastlines have been found to have *P. instructa* infestations in Indo-Pacific sailfish (*I. platyterus*). These include the Andaman Sea (Pradeep *et al.*, 2016) [43], the North West Coast (Varghese *et al.*, 2009) [50], the South West Coast (Vizhinjam & Theckhuvadi coast in the Gulf of Mannar), and the South East Coast (Devaraj and Bennet, 1972) [10]. More likely, *P. instructa* may select *I. platypus* as their specific host in Indian marine waters. Our study has discovered the occurrence of *P. instructa* infestation on *I. platyterus*, as well as the attachment of *C. virgatum* to *P. instructa*, from Ratnagiri coast of the Arabian Sea. Globally, sporadically documented *Penella* species infestations in the deep tissues and internal organs of the host, such as the heart, aorta, blood vessels, ovaries, intestines, and stomach (Suyama *et al.*, 2019; Speare, 1995) [45, 44]. In one case, Devaraj and Bennet (1972) [10] documented the presence of *P. instructa* infestation in the viscera of *I. platyterus* in Indian waters. Hence, there is a need for a focused research study to investigate the long-term infestation of *P. instructa* on different body sections of *I. platyterus* and other marine fish in Indian seas.

*C. virgatum* is commonly found attached to genus *Pennella* and other Lernaeid copepods that parasitize fish in the Indian Ocean, Pacific Ocean, Atlantic Ocean, and Mediterranean Sea (Balakrishnan, 1969) [2]. In their 1987 study, Eckert and Eckert determined that the period of barnacle attachment to the copepod can extend beyond 100 days, with a range of 9.5 to 128 days depending on the size of the barnacle. Hernandez-Trujillo *et al.* (2014) [21] proposed that the infestation of larger *P. filosa* copepods on Marlin fish might persist for a duration exceeding 4 months. Hence there is need of such studies on the attachment duration of these organisms on sailfish in the Arabian Sea of Indian waters.

Members of the Istiophoridae family had a swimming velocity exceeding 100 kilometres per hour. The presence of parasitic copepods and barnacles on fast-swimming sailfish leads to a decrease in their maximum swimming speed (6.5 km/s), requiring more muscular effort and increased energy expenditure. This also results in the weakening of both the swimming muscles and heart muscles of the sailfish (Holts and Bedford, 1990; Block *et al.*, 1992) [26, 4]. The presence of *Pennella* parasites on cultured tuna fish, which causes skin lesions and can lead to bacterial infections by *Aeromonas* sp., has a negative impact on the economic profitability of commercial fish farming (Toksen *et al.*, 2012; Munday *et al.*, 2003) [47, 34]. This also raises concerns regarding food safety. Observations in Indian markets so far revealed that sailfish affected by copepodiasis (Eissa *et al.*, 2012) [12] do not experience a significant decrease in their selling prices compared to non-infested sailfish. This is primarily due to the general public's lack of awareness regarding copepod infestation, the ignorance of infestation by wholesale dealers and marketing channels, the practice of selling sailfish chunks with the skin removed, which hides the infestation and removal of parasite by the fisherfolk at the time of harvest.

Estimated average landings of *I. platyterus* in the Maharashtra coast for five years from 2019 to 2023 were found to be 101.54 t, with the highest in 2019 at 295.66 t (FRAD, CMFRI 2019) and the latest in 2023 at 99.62 t (FRAD, CMFRI 2023). Varghese *et al.* (2004) estimated the *I. platyterus* catch rate in the EEZ of the north-western coast of India in the exploratory tuna long lining survey to be 39.42 kg/1000 hooks as by catch that constitutes 15% of the total catch. This shows that *I. platyterus* fish stock has the potential to contribute economically to the commercial fishing of the north-west coast of India, comprising the Maharashtra and Gujarat coasts, either as by catch or main catch. Hence, it is very essential to study the copepodid parasitism (*Pennella* sp. or *P. instructa*) impact on the sailfish resources, with an emphasis on the sailfish recruitment dynamics, mean size, and its potential yield.

**Table 1:** Morphometric measurements of 10 specimens of *P. instructa* of the present study

Specimens	Body Parts (size in mm)									
	1	2	3	4	5	6	7	8	9	10
Total length-TL (Cephalothorax tip to Abdomen tip)	111.92	113.38	114.02	101.41	89.61	94.75	101.93	112.90	112.2	104.26
Cephalothorax length-CL	6.04	9.58	9.63	5.29	4.67	4.15	4.23	9.46	9.02	5.70
Cephalothorax horn length-CHL	4.83	8.37	8.41	4.23	3.74	3.32	3.38	4.94	4.23	3.93
Neck region length-NRL	48.01	50.08	50.34	42.59	43.92	39.60	41.24	49.52	50.29	43.88
Trunk length-TL	37.55	37.31	37.52	31.67	33.01	38.00	39.00	37.14	36.93	34.32
Abdomen Length-AL	20.33	16.41	16.50	21.86	8.01	13.00	17.46	16.78	15.96	20.36





**Fig 1:** *P. instructa* with egg string isolated from the dorsal body of *I. platypterus*

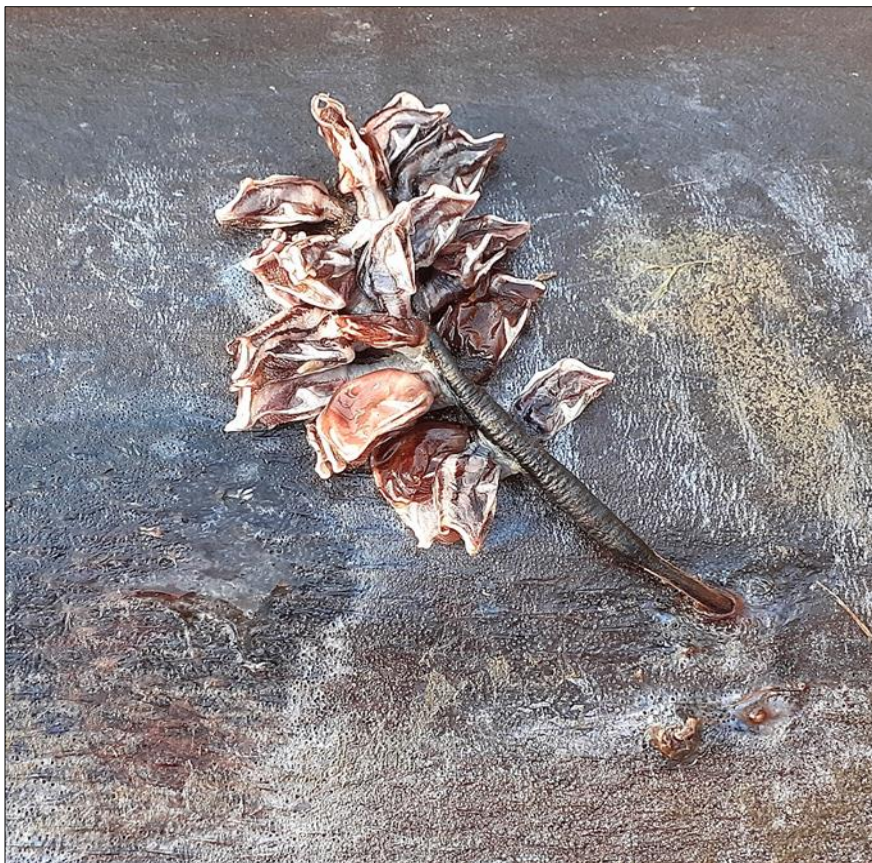


**Fig 2:** *P. instructa* without egg string isolated from the dorsal body of *I. platypterus*



**Fig 3:** *C. virgatum* attachment to the *P. instructa*, parasite infestation in *I. platypterus*





**Fig 4:** *C. virgatum* association on a single specimen of *P. instructa* in *I. platypterus*

#### Acknowledgments

We acknowledge the ICAR-CMFRI Mumbai Regional Station and Director, ICAR-CMFRI, for their support in providing access to funds for sampling and lab facility utilisation.

#### Conclusion

This study highlights the significant presence of *Pennella instructa* and its epibiont *Conchoderma virgatum* on Indo-Pacific sailfish (*Istiophorus platypterus*) along the Ratnagiri coast of Maharashtra, Eastern Arabian Sea. The year-round infestation of *P. instructa* and the seasonal attachment of *C. virgatum* were notable, with higher rates observed from April to September. These parasitic copepods and barnacles can impact sailfish health and swimming efficiency, potentially affecting commercial fishing yields. The study emphasizes the need for continuous monitoring and focused research on the parasitic dynamics and their implications on marine fisheries, ensuring the sustainability and economic viability of sailfish resources in Indian waters.

#### References

- Lozano AL, Nava-Duran PE, Frick MG. Epibionts of olive ridley turtles nesting at Playa Ceuta, Sinaloa, Mexico. *Mar Turtle News*. 2007;118:13-14.
- Balakrishnan KP. Observations of the occurrence of *Conchoderma virgatum* (Spangler) (Cirripedia) on *Diodon hystrix* Linnaeus (Pisces). *Crustaceana*. 1969;16:101-103.
- Beckett JS. New records of the barnacle *Conchoderma virgatum* in the northwest Atlantic. *J Fisheries Res Board Canada*. 1968;25:2707-2710.
- Block BA, Booth D, Carey FG. Direct measurement of swimming speeds and depth of blue marlin. *J Exp. Biol*. 1992;166:267-284.
- Pampillon C, Bua JASM, Dominguez RH, Garcia MJ, Fernandez AC, Estevez GJM. Selecting parasites for use in biological tagging of the Atlantic swordfish (*Xiphias gladius*). *Fish. Res*. 2002;59:259-262.
- Causey D. Parasitic copepoda from Mexican coastal fishes. *Bull. Mar. Sci. Gulf Carib*. 1960 ;10:323-337.
- Cicek E, Oktener A, Capar OB. First report of *Pennella balaenoptera* Koren and Danielsson, 1877 (Copepoda: Pennellidae) from Turkey. *Turk. Parazitol. Derg*. 2007;31:239-241.
- FRAD, CMFRI. Marine Fish Landings in India 2019. Technical Report. ICAR-Central Marine Fisheries Research Institute, Kochi; c2019.
- Daniel A, Premkumar VK. Pedunculate cirripedes, *Conchoderma virgatum* (Spangler) attached to a pennellid copepod, *Pennella* sp., parasitic on a flyingfish, *Cypsilurus speculiger* (Cuv. ET Val.), *J Bom Nat Hist Soc*. 1967; 64:132-133.
- Devaraj M, Bennet SP. *Pennella instructa* Wilson (Copepoda), parasitic on the Sailfish, *Istiophorus platypterus* (Shaw and Nodder). *Indian J of Fish*. 1972;19:171-175.
- Eckert KL, Eckert SA. Growth rate and reproductive condition of the barnacle *Conchoderma virgatum* on gravid leatherback sea turtles in Caribbean waters. *J Crust Biol*. 1987;7:682-690.
- Eissa IAM, El-Lamie M, Zakai M. Studies on crustacean diseases of seabass, *Morone Labrax*, in Suez Canal, Ismailia Governorate. *Life Sci. J* 2012;9:512-518.

13. Fernando A, Ramamoorthi K. Rare occurrence of *Conchoderma virgatum* (Spengler, 1790), (Cirripedia-Lepadomorpha) on a scyphozoan medusa. *Current Science India*. 1974;43:126.
14. Félix F, Bearson B, Falconí J Epizoic barnacles removed from the skin of a humpback whale after a period of intense surface activity. *Mar Mammal Sci*. 2006;22:979-984.
15. FRAD, CMFRI. Marine Fish Landings in India 2019. Technical Report. ICAR-Central Marine Fisheries Research Institute, Kochi; c2019.
16. FRAD, CMFRI. Marine Fish Landings in India 2023. Technical Report. ICAR-Central Marine Fisheries Research Institute, Kochi; c2023.
17. Fernández FN, Hortelano HA, Baraja AAE, Raga JA, Aznar FJ Taxonomic status and epidemiology of the mesoparasitic copepod *Pennella balaenoptera* in cetaceans from the western Mediterranean. *Dis. Aquat. Organ*. 2018;128:249-258. Available from: DOI: 10.3354/dao03226.
18. Garcia AM, Sureda EM, Gonzalez PG. *Pennella filosa* (Linnaeus, 1758) (Copepoda, Siphonostomatoida, Pennellidae) from *Coryphaena hippurus* (Pisces, Coryphaenidae) in western Mediterranean (Balearic Islands). *Morphol Biol Aspects. Nereis*. 2010;3:33-35.
19. Garcia AM, Sureda EM, Gonzalez PG. *Pennella filosa* (Linnaeus, 1758) (Copepoda, Siphonostomatoida, Pennellidae) from *Coryphaena hippurus* (Pisces, Coryphaenidae) in western Mediterranean (Balearic Islands). *Morphol Biol Aspects. Nereis* 2010;3:33-35.
20. Hastings RW. The barnacle, *Conchoderma virgatum* (Spengler), in association with the isopod, *Nerocila acuminata* Schioedte & Meinert, and the orange filefish, *Alutera schoepfi* (Walbaum). *Crustaceana*. 1972;22:274-278.
21. Trujillo HS, Rodriguez FR, Armas RG, Garcia OS. New record of the mesoparasitic copepod *Pennella Filosa* (L. 1758) on striped marlin *Kajikia audax* (Collette, 2006) from Cabo San Lucas, Baja California Sur, Mexico. *J Appl. Ichthyol*. 2014;30:1028-1030. Available from: doi:10.1111/jai.12349.
22. Ho JS, Nagasawa K. New records of parasitic Copepoda from the offshore pelagic fishes of Japan. *Bull. Nat. Res. Inst. Far Seas Fish*. 2001 Mar;38:1-5.
23. Ho JS. Maxillopoda-Copepoda. Siphonostomatoida. In: Young PS, editor. *Catalogue of crustacea of Brazil*. Museu Nacional. Serie Livro, Rio de Janeiro, c1998. p. 235-240.
24. Hogans W E. Redescription of *Pennella instructa* Wilson, 1917 (Copepoda: Pennellidae) from the swordfish. *Canadian J Zool*. 1986;64:727-730.
25. Hogans WE, Bratney J, Hulbut TR. *Pennella filose* and *Pennella instructa* (Copepoda: Pennellidae) on swordfish (*Xiphias gladius* L.) from the Northwest Atlantic Ocean. *J Parasitol*. 1985;71:111-112.
26. Holts D, Bedford D. Activity patterns of striped marlin in the southern California bight. In: Stroud RH. Editors, *Planning the future of billfishes*. National Coalition for Marine Conservation, Savannah, Georgia; c1990. p. 81-93.
27. Kabata Z, Editor. *Parasitic Copepoda of British Fishes*. The Ray Society, The British Museum, London; c1979.
28. Kabata Z. Diseases caused by Metazoans: Crustaceans. In: Kinne O, editor. *Diseases of Marine Animals 4<sup>th</sup> ed.*, Biologische Anstalt Helgoland, Hamburg; c1984. p. 73-183.
29. Reino LM, Abollo E, Pascual S. Morphological and genetic identification of *Pennella instructa* (Copepoda: Pennellidae) on Atlantic swordfish (*Xiphias gladius*, L. 1758). *Fish. Res*. 2019; 209:178-185. Available from: DOI: 10.1016/J.fishres.2018.09.012
30. Marcer F, Marchiori E, Centelleghè C, Ajzenberg D, Gustinelli A, Meroni V, *et al*. Parasitological and pathological findings in fin whales *Balaenoptera physalus* stranded along Italian coastlines. *Dis. Aquat. Organ*. 2019;133:25-37. Available from: DOI: 10.3354/dao03327
31. Mesaglio T, Dowse M, McMartin G. First record of the barnacle *Conchoderma virgatum* on an ephippid fish. *Journal of the Marine Biological Association of the United Kingdom* 2022;102(3-4):174-177. Available from: <https://doi.org/10.1017/S0025315422000340>.
32. Serna MFN, Gomez S, León PPDG. Parasitic copepods reported from Mexico. *Zootaxa*. 2012;3234:43-68, DOI: 10.11646/zootaxa.3234.1.2.
33. Mugetti D, Colombino E, Menconi V, Garibaldi F, Mignone W, Gustinelli A, *et al*. Unusual Localization of *Pennella* sp. in Swordfish (*Xiphias gladius*) Hearts. *Animals*. 2021; 11(6):1757. Available from: <https://doi.org/10.3390/ani11061757>.
34. Munday BL, Sawada Y, Cribb T, Hayward CJ: Diseases of tunas, *Thunnus* spp. *J Fish Dis*. 2003;26:187-206.
35. Nagasawa K, Imai Y, Ishida K. Long-term changes in the population size and geographical distribution of *Pennella* sp. (Copepoda) on the saury, *Cololabis saira*, in the western North Pacific Ocean and adjacent seas. *Hydrobiologia*. 1988;167:571-577.
36. Nagasawa K, Otani T, Nagahama T. ゴマフグの鰓腔部に多数着生したスジエボシ [Parasitic *Conchoderma virgatum* on the branchial cavity of a puffer fish]. *Nature of Kagoshima: An Annual Magazine for Naturalists*. 2020;46:243-246.
37. Nascimento C, Vanstreels R, Niemeyer C, Ruoppolo V, Dias CJ Occurrence of pedunculate barnacles (*Conchoderma virgatum*) (Cirripedia: Thoracica) on Magellanic penguins (*Spheniscus magellanicus*). *Boletín Chileno de Ornitología*. 2010;16:105-111.
38. Natarajan P, Nair BN. An instance of occurrence of *Conchoderma virgatum* (Spengler) on *Lernaenicus hemirhamphi* Kirtisinghe. *Curr Sci*. 1970; 39(23):545.
39. Nina LA, Pablo A, Izaskun P. The first naupliar stage of *Pennella balaenopterae* Koren and Danielssen, 1877 (Copepoda: Siphonostomatoida, Pennellidae). *Sarsia* 2002;87:333-337.
40. Ökter, A. *Pennella instructa* Wilson, 1917 (Copepoda: Pennellidae) on the cultured greater amberjack, *Seriola dumerili* (Risso, 1810). *Bull Europ Asso Fish Patholog*. 2009;29(3):98-100.
41. Ólafsdóttir D, Shinn AP. Epibiotic macrofauna on common minke whales, *Balaenoptera acutorostrata* Lacépède, 1804, in Icelandic waters. *Parasites Vectors*. 2013;6:1-10.
42. Pascual S, Gestal C, Abollo E. Effect of *Pennella* sp. (Copepoda, Pennellidae) on the condition of *Illex coindetii* and *Todaropsis eblanae* (Cephalopoda, Ommastrephidae). *Bull. Eur. Ass. Fish Pathol*. 1997;17:91-95.

43. Pradeep HD, Swapnil SS, Monalisha Devi S. Report of Epizootic Cirripede, *Conchoderma virgatum* (Spengler, 1790) on *Pennella instructa* (Wilson, 1917) parasitic on Indo-Pacific Sailfish *Istiophorus platypterus* caught from Andaman Sea. J Entomology Zoology Studies. 2016;4(4):1208-1210.
44. Speare P. Parasites as biological tags for sailfish, *Istiophorus platycephalus* from east coast Australian waters. Mar. Progress Ser. 1995;118:43-50.
45. Suyama S, Masuda Y, Yanagimoto T, Chow S. Genetic and morphological variation in *Pennella* sp. (Copepoda: Siphonostomatoida) collected from Pacific saury *Cololabis saira*. Mar. Biodivers. 2019;49:1233-1245.
46. Tanrikul TT, Akyol O. First record of the parasitic Copepoda, *Pennella filosa* (L., 1758), on swordfish from the Turkish Aegean Sea. J Appl. Ichthyol. 2011; 27:1392-1393.
47. Toksen E, Nemli E, Degirmenci U, Karacalar U. Parasitic diseases and their controls in sustainable development of aquaculture of bluefin tuna (*Thunnus thynnus*). 3rd Int. Symp. Sustainable Dev., Sarajevo; 2012 May 31 -June 01; p. 41-50.
48. Tuncer S, Celik ES, Oktener A. *Pennella filosa* (L. 1758) (Copepoda: Pennellidae) on Greater Amberjack, *Seriola dumerili* (Risso, 1810) from Turkey. Electron. J Ichthyol. 2010; 6:27-30.
49. Varghese S, Somvanshi VS, Sijo PV. Distribution, abundance and biology of Indo-pacific Sailfish, *Istiophorus platypterus* (Shaw and Nodder, 1792) in the north-western Indian EEZ. Occ. Pap. Fish. Surv. India. 2004;11: 1-5.
50. Varghese S, Somvanshi VS, Sijo PV. Occurrence of epizootic Cirripede, *Conchoderma virgatum* (Spengler, 1790) on *Pennella instructa* Wilson infected on Sailfish *Istiophorus platypterus* caught from north-west Indian EEZ, J Bombay Nat Hist Soc. 2009;106(3):344-346.
51. Yamaguchi M, Honma T. Parasitological study of the migration route of the Pacific saury, *Cololabis saira*, to the Okhotsk Sea. Sci Re Hokkaido Fish Exp Sn. 1992;39:35-44.
52. Yamaguti S, Editor. Parasitic copepoda and branchiura of fishes. Interscience Publishers, New York; c1963.