Infection of the Parasitic Isopods on Commercial Fishes of the Northern Part of the East Coast of India

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Abstract

The present study report the parasitic isopod infection on commercial fishes of the northern part of the east coast of India collected during the period 2010-2015 from the marine water of Odisha and West Bengal. During the study, 394 isopods were collected after examining 2668 fishes. These include 14 species of isopods, out of which 13 belong to 5 genera under the family Cymothoidae, and a single species *Alitropus typus* belongs to the family: Aegidae. Of theses, 03 species viz., *Catoessa boscii*, *Cymothoa eremita* and *Nerocila loveni* are first record to the northern part of east coast of India. Out of the 2668 fishes examined, 326 examples belonging to 34 species under 19 different families were infected by different isopods. Member of the host fish family Carangidae was more parasitized by isopods, followed by Clupeidae, Scoberidae, and Leiognathidae. The dominant isopods were *Nerocila phaiopleura* and *Catoessa boschii*. The total prevalence was 12.21. The prevalence was high on the host fish *Alepes djedaba* and lowest on *Lutjanus johnii*. The total infection caused by genus *Alitropus* was 1.52%, *Anilocra* was 5.07%, *Catoessa* was 24.87%, *Cymothoa* was 0.25%, *Nerocila* was 65.73%, and *Norileca* was 2.55%. The isopod prevention was high during the post-monsoon and low during the monsoon period.

Introduction

The parasitic isopods usually occur in the freshwater, estuarine and marine ecosystem, especially near the coastal environment. In these ecosystems, they play an essential role in the ecological food chain and removal of the decaying matter (Bharadhirajan 2014). Besides this ecological role, the study of these isopods is also important as they cause a range of damages to the fishes, thereby threatening the fisheries sector (Mohapatra et al. 2021; Seth et al. 2020 a, b; 2021). Out of the 144 known isopod families, only a few are parasitic. The family Cymothoidae is one of the most prominent families of the order Isopoda. The representative of the family is the obligate parasites, known to show a high degree of the host and site-specificity to the host fishes Ravichandran et al. (2019). However, in some species, host specificity is weak.

The family Cymothoidae consists of more than 380 species under 43 genera worldwide (Smith et al. 2014). Of these, 48 valid species under 16 genera are reported from Indian water (Ravichandran et al.2019). The adult forms of the family Aegidae White, 1850 of the order Isopoda, are considered temporary parasites as they often leave their host after a blood meal. Due to this nature, they have been recently classified as free-living micro-predators (Ravichandran et al. 2019). The family Aegidae includes around 152 species under 8 genera worldwide (Al-Zubaidy and Mhaisen 2014). The genus *Alitropus* H. Milne Edwards, 1840 is monotypic contains the only species *A. typus* (Yule and Sen 2004). This species primarily occurs in the coastal ecosystem's fresh water and low salinity zone (Bruce 1983).

In India, most of the reports and records on parasitic isopods are concentrated around the south-east coast of India (Ravichandran et al. 2019). There are reports on the isopods parasites from the northern part of the east coast of India (NPECI), mainly from the state of Odisha and West Bengal (Chliton 1924; Seth et al. 2014; Dev Roy et al. 2015; Behera et al. 2016; Ray et al. 2016; Dev Roy and Rath 2017; Balakrishnan and Tudu 2020; Ray et al. 2020; Seth et al. 2020 a, b; Mohapatra et al. 2021; Seth et al. 2021), but still, a comprehensive report is lacking (Seth et al. 2020 a, b; 2021). Further, on the prevalence of these isopods on the host fish species, there is hardly any report from the NPECI. Therefore, this study was carried out to know the infection and prevalence of these isopods along the NPECI.

Materials And Methods

During the study period (August 2010-January 2015), a routine observation (at the rate of 3-5 days per month/seasons) of the marine fishes from different selected fish landing stations of the NPECI viz. West Bengal (Digha, Shankarpur, Junput, Hijli-Dariapur, Kakdwip-Namkhana, and Sagar Island) and Odisha (Talsari, Chandipur, Dhamra, Paradip, Puri, Chilika, and Gopalpur) were conducted. Fishes and isopod were collected from fish landing centers where trawl net and gill net generally operated; some samples were also collected from shore seine nets. Fishes were checked carefully for ectoparasitic infection on their body surface, fins, gill, and buccal cavity. After photography, isopods were removed from their attachment sites with the help of fine forceps and placed into 70% ethanol. The isopods were examined using Leica-EZ4 microscope. Isopods were identified according to Trilles (1975 and 1979), Bowman and Tareen (1983), Bruce (1887), Rameshkumar et al. (2011) and (2012), and Trilles et al. (2013). The prevalence was calculated according to Margolis et al. (1982). Host species identification was based on Fischer and Bianchi (1984), Talwar and Kacker (1984), Froese and Pauly (2020). Specimens were deposited and registered in the Marine Aquarium and Regional Center (MARC), Zoological Survey of India, Digha. The specimens of *A. typus* was deposited and registered in Estuarine Biology Regional Centre, Zoological Survey of India, Gopalpur-on-Sea, Odisha. The registered specimens along with their voucher number are presented in table 1.The seasonal impacts of the parasites on the host were also examined.

Results

During the study, 14 species of parasitic isopods were found (Figure 1); from those, 13 species belong to family Cymothoidae and 01 species to the family Aegidae. Out of theses 14 species, 03 species viz., *Catoessa boscii*, *Cymothoa eremita* and *Nerocila loveni* are first record to the NPECI. Few selected photographs of hosts and their parasites collected during the study period are presented in figure 2. A comprehensive list of the isopods species along with their host collected during the study period and earlier report form Indian water are presented in Table 2. During this study, it was observed that isopods parasitized 34 species of host fishes under 19 families. Number of host fish species examined and parasitized by isopods are presented in Figure3. Most of the isopod attached with host species mainly three regions: body surface, buccal cavity, and inside the gill membrane (Branchial parasite). Host family-wise infection by isopods is provided in figure 4. Member of the family Carangidae are more parasitized by the isopods followed by Clupeidae, Scomberidae, and Leiognathidae (Figure 4). The percentage of dominating isopods genus wise and species wise are provided in figures 4 and 5 respectively. The dominating genus was *Nerocila* (Figure 5), *Nerocila phaeopleura* and *Catoessa boschii* are the main dominant isopod in these areas (Figure 6).The seasonal variation of isopod infection is presented in figure7. The Isopod prevalence was high during October to February (Post monsoon season of the study areas) and very low during April to August (monsoon season of the study areas) (Figure7). The prevalence is provided in table3. Total prevalence was 12.21. The prevalence was highest on *Alepes djedaba* (34.95) and lowest on *Lutjanus johnii* (1.29).

Discussion And Conclusion

The parasitic isopods viz., *Catoessa boscii*, *Cymothoa eremita*, and *Nerocila loveni* were not recorded earlier from the NPECI; therefore, this is the first materials evidence of these parasites from these regions. Further, the host record of *Alepes djedaba, Alepes kleinii,* and *Leiognathus blochii* for the parasite *Catoessa boschii;* the host record of *Sardinella longiceps*, *Lactarius lactarius*, and *Leiognathus blochii* for the parasite *Anilocra*

dimidiata; the host *Carangoides malabariucus* for the parasite *Nerocila depressa,* the host *Equulites leuciscus* for the parasite *N. loveni,* the host fish species *Siganus javas*, and *Epinephelus coioides* for the parasite *N. phaiopleura*, the host fish species *Alepes djedaba* for the parasite *N. poruvae*, the host fish species *Arius arius*, and *Terapon jarbua*, *Plotosus lineatus*, *Nibea maculate* for the parasite *N. serra,* and the host fish species *Nemipterus japonicus*, and *Priacanthus tayneus* for the parasite *N. sigani* are the new host records for the northern part of east coast of India (Table2).

As these isopods are connected with many host species during the study period (Figure 3 and 4, Table 2 and 3), it indicates higher diversity of fishes in the NPECI. The *Nerocila* is the dominating genus during the study period (Figure 5 and 6), which shows the high adaptability of the species of the genus to a range of environmental conditions prevailing in these regions. The high prevalence of isopod on the host species *Alepes djedaba* (Table3) may be due to the higher host-specificity of parasitic isopods for this host species in these regions.

The Isopod prevalence was high during post-monsoon than monsoon (Figure7). It may occur due to the lesser salinity of the water in these sampling areas during the monsoon period compared to post-monsoon. During monsoon, lower salinity is due to higher rainfall and freshwater discharge through estuarine influence. During post-monsoon, salinity gradually increases, and this condition facilitates the isopods infestation. During this study, it is observed that most of the *Nerocila* species were ovigerous throughout the year, but the prevalence was high during post-monsoon; thus, optimum salinity may be the reason and is helping in larval development. In many free-living crustaceans, post-monsoon plays a vital role in their breeding, and climatic conditions affect the reproduction of Cymothoidae (Sudha and Anilkumar 1996; Syama et al. 2010; Leanarods and Trilles 2003).

In recent times, study on the infection and prevalence of parasitic isopods on commercial fishes were reported from Paranagipettai coast, India (Bharadhirajan, 2014), Malabar Coast, India (Aneesh et al. 2016; Rijin et al. 2017), Mirri, East Malaysia (Anand Kumar et al.2015, 2017), Atlantic menhaden (Rose et al.2020) and other parts of the globe as well. However, before the present report, no such comprehensive study based on the infection parasitic isopods on the commercial fishes of NPECI was reported. Therefore, the extension of this work on the infection pattern and other aspects of the host-parasite relationship in these regions will provide more insight into the isopods biology.

Declarations

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Conflict of interest statements

Authors declare that they have no conflict of interest.

Research involving human participants and/or animals

Since the animals are not under schedule lists/protected categories, so ethical clearance is not applicable.

Informed Consent

Not applicable

Funding

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References

Anand Kumar A, Rameshkumar G, Ravichandran S, Priya ER, Nagarajan R, Alex Goh (2015) Occurrence of cymothoid isopod from Miri, East Malaysian marine fishes. J Parasit Dis 39(2):206–210.

Anand Kumar A, Rameshkumar G, Ravichandran , Nagarajan R, Prabakaran K , Ramesh M (2017) Distribution of isopod parasites in commercially important marine fishes of the Miri coast, East Malaysia. J Parasit Dis 41: 55–61. https://doi.org/10.1007/s12639-016-0749-6

Al-Zubaidy AB, Mhaisen FT (2014) The first record of four isopods from some red sea fishes, Yemeni coastal waters. Bull Iraq Nat Hist Mus
13 (1): 35-51

Aneesh PT, Helna AK, Sudha K (2016) Branchial cymothoids infesting the marine food fishes of Malabar coast. J Parasit Dis 40 (4):1270–1277.
https://doi.org/10.1007/s12639-015-0666-0

Aneesh PT, Helna AK, Valarmathi K, Chandra K, Mitra S (2017) Redescription of *Nerocila exocoeti* Pillai, 1954 (Crustacea: Isopoda:
Cymothoidae) parasitic on beloniform (Exocoetidae and Hemiramphidae)
hosts with *Nerocila madrasensis* Ramakrishna & Ramaniah, 1978 placed into
synonymy. Zootaxa 4365 (3): 385–394.

Aneesh PT, Sudha K, Arshad K, Anil kumar G, Trilles JP (2013) Seasonal fluctuation of the prevalence of Cymothoids representing the genus *Nerocila* (Crustacea, Isopoda), parasitizing commercially exploited marine fishes from the Malaber coast, India. Acta Parasitol 58(1). 80-90.

Bal DV, Joshi UN (1959) Some new isopod parasites on fishes. J Bombay Nat Hist Soc 56:563–569.

Balakrishnan S, Tudu PC (2020) New host records for *Nerocila depressa* Milne Edwards, 1840 (Crustacea, Isopoda, Cymothoidae) from Digha coast, Bay of Bengal, India. Indian J Geo-Mar Sci 49(4):698–702. http://nopr.niscair.res.in/handle/123456789/54638

Barnard KH (1936) Isopods collected by the R.I.M.S. “Investigator”. Records of the Indian Museum, Calcutta, 38:147–191.

Behera, PR, Ghosh S, Pattnaik P, Rao MV (2016) Maiden occurrence
of the isopod, *Norileca indica* (H. Milne Edwards, 1840) in
pelagic and demersal finfishes of Visakhapatnam waters along

north-west Bay of Bengal. Indian J Geo-Mar Sci 45(7):856–862. http://nopr.niscair.res.in/handle/123456789/35129

Bharadhirajan P, Murugan S, Sakthivel A Selvakumar P (2014) Isopods parasites infection on commercial fishes of Parangipettai waters, southeast coast of India. Asian Pac J Trop Dis 4 (Suppl 1): S268-S272. https://doi.org/10.1016/S2222-1808(14)60453-9

Bowman TE, Tareen IU (1983) Cymothoidae from fishes of Kuwait (Arabian Gulf) (Crustacea: Isopoda). Smit Contrib Zool 382:1–30.

Bruce NL (1983) Aegidae (Isopoda: Crustacea) from Australia with descriptions of three new species. J Nat Hist 17:757-788. https://doi.org/10.1080/00222938300770591

Bruce NL (1987) Australian species of *Nerocila* Leach, 1818, and *Creniola* n. gen. (Isopoda: Cymothoidae), crustacean parasites of marine Fishes. Rec Aus Mus 39:355–412.

Bruce NL, Harrison-Nelson EB (1988) New records of fish parasitic marine Isopod Crustaceans (Cymothoidae, subfamily Anilocrinae) from the Indo-West Pacific. P Biol Soc Wash 101: 585–602.

Chidambaram K, Menon DM (1945) The isopod parasite *Nerocila sundaica*, on West Coast food fishes. Curr Sci 14 (11): 308 pp

Chilton C (1924) Fauna of the Chilka Lake. Tanaidacea & Isopoda. Memoirs of the Indian Museum 5: 875–895.

Dev Roy MK (2012) A systematic list of isopod fauna hitherto known from India. Zoological Survey of India, Crustacea Section, 1-20.

Dev Roy MK, Mitra S (2013) New host record for *Nerocila sigani* (Isopoda:Cymothoidae) from Odisha coast, India. Curr Sci 104 (9): 1134-1135.

Dev Roy MK, Mitra S, Gokul A (2012) On a new host record of *Nerocila poruvae* (Crustacea: Isopoda: Cymothoidae) From West Bengal. J. Environ. & Sociobiol 9(1):105-107.

Dev Roy MK, Rath, S (2017) An inventory of crustacean fauna from Odisha coast, India. J Environ Sociobiol 14(1):49–112.

Dev Roy MK, Rath, S, Mitra S, Mishra SS (2015) Rabbit fish *Siganus canaliculatus*-a new host record for isopod parasite *Nerocila arres* Bowman and Tareen, 1983. J Bombay Nat Hist Soc 112(3):177–178. http://dx.doi.org/10.17087/jbnhs%2F2015%2Fv112i3%2F114432 .

Fischer W,Bianchi G (eds) (1984) FAO Species Identification sheets for Fishery purpose, Western Indian Ocean; (Fishing area 51), (Prepared and printed with the support of the Danish International Development Agency (DANIDA). Rome, Food and Agricultural Organization of the United Nations) vols 1-6: pag. var.

Froese R, Pauly D (2021) FishBase. World Wide Web electronic publication. Available from: http://www.Fishbase.org, Version (06/2021). Accessed 27 July 2021.

Ghatak SS (1998) Crustacea: Isopod. State fauna Series 3: Fauna of West Bengal, Part 10, Zool Surv India 315-327.

Jayadev Babu S, Sanjeeva Raj PJ (1984) Isopod parasites of fish of Pulicat Lake. Proceedings Symposium of Coastal Aquaculture (Fin Fish) 3: 818–823.

Jemi JN, Hatha AAM, Radhakrishnan CK (2020) Seasonal variation of the prevalence of cymothoid isopod *Norileca indica* (Crustacea, Isopoda), parasitizing on the host fish *Rastrelliger kanagurta* collected from the Southwest coast of India. J Parasit Dis 44: 314–318. https://doi.org/10.1007/s12639-020-01208-6 .

Leonardos I, Trilles JP (2003) Host-parasite relationships: occurrence and effect of the parasitic isopod *Mothocya epimerica* on sand smelt *Atherina boyeri* in the Mesolongand Etolikon Lagoons (W. Greece). Dis aquat Org 54: 243–251.

Margolis L, Esch GW, Holmes JC, Kuris AM, Schad GA (1982) The use of ecological terms in parasitology (report of an ad hoc committee of the American Society of Parasitologists). J Parasitol 68: 131-133.

Mitra S, Dev Roy MK (2011) On a new host record of *Alitropus typus* (Crustacea:Isopoda: Aegidae) and a new record from a freshwater river system of West Bengal. J Environnt Sociobiol 8(2):269– 271.

Mohapatra SK, Mohanty SR, Behera RK, Seth JK, Mohapatra A (2021) First record of *Mothocya renardi* and *Mothocya collettei* (Isopoda: Cymothoidae) from northern part of East Coast of India and new host record of *Mothocya collettei*. J Parasit Dis 45:651–654. https://doi.org/10.1007/s12639-021-01348-3

Nair GA, Nair NB (1983) Effect of infestation with the isopod, *Alitropus typus* M. Edwards (Crustacea: Flabellifera: Aegidae) on the haematological parameters of the host fish Channa striatus (Bloch). Aquac 30:11–19.

Neeraja T, Tripathi G, Shameem U (2014) Occurrence of the isopod, *Nerocila indiaca* (Isopoda: Cymothoidae) on bigeye scad, *Selar crumenophthalmus* (Bloch) off Mumbai coast, India. Indian J Fish 61(1): 49-56.

Parimala S (1984) *Nerocila pigmentata* Bal & Joshi (Isopoda: Cymothoidae) parasitic on *Nematalosa nasus* (Bloch). J Mar Biol Ass India 21(for 1979):180–181.

Parveen Rattan, Parulekar AH (1998) Diseases and parasites of laboratory reared and wild population of banded pearl spot *Etroplus suratensis* (Cichlidae) in Goa. Indian J Mar Sci 27(3-4):407–410.

Pillai NK (1954) A preliminary note on the Tanaidacea and Isopoda of Travancore. Bulletin of the Central Research Institute, University of Travancore (C) 3, no. 1, 1–21.

Raja K, Vijayakumar R, Karthikeyan V, Saravanakumar A, Sindhuja K, Gopalakrishnan A (2014) Occurrence of isopod *Nerocila phaiopleura* infestation on Whitefin wolf-herring (*Chirocentrus nudus*) from Southeast coast of India. J Parasit Dis 38(2):205-207.

Rajkumar M, Perumal P (2004) Effect of Isopod parasite, *Nerocila pheaopleura* on *Stolephorus commersonii* Fish from Parangipettai coastal waters (south east coast of India). Appl Fish Aqua IV (2):17–23.

Rajkumar M, Perumal P, Trilles JP (2006) On the occurrence of a double parasitism (copepod and isopod) on the anchovy fish in India. J Environ Biol 27(3): 613-614.

Rajkumar M, Thavasi R, Trilles JP, Perumal P (2008) Vibriosis and Parasitic Isopod Infections in the Black Fin Sea Catfish, *Arius jella*. Advances in Aquatic Ecology, 2, Chapter 13:102–109.

Ramakrishna G, Ramaniah V (1978) A new cymothoid of the genus *Nerocila* from Madras. Bull Zool Sur Ind 1: 177–180.

Rameshkumar G, Ramesh M, Ravichandranm S, Trillers, JP, Shobana C (2015b) *Nerocila sundaica* (Isopoda, Cymothoidae) parasitizing *Otolithes ruber* from Nagapattinam, Southeast coast of India J Parasit Dis 39(4):789-92.

Rameshkumar G, Ramesh, M, Ravichandran, S, Trillers, JP, Subbiah S (2015a) New record of *Norileca* indica from the west coast of India. J Parasit Dis 39(4):712-5.

Rameshkumar G, Ravichandran S (2010) New Host Record, *Rastrelliger kanagurta,* for *Nerocila phaeopleura* Parasites (Crustacea, Isopoda, Cymothoidae).Middle-East J Scientific Res 5 (1): 54-56.

Rameshkumar G, Ravichandran S (2013) Effect of the parasitic isopod, *Catoessa boscii* (Isopoda, Cymothoidae) a buccal cavity parasite of the marine fish, *Carangoides malabaricus*. Asian Pac J Trop Biomed 3(2):118–122.

Rameshkumar G, Ravichandran S, and Ramesh M (2016) Distribution of Isopod parasitesin Carangid fishes from Parangipettai, Southeast coast of India. J Parasit Dis 40(1):124-8.

Rameshkumar G, Ravichandran S, Sivasubramanian K (2013a) Invasion of parasitic isopod in marine fishes. J Coast Life Med1(2): 88-94.

Rameshkumar G, Ravichandran S, Sivasubramanian K, Trilles JP (2013b) New occurrence of parasitic isopods from Indian fishes. J Parasit Dis 37(1) 42-46.

Rameshkumar G, Ravichandran S, Trilles JP (2011) Cymothoidae (Crustacea, Isopoda) from Indian fishes. Acta Parasitol 56:(78–91). DOI: 10.2478/s11686-011-0002-5.

Ravichandran S, Ranjith Singh AJA, Veerappan N (2001) Parasite induced vibriosis in Chirocentrus dorab off Parangipettai coastal waters. Curr Sci 80:101–102.

Ravichandran S, Vigneshwaran P, Rameshkumar G (2019) A taxonomic review of the fish parasitic isopod family Cymothoidae Leach, 1818 (Crustacea: Isopoda: Cymothooidea) of India. Zootaxa 4622 (1):1–099. https://doi.org/10.11646/zootaxa.4622.1.1.

Ray D, Mitra S, Balakrishna S, Mohapatra A (2020) New host records of *Nerocila poruvae* (Isopoda: Cymothoidae) from the Northern part of the east coast of India and first report of a fish - *Ablennes hians* (Valenciennes, 1846) from West Bengal coast. Indian J Geo-Mar Sci 49 (08):1447-1451. http://nopr.niscair.res.in/handle/123456789/55302

Ray D, Mitra S, Mohapatra A (2016) First report of parasitic isopod *Norileca indica* Milne-Edwards, 1840 from Northern part of East Coast of India. Int J Exp Res Rev 4:19–25

Rijin K, Sudha K, Vineesh PJ, Anilkumar G (2017) Seasonal Variation in the Occurrence of Parasitic Isopods and Copepods (Crustacea) Infecting the Clupeidaen Fishes of Malabar Coast, India. Turk J Fish & Aqua. Sci 19(3), 241-249.http://doi.org/10.4194/1303-2712-v19_3_07.

Rose DP, Calhoun DM, Johnson PTJ (2020) Infection prevalence and pathology of the cymothoid parasite Olencira praegustator in Atlantic menhaden. Invertebr Biol 00:e12300. https://doi.org/10.1111/ivb.12300.

Saravanakumar A, Balasubramanian T, Raja K, Trilles JP (2012) A massive infestation of sea snakes by cymothoid isopods. Parasitol Res 110: 2529–2531.

Seepana R, Nigam NK, Musaliyarakam N, Chandrakasan S (2021) Occurrence of ectoparasitic isopod *Norileca indica* (H. Milne Edwards, 1840) on bigeye scad *Selar crumenophthalmus* (Bloch, 1793) from Great Nicobar Island, India. J Parasit Dis 45(2):306-312.

Seth JK, Behera AK, Mohanty SR, Mohapatra A. (2020a) Extension of host range for *Anilocra dimidiata*, *Nerocila sigani* and first record of *Nerocila depressa* (Isopod: Cymothiod) from Odisha coast, India. Indian J Geo-Mar Sci 49(8):1498–1500.

Seth JK, Chakraborty S, Roy S, Mohapatra A (2020b) New host record of *Joryma malabaricus*, *Joryma hilsae* and first record of *Joryma sawayah* (Isopoda: Cymothoidae) from Odisha coast, India. Indian J Geo-Mar Sci 49(8):1501-1504.

Seth JK, Mohapatra SK, Mohanty SR, Behera RK, Mohapatra A (2021) Confirmation on the occurrence of *Cymothoa indica*, and first record of *Norileca indica,* with a note on new host records of *Nerocila arres*, and *Nerocila depressa* (Isopoda: Cymothoidae) from Odisha coast, India. J Parasit Dis. https://doi.org/10.1007/s12639-021-01382-1

Seth JK, Sahoo S, Mitra S (2014) First record of isopod parasite, *Nerocila phaeopleura* on the host fish *Rastrelliger kanagurta* collected from Bay of Bengal, Odisha Coast, India. Int J Curr Res 6(4): 6092-6093.

Sivasubramanian K., Ravichandran S., Rameshkumar G, Allayie SA (2011) Infection of *Exocoetus volitans* (Linnaeus, 1758) a new host of *Nerocila exocoeti* (Crustacea,Isopoda, Cymothoidae). Sci Parasitol 2(2): 99-101.

Smit NJ, Bruce NL, Hadfield KA (2014) Global diversity of fish parasitic isopod crustaceans of the family Cymothoidae. International Journal for Parasitology: Parasites and Wildlife 3: 188–197.

Sudha K, Anilkumar G (1996) Seasonal growth and reproduction in a highly fecund brachyuran crab *Metopograpsus messor* (Forskal) (Grapsidae). Hydrobiologia. 319:15–21.

Syama VP, Supriya NT, Sudha K, Anil kumar G (2010) Seasonal growth and reproduction in two brachyuran species inhabiting diverse ecosystems. In: Gupta Verma VKAK, Singh JD (eds.) Perspectives in Animal Ecology and Reproduction. Daya Publications, Vol. VI, New Delhi, pp. 275–289.

Talwar P K & Kacker P K (1984) *Commercial Sea Fishes of India*, Zool Surv India,1-997.

Trilles JP (1975) Les Cymothoidae (Isopoda, Flabellifera) des cotes francaises. II. Les Anilocridae Schioedte et Meinert, 1881. Genres *Anilocra* Leach, 1818, et *Nerocila* Leach, 1818. Bull Mus natn Hist nat, Paris 3e serie 290 (Zoologie 200):347–378.

Trilles JP (1979) Les Cymothoidae (Isopoda, Flabellifera; Parasites de Poissons) du Rijksmuseum van Natuurlijke Historie de Leiden: II. Afrique, Amérique et régions Indo-Ouest-Pacifiques Zool meded, 54: 245- 275.

Trilles JP, Rameshkumar G, Ravichandran S (2013) *Nerocila* species (Crustacea, Isopod, Cymothoidae) from Indian marine fishes. Parasitol Res, 112: 1273-1286. DOI 10.1007/s00436-012-3263-5

Trilles JP, Ravichandran S, Rameshkumar G (2012) *Catoessa boscii* (Crustacea,Isopoda, Cymothoidae) parasitic on *Carangoides malabaricus* (Pisces, Carangidae)from India. Taxonomy and host-parasite relationships. Acta parasitol 57(2):179-189. DOI: 10. 2478/s11686-012-0020-y.

Veerapan N, Ravichandran S (2000) Isopod parasites from marine fishes of Parangipettai coast. Centre of Advanced Study in Marine Biology, Annamalai University, Parangipettai, 24 pp.

Yule CM, Sen YH (2004) Freshwater Invertebrates of the Malaysian Region. Academy of Sciences Malaysia, Kualalumpur.PP:298-306. https://research.usc.edu.au/discovery/fulldisplay/alma99450876802621/61USC_INST:ResearchRepository

Tables

Table 1: Specimens along with their voucher numbers

Name of the species	Voucher number
Anilocra dimidata	MARC/ZSI/A3962
Catoessa boschii	MARC/ZSI/A3963
Cymothoa eremita	MARC/ZSI/A3964
Nerocila depressa	MARC/ZSI/A3965
Nerocila exocoeti	MARC/ZSI/A3659, MARC/ZSI/A3966
Nerocila phaeopleura	MARC/ZSI/A3969
Nerocila poruvae	MARC/ZSI/A3660, MARC/ZSI/A3970
Nerocila longispina	MARC/ZSI/A3967
Nerocila loveni	MARC/ZSI/A3661, MARC/ZSI/A3968
Nerocila serra	MARC/ZSI/A3971
Nerocila sigani	MARC/ZSI/A3972
Nerocila sundaica	MARC/ZSI/A3973
Norileca indica	MARC/ZSI/A3662, MARC/ZSI/A3974
Alitropus typus	EBRC/ZSI/ Cr-13291

Table 2: A comprehensive host-parasite list and localities with references to 13 isopod species of family Cymothoidae and one species of the family Aegidae found along the northern part of the east coast of India and other regions of India (Note: * indicates new host record to the northern part of the east coast of India)

Isopod species	Host species	Localities	References
Buccal Parasites (Family:Cymothoidae)			
Catoessa boschii	*Carangoides malabaricus*	Parangipettai Coast and South-east coast	Trilleset al. 2012, Rameshkumaret al. 2016, Ravichandran et al.2019
	Alepes djedaba, Alepes kleinii*,Leiognathus blochii*, Carangoides malabaricus*	Present study	
Cymothoa eremita	*Eleutheronema tetradactylum*, *Lutjanus johnii*, *Lutjanus argentimaculatus*, *Mystus gulio*, *Nemapteryx nenga*, *Nematalosa nasus*, *Chanos chanos*, *Platycephalus indicus*.	Pulicat Lake	Jayadev Babu and Sanjeeva Raj, 1984.
	Etroplus suratensis	Goa Coast	Parveen Rattan and Parulekar, 1998.
	Lutjanus johnii , host (Unknown)	Present study	
Body Surface parasites (Family:Cymothoidae)			
Anilocra dimidiata	*Lactarius lactarius*	Travancore	Pillai, 1954.
	Sardinella longiceps, Leiognathus sp.	Vedaranyam Coast, Southeastern Coast	Rameshkumar, *et al*., 2011.
	Karalla daura	Gopalpur-on-Sea, Odisha coast	Seth et al.2020a
	Sardinella longiceps, Lactarius lactarius*, Leiognathus blochii **	Present Study	
Nerocila depressa	*Opisthopterus tardoore*	Mumbai Coast	Bal and Joshi, 1959; Parimala, 1984
	Sardinella gibbosa	Parangipettai Coast and South-east coast	Trilles, *et al.,* 2013
	Scleroides leptolepis, Carangoides malabaricus	Parangipettai Coast and South-east coast	Rameshkumar, *et al.,* 2016.

	Coilia dussumieri	Malabar coast	Aneesh, *et al.,* 2013.
	Selaroid leptolepis,Megalaspsis cordyla	Gopalpur-on-Sea, Odisha	Seth et al.2020
	Lagocephalus lunaris, Lepturalanthus pantalui	Dhigha, West Bengal	Balakrishna and Tudu,2020
	*Sardinella gibbosa, Opisthopterus trardoore, Carangoides malabariucus**	Present study	
N. exocoeti	*Exocoetus volitans*	Parangipettai Coast and South-east coast	Sivasubramanian, *et al*, 2011 and Trilles *et al.* 2013
	Parexocoetus brachypterus	Travancore	Pillai, 1954
	Parexocoetus brachypterus	Chennai, Tamil Nadu	Aneesh et al.2017
	Rhynchorhampus brachypterus	Malabar Coast	Aneesh et al.2017
	Hemirhampus far	Parangipettai Coast, South-east coast	Sivasubramanian and Ravichandran, 2013
	Host (Unknown)	Present Study	
N. longispina	*Terapon puta, Otolithes ruber*	Vedaranyam, Southeastern Coasts of India	Rameshkumar, *et al*., 2011.
	Ambassis ambassis	Malabar coast	Aneesh, *et al.,* 2013.
	Host (Unknown)	Present study	
N. loveni	*Eubleekeria splendens*	Parangipettai ; Nagapattinam and Tamilnadu coast	Trilles, *et al.,* 2013; Rameshkumar, *et al*., 2013a and 2013b.
	Carangoides malabaricus	Parangipettai	Rameshkumar, *et al.,* 2016
	Thryssa malabarica, Escualosa thoracata	Malabar coast	Aneesh, *et al.,* 2013.
	Equulites leuciscus; Deveximentum insidiator , Escualosa thoracata, Eubleekeria splendens*	Present study	
N. phaiopleura	*Ilisha melastoma,* *Parastromateus niger*	Kakinada, Tamil Nadu, Bay of Bengal, India	Bruce and Harrison-Nelson, 1988.

Chirocentrus dorab, Sardinella longiceps, S. sindensis, S. brachysoma, Dussumieria acuta, Thryssa dussumieri, T. mystax, Scomberomorus guttatus	Parangipettai Coast	Veerapan and Ravichandran, 2000.
Chirocentrus dorab	Parangipettai Coast	Ravichandran, *et al*., 2001.
Stolephorus commersonnii	Parangipettai Coast	Rajkumar and Perumal, 2004; Rajkumar, *et al*., 2006.
Arius jella	Parangipettai Coast	Rajkumar, *et al*., 2008.
Istiophorus platypterus	Bay of Bengal	Barnard, 1936.
Istiophorus platypterus	Chennai	Ramakrishna and Venkata Ramaniah,1978.
Rastrelliger kanagurta	Parangipettai, Southeast Coast	Rameshkumar and Ravichandran, 2010.
	Goapalpur-on-Sea, Odisha coast	Seth, *et al.,* 2014
Carangoides malabaricus, Chirocentrus dorab Dussumieria acuta, Gazza minuta, Eubleekeria splendens, Rastrelliger kanagurta, Sardinella gibbosa, S. longiceps, Scleroides leptolepis, Sphyraena jello, Tenualosa ilisha, Thryssa mystax.	Tamilnadu coast	Trilles, *et al*., 2013
Istiophorus platypterus	South 24 Parganas, West Bengal	Ghatak, 1998
Liza parsia, Thryssa dussumieri, Sardinella albella	Parangipettai	Bharadhrirajan, *et al*., 2014.
Thryssa mystax, Thryssa setirostris, Thryssa malabarica, Opisthopterus tardoore	Malabar coast	Aneesh, *et al.,* 2013
Sardinella gibbosa	Tamilnadu coast	Rameshkumar, *et al.,* 2013a.
Chirocentrus nudus	Cuddalore, Tamilnadu	Raja, *et al.,* 2014
Siganus javas, Sardinella gibbosa, Sardinella longiceps, Dusumeria acuta, Opisthopterus tardoore, Carangoides malabaricus, Epinephelus coioides*, Thryssa dusummeri, Scleroides leptolepis,*	Present study	

	Rastreliger kanagurta, Parastromateus niger, Leiognathus splendens		
N. poruvae	*Trichurus leturus; Thryssa mystax*	Vedaranyam Coast, Southeastern Coast	Rameshkumar, *et al.,* 2011.
	Setipinna tenuifilis	Bakkhali and Digha	Dev Roy, *et al.,* 2012.
	Siganus canaliculatus	Paradip, Odisha	Ray et al. 2020
	Setipinna taty, Ablennes hians, Rhynchirhampus gorgii, Pampus argentus	Digha, West Bengal	Ray et al. 2020
	Siganus canaliculatus, Alepes djedaba, Rhynchirhampus gorgii, Setipinna taty*	Present study	
N. serra	*Hexanematichthys sagor*	Off Devi River, Odisha Coast, Vizagapatam, Canjam Coast (Odisha)	Barnard, 1936.
	On several species of shoal fishes	Travancore	Pillai, 1954.
	Arius maculatus	Nagappatinam	Trilles, *et al.,* 2013
	Host (Unknown)	West Bengal, Odisha, Andhrapradesh	Ghatak, 1998.
	Enhydrina schistose (Sea snake)	Parangipettai coast	Saravanakumar, *et al.,* 2012.
	Arius arius; Arius maculatus, Terapon jarbua*, Plotosus lineatus*, Nibea maculate**	Present study	
N. sigani	*Parastromateus niger*	Formio niger Parastromateus niger	Bruce and Harrison-Nelson, 1988.
	Siganus oramin	Parangipettai and Nagapattinam	Trilles, *et al*., 2013 and Rameshkumar, *et al.*. 2013b.
	Terapon threps	Paradip, Odisha	Dev Roy and Mitra, 2013.
	Lutjanus lutjanus	Gopalpur-on-Sea, Odisha	Seth et al. 2020
	Lutjanus lutjanus, Nemipterus japonicas, Priacanthus tayneus*, Parastromateus niger.*	Present study	

N. sundaica	*Unknown*	off Godavari (Sacraments mouth), Ganjam Coast	Barnard, 1936.
	Otolithes ruber, *Terapon jarbua*, *Thryssa mystax*, *Epinephelus quoyanus*, *Ilisha melastoma*, *Sardinella fimbriata*	West Coast of India	Chidambaram and Devidas Menon, 1945.
	Estuarine fishes	West Bengal, odisha	Ghatak, 1998
	Carangoides malabaricus Ilisha melastomaOtolithoides ruber, Scleroides leptolepis, Terapon puta, Opisthopterus tardoore	Parangipettai Coast and South-east coast. Tamilnadu Coast	Trilles, *et al*., 2013; Rameshkumar*, et al.,* 2016; Rameshkumar, *et al*,. 2013b
	Otolithes ruber	Nagapattinam, Southeast coast	Rameshkumar, *et al.,* 2015 b.
	Terapon jarbua	Present study	
Norileca indica	*Rastrelliger kanagurta*	Parangipettai and Cochin	Rameshkumar, *et al*., 2013a & 2013b and 2015 a.
		Malabar coast	Aneesh et al. (2016)
		Visakhapatnam	Behera et al. (2016)
		Shankarpur, West Bengal	Ray et al. (2016)
		Cochin coast	Jemi et al. (2020)
	Atule mate	Gopalpur-on-Sea	Seth et al.2021
	Selar crumenophthalmus	Off Mumbai coast	Neeraja, et al., 2014
	Selar crumenophthalmus	Great Nicobar Island	Seepana (2021)
	Deveximentum insidiator, Nemipterus randalli	Visakhapatnam	Behera et al. (2016)
	Rastreliger kanagurta	*Present study*	

Body Surface parasites (Family:Aegidae)			
Alitropus typus	*Channa striata*	Tamil Nadu	Nair and Nair 1983
	Oreochromis mossambicus	Tamil Nadu	Rameshkumar and Ravichandran 2010
	Badis badis	Damoder river	Mitra and Deb Roy 2011
	Etroplus suratensis, Oreochromis mosambicus	Present Study	

Table 3: Prevalence of Isopod during the study period

Host Species	Family	Examined host species	Infected host species	Prevalence
Sardinella gibbosa	Clupeidae	125	38	30.4
Sardinella longiceps	Clupeidae	119	35	29.41
Dussumeria acuta	Clupeidae	34	4	11.76
Escualosa thoracata	Clupeidae	78	9	11.53
Thryssa dusummeri	Engraulidae	83	7	8.43
Setipinna tati	Engraulidae	78	4	5.12
Opisthopterus tardoore	Pristrigasteridae	121	16	13.22
Alepes djedaba	Carangidae	148	51	34.45
Alepes kleinni	Carangidae	143	16	11.18
Carangoides malabariucus	Carangidae	104	20	19.23
Parastromateus niger	Carangidae	128	6	4.68
Scleroides leptolepis	Carangidae	79	6	7.59
Rastrelliger kanagurta	Scomberidae	124	28	22.58
Rhynchorhamphus georgii	Hemirhamphidae	17	1	5.88
Ablennes hians	Belonidae	9	1	11.11
Lactarius lactarius	Lacteridae	25	1	4
Eubleekeria splendens	Leiogonathidae	61	7	11.47
Leiognathus blochii	Leiogonathidae	56	5	8.92
Equulites lecuciscus	Leiogonathidae	12	1	8.33
Secutor insidiator	Leiogonathidae	124	12	9.67
Plotosus lineatus	Plotosidae	62	7	11.29
Nibea maculata	Sciaenidae	89	6	6.74
Siganus canaliculatus	Siganidae	65	2	3.07
Siganus javus	Siganidae	32	1	3.12
Lutjanus johnii	Lutjanidae	77	1	1.29
Lutjanus lutjanus	Lutjanidae	54	1	1.85
Terapon jarbua	Terapontidae	102	8	7.84
Pryacanthus tayneus	Pryacanthidae	105	2	1.9
Nemipterus japonicus	Nemipteridae	125	11	8.8

Arius arius	Ariidae	98	9	9.18
Arius maculatus	Ariidae	37	2	5.4
Epinephelus coioides	Serranidae	49	2	2.53
Etroplus suratensis	Cichlidae	69	5	7.24
Tilapia mosambicus	Cichlidae	36	1	2.77
Total		2668	326	12.21

Figures

Figure 1

Parasitic isopods collected during the study

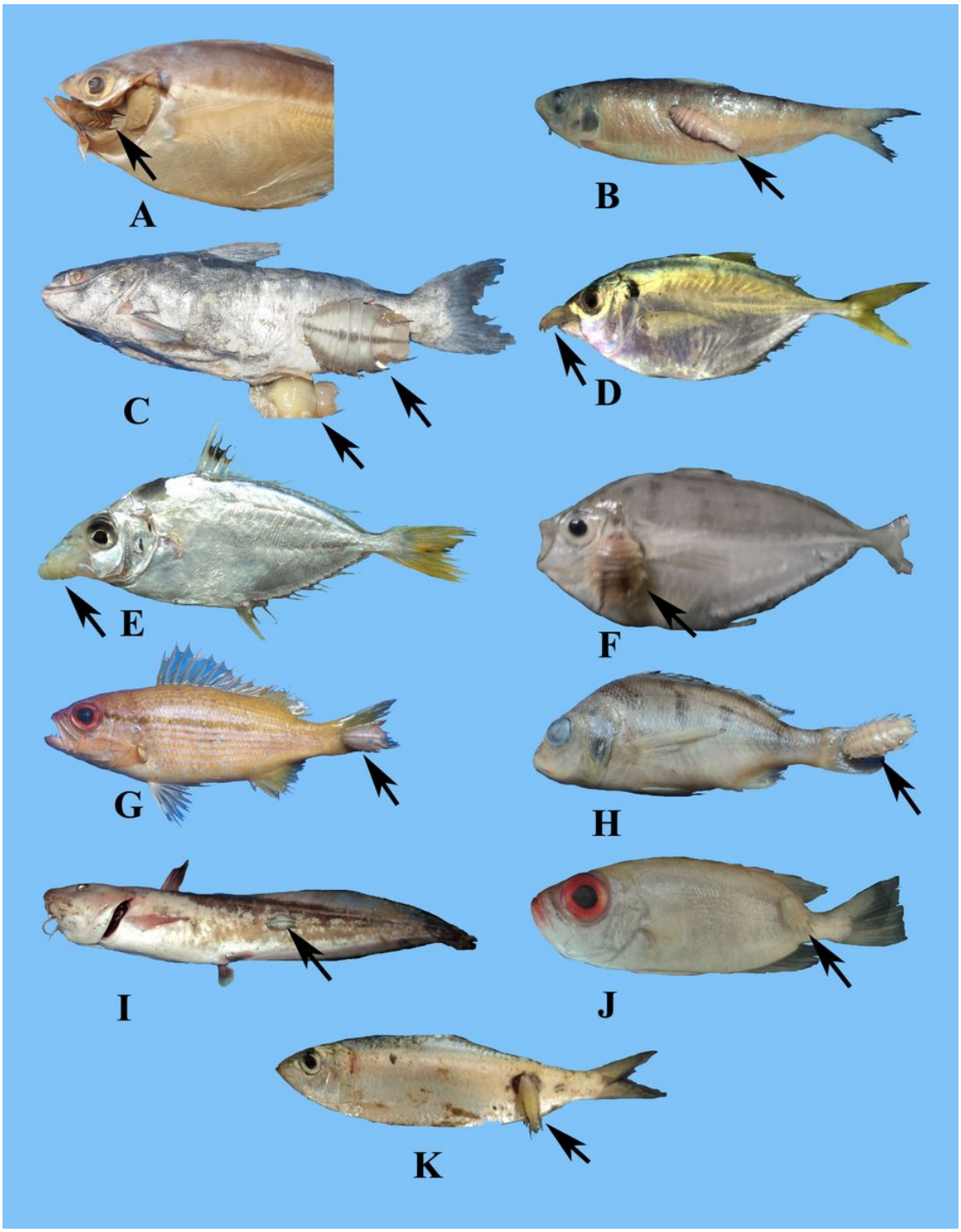

Figure 2

Host fish species and their parasites, (A) Catoessa boschii on Alepes djedaba, (B) Anilocra dimidiate on Sardinella longiceps, (C) Nerocila serra on Arius arius, (D) C. boschii on Alepes kleinii, (E) C. boschii on Leiognathus blochii. (F) N. loveni on Deveximentum insidiator, (G) N. sigani on Lutjanus lutjanus, (H) N. serra on Nibea maculate, (I) N. serra on Plotosus lineatus, (J) N. sigani on Priacanthus tayneus, (K) N. depressa on Sardinella gibbosa

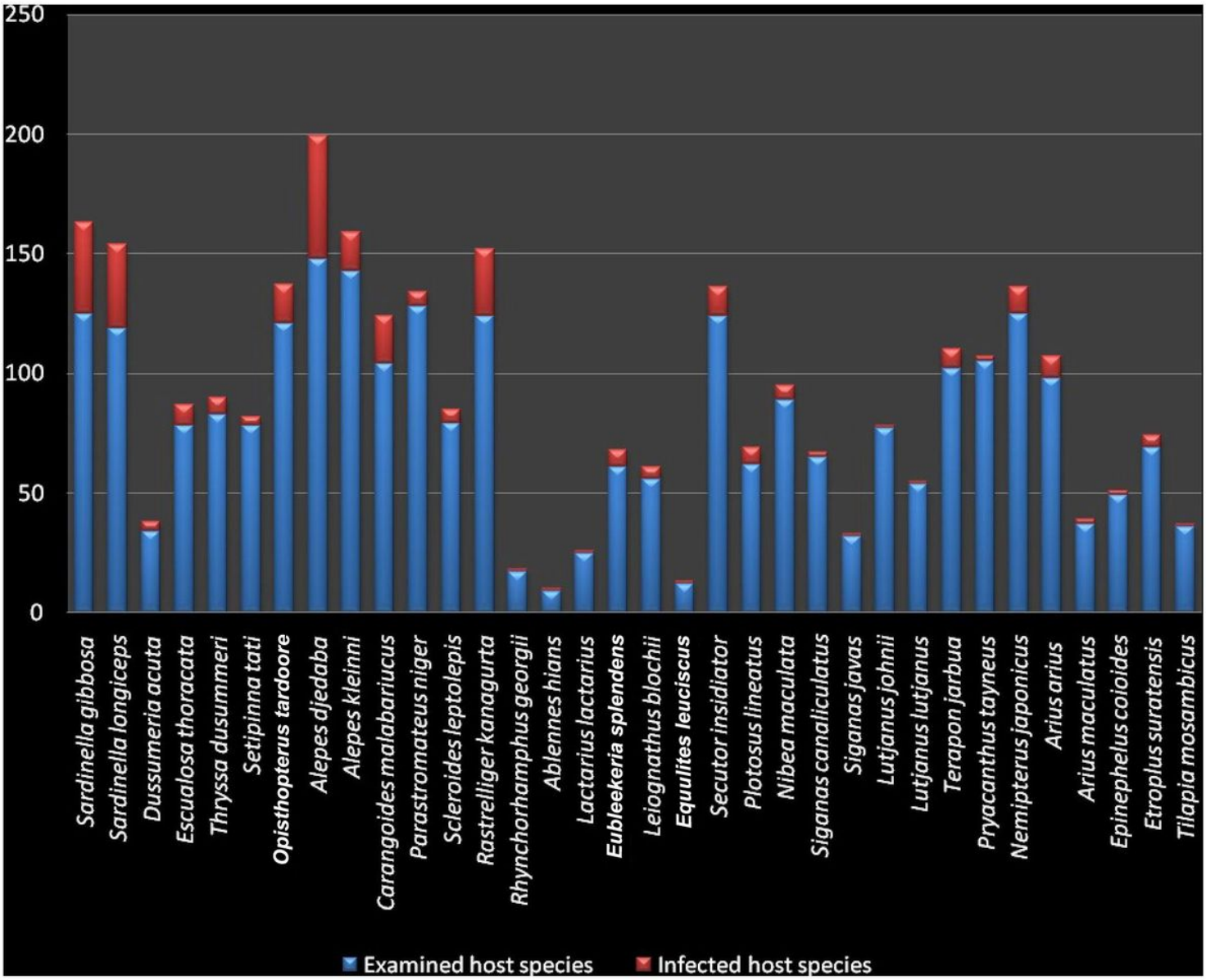

Figure 3

Number of fish species examined and parasitized by isopods during the study

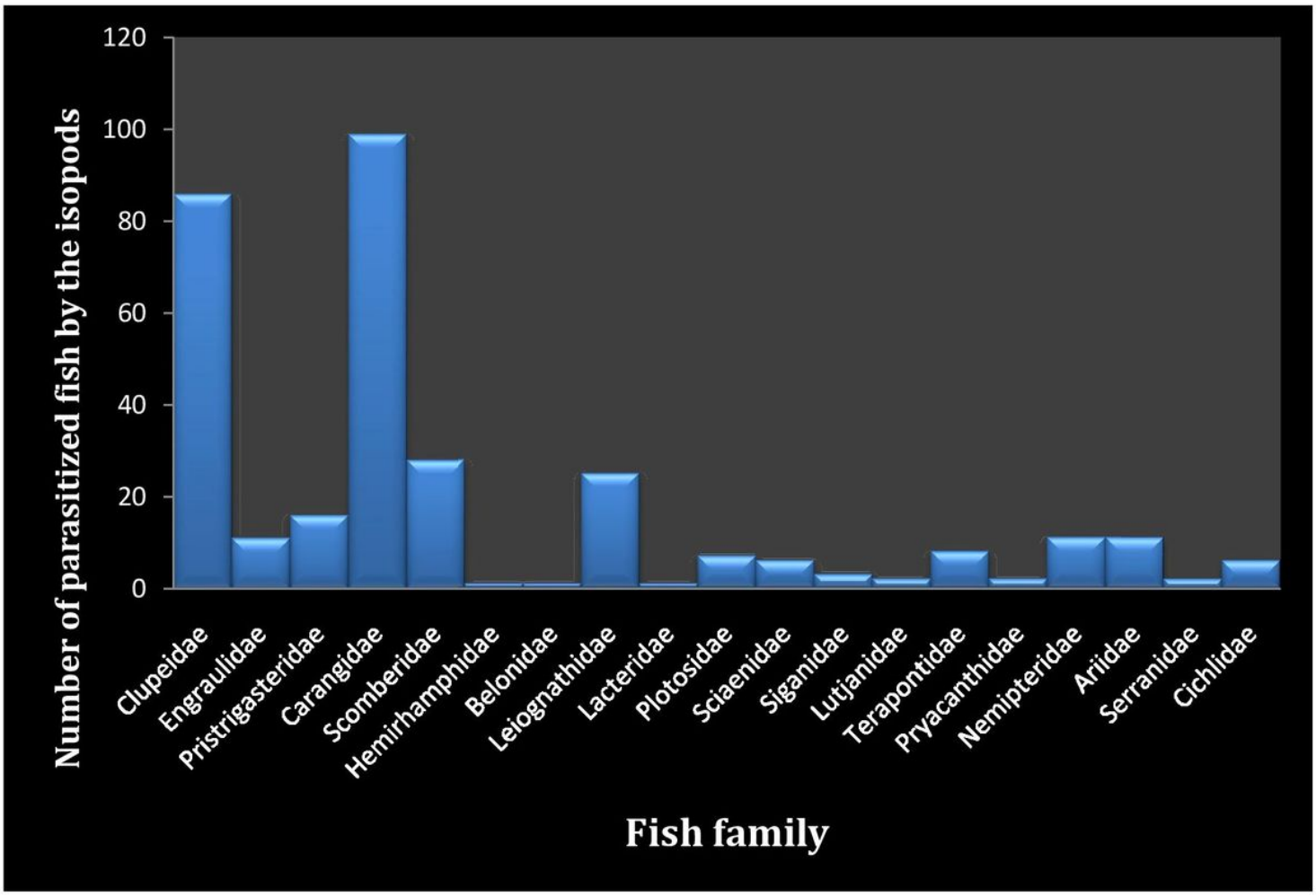

Figure 4

Fish (family-wise) isopod infection

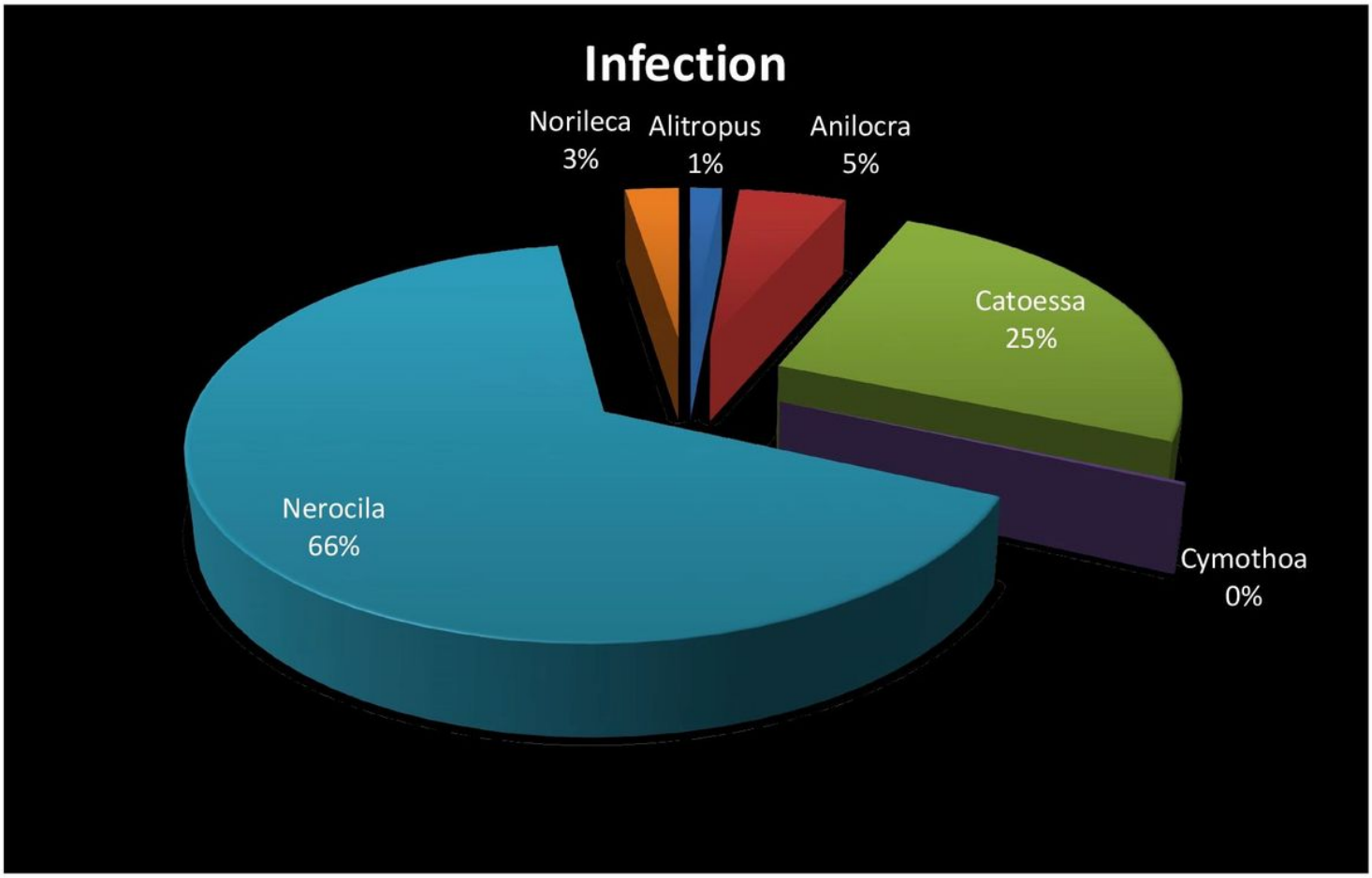

Figure 5

Pie chart of isopod (genus-wise) infecting the fish species during the study period

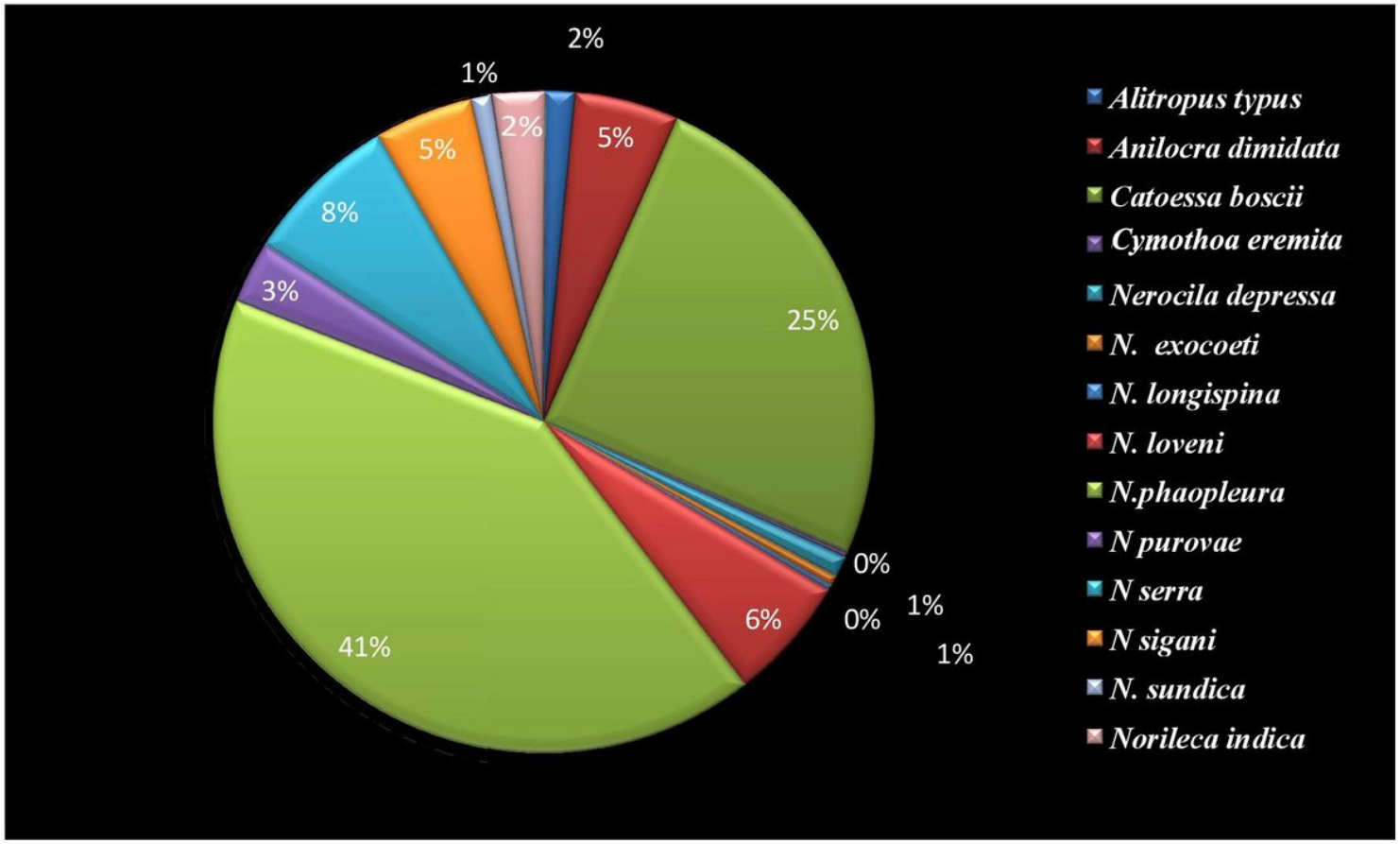

Figure 6

Pie chart of isopod (species wise) infecting the fish species during the study period

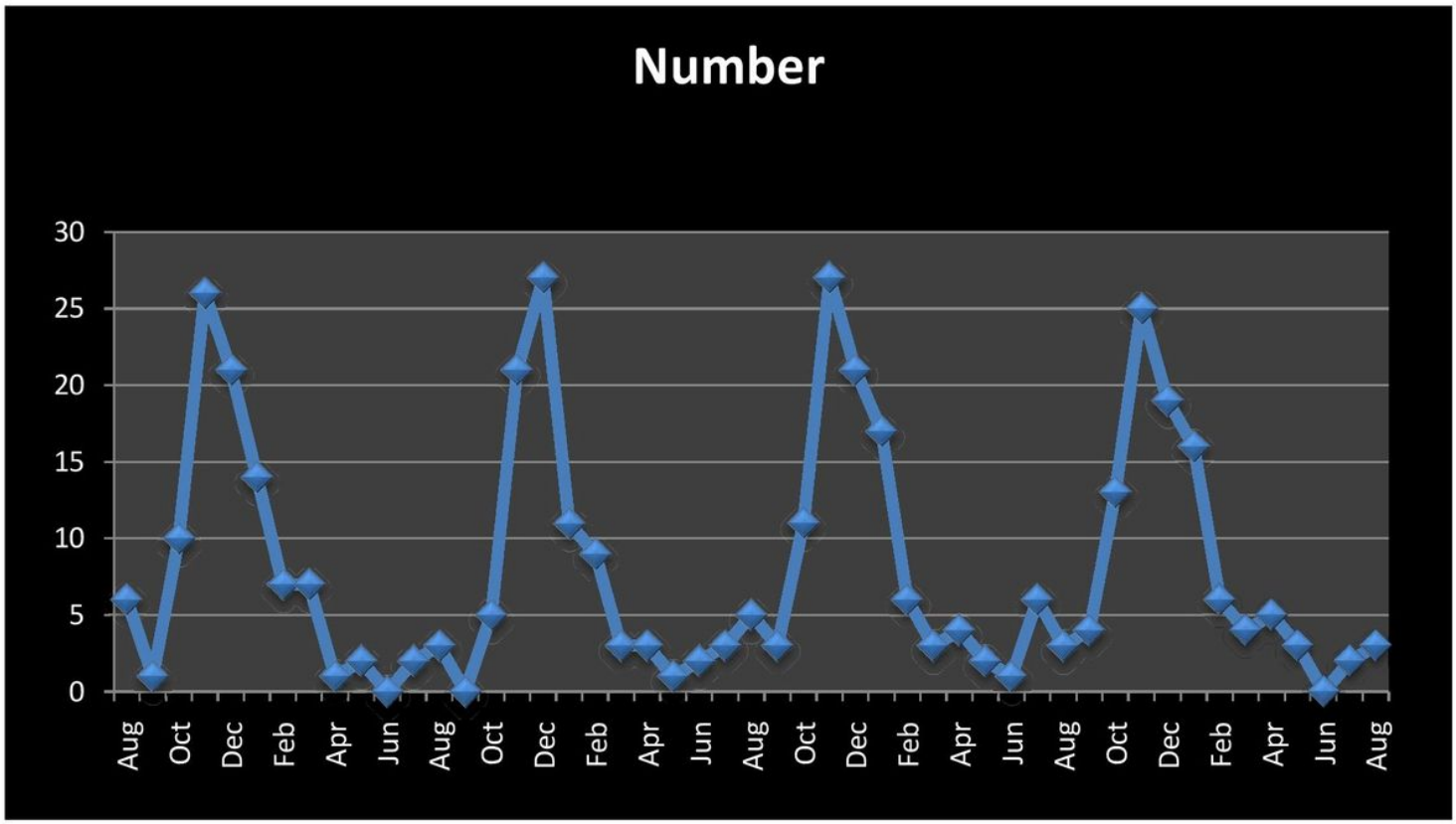

Figure 7

Seasonal variation of parasitic infection during the study period