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VERSITA

Seasonal fluctuation of the prevalence of cymothoids representing the genus *Nerocila* (Crustacea, Isopoda), parasitizing commercially exploited marine fishes from the Malabar Coast, India

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Abstract

The presently reported study investigated seasonal fluctuations in the prevalence in four species of *Nerocila* infesting commercially exploited marine fishes representing the families Engraulidae, Clupeidae and Ambassidae, from the Malabar coast (Kerala, India). Seven of 56 fish species belonging to 23 families were infested by either one or two species of *Nerocila*. All the collected *Nerocila* species showed significant seasonal fluctuations in the prevalence of infestation, reaching maximum from October through April and minimum (or total absence of the parasites) from May through September. Such fluctuations were analyzed based on environmental parameters. Body surface, postero-ventral side of the head and the lateral line of the host fish form the major infestation site for the recovered *Nerocila* species. Skin lesion and hemorrhages were observed on the fish parasitized with these cymothoids.

Keywords

Parasitic Isopoda, Cymothoidae, *Nerocila*, prevalence, seasonal fluctuations

Introduction

Cymothoidae (Crustacea, Isopoda) are ectoparasites of marine, freshwater or brackishwater teleost fishes. They generate a significant interest among the parasitologists as they adversely affect the health of both wild and cultured fishes (Trilles 1969, 1994). However, the Indian cymothoid fauna is still incompletely known despite several studies already published or reported (Aneesh *et al*. 2010, 2011; Rameshkumar *et al*. 2011; Trilles *et al*. 2011) and few of them provided information on the seasonal fluctuations of the prevalence of these parasitic crustaceans (Ravichandran *et al*. 2009, Saravanakumar *et al*. 2012). In this work, to partly correct this deficiency, we studied accurately the fluctuations in the prevalence of species belonging to the genus *Nerocila*, parasitizing the commercially important marine fishes from the Malabar Coast (Kerala, India).

Materials and methods

This study was conducted from November 2009 to November 2010. Host fishes were collected from the Ayyikkara fish landing center (lat. 11°51′N, long. 75°22′E; Malabar Coast, India). As soon as they were collected and transferred to the laboratory, all outer parts of their body were carefully examined for the presence and the pathogenic effects of isopod parasites. Cymothoids were removed from the hosts and preserved in 70% ethanol for further detailed examination. The isopods were identified, using a dissecting microscope and a stereomicroscope Leica-S6D, according to Ramakrishna 1980, Bowman and Tareen 1983, Bruce 1987, Bruce and Harrison-Nelson 1988 and Rameshkumar *et al*. 2011. The prevalence (P) was calculated according to Margolis *et al*. 1982 and Bush *et al*. 1997. The seasonal fluctuations of the prevalence were as-

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Table I. List of the edible marine fishes examined for the infestation of parasitic isopods belonging to the genus *Nerocila* from the Malabar Coast, India

Sl. No.	Family	Fish species	NFO	Infestation by *Nerocila* species
1	Scombridae	1) *Rastrelliger kanagurta* (Cuvier, 1817)	1329	–
		2) *Thunnus obesus* (Lowe, 1839)	69	–
		3) *Scomberomorus guttatus* (Bloch et Schneider, 1801)	323	–
2	Carangidae	4) *Parastromateus niger* (Bloch, 1975)	332	–
		5) *Decapterus russelli* (Ruppell,1830)	287	–
		6) *Megalaspis cordyla* (Linnaeus, 1758)	97	–
3	Teraponidae	7) *Terapon jarbua* (Forsskal, 1775)	312	–
		8) *Terapon puta* Cuvier, 1829	89	–
4	Clupeidae	9) *Escualosa thoracata* (Valenciennes, 1847)	803	+
		10) *Opisthopterus tardoore* (Cuvier, 1829)	398	+
		11) *Tenualosa ilisha* (Hamilton, 1822)	318	–
		12) *Anodontostoma chacunda* (Hamilton, 1822)	144	–
		13) *Dussumieria acuta* Valenciennes, 1847	422	–
		14) *Sardinella albella* (Valenciennes, 1847)	313	–
		15) *Amblygaster clupeoides* Bleeker, 1849	49	–
		16) *Sardinella gibbosa* (Bleeker, 1849)	375	–
		17) *Amblygaster sirm* (Walbaum, 1792)	42	–
		18) *Sardinella melanura* (Cuvier, 1829)	395	–
		19) *Ilisha melastoma* (Bloch et Schneider, 1801)	798	–
		20) *Pellona ditchela* Valenciennes, 1847	928	–
		21) *Ilisha megaloptera* (Swainson, 1839)	222	–
		22) *Tenualosa toli* (Valenciennes, 1847)	249	–
5	Stromateidae	23) *Pampus argenteus* (Euphrasen, 1788)	131	–
		24) *Pampus chinensis* (Euphrasen, 1788)	87	–
6	Ambassidae	25) *Ambassis ambassis* (Lacepède, 1802)	596	+
7	Dasyatidae	26) *Himantura bleekeri* (Blyth, 1860)	27	–
8	Megalopidae	27) *Megalops cyprinoides* (Broussonet, 1782)	187	–
9	Engraulidae	28) *Coilia dussumieri* Valenciennes, 1848	280	+
		29) *Stolephorus commersonnii* Lacepede, 1803	859	–
		30) *Thryssa dussumieri* (Valenciennes, 1848)	366	–
		31) *Thryssa malabarica* (Bloch, 1795)	502	+
		32) *Thryssa mystax* (Bloch et Schneider, 1801)	381	+
		33) *Thryssa setirostris* (Broussonet, 1782)	376	+
10	Aridae	34) *Plicofollis tenuispinis* (Day, 1877)	123	–
11	Hemiramphidae	35) *Hemiramphus far* (Forsskal, 1775)	45	–
12	Belonidae	36) *Strongylura strongylura* (van Hasselt, 1823)	68	–
		37) *Strongylura leiura* (Bleeker, 1850)	215	–
		38) *Tylosurus acus melanotus* Bleeker, 1850	19	–
		39) *Tylosurus crocodilus crocodilus* (Peron et Lesuer, 1821)	49	–
13	Leiognathidae	40) *Gazza minuta* (Bloch, 1795)	93	–
		41) *Eubleekeria splendens* (Cuvier, 1829)	66	–
		42) *Leiognathus bindus* (Valenciennes, 1835)	35	–
		43) *Leiognathus* sp.	29	–
14	Cynoglossidae	44) *Cynoglossus dubius* Day, 1873	306	–
		45) *Cynoglossus arel* (Bloch et Schneider, 1801)	293	–
15	Trichiuridae	46) *Lepturacanthus savala* (Cuvier, 1829)	34	–
16	Mugilidae	47) *Mugil cephalus* Linnaeus, 1758	96	–
17	Sphyraenidae	48) *Sphyraena forsteri* Cuvier, 1829	21	–
18	Lutjanidae	49) *Lutjanus johni* (Bloch,1792)	29	–
		50) *Lutjanus malabaricus* (Bloch et Schneider, 1801)	32	–
19	Nemipteridae	51) *Nemipterus japonicus* (Bloch,1791)	22	–
20	Exocoetidae	52) *Cypselurus oligolepis* (Bleeker, 1865)	18	–
		53) *Exocoetus volitans* Linnaeus, 1758	23	–
21	Chanidae	54) *Chanos chanos* (Forsskal,1775)	26	–
22	Carcharhinidae	55) *Scoliodon palasorra* (Bleeker, 1853)	39	–
23	Hemiscyllidae	56 *Chiloscyllium indicum* (Gmelin, 1789)	62	–

NFO – number of fishes observed.

sessed through the P-values calculated by Turkey-Kramer multiple comparisons test or through Student's t-test, using InStat Software (Graphpad InStat, Version 2.00, 2007). Host nomenclature and fish taxonomy are according to Fish Base (Froese and Pauly 2012).

Voucher specimens of all parasites were collected by Aneesh and Sudha from Ayyikkara fish landing centre (lat. 11°51′N, long. 75°22′E), Malabar Coast of Kerala, India and deposited in the Parasitic Crustacean Museum, Sree Narayana College, Kannur, Kerala, India. Abbreviations used: PCM – Parasitic Crustacean Museum, Sree Narayana College, Kannur, Kerala, India; LT – total length; OgF – ovigerous female; BP – brood pouch.

Nerocila phaiopleura Bleeker, 1857: OgF (LT, 20 mm) with empty BP from *Thryssa setirostris* (PCM N° NP-01), 30 November 2009; OgF (LT, 22 mm) with empty BP from *Thryssa mystax* (PCM N° NP-02), 30 November 2009; Male (LT, 14 mm) from *Thryssa mystax* (PCM N° NP-03), 08 January 2010; OgF (LT, 12 mm) with cephalized embryos in the BP from *Opisthopterus tardoore* (PCM N° NP-04), 16 January 2010; ovigerous female (LT, 13 mm) with eggs in the brood pouch, from *Thryssa malabarica* (PCM N° NP-05), 16 January 2010.

Nerocila loveni Bovallius, 1887: OgF (LT, 14 mm) without BP from *Escualosa thoracata* (PCM N° NL-01), 30 November 2009; OgF (LT, 16.5 mm) without BP from *Thryssa malabarica* (PCM N° NL-03), 08 December 2009; OgF (LT, 19 mm) with empty BP from *Escualosa thoracata* (PCM N° NL-05), 16 January 2010.

Nerocila depressa Milne Edward, 1840: OgF (LT, 16 mm) with eggs in the BP from *Opisthopterus tardoore* (PCM N° ND-01), 30 November 2009; OgF (LT, 26.5 mm) with pullus larvae in the BP from *Opisthopterus tardoore* (PCM N° ND-02), 30 November 2009; OgF (LT, 20 mm) from *Coilia dussumieri* (PCM N° ND-03), 08 December 2009.

Nerocila longispina Miers, 1800: All collected from *Ambassis ambassis*. OgF (LT, 17 mm) without BP (PCM N° NLg-01), 30 November 2009; OgF (LT, 28 mm) with eggs in the BP (PCM N° NLg-02), 30 November 2009; OgF (LT, 23 mm) with empty BP (PCM N° NLg-03), 16 January 2010; OgF (LT, 17.5 mm) with manca larvae in the BP (PCM N° NLg-10), 13 April 2010.

Results

Fifty-six fish species belonging to 23 families were examined (Table I). Among them, seven species, *Thryssa malabarica* (Bloch, 1795), *Thryssa mystax* (Bloch et Schneider, 1801), *Thryssa setirostris* (Broussonet, 1782) and *Coilia dussumieri* Valenciennes, 1848 (Engraulidae), *Opisthopterus tardoore* (Cuvier, 1829) and *Escualosa thoracata* (Valenciennes, 1847) (Clupeidae) and *Ambassis ambassis* (Lacépède, 1802) (Ambassidae) were found to be parasitized by one or two of the following four species, *Nerocila phaiopleura* Bleeker, 1857; *Nerocila loveni* Bovallius, 1887; *Nerocila depressa* Milne Edwards, 1840 and *Nerocila longispina* Miers, 1880 (Table II). Monthly occurrences of these *Nerocila* species and their respective host fishes are listed in Table III. *Nerocila phaiopleura* parasitized the three engraulid fishes (*Thryssa malabarica*, *T. mystax* and *T. setirostris*) and the clupeid fish (*Opisthopterus tardoore*) (Tables II and III). *Thryssa malabarica* was also infested by *Nerocila loveni*. The latter species was also recovered from *Escualosa thoracata*. *Opisthopterus tardoore* and *Coilia dussumieri* were parasitized by *Nerocila depressa* while *N. longispina* was only collected from *Ambassis ambassis* (Table II).

Table II. Parasitological indices of the parasitic isopods belonging to the genus *Nerocila* from the Malabar Coast, India

Parasites and their host fishes	NFO	NFI	P	Site of infestation
***Nerocila phaiopleura* Bleeker, 1857**				
Thryssa mystax (Engraulidae)	381	67	17.6	Body surface, under the base of pectoral fin, overlying the lateral line and the operculum
Thryssa setirostris (Engraulidae)	376	55	14.63	Body surface, under the base of pectoral fin, overlying the lateral line and the operculum
Thryssa malabarica (Engraulidae)	502	108	21.51	Body surface, under the base of pectoral fin, overlying the lateral line and the operculum
Opisthopterus tardoore (Clupeidae)	398	28	7.04	Body surface
***Nerocila loveni* Bovallius,1887**				
Thryssa malabarica (Engraulidae)	502	49	9.76	The body surface in the close vicinity of the lateral line
Escualosa thoracata (Clupeidae)	803	161	20.05	The body surface in the close vicinity of the lateral line
***Nerocila longispina* Miers, 1800**				
Ambassis ambassis (Ambassidae)	596	174	29.19	Body surface, postero-ventral side of the head, body surface, close to the lateral line
***Nerocila depressa* Milne Edward, 1840**				
Opisthopterus tardoore (Clupeidae)	398	89	22.36	Body surface
Coilia dussumieri (Engraulidae)	280	29	10.36	Body surface

Table III. Fluctuation of the prevalence of *Nerocila* according to the month and host fish. P – prevalence, NFO – number of fishes observed, NFI – number of fishes infested

Month	SI No.	Host fish	NFO	*Nerocila phaiopleura* Bleeker, 1857		*Nerocila loveni* Bovallius, 1887		*Nerocila longispina* Miers, 1880		*Nerocila depressa* Milne Edward, 1840	
				NFI	P	NFI	P	NFI	P	NFI	P
Nov. 2009	1	*Ambassis ambassis*	45	–	–	–	–	16	35.56	–	–
	2	*Thryssa mystax*	29	7	24.14	–	–	–	–	–	–
	3	*Thryssa setirostris*	19	2	10.53	–	–	–	–	–	–
	4	*Thryssa malabarica*	22	6	27.27	2	9.1	–	–	–	–
	5	*Escualosa thoracata*	68	–	–	14	20.58	–	–	–	–
	6	*Opisthopterus tardoore*	54	8	14.81	–	–	–	–	14	25.9
	7	*Coilia dussumieri*	19	–	–	–	–	–	–	3	15.78
Dec. 2009	1	*Ambassis ambassis*	32	–	–	–	–	11	34.38	–	–
	2	*Thryssa mystax*	42	11	26.2	–	–	–	–	–	–
	3	*Thryssa setirostris*	27	7	25.93	–	–	–	–	–	–
	4	*Thryssa malabarica*	39	9	23.1	3	7.7	–	–	–	–
	5	*Escualosa thoracata*	86	–	–	19	22.09	–	–	–	–
	6	*Opisthopterus tardoore*	28	2	7.14	–	–	–	–	6	21.43
	7	*Coilia dussumieri*	12	–	–	–	–	–	–	2	16.66
Jan. 2010	1	*Ambassis ambassis*	82	–	–	–	–	37	45.12	–	–
	2	*Thryssa mystax*	31	7	22.6	–	–	–	–	–	–
	3	*Thryssa setirostris*	22	8	36.36	–	–	–	–	–	–
	4	*Thryssa malabarica*	42	17	40.48	3	7.4	–	–	–	–
	5	*Escualosa thoracata*	78	–	–	21	26.92	–	–	–	–
	6	*Opisthopterus tardoore*	41	3	7.32	–	–	–	–	12	29.27
	7	*Coilia dussumieri*	11	–	–	–	–	–	–	2	18.18
Feb. 2010	1	*Ambassis ambassis*	38	–	–	–	–	15	39.47	–	–
	2	*Thryssa mystax*	42	15	35.71	–	–	–	–	–	–
	3	*Thryssa setirostris*	29	7	24.13	–	–	–	–	–	–
	4	*Thryssa malabarica*	48	17	35.42	6	12.5	–	–	–	–
	5	*Escualosa thoracata*	46	–	–	12	26.09	–	–	–	–
	6	*Opisthopterus tardoore*	29	2	6.9	–	–	–	–	11	37.93
	7	*Coilia dussumieri*	19	–	–	–	–	–	–	7	36.84
Mar. 2010	1	*Ambassis ambassis*	46	–	–	–	–	21	45.65	–	–
	2	*Thryssa mystax*	18	5	27.8	–	–	–	–	–	–
	3	*Thryssa setirostris*	35	13	37.14	–	–	–	–	–	–
	4	*Thryssa malabarica*	48	16	33.33	8	16.67	–	–	–	–
	5	*Escualosa thoracata*	95	–	–	29	30.52	–	–	–	–
	6	*Opisthopterus tardoore*	36	4	11.11	–	–	–	–	14	38.89
	7	*Coilia dussumieri*	25	–	–	–	–	–	–	2	8
April 2010	1	*Ambassis ambassis*	69	–	–	–	–	26	37.68	–	–
	2	*Thryssa mystax*	28	6	21.42	–	–	–	–	–	–
	3	*Thryssa setirostris*	33	7	21.21	–	–	–	–	–	–
	4	*Thryssa malabarica*	27	8	29.62	6	22.22	–	–	–	–
	5	*Escualosa thoracata*	44	–	–	9	20.45	–	–	–	–
	6	*Opisthopterus tardoore*	19	2	10.52	–	–	–	–	5	26.32
	7	*Coilia dussumieri*	18	–	–	–	–	–	–	1	5.51
May 2010	1	*Ambassis ambassis*	38	–	–	–	–	6	15.79	–	–
	2	*Thryssa mystax*	27	2	7.41	–	–	–	–	–	–
	3	*Thryssa setirostris*	39	2	5.13	–	–	–	–	–	–
	4	*Thryssa malabarica*	44	3	6.82	7	15.91	–	–	–	–
	5	*Escualosa thoracata*	62	–	–	8	12.9	–	–	–	–
	6	*Opisthopterus tardoore*	19	1	5.26	–	–	–	–	3	15.79
	7	*Coilia dussumieri*	28	–	–	–	–	–	–	2	7.14

Table III. Continuation

Month	SI No.	Host fish	NFO	*Nerocila phaiopleura* Bleeker, 1857		*Nerocila loveni* Bovallius, 1887		*Nerocila longispina* Miers, 1880		*Nerocila depressa* Milne Edward, 1840	
				NFI	P	NFI	P	NFI	P	NFI	P
June 2010	1	*Ambassis ambassis*	46	–	–	–	–	4	8.7	–	–
	2	*Thryssa mystax*	25	1	4	–	–	–	–	–	–
	3	*Thryssa setirostris*	29	1	3.45	–	–	–	–	–	–
	4	*Thryssa malabarica*	32	2	6.25	3	9.38	–	–	–	–
	5	*Escualosa thoracata*	39	–	–	6	15.38	–	–	–	–
	6	*Opisthopterus tardoore*	33	2	6.06	–	–	–	–	2	6.06
	7	*Coilia dussumieri*	13	–	–	–	–	–	–	1	7.6
July 2010	1	*Ambassis ambassis*	28	–	–	–	–	3	10.71	–	–
	2	*Thryssa mystax*	15	1	6.6	–	–	–	–	–	–
	3	*Thryssa setirostris*	12	–	0	–	–	–	–	–	–
	4	*Thryssa malabarica*	19	1	5.26	2	10.53	–	–	–	–
	5	*Escualosa thoracata*	42	–		6	14.29	–	–	–	–
	6	*Opisthopterus tardoore*	32	–	0	–	–	–	–	4	12.5
	7	*Coilia dussumieri*	29	–	–	–	–	–	–	2	6.8
Aug. 2010	1	*Ambassis ambassis*	56	–	–	–	7	12.5	–	–	–
	2	*Thryssa mystax*	15	–	0	–	–	–	–	–	–
	3	*Thryssa setirostris*	19	–	0	–	–	–	–	–	–
	4	*Thryssa malabarica*	35	3	8.6	–	–	–	–	–	–
	5	*Escualosa thoracata*	35	–	–	3	8.57	–	–	–	–
	6	*Opisthopterus tardoore*	26	–	0	–	–	–	–	4	15.38
	7	*Coilia dussumieri*	27	–	–	–	–	–	–	–	–
Sept. 2010	1	*Ambassis ambassis*	32	–	–	–	–	3	9.38	–	–
	2	*Thryssa mystax*	35	–	–	–	–	–	–	–	–
	3	*Thryssa setirostris*	26	–	0	–	–	–	–	–	–
	4	*Thryssa malabarica*	38	3	7.9	–	0	–	–	–	–
	5	*Escualosa thoracata*	73	–	–	4	5.48	–	–	–	–
	6	*Opisthopterus tardoore*	29	–	–	–	–	–	–	3	10.34
	7	*Coilia dussumieri*	19	–	–	–	–	–	–	–	–
Oct. 2010	1	*Ambassis ambassis*	45	–	–	–	–	11	24.44	–	–
	2	*Thryssa mystax*	35	4	11.43	–	–	–	–	–	–
	3	*Thryssa setirostris*	38	3	7.69	–	–	–	–	–	–
	4	*Thryssa malabarica*	49	9	18.37	4	8.16	–	–	–	–
	5	*Escualosa thoracata*	73	–	–	16	21.92	–	–	–	–
	6	*Opisthopterus tardoore*	25	–	–	–	–	–	–	4	16
	7	*Coilia dussumieri*	29	–	–	–	–	–	–	3	10.34
Nov. 2010	1	*Ambassis ambassis*	39	–	–	–	–	14	35.9	–	–
	2	*Thryssa mystax*	39	8	20.51	–	–	–	–	–	–
	3	*Thryssa setirostris*	48	5	10.42	–	–	–	–	–	–
	4	*Thryssa malabarica*	59	14	23.73	5	8.47	–	–	–	–
	5	*Escualosa thoracata*	62	–	–	14	22.58	–	–	–	–
	6	*Opisthopterus tardoore*	27	4	14.81	–	–	–	–	7	25.93
	7	*Coilia dussumieri*	31	–	–	–	–	–	–	4	12.9

Nerocila phaiopleura Bleeker, 1857

The prevalence on *Thryssa malabarica* was relatively high (P = 21.51%). Of 502 host fishes examined from November 2009 through November 2010, 108 specimens were infested by *Nerocila phaiopleura*. This species was collected from 67 of 381 *Thryssa mystax* (P = 17.6%). Among a total of 376 *Thryssa setirostris* examined, 55 were infested by *N. phaiopleura* (P = 14.63%). The lowest prevalence was found in *Opisthopterus tardoore*; among the 398 host fishes examined, only 28 specimens were infested by this species (P = 7.04%) (Table II).

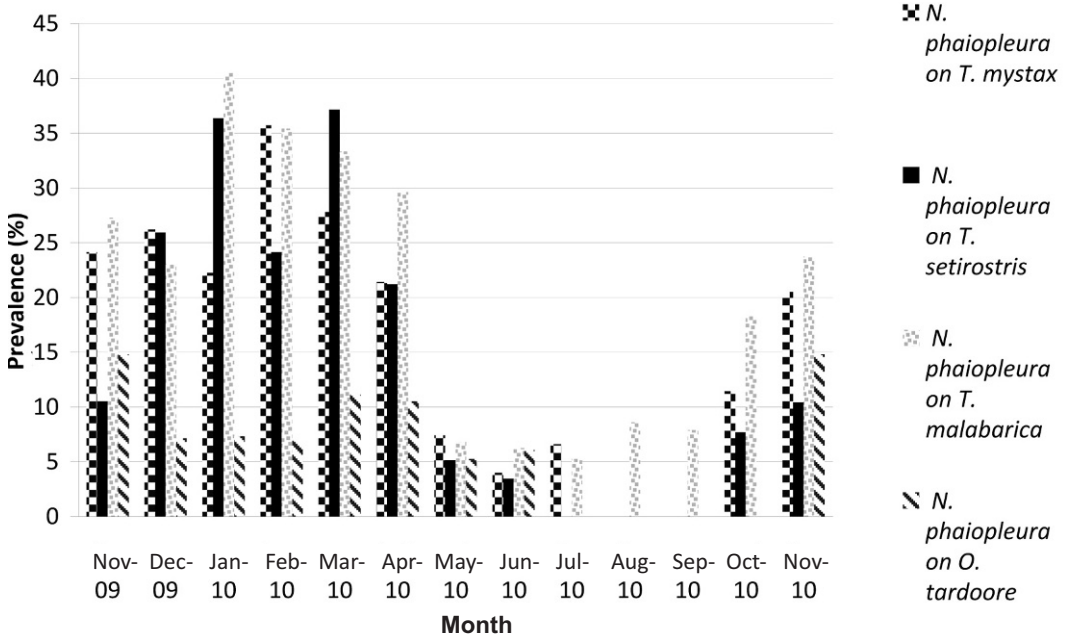

Fig. 1. Occurrence of *Nerocila phaiopleura* according to the season and the fish species

The prevalence of *N. phaiopleura* fluctuated significantly according to the season. In *Thryssa malabarica*, it was relatively high from October 2009 through April 2010 (29.40% ± 2.89) and maximum during January 2010 (P = 40.48%). The prevalence was significantly lower during May-September 2010 (P = 6.97% ± 0.59; t = 6.404; P<0.0001) than from October 2009 through April 2010 (Table III; Fig. 1)

The prevalence of *N. phaiopleura* parasitizing *T. mystax* was also high from October 2009 to April 2010 (23.93% ± 2.785). It was significantly low (P = 6.003% ± 1.03; t = 4.032, P<0.002) from May through July 2010. There was no sign of infestation on *T. mystax* by *N. phaiopleura* during August and September 2010 (P = 0%) (Table III and Fig. 1).

The prevalence of *N. phaiopleura* parasitizing *T. setirostris* gradually increased from October 2009 through April 2010 (P = 23.28% ± 4.32). Thereafter, it showed a significant decrease (P = 4.29% ± 0.84, t = 2.238, P<0.03). This host fish was unparasitized from July through September 2010 (Table III; Fig. 1).

Compared with the aforementioned three hosts (*T. malabarica*, *T. mystax* and *T. setirostris*), *N. phaiopleura* showed a relatively lower prevalence in *O. tardoore* (Table II, Fig. 1). The infestation was only restricted during November 2009 through June 2010 (P = 8.64% ± 1.14). No signs of infestation on this host fish were observed from July to October 2010.

In the three engraulid hosts, *T. malabarica*, *T. mystax* and *T. setirostris*, the base of the pectoral fin was the major site of

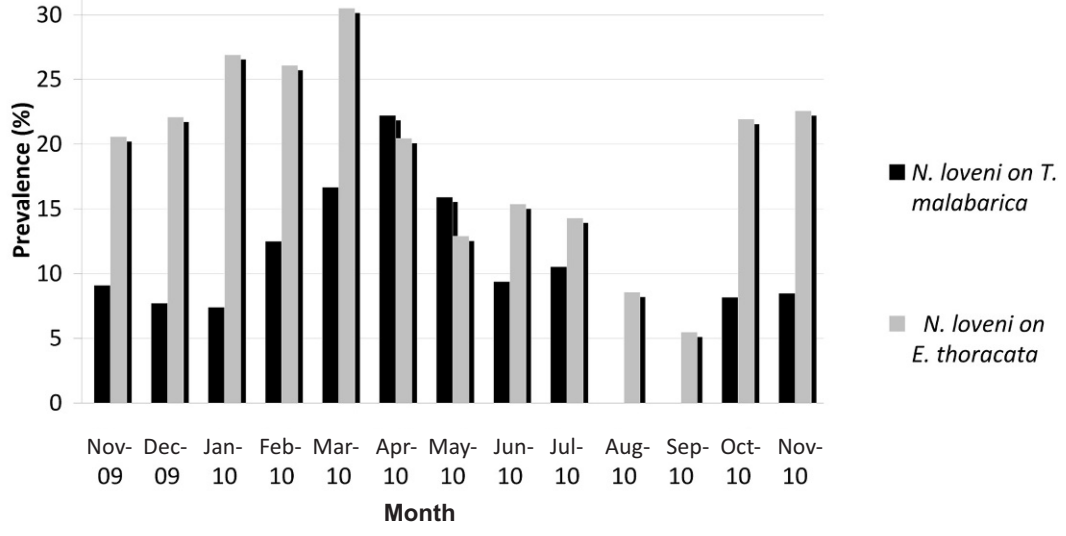

Fig. 2. Occurrence of *Nerocila loveni* according to the season and the fish species

attachment for *N. phaiopleura*. On several occasions, this species was collected from the body surface, adjacent to the lateral line and the operculum. However, in *O. tardoore*, *N. phaiopleura* was only collected from the body surface. In the parasitized fish, lesions with erosion of epidermis and underlying dermis were frequently observed at the site where the parasites were attached.

Nerocila loveni Bovallius, 1887

Nerocila loveni parasitized two fish species, *Escualosa thoracata* and *Thryssa malabarica*, the former showing a relatively higher prevalence (Table II) from November 2009 through November 2010.

Interestingly, seasonal variations in the rate of infestation were observed in both these host fishes (Fig. 2). Of 803 *E. thoracata* examined, 161 were infested (P = 20.05%). The prevalence was above than 20% (P = 24.22% ± 1.393) during the post monsoon and the summer seasons (October 2009-April 2010) with a maximum value in March 2010 (P = 30.52%). From May through September 2010, the rate of infestation was significantly less (P = 11.32% ± 1.86; t = 5.67; P<0.001).

Of 502 *T. malabarica* examined, only 49 specimens were infested by *N. loveni* (P = 9.76%). From February through May 2010, the infestation rate was the highest (16.83% ± 2.014) with a peak during April 2010 (P = 22.22%). However, from the onset of monsoon, the prevalence showed a gradual and significant decrease (P = 9.55% ± 0.58; t = 2.39; P<0.037) and the infestation rate was nil during August-September 2010. From October 2010, signs of infestation again appeared in *T. malabarica*.

The body surface in the close vicinity of the lateral line was the major site of attachment for *N. loveni*.

Nerocila depressa Milne Edward, 1840

Nerocila depressa parasitized two fish species, *Opisthopterus tardoore* and *Coilia dussumieri*, the prevalence being significantly higher in *O. tardoore* (21.32% ± 3.04) than in *C. dussumieri* (10.95% ± 2.87) (t = 2.48; P<0.01) (Table II and Fig. 3).

The infestation rate on *O. tardoore* was relatively high from October 2009 through April 2010 (P = 27.96% ± 3.14.), but subsequently it declined reaching a minimum value during May-September 2010 (P = 12.01% ± 1.79). Such decline was statistically significant (t = 3.94; P<0.001). The lowest value of the prevalence was observed in June 2010 (P = 6.06%).

Coilia dussumieri showed also seasonal variations in the infestation rate by *N. depressa* (Fig. 3). The prevalence was found to be generally highest from October 2009 through February 2010 (19.27% ± 4.58) with a peak during February 2010 (P = 36.84%). From March to July 2010, the prevalence was significantly the lowest (P = 7.01% ± 0.43) (t = 2.66, P<0.014) and no signs of infestation were observed during August and September 2010.

Nerocila depressa was collected from the body surface of *O. tardoore* and *C. dussumieri*.

Nerocila longispina Miers, 1880

Among the 56 fish species examined, only *Ambassis ambassis* was parasitized by *Nerocila longispina*. So, this *Nerocila* species showed an oligoxenous parasitic specificity.

Of a total of 596 *A. ambassis* examined, 174 specimens were infested (P = 29.19%) (Tables II and III). The prevalence was the highest from October 2009 through April 2010 (P = 37.49% ± 2.72) with two peaks during January and March 2010 (P = 45.39% ± 0.265) (Table III and Fig. 4). The infestation

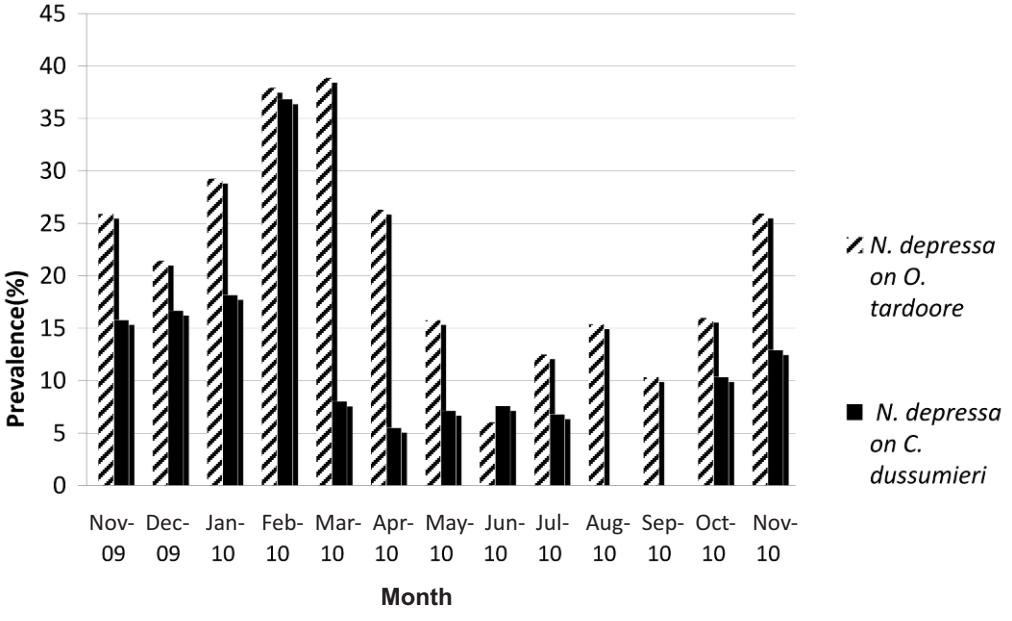

Fig. 3. Occurrence of *Nerocila depressa* according to the season and the fish species

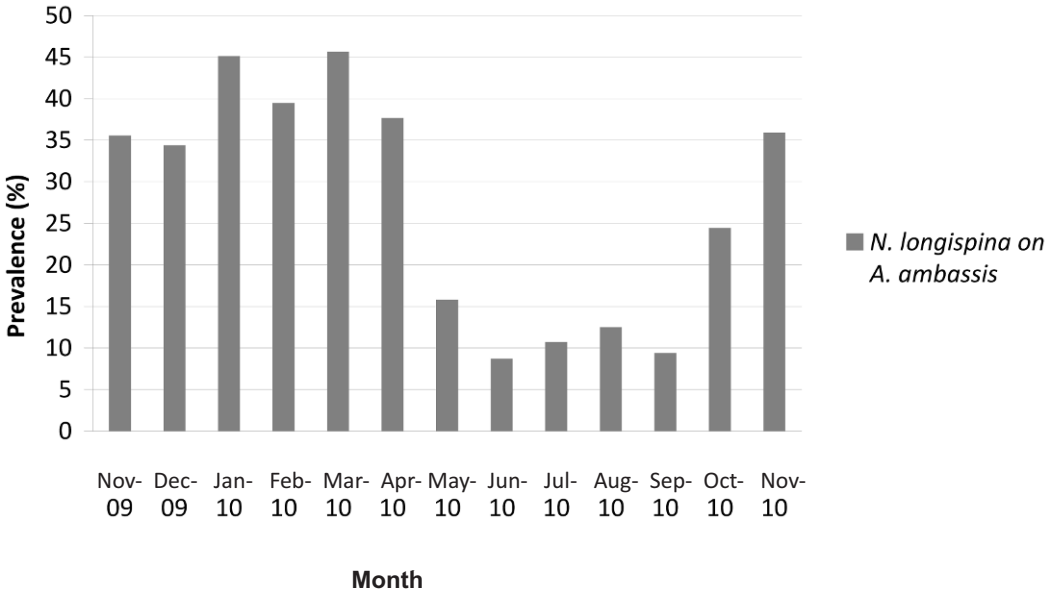

Fig. 4. Occurrence of *Nerocila longispina* parasitizing *Ambassis ambassis* according to the season

rate was relatively low from May through September 2010 (P = 10.42% ± 1.91), the prevalence reaching the lowest value in June 2010 (P = 8.7%).

The parasite was generally found attached to the postero-ventral side of the head. In few occasions, it was also observed clinging on to the body surface or close to the lateral line.

Discussion

The genus *Nerocila* Leach, 1818 represents one of the largest groups of the Cymothoidae family infesting several fish species of economic importance (Trilles 1969, 1994). About 65 species of *Nerocila* were reported so far from the different parts of the world (Trilles 1994) including particularly North America (Richardson 1905), Mediterranean Sea (Trilles 1975), California, eastern Pacific (Brusca 1981), Hong Kong and Australia (Bruce 1982, 1987), Yugoslavia, Kuwait (Bowman and Tareen 1983), Adriatic Sea (Radujkovic *et al*. 1984), Indo-West Pacific (Bruce and Harrison-Nelson 1988), Malaysia (Seng and Seng 1990), Turkey (Öktener and Trilles 2004), Lebanon (Bariche and Trilles 2005), Algeria (Ramdane *et al*. 2007), India (Trilles *et al*. 2011). The present study reports the occurrence of four species of *Nerocila*, *N. phaiopleura*, *N. loveni*, *N. depressa* and *N. longispina* parasitizing economically important marine fishes from the Malabar Coast of India. From this region, seven fish hosts belonging to the families Ambassidae, Clupeidae and Engraulidae showed heavy infestation by *Nerocila* species. Interestingly, four of them (*T. malabarica*, *T. mystax*, *T. setirostris* and *C. dussumieri*) belong to the family Engraulidae.

Until now, *N. phaiopleura* was collected from several host fishes in India (Trilles *et al*. 2011). In the present study, *T. mystax*, *T. setirostris*, *T. malabarica* and *O. tardoore* were identified as potential hosts for this species from the South-western coasts of India. Among them, *T. setirostris*, *T. malabarica* and *O. tardoore* are new hosts for *N. phaiopleura* while previous studies already reported the infestation of *T. mystax* by *N. phaiopleura* at Parangipettai, Southeastern Indian coasts (Veerapan and Ravichandran 2000, Rajkumar *et al*. 2010, Trilles *et al*. 2011). The highest prevalence was observed in the Engraulidae *T. malabarica* (P>20%) and it was significantly less in the Clupeidae *O. tardoore* (P<8%). Rameshkumar and Ravichandran (2010) reported *N. phaiopleura* parasitizing *Rastrelliger kanagurta* (Scombridae) from the Southeastern coast of India but with a very low prevalence. It seems that may be *R. kanagurta* is an occasional host for this species. At Parangipettai, the infestation of *Stolephorus commersonii* by *N. phaiopleura* was also reported (Rajkumar *et al*. 2007). So, we suggest provisionally that may be the parasitic specificity of this species differs according to the prospected Indian coasts.

It was observed that two species of *Nerocila*, *N. phaiopleura* and *N. loveni*, parasitized *T. malabarica*, a new host for these two parasites. However, the rate of infestation of *N. loveni* on *T. malabarica* is significantly less (P<10%) than the one observed for *N. phaiopleura* while *N. loveni* showed a prevalence significantly highest in its other host *E. thoracata*.

In India, *N. depressa* so far has been recorded from the Bombay coasts, parasitizing *O. tardoore* (Bal and Joshi 1959, Joshi and Bal 1960, Parimala 1984). This species was also reported from *C. dussumieri* at Sumatra (Bruce and Harrison-Nelson 1988). Along the Malabar coasts, we collected *N. depressa* from these same hosts, *O. tardoore* and *C. dussumieri*, but the prevalence in *O. tardoore* is significantly higher (P = 21.32% ± 3.04; t = 2.48; P<0.01) than in *C. dussumieri*

(P = 10.95% ± 2.87). It was observed that *O. tardoore* was parasitized by two *Nerocila* species, *N. depressa* and *N. phaiopleura*. However, the prevalence of infestation by *N. depressa* was significantly highest, suggesting that *O. tardoore* is a better potential host for *N. depressa* than for *N. phaiopleura*.

Of 56 fish species examined, *N. longispina* was only collected from *A. ambassis* (Ambassidae) and so, it showed an oligoxenous parasitic specificity. Also, it should be noted that, among the four species of the collected *Nerocila*, *N. longispina* showed the highest value of the prevalence. 174 of 596 *A. ambassis* examined from November 2009 through November 2010 were infested by *N. longispina* with an average prevalence of 29.19% and a peak of prevalence (P~ 45%) from January to March 2010.

Interestingly, that all the four species of *Nerocila* exhibited similar patterns of seasonal fluctuations in the rate of infestation. *N. phaiopleura* infested *T. malabarica*, *T. mystax* and *T. setirostris*, with a prevalence relatively high (>20%) from November 2009 through April 2010, decreasing during May-September 2010 and reaching a low or nil value (P<7% or P = 0%). In *C. dussumieri*, the infestation by *N. depressa* was restricted to October 2009-July 2010 with a peak of prevalence during February 2010 (P = 36.84%). *O. tardoore* was parasitized by *N. depressa* throughout the year with a highest prevalence from February to March 2010 (P = 38.41%). The infestation of *E. thoracata* by *N. loveni* and *A. ambassis* by *N. longispina* was observed throughout the year with highest rates during October 2009-April 2010, the prevalence being slightly above 30% during March 2010 (*N. loveni*) or equal to 45% during January and March 2010 (*N. longispina*).

At the beginning of the monsoon season, the prevalence generally showed a downward trend and only less or no infestation was observed during the post monsoon season (August-September). However, from October to November, the prevalence gradually increased and reached a maximum value during February-April 2010. These results suggest that the prevalence could be dependent on seasonal environmental parameters such as rainfall, salinity and temperature. A low value of the prevalence during the monsoon season suggests that the weak salinity (27–29 ppt), resulting from the heavy rain fall, induces an unfavourable environment for the parasite while the gradual increase of salinity (30–35 ppt) during the post-monsoon season (October-November) seems to facilitate the parasitic infestation (Sudha *et al*. unpublished). This situation continues until the premonsoon period (February-April/May) when the salinity reaches a maximum value (36–40 ppt). In all the *Nerocila* species studied (*N. loveni*, *N. depressa*, *N. phaiopleura* and *N. longispina*), the prevalence reached peak values during the premonsoon months but the exact mechanism by which the salinity plays a role in the parasitization is not clear. However, may be it would be worth to mention that all the *Nerocila* species collected during this study were ovigerous throughout the year. Now the necessity of an optimum salinity for the larval development has been reported in many free-living crustaceans (Sudha and Anilkumar 1996) and for them, the monsoon season is not generally a breeding season (Syama *et al*. 2010). Similarly, it was already reported that the climatic conditions affect the reproduction of several cymothoids (Trilles 1969, Leonardos and Trilles 2003). However, an increased parasitic prevalence with the onset of the monsoon rains was sometimes observed. The high temperatures of the ambient water during this season might be conductive to a prolonged presence and proliferation of some cymothoids (Papapanagiotou and Trilles 2001, Rajkumar *et al*. 2005). Therefore, further investigations will be very useful to resolve this question.

The principal sites of attachment for several *Nerocila* species are the caudal or dorsal fin and the base of the dorsal or pectoral fin (Trilles 1969, Morton 1974). However, in the present study, it was observed that the body surface of the host was the major site of attachment for *N. depressa* and *N. loveni* and to some extent for *N. phaiopleura*. Only in few cases, *N. longispina*, *N. loveni* and *N. phaiopleura* were found to be settled adjacent to the lateral line. *N. phaiopleura* was also attached at the base of the pectoral fin of the host and *N. longispina* on the postero-ventral side of the head. As already observed by Morton 1974, *N. phaiopleura* was preferably found attached on the posterior third of the body, overlying the lateral line of its host fishes. It is suggested that such a disposition makes accessible the streak of red muscles underlying the lateral line which contain much myoglobin and stored fats (Bowman and Tareen 1983).

Skin lesions were frequently observed at the site of attachment of *N. phaiopleura* on *T. malabarica*. The damaged area was particularly devoid of scales, sometimes eroded down to the myotomes and hemorrhages were often observed. Occurrence of such damages to the host body were already reported and has been noted as an accompanying sign in all diseases induced by parasitic isopods (Trilles 1969; Romestand 1979; Bragoni *et al*. 1983; Rajkumar *et al*. 2005, 2007; Ravichandran *et al*. 2010). The skin lesions could induce vibriosis and secondary bacterial infections, with often an increased mortality (Rajkumar *et al*. 2007).

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