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ORIGINAL ARTICLE

Branchial cymothoids infesting the marine food fishes of Malabar coast

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Abstract Occurrence of cymothoid isopods parasitizing the branchial chamber of marine food fishes along the Malabar coast was investigated. Live and fresh fishes collected from the Ayyikkara fish landing center (Lat. 11°51′N, Long. 75°22′E; Malabar coast, India) were subjected to the thorough observation for the presence of branchial cymothoids for 3 consecutive years (November 2009–November 2012). Among the recovered cymothoids, 11 species were branchial residents belonging to 6 genera; the species include *Agarna malayi, Catoessa gruneri, C. boscii, Joryma hilsae, J. brachysoma, J. engraulidis, J. sawayah, Mothocya collettei, M. renardi, Norileca indica* and *Ryukyua circularis*; highest prevalence being exhibited by two species of *Mothocya*, (*M. renardi* and *M. collettei*) parasitizing the belonidaen fishes, *Strongylura leiura* (92.15 %) and *Tylosurus crocodilus crocodilus* (87.2 %) respectively. Except *Mothocya* species, which preferred the branchial floor for infestation, all recovered branchial cymothoids were found attached the inner wall of the operculum. In several instances, the parasites appeared in male–female pairs, one in each branchial cavity. Ovigerous female members of all species of branchial cymothoids except *R. circularis* showed remarkable bending either towards left or right depending on whether they are located in right or left branchial cavity of their respective host fishes. The deleterious effects of parasitization by all recovered branchial cymothoids include the formation of a pit like depression in the branchial chamber and atrophy of the gill filament; the damage was more pronounced in the gill cavity of parasitized host fishes where the ovigerous female member was accommodated.

Keywords Cymothoids · Branchial cavity · Marine fishes · Infestation · Parasitic isopod

Abbreviations

PCM	Parasitic Crustacean Museum, Crustacean Biology Research Laboratory, Sree Narayana College, Kannur, Kerala, India
LT	Total length
OgF	Ovigerous female
BP	Brood pouch
ML	Manca larvae
PL	Pre-manca larvae
CTR	Curved towards right
CTL	Curved towards left

Introduction

Cymothoids, the obligate ectoparasitic isopods infest a diverse array of fishes and cause tremendous destructive activity in their hosts (Trilles 1969, 1994; Brusca 1978, 1981; Maxwell 1982; Bunkley-Williams et al. 2006; Elshahawy and Desouky 2012; Aneesh 2014; Smit et al. 2014). Cymothoids comprise 40 genera with more than 380 species (Ahyong et al. 2011) and they infest different parts of the fish body including buccal cavity, gill chamber, body surface and fins, or sometimes they burrow inside the host body (Trilles 1969; Brusca 1981). Their continuous feeding on host blood and fish tissues results the serious localized tissue damage or lesions, reduced growth, behavioral

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problems and in extreme cases death itself (Romestand and Trilles 1976, 1979; Brusca 1981; Grabda and Rokicki 1982; Brusca and Gilligan 1983; Colorni et al. 1997; Horton and Okamura 2001; dos Santos Costa and Chellapa 2010; Rameshkumar and Ravichandran 2014). Physiological modifications of the chimic composition of the fish plasma (Romestand and Trilles 1979; Horton and Okamura 2003) have also been reported. The sustained aerobic swimming speed and the swimming endurance of parasitized fish at high-water speeds were also found to be reduced due to the drag of the external isopod (Ostlund-Nilsson et al. 2005). Impaired reproduction and reduced lifespan in some hosts have also been reported due to cymothoid infestation (Adlard and Lester 1994).

Cymothoids are reported from the fishes of different geographic regions all over the world including marine, brackish and fresh waters. However, greatest diversity of the cymothoids occurs within the tropics, with a rapid attenuation in diversity towards high latitudes (Smit et al. 2014). Malabar coast (India) is notable for captured and cultured fish diversity (Aneesh 2014; Aneesh et al. 2013, 2014), but a comprehensive study on the occurrence of cymothoids, one of the major threats to these edible fishes has not been attempted yet. The present paper reports the occurrence of cymothoids infesting the branchial cavity of the marine fishes along the Malabar coast giving special emphasis on the host specificity, site specificity and deleterious effect of their parasitism.

Materials and methods

Edible marine fishes along the Malabar coast were surveyed for 3 consecutive years, during the period from November 2009 to November 2012 with a view to assess the occurrence of parasitic infestation by cymothoids. For this purpose, the fishes were collected from Ayyikkara, the major fish landing centre of Malabar coast (Lat. 11°51′N, Long. 75°22′E; Malabar coast, India). As soon as they were collected and transferred to the laboratory, various parts of the fish body including the body surface, the lateral line region, and the base of the pectoral fin, the branchial cavity, gill filaments and the inner wall of the operculum were carefully examined for the presence of the parasitic isopods. Recovered parasites were removed from the host and preserved in 70 % ethanol for further detailed examination. The identification at species level was done, according to the key characters and WoRMS (http://www.marinespecies.org/). The prevalence (P) was calculated according to Margolis et al. (1982) and Bush et al. (1997). Host nomenclature and fish taxonomy are according to Fish Base (Froese and Pauly 2013). The recovered cymothoids were further observed under dissection, stereo (Leica-S6D) and compound research (Las EZ) microscopes. Sampling data were analyzed using statistical software (Graphpad InStat, Version 2.00, 2007).

Voucher specimens of all parasites were collected by Aneesh, Helna and Sudha from Ayyikkara fish landing centre (Lat. 11°51′N, Long. 75°22′E), Malabar coast of Kerala, India and deposited in the collections of Parasitic Crustacean Museum, Sree Narayana College, Kannur, Kerala, India.

Agarna malayi (Tiwari 1953)

All from *Tenualosa toli*. OgF, CTR (LT. 15 mm) with ML in the BP (PCM N° AM-01), 17 February 2011; M, (LT. 13 mm) paired with the specimen PCM N° AM-01(PCM N° AM-02), 17 February 2011; OgF, CTL (LT. 18 mm) with empty BP (PCM N° AM-03), 7 September 2011.

Catoessa gruneri (Bowman and Tareen 1983)

All from *Eubleekeria splendens*. OgF (LT. 14 mm) with BP (PCM N° CG-01), 9 March 2010; OgF (LT. 8 mm) with BP (PCM N° CG-02), 28 April 2010.

Catoessa boscii (Bleeker 1857)

OgF (LT. 22 mm) with BP from *Ilisha megaloptera* (PCM N° CB-01), 30 November 2009.

Joryma brachysoma (Pillai 1964)

All from *Escualosa thoracata*. OgF body CTR (LT. 7 mm) with stage II embryo in the BP (PCM N° JB-04), 27 May 2010; OgF body CTL (LT. 11 mm) with PL in the BP and a male (LT. 4 mm) from the same host (PCM N° JB-7), 17 November 2011.

Joryma engraulidis (Barnard 1936)

All from *Thryssa setirostris*. OgF (LT. 12 mm) with empty BP (PCM N° JE-01), 30 November 2009; OgF (LT. 11 mm) without BP (PCM N° JE-02), 16 January 2010; Male (LT. 9 mm) (PCM N° JE-04) 2 June 2010.

Joryma hilsae Rameshkumar et al. 2011

All from *Pellona ditchela*. OgF body CTL (LT. 19 mm) with eggs in the BP (PCM N° JH-01), 14 May 2010; OgF body CTR (LT. 19.5 mm) with eggs in the BP (PCM N° JH-02), 14 May 2010; Male (LT. 11 mm) paired with the specimen, PCM N° JH- 02(PCM N° JH -03) 14 May 2010

Table 1 Parasitological indices of the branchial cymothoids recovered from the marine fishes along the Malabar coast, India

Sl. No.	Parasites and their host fishes	NFO	NFI	I	P
1	***Agarna malayi*** (Tiwari 1953)				
	Tenualosa toli (Clupeidae)	284	46	1.89	16.19
2	***Catoessa gruneri*** (Bowman and Tareen 1983)				
	Eubleekeria splendens (Leiognathidae)	108	29	1	26.85
3	***Catoessa boscii*** (Bleeker 1857)				
	Ilisha megaloptera (Pristigasteridae)	222	26	1	11.71
4	***Joryma hilsae*** Rameshkumar et al. 2011				
	Pellona ditchela (Pristigasteridae)	928	268	1.76	28.87
5	***Joryma brachysoma*** (Pillai 1964)				
	Escualosa thoracata (Clupeidae)	803	281	1.78	35
6	***Joryma engraulidis*** (Barnard 1936)				
	Thryssa setirostris (Engraulidae)	376	46	1	12.23
7	***Joryma sawayah*** (Bowman and Tareen 1983)				
	Ilisha melastoma (Pristigasteridae)	798	183	1.62	22.93
8	***Mothocya collettei*** Bruce 1986				
	Tylosurus crocodilus crocodilus (Belonidae)	94	82	1.9	87.2
9	***Mothocya renardi*** (Bleeker 1857)				
	Strongylura leiura (Belonidae)	408	376	1.81	92.15
10	***Norileca indica*** (Milne Edwards 1840)				
	Rastrelliger kanagurta (Scombridae)	1329	351	1.7	26.4
11	***Ryukyua circularis*** (Pillai 1954)				
	Amblygaster sirm (Clupeidae)	42	14	1.57	33.33

NFO number of fishes observed, *NFI* number of fishes infested, *P* prevalence, *I* intensity

Joryma sawayah (Bowman and Tareen 1983)

All from *Ilisha melastoma*. OgF body CTR (LT. 19 mm) with eggs in the BP and a male (LT. 12 mm) from the same host (PCM N° JS-03), 27 August 2011; OgF body CTL (LT. 16 mm) with ML in the BP and a male (LT. 9 mm) from the same host (PCM N° JS- 04), 17 November 2011.

Mothocya collettei Bruce (1986)

All from *Tylosurus crocodilus crocodilus*. OgF (LT. 22 mm) and a male (LT. 13 mm) pair from the same host (PCM N° MC-01), 13 October 2011; OgF (LT. 18.5 mm) with PL in the BP (PCM N° MC -04), 08 November 2011

Mothocya renardi (Bleeker 1857)

All from *Strongylura leiura*. OgF (LT. 31 mm) without BP (PCM N° MR-01), 24 December 2009; OgF (LT. 21.5 mm) with stage II embryo in the BP (PCM N° MR-03), 17 February 2010.

Norileca indica (Milne Edwards 1840)

All from *Rastrelliger kanagurta*. OgF body CTL (LT. 25 mm) with eggs in the BP (PCM N° NI-04), 21 May 2010; OgF body CTR (LT. 29.5 mm) with eggs in the BP (PCM N° NI-07), 29 May 2010; Male (LT. 16 mm) paired with the specimen, PCM N° JH- 07(PCM N° NI-08) 29 May 2010

Ryukyua circularis (Pillai 1954)

All from *Amblygaster sirm*. OgF (LT. 16 mm) with empty BP (PCM N° RC-01), 09 January 2010; OgF (LT. 10 mm) with empty BP (PCM N° RC-02), 5 November 2011.

Results and discussion

Twenty three species of isopods recovered from the marine fishes along the Malabar coast during the period of present study were invariably the representatives of the family Cymothoidae. Significantly, all of them exhibited

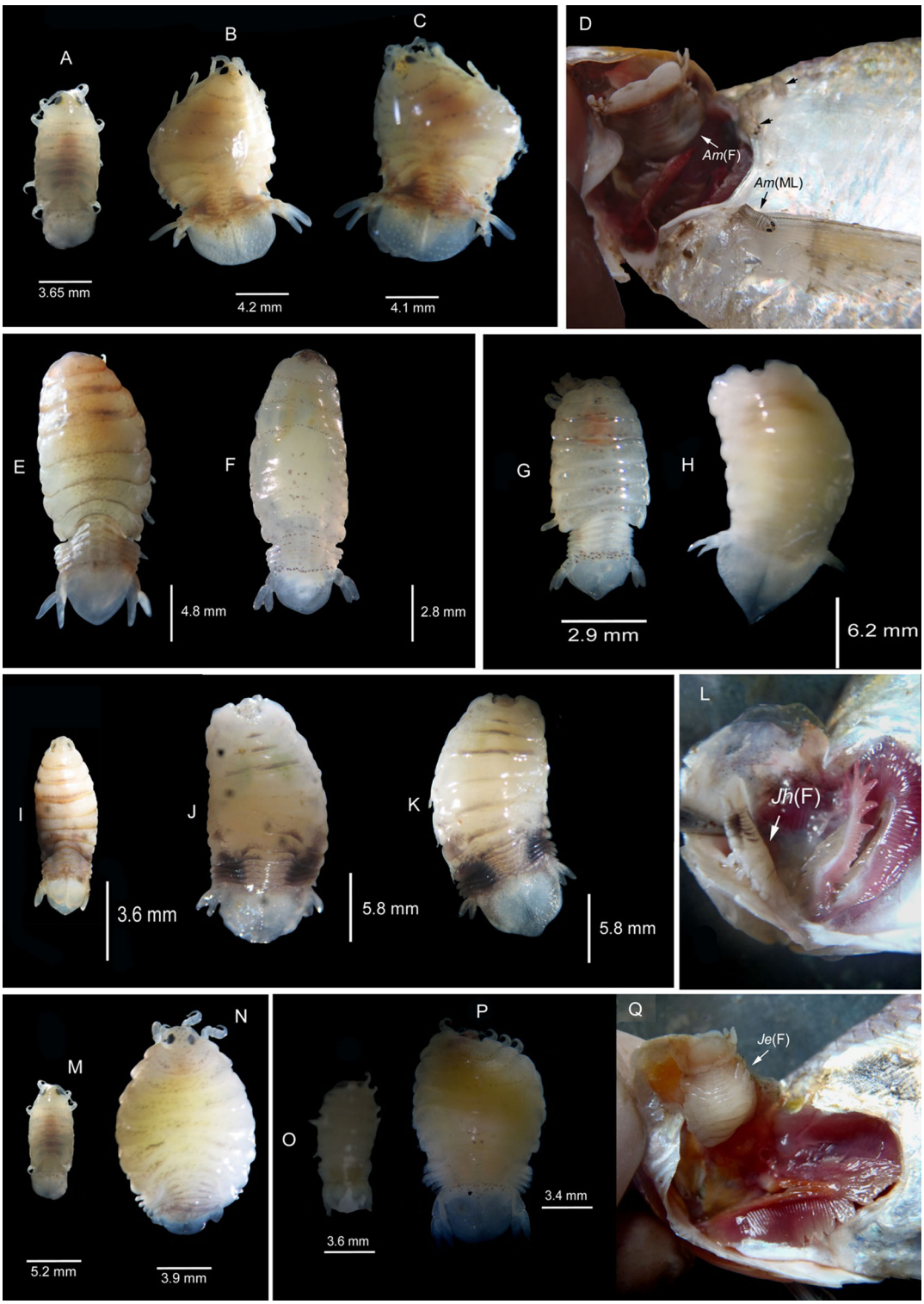

Fig. 1 **a** *Agarna malayi*—male; **b** *A. malayi* female—body showing bend towards *left*; **c** *A. malayi* female—body showing bend towards *right*; **d** *A. malayi* on the branchial cavity of the host fish *Tenualosa toli*; **e** *Catoessa boscii*—female; **f** *Catoessa gruneri*—female; **g** *Joryma sawayah*—male; **h** *J. sawayah*—ovigerous female; **i** *Joryma hilsae*—male; **j** *J. hilsae* ovigerous female—body showing bend towards *left*; **k** *J. hilsae* ovigerous female—body showing bend towards *right*; **l** *J. hilsae* on host fish *Pellona ditchela*; **m** *Ryukyua circularis*—male; **n** *R. circularis*—female; **o** *Joryma engraulidis*—male; **p** *J. engraulidis*—female; **q** *J. engraulidis* on host fish *Thryssa setirostris*. *Am(F)*, *Agarna malayi* female; *Am(ML)*, *Agarna malayi* manca larva; *Je(F)*, *Joryma engraulidis* female; *Jh(F)*, *Joryma hilsae* female; *Js(F)*, *Joryma sawayah* female

remarkable degree of host specificity and site specificity as well. Among them, 11 species appear to be branchial cymothoids belong to six genera; the species include *Agarna malayi, Catoessa gruneri, C. boscii, Joryma hilsae, J. brachysoma, J. engraulidis, J. sawayah, Mothocya collettei, M. renardi, Norileca indica* and *Ryukyua circularis* (Table 1; Figs. 1 and 2). Among the recovered branchial cymothoids, nine species preferred to attach the inner wall of

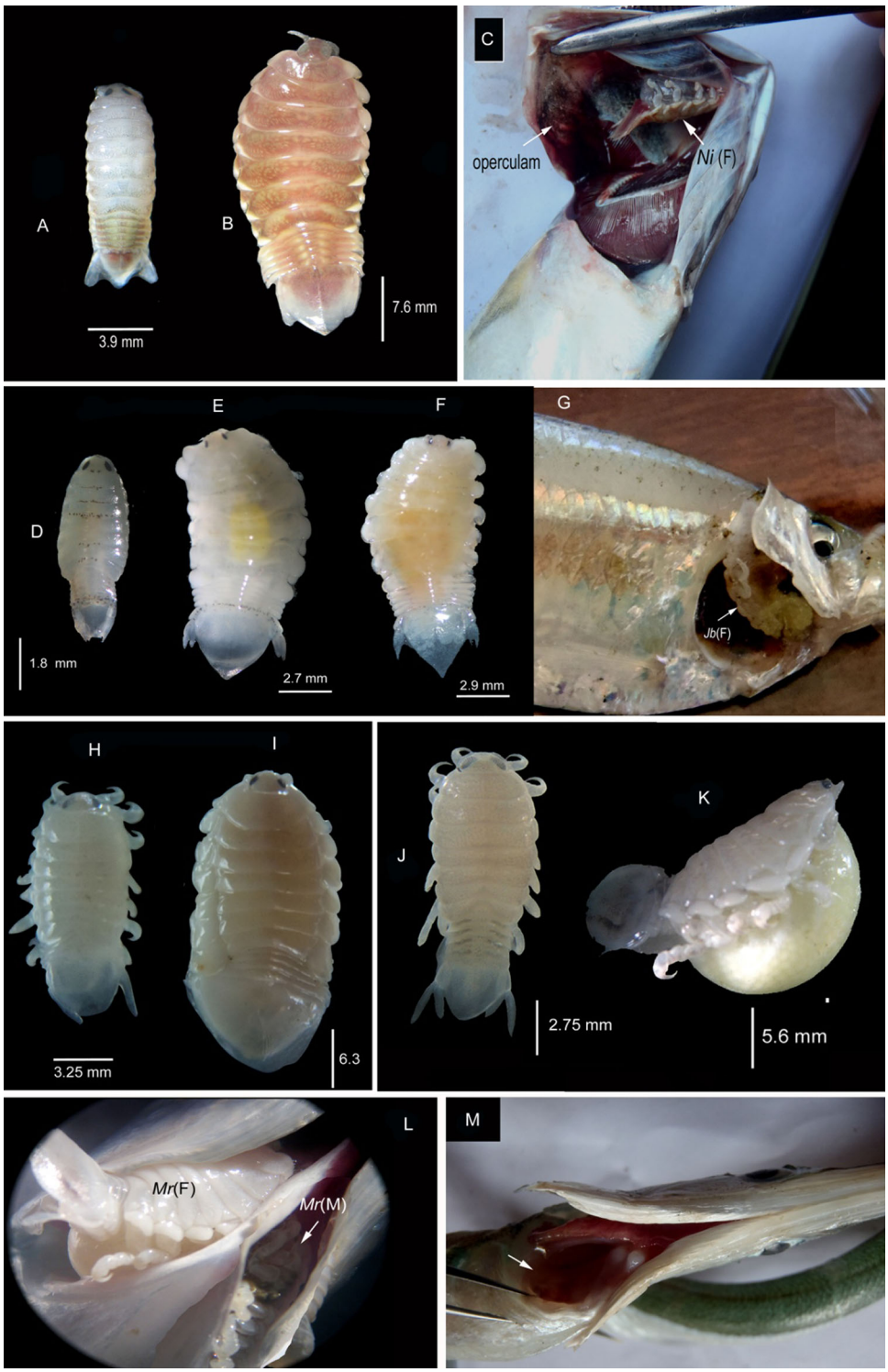

Fig. 2 **a** *Norileca indica*: male; **b** *N. indica*: female; **c** *N. indica* on host fish *R. kanagurta*; **d** *Joryma brachysoma* - male; **e** and **f** *J. brachysoma*—female; **g** *J. brachysoma* on host fish *Escualosa thoracata*; **h** *Mothocya collettei*: male; **i** *M. collettei*: ovigerous female; **j** *M. renardi*: male; **k** *M. renardi*: ovigerous female; **l** male and female *M. renardi* on *S. leiura*; **m** large pitted scar (*arrow*) formed in the branchial cavity of host (*S. leiura*) due to infestation of *M. renardi*. *Mr(F)*, *Mothocya renardi* ovigerous female; *Mr(M)*, *Mothocya renardi* male; *Ni(F)*, *Norileca indica* female, *Jb(F)*, *Joryma brachysoma* female

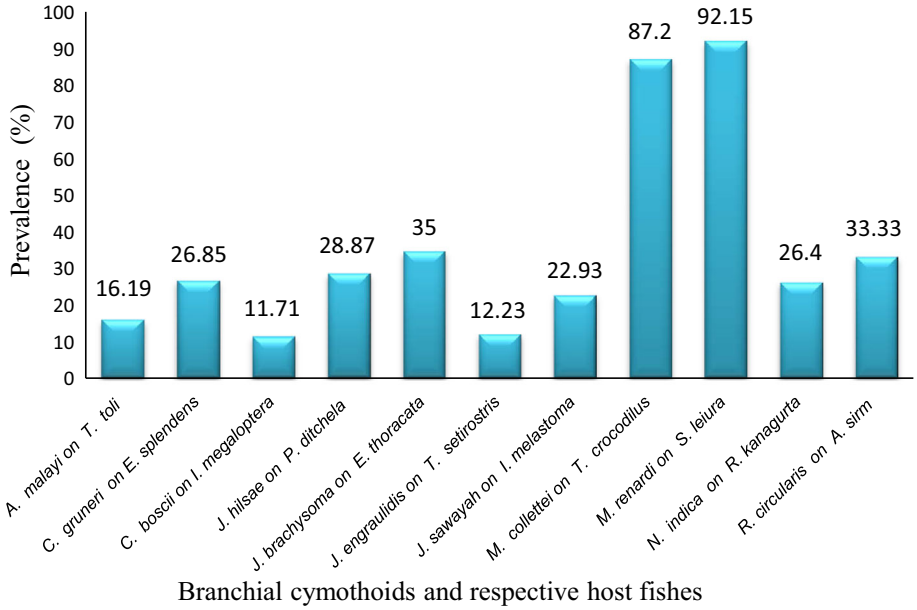

Fig. 3 Prevalence of branchial cymothoids recovered from the marine fishes along the Malabar coast from Nov 2009 to Nov 2012

the operculum and on the other hand, the remaining two species (*Mothocya*) were found attached the branchial floor (Table 1; Figs. 1d, e, f and 2 c, g, l, m). The site specific attachment of the cymothoids suggested to be very consistent within species and sometimes genus specific (Smit et al. 2014). Bowman and Mariscal (1968) found that the attachment position of *Renocila heterozota* on its host fish, *Amphiprion akallopisos* was always on the anterior trunk region, just behind the head. Likewise, attachment site of *Nerocila phaeopleura* is overlying the lateral line in the posterior third of the body (Morton 1974). The site specificity is determined by the needs of the parasite and the limitations exerted by the morphology and habits of the host (Morton 1974).

In most of the instances, the branchial cymothoids recovered during the present study were found in male–female pairs, one in each branchial cavity; male being smaller than the female. The male–female size difference is reported to be the one of the characteristics of the family Cymothoidae and this trait is most strongly expressed not only in branchial parasitic genera but in buccal parasites as well (Smit et al. 2014). It was quite interesting to note that except, *R. circularis* (Fig. 1n), the adult ovigerous females of all presently recovered branchial cymothoid species showed remarkable bending either towards left or right depending on whether they are located in right or left branchial cavity of their respective host fishes (Figs. 1b, c, e, f, h, j, k, p and 2b, e, f, i, k).

The prevalence shown by each recovered branchial cymothoids is represented in Table 1 and Fig. 3. Among the recovered branchial parasites, highest prevalence was exhibited by two species of *Mothocya*, *M. renardi* (92.15 %) and *M. collettei* (87.2 %) parasitizing the belonidaen fishes *Strongylura leiura* and *Tylosurus crocodilus crocodilus* respectively and least prevalence (11.7) was shown by *Catoessa boscii* parasitizing the fish *Ilisha megaloptera* (Table 1). Among the *Joryma* sp. the relatively high prevalence was found in *J. brachysoma* (35 %) infesting the fish *Escualosa thoracata* and least in *J. engraulidis* (12 %) infesting *Thryssa setirostris*.

Cymothoids are reported to cause serious damages to their fish hosts. In the present study, invariably, the branchial cavity and gill filaments of the infested fish showed significant damage which was more distinct in the gill chamber where the ovigerous females were harbored. Except *Mothocya* species, all recovered species of branchial parasites possessed flat belly and invariably found in clinged position on the surface of the inner operculum using their pereopods. On the other hand, the *Mothocya* species (*M. renardi* and *M. collettei*) attached the floor of the buccal cavity possess highly convexed belly, pushing of which against the gill and buccal floor caused the atrophy of the gill and the formation of a pit like depression on the buccal floor; the degree of damage was found to be high compared to that caused by other branchial cymothoid species. The degree of negative effects imparted by the cymothoids depend on the species and also its location on the host (Trilles 1994). Apart from causing branchial damage (Kroger and Guthrie 1972), deleterious impacts of branchial cymothoids were also reflected on the pericardium, heart, and respiratory metabolism (Trilles 1994).

Based on the overall observations made during the present study, it is concluded that the marine fishes of Malabar coast are under the threat of parasitic isopods of which 48 % is represented by branchial cymothoids including the species of *Joryma, Catoessa, Mothocya, Agarna, Norileca* and *Ryukyua;* except *Mothocya* sp. which

infest the floor of the branchial cavity, all recovered branchial cymothoids prefer the inner operculum as the infestation site signifying the consistent site specific parasitization within the microhabitat. Apart from the highly modified cephalic and thoracic appendages, the unique and characteristic body bending shown by the ovigerous females of the recovered parasitic species, appears to be one of the significant parasitic adaptations facilitating the permanent settlement of the parasite in the branchial cavity of their respective host fish. The branchial pits and atrophied gill filaments appeared in the infested gill cavity is apparently due to the permanent occupancy of the parasite and this aspect of host parasitic interaction demands further study at histopathological and physiological levels to quantitatively evaluate the deleterious effect of these branchial cymothoids on their host fishes.

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Conflict of interests The authors declare that they have no competing interests.

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