



New data on species of Didymozoidae parasitizing scombrids from the Southwestern Atlantic Ocean, Brazil

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Abstract

Seven species of Didymozoidae were found parasitizing three species of scombrid fishes along the Rio de Janeiro coast, southwestern Atlantic Ocean. All these species are reported here for the first time in Brazil and new hosts are presented, which adds to the knowledge of these species. The main morphological and morphometric features of each species are presented. A new combination of two species allocated to *Lobatocystis* Yamaguti, 1965 is proposed here, based on the previously established synonymy of *Lobatocystis* and *Lobatozoum* Ishii, 1935.

Keywords

Auxis thazard, didymozoid, Digenea, *Euthynnus alletteratus*, *Katsuwonus pelamis*, Scombridae.

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Introduction

The family Didymozoidae is composed of digenetic trematodes that are known for their rich diversity of species, distributed in six subfamilies, 12 tribes and 69 genera (see Pozdnyakov and Gibson, 2008). These trematodes parasitize scombrid fishes occurring in both tropical and subtropical areas (Nikolaeva 1985). The largest number of reports is from the Pacific Ocean, followed by the Indian Ocean, Atlantic Ocean, and Mediterranean Sea (see Pozdnyakov and Gibson 2008). The presence of these parasites may reduce the commercial value of fish, especially when they inhabit the musculature (Mota et al. 2019). In South America, Didymozoidae is represented by 33 marine species (see Kohn and Fernandes 2016; Moreira-Silva et al. 2019) and one species in freshwater fish (Thatcher 1979; Melo et al. 2013).

Scombrids such as mackerels, Spanish mackerels, bonitos, and tunas form the basis of important commercial and recreational fisheries throughout the tropical and temperate waters of the world (Collette et al. 2001). These fishes are of great importance as a fishing resource, for fresh consumption and for the canning industry (Block and Stevens 2001).

Katsuwonus pelamis (Linnaeus, 1758), commonly known as the skipjack tuna, is a pelagic species that has a wide geographic distribution, occurring in tropical and subtropical waters (Collette and Nauen 1983). It is of great commercial importance mainly as food resource in southeastern and southern Brazil (Menezes et al. 2010).

The little tunny, *Euthynnus alletteratus* (Rafinesque, 1810), is a medium-sized epipelagic and neritic tuna that is found in tropical and subtropical waters of the Atlantic

Ocean, including the Caribbean Sea and Gulf of Mexico, and in the Mediterranean and Black seas (Collette and Nauen 1983). Its oily meat is considered excellent, and it has great commercial value, appearing frequently in markets, in fresh, salted, smoked, or frozen form. The canning industry is its largest consumer. This fish also has sporting importance, as live bait to catch other fish species (Szpilman 2000).

The frigate tuna, *Auxis thazard* (Lacepède, 1800), is a coastal tuna species found circumglobally in tropical oceans down to depths of 50 m (Collette and Nauen 1983). It is more associated with the continental shelf than are other tuna and tuna-like species (Maguire et al. 2006). This fish is marketed in both fresh and frozen form and is also used in dried, salted, smoked, and canned forms (Froese and Pauly 2019).

During a survey of helminth parasites of marine fish on the coast of the state of Rio de Janeiro, Brazil, southwestern Atlantic Ocean, seven species of didymozoids were found parasitizing three species of Scombridae. The aim of this study was to contribute towards increasing the knowledge and expansion of the geographical distribution of didymozoid parasites in different species of fish in the area of the southwestern Atlantic Ocean.

Methods

Between 2007 and 2018, a total of 112 specimens of scombrid fishes were examined: 20 *A. thazard* (29–54

cm in total body length and 0.6–2.5 kg in weight), 31 *E. alletteratus* (27–71 cm in total body length and 0.5–4.0 kg in weight), and 61 *K. pelamis* (26–73 cm in total body length and 1.0–9.0 kg in weight). The fishes were obtained by local fishermen from the coastal zone of the state of Rio de Janeiro, Cabo Frio, Brazil (22°52'46"S, 042°01'07"W) (Fig. 1). The fishes were kept refrigerated until necropsied. Cysts containing parasites were carefully removed from the tissue and dissected, using needles. The parasites were fixed in AFA (95% ethanol 70°GL, 3% formaldehyde, 2% glacial acetic acid) under slight coverslip pressure or without pressure, stained with Langeron alcoholic acid carmine, dehydrated in an alcohol series, cleared in beachwood creosote and mounted in Canada balsam as permanent slides. All measurements are given in micrometers, unless otherwise stated. The range is followed by the mean in parentheses and the number of structures measured, when applicable. Values of prevalence, intensity, mean intensity and mean abundance follows Bush et al. (1997), accompanied by their respective standard deviation. The material studied was deposited in the Helminthological Collection of the "Instituto Oswaldo Cruz" (CHIOC), Rio de Janeiro, Brazil.

Results

In the present study, seven species of Didymozoidae were found parasitizing *A. thazard*, *E. alletteratus*, and

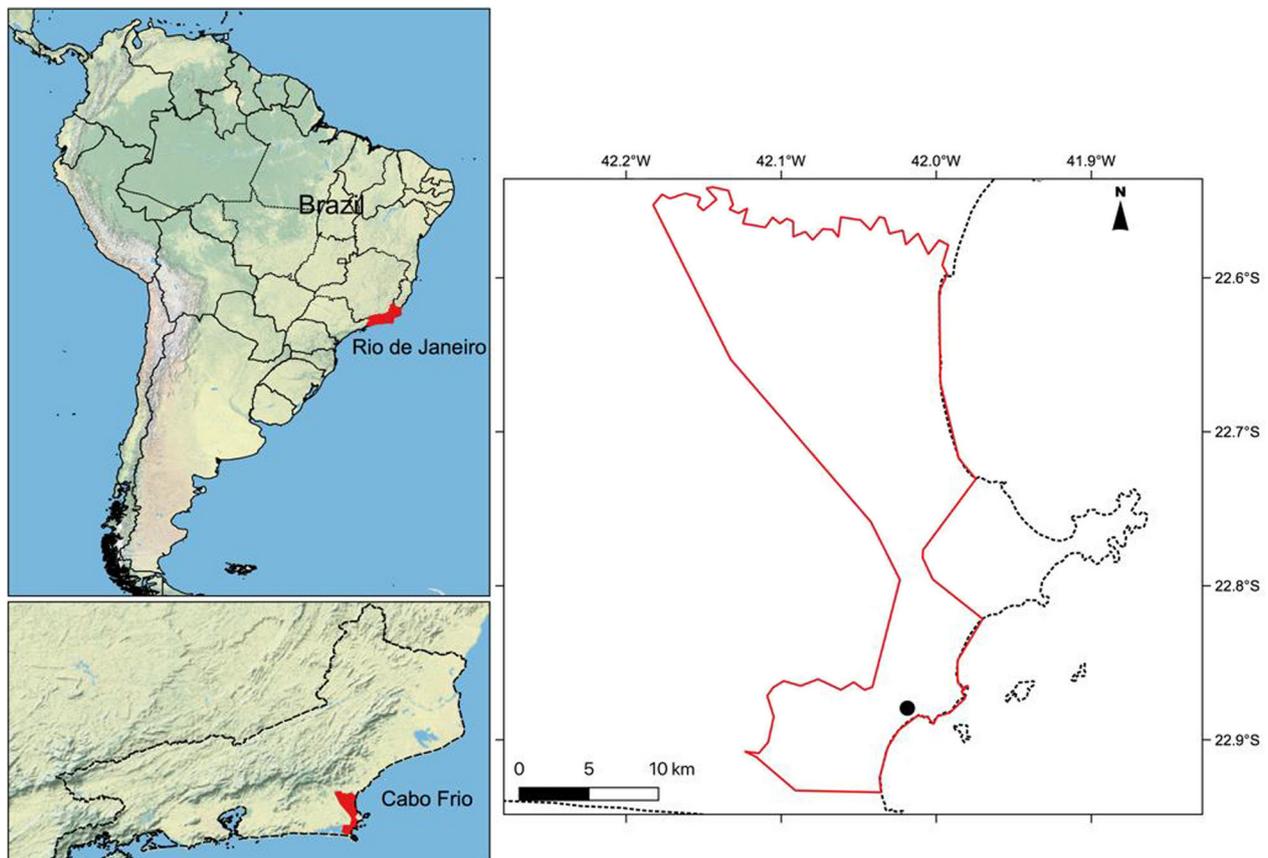


Figure 1. Map showing the region where the tuna were purchased.

K. pelamis. Four species belong to the subfamily Didymozoinae, *Didymocystis dissimilis* Yamaguti, 1938, *Didymocystis pinnicola* (Yamaguti, 1970) Pozdnyakov, 1990, *Lobatozoum euthynni* (Ching & Madhavi, 1999) n. comb., and *Melanocystis kawakawa* Yamaguti, 1970, and three belong to the subfamily Gonapodasmiinae, *Didymocodium euthynni* Yamaguti, 1970, *Phacelotrema claviforme* Yamaguti, 1951, and *Pseudocolocytotrema yaito* Yamaguti, 1970. All the species found are reported here for the first time in the southwestern Atlantic Ocean. *Auxis thazard* and *K. pelamis* are new hosts for *M. kawakawa*, while *E. alletteratus* is a new host for *L. euthynni*, *P. claviforme*, and *D. euthynni*.

Phylum Platyhelminthes Gegenbaur, 1859
Class Trematoda Rudolphi, 1808
Family Didymozoidae Monticelli, 1888
Subfamily Didymozoinae Monticelli, 1888
Genus *Didymocystis* Ariola, 1902

***Didymocystis dissimilis* Yamaguti, 1938**

Figure 2A

New records. Brazil: Rio de Janeiro state: Municipality of Cabo Frio (22°52'46"S, 042°01'07"W). Host: *Katsuwonus pelamis*. Site of infection: Encysted in pairs on the inner wall of the esophagus. Voucher specimens of helminths deposited: CHIOC: 32130a–f. Number of specimens: 50 specimens in one of 61 *K. pelamis* examined. Prevalence: 1.6%.

Identification. Main measurements (based on six specimens). Oval cysts containing two identical individuals paired by the flat faces of the posterior region. Anterior region rounded anteriorly 0.6–1.0 (0.7) mm long by 0.10–0.20 (0.16) mm wide. Posterior region flattened at one end, where the anterior region emerges 1.4–2.2 (1.7) mm long by 1.1–2.0 (1.6) mm wide. Oral sucker terminal, 37–62 (54) long by 32–65 (56) wide. Pharynx elliptical, muscular, 55–80 (64) long by 50–65 (56) wide. Oesophagus short, 100–155 (127) [*n* = 4] long. Two testes extending into the flat margin of the posterior region of the body. Ovary and vitellarium formed by tubular branches. Eggs embryonated, 12–15 (13) long by 7–12 (8) wide [*n* = 10].

Didymocystis dissimilis was originally described by Yamaguti (1938) parasitizing *Katsuwonus pelamis* (= *Euthynnus pelamys*) in the Pacific Ocean. *Didymocystis dissimilis* was reported by Mamaev (1968) parasitizing *Thunnus thynnus* (Linnaeus, 1758), *Euthynnus affinis* (Cantor, 1849) and *A. thazard* in the South China Sea. Based on characteristics such as habitat, body shape, ovary, and vitelline location, Yamaguti (1970) proposed *Oesophagocystis* Yamaguti, 1970 and transferred *D. dissimilis* as *O. dissimilis* (Yamaguti, 1938) Yamaguti, 1970. Muruges and Madhavi (1995) considered *Oesophagocystis* to be a synonym of *Didymocystis* and therefore restored *D. dissimilis* to its original genus, *Didymocystis*. This species was recorded as *O. dissimilis* by

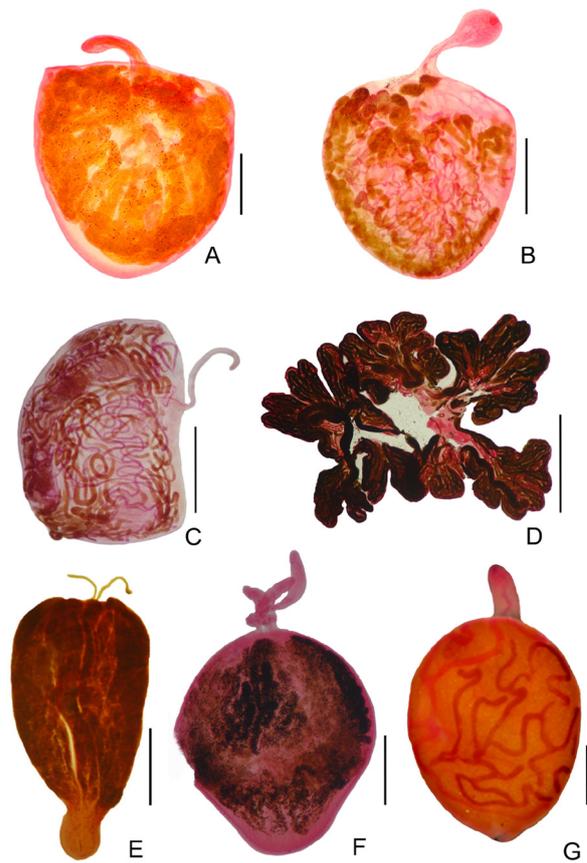


Figure 2. Didymozoidae parasitizing scombrids from Southwestern Atlantic Ocean. **A.** *Didymocystis dissimilis* Yamaguti, 1938 parasite of *Katsuwonus pelamis*. Scale bar = 0.5 mm. **B.** *Lobatozoum euthynni* (Ching & Madhavi, 1999) n. comb., parasite of *Euthynnus alletteratus*. Scale bar = 0.1 mm. **C.** *Didymocystis pinnicola* (Yamaguti, 1970) Pozdnyakov, 1990 parasite of *K. pelamis*. Scale bar = 0.1 mm. **D.** *Didymocodium euthynni* Yamaguti, 1970 parasite of *E. alletteratus*. Scale bar = 3 mm. **E.** *Phacelotrema claviforme* Yamaguti, 1951 parasite of *E. alletteratus*. Scale bar = 2 mm. **F.** *Pseudocolocytotrema yaito* Yamaguti, 1970 parasite of *E. alletteratus*. Scale bar = 0.5 mm. **G.** *Melanocystis kawakawa* Yamaguti, 1970 parasite of *A. thazard*, *E. alletteratus* and *K. pelamis*. Scale bar = 0.6 mm.

Pozdnyakov (1996), who did not refer to the synonymy proposed by Muruges and Madhavi (1995), probably through being unaware of this paper. *Didymocystis dissimilis* is reported here for the first time in the southwestern Atlantic Ocean.

***Didymocystis pinnicola* (Yamaguti, 1970) Pozdnyakov, 1990**

Figure 2C

New records. Brazil: Rio de Janeiro state: Municipality of Cabo Frio (22°52'46"S, 042°01'07"W). Host: *K. pelamis*. Site of infection: Encysted in pairs in dorsal fin membrane. Voucher specimens of helminths deposited: CHIOC: 40092a–d, 40093a–c. Number of specimens: seven specimens in two of 61 *K. pelamis* examined. Prevalence: 3.3%.

Identification. Main measurements (based on five specimens). Oval cysts containing two identical individuals.

Anterior region subcylindrical 0.50–1.50 (1.20) mm long by 0.06–0.10 (0.08) mm wide. Posterior region flattened anteriorly, convex dorsally 1.04–3.44 (2.56) mm long by 0.70–2.40 (1.86) mm wide. Oral sucker subterminal rather cellular, 13–20 (18) in diameter. Pharynx elliptical, muscular, 18–33 (28) long by 20–30 (25) wide. Oesophagus long, 138–187 [$n = 2$] long. Two tubular testes extending in anterior margin of the posterior region of the body, 13–77 (52) wide. Ovary slender, forming 7–9 tubular branches, 10–43 (34) wide. Vitellarium divided into 8–10 tubular branches, 12–35 (32) wide. Uterus forming a large egg reservoir that occupies much of the posterior region of the body. Eggs embryonated, 10–13 (11) long by 7–10 (9) wide [$n = 10$].

Didymocystis pinnicola was originally described as *Didymocystoides pinnicola* by Yamaguti (1970), parasitizing *K. pelamis*. Pozdnyakov (1990) considered *Didymocystoides* Yamaguti, 1970 to be a synonym of *Didymocystis* and transferred *Didymocystoides pinnicola* to this genus. This species was recorded parasitizing *K. pelamis* on the Visakhapatnam coast, Bay of Bengal, by Murugesh and Madhavi (1995). In the present study, this parasite is reported for the first time in the south-western Atlantic Ocean.

Genus *Lobatozoum* Ishii, 1935

***Lobatozoum euthynni* (Ching & Madhavi, 1999) n. comb.**

Figure 2B

New records. Brazil: Rio de Janeiro state: Municipality of Cabo Frio (22°52'46"S, 042°01'07"W). Host: *Euthynnus alletteratus* (new host record). Sites of infection: Encysted in pairs in gill and mouth. Voucher specimens of helminths deposited: CHIOC: 37125a–d, 37126a–d, 37127a–b. Number of specimens: 24 specimens in five of 31 *E. alletteratus* examined. Prevalence: 16.1%. Mean intensity: 4.8 ± 3.4 . Mean abundance: 0.77 ± 0.83 . Range: 2–12.

Identification (based on 10 specimens). Encysted in pairs. Anterior region scoop-shaped 0.5–1.9 (1.2) mm long by 0.2–0.7 (0.4) mm wide. Posterior region triangular in shape with smooth edges, flattened anteriorly, rounded posteriorly, 1.0–3.6 (2.6) mm long by 1.1–3.1 (2.4) mm wide. Oral sucker terminal presents one muscular and one non-muscular posterior part, 100–240 (158) long by 82–135 (108) wide. Rudimentary pharynx. Esophagus long, 220–270 (246) long [$n = 3$]. Genital pore at base of oral sucker. Testes divided into 4–6 long tubular branches, unbranched in anterior part of posterior region of the body. Ovary formed by 7 or 8 long and narrow branches, 30–70 (46) wide. Vitellarium consisting into seven tubular primary branches, 20–60 (38) wide, which divide into numerous branches that extend to periphery of posterior region of body. Uterus not forming an egg reservoir. Metratrum well developed. Eggs 12–15 (14) long by 7–10 (8) [$n = 10$] wide.

Lobatozoum euthynni n. comb. was originally described parasitizing *E. affinis* around Sulawesi island, Indonesia, by Ching and Madhavi (1999), under the name *Lobatocystis euthynni*. In a review of some genera of the subfamily Didymozoinae, Pozdnyakov (1989) considered the genus *Lobatocystis* Yamaguti, 1965, to be a synonym of *Lobatozoum*, but only made the formal new combination for the type species. Madhavi and Bray (2018), in a paper on didymozoids in India, did not mention this synonymy. They considered *Lobatocystis* to be a valid genus and included it in a key that they presented. In the present study, we had the opportunity to study specimens of *L. euthynni* collected in Brazil and agree with the synonymy of the genus proposed by Pozdnyakov (1989), in view of the generic diagnosis of *Lobatozoum* provided by this author. Considering that Pozdnyakov (1989) did not propose the new combination of the other species of the genus, we, therefore, propose *Lobatozoum bengalensis* (Hussain, Rao & Shyamasundari, 1985) n. comb. and *L. euthynni* n. comb. Since the original description, this is the first record of *L. euthynni* in a new locality and in a new host, *E. alletteratus*.

Genus *Melanocystis* Yamaguti, 1970

***Melanocystis kawakawa* Yamaguti, 1970**

Figure 2G

New records. Brazil: Rio de Janeiro state: Municipality of Cabo Frio (22°52'46"S, 042°01'07"W). Hosts: *A. thazard*, *E. alletteratus*, and *K. pelamis*. Sites of infection: Encysted in pairs on inner surface of stomach and intestine of *A. thazard*, stomach, esophagus and intestine of *E. alletteratus*, and intestine of *K. pelamis*. Voucher specimens of helminths deposited: CHIOC: 37084, 37085 a–b, 37086, 37087, 37088 a–f, 37089 a–d, 37090, 37091, 37092. Number of specimens: 48 specimens in 8 of 20 *A. thazard* examined, 1,854 specimens in 17 of 31 *E. alletteratus* examined and 807 specimens in 6 of 61 *K. pelamis* examined. Prevalence: 40% (*A. thazard*); 48.4% (*E. alletteratus*); 9.8% (*K. pelamis*). Mean intensity: 6 ± 4.03 (*A. thazard*); 109.06 ± 68.96 (*E. alletteratus*); 134.50 ± 148.25 (*K. pelamis*). Mean abundance: 2.40 ± 2.10 (*A. thazard*); 59.81 ± 42.05 (*E. alletteratus*); 13.2 ± 67 (*K. pelamis*). Range: 2–16 (*A. thazard*); 2–636 (*E. alletteratus*); 8–500 (*K. pelamis*).

Identification (based on 18 specimens). Cyst oval presenting two similar individuals in shape and size, flattened on the ventral surface. Anterior region cylindrical, 0.5–0.9 (0.7) mm [$n = 10$] long by 0.08–0.20 (0.10) mm [$n = 10$] wide. Posterior region, ranging from oval to elliptical, occasionally circular, 0.8–1.9 (1.4) mm long by 0.6–1.5 (0.9) mm wide. Oral sucker terminal, 25–37 (32) long by 25–40 (35) [$n = 10$] wide. Pharynx muscular conical, 37–55 (45) [$n = 10$] in diameter; esophagus long; cecum narrow in the anterior body, but distended in the posterior region, with dark coloring derived from the digestion content. Testes cylindrical, arranged symmetrically

in the anterior margin of the posterior region of the body. Ovary extended along the anterior margin of the posterior region of the body consisting of three long and two short tubular branches, 25–62 (46) in the widest width. Vitellarium consists of a short system that divides into two main branches, each giving rise to ten terminal branches 20–47 (38) [$n = 15$] wide. Uterus formed by numerous irregular loops that occupy the entire space of the posterior region of the body, without forming eggs reservoir. Embryonated eggs, 12–15 (14) long by 10 [$n = 30$] wide.

Melanocystis kawakawa was originally described by Yamaguti (1970) from encysted pairs on the inner surface of the posterior end of the esophagus of *E. affinis* (= *E. yaito*) from the Pacific Ocean. This species was reported by Madhavi and Sai Ram (2000) also in *E. affinis* in the Indian Ocean. It was reported as *Melanocystis* cf. *kawakawa* by Mele et al. (2016), parasitizing *E. alletteratus*. This species is reported here for the first time parasitizing *A. thazard* and *K. pelamis* in the southwestern Atlantic Ocean, which thus are new hosts and new geographical records.

Subfamily Gonapodasmiinae Ishii, 1935

Genus *Didymocodium* Yamaguti, 1970

***Didymocodium euthynni* Yamaguti, 1970**

Figure 2D

New records. Brazil: Rio de Janeiro state: Municipality of Cabo Frio (22°52'46"S, 042°01'07"W). Host: *Euthynus alletteratus*. Site of infection: Sub-serosa of pyloric caeca. Voucher specimens of helminthes deposited: CHIOC: 37138a, b. Number of specimens: two specimens in one of 31 *E. alletteratus* examined. Prevalence: 3.2%.

Identification. Main measurements (based on two specimens). Two parasites completely fused by the posterior region of the body. Body of each one divided into two distinct regions: one anterior region slender and one completely fused to posterior region, formed by a central trunk and several primary lobes of different sizes. Oral sucker terminal 60 in diameter; muscular pharynx 45 long by 35 wide. Each fused individual with a pair of cylindrical and branched testes. Ovary and vitellarium tubular, branched, confined in the posterior region of the body, extending to the lobes. Eggs 15 long by 10 wide [$n = 5$].

Didymocodium euthynni was originally described by Yamaguti (1970), parasitizing the subserosa of the pyloric caeca of *E. affinis* (= *E. yaito*) from Hawaii, Pacific Ocean. This species was also reported by Shen (1990), parasitizing *A. thazard* in the South China Sea; by Pozdnyakov (1996), parasitizing *E. affinis* in the Pacific Ocean; and by Madhavi and Sai Ram (2000) on the Visakhapatnam coast, Bay of Bengal. This species is reported here for the first time parasitizing *E. alletteratus* in the southwestern Atlantic Ocean, Brazil, thus

representing a new host record and a new geographical distribution.

Genus *Phacelotrema* Yamaguti, 1951

***Phacelotrema claviforme* Yamaguti, 1951**

Figure 2E

New records. Brazil: Rio de Janeiro state: Municipality of Cabo Frio (22°52'46"S, 042°01'07"W). Host: *Euthynus alletteratus* (new host record). Site of infection: Pyloric caeca. Voucher specimens of helminthes deposited: CHIOC: 37115a, b. Number of specimens: 20 specimens in one of 31 *E. alletteratus* examined. Prevalence: 3.2%.

Identification. Main measurements (based on two specimens). Two parasites completely fused by the posterior region of the body, protected by a cyst of very thin transparent wall. Each parasite has a very thin and elongated anterior region, 1.0 and 1.1 mm long by 0.13 and 0.14 mm wide. Posterior region in disc-shaped, 1.06 and 1.20 mm wide. Oral sucker terminal, 55 long by 48 wide, directly followed by the pharynx, 48 long by 43 wide. Two elongated testes in each individual. Genital junction located in the discoid part of the posterior region of the body. The posterior region of the body longitudinally fused, divided into longitudinal lobes, 7.0 and 7.3 mm long by 2.4 and 3.8 mm wide; Ovary and vitellarium branched. Eggs 15 long by 10 wide [$n = 10$].

Phacelotrema claviforme was originally described by Yamaguti (1951), parasitizing the pyloric caeca of *A. thazard* in Japan. It was also reported by Nikolaeva and Dubina (1985) and by Mordvinova and Nikolaeva (1990), parasitizing *K. pelamis* in the Indian Ocean; by Shen (1990), parasitizing *A. thazard* in the South China Sea; and by Pozdnyakov (1996) in the Pacific Ocean. This species is reported here for the first time parasitizing *E. alletteratus* in the southwestern Atlantic Ocean, and thus represents a new host record and a new geographical distribution.

Genus *Pseudocolocytotrema* Yamaguti, 1970

***Pseudocolocytotrema yaito* Yamaguti, 1970**

Figure 2F

New records. Brazil: Rio de Janeiro state: Municipality of Cabo Frio (22°52'46"S, 042°01'07"W). Host: *Euthynus alletteratus*. Site of infection: Pyloric caeca. Voucher specimens of helminthes deposited: CHIOC: 37116, 37117. Number of specimens: 414 specimens in 13 of 31 *E. alletteratus* examined. Prevalence: 41.9%. Mean intensity: 31.85 ± 20.38. Mean abundance: 13.35 ± 10.06. Range: 2–118.

Identification. Main measurements (based on four specimens). Two or more hermaphroditic individuals completely fused, encapsulated by a spherical and thin cuticle, presenting two distinct regions. Anterior region measuring 0.8 mm long by 0.2 mm wide. Fused posterior

region spherical, 0.8–2.2 (1.5) mm long by 0.5–2.7 (1.4) mm wide [$n = 4$]. Oral sucker 35 long by 47 wide [$n = 3$], pharynx 30–35 long by 25–40 wide [$n = 2$]. Two tubular testes in each fused individual. Ovary and vitellarium branched. Uterus forming intricate convolution and occupying all available space of posterior region. Eggs 10–13 long by 8–10 wide [$n = 10$].

Pseudocolocytotrema yaito was originally described by Yamaguti (1970), parasitizing the pyloric caeca and small intestine of *E. affinis* (= *E. yaito*) in Hawaii, Pacific Ocean. This species was reported on the Visakhapatnam coast, Bay of Bengal, by Madhavi (1982) and by Madhavi and Sai Ram (2000), parasitizing the type host. Later, Pozdnyakov (1996) reported *P. yaito* in *A. thazard*, *E. alletteratus*, and *E. affinis* in the Pacific Ocean. This species is reported here for the first time in the southwestern Atlantic Ocean, thus representing a new geographical distribution.

Discussion

The migratory habits of widely distributed scombrid fish, in different oceans, may leave these fish vulnerable to several parasitic groups, especially didymozoids (Justo and Kohn 2014a). In Brazil, a diverse community of digenean parasites, mostly in the family Didymozoidae, infect scombrids in the southeastern coastal zone (see Justo and Kohn 2014b). In the present study, seven known species of Didymozoidae were found in three host species, thus providing data on new hosts and new geographical records.

Lester et al. (1985) studied parasites from *K. pelamis* in 15 different areas of the Pacific and Atlantic oceans and demonstrated that the average of number of specimens of *D. dissimilis* per fish ranged from 3 to 12. However, in the present study, the intensity was much higher, i.e. 50 specimens in a single host, but with a low prevalence (1.6%): all the specimens were found in only one host out of the 61 examined. This species was also reported by Mladineo et al. (2008), parasitizing *T. thynnus* reared in cages in the Adriatic Sea, in a study conducted between 2003 and 2006 that showed an average prevalence of 2.73%, which is similar to the present study. These prevalence rates are comparatively much lower than those found in *K. pelamis* by Muruges and Madhavi (1995) on the Visakhapatnam coast, Bay of Bengal, and by Hermida et al. (2018) around Madeira in the eastern Atlantic, which were 30% and 66.7%, respectively.

Compared with the results presented by Muruges and Madhavi (1995), regarding parasitism by *D. pinnicola* in the same host, *K. pelamis*, on the Visakhapatnam coast, Bay of Bengal, in which these authors observed a much higher prevalence rate (60%), the prevalence rate of the present study was much lower, i.e. only 3.3%. Madhavi and Sai Ram (2000) observed higher prevalence rates (24.5%) for *D. euthynni* on the Visakhapatnam coast compared with those of the present study

(3.2%), in which only two specimens were found parasitizing one specimen of *E. alletteratus*.

Lobatozoum euthynni n. comb. was originally described in *E. affinis* as *Lobatocystis euthynni*, by Ching and Madhavi (1999). In a review of some genera of the subfamily Didymozoinae, Pozdnyakov (1989) synonymized *Lobatocystis*, *Kamegaia* Yamaguti, 1970, and *Yamaguticystis* Nikolayeva & Dubina, 1978 with *Lobatozoum*, but only made a formal new combination for the type species. On this occasion, we are proposing new combination for the two remaining species of the genus, *L. euthynni* and *Lobatozoum bengalensis* (Hussain, Rao & Shyamasundari, 1985) n. comb. Specimens of *L. euthynni* studied here presented a prevalence of 16.1%, i.e. much higher than what was observed in the original description, which was only 2%.

Melanocystis kawakawa was found in all three hosts species examined, exhibiting a prevalence rate in *E. alletteratus* (54.8%) that was similar to that found by Madhavi and Sai Ram (2000) in *E. affinis* in the Indian Ocean (50%) and higher prevalence than what was found by Mele et al. (2016) in *E. alletteratus* in the western Mediterranean Sea, which was 36%. The prevalence of this species in *A. thazard* (40%) was within the range of the previous records, but in *K. pelamis*, it was lower than in previous records (13.6%). The specimens of *P. yaito* reported by Madhavi and Sai Ram (2000) showed higher prevalence and mean intensity rates (91.8% and 131.6, respectively), compared with the findings from the present study (41.9% and 31.85, respectively).

Tunas are infected by a rich metazoan parasite fauna that seems to be a promising tool for inferring information on the host biology and ecology. Didymozoids are likely the most useful group as tags, because they are permanent parasites and because of their site specificity (Culurgioni et al. 2014). In the present study, all the species recorded from scombrid fishes represented new distributional records for the area of the southwestern Atlantic Ocean, thereby increasing the knowledge of Didymozoidae species diversity in this area from 33 (Kohn and Fernandes 2016; Moreira-Silva et al. 2019) to 40 species. Considering the species richness, which is the highest among all the families that parasitize Scombridae, mainly in the Atlantic, Indian, and Pacific oceans, more studies are necessary to elucidate the diversity of these helminths in the southwestern Atlantic Ocean.

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Authors' Contributions

MCNJ, MQC, MSL, and SCC necropsied the hosts and fixed the parasites. MCNJ measured and identified the

parasites. MCNJ, MQC, and SCC discussed the results, co-wrote the text and contributed to the final manuscript.

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