八重山産の水産有用魚種から得られたScaphanocephalus adamsi (扁形動物門: 吸虫綱)の新宿主記録

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New host records for *Scaphanocephalus adamsi* (Platyhelminthes: Trematoda: Heterophyidae) from commercial fishes off Yaeyama Islands

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Abstract. Encysted metacercariae of a poorly investigated digenean, *Scaphanocephalus adamsi*, are commonly found on fins and under scales of coastal marine fishes in the Ryukyu Archipelago, Japan. We here report its host range, focusing on commercial fishes landed at the Yaeyama Fisheries Cooperative of Ishigaki Island. During the study period from February 2017 to May 2018, metacercariae were recovered from four species of goatfishes (Mullidae spp.) and 14 species of parrotfishes (Scaridae spp.), with new host records for four species. Since metacercaria infection decreases the rating of fish prices in local fishery cooperatives due to their poor appearance, the occurrence conditions in newly recognized hosts should be evaluated to help protect commercial values.

Introduction

The genus *Scaphanocephalus* Jägerskiöld, 1903 is a small group of digenean parasites consisting of three species, *S. adamsi* Tubangui, 1933, *S. australis* Johnston, 1917 and *S. expansus* (Creplin, 1842) (e.g. Kifune & Kugi 1979). Adults and metacercaria larvae possess a characteristic anteriorly flared T-shaped body (Tubangui 1933; see also Yamaguti 1971; Pearson 2008) that looks like a cross-section of a mushroom. The life cycle of *Scaphanocephalus* species are thought to be complex, probably using coastal molluscans as the first intermediate hosts, marine fishes as the second intermediate hosts, and piscivorous raptors as final hosts (reviewed in Iwata 1997; see also Galaktionov & Dobrovolskij 2003), although this has not been fully demonstrated.

Scaphanocephalus adamsi was originally described based on metacercaria larvae recovered from the fins and under the scales of the splitlevel hogfish *Bodianus mesothorax* (Block & Schneider, 1801) (as *Lepidaplois mesothorax*) from an aquarium in Manilla, Philippines (Tubangui 1933). In Japanese waters, Yamaguti (1942) firstly reported encysted metacercariae (as *Scaphanocephalus* sp. but later identified as *S. adamsi* by Kifune & Kugi 1979) from under the scales and the caudal fin of the five-barred goatfish *Parupeneus multifasciatus* (Quoy & Gaimard, 1825). Kifune & Kugi (1979) subsequently recovered adult worms from the Japanese buzzard *Buteo buteo japonicus* Temminck & Schlegel, 1844 (as *Buteo buteo burmanicus*) in Oita Prefecture, southern Japan, while Iwata (1997) noted metacercaria larvae recovered from coastal fishes in the Iriomote Island (see Table 1).

Our research group has recently been investigating infection statuses of the metacercariae on commercial fishes landed at Ishigaki Island, because of the problem of reduced prices in fish with parasite infections (see Shimose et al. 2019). Human infection by this parasite has never been reported, but the presence of metacercaria on commercial fishes gives a negative impression and lowers fish prices in fish markets. In this context, Shimose et al. (2020) have reported the occurrence of *Scaphanocephalus* metacercariae on 30 parrotfish species that are commercially consumed in the Yaeyama Islands, and focused their work on parasite prevalence variation among host species. They suggested that the degree of infection reflects the host's feeding habits, which was related to their habitat use. On the other hand, as Iwata (1997) has shown the wide range of host use in *S. adamsi*, it can still be expected that many other fishery resources also harbor the metacercariae. We here report further commercial fish species infected by *S. adamsi* and complement the preliminary parasite identification in Shimose et al. (2020). An updated host list is also provided based on these findings.

Materials and methods

Sampling was conducted at the Yaeyama Fisheries Cooperative (24°20′53″N, 124°08′44″W) on Ishigaki Island, located in the southwestern Ryukyu Archipelago. Coastal fishes, such as goatfishes (Mullidae spp.) and parrotfishes (Scaridae spp.; some authors categorize this group as the tribe Scarini, but the present report follows the classification of Nakabo (2013)) were targeted in the present survey, and these mainly caught by night-spearfishing and partially by gill-net from off the Yaeyama Islands. The caught fishes were landed in the early morning. These caught fish were usually put in a box covered with ice (Fig. 1B) and subsequently auctioned.

During the period of February 2017 to May 2018, landed fishes were visually observed before auctions. Individual fishes that exhibited colored spots on their body and fins, likely caused by metacercaria infections, were arbitrarily selected, and their infected sites and surrounding tissues were cut off using forceps (Fig. 1A). The cut-off pieces were preserved in small glass vials (ca. 6 ml) filled with 60–70% ethanol.

These samples were transported to Mie University, where metacercariae were extracted from the cysts by using fine forceps and dissection needles under a stereo-microscope. Individual worms recovered were re-fixed in 70% ethanol after being placed on glass slides with a cover slip with their folded body extended as much as possible. These metacercariae were stained with alum carmine, dehydrated in a series of ascending ethanol concentrations, cleared in xylene, and mounted in Canada balsam.

For species identification, all flattened specimens were observed by using an Olympus BX51 light microscope with phase contrast optics. The targeted species, *S. adamsi*, can be distinguished from the other two congeners in having a wide body and strongly branched testes (Kifune & Kugi 1979; Iwata 1997). All measurements are given in micrometers (µm) unless otherwise indicated. A part of the specimens mounted was deposited in the collection of the Meguro Parasitological Museum, Tokyo (MPM Coll. Nos. 21730–21732). Scientific names of the fishes mentioned follow Nakabo (2013) mainly; part of the species follow Froese & Pauly (2019). The scientific names of birds follow the Ornithological Society of Japan (2012).

Results

The metacercariae were recovered from four species of two mullid genera *Mulloidichtys* and *Parupeneus* and 14 species of the three scarid genera *Bolbometopon*, *Chlorurus*, and *Scarus*, of which four species represent new host records (Table 1). Three parrotfishes, *Hipposcarus longiceps* (Valenciennes, 1840), *Scarus spinus* (Kner, 1868) and *Scarus rivulatus* Valenciennes, 1840, were also infected by metacercariae with the diagnostic features of *Scaphanocephalus*, but their species level identification was suspended due to contraction of the mounted specimens.

Approximate maximum body length and width of the specimens examined (n = 21) are 1.0–3.2 mm (mean 2.2) and 1.0–2.5 mm (mean 1.8), respectively (see also Fig. 1D–E). The width to length ratios are larger than 0.72–1.08 (mean 0.87). Oral sucker and pharynx are rounded-square shape, with sizes of 70–115 (mean 86.3) in length × 70–130 (mean 99.1) in width and 60–90 (mean 72.2) × 50–75 (mean 62.2), respectively. Ventral sucker is formed as a combined structure with the genital end, having oval shape with the size of 95–200 (mean 140.3) × 75–130 (mean 99.7). Ovary is lobed-shaped and situated in the right side of the body with a size of 45–120 (mean 83.6) × 105–200 (mean 163.9). Mehlis' gland is oval shape and 35–75 (mean 47.8) × 50–85 (mean 64.2). Testes are branch-shaped and arranged in tandem. The anterior testis is slightly smaller than the posterior one in many cases, with a size of 100–260 (mean 166.7) × 305–525 (mean 416.7) and 95–345 (mean 178.6) × 300–605 (mean 465.6), respectively. The strong branching of the testes is consistently found in all specimens regardless of size and host difference (Fig. 1F–G).

Infection sites, where the parasite individuals were encysted, were usually represented by yellowish or whitish spots. In similar cases of infection, *Cetoscarus bicolor* (Rüppell, 1829) sometimes exhibited black colored spots on its fins, but they were filled with a tissue mass probably comprised of fat (Fig. 1C).

Discussion

The specimens collected in this study morphologically match with the original description of *S. adamsi* (Tubangui, 1933). In the past survey of Iwata (1997), metacercariae of this parasite have been recorded from eight coastal fishes belonging

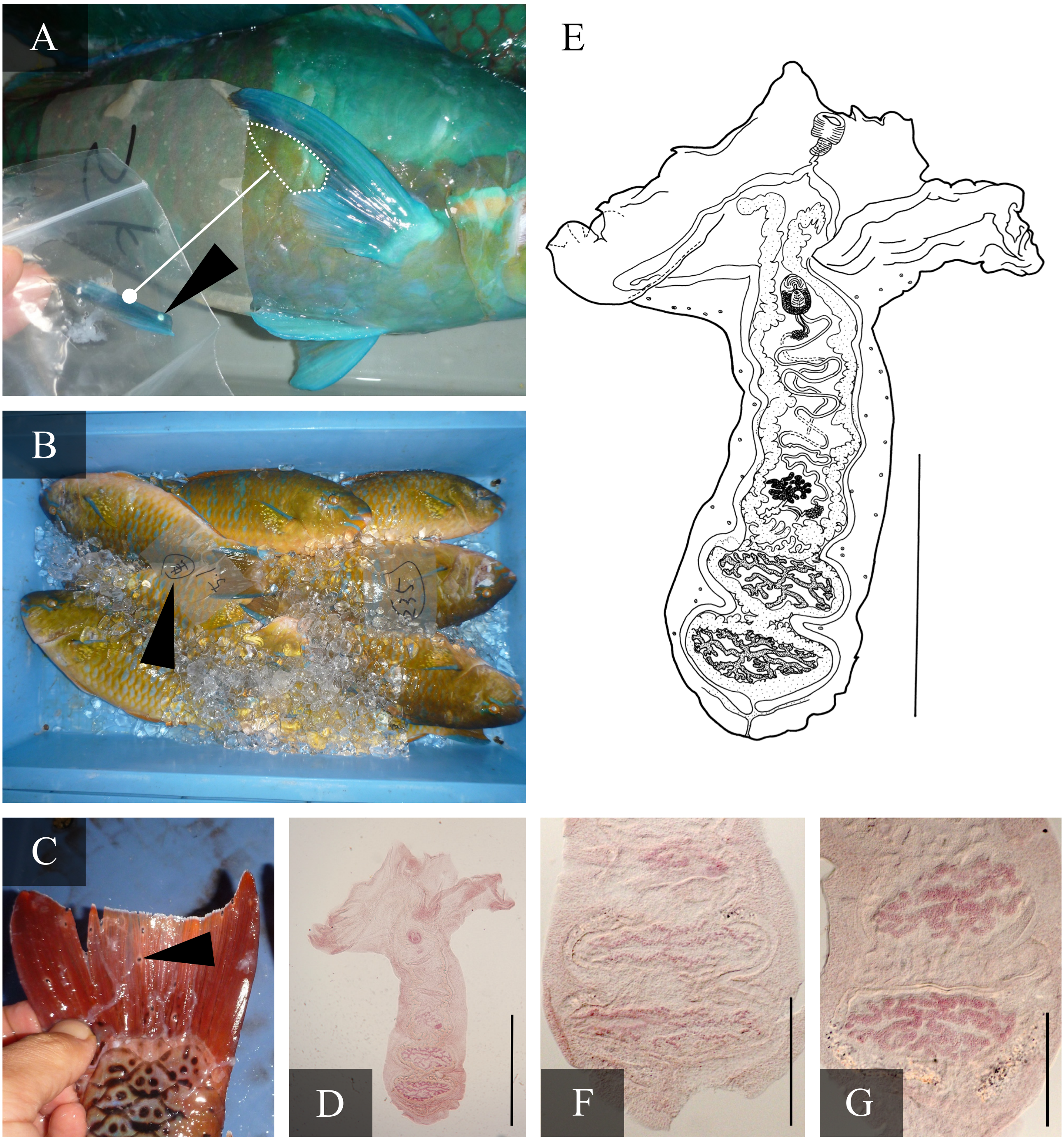

Fig. 1. Overview of the host and parasite samplings. A: an example of metacercaria infection: arrowhead indicates a cut-off piece of the pectoral fin exhibiting a yellow spot, B: examples of low-rated fishes: arrowhead indicates staff's mark of a suspected parasite infection, C: a case in *Cetoscarus bicolor* exhibiting black colored spots, D: individual example of *Scaphanocephalus adamsi* from *Bolbometopon muricatum*, mounted as prepared specimens, E: line drawing of D, F–G: enlarged views of other examples on strongly branched testes: specimens from *Parupeneus cyclostomus* and *Scarus forsteni*, respectively. Scale bars: D = 1.0 mm, E = 1.0 mm, F = 1.0 mm and G = 0.3 mm.
図 1. 宿主および寄生虫の採集概要 . A: メタセルカリア感染の一例 : 三角矢印は胸ビレの一部ごと切り出された黄斑部を示す , B: 虫体感染による低評価の一例：三角矢印は寄生虫の存在を知らせるラベルを示す , C: イロブダイにおける黒斑事例 , D: カンムリブダイより得られた虫体標本 , E: D の線画 , F–G: マルクチヒメジ・イチモンジブダイより得られた虫体の精巣拡大図 . 各スケールバーは 1.0, 1.0, 0.3, 0.3 mm.

to five different families and eight genera around Iriomote Island (see Table 1). The present survey re-confirmed that taxonomically distant host fishes belonging to two different families (i.e. Mullidae and Scaridae) are exploited by this digenean.

For the host range in this parasite, careful interpretations are needed. Since each host fish has specific habitat use and/or immune system,

Table 1. Previous and present reports on fishes infected with metacercaria of *Scaphanocephalus adamsi* and unidentified congeners. *Worms recovered were tentatively identified as *Scaphanocephalus* sp., due to contruction of the specimens. **Meracercalial infections were noted as the personal communication by Dr. M. Machida. ***Scientific name follows Froese & Pauly (2019).

表 1. 過去の研究および本研究において *Scaphanocephalus adamsi* あるいは同属未同定種のメタセルカリアが認められた魚類 . * 標本の状態不良により暫定的に *Scaphanocephalus* sp. と同定した . ** メタセルカリアの寄生が町田博士私信として紹介されている . *** 学名は Froese & Pauly (2019) に従った .

宿主魚類 Host fish			文献 Reference	新宿主記録 New host record
Family 科名	Genus 属名	種名 Species name		
ヘラヤガラ科 Aulostomidae	ヘラヤガラ属 *Aulostomus*	ヘラヤガラ *Aulostomus chinensis* (Linnaeus, 1766)	Iwata (1997)	
ヒメジ科 Mullidae	アカヒメジ属 *Mulloidichthys*	モンツキアカヒメジ *Mulloidichthys flavolineatus* (Lacepède, 1801)	本研究 Present study	+
		アカヒメジ *Mulloidichthys vanicolensis* (Valenciennes, 1831)	本研究 Present study	+
	ウミヒゴイ属 *Parupeneus*	マルクチヒメジ *Parupeneus cyclostomus* (Lacepède, 1801)	本研究 Present study	+
		タカサゴヒメジ *Parupeneus heptacanthus* (Lacepède, 1802)	本研究 Present study	+
		オジサン *Parupeneus multifasciatus* (Quoy & Gaimard, 1825)	Yamaguti (1942)	
		" (as *P. trifasciatus*)	Iwata (1997)	
ベラ科 Labridae	タキベラ属 *Bodianus*	スミツキベラ *Bodianus axillaris* (Bennett, 1831)	Iwata (1997)	
		ケサガケベラ *Bodianus mesothorax* (Block & Schneider, 1801)	Tubangui (1933)	
	モチノウオ属 *Cheilinus*	ミツバモチノウオ *Cheilinus trilobatus* Lacepède, 1801	Iwata (1997)	
	ニシキベラ属 *Thalassoma*	ヤマブキベラ *Thalassoma lutescens* (Lay & Bennett, 1839)	Iwata (1997)	
ブダイ科 Scaridae	カンムリブダイ属 *Bolbometopon*	カンムリブダイ *Bolbometopon muricatum* (Valenciennes, 1840)	Shimose et al. (2020), 本研究 Present study	
	ブダイ属 *Calotomus*	タイワンブダイ *Calotomus carolinus* (Valenciennes, 1840)	Shimose et al. (2020)	
	イロブダイ属 *Cetoscarus*	イロブダイ *Cetoscarus bicolor* (Rüppell, 1829)	Shimose et al. (2020), 本研究 Present study	
	ハゲブダイ属 *Chlorurus*	オカメブダイ *Chlorurus bleekeri* (de Beaufort, 1940)	Shimose et al. (2020)	
		オオモンハゲブダイ *Chlorurus bowersi* (Snyder, 1909)	Shimose et al. (2020), 本研究 Present study	
		Chlorurus capistratoides (Bleeker, 1847)***	Shimose et al. (2020)	
		オニハゲブダイ *Chlorurus frontalis* (Valenciennes, 1840)	Shimose et al. (2020)	
		シジュウカラ *Chlorurus japanensis* (Bloch, 1789)	Shimose et al. (2020)	
		ナンヨウブダイ *Chlorurus microrhinos* (Bleeker, 1854)	Shimose et al. (2020), 本研究 Present study	
		コブブダイ *Chlorurus oedema* (Snyder, 1909)	Shimose et al. (2020), 本研究 Present study	
		ハゲブダイ *Chlorurus sordidus* (Forsskål, 1775)	Shimose et al. (2020), 本研究 Present study	
		" (as *Scarus sordidus*)	Iwata (1997)	
	キツネブダイ属 *Hipposcarus*	キツネブダイ *Hipposcarus longiceps* (Valenciennes, 1840)	Shimose et al. (2020), 本研究 Present study*	
	アオブダイ属 *Scarus*	カメレオンブダイ *Scarus chameleon* Choat & Randall, 1986	Shimose et al. (2020)	
		カワリブダイ *Scarus dimidiatus* Bleeker, 1859	Shimose et al. (2020), 本研究 Present study	
		ツキノワブダイ *Scarus festivus* Valenciennes, 1840	Shimose et al. (2020), 本研究 Present study	
		イチモンジブダイ *Scarus forsteni* (Bleeker, 1861)	Shimose et al. (2020), 本研究 Present study	
		アミメブダイ *Scarus frenatus* Lacepède, 1802	Shimose et al. (2020)	
		ヒブダイ *Scarus ghobban* Forsskål, 1775	Shimose et al. (2020), 本研究 Present study	
		ダイダイブダイ *Scarus globiceps* Valenciennes, 1840	Shimose et al. (2020), 本研究 Present study	
		キブレブダイ *Scarus hypselopterus* Bleeker, 1853	Shimose et al. (2020)	
		ブチブダイ *Scarus niger* Forsskål, 1775	Shimose et al. (2020)	
		ヒメブダイ *Scarus oviceps* Valenciennes, 1840	Shimose et al. (2020)	
		ニシキブダイ *Scarus prasiognathos* Valenciennes, 1840	Shimose et al. (2020), 本研究 Present study	

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Table 1 continued 前頁より

		オウムブダイ *Scarus psittacus* Forsskål, 1775	Shimose et al. (2020)
		レモンブダイ *Scarus quoyi* Valenciennes, 1840	Shimose et al. (2020)
		スジブダイ *Scarus rivulatus* Valenciennes, 1840	Shimose et al. (2020), 本研究 Present study*
		" (as *S. fasciatus*)	Kifune & Kugi (1979)**
		ナガブダイ *Scarus rubroviolaceus* Bleeker, 1847	Iwata (1997), Shimose et al. (2020), 本研究 Present study
		オビブダイ *Scarus schlegeli* (Bleeker, 1861)	Shimose et al. (2020), 本研究 Present study
		シロオビブダイ *Scarus spinus* (Kner, 1868)	Shimose et al. (2020), 本研究 Present study*
		アカブダイ *Scarus xanthopleura* Bleeker, 1853	Shimose et al. (2020)
		未同定種 *Scarus* sp.	Kifune & Kugi (1979)**
フグ科 Tetraodontidae	モヨウフグ属 *Arothron*	コクテンフグ *Arothron nigropunctatus* (Block & Schneider, 1801)	Iwata (1997)

its suitability as a preferred host for *S. adamsi* should vary among the species (see Combes 1991; Poulin 2007). For example, host fishes that are more nektonic or stay in deep areas may exhibit low prevalences, as infective larvae (i.e. cercariae), released from the probable first intermediate molluscan host, cannot come into contact with these candidates as the next hosts due to spatial mismatch (called an encounter filter, Combes 1991; Poulin 2007). Parrotfishes with high prevalences are indeed known to feed on epilithic algae and sand surfaces, as well as on crustacean bait used by recreational anglers, contrary to uninfected or less-infected species (Shimose et al. 2020). This suggest that infectious hot spots are distributed in nearshore sandy areas and/or habitats of krill-like crustaceans around Ishigaki Island. Since the examined goatfishes also use sandy seafloors (Randall 2001), their infection may be due to similar reasons as indicated in the high prevalence in parrotfishes. Alternatively, even in fishes with high prevalences, they may be dead-end hosts that prevent the parasite from completing its life cycle without acting as a normal source of infection into the definitive host (e.g. the western osprey, *Pandion haliaetus haliaetus* (Linnaeus, 1758), distributed around Ishigaki Island). In any case, quantitative verifications, especially for variance in prevalences or in their development on host fishes, are needed while also considering sample sizes not only on scarid fishes but also on mullid fishes.

Previous records of *S. adamsi* indicate that this species is distributed mainly in East Asia from the Philippines to the Ryukyu Archipelago (see Iwata 1997). The economic loss due to this parasite is a unique problem to this region (Shimose et al. 2019; 2020). However, depending on the marine environmental changes accompanied by global warming in the future, geographical ranges or source populations might shift northward along the Japanese islands and become common in the mainland region of Japan. Since parasite infection gives a bad appearance to fish and lowers fish prices (Shimose et al. 2019), parasite spreading has a risk of negatively influencing fish markets. Further studies, including explorations on intermediate and definitive host uses, are thus required to clarify the factors deciding the distribution of *S. adamsi* and to predict future trends.

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八重山産の水産有用魚種から得られた *Scaphanocephalus adamsi*（扁形動物門：吸虫綱）の新宿主記録

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要旨 . 吸虫の一種 *Scaphanocephalus adamsi* は , フィリピン周辺および琉球列島沿岸に生息する海産魚類のヒレや鱗下に被嚢幼虫 (メタセルカリア) として寄生する . 市場に並ぶ水産魚種への寄生も日常的に確認されるため，宿主範囲を含めた情報の蓄積が求められる . そこで本稿では , 八重山漁協において被嚢幼虫が認められたヒメジ類およびブダイ類を報告する . 2017 年 2 月から 2018 年 5 月までの間に , 4 種のヒメジ科魚類および 14 種のブダイ科魚類から本種幼虫が得られ , 4 種が新宿主記録に該当することが明らかとなった . 被嚢幼虫の存在は魚価低下の一要因であるため , 各宿主魚類における寄生条件を明らかにし , 価格安定へ向けた取り組みがなされる必要がある .

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