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Digeneans (Trematoda) Found in Freshwater Fishes of Wakayama, Tokushima, and Kochi Prefectures, Japan

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Abstract Freshwater fishes (25 identified and 5 unidentified species) were caught in rivers in Wakayama Prefecture (Kinki), and Tokushima and Kochi Prefectures (Shikoku), Japan, in 1998, 1999, and 2000 and examined fresh for adult digeneans (Trematoda). Digeneans of nine species were found, mainly in the digestive tract. Eight of them were identified as previously known species, and one remained unidentified. A single specimen of the latter, *Allocreadium* sp., was found in *Zacco temminckii* (Temminck and Schlegel) (Cyprinidae) (Japanese name kawamutsu) from the Kaifu River in Kaiyo, Tokushima Prefecture. It probably represents an undescribed species. The digeneans are described and figured. Their final fish hosts, geographical distributions, and life cycles, where known in Japan, are discussed.

Key words : Trematoda, digeneans, freshwater fishes, Wakayama Prefecture, Tokushima Prefecture, Kochi Prefecture, Japan.

Introduction

There have been no published records of adult digeneans (Trematoda) from freshwater fishes of Wakayama Prefecture (Kinki), and Tokushima and Kochi Prefectures (Shikoku), Japan (Shimazu, 1999, 2003b). Freshwater fishes collected in several rivers in these prefectures were examined for adult digeneans from 1998 to 2000. This paper reports the results of these examinations and discusses the final fish hosts, geographical distributions, and life cycles, where known, for each of the digeneans, with respect to Japan.

Materials and Methods

Freshwater fishes were collected in rivers in Wakayama Prefecture (Kinki), and Tokushima and Kochi Prefectures (Shikoku), Japan, for examination for adult digeneans. Figure 1 and Table 1 show the prefectures, rivers, sampling sites, and dates.

Unidentified fishes of the genus *Rhinogobius* were classified into five types, CB, CO, DA, LD, and OR, according to Kawanabe and Mizuno (1989).

Fish specimens were examined fresh for adult digeneans. Digenean worms found were treated as follows: either (1) flattened under pressure of cover slip, fixed with AFA, and stained with Heidenhain's iron hematoxylin; or (2) flattened, fixed with 70% ethanol, and stained with Grenacher's alum carmine; or (3) fixed in hot 10% neutralized formalin and stained with acetocarmine. These stained specimens were mounted in Canada balsam.

Some related institutional specimens were borrowed from Meguro Parasitological Museum, Tokyo (MPM); the National Museum of Nature and Science, Tokyo (formerly the National Science Museum, Tokyo, NSMT); and Dr. Misako Urabe of the University of Shiga Prefecture, Hikone, Shiga Prefecture. Drawings were made with the aid of a drawing tube. Measurements

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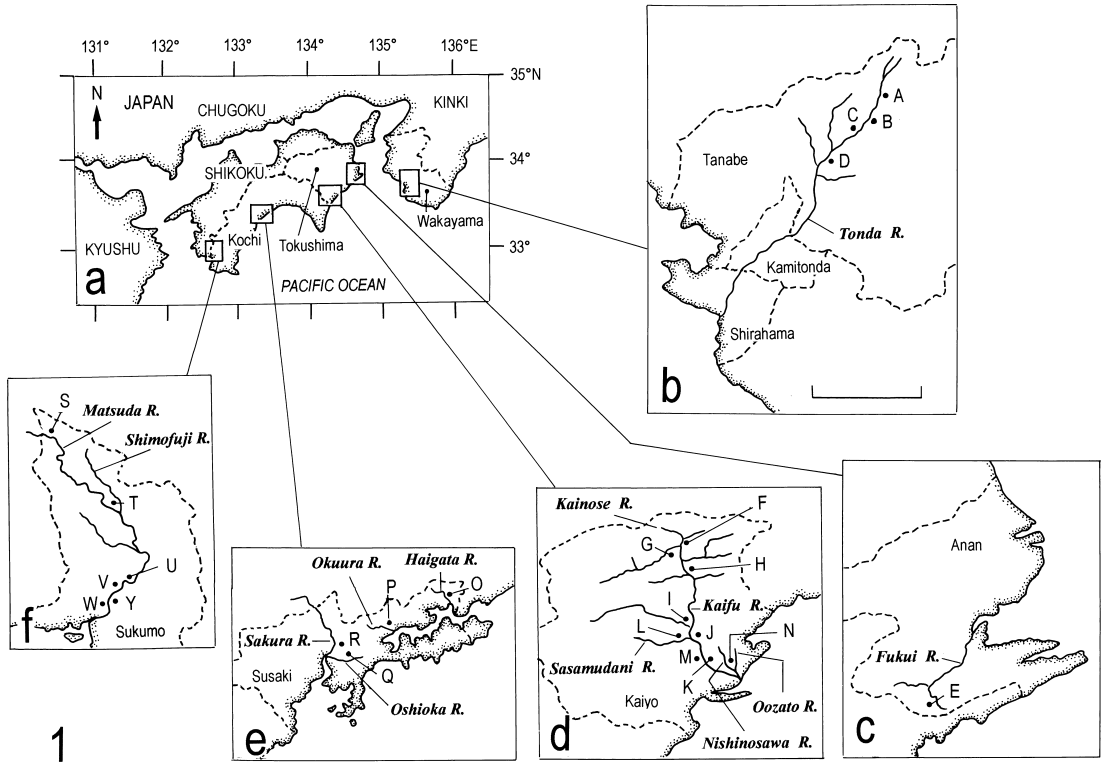


Fig. 1. Maps showing the prefectures, rivers, and sampling sites. Scale bar: 10 km.

Table 1. The prefectures, rivers, sampling sites, and dates. The former three correspond to those in Fig. 1.

Prefecture River	Sampling site	Date
Wakawama Prefectue, Kinki (Fig. 1a, b)		
Tonda River	Nakahechi, Tanabe: A, Hyozei; B, Fukusada; C, Ookawa; D, Kurisugawa	2–4 August 1999
Tokushima Prefecture, Shikoku (Fig. 1a, c, d)		
Fukui River (a tributary)	Fukui, Anan: E, Kono	13 September 1998
Kainose River	Ogawa, Kaiyo: F, Kainose	12 September 1998
Kaifu River	Ogawa, Kaiyo: G, Uke; H, Higashikuwabara	11–16 September 1998
	Aikawa, Kaiyo: I, Nakano	11–16 September 1998
	Kaiyo: J, Ooi; K, Yoshino	11–16 September 1998
Kaifu River (a small tributary)	Kaiyo: M, Yoshida	12 September 1998
Sasamudani River	Aikawa, Kaiyo: L, Sasamudai	12 September 1998
Nishinosawa River	Kaiyo: N, Shihohara	13 and 15 September 1998
Oozato River	Kaiyo: N, Shihohara	12 September 1998
Kochi Prefecture, Shikoku (Fig. 1a, e, f)		
Haigata River	Susaki: O, Uranouchihaigata	30 July 2000
Okuura River	Susaki: P, Uranouchihigashibun	30 July 2000
Oshioka River	Susaki: Q, Oshioka	30 July 2000
Sakura River	Susaki: R, Koda	29 July 2000
Matsuda River	Hashikami, Sukumo: S, Idei	5–7 August 2000
	Sukumo: U, Nakatsuno; V, Ninomiya; W, Chuo; Y, Wada	5–7 August 2000
Shimofuji River	Hashikami, Sukumo: T, Sakamoto	5 August 2000

(length by width) are given in millimeters unless otherwise stated. The digenean specimens found have been deposited in the National Museum of Nature and Science, Tokyo, under the name abbreviation NSMT-Pl.

Results

Table 2 summarizes the freshwater fishes examined and the adult digeneans found in the present examinations. The following are the digenean species found.

Class Trematoda
Subclass Digenea
Family Derogenidae

Genarchopsis goppo Ozaki, 1925

(Fig. 2)

Genarchopsis goppo Ozaki, 1925: 101–103, figs. 1–3; Takahashi, 1929: 1928–1929, pl. 3, fig. 12; Yamaguti, 1934: 500–501, fig. 128; Yamaguti, 1938: 133, in part; Yamaguti, 1942: 388–389; Urabe, 2001: 1407, fig. 3E; Shimazu and Urabe, 2005: 2–3, figs. 1–3.
Progonus goppo: Srivastava, 1933: 55.
Genarchopsis anguillae Yamaguti, 1938: 132–133, fig. 81; Yamaguti, 1942: 388; Shimazu, 1995: 11, fig. 6.
Genarchopsis gigi Yamaguti, 1939: 227, pl. 29, fig. 6; Shimazu, 1995: 9, fig. 5.
Genarches anguillae: Skryabin and Gushanskaya, 1955: 680, fig. 199.
Genarches gigi: Skryabin and Gushanskaya, 1955: 680, 685, fig. 200.
Genarches goppo: Skryabin and Gushanskaya, 1955: 685–686, 689, fig. 201.
Genarchapsis [sic] *goppo*: Shimazu, 1995: 6–9, figs. 1–5.

Specimens studied. One mature and 1 immature and 16 mature specimens (NSMT-Pl 5515 and 5516) found in the stomach of *Rhinogobius giurinus* (Rutter) (Gobiidae) from the Kaifu (sampling site, K) and Oshioka (Q) rivers, respectively; 1 and 7 mature specimens (NSMT-Pl 5517 and 5518–5520) found in the stomach of *Odontobutis obscura* (Temminck and Schlegel) (Odontobutidae) from the Fukui (E) and Matsuda (U, V, Y) rivers, respectively; 23 and 15 mature specimens (NSMT-Pl 5521 and 5522) found in the stomach of *Gymnogobius petschiliensis* (Rendahl) (Gobiidae) from the Okuura (P) and Oshioka (Q) rivers, respectively; 1 mature specimen (NSMT-Pl 5531) found in the stomach of *Rhinogobius flumineus* (Mizuno) from the Sakura River (R); 2 immature and 4 mature specimens (NSMT-Pl 5523) found in the stomach of *Rhinogobius* sp. CB (Gobiidae) from the Oshioka River (Q); and 6 mature specimens (NSMT-Pl 5524) found in the stomach of *Tridentiger brevispinis* Katsuyama, Arai, and Nakamura (Gobiidae) from the Oshioka River (Q).

Description. Ten gravid specimens with numerous uterine eggs measured. Body 1.36–2.64 by 0.51–0.77; forebody 0.72–1.44 long, occupying 50–56% of total body length. Oral sucker 0.12–0.21 by 0.15–0.24. Pharynx 0.05–0.09 in diameter. Esophagus short, with small esophageal pouch. Intestines fusing to form cyclocoel anterior to vitellaria. Ventral sucker large, about equatorial, 0.28–0.43 by 0.28–0.44; sucker width ratio 1 : 1.60–2.00. Testes 0.16–0.22 by 0.17–0.22. Ovary immediately anterior to vitellaria, smaller than testes, 0.12–0.15 by 0.09–0.16. Uterus much folded in forebody and hindbody. Eggs numerous, elongate-oblong, slightly reniform, fully embryonated when laid, 48–70 by 24–35 μm, with a long anopercular filament. Vitellaria consisting of 2 elliptical symmetrical or diagonal masses measuring 0.12–0.16 by 0.09–0.12, near posterior end of body.

The uterus was more folded, especially in the forebody, and uterine eggs were more numerous in larger specimens.

Discussion. These specimens agree in morphology and measurements with *Genarchopsis goppo* as redescribed by Shimazu (1995). Their eggs (48–70 by 24–35 μm) are larger than those (46–50 by 25–26 μm) in Ozaki's (1925) original description and those (40–45 by 18–19 μm (collapsed)) in one specimen (MPM Coll. No. 30028) in Ozaki's Collection (Shimazu, 1995). However, eggs are 51–84 by 21–42 μm (combined) in other previous descriptions for *G. goppo* from Japan (Yamaguti, 1934, 1942; Shimazu, 1995; Urabe, 2001; Shimazu and Urabe, 2005).

Table 2. Fishes examined and digeneans found.

Fish examined				Digenean found	
Species name (Japanese name)	River (sampling site)[1)]	Number of fish examined	Body size[2)] of fish examined	Species name (sampling site[3)])	Prevalence[5)]
Adrianichthyidae					
Orygias latipes (medaka)	Oozato R. (N)	11	30	–[4)]	
Amblycipitidae					
Liobagrus reinii (akaza)	Kaifu R. (H, I, K)	24	65–90	–	
Anguillidae					
Anguilla japonica (unagi)	Kaifu R. (J)	3	380–410	*Phyllodistomum anguilae* (J)	1/3
	Sakura R. (R)	1	210	–	
Cobitidae					
Cobitis biwae (shimadojo)	Tonda R. (D)	1	105	–	
	Kaifu R. (G, H, I, K)	28	70–120	–	
	Okuura R. (P)	12	40–90	–	
Misgurnus anguillicaudatus (dojo)	Okuura R. (P)	4	55–75	–	
Cottidae					
Cottus kazika (ayukake)	Kaifu R. (K)	21	50–185	–	
	Haigata R. (O)	1	160	–	
Cyprinidae					
Carassius auratus buergeri (ookimbuna)	Oshioka R. (Q)	1	155	–	
	Sakura R. (R)	17	35–133	–	
Ca. a. langsdorfii (gimbuna)	Kaifu R. (I)	6	60–120	–	
	Matsuda R. (U)	5	90–100	–	
Cyprinus carpio carpio (koi)	Matsuda R. (V)	2	110–200	–	
Moroco jouyi (takahaya)	Kaifu R. (H, I)	28	65–85	–	
	Sasamudani R. (L)	1	90	–	
	Sakura R. (R)	14	36–90	–	
Pseudogobio esocinus (kamatsuka)	Kaifu R. (K)	5	95–185	–	
Tribolodon hakonensis (ugui)	Tonda R. (B, D)	3	150–195	*Asymphylodora macrostoma* (D)	1/3
	Kaifu R. (G, H, I, K)	35	75–225	–	
	Sasamudani R. (L)	5	95–120	–	
	Sakura R. (R)	3	125–250	–	
	Matsuda R. (S, U)	9	35–175	*As. macrostoma* (S)	2/9
Zacco platypus (oikawa)	Tonda R. (C)	2	105–110	*Neoplagioporus zacconis* (C)	2/2
	Kaifu R. (G, H, I, K)	45	80–135	*N. zacconis* (H, I, K)	10/45
	Oshioka R. (Q)	3	90–100	–	
	Sakura R. (R)	9	70–115	–	

Table 2. Continued

Fish examined				Digenean found	
Species name (Japanese name)	River (sampling site)[1)]	Number of fish examined	Body size[2)] of fish examined	Species name (sampling site[3)])	Prevalence[5)]
Zacco platypus (oikawa)	Matsuda R. (S, U, V)	12	80–110	*N. zacconis* (V)	1/12
Z. temminckii (kawamutsu)	Tonda R. (B, C, D)	17	80–145	*N. zacconis* (B, C, D)	7/17
	Kaifu R. (G, H, I, K)	48	45–150	*Allocreadium* sp. (K)	1/48
	Oshioka R. (Q)	6	65–75	–	
	Sakura R. (R)	15	70–14	*N. zacconis* (R)	4/15
	Matsuda R. (S, U, V)	23	70–160	–	
Eleotridae					
Eleotris oxycephala (kawaanago)	Haigata R. (O)	2	110–145	–	
	Matsuda R. (V)	3	165–190	–	
Gobiidae					
Gymnogobius petschiliensis (sumiukigori)	Haigata R. (O)	1	90	–	
	Okuura R. (P)	9	45–80	*Genarchopsis goppo* (P)	6/9
	Oshioka R. (Q)	9	45–55	*G. goppo* (Q)	5/9
	Sakura R. (R)	1	45	–	
	Matsuda R. (W)	1	70	–	
Rhinogobius flumineus (kawayoshinobori)	Tonda R. (D)	4	30–37	–	
	Kaifu R. (H)	20	35–50	*Dimerosaccus oncorhynchi* (H)	3/20
	Sakura R. (R)	7	30–45	*G. goppo* (R)	1/7
				D. oncorhynchi (R)	5/7
R. giurinus (gokurakuhaze)	Kaifu R. (K)	27	45–60	*G. goppo* (K)	1/27
	Haigata R. (O)	4	40–60	–	
	Oshioka R. (Q)	3	35–50	*G. goppo* (Q)	2/3
	Sakura R. (R)	1	40	–	
Rhinogobius sp. CB (shimayoshinobori)	Tonda R. (D)	27	35–65	*D. oncorhynchi* (D)	5/27
	Kaifu R. (K)	10	35–50	–	
	Oshioka R. (Q)	5	40–45	*G. goppo* (Q)	1/5
				D. oncorhynchi (Q)	1/5
	Sakura R. (R)	19	30–60	–	
	Matsuda R, (S, W, Y)	11	35–65	*D. oncorhynchi* (S)	1/11
Rhinogobius sp. CO (ruriyoshinobori)	Tonda R. (B, C)	2	60–77	*D. oncorhynchi* (B, C)	2/2
	Oshioka R. (Q)	5	35–50	–	
	Matsuda R. (W)	3	55–70	*D. oncorhynchi* (W)	1/3
	Shimofuji R. (T)	9	40–90	–	
Rhinogobius sp. DA (kuroyoshinobori)	Kaifu R. (H)	1	70	*D. oncorhynchi* (H)	1/1
	Haigata R. (O)	1	50	–	

Table 2. Continued

Fish examined				Digenean found	
Species name (Japanese name)	River (sampling site)[1)]	Number of fish examined	Body size[2)] of fish examined	Species name (sampling site[3)])	Prevalence[5)]
Rhinogobius sp. LD (ooyoshinobori)	Kaifu R. (H, I)	4	65–90	*D. oncorhynchi* (H)	1/4
	Oshioka R. (Q)	20	35–65	–	
	Sakura R. (R)	2	35–45	–	
	Matsuda R. (S)	1	75	–	
Rhinogobius sp. OR (toyoshinobori)	Kaifu R. (H, K)	13	35–55	*D. oncorhynchi* (H, K)	4/13
Sicyopterus japonicus (bozuhaze)	Tonda R. (C)	1	100	–	
	Kaifu R. (H, K)	10	40–85	–	
	Sakura R. (R)	5	70–90	–	
	Matsuda R. (Y)	2	95–115	–	
Tridentiger brevispinis (numachichibu)	Tonda R. (C, D)	6	55–85	*D. oncorhynchi* (C)	1/6
	Kaifu R. (H, K)	43	35–100	*Coitocaecum plagiorchis* (K)	6/43
	Haigata R. (O)	2	30–80	–	
	Oshioka R. (Q)	8	30–40	*G. goppo* (Q)	2/8
	Sakura R. (R)	6	60–100	–	
	Matsuda R. (W)	5	45–65	–	
T. obscurus (chichibu)	Sakura R. (R)	1	75	–	
Odontobutidae					
Odontobutis obscura (donko)	Fukui R. (E)	9	65–115	*G. goppo* (E)	1/9
	Sakura R. (R)	1	100	–	
	Matsuda R. (S, U, V, Y)	19	65–160	*G. goppo* (U, V, Y)	5/19
Plecoglossidae					
Plecoglossus altivelis altivelis (ayu)	Tonda R. (A, B, C, D)	40	120–175	*N. ayu* (B, C)	2/40
	Kaifu R. (G, H, I, K)	21	105–195	–	
	Sakura R. (R)	2	100–115	–	
	Matsuda R. (U, V)	20	135–180	*N. ayu* (U, V)	4/20
Salmonidae					
Oncorhynchus masou ishikawae (amago)	Kainose R. (F)	2	170–200	*D. oncorhynchi* (F)	292
	Sasamudani R. (L)	9	90–170	*D. oncorhynchi* (L)	8/9
Siluridae					
Silurus asotus (namazu)	Kaifu R. (M)	1	125	*Pseudexorchis major* (M)	1/1
	Nishinosawa R. (N)	3	230–410	*Ps. major* (N)	3/3

[1)] Correspond to those in Fig. 1 and Table 1.
[2)] Standard body length (mm).
[3)] The sampling site where the digenean species was obtained.
[4)] Not infected.
[5)] Number of individuals of a particular fish species infected with a particular digenean species/number of individuals of the fish species examined for the digenean species from the river.

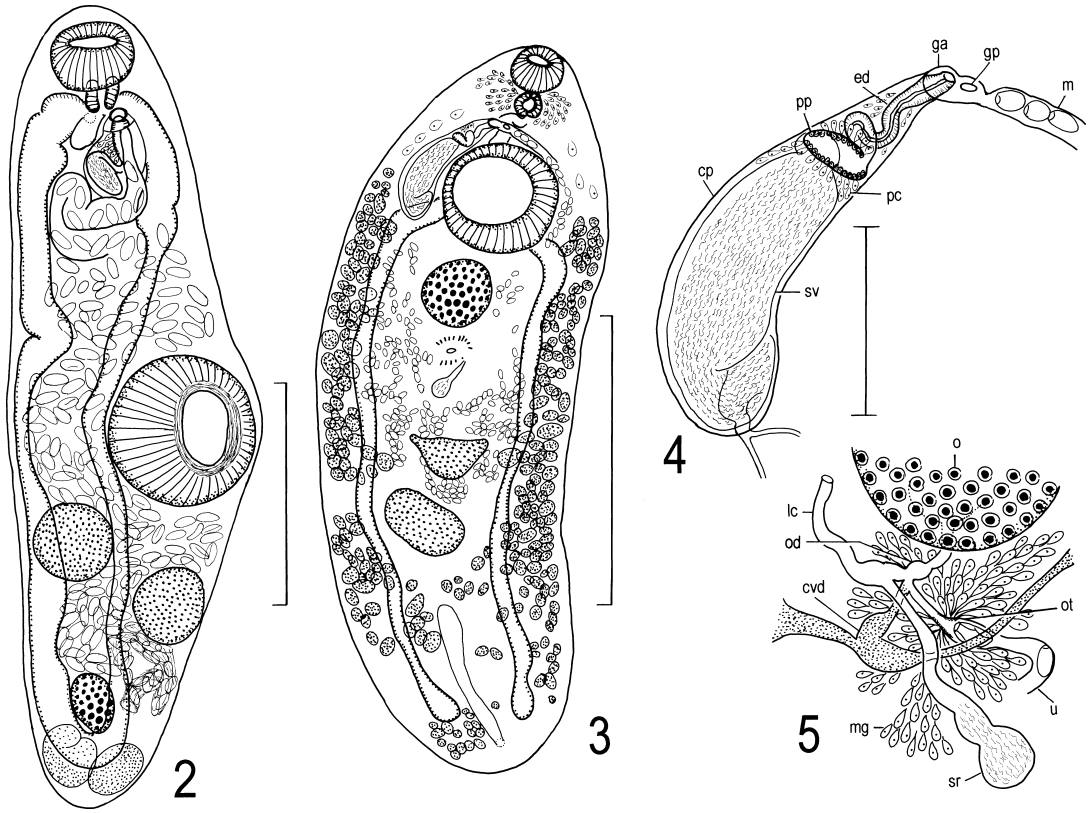


Fig. 2. *Genarchopsis goppo*. Adult specimen found in *Odontobutis obscura* from the Matsuda River (U), entire body, ventral view. Anopercular filament of eggs omitted. Scale bar: 0.5 mm.

Figs. 3–5. *Allocreadium* sp. 3, adult specimen found in *Zacco temminckii* from the Kaifu River (K), entire body, ventral view; 4, terminal genitalia, ventral view; 5, Ovarian complex, dorsal view. cvd, common vitelline duct; cp, cirrus pouch; ed, ejaculatory duct (cirrus); ga, genital atrium; gp, genital pore; lc, Laurer's canal; m, metraterm; mg, Mehlis' gland; o, ovary; od, oviduct; ot, ootype; pc, prostatic cells; pp, pars prostatica; sr, seminal receptacle; sv, seminal vesicle; u, uterus. Scale bars: 1 mm in Fig. 3; 0.5 mm in Figs. 4 and 5.

It seems evident from the above description that, as worms grow further after attaining sexual maturity in the final host, the uterus becomes much more folded, especially in the forebody, and uterine eggs increase in number.

Fish species previously recorded as the final host of *Genarchopsis goppo* including *G. anguillae* and *G. gigi* in Japan are: *Odontobutis obscura* (syn. *Mogurnda obscura* (Temminck and Schlegel)) (Odontobutidae), *Gymnogobius castaneus* (O'Shaughnessy) (syn. *Chaenogobius laevis* (Steindachner)) (Japanese name juzukakehaze), *Gy. isaza* (Tanaka) (syn. *Ch. isaza* Tanaka) (isaza), *Gy. urotaenia* (Hilgendorf) (syn. *Ch. urotaenia* (Hilgendorf), *Ch. annularis urotaenia*) (ukigori), *Rhinogobius flumineus*, *Rhinogobius* sp. OR, *Rhinogobius* sp. (or possibly spp.) (syn. *R. brunneus* (Temminck and Schlegel), *Gobius similis* (Gill)) (yoshinobori), *Tridentiger brevispinis* (Gobiidae), *Pelteobagrus nudiceps* (Sauvage) (Bagridae) (gigi), *Cottus pollux* Günther (kajika), *Co. reinii* Hilgendorf (Cottidae) (utsusemikajika), *Anguilla japonica* (Anguillidae), *Silurus asotus* (Siluridae), *Lepomis macrochirus* Rafinesque (burugiru), and *Micropterus salmoides* Lacepède (Centrarchidae) (ookuchibasu) in Ibaraki, Nagano, Fukui, Shiga, Kyoto, Nara, Okayama, and Hiroshima Prefectures (Ozaki, 1925; Yamaguti, 1934, 1938, 1942; Takahashi, 1929; Shimazu, 1995, 2007; Nakamura *et al.*, 2000; Urabe, 2001;

Shimazu and Urabe, 2005). In addition, the fish (Japanese name "gori") is known as the final host (Shimazu, 1995, 2000). *Rhinogobius giurinus* and *Gymnogobius petschiliensis*, at least, are new host records for *G. goppo*. New locality records are the Fukui River in Anan and the Kaifu River in Kaiyo, Tokushima Prefecture; and the Okuura, Oshioka, and Sakura rivers in Susaki and the Matsuda River in Sukumo, Kochi Prefecture.

Urabe (2001) experimentally elucidated the life cycle of *Genarchopsis goppo* in Nara, Nara Prefecture: a natural first intermediate host was a pleurocerid snail, *Semisulcospira libertina* (Gould) (Japanese name kawanina), in which a cystophorous cercaria similar to *Cercaria yoshidae* Cort and Nichols, 1920 was produced in a redia; experimental second intermediate hosts were copepods, *Mesocyclops leuckarti* (Claus) (asagaokemmijinko), *Thermocyclops hyalinus* (Rehberg) (Japanese name not yet given), and *Eucyclops serrulatus* (Fischer) (nokogirikemmijinko), in which an unencysted metacercaria grew; and experimental and natural final hosts were *Rhinogobius* sp. OR and *Odontobutis obscura*. Urabe (2001) discussed the importance of each of the host fish species known at that time as the final host in the life cycle of *G. goppo*.

Family Allocreadiidae

Allocreadium sp.

(Figs. 3–5)

Specimen studied. One mature specimen (NSMT-Pl 5525) found in the intestine of *Zacco temminckii* (Temminck and Schlegel) (Cyprinidae) from the Kaifu River (sampling site, K).

Description. Body elongate, 6.40 by 2.19; forebody 1.28 long, occupying 20% of body length. Tegument smooth. Eyespot pigment not seen. Oral sucker globular, subterminal, 0.40 by 0.41. Prepharynx almost absent. Pharynx globular, 0.20 in diameter. Esophagus slightly undulating, bifurcating dorsally to ventral sucker, surrounded anteriorly by numerous small gland cells. Intestinal ceca terminating some distance from posterior end of body. Ventral sucker globular, located at about junction of anterior and second fifths of body, 0.94 by 0.98; sucker width ratio 1 : 2.35. Testes slightly oblique, separated, in middle fifth of hindbody; anterior testis triangular, apparently atrophied, 0.38 by 0.55; posterior testis elliptical, healthy, 0.69 by 0.44. Cirrus pouch claviform, large, 1.16 by 0.31, dextral to ventral sucker, extending posteriorly slightly beyond middle level of ventral sucker. Seminal vesicle large, occupying posterior two-thirds of cirrus pouch, constricted to form small anterior portion and large posterior portion, making a small loop posteriorly. Pars prostatica oblong, 0.02 by 0.01; prostatic cells small. Ejaculatory duct long, winding, everted into genital atrium. Genital atrium small. Genital pore median, immediately in front of ventral sucker. Ovary globular, median, slightly posterior to ventral sucker, 0.57 in diameter. Seminal receptacle retort-shaped, submedian, between ovary and anterior testis, 0.63 by 0.14. Laurer's canal short, running forward, sinistral to ventral sucker. Ootype postovarian. Uterus coiled inter-cecally between posterior tests and ventral sucker, extending into intertesticular region of body; metraterm weakly developed, short. Eggs numerous, operculate, oval, 80–86 by 51–56 μm, not embryonated when laid. Vitelline follicles large, distributed from bifurcal level to posterior end of body, separated anteriorly, almost confluent in post-testicular region of body. Excretory vesicle I-shaped, ending anteriorly some distance from posterior testis; excretory pore postero-dorsal.

Discussion. This specimen is characterized by a small oral sucker, a long esophagus bifurcating dorsally to the ventral sucker, a large ventral sucker, a large sucker width ratio (1 : 2.35), and a large cirrus pouch extending posteriorly slightly beyond the middle level of the ventral sucker. In these characteristics, the specimen differs from all of the species of the genus *Allocreadium* Looss, 1900 previously known from Japan: *A. gotoi* (Hasegawa and Ozaki, 1926) Shimazu, 1988, *A. hasu* Ozaki, 1926, *A. japonicum* Ozaki, 1926, *A. tosai* Shimazu, 1988, *A. brevivitellatum*

Shimazu, 1992, *A. tribolodontis* Shimazu and Hashimoto, 1999, *A. shinanoense* Shimazu, 2003, *A. aburahaya* Shimazu, 2003, *Allocreadium* spp. 1–3 of Shimazu, 1999 (namely, *Allocreadium* sp. of Kataoka and Momma, 1934 and *Allocreadium* spp. of Shimazu, 1988), and *Allocreadium* sp. of Shimazu, 2005 (Hasegawa and Ozaki, 1926; Ozaki, 1926; Kataoka and Momma, 1934; Yamaguti, 1934; Shimazu, 1988a, 1992a, 1999, 2003a, 2005; Shimazu and Hashimoto, 1999). From India there have previously been described two species with the sucker width ratio of 1 : more than 2.0: *A. kamalai* Gupta, 1956, from *Chela bacaila* (Hamilton) (Cyprinidae); and *A. mehrai* Gupta, 1956, from *Rhynochobdella aculeata* (Bloch) (Mastacembelidae) (Gupta, 1956). The present specimen is different from these species in other morphological features, host fish species, and geographical distribution. It is likely to represent an undescribed species of the genus. However, it remains unidentified until additional specimens are available for definite identification.

Family Gorgoderidae

Phyllodistomum anguilae Long and Wai, 1958

(Fig. 6)

Phyllodistomum (*Phyllodistomum*) *anguilae* Long and Wai, 1958: 351–352, 365–366, fig. 3.
Phyllodistomum anguilae: Shimazu, 2005: 142–143, figs. 7–9; Shimazu, 2007: 11–12, figs. 16–19.

Specimen studied. One mature specimen (NSMT-Pl 5526) found in the urinary bladder of *Anguilla japonica* Temminck and Schlegel (Anguillidae) from the Kaifu River (sampling site, J).

Description. Body 3.84 by 1.89; forebody 1.15 long, occupying 30% of body length. Oral sucker 0.30 by 0.32. Esophagus thick-walled, winding, bifurcating at about junction of anterior and middle thirds of forebody; intestinal ceca slightly undulating, ending some distance from posterior extremity of body. Ventral sucker at about junction of anterior and middle thirds of body, 0.40 by 0.42; sucker width ratio 1 : 1.31. Testes lobed irregularly, oblique, separated, intercecal, in middle third of hindbody; anterior testis 0.25 by 0.31, posterior testis 0.30 by 0.38. Common sperm duct anterior to ventral sucker, short. Seminal vesicle pyriform, median, dorsal to metraterm, 0.23 by 0.13. Ejaculatory duct long, distally surrounded by gland cells, anterior to metraterm, slightly everted through genital pore. Genital atrium large, shallow. Genital pore large, median, slightly postbifurcal. Ovary cordate, dextro-submedian, intercecal, slightly anterior to anterior (or left) testis, 0.21 by 0.20 in diameter. Ovarian complex median, posterior to ventral sucker. Uterus much folded in hindbody, inter- and post-cecal; metraterm well developed, anterior to ventral sucker; uterine seminal receptacle seen. Uterine eggs numerous, slightly curved, large embryonated eggs 68–77 by 46–56 μm, miracidia not seen in uterus. Vitellaria in form of 2 compact masses, elliptical, submedian, separated, inter-cecal, 0.10–0.23 by 0.17–0.25. Excretory vesicle I-shaped, extending anteriorly to level of ovary; excretory pore postero-terminal.

Discussion. This specimen is similar in morphology and measurements to those described as *Phyllodistomum anguilae* by Shimazu (2005, 2007) from *Anguilla japonica* caught in Lake Ogawara at Kamikita, Aomori Prefecture, and Lake Suwa at Suwa, Nagano Prefecture, respectively. Close examination of the present specimen and Shimazu's (2005, 2007) ones (NSMT-Pl 5247 and 5322–5325) suggested that "weakly-embryonated eggs" and "fully-embryonated eggs" in Shimazu (2007) should be read "large embryonated eggs" and "miracidia in uterus," respectively. Most of the miracidia were found enclosed tightly by their thin, torn respective eggshells.

The Kaifu River in Kaiyo, Tokushima Prefecture, is a new locality record for *P. anguilae*. The life cycle of *P. anguilae* is not known.

Family Opecoelidae

Coitocaecum plagiorchis Ozaki, 1926

(Fig. 7)

?*Cercaria* No. 16 of Nakagawa, 1915: 117, fig. 16.
?*Cercaria distyloides* Faust, 1924: 295.

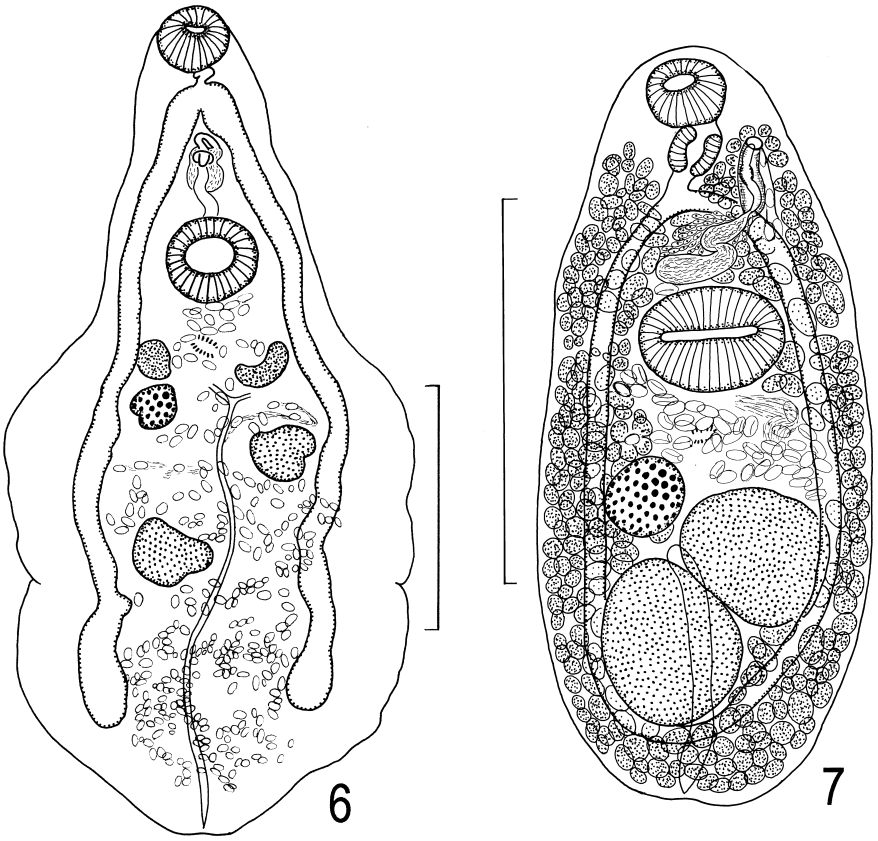


Fig. 6. *Phyllodistomum anguilae*. Adult specimen found in *Anguilla japonica* from the Kaifu River (J), entire body, ventral view. Scale bar: 1 mm.

Fig. 7. *Coitocaecum plagiorchis*. Adult specimen found in *Tridentiger brevispinis* from the Kaifu River (K), entire body, ventral view. Scale bar: 1 mm.

Coitocoecum plagiorchis Ozaki, 1926: 125–128, no figure; Yoshida and Urabe, 2005: 239, fig. 1.

Coitocaecum plagiorchis: Ozaki, 1929; 77–78, 80–82, figs. 1–3; Yamaguti, 1934: 359–360, fig. 56; Yamaguti, 1939: 218–219; Yamaguti, 1942: 351–352; Shimazu, 1988b: 6–7, figs. 1–4; Shimazu, 2000: 18–19, figs. 1–4.

Ozakia plagiorchis: Wiśniewski, 1934: 36–38.

Specimens studied. Seventeen mature specimens (11 flattened and 6 hot formalin-fixed, NSMT-Pl 5527) found in the intestine of *Tridentiger brevispinis* (Gobiidae) from the Kaifu River (sampling site, K).

Description. Based on 11 flattened, gravid specimens, with measurements of 6 hot formalin-fixed specimens in parentheses. Body 1.68–2.56 (1.44–1.55) by 0.72–1.14 (0.46–0.56); forebody 0.69–0.99 (0.59–0.64), occupying 35–43 (38–44)% of total body length. Oral sucker 0.17–0.25 (0.14–0.19) by 0.19–0.28 (0.16–0.19). Pharynx 0.11–0.15 (0.09–0.10) by 0.11–0.19 (0.10–0.12). Esophagus short, 0.06–0.19 long. Cyclocoel present, near posterior end of body. Ventral sucker usually larger than testes but rarely as large as or slightly smaller than them, 0.26–0.37 (0.22–0.31) by 0.32–0.44 (0.24–0.34); sucker width ratio 1 : 1.55–2.00 (1 : 1.63–2.00). Testes diagonal to nearly tandem, contiguous, usually in front of cyclocoel but rarely anterior testis in front of cyclocoel and posterior testis behind it; anterior testis 0.23–0.44 (0.17–0.27) by 0.32–0.49 (0.21–0.31), posterior testis 0.27–0.45 (0.19–0.28) by 0.35–0.50 (0.24–0.28). Cirrus pouch thick-walled, muscular, sinistro-submedian, in front of left in-

testine, 0.20–0.40 by 0.06–0.09, enclosing tubular internal seminal vesicle 0.04–0.09 long, oval pars prostatica 0.05–0.07 long, and thick-walled, straight ejaculatory duct 0.03–0.05 long. External seminal vesicle voluminous, convoluted between intestinal bifurcation and ventral sucker or extending farther between ventral sucker and left intestine, but not beyond ventral sucker. Prostatic cells present mostly around anterior part of external seminal vesicle. Ovary usually globular but rarely triangular, 0.19–0.29 (0.11–0.23) by 0.20–0.37 (0.12–0.16), dextro-submedian, antero-dextral or dextral to anterior (left) testis. Uterus preovarian and pretesticular, rarely extending posteriorly on left side of anterior testis to middle level of anterior testis. Eggs numerous, 54–64 by 35–41 μm, not embryonated. Excretory vesicle I-shaped, extending to anterior testis; excretory pore postero-terminal.

Discussion. These specimens are similar in general morphology to, but slightly larger in measurements than, those previously described as *Coitocaecum plagiorchis* by Ozaki (1926, 1929), Yamaguti (1934, 1939, 1942), Shimazu (1988b, 2000), and Yoshida and Urabe (2005). Ozaki (1929) states that the type locality of this species is Saijo (now Higashihiroshima), Hiroshima Prefecture, Japan. Although Ozaki (1926, 1929, fig. 1) described the testes as smaller than the ventral sucker, the testes were usually smaller than the ventral sucker but rarely as large as or slightly larger than the ventral sucker in the present specimens, as seen in those previously described by Yamaguti (1934, 1939, 1942), Shimazu (1988b, 2000), and Yoshida and Urabe (2005). My reexamination of Yoshida and Urabe's specimens (5 gravid specimens, NSMT-Pl 5437 and 5441; and 11 gravid specimens in Urabe's personal collection) has confirmed their description. In one of the last specimens, the ovary is exceptionally anterosinistral to the anterior testis.

In Japan, the adult of *Coitocaecum plagiorchis* has previously been recorded from *Odontobutis obscura* (Odontobutidae), *Gymnogobius urotaenia* (syn. *Chaenogobius annularis urotaenia*), *Gy. isaza* (syn. *Ch. isaza*), "small goro" (?*Gy. isaza*), *Rhinogobius flumineus*, *Rhinogobius* sp. (syn. *Gobius similis*) (Gobiidae), *Coreoperca kawamebari* (Temminck and Schlegel) (syn. *Bryttosus kawamebari* (Temminck and Schlegel)) (Percichthyidae) (Japanese name kawamebaru), *Cottus reinii* (Cottidae), *Misgurnus anguillicaudatus* (Cobitidae), and *Pelteobagrus nudiceps* (Bagridae) in Shiga, Kyoto, Hyogo, Hiroshima, Fukuoka, and Ooita Prefectures (Ozaki, 1926, 1929; Yamaguti 1934, 1939, 1942; Shimazu, 1988b, 2000; Yoshida and Urabe, 2005). The fish (Japanese name "gori") (other data not given) is also known as the final host (Shimazu, 1995, 2000). *Tridentiger brevispinis* is a new host record for *C. plagiorchis*. The Kaifu River in Kaiyo, Tokushima Prefecture, is a new locality record.

Yoshida and Urabe (2005) experimentally elucidated the life cycle of *Coitocoecum plagiorchis* in the Futatsu River at Mitsuhashi, Fukuoka Prefecture, and the Chikugo River at Hita, Ooita Prefecture, Kyushu, and in the laboratory: natural first intermediate hosts were pleurocerid snails, *Semisulcospira reiniana* (Brot) (Japanese name chirimenkawanina), *Se. libertina*, and a hybrid between them, in which a cotylomicrocercous cercaria with a 2-point stylet was produced in an elongate sporocyst; an atyid shrimp, *Neocaridina denticulata* (de Haan) (Japanese name minaminumaebi) acted as a natural and an experimental second intermediate hosts, in which an encysted metacercaria grew; and natural final hosts were *Coreoperca kawamebari*, *Odontobutis obscura*, *Rhinogobius flumineus*, and *Rhinogobius* sp. Yoshida (1917) detected *Cercaria* D, a cotylomicrocercous cercaria with a 2-point stylet produced in an elongate sporocyst (not "redia"), in *Melania* (syn. of *Semisulcospira*, species not specified) from Tomioka, now in Anan, Tokushima Prefecture. Yoshida's *Cercaria* D is similar to Yoshida and Urabe's cercaria. Shimazu (2003b) and Yoshida and Urabe (2005) mention other previous records of the metacercaria of *C. plagiorchis* from Japan and China.

Yoshida and Urabe (2005) identified their cercaria as *Cercaria distyloides* Faust, 1924. It was

Cercaria No. 16 of Nakagawa (1915) that Faust (1924) originally named *Ce. distyloides*. This cercaria, "Microcerke Cercarien," was found in an elongate "redia" (most presumably sporocyst) in the "liver" of a freshwater snail (Japanese name "kawanina B") (?*Semisulcospira* sp.) from Nanga-sho, Shinchiku-cho, Taiwan (Nakagawa, 1915). Nakagawa (1915) says nothing about a stylet in the cercaria, but the figure (fig. 16) suggests the presence of a 1-point stylet in the position of the mouth of the oral sucker. The cercaria is different from Yoshida and Urabe's cercaria in having a larger body and larger organs and in the site of infection. Yoshida and Urabe's cercaria cannot be referred at present to *Ce. distyloides* until further studies indicate that Nakagawa's and Yoshida and Urabe's cercariae are identical in morphology and that *C. plagiorchis* actually occurs at the same locality in Taiwan.

Nicoll (1915) erected the genus *Coitocoecum* to contain a new species, *gymnophallus*. Subsequently, Ozaki (1926) added two new species to the genus, *plagiorchis* and *orthorchis*. However, later and without explanation, Ozaki (1929) used the spelling *Coitocaecum* (substituting an "a" for the original "o") and attributed it to the authorship and date of the original spelling, namely, *Coitocaecum* Nicoll, 1915, for the generic name when describing further new taxa and erecting a new family Coitocaecidae. Since then this spelling, *Coitocaecum* Nicoll, 1915, has usually been used for the genus (see Yamaguti, 1971), although the original spelling *Coitocoecum* has occasionally been used, most recently by Yoshida and Urabe (2005). Since the International Commission on Zoological Nomenclature (1999) provides the rulings (ICZN Articles 33.2.1, 33.2.3, 33.2.3.1, 33.3, 33.3.1, and 33.5) that justify the emendation to and maintenance of the combination *Coitocaecum* Nicoll, 1915 as correct, I assert that this spelling of the generic name should be adopted to avoid future confusion.

Dimerosaccus oncorhynchi (Eguchi, 1931)
(Figs. 8 and 9)

Allocreadium oncorhynchi Eguchi, 1931: 21–22; Eguchi, 1932: 24–28, 1 pl., figs. 1–6.

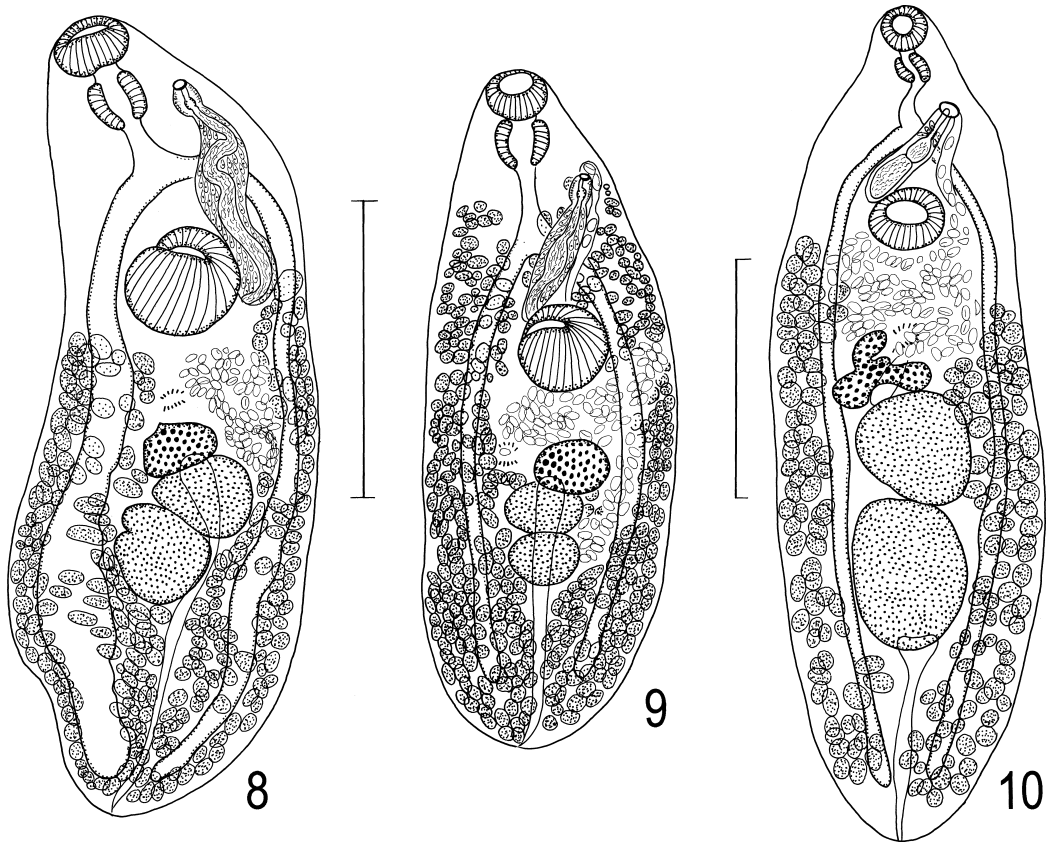
Plagioporus oncorhynchi: Peters, 1957: 140.

Dimerosaccus oncorhynchi: Shimazu, 1980: 164, 166, figs. 1–7; Shimazu, 1988b: 10–11, figs. 5–7; Shimazu, 2000: 25–26, figs. 11–13; Shimazu and Urabe, 2005: 4–5, figs. 4–7.

Plagioporus honshuensis Moravec and Nagasawa, 1998: 283–284, fig. 1.

Specimens studied. Thirteen and 48 mature specimens (NSMT-Pl 5528 and 5529) found in the intestine of *Oncorhynchus masou ishikawae* Jordan and McGregor in Jordan and Hubbs (Salmonidae) from the Kainose (sampling site, F) and Sasamudani (L) rivers, respectively; 1 immature and 2 mature and 11 mature specimens (NSMT-Pl 5530 and 5531) found in the intestine of *Rhinogobius flumineus* (Gobiidae) from the Kaifu (H) and Sakura (R) rivers, respectively; 2 immature and 11 mature, 1 mature, and 1 mature specimens (NSMT-Pl 5532, 5533, and 5534) found in the intestine of *Rhinogobius* sp. CB from the Tonda (D), Oshioka (Q), and Matsuda (S) rivers, respectively; 2 mature and 1 immature specimens (NSMT-Pl 5535–5536 and 5537) found in the intestine of *Rhinogobius* sp. CO from the Tonda (B, C) and Matsuda (W) rivers, respectively; 3 immature and 1 mature specimens (NSMT-Pl 5538) found in the intestine of *Rhinogobius* sp. DA from the Kaifu River (H); 2 mature specimens (NSMT-Pl 5539) found in the intestine of *Rhinogobius* sp. LD from the Kaifu River (H); 9 immature specimens (NSMT-Pl 5540–5541) found in the intestine of *Rhinogobius* sp. OR from the Kaifu River (H, K); and 1 mature specimen (NSMT-Pl 5542) found in the intestine of *Tridentiger brevispinis* (Gobiidae) from the Tonda River (C).

Description. Measurements taken on 5 large, gravid specimens from *Oncorhynchus masou ishikawae*, with those taken on 5 large, gravid specimens from gobiids (6 species of *Rhinogobius* and *Tridentiger brevispinis*) in parentheses. Body 2.64–3.12 by 0.91–1.12 (1.24–2.36 by 0.51–0.85); forebody 0.88–1.12 (0.56–0.96), occupying 33–37% (37–45%) of total body length.



Figs. 8 and 9. *Dimerosaccus oncorhynchi*. 8, adult specimen found in *Oncorhynchus masou ishikawae* from the Kainose River (F), entire body, ventral view; 9, adult specimen found in *Rhinogobius* sp. CB from the Tonda River (D), entire body, ventral view. Scale bar: 1 mm.

Fig. 10. *Neoplagioporus ayu.* Adult specimen found in *Plecoglossus altivelis altivelis* from the Tonda River (C), entire body, ventral view. Scale bar: 1 mm.

Oral sucker 0.17–0.22 by 0.23–0.27 (0.13–0.20 by 0.15–0.25). Pharynx 0.17–0.19 by 0.19–0.22 (0.11–0.15 by 0.09–0.15). Esophagus 0.17–0.21 (0.11–0.27) long, bifurcating between pharynx and ventral sucker. Ventral sucker 0.32–0.37 by 0.36–0.41 (0.25–0.31 by 0.28–0.37); sucker width ratio 1 : 1.45–1.70 (1 : 1.10–1.87). Testes transversely elongated or elliptical, median; anterior testis 0.18–0.25 by 0.34–0.44 (0.06–0.17 by 0.20–0.31), posterior testis 0.25–0.31 by 0.34–0.44 (0.09–0.20 by 0.17–0.29). Cirrus pouch large, divided into anterior and posterior portions; anterior portion thick-walled, muscular, small, 0.11–0.15 by 0.08–0.11 (0.07–0.15 by 0.05–0.08), enclosing small distalmost part of seminal vesicle, small pars prostatica surrounded by a small number of prostatic cells, and short ejaculatory duct; posterior portion thin-walled, large, 0.58–0.72 by 0.19–0.25 (0.22–0.50 by 0.11–0.15), anterior to posterior margin of ventral sucker, enclosing greater part of undulating tubular seminal vesicle and a large number of prostatic cells. Genital pore sinistro-submedian, located at pharyngeal level or slightly posterior to it. Ovary transversely elongated or elliptical, submedian, 0.14–0.20 by 0.26–0.34 (0.07–0.18 by 0.16–0.26). Uterus usually pretesticular (Fig. 8) but rarely extending posteriorly to level of posterior testis (Fig. 9). Eggs numerous, not embryonated, 48–57 by 29–33 μm (49–59 by 29–40

μm). Vitelline follicles anteriorly separate and distributed usually to postbifurcal level (Fig. 8) but rarely to middle level of esophagus in the specimens from *On. masou ishikawae*, but on the contrary, usually to middle level of esophagus (Fig. 9) but rarely to postbifurcal level in those from the gobiids; posteriorly confluent and extending to posterior end of body. Excretory vesicle I-shaped, usually reaching anteriorly to ovary; excretory pore postero-terminal.

Discussion. The specimens obtained from *Oncorhynchus masou ishikawae* differ from those obtained from the gobiids in that the body is larger; that the ventral sucker is located slightly more posterior; and that the anterior distribution of the vitelline follicles is limited more posteriorly, namely, usually postbifurcal instead of prebifurcal. They closely resemble one another in other morphological features. It is uncertain that the above differences are sufficient to separate species. All the present specimens are assigned at present to *Dimerosaccus oncorhynchi* as described by Eguchi (1931, 1932), Shimazu (1980, 1988b, 2000), and Shimazu and Urabe (2005).

Fish species previously recorded as the final host of *Dimerosaccus oncorhynchi* are: *Oncorhynchus masou ishikawae*, *On. masou masou* (Brevoort) (Japanese name sakuramasu or yamame), *Salvelinus leucomaenis leucomaenis* (Pallas) (amemasu), *S. leucomaenis pluvius* (Hilgendorf) (Salmonidae) (nikkoiwana), *Cottus nozawae* Snyder (hanakajika), *Co. pollux* Günther (Cottidae) (kajika), *Rhinogobius flumineus* (Gobiidae), and *Liobagrus reinii* (Amblycipitidae) from Hokkaido, Iwate, Nagano, Toyama, Gifu, and Nara Prefectures (Eguchi, 1931, 1932; Shimazu, 1980, 1988b, 2000; Moravec and Nagasawa, 1998; Nakamura *et al*., 2000; Shimazu and Urabe, 2005). Yoshida and Urabe (2005) recorded *D. oncorhynchi* from the Chikugo River at Hita, Ooita Prefecture, without stating the host fish. *Rhinogobius* sp. CB, CO, DA, LD, and OR and *Tridentiger brevispinis* are new host records. New locality records are the Tonda River in Tanabe, Wakayama Prefecture; the Kaifu, Kainose, and Sasamudani rivers in Kaiyo, Tokushima Prefecture; and the Oshioka and Sakura rivers in Susaki and the Matsuda River in Sukumo, Kochi Prefecture.

Some well-grown adults of *Dimerosaccus oncorhynchi* have been found in *Liobagrus reinii* from the Sho River in Ohta, Toyama Prefecture (Moravec and Nagasawa, 1998; Shimazu, 2000), and the Takami River in Higashiyoshino, Nara Prefecture (Shimazu and Urabe, 2005). It remains to be explained why *L. reinii* was not infected with *D. oncorhynchi* in the Kaifu River (sampling sites, H, I, K) though *Rhinogobius flumineus* and *Rhinogobius* spp. DA, LD, and OR were infected in the same river (H, K) (Table 2). The life cycle of *D. oncorhynchi* is not known.

Neoplagioporus ayu (Takahashi, 1928)

(Fig. 10)

Podocotyle ayu Takahashi, 1928: 51–55, figs. 1–3; Takahashi, 1929: 1927–1928, fig. 8; Yamaguti, 1934: 295, fig. 22.

Neoplagioporus ayu: Shimazu, 1990: 390–391, figs. 6–9.

Specimens studied. Two and 6 mature specimens (NSMT-Pl 5543–5544 and 5545–5546) found in the intestine and pyloric ceca of *Plecoglossus altivelis altivelis* (Temminck and Schlegel) (Plecoglossidae) from the Tonda (sampling sites, B, C) and Matsuda (U, V) rivers, respectively.

Description. Three intact, gravid specimens measured. Body elongated, 3.04–3.92 by 0.96–1.15; forebody 0.88–1.12 long, occupying 25–28% of total body length. Oral sucker 0.17–0.23 by 0.20–0.23. Pharynx 0.14–0.17 by 0.13–0.17. Esophagus 0.22–0.25 long. Ventral sucker 0.27–0.39 by 0.30–0.39; sucker width ratio 1 : 1.37–1.93. Testes in middle third of hindbody; anterior testis 0.44–0.48 by 0.47–0.51, posterior testis 0.61–0.63 by 0.46–0.49. Cirrus pouch 0.47–0.52 by 0.12–0.19, extending posteriorly to middle level of ventral sucker. Seminal vesicle distinctly bipartite. Genital pore sinistro-submedian, at esophageal level. Ovary deeply trilobed, dextro-anterior to anterior testis, 0.19–0.28 by 0.34–0.47. Seminal receptacle medial to ovary, 0.19–

0.44 by 0.07–0.19. Eggs numerous, 64–72 by 45–48 μm. Vitelline follicles extending anteriorly to level of posterior margin of ventral sucker and posteriorly to near posterior end of body. Excretory vesicle I-shaped, reaching anteriorly to ovary or not; excretory pore postero-subterminal.

Discussion. These specimens agree in morphology and measurements with the descriptions of *Neoplagioporus ayu* found in *Plecoglossus altivelis altivelis* from Kyoto and Okayama Prefectures (Takahashi, 1929; Yamaguti, 1934; Shimazu, 1990). Yoshida and Urabe (2005) recorded *N. ayu* from the Chikugo River at Hita, Ooita Prefecture, without mentioning the fish host. The Tonda River in Tanabe, Wakayama Prefecture, and the Matsuda River in Sukumo, Kochi Prefecture, are new locality records. The life cycle of *N. ayu* is not known.

Neoplagioporus zacconis (Yamaguti, 1934)

(Fig. 11)

Caudotestis zacconis Yamaguti, 1934: 292–294, fig. 21; Yamaguti, 1938: 20, plate-fig. 1; Yamaguti, 1942: 332–333.

Plagioporus (*Caudotestis*) *zacconis*: Yamaguti, 1954: 76.

Plagioporus (*Plagioporus*) *zacconis*: Skryabin and Koval', 1958: 533–534, fig. 180.

Neoplagioporus zacconis: Shimazu, 1990: 387–388, figs. 1–5; Shimazu and Urabe, 2005: 7–8, figs. 11–14.

Specimens studied. Five mature, 1 immature and 16 mature, and 1 mature specimens (NSMT-Pl 5547, 5548–5550, and 5551) found in the intestine of *Zacco platypus* (Temminck and Schlegel) (Cyprinidae) from the Tonda (sampling site, C), Kaifu (H, I, K), and Matsuda (V) rivers, respectively; and 14 mature and 1 immature and 12 mature specimens (NSMT-Pl 5552–5554 and

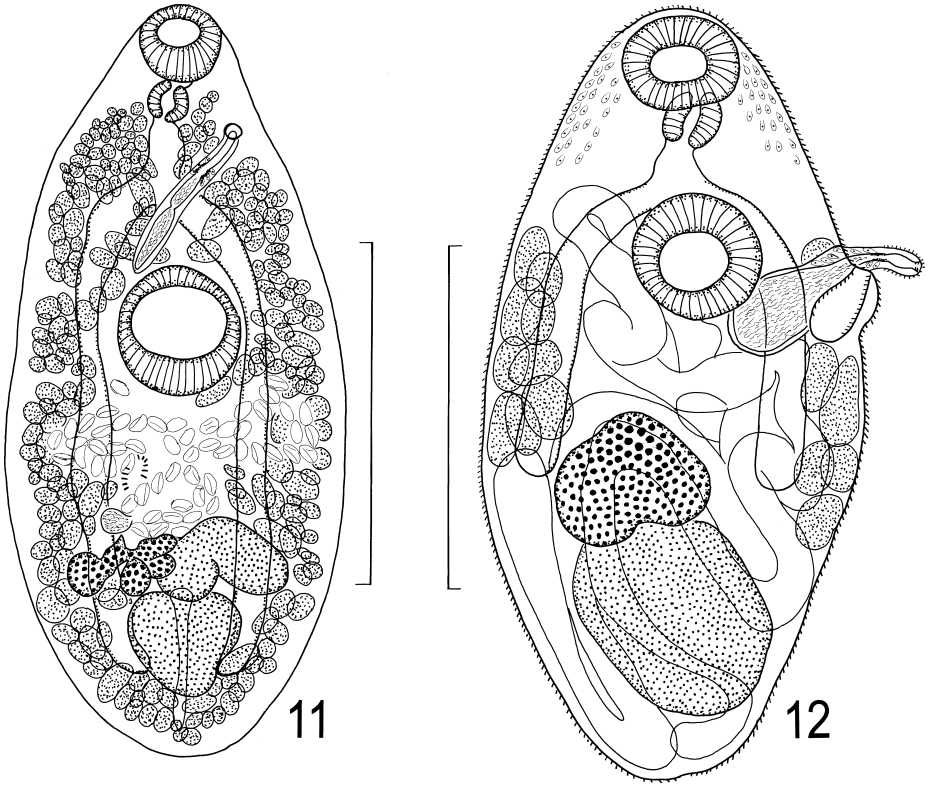


Fig. 11. *Neoplagioporus zacconis.* Adult specimen found in *Zacco platypus* from the Tonda River (C), entire body, ventral view. Scale bar: 1 mm.

Fig. 12. *Asymphylodora macrostoma.* Adult specimen found in *Tribolodon hakonensis* from the Tonda River (D), entire body, ventral view. Uterine eggs omitted. Scale bar: 0.5 mm.

5555) found in the intestine of *Z. temminckii* from the Tonda (B, C, D) and Sakura (R) rivers, respectively.

Description. Ten large, gravid specimens measured. Body oval, 1.87–2.96 by 0.91–1.29; forebody 0.72–1.36 long, occupying 38–48% of total body length. Oral sucker 0.19–0.27 by 0.23–0.28. Pharynx 0.10–0.17 by 0.10–0.15. Esophagus 0.09–0.24 long, bifurcating about halfway between two suckers; intestinal ceca extending to about middle level of to posterior border of posterior testis. Ventral sucker 0.37–0.49 by 0.32–0.48; sucker width ratio 1 : 1.54–1.75. Testes globular to transversely elongated, entire or indented, median, tandem or slightly oblique, contiguous, in posterior half of hindbody; anterior testis 0.19–0.31 by 0.25–0.50, posterior testis 0.19–0.37 by 0.25–0.50. Cirrus pouch claviform, lying diagonally in front of ventral sucker, 0.36–0.63 by 0.06–0.22. Genital pore sinistro-submedian, at pharyngeal level. Ovary deeply trilobed, with lobes rarely further lobulated, dextro-anterior to or side by side with anterior testis, 0.12–0.25 by 0.25–0.37. Seminal receptacle dextro-submedian, 0.08–0.25 by 0.08–0.14. Uterus coiled between anterior testis and ventral sucker, extending into extracecal fields; metraterm well developed. Eggs numerous, not embryonated, 61–75 by 40–46 μm. Vitelline follicles distributed along intestinal ceca, anteriorly extending to pharyngeal level, separate there, posteriorly entering post-testicular region, confluent there, absent from peripheral lateral fields of body. Excretory vesicle I-shaped, reaching to anterior testis; excretory pore postero-subterminal.

Discussion. These specimens are closely similar to *Neoplagioporus zacconis* as redescribed by Shimazu (1990) and Shimazu and Urabe (2005).

Fish species previously recorded as the final host of *N. zacconis* in Japan are: *Zacco platypus*, *Z. temminckii*, *Pungtungia herzi* Herzenstein (Cyprinidae) (Japanese name mugitsuku), *Oncorhynchus masou masou* (Salmonidae), and *Liobagrus reinii* (Amblycipitidae) from Ibaraki, Saitama, Nagano, Kyoto, Nara, Hyogo, and Hiroshima Prefectures (Yamaguti, 1934, 1938, 1942; Shimazu, 1990; Nakamura *et al.*, 2000; Shimazu and Urabe, 2005). Yoshida and Urabe (2005) recorded *N. zacconis* from the Chikugo River at Hita, Ooita Prefecture, without mentioning the fish host. The Tonda River in Tanabe, Wakayama Prefecture; Kaifu River in Kaiyo, Tokushima Prefecture; and Sakura River in Susaki and Matsuda River in Sukumo, Kochi Prefecture, are new locality records. The life cycle of *N. zacconis* is not known.

Family Lissorchiidae

Asymphylodora macrostoma Ozaki, 1925

(Fig. 12)

Cercaria H of Kobayashi, 1918: 70–73, 1 pl., fig. 16.
Cercariaeum A of Kobayashi, 1922: 266–267.
Cercariaeum innominatum: Faust, 1924: 295.
Asymphylodora macrostoma Ozaki, 1925: 104–106, fig. 4; Yamaguti, 1934: 393; Shimazu, 1992b: 8–10, figs. 6–11; Shimazu and Urabe, 2005: 11–12, figs. 18–20
Parasymphylodora macrostoma: Szidat, 1943: 44–45, table 1, fig. 12.
Cercaria innominatum [sic]: Ito, Mochizuki, and Noguchi, 1959: 918; Ito, 1960: 67–68, fig. 13.
Orientotrema macrostoma: Tang, 1962: 169, 182.

Specimens studied. Six and 14 mature specimens (NSMT-Pl 5556 and 5557) found in the intestine of *Tribolodon hakonensis* (Günther) (Cyprinidae) from the Tonda (sampling site, D) and Matsuda (S) rivers, respectively.

Description. Measurements taken on each of 5 gravid specimens from the Tonda and Matsuda rivers. Body 0.89–1.35 by 0.41–0.58; forebody 0.28–0.51, occupying 31–40% of total body length. Oral sucker 0.12–0.16 by 0.14–0.20. Pharynx 0.08–0.10 by 0.07–0.10. Esophagus 0.06–0.07 long. Ventral sucker 0.15–0.19 by 0.15–0.25; sucker width ratio 1 : 1.00–1.48. Testes 0.22–0.31 by 0.17–0.27. Cirrus pouch 0.17–0.27 by 0.07–0.10. Seminal vesicle 0.08–0.17 by 0.06–0.09. Cirrus 0.06–0.09 long. Ovary 0.11–0.19 by 0.12–0.22. Uterus much folded in all available space of hindbody even in post-testicular region; its proximal parts folded dorsally and slightly anteriorly to ventral sucker, acting as a

uterine seminal receptacle. Metraterm 0.07–0.13 by 0.05–0.06. Eggs 22–25 by 11–14 μm.

Discussion. These specimens agree in morphology and measurements with *Asymphylodora macrostoma* as redescribed by Shimazu (1992b) and Shimazu and Urabe (2005).

Fish species previously recorded as the final host of *Asymphylodora macrostoma* in Japan are: *Odontobutis obscura* (syn. *Mogurnda obscura*) (Odontobutidae), *Hemibarbus barbus* (Temminck and Schlegel) (Japanese name nigoi), *Moroco steindachneri* (Sauvage) (aburahaya), *Opsariichthys uncirostris* (Temminck and Schlegel) (hasu), *Tribolodon hakonensis*, the fish (Japanese name "bote"), the fish (Japanese name "ukikamatsuka(?)") (Cyprinidae), *Gymnogobius isaza* (syn. *Chaenogobius isaza*), and *Tridentiger brevispinis* (Gobiidae) from Ibaraki, Saitama, Nagano, Toyama, Fukui, Shiga, Kyoto, Nara, and Hiroshima Prefectures (Ozaki, 1925; Yamaguti, 1934; Shimazu, 1992b, 2003b, 2007; Nakamura *et al*., 2000; Shimazu and Urabe, 2005). In addition, the fish (Japanese name "gori") (other data not given) and *Op. uncirostris* from the Yodo River (locality not specified) have been recorded (Yamaguti, 1934; Shimazu, 1992b). The Tonda River in Tanabe, Wakayama Prefecture; and Matsuda River in Sukumo, Kochi Prefecture, are new locality records.

Shimazu (2007) elucidated the life cycle of *Asymphylodora macrostoma* in the laboratory and field in Nagano Prefecture: natural first intermediate hosts were pleurocerid snails, *Semisulcospira libertina* and *Se. dolorosa* (Gould) (Japanese name kitanokawanina), in which a tailless cercaria (*Cercaria innominata*) was produced in a redia; natural and experimental second intermediate hosts were cyprinids, in which an encysted metacercaria grew; *Tribolodon hakonensis* served as a natural and an experimental final host.

Family Heterophyidae

Pseudexorchis major (Hasegawa, 1935)

(Fig. 13)

Exorchis major Hasegawa, 1935a: 1193–1197, 1 pl., figs. 1–2; Hasegawa, 1935b: 1546, 1 pl.

Pseudexorchis major: Yamaguti, 1938: 66, 68; Shimazu, 2007: 24–25, figs. 31–34.

Specimens studied. Eight mature and many immature and mature specimens (NSMT-Pl 5558 and 5559) found in the intestine of *Silurus asotus* Linnaeus (Siluridae) from a small tributary of the Kaifu River (M) and the Nishinosawa River (N), respectively.

Description. Ten large, gravid specimens measured. Body 0.26–0.31 by 0.22–0.28; forebody 0.11–0.13 long, occupying 41–44% of total body length. Oral sucker 0.07–0.09 by 0.10–0.11. Pharynx 0.02–0.03 in diameter. Esophagus short; intestinal ceca ending at about middle level of hindbody. Ventral sucker slightly anterior to middle level of body, 0.03–0.04 by 0.04; sucker width ratio 1 : 0.35–0.45. Ventrogenital sac small, shallow, enclosing antero-ventral half of ventral sucker. Ventral invagination present between two suckers, usually inverted but rarely everted. Testes 0.05–0.08 by 0.04–0.06. Seminal vesicle bipartite, 0.07–0.12 by 0.04–0.07. Pars prostatica antero-internal to seminal vesicle. Hermaphroditic duct fairly long, opening into ventrogenital sac through genital pore on anterior wall of ventrogenital sac. Ovary 3-lobed, 0.06–0.10 by 0.05–0.06. Seminal receptacle 0.04–0.09 by 0.03–0.06. Eggs 29–38 by 14–21 μm. Vitelline follicles large, 7 each making compact cluster at level of and dorsally to ovary on either side of body. Excretory vesicle Y-shaped, with arms extending anteriorly to level of ventral sucker but not beyond it; excretory pore postero-dorsal or -terminal.

Discussion. These specimens agree well in morphology and measurements with *Pseudexorchis major* as redescribed by Shimazu (2007). The Kaifu and Nishinosawa rivers in Kaiyo, Tokushima Prefecture, are new locality records.

The life cycle of *Pseudexorchis major* is well known (Ito, 1956, 1964; Komiya, 1965; Shimazu, 1999, 2003b). Pleurocerid snails, *Semisulcospira* spp., serve as the first intermediate host, in which a parapleurolophocercous cercaria is produced in a redia. Fishes of various species act as the second intermediate host, in which a

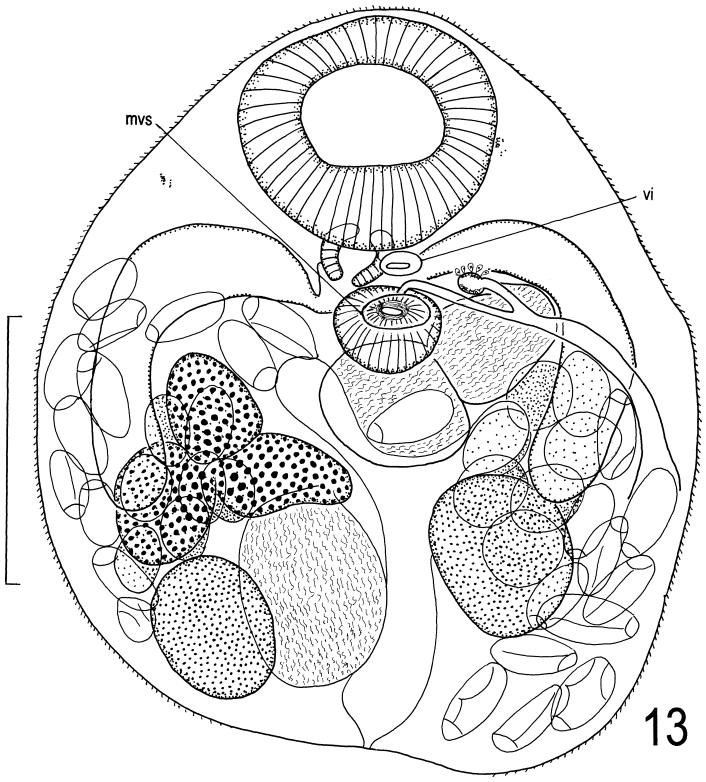


Fig. 13. *Pseudexorchis major.* Adult specimen found in *Silurus asotus* from the Nishinosawa River (N), entire body, ventral view. vi, ventral invagination; mvs, mouth of ventrogenital sac. Scale bar: 0.1 mm.

metacercaria encysts. *Silurus asotus* is the final host. Ito (1956) found the cercaria in *Se. japonica* (Reeve) (Japanese name misujikawanina, syn. of *Se. libertina*) from Hatta-gun (correctly Hata-gun) (locality not specified), Kochi Prefecture. Sukumo (sampling sites, S-Y) is included in Hata-gun, but *Si. asotus* was not examined there in the present study.

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