

## Digeneans Found in Fresh- and Brackish-water Fishes of Lake Ogawara in Aomori Prefecture, Japan

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**Abstract** Fresh- and brackish-water fishes caught in Lake Ogawara at Kamikita, Aomori Prefecture, Japan, were examined for helminth parasites in September 1997. Digeneans of seven species found are reported in this paper. *Phyllodistomum biringo* sp. nov. (Gorgoderidae) is described from adults found in the urinary bladder of *Gymnogobius breunigii* (Steindachner) (Gobiidae). *Exorchis oviformis* Kobayashi, 1915 (Cryptogonimidae) is redescribed from adults found in the intestine of *Silurus asotus* Linnaeus (Siluridae). The generic diagnosis of *Exorchis* Kobayashi, 1915 is amended in part.

**Key words:** digeneans, *Phyllodistomum biringo* sp. nov., *Exorchis*, fresh- and brackish-water fishes, Lake Ogawara, Japan.

### Introduction

Little is known of digeneans parasitic in fresh-water fishes in northern parts of Tohoku, Japan. Probably the only species reported from there is *Azygia anguillae* Ozaki, 1924 (syn. *Cercaria gotoi* Ariake, 1922; *A. gotoi* (Ariake, 1922) Shimazu, 1979) (Azygiidae) found in the stomach of *Anguilla japonica* Temminck & Schlegel (Anguillidae) caught at Hiranuma, Rokkasho, Aomori Prefecture (Shimazu, 1979). In order to obtain further information on the digenean fauna of the freshwater fishes of the parts, I examined several species of fresh- and brackish-water fishes caught in Lake Ogawara, Kamikita, located near Hiranuma, in Aomori Prefecture in September 1997. This paper aims at reporting digeneans found in the examination. Cestodes, nematodes, and acanthocephalans found will be dealt with elsewhere.

### Materials and Methods

Fresh- and brackish-water fishes were collected by a local fisherman in Lake Ogawara at Kamikita, Aomori Prefecture, Japan, on 2–10 September 1997. Fishes examined were: *Lethen-*

*teron reissneri* (Dybowski) (Petromyzontidae) (number of fish examined, 1; standard body length of fish examined, 180 mm), *Anguilla japonica* Temminck & Schlegel (Anguillidae) (27; 210–450), *Carassius auratus langsdorffii* Valenciennes in Cuvier & Valenciennes (38; 45–230), *Cyprinus carpio* Linnaeus (1; 330), *Pseudorasbora parva* (Temminck & Schlegel) (2; 45–50), *Tribolodon hakonensis* (Günther) (Cyprinidae) (59; 56–185), *Silurus asotus* Linnaeus (Siluridae) (55; 160–340), *Pungitius tyemensis* (Nikolsky) (Gasterosteidae) (2; 47–57), *Hypomesus nipponensis* McAllister (Osmeridae) (93; 30–80), *Plecoglossus altivelis altivelis* Temminck & Schlegel (Plecoglossidae) (1; 185), *Micropterus salmoides* (Lacepède) (Centrarchidae) (2; 190–205), *Gymnogobius breunigii* (Steindachner) (70; 25–55), *G. urotaenia* (Hilgendorf) (8; 57–120), *Tridentiger brevispinis* Katsuyaman, Arai & Nakamura (Gobiidae) (114; 40–75), and *Platichthys stellatus* (Pallas) (Pleuronectidae) (23; 70–180). The fishes were examined fresh for helminth parasites.

Digeneans found were slightly flattened, fixed with AFA, stained with Heidenhain's iron hematoxylin, and mounted in Canada balsam. Some related whole-mounted specimens were borrowed

for comparison from Dr. Satyu Yamaguti's Collection deposited in Meguro Parasitological Museum (MPM), Tokyo. Drawings were made with the aid of a drawing tube. Measurements (length by width) are given in millimeters unless otherwise stated. The specimens studied have been deposited in the National Science Museum, Tokyo (NSMT).

#### Family Waretrematidae

##### *Carassotrema koreanum* Park, 1938

*Hosts (site of infection).* *Carassius auratus langsdorfii* (intestine) and *Tribolodon hakonensis* (intestine).

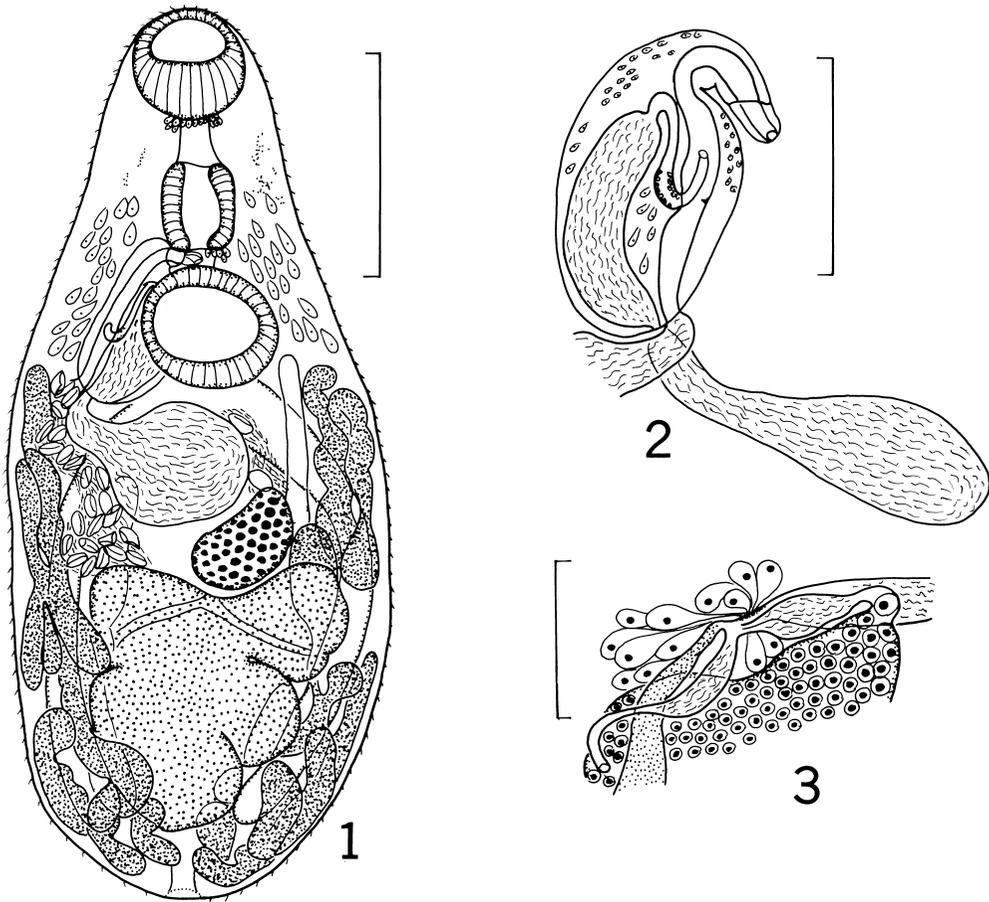
*Prevalence and intensity of infection.* Nine (or 23.7%) of the 38 fish (*C. auratus langsdorfii*) examined were infected with 1 to 12 (mean, 4.1) worms. One (or 1.7%) of the 59 fish (*T. hakonensis*) examined was infected with 2 worms. A total of 6 immature and 33 mature worms were obtained.

*Specimens.* NSMT-PI 5245 from *C. auratus langsdorfii* and 5246 from *T. hakonensis*.

*Description* (Figs. 1–3). Based on 12 gravid specimens. Body elongate-oval, 1.52–2.26 by 0.60–0.85; forebody 0.51–0.72 long, occupying 32–38% of total body length. Tegument spined. Eyespot pigment scattered on both sides of pharynx. Numerous large gland cells of two types (with fine and coarse granular cytoplasm, respectively) seen on ventral and dorsal parts of body, especially in forebody. Oral sucker subterminal, 0.17–0.23 by 0.19–0.24. Prepharynx 0.05–0.12 long. Small gland cells massed together between oral sucker and prepharynx. Pharynx large, 0.14–0.19 by 0.14–0.17. Esophagus 0.16–0.29 long, bifurcating posterodorsally to ventral sucker; intestinal ceca extending to near posterior extremity of body. Small gland cells massed together between pharynx and esophagus. Ventral sucker at about junction of anterior and middle thirds of body, 0.21–0.26 by 0.25–0.30; sucker width ratio 1: 1.16–1.34. Testis single, cordate, irregularly indented, median, almost intercecal, in posterior half of hindbody, 0.39–0.62 by 0.26–0.55.

Hermaphroditic sac usually on either side of ventral sucker but rarely dorsal to ventral sucker, elongate, usually with curved anterior part, longer than ventral sucker, 0.23–0.39 by 0.15–0.22. Internal seminal vesicle elongate, connecting with an inverted U-shaped tube to well developed pars prostatica surrounded by prostatic cells. Ejaculatory duct entering side wall of junction of metraterm and hermaphroditic duct, slightly projecting into hermaphroditic duct. Hermaphroditic duct long, eversible. Genital atrium not seen. Genital pore usually slightly to right of anterior end of esophagus. External seminal vesicle large, retort-shaped, lying obliquely between ventral sucker and ovary. Ovary reniform, submedian, immediately pretesticular, 0.15–0.32 by 0.08–0.16. Oviduct dilated to include spermatozoa. Laurer's canal proximally dilated to include spermatozoa. Ootype-complex anterolateral to ovary. Mehlis' gland large. Seminal receptacle absent. Uterus coiled on both sides of external seminal vesicle between testis and ventral sucker; uterine seminal receptacle present; metraterm well developed in hermaphroditic sac. Uterine eggs not embryonated, 56–62 by 34–42  $\mu\text{m}$  (collapsed). Vitellaria digitate, spreading anteriorly and posteriorly on ventral and dorsal sides of intestinal ceca in lateral fields of hindbody, usually separated posteriorly; digits a few, long, rarely branched. Excretory vesicle Y-shaped, with arms extending anteriorly to level of ventral sucker; excretory pore posterodorsal.

*Discussion.* Park (1938) described a new genus and species, *Carassotrema koreanum*, on the basis of the adults found in the intestine of *Carassius auratus* in the vicinity of Seoul, Korea. Yamaguti (1942) briefly described the adults found in the intestine of *Cyprinus carpio* from Lake Kasumigaura, Ibaraki Prefecture, and *Carassius carassius* from Kawati Province [Osaka Prefecture], slightly emending Park's original description. I reexamined one specimen (MPM Coll. No. 22270) from Lake Kasumigaura (Tuchiura on 4 April 1940; Yamaguti, 1942). The present specimens agree fairly well in morphology and measurements with Yamaguti's descrip-



Figs. 1–3. *Carassotrema koreanum*. 1. Entire body, ventral view. 2. Terminal genitalia, ventral view. 3. Ovarian complex, dorsal view. Scale bars: 0.5 mm in Fig. 1; 0.2 mm in Figs. 2 and 3.

tion and specimen. Lake Ogawara is a new locality record for *C. koreanum*.

Neither Park (1938) nor Yamaguti (1942) mentioned the uterine seminal receptacle. Park (1938) seems to have considered the dilated proximal portion of Laurer's canal the seminal receptacle, but his figure (pl. 13, fig. 7) shows that the dilatations of the oviduct, common oviduct, and Laurer's canal include spermatozoa. Yamaguti (1942, 1971) regarded the dilatation of the oviduct as the seminal receptacle. In the present specimens, however, the dilatations of the oviduct and Laurer's canal certainly included spermatozoa, and the uterus also included much more spermatozoa as a uterine seminal receptacle than the dilatations (Figs. 1–3). Park (1938) said

the genital atrium as present. This organ was not seen in the present specimens (Fig. 2). Yamaguti (1942) detailed gland cells of three types, the parenchymatous, prepharyngeal, and cervical, in fresh specimens. These were not clearly distinguished in the present whole-mounted specimens.

#### Family Allocreadiidae

##### *Allocreadium* sp.

*Host (site of infection)*. *Tribolodon hakonensis* (intestine).

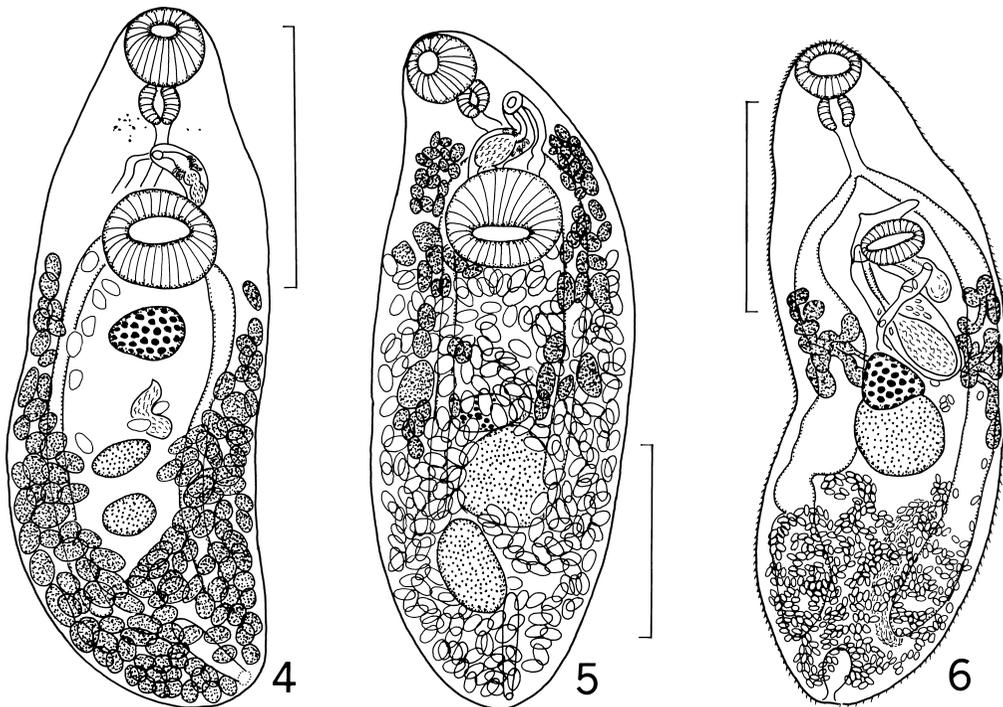
*Prevalence and intensity of infection*. One (or 1.7%) of the 59 fish examined was infected with 1 mature worm.

*Specimen.* NSMT-PI 5246.

*Description* (Fig. 4). Based on 1 gravid specimen. Body elongate, 2.69 by 0.88; forebody 0.83 long, occupying 31% of total body length. Tegument smooth. Eyespot pigment scattered in forebody. Oral sucker subterminal, 0.28 by 0.31. Prepharynx absent. Pharynx globular, 0.15 by 0.15. Esophagus 0.37 long, bifurcating dorsally to ventral sucker; intestinal ceca terminating some distance from posterior end of body. Ventral sucker located at near junction of anterior and middle thirds of body, 0.39 by 0.44; sucker width ratio 1: 1.41. Testes (slightly degenerated) almost entire, median, tandem, separated, in middle third of hindbody; anterior testis 0.29 by 0.15; posterior 0.15 by 0.20. Cirrus pouch clavate, curved, 0.21 by 0.10. Seminal vesicle internal, bipartite; posterior portion larger than anterior. Pars prostatica globular, surrounded by well-developed prostatic cells. Cirrus short. Genital atrium small. Genital pore median, located at middle of esophagus. Ovary elliptical, posterior

to ventral sucker, almost median, 0.21 by 0.29. Ootype-complex posterolateral to ovary. Laurer's canal short. Mehlis' gland poorly developed. Seminal receptacle retort-shaped, 0.43 by 0.15. Uterus coiled a few times in area between anterior testis and cirrus pouch; metraterm well developed. Uterine eggs few, not embryonated, 77–87 by 50–60  $\mu\text{m}$ . Vitellaria follicular, large, distributed from bifurcal level to posterior end of body, present ventral and dorsal to intestinal ceca, separated anteriorly, confluent in posttesticular region. Excretory vesicle I-shaped, extending to level of posterior cecal end; excretory pore posterodorsal.

*Discussion.* This gravid specimen seems to resemble *A. tribolodontis* Shimazu & Hashimoto, 1999 as described by Shimazu & Hashimoto (1999) from *Tribolodon ezoe* Okada & Ikeda caught in the Kushiro River at Toro, Shibechea, Hokkaido, and *T. hakonensis* (syn. *T. hakuensis*) caught in the Hei River at Kanioka, Kawai, Iwate Prefecture. However, it differs slightly from the



Figs. 4–6. 4. *Allocreadium* sp., entire body, ventral view. 5. *Urorchis goro*, entire body, ventral view. 6. *Lasiotocus* sp., entire body, dorsal view. Scale bars: 1 mm in Fig. 4; 0.5 mm in Figs. 5 and 6.

latter in having a larger sucker width ratio (1: 1.41 instead of 1: 1.05–1.30), larger eggs (77–87 by 50–60  $\mu\text{m}$  instead of 64–80 by 48–62  $\mu\text{m}$ ), and a shorter excretory vesicle (extending to the level of the posterior cecal ends instead of more anteriorly to it). It remains unidentified until further specimens are available.

#### Family Opecoelidae

##### *Urorchis goro* Ozaki, 1927

*Host (site of infection).* *Tridentiger brevispinis* (rectum).

*Prevalence and intensity of infection.* One or 0.9% of the 114 fish examined was infected with 5 mature worms.

*Specimens.* NSMT-PI 5241.

*Description* (Fig. 5). Based on 5 gravid worms. Body elongate-oval, 1.50–1.75 by 0.58–0.66; forebody 0.40–0.54 long, occupying 23–34% of total body length. Tegument smooth. Oral sucker subterminal, 0.13–0.17 by 0.14–0.18. Prepharynx very short. Pharynx almost globular, 0.06–0.08 in diameter. Esophagus curved, 0.03–0.09 long, bifurcating about midway between pharynx and ventral sucker; intestinal ceca extending to testicular region. Ventral sucker at about junction of anterior and middle thirds of body, 0.23–0.26 by 0.25–0.29; sucker width ratio 1: 1.59–1.79. Testes double, almost entire, median, tandem or slightly diagonal, contiguous, in third quarter of hindbody; anterior testis 0.19–0.23 by 0.16–0.23; posterior 0.22–0.25 by 0.21–0.23. Cirrus pouch clavate, curved, overlapping ventral sucker posteriorly, 0.26–0.31 by 0.05–0.08. Seminal vesicle internal, bipartite; pars prostatica small, surrounded by poorly-developed prostatic cells; cirrus short. Genital atrium shallow. Genital pore median, located at middle of esophagus. Ovary globular to cordiform, dextro-submedian, pretesticular, 0.08–0.12 by 0.09–0.15. Ootype-complex preovarian. Seminal vesicle retort-shaped, 0.14–0.15 by 0.09–0.10. Laurer's canal running forward, sinistrosubmedian. Uterus occupying all available space of hindbody. Metraterm well developed in forebody.

Eggs numerous, fully embryonated, 70–80 by 40–44  $\mu\text{m}$  (slightly collapsed). Vitellaria follicular, sparse, surrounding intestinal ceca, beginning at level of middle of esophagus, ending short of cecal termination, separated anteriorly, confluent posteriorly. Excretory vesicle I-shaped, extending to posterior margin of posterior testis; excretory pore terminal.

*Discussion.* These specimens are tentatively identified as *U. goro* because they agree better in morphology, measurements, and host species with *U. goro* than *U. acheilognathi* Yamaguti, 1934 both as described by Shimazu (1990) from the intestine of freshwater fishes of several species including *Tridentiger obscurus* (Temminck & Schlegel) from Japan. The prevalence and intensity of infection were rare, and the site of infection was the rectum. Possibly the infected fish (*T. brevispinis*) was an accidental host that had ingested a true final host fish (still unknown in Lake Ogawara, though) harboring worms in the intestine.

#### Family Monorchiiidae

##### *Lasiotocus* sp.

*Host (site of infection).* *Anguilla japonica* (intestine).

*Prevalence and intensity of infection.* One (or 3.7%) of the 27 fish examined was infected with 1 mature worm.

*Specimen.* NSMT-PI 5242.

*Description* (Fig. 6). Based on 1 gravid specimen. Body elongate-oval, 1.85 by 0.51; forebody 0.49 long, occupying 26% of total body length. Tegument spinose. Eyespot pigment not seen. Oral sucker subterminal, bowl-shaped, 0.12 by 0.16. Prepharynx absent. Pharynx globular, 0.08 in diameter. Esophagus 0.11 long, bifurcating about midway between pharynx and ventral sucker; intestinal ceca ending posteriorly short distance from posterior extremity of body. Ventral sucker slightly anterior to border between anterior and middle thirds of body, 0.11 by 0.14; sucker width ratio 1: 0.89. Testis single, globular, median, at about border between middle and pos-

terior thirds of body, 0.23 by 0.24. Sperm duct single. Cirrus pouch clavate, thick-walled, muscular, 0.47 by 0.14. Seminal vesicle internal, elliptical, 0.14 by 0.09. Pars prostatica and prostatic cell poorly developed. Cirrus long, slender, bearing spines internally at about its middle third. Genital atrium wide, probably unspined. Genital pore median, anterior to ventral sucker, possibly opening wide. Ovary nearly cordate, just pretesticular (slightly overlapping it posteriorly), 0.14 by 0.15. Ootype-complex not worked out. Uterus much convoluted in posttesticular space, entering terminal organ laterally at border between two portions; uterine seminal receptacle present. Terminal organ club-shaped, 0.21 by 0.05, divided into an anterior spined tubular and a posterior unspined saccular portion. Uterine eggs numerous, embryonated, 27–32 by 15–17  $\mu\text{m}$ , usually with a small process at anopercular pole. Vitellaria almost follicular, massed dorsally to intestinal ceca between ventral sucker level and testicular level. Excretory vesicle saccular, small, 0.11 by 0.06; excretory pore posterodorsal.

*Discussion.* This specimen appears to morphologically resemble *Lasiotocus chichibu* Iwashita, Hirose & Deguchi, 1995 as described by Iwashita *et al.* (1995) on the basis of the adults found in the intestine of *Tridentiger obscurus* caught in the estuaries of the Tsurumi and Jiju rivers in Kanagawa Prefecture, Japan. However, it differs from the latter in that: the ventral sucker is located closer to the intestinal bifurcation, the ovary and testis are farther apart from the ventral sucker, the cirrus pouch and terminal organ are posterior instead of anterior to the ventral sucker, eggs are larger (27–32 by 15–17  $\mu\text{m}$  instead of 13–17 by 10–12  $\mu\text{m}$ ), and the excretory vesicle is saccular and short instead of tubular and reaching to the testis. A single sperm duct is seen in the specimen, but two sperm ducts are present in *L. chichibu* (Iwashita *et al.*, 1995). The specimen remains unidentified until further specimens are obtained. It is uncertain whether *A. japonica* is a true final or an accidental host for this parasite.

#### Family Gorgoderidae

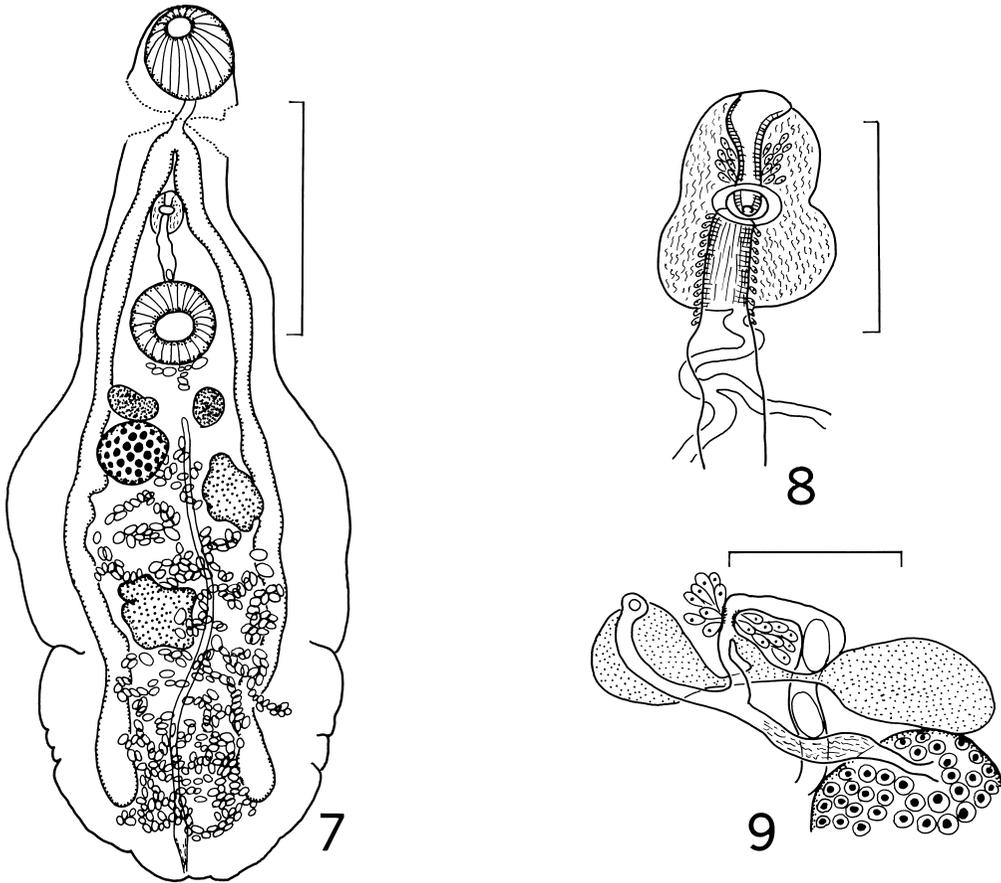
##### *Phyllodistomum anguilae* Long & Wai, 1958

*Hosts (site of infection).* *Anguilla japonica* (urinary bladder).

*Prevalence and intensity of infection.* Two (or 7.4%) of the 27 fish examined were infected with 1 mature worm each.

*Specimens.* NSMT-PI 5247.

*Description* (Figs. 7–9). Based on 2 gravid specimens. Body flattened, translucent, lanceolate-oblong, 2.64–3.21 by 1.13–1.39; forebody 1.04–1.42 long, occupying 39–44% of total body length. Tegument smooth. Oral sucker subterminal, 0.26–0.38 by 0.28–0.39. Pharynx absent. Esophagus thick-walled, 1.26–1.39 long, bifurcating at about border of anterior and middle thirds of forebody; intestinal ceca long, undulating, slightly diverticulate irregularly, ending at near posterior extremity of body. Ventral sucker slightly preequatorial, 0.31–0.36 by 0.35–0.36; sucker width ratio 1: 0.92–1.24. Testes double, weakly indented irregularly, oblique, separated, intercecal, in middle third of hindbody, 0.31–0.38 by 0.25–0.31. Sperm ducts long; common sperm duct short. Cirrus pouch absent. Seminal vesicle pyriform, median, dorsal to metraterm, 0.18–0.22 by 0.12–0.18. Pars prostatica not seen. Ejaculatory duct fairly long, slightly everted, distally surrounded by gland cells, opening into small genital atrium anteriorly to pore of metraterm. Genital pore median, slightly postbifurcal. Ovary globular, dextrosubmedian, intercecal, pretesticular, 0.25–0.28 in diameter. Ootype-complex median, posterior to ventral sucker. Mehlis' gland large. Seminal receptacle absent. Oviduct dilated to include spermatozoa. Laurer's canal running transversely to open dorsally to left vitellarium located opposite to ovary. Uterus much folded in hindbody, inter- and post-cecal; metraterm well developed, anterior to ventral sucker; uterine seminal receptacle not seen. Uterine eggs numerous, fully embryonated, 61–80 by 35–48  $\mu\text{m}$ ; operculum not seen. Vitellaria in form of two compact elliptical masses, submedian, separated, intercecal, 0.14–0.19 by 0.11–0.14.



Figs. 7–9. *Phyllodistomum anguillae*. 7. Entire body, ventral view. 8. Terminal genitalia, ovarian complex, dorsal view. 9. Ovarian complex, dorsal view. Scale bars: 1 mm in Fig. 7; 0.2 mm in Figs. 8 and 9.

Excretory vesicle I-shaped, extending anteriorly to level of vitellaria; excretory pore posteroventral.

*Discussion.* These specimens are identified as *P. anguillae* [sic] Long & Wai, 1958 because they are most closely similar in general morphology to this species as described by Long & Wai (1958) from *A. japonica* and *Siniperca chuatsi* (Basilewsky) (Percichthyidae) from Taihu, Zhejiang, China, though they have a slightly larger body, slightly larger main internal organs, and a less expanded hindbody. If this identification is correct, this is the first published record of the species from Japan.

In Yamaguti's Collection are two immature specimens (MPM Coll. No. 22261) (labeled

*Phyllodistomum*, unpublished) found in the intestine of *A. japonica* from Tsuchiura, Ibaraki Prefecture, on 16 April 1929. They are identified as *P. anguillae* because they are morphologically similar nearly to the present specimens.

Encysted metacercariae (NSMT-PI 5238) morphologically similar to the above-described adults were found in the shrimp *Palaemon paucidens* de Haan (Palaemonidae) from Lake Ogawara on 8 September 1997.

***Phyllodistomum biringo* sp. nov.**

*Hosts (sites of infection).* *Gymnogobius breunigii* (type host) (urinary bladder) and *Silurus asotus* (rectum).

*Type locality.* Lake Ogawara, Kamikita, Aomori Prefecture, Japan.

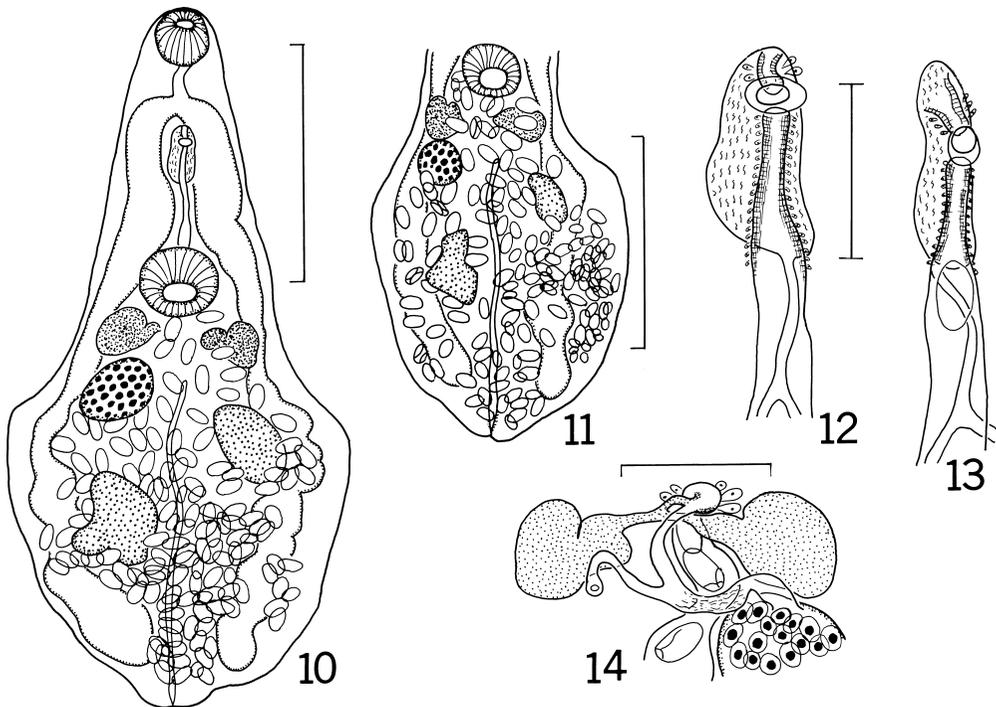
*Prevalence and intensity of infection.* Five (or 7.1%) of the 70 fish (*G. breunigii*) examined were infected with 1 to 4 (mean, 2.4) worms. One (or 1.8%) of the 55 fish (*S. asotus*) examined was infected with 1 worm. A total of 1 immature and 13 mature worms were obtained.

*Specimens.* Holotype and 12 paratypes (NSMT-PI 5239) from *G. breunigii* and a voucher specimen (NSMT-PI 5240) from *S. asotus*.

*Etymology.* The specific name “*biringo*” is derived from the Japanese common name “*biringo*” for *G. breunigii*.

*Description* (Figs. 10–14). Based on 7 gravid specimens. Body flattened, translucent, banjo-shaped, 0.70–1.46 by 0.37–0.59; forebody 0.31–0.56 long, occupying 35–48% of total body length. Tegument smooth. Oral sucker subterminal, 0.08–0.12 by 0.09–0.11. Pharynx absent. Esophagus thick-walled, 0.03–0.07 long, bifur-

cating at about border of anterior and second thirds of forebody; intestinal ceca long, undulating, slightly diverticulate irregularly, ending at near posterior extremity of body. Ventral sucker slightly preequatorial, 0.12–0.14 by 0.11–0.16; sucker width ratio 1: 1.23–1.43. Testes double, irregularly indented, oblique, separated, intercecal, in middle third of hindbody, 0.09–0.17 by 0.09–0.14. Sperm ducts long; common sperm duct short. Cirrus pouch absent. Seminal vesicle pyriform, median, dorsal to metraterm, 0.12–0.25 by 0.05–0.11. Pars prostatica not seen. Ejaculatory duct short, distally surrounded by gland cells, opening into small genital atrium anteriorly to pore of metraterm. Genital pore median, slightly postbifurcal. Ovary globular, dextro- or sinistrosbmedian, intercecal, pretesticular, 0.06–0.15 by 0.09–0.14. Ootype-complex median, posterior to ventral sucker. Mehli’s gland large. Seminal receptacle absent. Oviduct dilated to include spermatozoa. Laurer’s canal opening dorsally to



Figs. 10–14. *Phyllodistomum biringo* sp. nov. 10: Entire body, holotype, ventral view. 11: Hindbody, paratype, ventral view. 12: Terminal genitalia, holotype, ventral view. 13: Terminal genitalia, paratype, ventral view. 14: Ovarian complex, holotype, dorsal view. Scale bars: 0.5 mm in Figs. 10 and 11; 0.1 mm in Figs. 12–14.

vitellarium located opposite to ovary. Uterus much folded in hindbody, intercecal, sometimes extending ventrally to intestinal ceca and into extracecal fields in places; metraterm well developed; uterine seminal vesicle not seen. Uterine eggs numerous, fully embryonated, 56–65 by 30–35  $\mu\text{m}$ ; operculum not seen. Vitellaria in form of two compact elliptical masses, submedian, separated, intercecal, 0.05–0.06 by 0.09–0.11. Excretory vesicle I-shaped, long, extending anteriorly to level of vitellaria; excretory pore posteroventral.

*Discussion.* In general morphology *Phyllodistomum biringo* sp. nov. is similar to *Pseudophyllodistomum macrobrachicola* (Yamaguti, 1934) Cribb, 1987. Yamaguti (1934) described the latter species as *Phyllodistomum macrobrachicola* on the basis of the adult (holotype) recovered 78 days after infection from the urinary bladder of *Mogurnda obscura* (Temminck & Schlegel) (now in *Odontobutis*) (Odontobutidae) to which he had experimentally fed metacercariae found in the shrimp *Macrobrachium nipponense* (de Haan) from Kasumiga-ura, Ibaraki Prefecture, and the Yodo River (locality not specified). I reexamined Yamaguti's (1934) specimen (MPM Coll. No. 22543). This new species is different from *Ps. macrobrachicola* chiefly in having a smaller body (0.70–1.46 mm long by 0.37–0.59 mm wide instead of 1.65 mm long by 0.84 mm wide), a much shorter ejaculatory duct, and smaller eggs (56–65 by 30–35  $\mu\text{m}$  instead of 60–73 by 30–33  $\mu\text{m}$ ).

The occurrence of a single worm in the rectum of one of the 55 fish (*S. asotus*) examined suggests that this fish was an accidental host that had acquired infection with the worm by having ingested the true final host fish (*G. breunigii*) harboring worms in the urinary bladder.

#### Family Cryptogonimidae

##### *Exorchis oviformis* Kobayashi, 1915

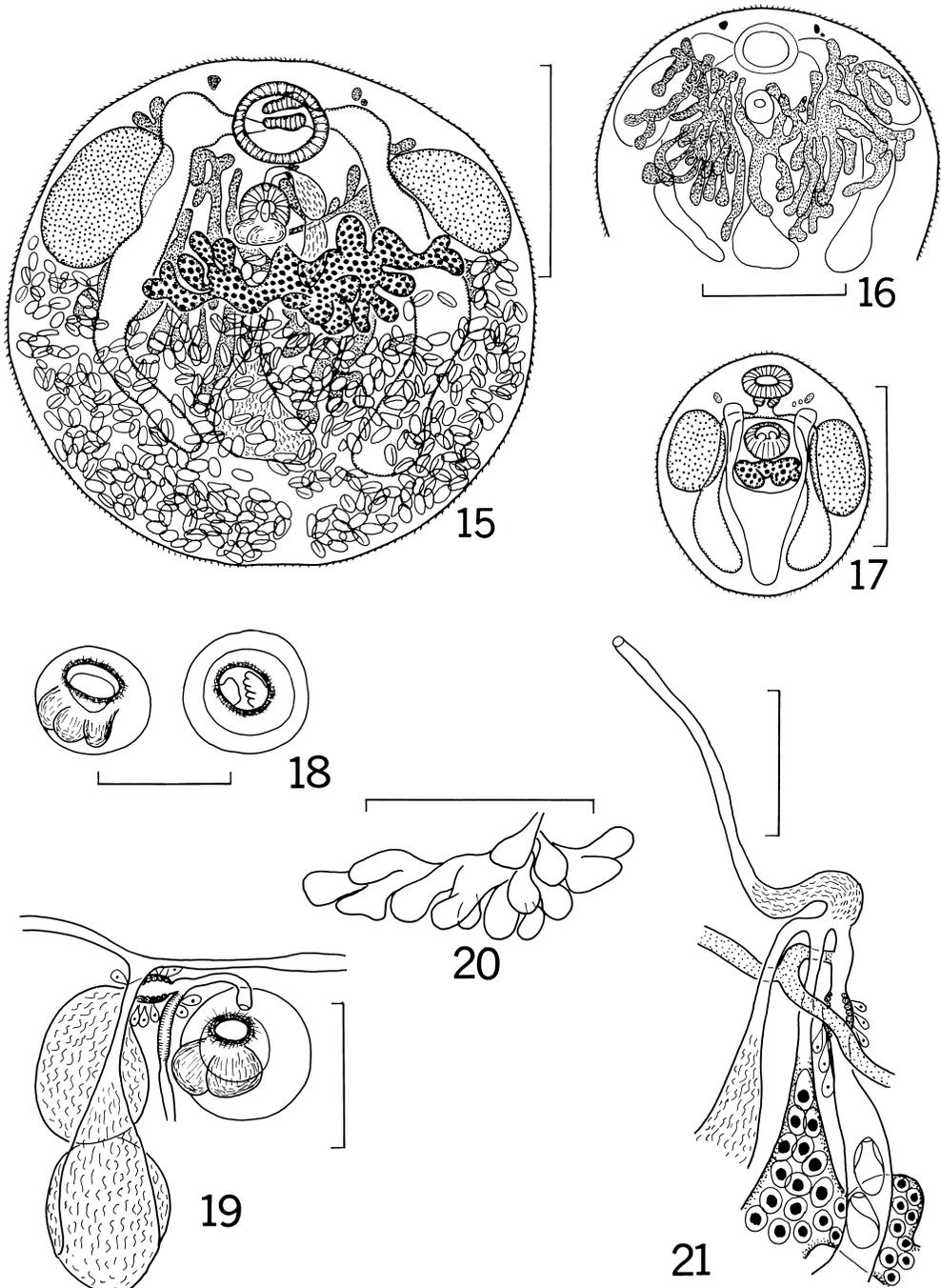
*Host (site of infection).* *Silurus asotus* (intestine).

*Prevalence and intensity of infection.* Every

one (or 100%) of the 55 fish examined was infected with a large number of worms (not counted).

*Specimens.* NSMT-PI 5243.

*Description* (Figs. 15–21). Based on 10 larger gravid specimens. Body oval to round, 0.43–0.70 by 0.33–0.63; forebody 0.11–0.20 long, occupying 21–31% of total body length. Tegument spinose; circumoral spines absent. Eyespot pigment usually solid in dorsal part of forebody. Numerous large gland cells present around oral sucker in anterior half of body, each emptying at periphery of body around oral sucker (not illustrated). Oral sucker subterminal or almost ventral, 0.06–0.10 by 0.07–0.12. Prepharynx very short. Pharynx oval, 0.04–0.06 by 0.03–0.06. Esophagus very short, bifurcating anteriorly to ventral sucker; intestinal ceca ending at near posterior extremity of body. Ventral sucker median, located at border of anterior and middle thirds of body or slightly anterior to it, small, 0.04–0.06 by 0.05–0.07, enclosed in body fold (ventrogenital sac?); sucker width ratio 1: 0.55–0.78. Two or rarely three protrusible muscular structures (gonotyls?) present between posterior wall of ventral sucker and body fold, sometimes protruded anteriorly to seal pore of body fold. Testes double, elliptical, symmetrical, almost extracecal, 0.11–0.20 by 0.06–0.13, anterior to middle of body. Sperm ducts fusing together between oral and ventral suckers to form a common sperm duct; common sperm duct running posteriorly. Seminal vesicle bipartite in ventral view (probably its posterior portion folded double posteriorly), lateral or dorsal to ventral sucker, overlapping ovary posteriorly, 0.08–0.20 by 0.03–0.07. Cirrus pouch absent. Pars prostatica small, surrounded by prostatic cells. Ejaculatory duct short, united with metraterm to form a curved hermaphroditic duct. Genital pore median, opening between body fold and anterior wall of ventral sucker. Ovary irregularly multilobulate, in ventral part of body, posterior to ventral sucker, transversely elongated between posterior halves of testes, sometimes overlapping posterior parts of testes ventrally, 0.06–0.16 by 0.20–0.37.



Figs. 15–21. *Exorchis oviformis*. 15 and 16. Gravid worm, entire body (15), multidigitate vitellaria (16), ventral view. Large gland cells around the oral sucker in the anterior half of the body are omitted because they would obscure important internal organs. 17. Immature worm, ventral view. 18. Body fold, ventral sucker, and muscular structures, ventral view. 19. Terminal genitalia and ventral sucker, ventral view. 20. Multilobulate ovary, ventral view. 21. Ovarian complex, dorsal view. Scale bars: 0.2 mm in Figs. 15 and 20; 0.1 mm in Fig. 17; 0.05 mm in Figs. 18, 19 and 21.

Seminal receptacle retort-shaped, postovarian, 0.09–0.20 by 0.07–0.11, sometimes extending to posterior extremity of body. Ootype small, surrounded by Mehlis' gland, preovarian, usually dorsal to ventral sucker. Laurer's canal long, to right or left side of body, dilated proximally to store spermatozoa in it, opening dorsally at level of oral sucker. Uterus much coiled in postovarian region of body; metraterm short. Eggs numerous, lanceolate-oblong, with a small operculum, 21–28 by 12–14  $\mu\text{m}$ , embryonated when laid; surface markings seen on eggshell. Vitellaria multidigitate, in dorsal part of body, spreading widely between bifurcal level and middle of postovarian region of body and even dorsal to testes, confluent; digits numerous, long, rarely branched. Excretory vesicle rather Y-shaped; arms extending anteriorly to shoulders of intestinal ceca or slightly beyond them; excretory pore usually posterodorsal.

*Discussion.* Kobayashi (1915) described a new genus and species, *Exorchis oviformis*, in Japanese on the basis of the adults found in the intestine of *Parasilurus asotus* (now in *Silurus*) from Tokyo, Lake Biwa in Shiga Prefecture, and various places in Okayama Prefecture (type locality not designated). Kobayashi (1921) later gave an English description for this species, but he removed Lake Biwa from the localities for some reason or other. Takahashi (1929) detailed the structure of the female genital organs in the adults found in the intestine of *P. asotus* in the vicinity of Okayama. Hasegawa (1935) noted the surface markings on the eggshell (locality not indicated). Yamaguti (1938) briefly described the adults found in the intestine of *P. asotus* caught at Okinohata, Fukuoka Prefecture. Okabe (1936) worked out of the life cycle at Katakasu, Fukuoka, Fukuoka Prefecture, but he did not refer to the adult stage. Yamaguti (1942) recorded the adult from *P. asotus* from Yodo [the Yodo River?] (locality not specified).

None of Kobayashi's (1915) original specimens have yet been located anywhere. I reexamined Yamaguti's whole-mounted specimens identified by him as either *E. oviformis* or *Pseudex-*

*orchis major* (Hasegawa, 1935) Yamaguti, 1938: 1 slide (MPM Coll. No. 22298) from Okinohata (24 April 1935; Yamaguti, 1938); 1 slide (MPM Coll. No. 22928) from Yodo (12 December 1939; Yamaguti, 1942); and 4 slides (MPM Coll. Nos. 22295 and 22298) found in *P. asotus* from Kojo, Okayama Prefecture (28 September 1935; Yamaguti, unpublished).

The present specimens show two important morphological features: the shape and size of the ovary; and the shape, size, and distribution area of the vitellaria. The ovary is irregularly multilobulate in the ventral part of the body, transversely elongated between the posterior halves of the testes, and sometimes overlaps the posterior parts of the testes (Figs. 15 and 20). The vitellaria are multidigitate in the dorsal part of the body and spread widely between the bifurcal level and the middle of the postovarian region of the body and even dorsally to the testes (Figs. 15 and 16). My reexamination of Yamaguti's specimens has indicated that they also have these two morphological features though Yamaguti (1938, 1942) did not mention any of them. According to Yamaguti (1938), the size of the ovary is nearly half the size of the testes. This is erroneous. Consequently, the present specimens also are identified as *E. oviformis*.

The ovary is much more lobed (rather lobulated) and much larger than described and illustrated by Kobayashi (1915, pl. 2, fig. 7; 1921, pl. 26, fig. 5) as "lies posterior to the ventral sucker. It is smaller than the testes and has 4–5 lobes" and by Takahashi (1929, pl. 2, fig. 6). The vitellaria are not follicular but multidigitate and much more widely distributed than described and illustrated by Kobayashi (1915, pl. 2, fig. 7; 1921, pl. 26, fig. 5) as "occupy the anterior dorsal part of the body and have a dendritic outline." It does not seem likely, judging from the relative positions between the ovary, testes, and vitelline follicles, that the entire worm illustrated in the figures (1915, pl. 2, fig. 7; 1921, pl. 26, fig. 5) and the sectioned worms illustrated in the figures (1915, pl. 2, figs. 8 and 9) are the same species. The descriptions and illustrations of Kobayashi (1915,

1921) for the ovary and vitellaria are obviously questionable. In addition, Kobayashi (1915, 1921) described and illustrated (1) the seminal vesicle as “very large, .... Slightly distal to the middle part, ...constricted, the constriction dividing the organ to the two unequal parts”; (2) the seminal receptacle as absent; (3) the eggs as 0.04 by 0.02 mm. As pointed out by Yamaguti (1938) and as described above, (1) Kobayashi (1915, 1921) could not distinguish between the seminal vesicle and the seminal receptacle; (2) both a bipartite seminal vesicle and a large retort-shaped seminal receptacle are distinctly differentiated; and (3) the egg size given by Kobayashi is obviously erroneous. The present study convinces that Takahashi (1929) and Hasegawa (1935) correctly described the ovarian complex and the surface markings on the eggshell, respectively. The present and Yamaguti’s specimens had two or rarely three muscular structures (gonotyls?) between the posterior wall of the ventral sucker and the body fold (Figs. 15 and 17–19). They were found protruded anteriorly to seal the pore of the body fold in some of the specimens (Fig. 18). Komiya and Tajimi (1940, 1941) noted three papillary projections just posterior to the ventral sucker in the metacercarial stage of *E. oviformis* in Shanghai, China, suggesting that their function was a sort of sensory organ.

The generic diagnosis of *Exorchis* given by Yamaguti (1971) is evidently based on the above-mentioned erroneous descriptions. Therefore, it should be further amended in part, as follows: numerous large gland cells present around oral sucker in anterior half of body, each emptying at periphery of body around oral sucker; ventral sucker enclosed by body fold; two or three protrusible muscular structures present between dorsal wall of ventral sucker and body fold; ovary irregularly multilobulate, in ventral part of body, posterior to ventral sucker, transversely elongated at level of posterior half of testes, sometimes overlapping posterior parts of testes ventrally; seminal receptacle retort-shaped, postovarian; Laurer’s canal opening dorsally near oral sucker; surface markings present on eggshell; and vitel-

laria multidigitate, distributed widely between bifurcal level and middle of postovarian region in dorsal part of body and even dorsally to testes, confluent.

In China, Komiya & Tajimi (1940, 1941) discovered the first and second intermediate hosts of *E. oviformis* at Shanghai, China. However, they did not refer to the adult stage. Adult specimens found in *P. asotus* from Hubei, China, appear as *E. oviformis* in the book edited by the Institute of Hydrobiology, Hubei Province (1973). They resemble those of *E. oviformis* as described above, especially in the shape and distribution area of the vitellaria; but they have a much larger bi- or tri-partite seminal vesicle and a much smaller ovary. The seminal receptacle is not mentioned. Zhang *et al.* (1993) elucidated the life cycle of a new species, *E. dongtinghuensis*, at Dongtinghu, Hunan, China. The adult stage of this species found in *P. asotus* is closely similar to that of *E. oviformis* as described above except for a smaller ovary. Cao (1990) described a new species, *E. ovariolabularis*, from the adults found in *P. asotus* from Fuzhou, Fujian, China. This species also is similar to *E. oviformis* as described above; but it has a large tripartite seminal vesicle, a much smaller seminal receptacle (a dilatation of Laurer’s canal), and smaller eggs (11–14 by 7–9  $\mu\text{m}$ ). Pan (1984) proposed a new species, *E. multivitellaris*, from the adults found in *P. asotus* from Guangzhou and Zhaoqing, Guangdong, China, separating it from *E. oviformis* [most presumably as described by Kobayashi (1921) and Yamaguti (1938)] chiefly by that the vitellaria consist of much more ribbon-shaped branches spreading in the intertesticular field anterior to the seminal receptacle, that the testes are nearer to the bifurcal level, and that the intestinal ceca extend posteriorly slightly beyond the middle of the body. Besides, eggs are smaller (16–20 by 9–11  $\mu\text{m}$ ), and the ovary is globular and much smaller (pl. 1, fig. 1) or irregular in outline (pl. 1, fig. 3). Pan (1984) also created a new genus and species, *Parametadena macrobursae*, from the adults found in *Pelteobagrus fluvidraco* (Richardson) (Bagridae) from

Guangzhou. This species also is similar to *E. oviformis*. In southern Prymor'e, Russia, Besprozvannykh *et al.* (2000) worked out the life cycle of *E. oviformis*. The adult stage found in *P. asotus* has a small entire ovary and pretesticular vitelline follicles. These Chinese and Russian specimens need reexamination and morphological comparison with the present specimens.

The life cycle of *E. oviformis* has been studied in Japan (Kobayashi, 1915, 1921; Okabe, 1936). Adults of this species also were found in the intestine of *S. asotus* caught in the Ishikari River at Ishikari, Hokkaido, on 28 November 1999 (my unpublished data, NSMT-PI 5244). Shimazu (2003) discussed the geographical distribution of the species in Japan. Lake Ogawara in Aomori Prefecture and the Ishikari River in Hokkaido are new locality records for *E. oviformis*.

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