

Research Article

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# Studies on trematodes and acanthocephalans from freshwater fishes of Hubei Province, central China, with the erection of a new genus *Quadrihexaspiro* gen. n. (Acanthocephala: Neoechinorhynchidae)

František Moravec<sup>1</sup>  and Pin Nie<sup>2</sup> 

<sup>1</sup> Institute of Parasitology, Biology Centre of the Czech Academy of Sciences, České Budějovice, Czech Republic;

<sup>2</sup> State Key Laboratory of Freshwater Ecology and Biotechnology, and Laboratory of Fish Diseases, Institute of Hydrobiology, Chinese Academy of Sciences, Wuhan 430072, Hubei Province, People's Republic of China

**Abstract:** The present paper comprises a systematic survey of trematodes and acanthocephalans based on helminthological examinations of 64 specimens of 14 species of freshwater fishes, belonging to six families of four fish orders, mostly from localities in Hubei Province, central China, collected in the autumn of 2002. A total of 15 trematode species (in 12 families) and 5 acanthocephalan species (in four families) was recorded. Almost all parasites are briefly described and illustrated and problems concerning their morphology, taxonomy, hosts and geographical distribution are discussed. Some findings represent new host and geographical records. New acanthocephalan genus *Quadrihexaspiro* gen. n. (Neoechinorhynchidae) is erected to accommodate two species from China, *Quadrihexaspiro spinibarbi* (Yu et Wang, 1997) comb. n. (type species) and *Quadrihexaspiro parabramis* (Yin et Wu, 1984) comb. n., originally placed in *Hexaspiro* Dollfus et Golvan, 1956; *Hexaspiro* is recognised as a genus belonging to Quadrigyridae. The trematode species *Orientocreadium elegans* Besprozvannykh, Ermolenko et Deveney, 2009 is considered to be possibly identical with *Orientocreadium pseudobagri* Yamaguti, 1934, whereas the morphologically similar acanthocephalan species *Micracanthorhynchina dakusuiensis* (Harada, 1938) and *Micracanthorhynchina brevelemniscus* Lisitsyna, Barčák, Orosová, Fan et Oros, 2023 may prove to be conspecific with *Micracanthorhynchina motomurai* (Harada, 1935). A re-examination of the type specimens of *Neoechinorhynchus afghanus* Moravec et Amin, 1978 (Acanthocephala), a parasite of fishes in Afghanistan, revealed the presence of minute trunk spines in this species and, consequently, it is transferred to the genus *Quadrigyrus* Van Cleave, 1929 (Quadrigyridae) as *Quadrigyrus afghanus* (Moravec et Amin, 1978) comb. n.

**Keywords:** helminth parasites, taxonomy, morphology, zoogeography, Pisces, East Asia

As already mentioned by Moravec et al. (2003a), the extensive territory of China, noted for the varied types of waters and the wealth of fish species, is an interesting area from a zoogeographical point of view where the Palaearctic and Oriental faunas come into contact and many endemic forms occur. Although many papers dealing with helminth parasites of Chinese freshwater fishes have been published (mostly in Chinese), including some important monographs (e.g., Chen 1973, Pan et al. 1990, Wu 1991, Zhang et al. 1999), there are still many gaps in the present knowledge of the parasite fauna of fishes in this country.

Such investigations are not only of theoretical significance but they may have practical implications. In addition to the recognition of the fauna of parasites, the geographical distribution of its individual members and their host-parasite relationships, the results may prove to be important from the medical and veterinary points of view.

In 2001 and 2002, studies on the helminth parasites of fishes in central China were carried out by a Czech-Chine-

se research team within the framework of a joint project between the Institute of Hydrobiology, Chinese Academy of Sciences, and the Institute of Parasitology, Czech Academy of Sciences. Examinations of fishes originating mostly from the Yangtze River drainage system in Hubei Province yielded many helminths, which made it possible to acquire new data on fish helminths for this zoogeographically interesting region. Data based on the material (cestodes, trematodes, nematodes and acanthocephalans) collected in 2001 were published in papers by Moravec and Nie (2002), Moravec and Wang (2002) and Moravec et al. (2003a,b).

Results based on the material collected during September 2002 were published only for nematodes (Moravec et al. 2004a,b), whereas fish trematodes and acanthocephalans (stained specimens mounted as slides) remained unexamined. The results of the recent systematic evaluation of the trematodes and acanthocephalans are presented in this paper as additional data that are intended to complement the original descriptions. Because of the

\*Address for correspondence: František Moravec, Institute of Parasitology, Biology Centre of the Czech Academy of Sciences, Branišovská 31, 370 05 České Budějovice, Czech Republic. E-mail: moravec@paru.cas.cz, ORCID: 0000-0003-1086-1181

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frequent confusion in the literature and often insufficient knowledge of the helminth species in this region, the authors consider it necessary to briefly describe most of the species recorded.

## MATERIALS AND METHODS

The trematodes and acanthocephalans were obtained from the following 14 freshwater fish species, almost all collected from localities in Hubei Province, China. Live fishes were bought in fish markets in Wuhan, where information on their origin was obtained. The following fish species were examined:

Cypriniformes, Cyprinidae: *Carassius carassius* (Linnaeus) – crucian carp (3 specimens, Liangzihu Lake, Jiangxia District, Hubei Province) and *Cyprinus carpio* Linnaeus – common carp (1 specimen, Liangzihu Lake, Jiangxia District); Xenocyprididae: *Chanodichthys erythropterus* (Basilewsky) – predatory carp (17 specimens, Liangzihu Lake, Jiangxia District), *Ctenopharyngodon idella* (Valenciennes) – grass carp (1 specimen, Liangzihu Lake, Jiangxia District), *Hemiculter bleekeri* Warpachowski (1 specimen, Poyanghu Lake, Jiangxi Province), *Hemiculter leucisculus* (Basilewsky) – sharpbelly (1 specimen, Liangzihu Lake, Jiangxia District), *Hypophthalmichthys nobilis* (Richardson) – bighead carp (3 specimens, Liangzihu Lake, Jiangxia District) and *Parabramis pekinensis* (Basilewsky) – white Amur bream (2 specimens, Liangzihu Lake, Jiangxia District).

Siluriformes, Bagridae: *Pelteobagrus eupogon* (Boulenger) (1 specimen, Liangzihu Lake, Jiangxia District), *Tachysurus dumerili* (Bleeker) – Chinese longsnout catfish (2 specimens, Qingjiang and Yangtze Rivers, Hubei Province) and *Tachysurus fulvidraco* (Richardson) – yellow catfish (20 specimens, Liangzihu Lake, Jiangxia District); Siluridae: *Silurus asotus* Linnaeus – Amur catfish (7 specimens, Honghu Lake, Hubei Province).

Synbranchiformes, Synbranchidae: *Monopterus albus* (Zuiew) – Asian swamp eel (5 specimens, Liangzihu Lake, Jiangxia District).

Centrarchiformes, Sinipercaidae: *Siniperca chuatsi* (Basilewsky) – Mandarin fish (1 specimen, Liangzihu Lake, Jiangxia District).

The trematode and acanthocephalan specimens from dissected fishes were fixed in 4% formalin slightly compressed under a coverslip. Later they were stained in carmine, dehydrated through an ethanol series and mounted in Canada balsam as permanent slides. Drawings were made with the aid of a Zeiss drawing attachment. All measurements are given in micrometres unless otherwise stated. The specimens were deposited in the Helminthological Collection of the Institute of Parasitology, Biology Centre of the Academy of Sciences, České Budějovice, Czech Republic (IPCAS).

In addition to the newly collected worms, the following helminth specimens deposited in the Helminthological Collection of the Institute of Parasitology, BC CAS, České Budějovice were studied for comparative purposes: two trematode voucher specimens of *Orientocreadium elegans* Besprozvanynkh, Ermolenko et Deveney, 2009 (IPCAS D-782) and two type male specimens (holotype and paratype) of the acanthocephalan *Neoechinorhynchus afghanus* Moravec et Amin, 1978 (IPCAS A-13). Fish nomenclature follows FishBase (Froese and Pauly 2024).

## RESULTS

### TREMATODA

#### Family Bucephalidae Poche, 1907

##### *Dolfustrema vaneyi* (Tseng, 1930) Eckmann, 1934

Syn.: *Prosorhynchus vaneyi* Tseng, 1930

Description and illustration of this trematode species from China were already provided by Moravec et al. (2003a).

Host: *Siniperca chuatsi* (Basilewsky) (Sinipercaidae, Centrarchiformes), mandarin fish (body length 25 cm).

Site of infection: Intestine (its anterior part).

Prevalence and intensity: 1 fish infected/1 fish examined; 8 trematodes.

Locality: Liangzihu Lake, Jiangxia District, Hubei Province, China (collected 9 September 2002).

Deposition of voucher specimens: IPCAS D-466.

**Comments:** Problems of this species in China have already been discussed in the paper of Moravec et al. (2003a), who recorded *D. vaneyi* from the same host species (*S. chuatsi*) in Bao'an Lake, Hubei Province.

##### *Prosorhynchoides ozakii* (Nagaty, 1937) Margolis et Arthur, 1979

Fig. 1A, B

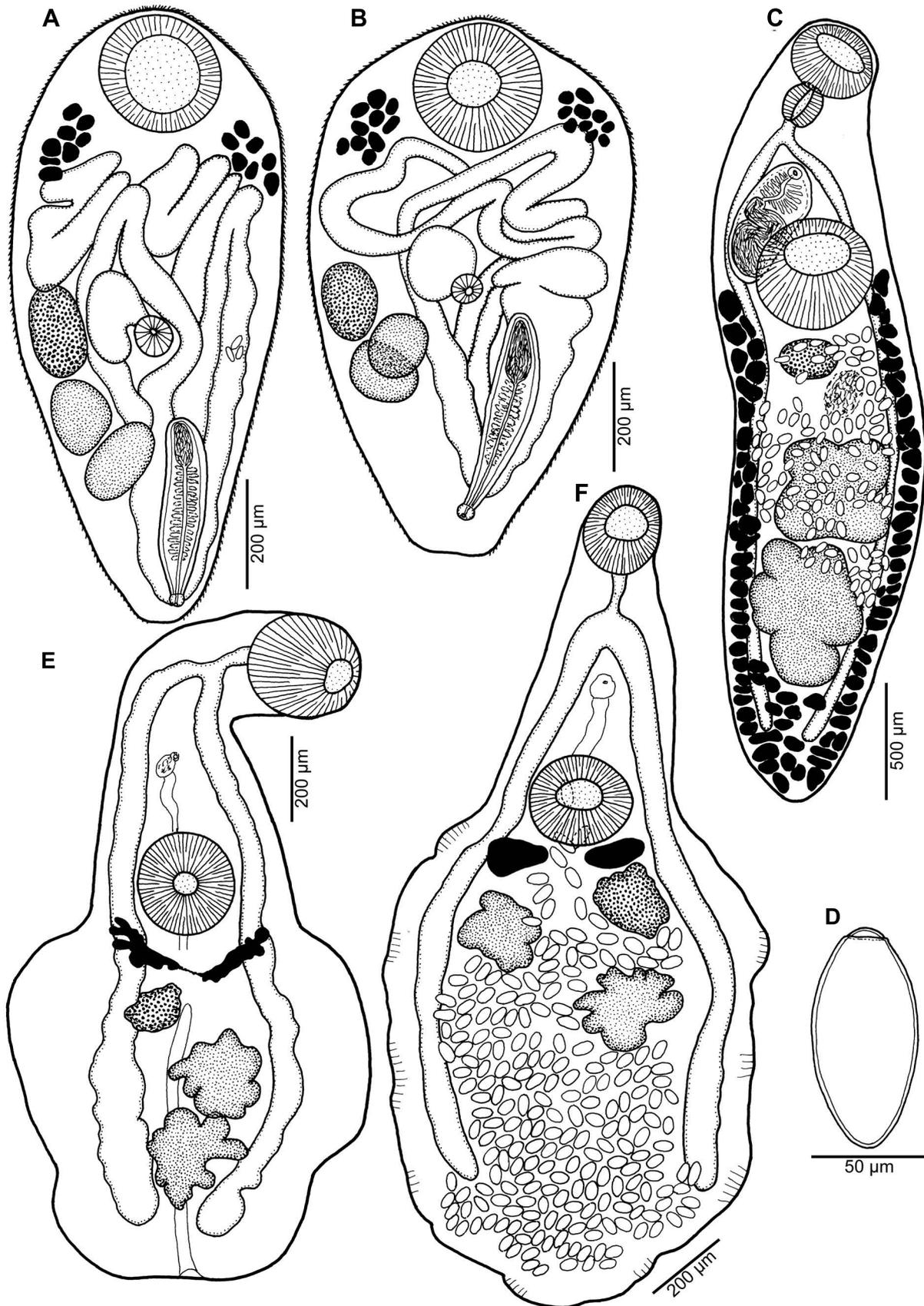
Syn.: *Bucephalopsis ozakii* Nagaty, 1937

**Description** (based on ten ovigerous specimens): Body ovoid, usually distinctly broader in anterior half, 571–1,290 long, maximum width 245–625. Tegumental densely covered with small spines, their density and size decreasing in posterior half of body. Rhynchus subterminal, sucker-like, approximately circular, size 136–272 × 163–258. Pharynx relatively large, size 39–95 × 27–82, median, situated approximately at mid-length of body. Oesophagus very short. Intestine saccular, bent posteriorly, its posterior end slightly exceeding posterior margin of pharynx. Two ovoid or oval testes tandem or diagonal, close to each other or sometimes partly overlapping, located laterally just below ovary in posterior half of body; size of anterior testis 68–190 × 82–163, of posterior testis 82–204 × 68–136. Genital pore almost median, at short distance from posterior extremity. Cirrus sac tubular, 245–476 long and 41–95 wide, containing short seminal vesicle, long straight prostatic part and short ejaculatory duct; cirrus sac longitudinal, somewhat shifted to side of body opposite testes, reaching anteriorly to level of testes. Vitellarium forming two compact lateral groups of follicles near posterior margin of rhynchus, mostly extending anteriorly up to level of posterior half of rhynchus. Uterus long, its loops filling up almost whole space of body from rhynchus up to posterior extremity. Eggs numerous, oval-shaped, size 30–42 × 6–9.

Host: *Silurus asotus* Linnaeus (Siluridae, Siluriformes), Amur catfish (body length 29 cm).

Site of infection: Intestine (its middle part).

Locality: Honghu Lake, Hubei Province, China (collected 18 September 2002).



**Fig. 1.** A, B – *Prosorhynchoides ozakii* (Nagaty, 1937) from *Silurus asotus*, two specimens with different location of testes; C, D – *Eucreadium aristichthydis* Wang in Chen, 1973 from *Hypophthalmichthys nobilis*, gravid specimen and egg, respectively; E – *Phyllodistomum pawlovskii* (Zmееv, 1936) from *Tachysurus fulvidraco*, nongravid specimen; F – *Phyllodistomum anguillae* Long et Wai, 1958 from *Siniperca chuatsi*.

Prevalence and intensity: 1 fish infected/7 fish examined; 36 trematodes.

Deposition of voucher specimens: IPCAS D-210.

**Comments:** The species name of this trematode was proposed by Nagaty (1937) for *Bucephalopsis ovata* (as *ovatus*) Ozaki, 1928, a species described from the intestine of *Silurus asotus* in Korea, which proved to be a junior homonym. A very detailed redescription of *P. ozakii*, based on two specimens from the original Ozaki's material from *S. asotus* in Korea and those from *Silurus biwaensis* (Tomoda) in Japan, was provided by Shimazu (2014b).

The morphology of the present specimens is in agreement with the redescription of *P. ozakii* by Shimazu (2014b). Although they are somewhat smaller, which can be considered to be within intraspecific variability, they undoubtedly belong to this species. Smaller body measurements, similar to those of our trematodes, were, for example, reported for *P. ozakii* from the catfish *Pseudobagrus vachellii* (Richardson) in North Vietnam (Moravec and Sey 1989).

*Prosohynchoides ozakii* has been reported from the intestine of catfishes *Silurus asotus* (type host) in Korea, *S. asotus*, *S. biwaensis* and *S. lithophilus* (Tomoda) in Japan, *S. asotus* and *Pseudobagrus vachellii* in China, and *P. vachellii* and *Pangasianodon hypophthalmus* (Sauvage) in Vietnam (e.g., Moravec and Sey 1989, Wang and Wang 1998, Thuy and Buchmann 2008, Shimazu 2014b); an occasional finding of a single specimen of this trematode from *Saurogobio dabryi* Bleeker (Gobiidae) (erroneously reported as *Saurogobius dobryi*) in North Vietnam was recorded by Moravec and Sey (1989).

Thuy and Buchmann (2008) reported high *P. ozakii* infections in pond-cultured pangasiid catfish *P. hypophthalmus* in the Mekong Delta, Vietnam. They observed a clear trend for increasing worm loads in larger fish. This trend is also apparent from our findings in *S. asotus*, where a relatively high intensity of infection (37 specimens) was recorded in the largest fish examined (total body length 29 cm), whereas six smaller fish specimens (total body length 18–21 cm) were not infected by this parasite.

This phenomenon is evidently associated with the mode of acquiring the infection by the definitive host, because the source of *P. ozakii* infection is the parasite's metacercariae encysted in the body muscles of various fishes serving as the second intermediate hosts (Shimazu 2014b). Accordingly, only larger fish specimens are capable of preying on other fishes and thus to become infected.

## Family Opecoeliidae Ozaki, 1925

### *Eucreadium aristichthydis* Wang in Chen, 1973

Fig. 1C, D

**Description** (based on ten ovigerous specimens): Body elongate-oval, somewhat tapered posteriorly, 2.49–3.90 mm long, maximum width 748–1,006; body width/length ratio 1:3.05–3.42. Tegument smooth. Oral sucker subterminal, size 313–367 × 326–435; ventral sucker oval, larger

than oral sucker, 449–571 × 476–571, located in anterior half of body; size ratio of suckers 1 : 1.45–1.46.

Prepharynx indistinct. Pharynx spherical to oval, muscular, 136–190 long and 136–204 wide. Oesophagus short, 41–68 long. Caeca blind, narrow, extending nearly to body end.

Testes large, tandem, distinctly separated from posterior end of body, deeply lobed in larger specimens and almost unlobed in smallest specimens, located in posterior half of body; size of anterior testis 381–639 × 408–503, of posterior testis 408–734 × 390–530. Genital pore median, located between intestinal bifurcation and ventral sucker. Cirrus sac large, elongate-oval, 340–693 long and 218–276 wide, situated just anterior to ventral sucker, containing large twisted seminal vesicle, pars prostatica and ejaculatory duct. Ovary entire to slightly lobed, 163–231 × 218–299, located posterior to ventral sucker. Large oval seminal receptacle present between ovary and anterior testis. Vitelline follicles extracaecal in region between posterior half of ventral sucker and posterior testis, filling up entire space between posterior margin of posterior testis and body end. Uterus restricted to area between anterior half of posterior testis and genital pore. Eggs oval, 90–105 long and 51–57 wide, with distinct opercule at one pole. Excretory vesicle tubular.

Host: *Hypophthalmichthys nobilis* (Richardson) (Xenocyprididae, Cypriniformes) bighead carp (body length 43–45 cm).

Site of infection: Intestine.

Locality: Liangzi Lake, Jiangxia District, Hubei Province, China (collected 9 September 2002).

Prevalence and intensity: 2 fish infected/3 fish examined; 11 and 1 trematodes.

Deposition of voucher specimens: IPCAS D-888.

**Comments:** The authority of *Eucreadium aristichthydis* was reported to be Wang, 1964 in the publication of Chen (1973), but the first descriptions and illustrations of this species were published only in the book of Chen (1973) (see Pulis 2014). The morphology and measurements of the present specimens are more or less in agreement with the descriptions of *E. aristichthydis* provided by Chen (1973) and Zhang et al. (1999) and, accordingly, they are assigned to this species. At present, *Eucreadium* Dayal, 1942 includes 11 nominal species, mostly parasites of freshwater fishes in India (Marine Species Traits Editorial Board 2024). From the type species *Eucreadium eutropiichthyus* Dayal, 1942 (syn. *E. eucreadium* Dayal, 1950) (see Yamaguti 1971) parasitising catfishes in India, *E. aristichthydis* is easily distinguished by the extent of vitelline follicles and by the shape and size of eggs.

*Eucreadium aristichthydis* is the only species of the genus in China, previously reported from *H. nobilis* in Provinces Hubei, Hunan, Jiangsu and Zhejiang (Chen 1973, Wu 1991, Zhang et al. 1999). It is also reported from *Zacco platypus* (Temminck et Schlegel) (Xenocyprididae) in Zhejiang Province (Wu 1991).

## Family Gorgoderidae Looss, 1899

### *Phyllodistomum anguillae* Long et Wai, 1958 Fig. 1F

**Description** (based on one ovigerous specimen): Body flattened, spatulate, with lateral undulations on hindbody; forebody tapered anteriorly. Tegument smooth. Total body length 2.05 mm, length of its anterior narrowed part 816, of posterior foliate part 1.24 mm; maximum width of anterior part (at its base) 476, that of posterior part 966. Oral sucker subterminal, size  $204 \times 177$ . Ventral sucker transverse oval, somewhat larger than oral sucker ( $245 \times 272$ ), situated at base of narrowed anterior part of body, at 762 from anterior extremity (37% of body length). Size ratio of oral and ventral sucker 1 : 1.36. Oesophagus 82 long. Caecal bifurcation distinctly nearer to oral sucker than to ventral sucker. Caeca not extending posteriorly to body end. Testes lobular, postequatorial, somewhat diagonal; size of anterior testis  $204 \times 177$ , of posterior testis  $218 \times 286$ . Genital pore median, closer to caecal bifurcation than to ventral sucker. Seminal vesicle small,  $51 \times 54$ . Ovary submedian, slightly lobular, size  $204 \times 204$ , anterior to anterior testis on opposite side. Vitellarium in two compact, entire masses (size 109–150 and 95–163), situated just posterior to ventral sucker. Uterus intercaecal, extending posteriorly nearly to body end. Eggs large, embryonated, size 63–72  $\times$  36–42. Excretory vesicle indistinct.

Host: *Siniperca chuatsi* (Basilewsky) (Siniperidae, Centrarchiformes), Mandarin fish (body length 25 cm).

Site of infection: Intestine.

Locality: Liangzihu Lake, Hubei Province, China (collected 9 September 2002).

Prevalence and intensity: 1 fish infected/1 fish examined; 1 trematode.

Deposition of voucher specimen: IPCAS D-889.

**Comments:** The morphology and measurements of the only available specimen correspond to those of *P. anguillae*, a species originally described from the urinary bladder of *Anguilla japonica* Temminck et Schlegel (Anguillidae) and *S. chuatsi* in Lake Thai Hu near Shanghai (Long and Wai 1958) and redescribed in detail by Shimazu (2005, 2007) from the former host species in Japan. Therefore, the present specimen was assigned to this species.

Long and Wai (1958) described another congeneric species, *P. sinipercae* Long et Wai, 1958, from *S. chuatsi* of the same locality (Lake Thai Hu) as *P. anguillae*, later being also reported from the same host species in Hubei Province (Chen 1973). However, in contrast to *P. anguillae*, *P. sinipercae* has a body surface covered by minute spines, the oral sucker is larger than the ventral sucker and the eggs are distinctly smaller (at most 40  $\mu$ m long) (see Chen 1973).

The general morphology of *P. anguillae* also somewhat resembles that of *Pseudophyllodistomum mingense* (Tang, 1985) Cribb, 1987 reported from the urinary bladder of *Lateolabrax japonicus* (Cuvier) (Lateolabracidae) in freshwaters of China (Tang 1985, Wang 1985). *Phyllodistomum anguillae* is reported here from Hubei Province for the first time.

The site of infection (intestine) of the present specimen of *P. anguillae* in the fish host is unusual, but it cannot be excluded that the worm got there secondarily from the urinary system during the fish dissection.

### *Phyllodistomum pawlovskii* (Zmееv, 1936) Pigulevskiy, 1953 Fig. 1E

Syn.: *Vitellarinus pawlovskii* Zmееv, 1936

**Description** (based on 1 nongravid specimen): Body pear-shaped, forebody tapered anteriorly, hindbody almost circular, with smooth surface. Total body length 1.99 mm, length of its narrowed anterior part 1.09 mm, of posterior foliate part 898; maximum width of anterior part (at its base) 544, that of posterior part 938. Oral sucker subterminal, size  $299 \times 258$ . Ventral sucker circular, slightly smaller than oral sucker ( $258 \times 245$ ), situated at base of narrowed anterior part of body, at 979 from anterior extremity (47% of body length). Size ratio of oral and ventral sucker 1 : 0.90. Oesophagus 82 long. Caecal bifurcation distinctly nearer to oral sucker than to ventral sucker. Caeca not extending posteriorly to body end. Testes lobular, somewhat diagonal; size of anterior testis  $204 \times 245$ , of posterior testis  $245 \times 204$ . Genital pore in mid-way between caecal bifurcation and ventral sucker. Seminal vesicle small,  $68 \times 54$ . Ovary lobular, size  $136 \times 150$ , anterior to anterior testis on opposite side. Vitellarium in 2 compact masses, branched (about five branches in each mass), situated just posterior to ventral sucker. Uterus empty. Excretory vesicle tubular, long, extending anteriorly to level of ovary.

Host: *Tachysurus fulvidraco* (Richardson) (Bagridae, Siluriformes), yellow catfish (body length 17 cm).

Site of infection: Urinary bladder.

Locality: Liangzi Lake, Jiangxia District, Hubei Province, China (collected 18 September 2002).

Prevalence and intensity: 5% (1 fish infected/20 fish examined); 3 trematodes.

Deposition of voucher specimens: IPCAS D-463.

**Comments:** The three available nongravid specimens (one complete and two damaged) were identified as *P. pawlovskii* mainly based on the presence of branched vitelline masses, ovary and testes, the size ratio of suckers and the host species (*T. fulvidraco*). In contrast to the fully gravid trematodes, as redescribed by Moravec and Nie (2002), these nongravid specimens are much smaller (about 2 mm vs 4.76–6.60 mm long), their ventral sucker is located at the base of the narrowed anterior part of body (vs somewhat more posteriorly) and the posterior testis is closer to the posterior end of the body.

This species, originally described by Zmееv (1936) from the urinary bladder of bagrid catfishes in the lower reaches of the Amur River, Russian Far East, was first reported in China from the yellow catfish *T. fulvidraco* of Lake Thai Hu near Shanghai by Long and Wai (1958). Later, Moravec and Nie (2002) and Moravec et al. (2003a) recorded *P. pawlovskii* from the same host species (*T. fulvidraco*) in Bao'an Lake (Yangtze River basin), Hubei Province, central China; the former authors mention that the speci-



mens of *Phyllostomum* sp. previously reported from *T. fulvidraco* of the same lake by Wu et al. (1991) apparently belonged to *P. pawlovskii*. Li et al. (2005) reported *P. pawlovskii* from the same host species in Liangzi Lake, Hubei Province where the present specimens were collected.

#### Family Cladorchiidae Fiscoeder, 1901

##### *Amurotrema dombrowskajae* Akhmerov, 1959 Fig. 2A

**Description** (based on five ovigerous specimens): Body elongate, subcylindrical, attenuated anteriorly; body length 3.91–5.33 mm, maximum width 0.72–1.32 mm. Oral sucker absent. Ventral sucker ventroterminal, size 653–816 × 707–979. Pharynx pear-shaped, size 462–558 × 367–476, with 2 prominent pharyngeal sacs (external diverticula) shorter than pharynx, 163–204 × 136–150. Oesophagus 150–163 long. Oesophageal bulb present, 95–163 long, 68–95 wide. Caeca short, terminating at level of ovary. Testes oval, intercaecal, diagonal, in middle third of body; size of anterior testis 422–612 × 340–476, of posterior testis 408–653 × 313–476. Cirrus sac oval, 109–136 × 82–95, containing coiled ejaculatory duct. Genital pore median, closer to pharyngeal sacs than to intestinal bifurcation. Ovary round to oval, size 136–340 × 272–275, median or submedian, located between caecal ends. Vitelline follicles in extracaecal lateral fields from level of posterior testis to that of ovary. Uterus forms descending coils to level of ventral sucker, then ascends to form coils anteriorly to bifurcation. Eggs large, oval, size 51–163 × 33–95; larger eggs containing miracidia. Excretory vesicle not observed.

Host: *Ctenopharyngodon idella* (Valenciennes) (Xenocyprididae, Cypriniformes), grass carp (body length 56 cm).

Site of infection: Intestine (mainly its middle).

Locality: Liangzihu Lake, Hubei Province, China (collected 9 September 2002).

Prevalence and intensity: 1 fish infected/1 fish examined; 60 trematodes.

Deposition of voucher specimens: IPCAS D-890.

**Comments:** This species was originally described from the grass carp *C. idella* from the Amur River in the Russian Far East and later it was recorded in this host species also in China and North Vietnam (e.g., Chen 1973, Zhang et al. 1999, Sey 2001). It was introduced into water bodies of Kazakhstan, the Volga River Delta in Russia and Central Europe (Hungary) (Sey 2001, Sokolov et al. 2016). In addition to its type host (*C. idella*), *A. dombrowskajae* was occasionally recorded also from the silver carp *Hypophthalmichthys molitrix* (Valenciennes).

From Vietnam, it was also recorded from the cypriid *Spinibarbus denticulatus* (Oshima) (Ky 1969, Sey 1985, Moravec and Sey 1989), although another congeneric species, *Amurotrema spinibarbi* Zhang et al. 1985 was reported from this host species in China (Zhang et al. 1999). Molecular data on *A. dombrowskajae* based on specimens from the type host in the Volga River Delta were provided by Sokolov et al. (2016).

#### Family Haploporidae Nicoll, 1914

##### *Carassotrema megapharyngus* Wang in Chen, 1973

Fig. 2B, C

**Description** (based on ten ovigerous specimens): Body elongate-oval, cuticle covered by minute spines, sometimes indistinct on posterior part of body. Length of body 0.88–1.97 mm, maximum width 476–911. Oral sucker subterminal, almost circular, size 122–245 × 150–250. Ventral sucker 150–272 × 163–272, situated in anterior half of body. Size ratio of oral and ventral sucker 1 : 1.02–1.17. Prepharynx indistinct. Pharynx muscular, large, size 136–218 × 150–218. Size ratio of oral sucker and pharynx 1 : 0.76–1.05. Oesophagus 82–190 long. Intestinal bifurcation at level of ventral sucker. Caeca extending posteriorly to level of posterior end of testis. Testis single, usually with depression on its expanded anterior end, 313–571 long and 245–435 wide, situated in posterior half of body. Hermaphroditic sac large, oval-shaped, 204–340 long and 109–218 wide; length of external seminal vesicle 95–204. Genital pore just posterior to pharynx. Ovary small, almost circular to transversely oval, 95–190 × 109–204, located medially just anterior to testis. Vitelline follicles rather tubular, in lateral fields, extending from level of ventral sucker to end of body. Uterus anterior to ovary. Eggs oval, measuring 60–69 × 30–33. Excretory vesicle not observed, excretory pore terminal.

Host: *Parabramis pekinensis* (Basilewsky) (Xenocyprididae, Cypriniformes), white Amur bream (body length 24–28 cm).

Site of infection: Intestine (middle and posterior parts).

Locality: Liangzihu Lake, Jiangxia District, Hubei Province, China (collected 9 September 2002).

Prevalence and intensity: 2 fish infected/2 fish examined; 3 and 32 trematodes.

Deposition of voucher specimens: IPCAS D-892.

**Comments:** According to the revisional paper of Pulis (2014), eight species of *Carassotrema* Park, 1938 parasitising freshwater fishes in China can be accepted: *C. ginecinskajae* Kulakova et Ky, 1976, *C. heterorchis* Wang et Pan, 1984, *C. koreanum* Park, 1938, *C. kui* Tang et Lin, 1979, *C. lamellorchis* Wang, 1973, *C. megapharyngus* Wang, 1973, *C. pterorchis* Wang, 1973 and *C. schistorchis* Wang et Pan, 1984. Two of them, *C. heterorchis* and *C. megapharyngus* (including the tentative synonym *C. ginecinskajae*) were transferred by Overstreet and Curran (2005) to the newly erected genus *Platydidymus* Overstreet et Curran, 2005, but later Pulis (2014) returned them back to *Carassotrema*. The authorities of *C. lamellorchis*, *C. megapharyngus* and *C. pterorchis* were reported to be Wang, 1964 in the publication of Chen (1973), but the first descriptions and illustrations of these species were published only in the book of Chen (1973) (see Pulis 2014). Consequently, the correct authorities of the three species in question are Wang in Chen, 1973.

As mentioned by Moravec and Sey (1989), the morphological features used in the taxonomy of *Carassotre-*

*ma* spp. apparently subject to a considerable interspecific variability, which complicates the species identification of these trematodes and makes the validity of some of them questionable. This concerns namely the species of *Carassotrema* reported from freshwater fishes in China. Despite the useful attempt of Pulis (2014) to revise *Carassotrema* spp. and his characterisation of individual species, it is unclear whether all of the morphological features used to separate species are actually interspecific or representing only intraspecific variability. Therefore, further detailed studies based on extensive, newly collected materials are necessary.

It is also remarkable that almost all *Carassotrema* spp. from freshwater fishes in China are reported mainly from very many cypriniform host species (Pulis 2014). On the contrary, usually the same host species is reported to harbour different species of *Carassotrema*. For example, the white Amur bream *P. pekinensis* is reported to host *C. koreanum*, *C. lamellorchis*, *C. megapharyngus*, *C. pterorchis* and *C. schistorchis* (see Pulis 2014). This indicates that there is either low host specificity in species of *Carassotrema* or the congeneric trematodes were frequently misidentified.

All the present specimens possess a large pharynx of a size similar to that of the oral sucker. According to Pulis (2014), there are only two species, *C. ginecinskajae* and *C. megapharyngus*, among the *Carassotrema* spp. parasitising freshwater fishes in China, that possess this feature. Overstreet and Curran (2005) considered the former species to be a possible synonym of the latter, but Pulis (2014) took *C. ginecinskajae* for a valid species characterised by the presence of a distinct prepharynx and the pharynx occupying the entire length between both suckers. Since our specimens from *P. pekinensis* have no prepharynx and their pharynx is far from the ventral sucker, we identify them as *C. megapharyngus*. The testis is considerably larger than that illustrated for this species in Chen (1973), but this is considered intraspecific variability. Previously *C. megapharyngus* was reported from the same host species (*P. pekinensis*) several times in China (Pulis 2014) as our trematodes.

Moravec and Sey (1989) identified *Carassotrema* specimens from three host species in North Vietnam as *C. koreanum*, the type species of the genus, considering *C. ginecinskajae* its synonym. Shimazu (2013), when redescribing *C. koreanum* from specimens in Japan, remarked that those reported by Moravec and Sey (1989) from Vietnam were slightly different in the egg size from his and Park's (1938) materials. According to Pulis (2014), the Vietnamese specimens from *Hemiculter leucisculus* (Basilewsky) belonged in fact to the resurrected *C. ginecinskajae*. However, the absence of a prepharynx, a rather long distance between the pharynx and the ventral sucker, and the extracaecal vitelline follicles show that these trematodes should be considered *C. megapharyngus*, the species reported from the same host (*H. leucisculus*) in China (see below).

*Carassotrema megapharyngus* was characterised by Pulis (2014) to have a pharynx larger than the oral sucker. However, in most specimens of the present material

the pharynx was slightly smaller, the size ratio of the oral sucker and pharynx being 1 : 0.76–1.05. The same ratio in *C. koreanum* is 1 : 0.69–0.86 (calculated from the illustrations of Park 1938 and Shimazu 2013).

According to Pulis (2014), *C. megapharyngus* is known only from China (Provinces Guangdong, Hubei, Fujian, Jiangsu, Jiangxi and Zhejiang), where it was reported mainly from Cypriniformes: *Acheilognathus taenianalis* (Günther) (Acheilognathidae), *Carassius auratus* (Linnaeus) (Cyprinidae), *Hemibarbus maculatus* Bleeker (Gobiionidae), *Ctenopharyngodon idella* (Valenciennes), *Hemiculter leucisculus* (Basilewsky), *Hypophthalmichthys molitrix* (Valenciennes), *Megalobrama amblycephala* Yih, *M. terminalis* (Richardson) and *P. pekinensis* (all Xenocyprididae), and also from *Crenimugil crenilabis* (Forskål) (Mugilidae, Mugiliformes). This trematode (*C. megapharyngus*) also occurs in Vietnam (see above).

#### ***Carassotrema pterorchis* Wang in Chen, 1973** Fig. 2D, E

**Description** (based on five ovigerous specimens): Body elongate-oval, tegumental covered by minute spines, sometimes indistinct on posterior part of body. Length of body 1.09–1.92 mm, maximum width 408–612. Oral sucker subterminal, almost circular, size 136–190 × 163–218. Ventral sucker 136–313 × 150–218, situated in anterior half of body. Size ratio of oral and ventral sucker 1 : 0.88–1.19. Prepharynx distinct, 41–95 long. Pharynx muscular, large, size 136–177 × 109–136. Size ratio of oral sucker and pharynx 1 : 0.72–0.83. Oesophagus 68–109 long. Intestinal bifurcation at level of ventral sucker. Caeca extending posteriorly to level of posterior end of testis. Testis single, with distinct depression on its anterior end, 367–653 long and 204–408 wide, situated in posterior half of body. Hermaphroditic sac large, oval-shaped, 163–381 long and 109–245 wide; length of external seminal vesicle 136–272. Genital pore just posterior to pharynx. Ovary small, almost circular to transversely oval, 82–109 × 95–163, located medially just anterior to testis. Vitelline follicles rather tubular, in lateral fields, extending from level of ventral sucker to end of body. Uterus anterior to ovary. Eggs oval, measuring 63–75 × 30–45. Excretory vesicle not observed, excretory pore terminal.

Host: *Ctenopharyngodon idella* (Valenciennes) (Xenocyprididae, Cypriniformes), grass carp (body length 56 cm).

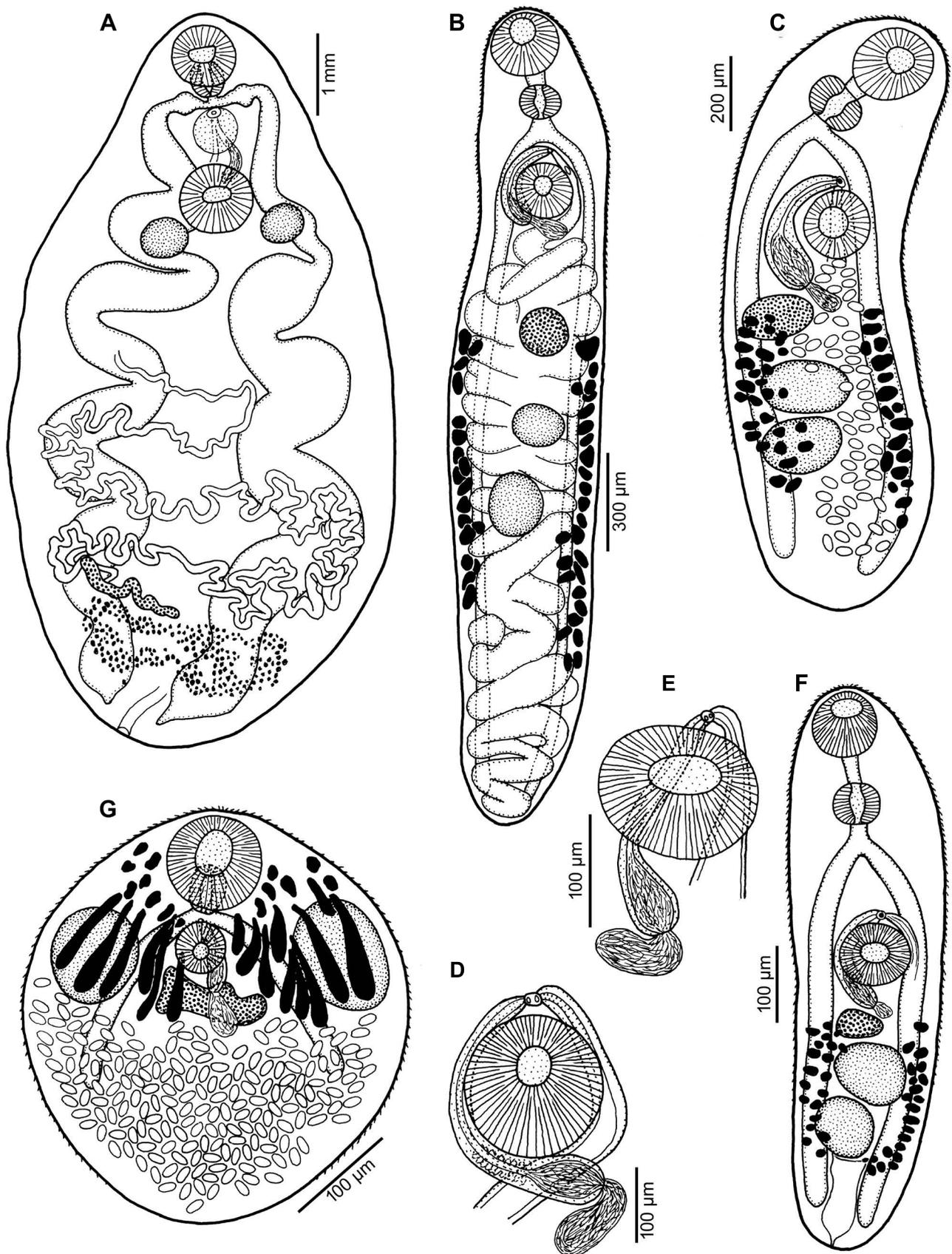
Site of infection: Intestine (mainly its posterior part).

Locality: Liangzihu Lake, Jiangxia District, Hubei Province, China (collected 9 September 2002).

Prevalence and intensity: 1 fish infected/1 fish examined; 29 trematodes.

Deposition of voucher specimens: IPCAS D-893.

**Comments:** The available specimens from *Ct. idella* are morphologically and biometrically rather similar to those of *Ca. megapharyngus* from *P. pekinensis* (see above) and the size of their pharynx in relation to the size of the oral sucker also somewhat resembles that of the latter species (oral sucker/pharynx size ratio being 1 : 0.72–0.83 vs 1 : 0.76–1.05). However, both these forms differ markedly from each other by the presence/absence of the prepharynx, this be-



**Fig. 3.** A – *Isoparorchis hypselobagri* (Billet, 1898) from *Silurus asotus*, gravid specimen; B–F – *Orientocreadium pseudobagri* Yamaguti, 1934 from *Tachysurus fulvidraco* (B – large gravid specimen; C – small gravid specimen; D – cirrus sac in lateral position to ventral sucker; E – cirrus sac in median position to ventral sucker; F – nongravid specimen); G – *Exorchis oviformis* Kobayashi, 1915 from *Silurus asotus*.

ing rather long in specimens from *Ct. idella* and indistinct in those from *P. pekinensis*. Therefore, mainly based on the relatively large pharynx as compared with the size of suckers and some other features (see Chen 1973, Pulis 2014), we identify the present specimens as *C. pterorchis*.

In contrast to the shape of the testis in our specimens, the testis of the specimen of this species illustrated in Chen (1973) is markedly Y-shaped. However, the latter specimen was evidently more advanced, containing many eggs, whereas the gravid specimens at our disposal (the material also contained nongravid specimens) were less developed, containing just a few eggs. Vitelline follicles extended anteriorly to the level of the ovary only in the largest specimens of the present material (Fig. 2E), as also illustrated for this species in Chen (1973), but to the level of the ventral sucker in smaller specimens (Fig. 2D). This indicates that both the shape of the testis and the extent of vitelline follicles may be age-dependent in this species.

In China, *Ct. idella* has been reported by different authors as the definitive host of seven species of *Carassotrema* (*C. koreanum*, *C. heterorchis*, *C. kui*, *C. lamellorchis*, *C. megapharyngus*, *C. pterorchis* and *C. schistorchis*) (for overview see Pulis 2014). This indicates, similarly as in the case of the Amur bream *P. pekinensis* harbouring allegedly five species of *Carassotrema* (see above), that there is either broad host specificity in species of *Carassotrema* or, more probably, the congeneric trematodes were frequently misidentified due to high intraspecific variability of these trematodes.

According to Pulis (2014), *C. pterorchis* is known only from China (Guandong, Hubei, Jiangsu, Jiangxi and Zhejiang), where it is reported from ten species of cypriniforms (Cyprinidae and Xenocyprididae) and from the yellow catfish *T. fulvidraco* (Bagridae, Siluriformes).

## Family Isoparorchidae Travassos, 1922

### *Isoparorchis hypselobagri* (Billet, 1898) Ejsmont, 1932

Fig. 3A

**Description** (based on five ovigerous specimens from *S. asotus*): Body large, stout, elongate-oval, dorsoventrally flattened, 10.12–12.62 mm long, maximum width 3.97–5.21 mm. Body surface smooth. Oral sucker subterminal, 721–816 × 707–870. Ventral sucker somewhat larger than oral sucker, situated in anterior half of body, size 830–1,034 × 925–1,047; size ratio of suckers 1 : 1.15–1.29. Pharynx well developed, muscular, size 422–503 × 435–449. Oesophagus very short or indistinct, 0–109 long. Intestinal caeca first running laterally and then suddenly curved posteriorly, then pass sinuously to end blindly near posterior extremity; anterior end of each caecum extended into “glandular stomach”. Testes two, symmetrical, intracaecal, almost circular, at level of posterior half of ventral sucker; size of right testis 544–612 × 612–830, of left testis 598–721 × 612–680. Deflectable genital atrium large, 666–680 × 612–680, median, situated between caecal bifurcation and ventral sucker. Seminal vesicle tubular, 544–816 long, winds in forebody; extruded part of genital atrium in 1 specimen 952

long and 653 wide. Hermaphroditic duct opens into genital atrium through stout sinus-organ. Genital pore median, below caecal bifurcation. Ovary tubular, 177–204 × 1,224–1,442, in posterior part of body, just anterior to vitelline follicles. Vitellarium postovarian, tubular, with dendritic branches arising from collecting ducts and ending in numerous follicles. Uterus preovarian, mainly coiled in posterior half of body. Eggs numerous, nonfilamented, size 45–48 × 21–27. Excretory pore near posterior extremity of body.

**Hosts:** *Silurus asotus* Linnaeus (Siluridae), Amur catfish (body length 18–21 cm), and *Tachysurus fulvidraco* (Richardson) (Bagridae), yellow catfish (body length 16 cm) (both Siluriformes).

**Site of infection:** Swimbladder and body cavity.

**Locality:** Honghu Lake (*S. asotus*) and Liangzihu Lake (*T. fulvidraco*), both Hubei Province, China (collected 18 September 2002).

**Prevalence and intensity:** *S. asotus*: 4 fish infected/7 fish examined; 2–5 (mean 2) trematodes per fish; *T. fulvidraco*: 5% (1 fish infected/20 fish examined); 1 trematode.

**Deposition of voucher specimens:** IPCAS D-213.

**Comments:** This species is widely distributed in Australia, Indonesia, India, Vietnam, China, Japan and in the Amur River basin in the Russian Far East (e.g., Yamaguti 1971, Bykhovskaya-Pavlovskaya and Kulakova 1987, Moravec and Sey 1989). Adults of *I. hypselobagri* are parasitic in the swimbladder of some piscivorous freshwater fishes, mainly catfishes, whereas its larvae and nongravid forms occur in the various organs, body cavity and musculature of numerous fish species. The present material of this trematode species included both the large ovigerous specimens from the swimbladder and smaller nongravid specimens from the body cavity of *S. asotus*, whereas only a single small nongravid specimen was found in the body cavity of *T. fulvidraco*.

In China, *I. hypselobagri* is reported, e.g., from *S. chuatsi*, *T. fulvidraco* and *S. asotus* from Hubei Province by Chen (1973), Wu et al. (1991) found it in 75% of *S. asotus* examined from Bao'an Lake, and Moravec et al. (2003a) recorded two nongravid specimens of *I. hypselobagri* from the body cavity of the catfish *Leiocassis longirostris* Günther of the Yangtze River at Wuhan, Hubei Province.

## Family Derogenidae Nicoll, 1910

### *Genarchopsis goppo* Ozaki, 1925

Syn: *Genarchopsis anguillae* Yamaguti, 1938

**Host:** *Silurus asotus* Linnaeus (Siluridae, Siluriformes), Amur catfish (body length 18 cm).

**Site of infection:** Stomach.

**Locality:** Honghu Lake, Hubei Province, China (collected 18 September 2002).

**Prevalence and intensity:** 1 fish infected/7 fish examined; 2 trematodes.

**Deposition of voucher specimen:** IPCAS D-265.

**Comments:** Only two broken gravid specimens of *Genarchopsis goppo* Ozaki, 1925 were collected. This species was already redescribed by Moravec et al. (2003a), based on specimens from *S. asotus* of Dongting Lake, Hunan Province, China.

*Genarchopsis goppo* is a parasite of many freshwater, mostly perciform fish hosts in Japan, China India and Laos (e.g., Yamaguti 1971, Chen 1973, Scholz 1991, Wang 1991, Moravec et al. 2003a).

#### Family Orientocreadiidae Yamaguti, 1958

***Orientocreadium pseudobagri* Yamaguti, 1934** Fig. 3B–F  
Syn.: *Macroderoides asiaticus* Belous, 1958

**Description** (based on seven ovigerous specimens; measurements of one nongravid specimen in parentheses): Body elongate, 0.93–2.72 (0.86) mm long, maximum width 299–517 (257). Tegument densely covered by minute spines; spination extending posteriorly to level of posterior testis in smallest specimens and to short distance posterior to ovary in largest specimens. Oral sucker subterminal, circular or nearly circular, size 109–218 × 109–218 (95 × 109). Ventral sucker circular to transversely oval, 109–218 × 109–218 (82 × 109), in approximately 1/3 to 1/4 (1/2) of body length. Size ratio of oral to ventral sucker 1 : 0.9–1.0 (1 : 1.1). Prepharynx distinct, 27–109 (68) long. Pharynx transverse-oval, 68–122 (68) long, 82–163 (68) wide. Oesophagus short, 41–95 (0) long. Caeca terminate blindly near posterior extremity. Testes two, entire, tandem, in posterior half of body. Cirrus sac claviform, 231–313 (150) long and 54–82 (41) wide, with voluminous internal seminal vesicle; large external seminal vesicle 136–163 (41) long. Inner surface of ejaculatory duct with fine minute, hardly visible spine-like formations. Location of cirrus sac relative to ventral sucker rather variable: mostly lateral to sucker, less frequently submedian or median (dorsal). Genital pore median, immediately anterior to ventral sucker. Ovary spherical to oval-shaped, entire, submedian, located short distance anterior to anterior testis in small specimens and relatively far from anterior testis in largest specimens. Vitelline follicles in lateral fields, extending from level of ovary posteriorly to some distance posterior to posterior testis, by far not reaching posterior extremity. Uterine coils extend posteriorly to body end, reaching extracaecally in largest specimens. Metraterm well developed, its inner surface with fine minute, hardly visible spine-like formations. Eggs operculate, oval, size 33–39 × 18–21. Excretory vesicle not observed in ovigerous specimens (I-shaped, extending anteriorly to posterior margin of posterior testis in nongravid specimen).

Host: *Tachysurus fulvidraco* (Richardson) (Bagridae, Siluriformes), yellow catfish (body length 13–16 cm).

Site of infection: Intestine.

Locality: Liangzihu Lake, Hubei Province, China (collected 18 September 2002).

Prevalence and intensity: 30% (6 fish infected/20 fish examined); 1–4 (mean 2) trematodes per fish.

Deposition of voucher specimens: IPCAS D-891.

**Comments:** The general morphology of the present specimens is in agreement with the original description of *Orientocreadium pseudobagri* by Yamaguti (1934) and the detailed redescription of this species, partly based on the type series, by Shimazu (1990). Yamaguti (1934) reported the bagrid catfish *Pseudobagrus aurantiacus* (Temminck et Schlegel) as its type host in the type locality (Lake Biwa). However, according to Shimazu (1990), the type specimens are labelled as “gigi”, which is the Japanese name of *Tachysurus nudiceps* (Sauvage) and, moreover, *P. aurantiacus* does not occur in Lake Biwa. Therefore, the type host of *O. pseudobagri* is *T. nudiceps*.

Although Yamaguti (1934) had at his disposal *O. pseudobagri* specimens only 1.16–1.49 mm long and he did not mention the presence of spines in their ejaculatory duct and metraterm, Shimazu (1990) studied additional conspecific trematodes from the type locality (collected in *T. nudiceps* and *Silurus lithophilus* [Tomoda] attaining the body length up to 2.84 mm and possessing minute spines inside the ejaculatory duct and metraterm (he also confirmed these spines in type specimens).

The presence/absence of spines in the ejaculatory duct was considered to be one of the main taxonomic features distinguishing *O. pseudobagri* from the morphologically very similar species *O. siluri* (Bykhovskiy et Dubinina, 1954), a parasite of catfishes in the Baltic, Black, Caspian and Aral Seas river drainage systems (Skryabin and Koval 1963, Bykhovskaya-Pavlovskaya and Kulakova 1987). Such spines in *O. pseudobagri* were illustrated by Shimazu (1990) as extremely small and fine. In the present specimens, first we were unable to observe any spines inside the ejaculatory duct and metraterm under LM; very fine, extremely small spine-like formations were visible only when phase contrast was used. These formations seemed not to be true sclerotised spines but rather small pointed outgrowths of cells.

Since these fine structures (spines) can easily be overlooked (Fischthal and Kuntz 1963 even considered *O. siluri* a junior synonym of *O. pseudobagri*), it is possible to distinguish both the above-mentioned species based on the extent of their vitelline follicles (beginning at the level of ovary in *O. pseudobagri* and in the level of the posterior margin of ventral sucker to the mid-way between the ventral sucker and ovary in *O. siluri*) (see also Shimazu 1990).

*Orientocreadium pseudobagri* is known as a parasite of catfishes and less frequently of some other freshwater fishes in Japan (from *T. nudiceps* and *S. lithophilus*), Russian Far East (from *Percottus glenni* Dybowski, *Silurus asotus* and *T. fulvidraco*) and China (from *T. fulvidraco*) (Yamaguti 1934, Zmeev 1936, Wang et al. 1985, Bykhovskaya-Pavlovskaya and Kulakova 1987, Shimazu 1990, 2014a, Besprozvannykh et al. 2009).

In China, *O. pseudobagri* was recorded from the Fujian Province (Wang et al. 1985), whereas another congeneric species, *O. siluri*, was reported from *T. fulvidraco* in Hubei Province (Chen 1973). However, the trematodes (body length 1.44–2.75 mm) reported by Chen (1973) had the extent of vitelline follicles typical of *O. pseudobagri* (i.e., beginning at the level of ovary – see plate CV, fig. 20), as men-

tioned above. Consequently, in fact, specimens of *O. pseudobagri* were misidentified as *O. siluri* by Chen (1973). The present finding of *O. pseudobagri* from the same host species in Hubei Province confirms this.

Besprozvannykh et al. (2009) described another species of *Orientocreadium* Tubangui, 1931, *O. elegans*, from the yellow catfish *T. fulvidraco* from the Ilistaya River (Khanka Lake basin), Primorsky region, eastern Russia, where also a morphologically very similar *O. pseudobagri* occurs in the same host species (*T. fulvidraco*). According to authors, *O. elegans* differs from *O. pseudobagri* principally by the more slender body, position of the cirrus sac relative to the ventral sucker (mediodorsal vs lateral) and smaller oral and ventral suckers (95–123 × 89–117 µm and 84–123 × 89–117 µm, respectively).

However, the same suckers in a small ovigerous specimen (body length 925 µm) of *O. pseudobagri* of the present material were approximately of the same size (109 × 109 µm and 109 × 109 µm) as those given for *O. elegans*, whereas the suckers in a nongravid specimen (body length 857 µm) were also of a similar size (95 × 109 µm and 82 × 109 µm, respectively).

Regarding the location of the cirrus sac relative to the ventral sucker, its position is rather variable in the present specimens: most (four) specimens have it lateral to the sucker (Fig. 3D), whereas in two others it is submedian and in two specimens it is median (Fig. 3E). However, both the body shape and the location of the cirrus sac relative to the ventral sucker considerably depend on the condition of trematodes at the moment of their fixation as well as on the method of fixation.

The original drawings of *O. elegans* adults indicate that only small gravid specimens were studied, as visible from a small amount of eggs present in the uterus, representing apparently young adults. A similar location of the ventral sucker, ovary, testes and both fields of vitelline follicles in the body was observed in small specimens of *O. pseudobagri* of the present material. However, as the trematodes gradually grow, their uterus extends considerably, displacing other internal organs, so that the uterine coils in largest specimens fill up most of the body space, their ventral sucker and the cirrus sac as well as the fields of vitelline follicles are shifted more anteriorly and about the most posterior fourth of the body contains uterine coils (Fig. 3B).

Since there are no reliable morphometrical differences between adults of these two species, which occur in the same host species (*T. fulvidraco*) in the same locality and whose first intermediate hosts are identical (see Besprozvannykh et al. 2009), *O. elegans* seems to be conspecific with *O. pseudobagri*. This is also showed by the re-examination of two specimens identified as *O. elegans* from the Helminthological Collection of the Institute of Parasitology, BC CAV (IPCAS D-782) (see above); these trematodes were collected from the type host (*T. fulvidraco*) in the type locality (Ilistaya River, Primorskiy Region, Russia) of *O. elegans* by T. Scholz on 22 June 2011. These specimens are 1.44 and 1.80 mm long, their maximum width is 231 and 245 µm; the sizes of their oral and ventral suckers are 109–122 × 109–122 µm and 122 × 109–122 µm, respecti-

vely; eggs measure 36–39 × 18–21 µm. In contrast to the present specimens, these trematodes were not fixed while being slightly pressed by the coverslip, so that their bodies remained more slender and elongate.

In addition to the alleged morphological differences between adults of *O. pseudobagri* and *O. elegans*, Besprozvannykh et al. (2009) also reported interspecific differences in the chaetotactic structures of the cercariae of these two trematodes. Therefore, we refrain from synonymising these species, but, in our opinion, further studies are needed to confirm the validity of *O. elegans*.

## Family Cryptogonimidae Ward, 1917

### *Exorchis oviformis* Kobayashi, 1915

Fig. 3G

**Description** (based on five ovigerous specimens): Body squat, oval to almost circular, 354–435 long, maximum width 326–435; body length/width ratio 1 : 0.74–1.07. Tegument covered with scales appearing as small spines in lateral view, diminishing in size and becoming sparser posteriorly, and absent from posterior body end. Oral sucker subterminal, almost circular, size 66–87 × 66–105, without enlarged oral spines. Ventral sucker smaller than oral sucker, almost circular, 48–66 × 42–63, located in anterior half of body. Oral/ventral sucker size ratio 1 : 0.60–0.93. Prepharynx absent. Pharynx muscular, oval, 45–63 long, 30–54 wide. Oesophagus very short or indistinct. Intestinal bifurcation anterior to ventral sucker. Intestinal caeca extending posteriorly to some distance from posterior extremity. Testes two, large, oval-shaped, symmetrical, predominantly extracaecal, at level of ventral sucker; size of right testis 75–135 × 66–99, that of left testis 78–165 × 66–111. Seminal vesicle tubulosaccular, bipartite in ventral view, lateral or dorsal to ventral sucker, overlapping ovary posteriorly. Genital pore median, just anterior to ventral sucker. Ovary irregularly slightly to deeply lobed, posterior to ventral sucker, transversely elongate, 20–78 long and 45–102 wide. Vitelline follicles in two lateral groups or confluent medially, from region anterior to testes to region somewhat posterior to ovary, forming numerous longitudinally elongate digits posteriorly, and partially overlapping testes, intestinal caeca and ovary. Numerous uterine coils in postovarian region of body, extending to posterior extremity. Eggs numerous, oval, size 21–24 × 12–15.

Host: *Silurus asotus* Linnaeus (Siluridae, Siluriformes), Amur catfish (body length 18 and 29 cm).

Site of infection: Intestine (mainly its anterior part).

Locality: Honghu Lake, Hubei Province, China (collected 18 September 2002).

Prevalence and intensity: 2 fish infected/7 fish examined; 1 and about 750 trematodes.

Deposition of voucher specimen: IPCAS D-894.

**Comments:** At present, six valid species of *Exorchis* Kobayashi, 1915, all parasites of freshwater catfishes, are reported from East Asia: *E. convictus* Solodovnik, Tatono-va, Urabe, Besprozvannykh, Nakao et Inoue, 2021 from *Silurus asotus* in the Russian southern Far East; *E. dong-*

*tinghuensis* Zhang, Zuo, Liu et Zhou, 1993 from *S. asotus* in China (Hunan); *E. macrobursae* (Pan, 1984) Miller et Cribb, 2001 from *Tylosurus fulvidraco* in China (Guangdong); *E. multivitellaris* Pan, 1984 from *S. asotus* in China (Guangdong); *E. ovariobularis* Cao, 1990 from *S. asotus* in China (Fujian); and *E. oviformis* Kobayashi, 1915 (type species) from *S. asotus* in Japan, China, Korea and the Russian Far East (metacercariae reported also from Vietnam) (e.g., Kobayashi 1915, 1921, Chen 1973, Pan 1984, Cao 1990, Zhang et al. 1993, 1999, Shimazu 2005, 2017, Solodovnik et al. 2021).

It is necessary to note that the correct authority of *Exorchis* and *E. oviformis* is Kobayashi, 1915 (see Shimazu 2005) and not Kobayashi, 1918 or Kobayashi, 1921 as incorrectly reported by Chen (1973) or Miller and Cribb (2008) and Solodovnik et al. (2021), respectively.

However, all these species are morphologically very similar to each other and, except for *E. macrobursae* from *T. fulvidraco* (Bagridae), they are reported from the same host species, *S. asotus* (Siluridae). As pointed out by Shimazu (2005), the morphology of the type species *E. oviformis* is rather difficult to study and, in fact, all previous descriptions of this species were erroneous. Shimazu (2005, 2017) provided a detailed redescription of *E. oviformis*, showing, among others, two important morphological features, the shape and size of the ovary and the shape, size and distribution area of vitellarium.

*Exorchis dongtinghuensis*, a species closely similar to *E. oviformis*, differs from it only in having a smaller ovary, whereas *E. multivitellaris* was separated from *E. oviformis* (most probably based on its previous erroneous descriptions) chiefly by much more ribbon-shaped vitelline branches spreading in the intertesticular field, intestinal caeca extending posteriorly slightly beyond the middle of the body and by the much smaller globular or irregularly shaped ovary (Shimazu 2005).

As confirmed in the present specimens, there is a high degree of intraspecific variability in these features, especially in the size, shape and width of the ovary, where the ovary may be rather small to very broad. Moreover, one must also consider that such structures are not always clearly visible in these trematodes, so that the observations of some authors may not be exact. Therefore, taking into account that *E. dongtinghuensis* and *E. multivitellaris* occur in the same host species (*S. asotus*) and in the same geographical region as *E. oviformis*, we consider all of them to be probably conspecific.

According to Solodovnik et al. (2021), *E. convictus* allegedly differs from *E. oviformis* in the biometrical data on the body and organs but, in fact, the measurements are the same or very similar to those of *E. oviformis* (including the present specimens) or *E. multivitellaris* (a synonym of *E. oviformis*, see above). The authors found some molecular differences between *E. convictus* and *E. oviformis*, but because these are not supported by morphological features and both forms occur in the same host species (*S. asotus*) in the same geographical region (the Russian southern Far East), we consider *E. convictus* to be probably a junior synonym of *E. oviformis*.

It may well be that future studies will also show *E. macrobursae* and *E. ovariobularis* to be conspecific with *E. oviformis*. Nevertheless, for the time being, we take them for valid species, because *E. macrobursae* was described from the host belonging to a different fish family (Bagridae vs Siluridae), whereas *E. ovariobularis* was reported to have a large tripartite seminal vesicle and markedly smaller eggs (11–14 × 7–9 µm) (Shimazu 2005).

The morphology of the present specimens corresponds, more or less, to the redescription of *E. oviformis* by Shimazu (2005, 2017) and Solodovnik et al. (2021). Some specimens resemble especially that illustrated by Shimazu (2005), but also those illustrated by Chen (1973) as *E. oviformis* or Zhang et al. (1999) as *E. multivitellaris*. From Hubei Province in China, *E. oviformis* was previously reported from *S. asotus* by Chen (1973).

### Family Azygiidae Lühe, 1909

#### *Azygia* sp.

Fig. 4A

**Description** (based on one juvenile specimen): Body oval, 857 long, maximum width 245, with smooth surface. Oral sucker subterminal, 190 × 177; ventral sucker 177 × 190, situated in middle of body; size ratio of suckers 1 : 1. Prepharynx absent. Pharynx oval, muscular, 63 × 60. Caeca rather broad, undulating, extending almost to posterior extremity. Anlagen of genital organs present: cirrus sac median, just anterior to ventral sucker; median ovary (45 in diameter) somewhat anterior to submedian, somewhat diagonal testes (each 30 in diameter), all located in middle between posterior margin of ventral sucker and posterior extremity. Excretory vesicle Y-shaped, with anterior arms between ovary and testes.

Host: *Tachysurus fulvidraco* (Ricardson) (Bagridae, Siluriformes), yellow catfish (body length 15 cm).

Site of infection: Stomach.

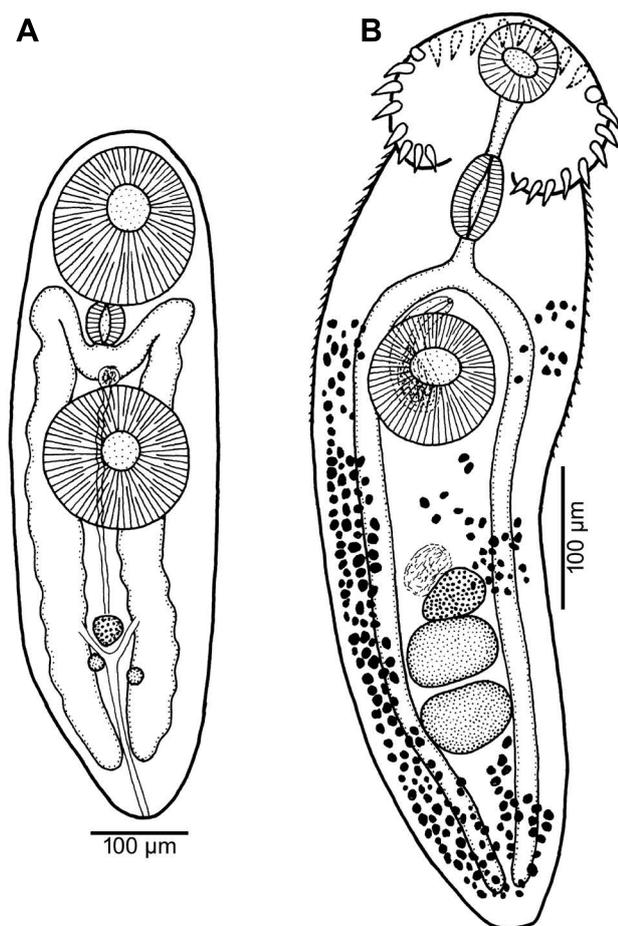
Locality: Liangzihu Lake, Hubei Province, China (collected 18 September 2002).

Prevalence and intensity: 5% (1 fish infected/20 fish examined); 1 trematode.

Deposition of voucher specimen: IPCAS D-467.

**Comments:** The general morphology of this worm is similar to that of the juvenile specimens of *Azygia* spp. described and illustrated, e.g., by Odening (1976) for *A. lucii* (Müller, 1776) in Europe or Shimazu (2014b) for *A. gotoi* (Ariake, 1922) and *A. rhinogobii* Shimazu, 2007 in Japan. Moravec et al. (2003a) reported two similar juvenile specimens as Digenea gen. sp. juv. (IPCAS D-467) from the stomach of the catfish *S. asotus* in Dongting Lake, Hunan Province, China, which evidently also belonged to *Azygia* Looss, 1899.

Three morphologically very similar species of *Azygia*, *A. gotoi* (Ariake, 1922) (syn. *A. anguillae* Ozaki, 1924), *A. hwangtsiyui* Tsin, 1933 and *A. sinipercae* Wang et Pan, 1973, have been reported from freshwater fishes in China (e.g., Chen 1973, Zhang et al. 1999, Moravec et al. 2003a, Shimazu 2014b). However, considering that some species



**Fig. 4.** **A** – *Azygia* sp. juvenile worm from *Tachysurus fulvidraco*; **B** – *Dietziella minjiana* Wang, 1976, juvenile worm from *Tachysurus fulvidraco*.

of *Azygia*, such as *A. lucii*, exhibit only a low degree of specificity at the level of definitive hosts (Yamaguti 1971, Bykhovskaya-Pavlovskaya and Kulakova 1987, Moravec et al. 2003a), the validity of some species can be questioned. Moravec et al. (2003a) reported gravid *A. hwangtsiyui* from host species belonging to three different fish orders in China.

According to Shimazu (2014b), juveniles similar to *A. gotoi* were also found in the stomach of *S. asotus* (Siluridae), *Micropterus salmoides* (Lacepède) and *M. dolomieu* (Lacepède) (both Centrarchidae) from some lakes in Japan. The author considered these fishes to be paratenic hosts, which acquire juveniles by ingesting small transport hosts, but which are probably not eaten by the definitive host. However, in our opinion and considering most probably a low degree of host specificity in *Azygia* spp., it cannot be excluded that also these predatory fishes may become definitive hosts for these trematodes.

#### Family Echinostomatidae Looss, 1899

##### *Dietziella minjiana* Wang, 1976

Fig. 4B

**Description** (based on five nongravid specimens): Body elongate, its anterior end with distinct collar armed with spines; length of entire body 558–775, maximum width 204–245; width of collar 136–177. Anterior half of body

densely covered by small tegumental spines diminishing posteriorly. Collar spines 25 in number, 30–36 long, arranged in one row not interrupted dorsally. Oral sucker subterminal, relatively small, size 51–69 × 54–69. Ventral sucker large, almost circular, 105–150 × 105–156, located close below intestinal bifurcation. Size ratio of suckers 1 : 1.75–2.34. Prepharynx present, 12–48 long. Pharynx muscular, elongate-oval, size 54–60 × 27–30. Oesophagus short, 30–48 long. Caeca extending posteriorly along sides of body, reaching nearly to its end. Testes two, transversely oval, almost equal in size, tandem, situated in space between intestinal caeca in posterior half of body; size of anterior testis 30–54 × 63–105, of posterior testis 51–60 × 69–93. Cirrus sac large, containing large seminal vesicle at its posterior part, size 90–105 × 30–39, located subdorsally to ventral sucker; genital pore median, just anterior to ventral sucker. Ovary irregularly shaped, 36–45 × 57–66, located close anteriorly to testes. Uterus empty, without eggs. Vitelline follicles extend posteriorly along each side of body from ventral sucker to near posterior end, somewhat merging in post testicular area.

**Host:** *Tachysurus fulvidraco* (Richardson) (Bagridae, Siluriformes), yellow catfish (body length 18 cm).

**Site of infection:** Intestine.

**Locality:** Liangzihu Lake, Hubei Province, China (collected 18 September 2002).

**Prevalence and intensity:** 5% (1 fish infected/20 fish examined); 9 trematodes.

**Deposition of voucher specimens:** IPCAS D-899.

**Comments:** Although only very small nongravid specimens were available in the present material, these are identified as *Dietziella minjiana* Wang, 1976 based on some morphological features, such as the number (25) and arrangement of collar spines or the size and location of the cirrus sac, and the family of the fish host. In contrast to the fully developed ovigerous specimens of *D. minjiana*, originally described by Wang (1976) from *Pseudobagrus vachellii* (Richardson) (Bagridae) in China (Fujian Province), vitelline follicles in the present specimens extend anteriorly to the level of the ventral sucker (vs only to mid-length between the ovary and the ventral sucker).

Probably such differences in the extent of vitelline follicles represent intraspecific variation, depending on the state of development of specimens. Later Wang (1989) described a different subspecies of this species, *D. minjiana paurovata* Wang, 1989, from *T. fulvidraco* in China (Shangaro County), in which vitelline follicles extended anteriorly to the level of the ventral sucker as in our specimens. The author differentiated this subspecies also by a shorter body, more numerous collar spines (26) and smaller eggs.

In addition to its type host (*P. vachellii*), *D. minjiana* occurs in China also in *T. fulvidraco*. This trematode species has been reported from Fujian, Jiangxi and Zhejiang Provinces (Zhang et al. 1999).

Five more nominal species of *Dietziella* Skryabin et Bashkirova, 1956, *D. fusiforme* Wang, Zhao, Chen et Tao,

1983, *D. huaiheensis* Liu, 1989, *D. jinxiense* Wang, 1982, *D. kangsanense* Wang, 1982 and *D. laminae* Wang, Zhao, Chen et Tao, 1983, were reported from fishes in China (e.g., Wang 1982, Wang et al. 1983, Liu 1989, Zhang et al. 1999, Kostadinova 2005). However, Kostadinova (2005) considers *Dietziella* to be a *genus inquirendum*; according to her, the generic affiliation of the above-mentioned species of *Dietziella* from fishes in China should be elucidated, although it shows a certain affinity to *Caballerotrema* Prudhoe, 1960.

#### Family Diplostomidae Poirier, 1886

##### *Diplostomum commutatum* (Diesing, 1850), metacercariae

Syns.: *Amphistoma commutatum* Diesing, 1850; *Diplostomum rutili* Razmashkin, 1969

Description and illustration of these metacercariae from China were already provided by Moravec et al. (2003a).

Hosts: *Chanodichthys erythropterus* (Basilewsky), predatory carp (body length 15–34 cm); *Ctenopharyngodon idella* (Valenciennes), grass carp (56 cm); *Hypophthalmichthys nobilis* (Richardson), bighead carp (42–45 cm); *Parabramis pekinensis* (Basilewsky), white Amur bream (24–28 cm) (all Xenocyprididae, Cypriniformes).

Site of infection: Lens of eyes.

Locality: Liangzihu Lake, Hubei Province, China (collected 9 September 2002).

Prevalence and intensity: *Ch. erythropterus*: 9 fish infected/17 fish examined; 1–6 (mean 4) trematodes per fish; Nanbeizui Lake: 5 fish infected/10 fish examined; 1–15 trematodes per fish. *Ct. idella*: 1 fish infected/1 fish examined; 1 trematode. *H. nobilis*: 3 fish infected/3 fish examined; 1–14 (mean 7) trematodes per fish. *P. pekinensis*: 2 fish infected/2 fish examined; 9 and 13 trematodes.

Deposition of voucher specimens: IPCAS D-598.

**Comments:** The present specimens are morphologically identical with those from some xenocyprinid fish hosts in Liangzi and Bao'an Lakes, Hubei Province, reported previously by Moravec et al. (2003a) as *D. commutatum*. The metacercariae of this species are characterised by the presence of ear-shaped, markedly anteriorly protruding pseudosuckers, a funnel-shaped oral sucker, a relatively large ventral sucker and a well-developed oesophagus. Definitive hosts of *D. commutatum* are gulls. This species is widespread in the Palaearctic Region (Bykhovskaya-Pavlovskaya and Kulakova 1987).

Two other species of metacercariae similar to those of *D. commutatum*, *D. hupehensis* Pan et Wang, 1963 and *D. niedashui* Pan et Wang, 1963, were previously reported from xenocyprinid fishes in Hubei Province (including those recorded in this paper) by Chen (1973), Wu et al. (1991) and Zhang et al. (1999). However, in contrast to *D. commutatum*, both these types of metacercariae appear to have a different type of pseudosuckers, the oesophagus is lacking and the ventral sucker is equal to or smaller than the oral sucker (Moravec et al. 2003a).

#### ACANTHOCEPHALA

##### Family Quadrigyridae Van Cleave, 1920

##### *Acanthogyrus (Acanthosentis) pseudoholospinosus*

Wang, 1963 Fig. 5A–E

Syn.: *Acanthogyrus (Acanthosentis) multispinus* Wang, 1966

**Description** (based on three largest non gravid females): Body (trunk) elongate, tapering at both ends, 6.64–7.21 mm long, maximum width 1.09–1.16 mm. Body wall thick, provided with 6–11 giant hypodermal nuclei. Surface of entire trunk with transverse rows of minute spines 3–6 long, each with broad root, most prominent at anterior portion of trunk. Proboscis short, with rounded anterior end, its length 136–150, width 150. Hooks arranged in 6 spiral rows of 3 each; length of anterior hooks 66–72, of middle hooks 39–42, of posterior hooks 21–30. Proboscis receptacle 408 long and 204–231 wide, with nerve ganglion at its base. Lemnisci equal, 1.43–3.06 mm long and 78–81 wide, each with one giant nucleus at its anterior part. Body filled in with numerous ovarian balls; eggs not yet present.

Host: *Hypophthalmichthys nobilis* (Richardson) (Xenocyprididae, Cypriniformes), bighead carp (body length 43–45 cm).

Site of infection: Intestine (its middle part).

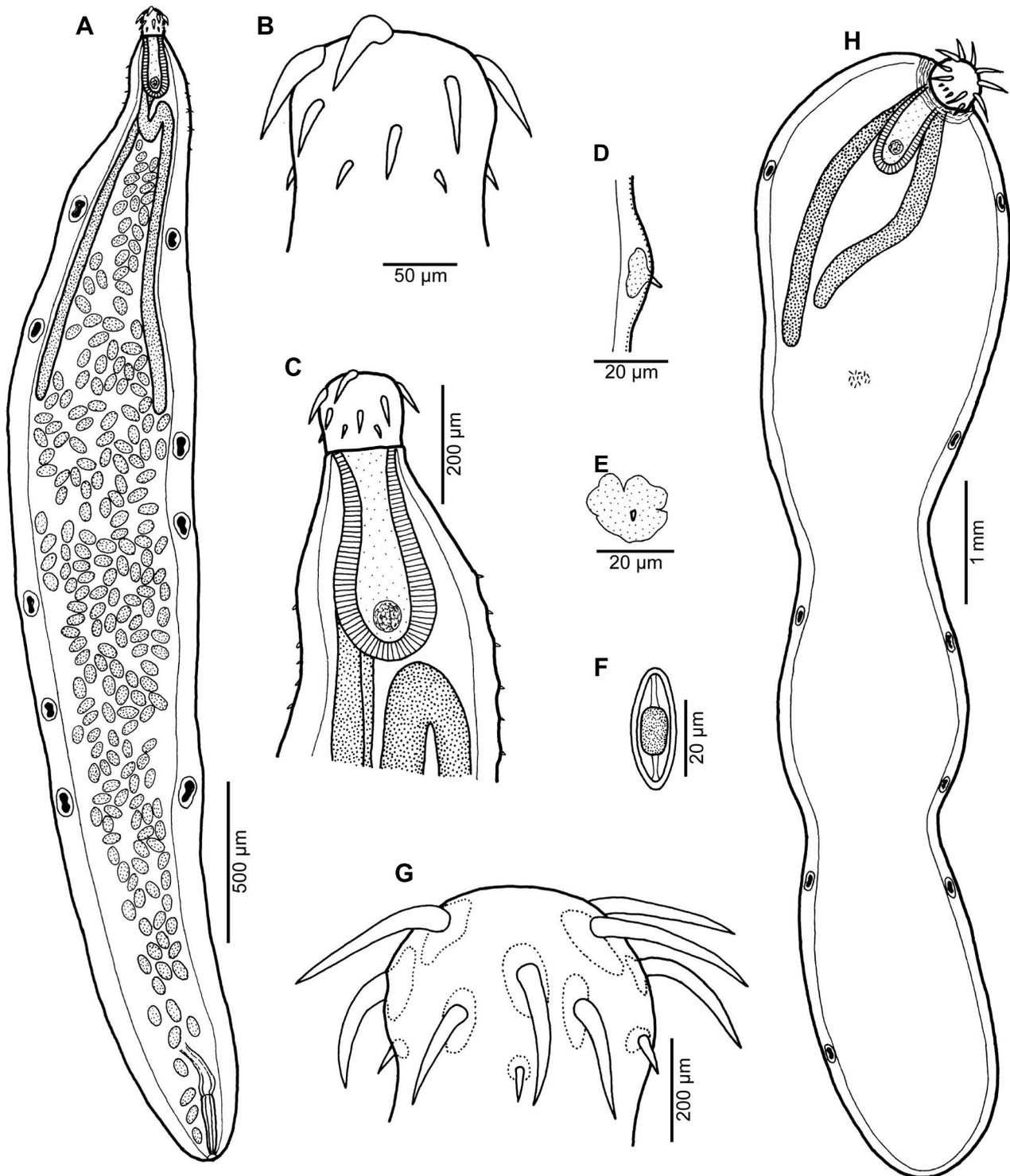
Prevalence and intensity: 2 fish infected/3 fish examined; 2 and 3 acanthocephalans per fish.

Locality: Liangzihu Lake, Hubei Province, China (collected 9 September 2002).

Deposition of voucher specimens: IPCAS A-142.

**Comments:** The original description of *Acanthogyrus pseudoholospinosus* Wang, 1963 was not available to us, but the full description and illustrations of this species were provided by Chen (1973), who reported this acanthocephalan as a parasite of *Hypophthalmichthys molitrix* (Valenciennes) and *H. nobilis* in Hubei Province. Later Yu and Wu (1989) considered *A. pseudoholospinus* to be a synonym of *Acanthosentis multispinus* Wang, 1966 (see Wang 1966) and they reported the latter species from *H. nobilis* and *Squaliobarbus curriculus* (Richardson) (Xenocyprididae) in the middle reaches of the Changjiang (Yangtze) River. However, the name *A. pseudoholospinus* has priority according to International Code of Zoological Nomenclature and, therefore, *A. multispinus* is a junior synonym of *A. pseudoholospinus*, provided that both these forms are conspecific.

Nevertheless, despite the paper of Yu and Wu (1989), this acanthocephalan species is reported as *A. pseudoholospinus* by Pan et al. (1990) and Zhang et al. (1999). On the contrary, *A. pseudoholospinus* is absent from the lists of valid *Acanthogyrus (Acanthosentis)* species provided by Amin (2005, 2013), whereas *A. (A.) multispinus* is present. As mentioned above, *A. (Acanthosentis) pseudoholospinus* is the valid name and *A. (A.) multispinus* is its junior synonym. The present material consisted of only non gravid female specimens.



**Fig. 5.** A–F – *Acanthogyvus (Acanthosentis) pseudoholospinosus* Wang, 1963 from *Hypophthalmichthys nobilis*, non-gravid female (A – general view; B – proboscis; C – anterior end of body; D, E – trunk spine, lateral and apical views, respectively; F – egg); G, H – *Pseudohexaspiron spinibarbi* (Yu et Wang, 1997) comb. n. from *Hemiculter bleekeri* gravid female (G – proboscis; H – general view).

#### Family Neoechinorhynchidae Ward, 1917

#### *Quadrihexaspiron* gen. n.

ZooBank number for species:

[urn:lsid:zoobank.org:act:5DF23228-6A67-4C17-B647-2F54F4EEF0F5](https://zoobank.org/act:5DF23228-6A67-4C17-B647-2F54F4EEF0F5)

**Diagnosis:** Neoechinorhynchidae. Proboscis spherical, armed with 24 hooks arranged in 4 circles of 6 hooks each. Trunk smooth; its wall thick, with giant hypodermic nuclei (3–5 dorsal and 2–5 ventral). Proboscis receptacle one-layered, short, with cephalic ganglion at its base. Lemnisci much longer than proboscis receptacle. Testes oval, tandem to somewhat oblique, situated at middle of body.

Cement gland syncytial, almost spherical, with 6–8 nuclei. Eggs elongate-oval. Intestinal parasites of freshwater fishes.

**Type species:** *Quadrihexaspiro spinibarbi* (Yu et Wang, 1997) comb. n.

**Other species:** *Quadrihexaspiro parabramis* (Yin et Wu, 1984) comb. n.

**Etymology:** The generic name *Quadrihexaspiro* relates to the hook configuration on the proboscis, i.e., four circles of six hooks.

**Differential diagnosis:** At present, the Neoechinorhynchidae contains many genera, of which the following were listed as a separate subfamily Neoechinorhynchinae: *Dispiro* Bilqees, 1970, *Gorytocephalus* Nickol et Thatcher, 1971, *Mayarhynchus* Pinacho-Pinacho, Hernández-Orts, Sereno-Urbe, Pérez-Ponce de León et García-Varela, 2017, *Microsentis* Martin et Multani, 1966, *Neoechinorhynchus* Stiles et Hassall, 1905, *Octospinifer* Van Cleave, 1919, *Octospiniferoides* Bullock, 1957, *Paraechinorhynchus* Bilqees et Khan, 1983, *Paulisentis* Van Cleave et Bangham, 1949 and *Zeylonechinorhynchus* Fernando et Furtado, 1963 (see Amin 2013, Pinacho-Pinacho et al. 2017). *Quadrihexaspiro* gen. n. differs from all of them, as from all other neoechinorhynchid genera in the number and arrangement of hooks on the proboscis. The only other neoechinorhynchids with 24 hooks are *Octospinifer* and *Octospiniferoides*, which have three circles of eight hooks, whereas there are four circles of six hooks in *Quadrihexaspiro* gen. n.

***Quadrihexaspiro spinibarbi* (Yu et Wang, 1997) comb. n.**  
Fig. 5F–H

ZooBank number for species:

[urn:lsid:zoobank.org:act:09A061E1-76F7-4990-8A79-96812BC4B5A4](https://zoobank.org/act:09A061E1-76F7-4990-8A79-96812BC4B5A4)

Syn.: *Hexaspiro spinibarbi* Yu et Wang, 1997

**Description of female** (based on four gravid female specimens): Body stout, elongate, with rounded posterior end. Trunk 10.34–13.73 mm long, maximum width 2.38–3.06 mm. Body wall thick, provided with 8–10 large hypodermal nuclei. Proboscis short, its length equal or only slightly exceeding width; length of proboscis 476–544, its maximum width 476–544. Proboscis armed with hooks arranged in 4 circles of 6 hooks each. Anterior hooks conspicuous, measuring 326–354 in length, oriented sublaterally. Second hooks somewhat smaller, 218–245 long, oriented posteriorly. Third and fourth hooks 82–109 and 54–68 long, respectively, oriented posteriorly. First, second and third hooks of each circle with prominent roots with anterior process; roots of posteriormost hooks small. Proboscis receptacle 585–884 long and 354–435 wide; cephalic ganglion near receptacle base. Lemnisci almost equally long, measuring about 1.70 mm in smallest specimen; lemnisci of two other specimens overlapped by mass of eggs and consequently indistinct. Giant nuclei in lemnisci not observed. Body of two specimens contained

masses of eggs, whereas body of third specimen was filled in with very many ovarian balls but no eggs. Eggs 30–36 long and 6–9 wide.

**Host:** *Hemiculter bleekeri* Warpachowski (Xenocyprididae, Cypriniformes).

**Site of infection:** Intestine.

**Prevalence and intensity:** 1 fish infected/1 fish examined; 4 acanthocephalans.

**Locality:** Poyanghu Lake, Jiangxi Province, China (collected 9 September 2002).

**Deposition of voucher specimens:** IPCAS A-144.

**Comments:** Dollfus and Golvan (1956) established the genus *Hexaspiro* Dollfus et Golvan, 1956, placed in the Neoechinorhynchidae, for *H. nigericum* Dollfus et Golvan, 1956, a parasite of the catfish *Synodontis membranaceus* (Geoffroy Saint-Hilaire) (Mochokidae) in Niger, Africa. However, later, based on newly collected specimens from *S. membranaceus* in Niger, Golvan (1988) redescribed the same species and renamed it *H. nigriensis* Dollfus et Golvan, 1956. Since he observed seven rings of minute spines on the anterior part of the trunk of these specimens, he transferred the species to the family Quadrigyridae.

However, according to the ICZN (1999), the name *nigriensis* cannot be accepted and it is reported as “unaccepted (lapsus; malformed suffix)” both in WoRMS Taxon List (2024) and Wikipedia (2024), where the accepted name for this species, *H. nigericum*, is assigned to the Neoechinorhynchidae. Also Amin (2013) listed *Hexaspiro* within Neoechinorhynchidae, placing in it two species, the type species *H. nigericum* and *H. spinibarbi* Yu et Wang, 1977 (sic; correctly 1997) from China; nevertheless, he omitted the second species from China, *H. parabramis* Yin et Wu, 1984.

Considering that the specimens studied by Dollfus and Golvan (1956) and Golvan (1988) were collected from the same host species (*S. membranaceus*) in the same locality (Niger River in Niger), there is no doubt that both these acanthocephalan forms were conspecific and that Golvan (1988) was right to take his newly collected specimens for the species identical with *H. nigericum* (although incorrectly renamed by him). His redescription of this type species of the genus, based on many available specimens, showed clearly the presence of rows of minute spines on the trunk, which assigns *Hexaspiro* to Quadrigyridae as correctly reported by Golvan (1988). It is necessary to note that trunk spines are sometimes difficult to observe and can be easily overlooked in some quadrigyrid specimens (see p. 18).

In addition to the type species of *Hexaspiro* reported from Africa, belonging to Quadrigyridae, two other species placed in this genus were described from freshwater fishes in China: *H. parabramis* Yin et Wu, 1984 from *Parabramis pekinensis* (Basilevsky) and *S. curriculus* (both Xenocyprididae) in Liao He, and *H. spinibarbi* Yu et Wang, 1997 from *Spinibarbus hollandi* Oshima (Cyprinidae), *Sinibrama wui* (Rendahl) (Xenocyprididae) and *Siniperca scherzeri* Steindachner (Siniperacidae) in Wuling

Mountains area, Hunan Province (Yin and Wu 1984, Yu and Wang 1997). Since both these Chinese species have no trunk spines, they are representatives of the *Neoechinorhynchidae*, where they can be assigned to *Neoechinorhynchinae*. However, their number and arrangement of proboscis hooks are distinctly different from those in representatives of the presently recognised genera of this family (see above) and, therefore, we propose a new genus *Quadrihexaspiro* gen. n. to accommodate these two species.

The present specimens are morphologically similar to both species of *Quadrihexaspiro* parasitising fishes in China, but the lengths of their proboscis hooks are almost the same as in *Pseudohexaspiro spinibarbi* (Yu et Wang, 1997), whereas the same hooks in *P. parabramis* are considerably shorter (100–130, 90–100, 65–70 and 38–40  $\mu\text{m}$  vs 326–354, 218–245, 82–109 and 54–68  $\mu\text{m}$ ). On the contrary, the body length of available nongravid females of *P. spinibarbi* was only 3.00–4.55 mm (vs 10.34–13.73 mm); the females of *P. parabramis* were 7.6–16 mm long, but these also had not yet fully mature eggs. While the present specimens had 8–10 giant nuclei in their body wall, the numbers of giant nuclei were illustrated to be 7 and 8 in *P. parabramis* and *P. spinibarbi*, respectively.

Considering mainly the size of proboscis hooks, the present female specimens are provisionally identified as *P. spinibarbi* (unfortunately, the type specimens of *P. spinibarbi* could not be found for comparison), although future studies may show that they belong to another, hitherto undescribed species. However, having only the females at disposal, we refrain from establishing such a new species. Also it cannot be quite excluded that *Q. parabramis*, *Q. spinibarbi* and the present specimens might belong in fact to one and the same species, because the proboscis hook measurements for *P. parabramis* were given for the male with a note that those of the female are larger (Yin and Wu 1984).

The present finding of *P. spinibarbi* in *H. bleekeri* represents a new host record.

### *Neoechinorhynchus (Hebesoma) violentus* (Van Cleave, 1928) Salgado-Maldonado, 1978

Syn.: *Hebesoma violentum* Van Cleave, 1928.

Description and illustrations of adult and immature specimens of this species (as *H. violentum*) from China were already provided by Moravec et al. (2003b).

Host: *Siniperca chuatsi* (Basilewsky) (Siniperacidae, Centrarchiformes), mandarin fish (body length 25 cm).

Sites of infection: Intestine and pyloric caeca.

Prevalence and intensity: 1 fish infected/1 fish examined; 7 acanthocephalans.

Locality: Liangzihu Lake, Hubei Province, China (collected 9 September 2002).

Deposition of voucher specimens: IPCAS A-71.

**Comments:** All collected specimens were immature. This parasite species is widely distributed in fishes of China and the Russian Far East, where it occurs mainly in *S. chuatsi* (type host), but also in some other fish species (for more information see Moravec et al. 2003b). *Hebesoma*

Van Cleave, 1928 is a subgenus of *Neoechinorhynchus* Hamann, 1892 according to the Amin's (2013) classification system of the Acanthocephala.

**Taxonomic remark on *Neoechinorhynchus*:** While comparing some neoechinorhynchid acanthocephalans from the Helminthological Collection of the Institute of Parasitology, BC CAS with those in the present Chinese material, the species *Neoechinorhynchus afghanus* originally described from two males found in the cyprinid *Bangana dero* (Hamilton) of the Kabul River, Afghanistan (Moravec and Amin 1978), was re-examined. Surprisingly, the anterior part of the trunk of the holotype was found to bear 14 transverse rows of extremely small (about 3  $\mu\text{m}$  long) and fine spines provided with relatively large roots on the trunk ventral side, whereas only three such spines were observed on the dorsal side (Fig. 6). The spines are hardly visible on the body of stained and mounted specimens and this was apparently the reason why they were overlooked during the original species description. Based on this feature, the species is transferred from *Neoechinorhynchus* to *Quadrigyrus* Van Cleave, 1920 (Quadrigyridae) as *Quadrigyrus afghanus* (Moravec et Amin, 1978) comb. n.

### Family Ahythmacanthidae Yamaguti, 1935

#### *Heterosentis parasiluri* Yin et Wu, 1984 Fig. 6A–C

**Description** (based on two female specimens from *T. fulvidraco*): Body fusiform. Length of trunk 2.96–3.56 mm, maximum width 0.95–1.06 mm. Anterior part of trunk up to level of posterior end of proboscis receptacle densely covered by numerous small, posteriorly oriented spines 9–12 long. Proboscis oval, armed with hooks of two types differing markedly in size: anterior large hooks (anteriormost hooks somewhat shorter than others) 81–90 long, arranged in 6 spiral rows of 7 hooks each; posterior small hooks 18–30 long, arranged in 13 longitudinal rows of 2–3 hooks each. Neck short. Proboscis including neck 245–503 long and 204 wide. Proboscis receptacle short, double-walled, 476–588 in length and 231–272 in maximum width; cephalic ganglion located at base of receptacle. Lemnisci short, saccular, 503–544 long. Eggs elongate-oval, 33–36  $\times$  6–7, present only in larger specimen.

Hosts: *Tachysurus fulvidraco* (Richardson) (Bagridae), yellow catfish body (length 13 cm) and *Silurus asotus* Linnaeus (Siluridae), Amur catfish (body length 19 cm) (both Siluriformes).

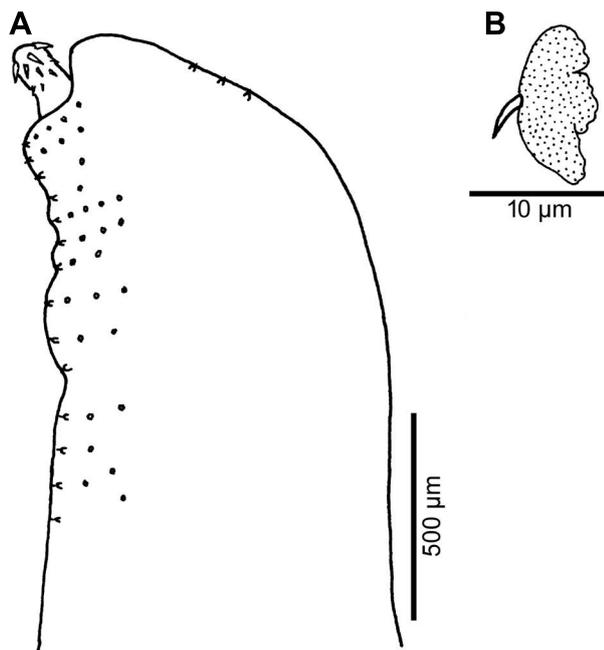
Sites of infection: Intestine.

Prevalence and intensity: *T. fulvidraco*: 5% (1 fish infected/20 fish examined); 3 acanthocephalans. *S. asotus*: 1 fish infected/7 fish examined; 2 acanthocephalans.

Localities: Liangzihu Lake (*T. fulvidraco*) and Honghu Lake (*S. asotus*), both Hubei Province, China (collected 18 September 2002).

Deposition of voucher specimens: IPCAS A-74.

**Comments:** The present material included one posterior body fragment of the male and two complete females (one gravid and one nongravid) from *T. fulvidraco*, and one male and a nongravid female from *S. asotus*. Since *Heterosentis parasiluri* Yin et Wu, 1984 was already redescribed



**Fig. 6.** Holotype (male) of *Quadrigyrus afghanus* (Moravec et Amin, 1978) comb. n. from Afghanistan. **A** – distribution of trunk spines on anterior part of body, lateral view; **B** – trunk spine, lateral view.

and illustrated in the paper of Moravec et al. (2003b) based on males and nongravid females from *S. asotus*, we present only the redescription of females, including the ovigerous specimen, from *T. fulvidraco*.

*Heterosentis parasiluri* was originally described by Yin and Wu (1984) from *S. asotus* (type host), *S. asotus* × *Silurus soldatovi* Nikolskii et Soin (both Siluridae), and *Tachysurus brashnikovi* (Berg) and *T. dumerili* (Bleeker) (syn. *Leiocassis longirostris* Günther) (both Bagridae) of the Liaohe and Yangtze Rivers in Liaoning Province. Later Yu and Wu (189) recorded this species from fishes of the middle reaches of the Yangtze River, adults in *T. dumerili* and immature forms in the catfishes *Pseudobagrus crassilabris* (Günther), *P. vachellii*, *Pelteobagrus eupogon* (Boulenger), *Hemibagrus macropterus* Bleeker (all Bagridae) and several species of Acipenseridae, Botiidae, Cotto-stomidae, Cyprinidae and Gobionidae.

Moravec et al. (2003b) found *H. parasiluri* in bagrid catfishes *Tachysurus nitidus* (Sauvage et Dabry de Thiersant), *P. crassilabris* and *P. vachellii* of the Yangtze River at Wuhan, Hubei Province. The present finding of this acanthocephalan in *T. fulvidraco* represents a new host record.

#### Family Rhadinorhynchidae Lühe, 1912

##### *Micracanthorhynchina motomurai* (Harada, 1935)

Ward, 1951

Fig. 6D–G

Syns.: *Micracanthorhynchus motomurai* Harada, 1935

**Description of female** (based on two ovigerous specimens): Body elongate, broadest in its anterior part and distinctly narrowed posteriorly. Trunk 5.14–6.19 mm long,

maximum width 0.93–1.17 mm. Anterior part of trunk armed with minute spines up to 6 long, arranged in 12–13 transverse rows forming complete rings around body (about 20–22 spines in each row) in smaller specimen, whereas spines in several posterior rows seem to be absent on dorsal side of body in larger specimen. Proboscis cylindrical to somewhat claviform, 476–598 long and 218–231 wide, provided with 12 longitudinal rows of hooks; each row formed by 9 hooks with moderately developed roots. Largest hooks up to 60–66 long present in anterior part of proboscis (except for anteriormost hooks 45–51 long), diminishing gradually in posterior direction; posteriormost hooks 21 long. Proboscis receptacle narrow, fairly long, two-layered, with cephalic ganglion situated near its middle; length of receptacle 925–1,115, its maximum width 136–177. Lemnisci short, 680–754 long, not reaching posteriorly level of proboscis receptacle end. Whole body densely filled in with eggs or eggs and ovarian balls. Spherical vaginal sphincter distinct. Eggs spindle-shaped, size 42–54 × 15.

Host: *Hemiculter bleekeri* Warpachowski (Xenocypridae, Cypriniformes).

Site of infection: Intestine.

Prevalence and intensity: 1 fish infected/1 fish examined; 2 acanthocephalans.

Locality: Poyanghu Lake, Jiangxi Province, China (collected 9 September 2002).

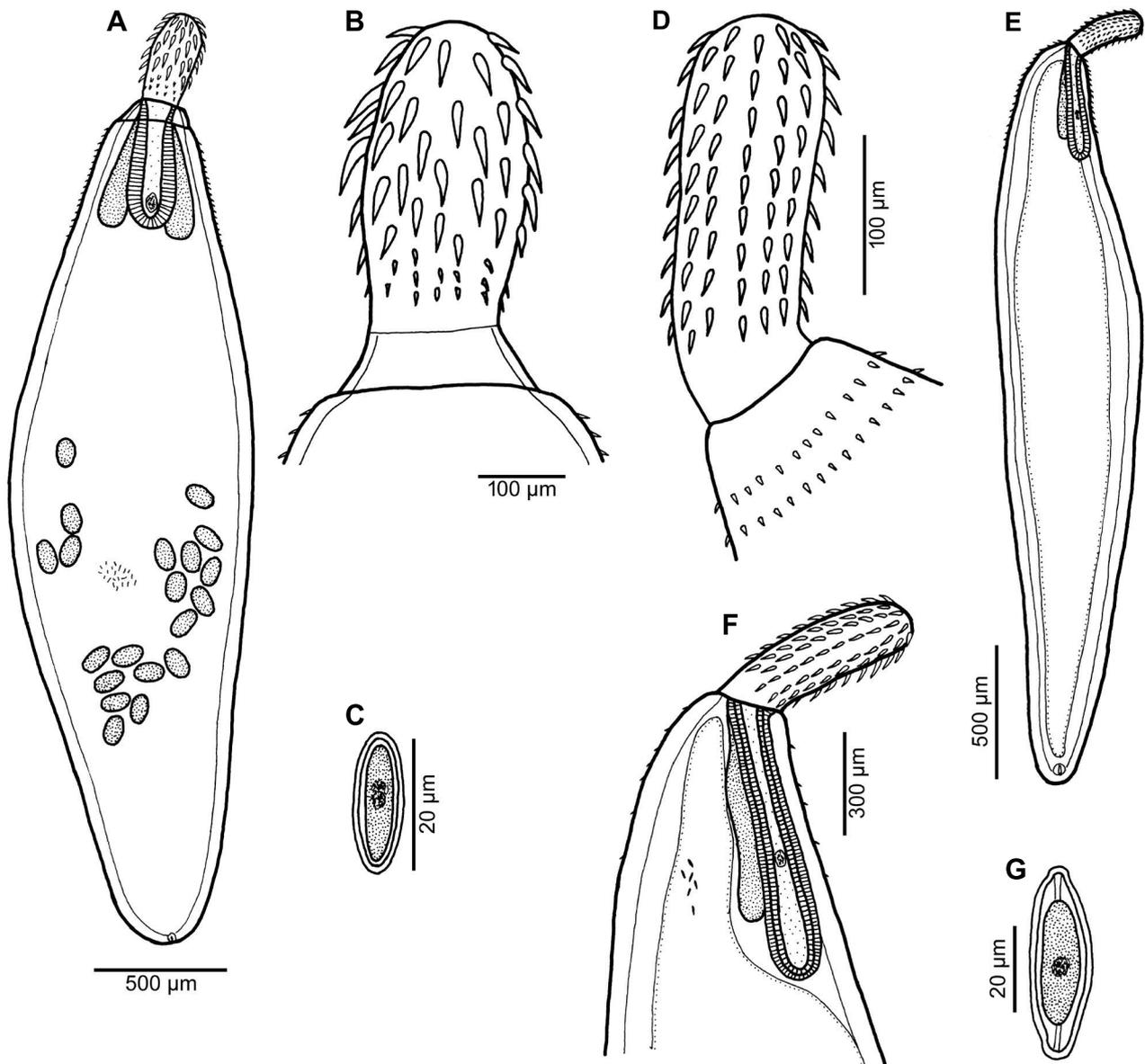
Deposition of voucher specimens: IPCAS A-143.

**Comments:** Two morphologically similar species of *Micracanthorhynchina* Strand, 1936 (reported as *Micracanthorhynchus*), *M. motomurai* (Harada, 1935) from *Nipponocypris temmincki* (Temminck et Schlegel), *Sinibrama macrops* (Günther) and *Z. platypus* (all Xenocypridae) in Korea and Taiwan and *M. dakusuiensis* (Harada, 1938) from *N. temmincki* in Taiwan were described (see Petrochenko 1956).

Both these species are characterised by the proboscis armed with hooks arranged in 12 longitudinal rows formed by 8–9 or 9 hooks each. They differ from each other by the length of the body (females 3.2–4.5 mm vs 7.6 mm in *M. motomurai* and *M. dakusuiensis* Harada, 1938, respectively), somewhat smaller eggs in *M. motomurai* (40 × 16 µm vs 63 × 16 µm) and mainly in the number of cement glands in the male (four in *M. motomurai* vs six in *M. dakusuiensis*).

Recently Amin and Rubtsova (2024) redescribed *M. motomurai* based on specimens from *N. temmincki* and *Z. platypus* collected in Korea and confirmed the presence of four cement glands and some other features in this species. However, the female body length (5.14–6.19 mm) and the size of eggs (42–54 × 15 µm) of the present specimens are intermediate between those of *M. motomurai* and *M. dakusuiensis* and, consequently, the only difference between these species should be the number of cement glands in the male (see above).

Nevertheless, the original Harada's drawings of adults (see Petrochenko 1956) show no difference in the number



**Fig. 7.** A–C – *Heterosentis parasiluri* Yin et Wu, 1984 from *Tachysurus fulvidraco*, gravid female (A – general view; B – proboscis; C – egg); D–G – *Micracanthorhynchina motomurai* (Harada, 1935) from *Hemiculter bleekeri*, gravid female (D – proboscis; E – general view; F – anterior end of body; G – egg).

of cement glands between these two species and their cement glands appear to be much the same. Also it is necessary to remark that sometimes it is difficult to establish the exact number of cement glands in some mounted specimens. Accordingly, the reported number of cement glands in *M. dakusuiensis* can be questioned or, perhaps, might be within intraspecific variability of *M. motomurai*, as are apparently the reported biometrical differences between these two species.

Therefore, taking into account also the fact that both these acanthocephalan species were described from the same host species (*N. temmincki*) in the same region (Taiwan), it is highly probable that *M. dakusuiensis* is conspecific with *M. motomurai*.

Lisitsyna et al. (2023) recorded *M. dakusuiensis* (probably a synonym of *M. motomurai*) from *Opsariichthys*

*pachycephalus* Günther (Xenocypridae) in Taiwan (Daja River) and established a new congeneric species, *M. brevellemniscus* Lisitsyna, Barčák, Orosová, Fan et Oros, 2023, from *O. pachycephalus* (type host), *Candidia barbata* (Regan) and *Onychostoma alticorpus* (Oshima) (all Xenocypridae) in the same locality (Daja River near Taichung City) in Taiwan. The morphology of this species is also very similar to that of *M. motomurai* and *M. dakusuiensis*, differing from them mainly by the lemnisci distinctly shorter than the proboscis receptacle and by shorter body lengths. However, it cannot be excluded that the relative length of lemnisci to the length of the receptacle depends on the body length of these worms, as indicated by the present specimens of *M. motomurai*, where the lemnisci are also somewhat shorter than the proboscis receptacle (Fig. 7E, F). Subsequent studies based on more numerous newly co-

llected specimens may show that the reported differences among *M. motomurai*, *Micracanthorhynchina dakusuiensis* (Harada, 1938) and *M. brevelemniscus* are in fact within intraspecific variation of a single species and that the two last-named species are synonyms of the former one.

Demshin (1965) described another species of *Micracanthorhynchina* Strand, 1936, *M. hemiculterus* (Demshin, 1965), from *Hemiculter leucisculus* (Xenocypridae) in Vietnam. The female of this species is morphologically similar to those of the present specimens, but differs in the number (12 vs 9) of proboscis hooks per row, the presence of two marked anterior outgrowths on the roots of hooks and larger eggs ( $62 \times 23 \mu\text{m}$ ).

The general morphology and measurements of the two available female specimens of the present material are also similar to those of *Pseudorhadinorhynchus vietnamensis* Moravec et Sey, 1989, a species described from *S. curriculus* (Xenocypridae) in North Vietnam (Moravec and Sey 1989); this fish also occurs in China (Froese and Pauly 2024). However, although the female body lengths of these two forms are much the same, 5.92–6.32 mm in *P. vietnamensis* and 5.14–6.19 mm in the present specimens, the proboscis is distinctly longer in *P. vietnamensis* (612–721  $\mu\text{m}$  vs 476–598  $\mu\text{m}$ ) and has 12 (vs 9) hooks per row, although the number (12) of longitudinal rows of hooks is identical in both these forms. Also the eggs of *P. vietnamensis* are somewhat larger than those of the present specimens ( $60\text{--}66 \times 12 \mu\text{m}$  vs  $42\text{--}54 \times 15 \mu\text{m}$ ). *Pseudorhadinorhynchus* spp. are characterised by the presence of eight cement glands in the male.

Representatives of *Pseudorhadinorhynchus* Akhmerov et Dombrovskaya-Akhmerova, 1941 have not yet been reported from freshwater fishes in China, but three congeneric species, *P. leuciscus* (Krotov et Petrochenko, 1956), *P. markewitchi* Akhmerov et Dombrovskaya-Akhmerova, 1941 and *P. samegaiensis* Nakajima et Egusa, 1975, are known to parasitise some freshwater cypriniforms and salmonids of the Amur River basin in the Russian Far East or in Japan (Nakajima and Egusa 1975, Machida and Araki 1982, Bauer 1987). However, all these species differ from the present specimens in having 10 or 14 (instead of 12) longitudinal rows of proboscis hooks.

The species *M. motomurai* was previously reported in mainland China (Fukien) from cypriniform fishes

*C. erythropterus*, *Elopichthys bambusa* (Richardson), *Hemiculter leucisculus*, *Pseudolaubuca sinensis* Bleeker and *S. curriculus* (all Xenocypridae), and *Hemibarbus labeo* (Pallas) (Gobionidae) by Wang (1966). Later it was also recorded by Yu and Wang (1997) from three fish species, *Perccocypris pingi* (Tchang) (Cyprinidae), and *Pseudohemiculter dispar* (Peters) and *Opsariichthys bidens* Günther (both Xenocypridae), in Wuling Mountains area, southwestern China. In China it was also reported under the possible synonym *M. dakusuiensis* from *C. erythropterus* and *O. bidens* by Wang (1981) and by Gao et al. (2022) from *Tachysurus fulvidraco* (Bagridae). The present finding of *M. motomurai* in *H. bleekeri* represents a new host record.

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