

# Cestoda and Acanthocephala of fishes from cenotes (= sinkholes) of Yucatan, Mexico

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**Abstract.** During a study on parasites of fish from cenotes (= sinkholes) in the Yucatan Peninsula, the following cestodes and acanthocephalans were found in 581 freshwater fish of 15 species: the cestodes *Bothriocephalus acheilognathi* Yamaguti, 1934, *Bothriocephalus* sp. (Bothriocephalidae), *Nomimoscolex* sp. (Monticellidae), *Proteocephalidea* gen. sp. larv., *Dendrouterina papillifera* (Fuhrmann, 1908) larv. and *D. pilherodiae* Mahon, 1956 larv. (Dilepididae), and the acanthocephalans *Octospiniferoides chandleri* Bullock, 1957, *Neoechinorhynchus golvani* Salgado-Maldonado, 1978 (Neoechinorhynchidae), *Polymorphus* (syn. *Arhythmorhynchus*) *brevis* (Van Cleave, 1916) larv. (Polymorphidae), and an echinorhynchid larva. With the exception of *B. acheilognathi*, all tapeworms are found in Mexico for the first time; second-stage larvae of *D. papillifera* and *D. pilherodiae* from fish are reported for the first time.

In 1993–1995, an investigation into parasites of fish from cenotes (= sinkholes) in the Yucatan Peninsula, was carried out. Survey of the trematodes (adults and metacercariae) and nematodes (adults and larvae) found in cenote fish has already been published by Moravec et al. (1995a,b) and Scholz et al. (1995a,b). The present paper reports the occurrence of cestodes and acanthocephalans.

## MATERIALS AND METHODS

The study was carried out in the Peninsula of Yucatan from September 1993 to January 1995. A total of 581 fish of the following 15 species was examined: *Astyanax fasciatus* (Cuvier) (a total of 124 specimens examined) (Characidae); *Rhamdia guatemalensis* (Günther) (229) (Pimelodidae); *Poecilia petenensis* Günther (10); *P. latipunctata* Meek (4); *P. velifera* (Regan) (51); *Poecilia* sp. (23); *Gambusia yucatanana* Regan (20) (Poeciliidae); *Cichlasoma friedrichstahli* (Heckel) (4); *C. meeki* (Brind) (11); *C. octofasciatum* (Regan) (5); *C. pearsei* (1); *C. synspilum* Hubbs (17); *C. urophthalmus* (Günther) (77); *Petenia splendida* Günther (2) (Cichlidae); and *Gobiomorus dormitor* (2) (Gobiidae). Samples of fish were taken from 39 cenotes in the States of Yucatan and Quintana Roo; a list of cenotes with their descriptions and number of fish sampled from individual cenotes was provided by Scholz et al. (1995a). Fish were routinely examined as outlined by Bykhovskaya-Pavlovskaya (1969); parasites found were isolated and fixed under a slight coverslip pressure with 4 % formalin (adult cestodes, acanthocephalans); tapeworm larvae were

fixed using ammonium-picrate (Ergens 1969). Scolices of *Bothriocephalus acheilognathi*, used for scanning electron microscopy (SEM), were fixed with hot 4 % formaldehyde, dehydrated in an alcohol series, critical point dried and coated with gold. Photomicrographs were made using a Jeol scanning electron microscope. In descriptions, measurements are given in micrometres (µm) unless otherwise stated. Voucher specimens have been deposited in the helminthological collection of the Institute of Parasitology, Czech Academy of Sciences, České Budějovice, in the parasite collection of the Institute of Biology, Universidad Nacional Autónoma de México, México, and at the Laboratory of Parasitology, CINVESTAV-IPN Mérida.

## SURVEY OF SPECIES

### CESTODA

Family Bothriocephalidae Blanchard, 1849

#### 1. *Bothriocephalus acheilognathi* Yamaguti, 1934 Figs. 1A, B, D, E, 2

**Host and locality:** *Gambusia yucatanana* – Homún (20°44'19"N; 89°17'49"W; 3 November 1993) – infected 5 fish of 5 examined; mean intensity of infection 7 worms (range 2–13 cestodes).

**Site of infection:** intestine.

**Material studied:** 9 not fully mature and 2 juvenile specimens from *G. yucatanana*; in addition, five scolices were used for scanning electron microscopy (SEM).

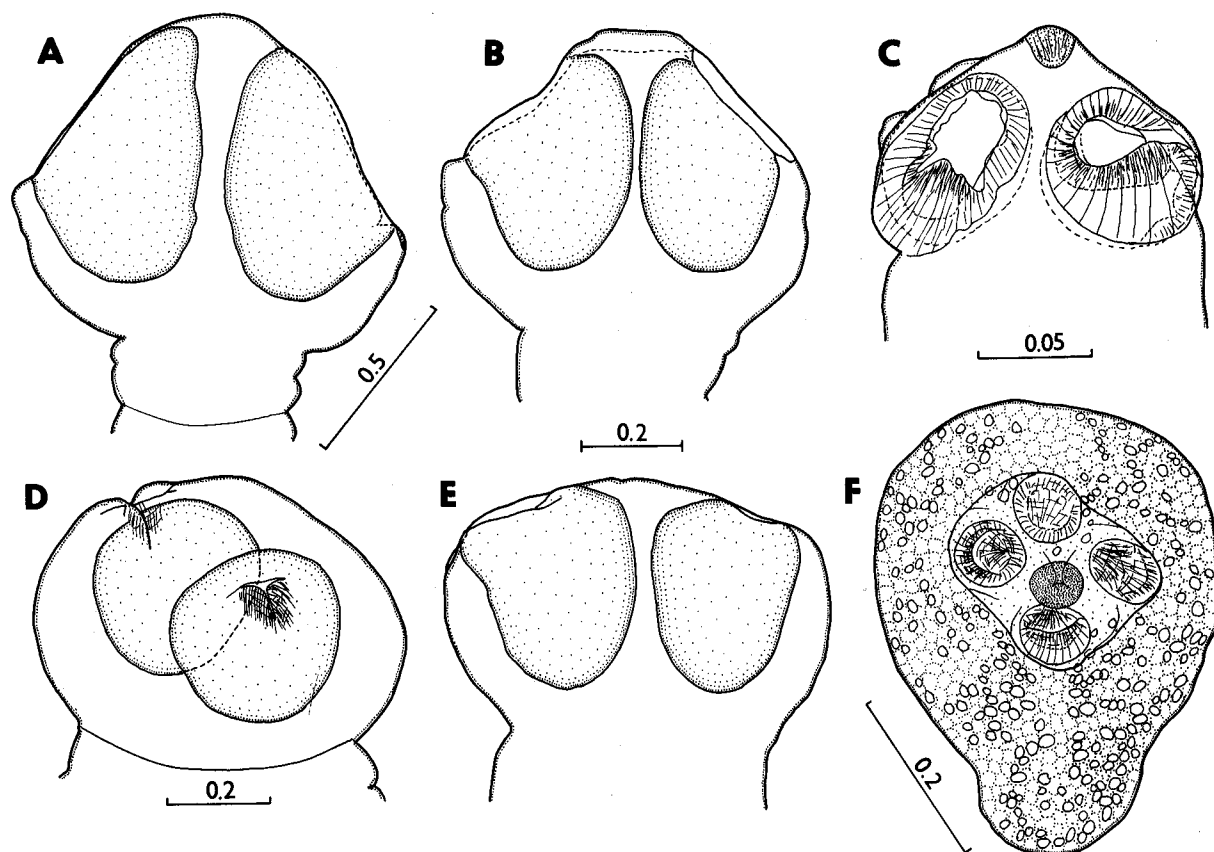


Fig. 1. *Bothriocephalus acheilognathi* (Yamaguti, 1934) from *Gambusia yucatana* – variation in the scolex morphology (A, B, D, E); *Nomimoscolex* sp. from *Rhamdia guatemalensis* – scolex (C); *Proteocephalidea* gen. sp. – encysted larva from the mesentery of *R. guatemalensis* (F). Scale bars in millimetres (mm).

**Description** (N = 8): Tapeworms up to 9.70 mm long; maximum width 0.87 mm. Scolex mostly heart-shaped (Fig. 1A, B), measuring 488–1080 × 710–1040, provided with terminal disc, 200–320 wide, and dorsally and ventrally opening deep and narrow bothria, 312–660 long and 280–440 wide. Width of neck 328–650. Body segmented; segments wider than long; most developed, not fully mature proglottides 112–224 long.

**Remarks:** The present material consists of maturing or juvenile specimens, without completely developed genital organs. Nevertheless, the shape of the scolex (Figs. 1, 2) clearly indicates that the tapeworms from *Gambusia yucatana* belong to the species *Bothriocephalus acheilognathi*. This tapeworm, originally occurring only in East Asia (Yamaguti 1934), has been distributed during last three decades to almost all continents, including America (Riggs and Esch 1987 and others). In Mexico, *B. acheilognathi* has been found in 15 fish species of the families Cyprinidae, Centrarchidae, Atherinidae and Goodeidae from 6 Mexican states (Hidalgo, Jalisco, Michoacán, Tlaxcala and Campeche) – García-Prieto and Osorio-Sarabia (1991).

Notwithstanding a wide distribution of *B. acheilognathi*, its occurrence in fish from a small cenote in the central zone of the Yucatan Peninsula is noteworthy. The only explanation of this finding seems to be man-made introduction of fish infected with the tapeworm into the cenote. This assumption is supported by the fact that local people often introduce small fish, mostly poeciliids, to those cenotes which serve as swimming pools as is the case of the cenote in the village of Homún.

Comparison of the specimens studied revealed that 8 of 11 specimens possessed heart-shaped scolex of a typical appearance (Figs. 1A,B, 2C,D); two tapeworms have the scolex spherical, with contracted bothria and weakly recognisable apical disc (Fig. 1D), which corresponds to *Schyzocotyle fluviatilis* Akhmerov, 1960, a species synonymized with *B. acheilognathi* by Pool and Chubb (1985); the last specimen is characterized by strongly contracted, almost rectangular scolex, with short bothria (Fig. 1E). As documented by Pool and Chubb (1985) and Pool (1986), variation in the scolex morphology of *B. acheilognathi* may be caused by intraspecific variability of the tapeworm and the fixation method.

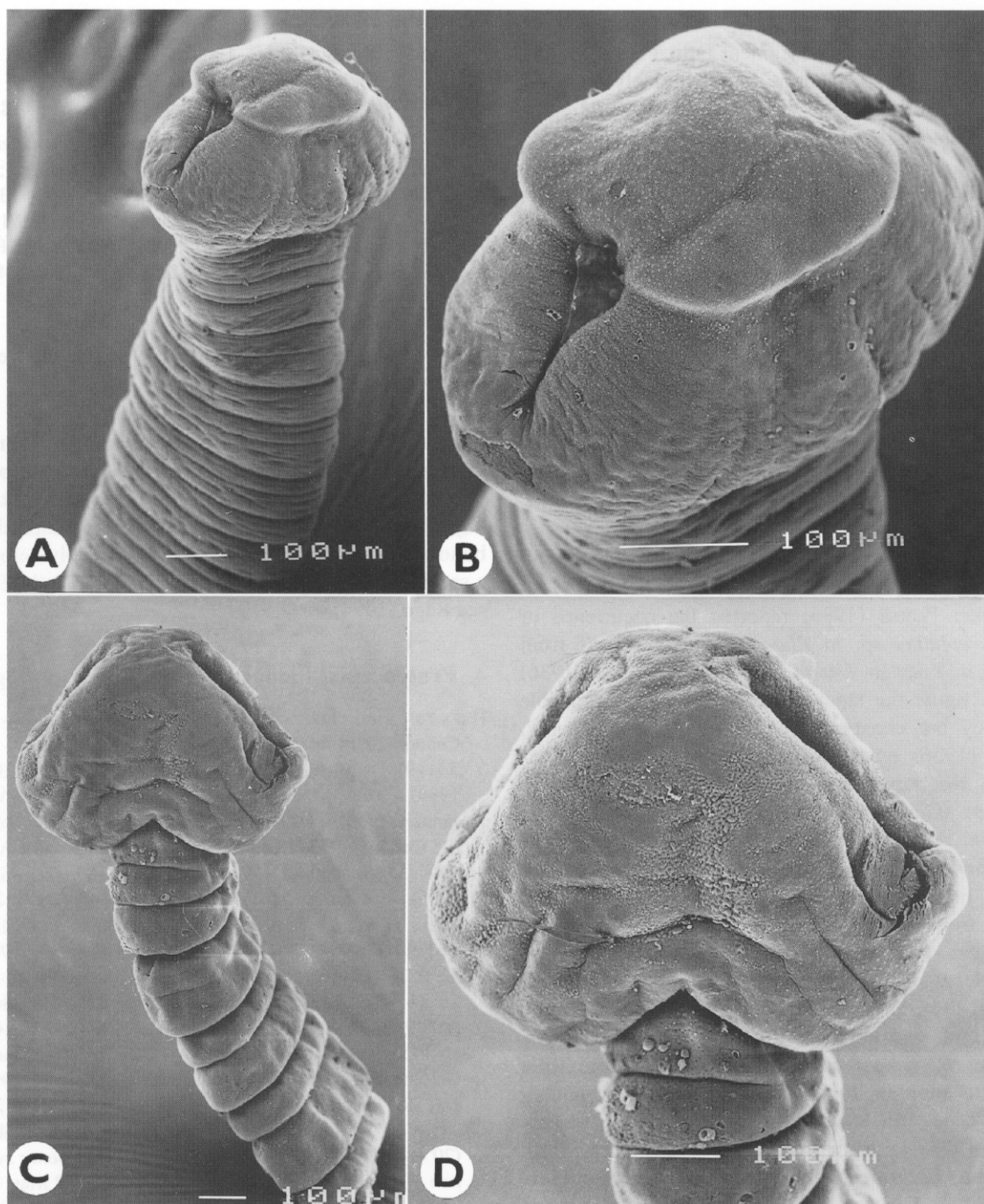


Fig. 2. Scanning electron micrographs of *Bothriocephalus acheilognathi* Yamaguti, 1934 from *Gambusia yucatana*. A, C – total view of the anterior part of the body; B, D – detail of scolex.

## 2. *Bothriocephalus* sp.

Fig. 3

Hosts and localities: *Rhamdia guatemalensis* – Xmucuy (20°33'36"N; 88°59'50"W; 26 October 1993, 16 November 1993) – 2/22; 1.5 (1–2); Zaci (20°41'29"N; 88°11'40"W; 18 April 1994) – 1/3; 2; *Cichlasoma urophthalmus* – Zaci (18 April 1994) – 1/1; 2.

Site of infection: anterior intestine.

Material studied: 3 specimens from *R. guatemalensis* and 2 immature specimens from *C. urophthalmus*.

**Description** (N = 5) (measurements of worms from *C. urophthalmus* in parentheses): Strobila segmented, short, up to 13.2 (12.2) mm long. Scolex elongate, 700–904 × 186–224 (816–880 × 320–352); provided with prominent terminal disc, 166–173 (216–237) wide; disc with two lateral indentations; lateral grooves long, narrow and deep, up to 640 long, bothria weakly developed (Fig. 3B). Neck absent, first segment immediately behind scolex; width of “neck” region 166–173 (154–168). Mature segments (4 in number)

slightly wider than long (segment ratio 1 : 1.07–1.45), 376–592 × 472–568; only one extremely elongate segment slightly longer than wide (ratio 1.03 : 1); gravid segments (15 in number), measuring 264–560 × 472–700; anterior gravid segments slightly wider than long (ratio 1 : 1.09–1.33); posterior segments wider than long (ratio 1 : 1.61–2.44); one gravid segment elongate, longer than wide (ratio 1.14 : 1). Testes numbering 31–37, oval, 25–52 × 22–41, forming two lateral fields along ovary and uterus, confluent between segments. Cirrus sac weakly muscular, oval, situated anterolaterally to ovary. Ovary bilobate, lying near posterior margin of segments; vagina tubular, opening posterior to male pore. Vitelline follicles numerous, oval, arranged in two lateral fields, filling segments between lateral margins and uterus, not transversally connected; field may be confluent between segments. Uterus tubular, slightly sinuous, opening near anterior margin of segments; in gravid segments filled with operculate eggs, 48–55 long and 34–36 wide.

**Remarks:** Pearse (1936) reported the occurrence of *Bothriocephalus* sp. in *Rhamdia guatemalensis* from cenotes in Yucatan. Despite the fact that Pearse (1936) did not figure the tapeworms, it seems very probable that they are conspecific with the present material. Pearse (1936) mentioned that some specialists considered the tapeworms to be conspecific with *B. claviceps* (Goeze, 1782), a specific parasite of eels (*Anguilla* spp.), the others identified the tapeworms from the bagre as *B. scorpii*, a common parasite of marine fish (Protasova 1977). However, the tapeworms from cenotes distinctly differ from the above mentioned taxa, mainly in the scolex morphology. *B. claviceps* has a very long scolex with prominent terminal disc, as wide as the maximum width of the scolex, and two long bothria (Protasova 1977). The scolex of *B. scorpii* has also very long bothria (Rees 1958). In addition, *B. scorpii*, which has considerably larger eggs (66–80 × 43–45 µm according to Protasova 1977) is a marine species. Of other North American *Bothriocephalus* species, *B. formosus* Mueller et Van Cleave, 1932 differs from the present material in the scolex morphology (scolex of *B. formosus* is clavate, lacking a prominent terminal disc and without lateral grooves) and in the medial position of vitelline follicles. *B. cuspidatus* Cooper, 1917 has arrow-shaped scolex, with posteriorly notched bothria (unpubl. data).

Geographical isolation of cenotes where *Bothriocephalus* tapeworms were found supports the assumption that *Bothriocephalus* sp. might be an endemic species, limited in its distribution to the Peninsula of Yucatan as it can be the case of some nematode species quite recently described from cenote fish in the same region (see Moravec et al. 1995a,b).

Family Monticelliidae La Rue, 1911

### 3. *Nomimoscolex* sp.

Fig. 1C

**Host and localities:** *Rhamdia guatemalensis* – Xmucuy (26 October 1993; 25 July 1994) – 2/22; 1; Ixinhá (20°37'14"N; 89°06'40"W; 26 October 1993, 13 June 1994, 22 August 1994, 20 September 1994) – 9/106; 5 (1–16); San Pedro 2 (20°27'27"N; 87°50'04"W; 23 February 1994) – 1/8; 4; Sacamucuy (20°33'33"N; 88°59'49"W; 31 January 1995) – 1/6; 1.

**Site of infection:** intestine.

**Material studied:** 29 specimens from *R. guatemalensis*.

**Remarks:** The adult tapeworms from the bagre *R. guatemalensis* will be described in a separate paper. Their morphology as shape of the scolex and suckers – Fig. 1C, position of vitelline follicles and their distribution, etc., indicates that they most probably belong to a species of the genus *Nomimoscolex* Woodland, 1934 – see Rego (1994).

### 4. *Proteocephalidea* gen. sp. larvae

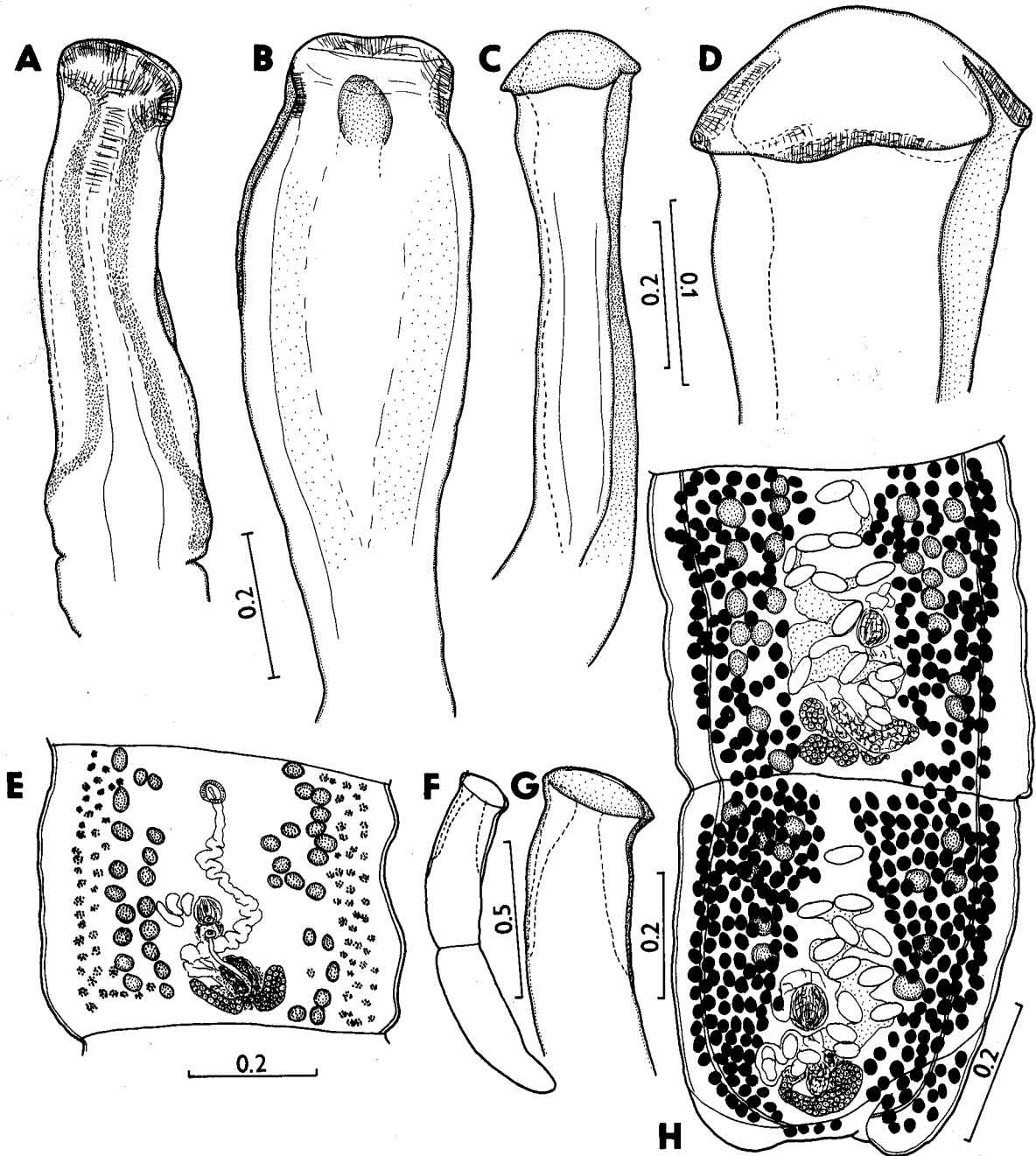
Fig. 1F

**Hosts and localities:** *Astyanax fasciatus* – Gran Cenote (20°14'44"N; 87°27'54"W; 25 April 1994) – 2/18; 5 (1–9); Dzibilchaltún (21°05'28"N; 89°38'55"W; 13 May 1994) – 1/8; 5; Dos Bocas (17°54'38"N; 88°51'20"W; 26 January 1995) – 1/17; 1; *Rhamdia guatemalensis* – Ixinhá (26 October 1993, 13 June 1994; 11 July 1994, 22 August 1994, 20 September 1994, 17 October 1994, 31 January 1995) – 44/106; 32 (1–165); Scan Yui (20°40'20"N; 88°32'51"W; 25 January 1994) – 3/16; 33 (3–92); San Pedro 1 (20°27'27"N; 87°50'04"W; 23 February 1994) – 4/11; 36 (13–56); San Pedro 2 (23 February 1994) – 4/8; 25 (1–90); Zaci (18 April 1994) – 1/4; 11; Hubiku (20°49'79"N; 88°10'21"W; 18 April 1994) – 12/16; 37 (1–195); Xmucuy (25 July 1994) – 2/22; 1; Sacamucuy (10 October 1994) – 1/6; 1; Dos Bocas (26 January 1995) – 1/1; 5; *Poecilia petenensis* – Box Toro (20°16'27"N; 87°29'09"W; 12 May 1994) – 1/2; 1; *P. velifera* – Sahkaba (20°48'41"N; 88°07'27"W) – 1/17; 1; *Cichlasoma synspilum* – Framboyán (20°08'16"N; 87°34'38"W; 8 May 1994) – 3/3; 7 (1–11); *C. urophthalmus* – Zaci (18 April 1994) – 1/9; 102.

**Site of infection:** mesentery, intestinal wall, body cavity.

**Material studied:** 5 specimens from *R. guatemalensis*.

**Description** (N = 5): Larvae oval, cyst 400–592 long and 344–432 wide. Body surface covered with dense microtriches. Scolex almost rectangular, 192–250 × 173–202. Lateral suckers oval, 65–79 long and 44–75 wide, strongly muscular, with prominent rim in posterior part (Fig. 1F); apical organ spherical, difficult to observe in some specimens, in form of granular mass,



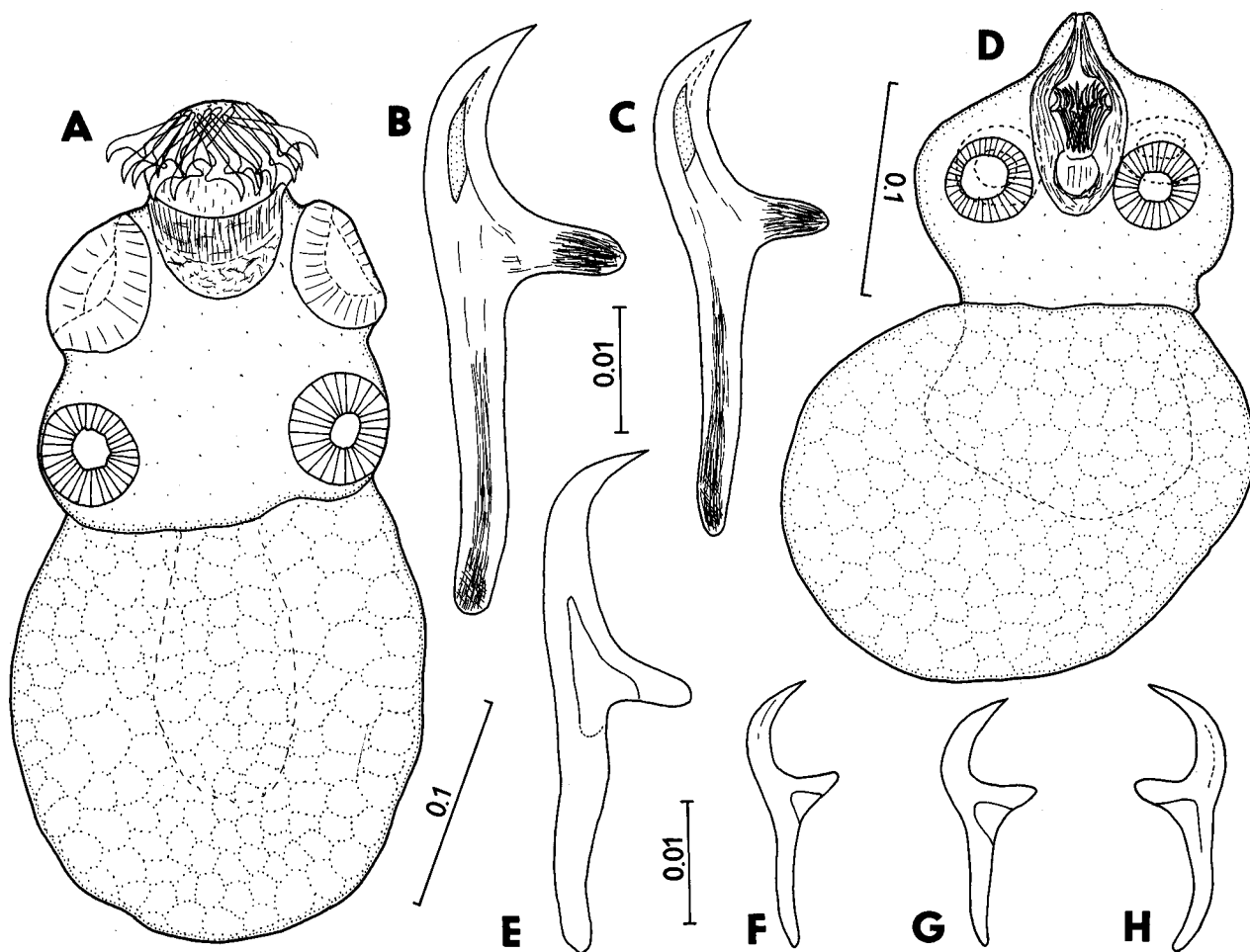
**Fig. 3.** *Bothriocephalus* sp. from *Rhamdia guatemalensis* (A, C–H) and *Cichlasoma urophthalmus* (B). A–D, G – scolices; E – mature proglottis; F – juvenile tapeworm; H – gravid proglottides. Scale bars in millimetres (mm).

53–58 × 46–54 in diameter. Numerous calcareous corpuscles scattered throughout body.

**Remarks:** These larvae apparently belong to the order Proteocephalidea. In some morphological features (the structure of lateral suckers, which are provided with a prominent rim in the posterior part, shape of the scolex) the larvae are similar to adults of *Nomimoscolex* sp. This similarity, together with simultaneous occurrence of larvae and adults of *Nomimoscolex* sp. in some cenotes (Ixim-há, Xmucuy, Sacamucuy, San Pedro 2),

strongly supports the assumption of the identity of both the forms. However, the larvae possess an apical organ, which is considerably larger than that of *Nomimoscolex* sp. adults (diameter 23–43 μm, unpubl. data). The identity of these larvae with adults from *R. guatemalensis* could only be confirmed by experimental infections.

The bagre *R. guatemalensis* apparently serves as a principal second intermediate host of the larvae as indicated by high values of prevalence and intensity of infection of this fish. Moravec and Baruš (1971) found



**Fig. 4.** *Dendrouterina pilherodiae* Mahon, 1956 larv. (A–C) and *D. papillifera* (Fuhrmann, 1908) larv. (D–F) from *Rhamdia guatemalensis*. A, D – total view; B, E – larger rostellar hooks; C, F–H – smaller rostellar hooks. Scale bars in millimetres (mm).

larvae (“cysticeroids”), designated as Proteocephalidae gen. sp., in the body cavity of *Cichlasoma tetracantha* and *Cubanichthys cubensis* in Cuba. The larvae are morphologically and biometrically very similar to those found in *R. guatemalensis*. The authors considered the larvae to belong probably to the genus *Ophiotaenia* La Rue, 1911 or *Proteocephalus* Weinland, 1858.

Family Dilepididae Fuhrmann, 1907

**5. *Dendrouterina pilherodiae* Mahon, 1956 larv.**  
Fig. 4A–C

Host and locality: *Rhamdia guatemalensis* – Ixinhá (22 August 1994) – 1/106; 1.

Site of infection: gall bladder.

Material studied: 1 specimen from *R. guatemalensis*.

**Description** (N = 1): Body small, 403 long and 192 wide, divided into scolex and hindbody. Scolex rec-

tangular,  $198 \times 166$ , with four suckers,  $55\text{--}65 \times 52\text{--}55$ , and rostellum,  $102 \times 72$ , armed with 20 hooks arranged in two circles of 10 hooks each. Rostellar hooks slightly differing in shape and size; larger hooks 48–49 long (N = 5), with weakly curved blade, 19–20 long, and almost straight handle, 31–33 long; blade/handle ratio 0.59–0.63; smaller hooks more concave, 40–45 long (blade 14.5–16; handle 26–32; blade/handle ratio 0.45–0.62). Hindbody oval,  $224 \times 192$ ; neck 141 wide.

**Comments:** The larva studied is similar, mainly in the shape and number of rostellar hooks, to the dilepidid *Dendrouterina pilherodiae* described from *Nycticorax pileatus* from Brazil by Mahon (1956). There is only slight difference in the size of rostellar hooks, which are larger in the present material (48–49 in distal and 40–45 in proximal hooks versus 42 and 38 in *D. pilherodiae*). The only preserved scolex of *D. pilherodiae* (holotype), however, is in rather poor conditions with most rostellar hooks lacking (see Bona 1975 – pp. 39–40).

Somewhat later, Bona (1983) redescribed the species on the basis of material from Argentina and provided

some biometrical observations. He found the length of hooks in specimens from Argentina to be distinctly larger (distal hooks 52–56 and proximal hooks 45–49 long) than that of the holotype and also the present material. On the basis of these differences, Bona (1983) described a new subspecies, *D. pilherodiae meridionalis* for material found in Argentina. Mexican specimen represents an intermediate form, indicating that hooks of *D. pilherodiae* are extremely variable in size (but not in their shape) up to 28–29 % above the minimum size (F. V. Bona – pers. comm.). Size of rostellar hooks in the specimen from *R. guatemalensis* also casts doubts about the validity of the subspecies *D. pilherodiae meridionalis*. Measurements of hooks of adult worms from Mexico would be of a great interest for supporting this assumption.

The present finding is the first report of the second-stage larva of *D. pilherodiae*.

#### 6. *Dendrouterina papillifera* (Fuhrmann, 1908)

larv.

Fig. 4D–H

Host and localities: *Rhamdia guatemalensis* – San Pedro 2 (23 February 1994) – 1/8; 1; Ixin-há (13 June 1994; 22 August 1994; 31 January 1995) – 4/106; 1 (1–2).

Site of infection: gall bladder.

Material studied: 4 larvae from *Rhamdia guatemalensis*.

**Description** (N = 4; measurements of two specimens fixed under a slight coverslip pressure in ammonium-picrate in parentheses): Body small, 291–319 long and 179–221 wide (872–912 × 232–288), divided into scolex and hindbody. Scolex almost spherical, measuring 109–134 × 147–157 (320–376 × 280–312), with four suckers, 40–48 long and 40–43 wide (75–93 × 70–81), and rostellum, measuring 59–65 × 36–43 (89–95 × 50–59), armed with two circles of 20 hooks (10 in one circle). Rostellar hooks markedly differing in shape and size; distal hooks 38–43 long (N = 8; hooks from several scolices measured), with almost straight handle, 21–24.5 long, and slightly curved blade, 16–19.5 long; blade/handle ratio 0.70–0.89; proximal hooks more concave, 21–23 long (N = 8), with weakly curved handle, 13–16 long, and sharply curved blade, 8–9 long; blade/handle ratio 0.48–0.69. Hindbody widely oval, 182–186 long and 179–221 wide (520–544 × 232–288); neck 110–129 (147–150) wide.

**Remarks:** The hook morphology (number of hooks, their shape and size) clearly indicates the conspecificity of the larvae from *Rhamdia guatemalensis* with the species *Dendrouterina papillifera* (Fuhrmann, 1908) (syn. *Dilepis hillii* Polk, 1941 according to Bona 1975), an intestinal parasite of *Hydranassa coerulea* (L.) in Brazil, USA and Cuba (Ryšavý and Macko 1973, Bona 1975).

Bona (1975) found great differences in the measurements of rostellar hooks presented by individual authors: length of larger hooks from 42–50, that of smaller hooks 12.5–27 (!). He stated that these differences are caused by inaccurate measuring by individual authors rather than by intraspecific variability. On the basis of the examination of type material and reference specimens, Bona (1975) found length of hooks being 42–43 and 27 in material from the USA and 44–44.5 and 28.5–29.5 in cestodes from Cuba collected by Ryšavý and Macko (1973). This agrees more or less with the present data for distal hooks; smaller hooks in the larvae from Yucatan are distinctly shorter (21–23), however, not as short as 12.5. This difference probably represents an intraspecific variability as documented above in the comparison of Mexican material of *D. pilherodiae* with that from Brazil and Argentina. Variability in hook size can also reflect the fact that the present material consists of the larvae from fish, not from the definitive host.

The larvae in *R. guatemalensis* represents a new geographical record of *D. papillifera* from Mexico and the first report of second-stage larva of the parasite from the fish intermediate host.

## ACANTHOCEPHALA

Family Neoechinorhynchidae Ward, 1918

### 1. *Octospiniferoides chandleri* Bullock, 1957

Fig. 5C–G, L, M

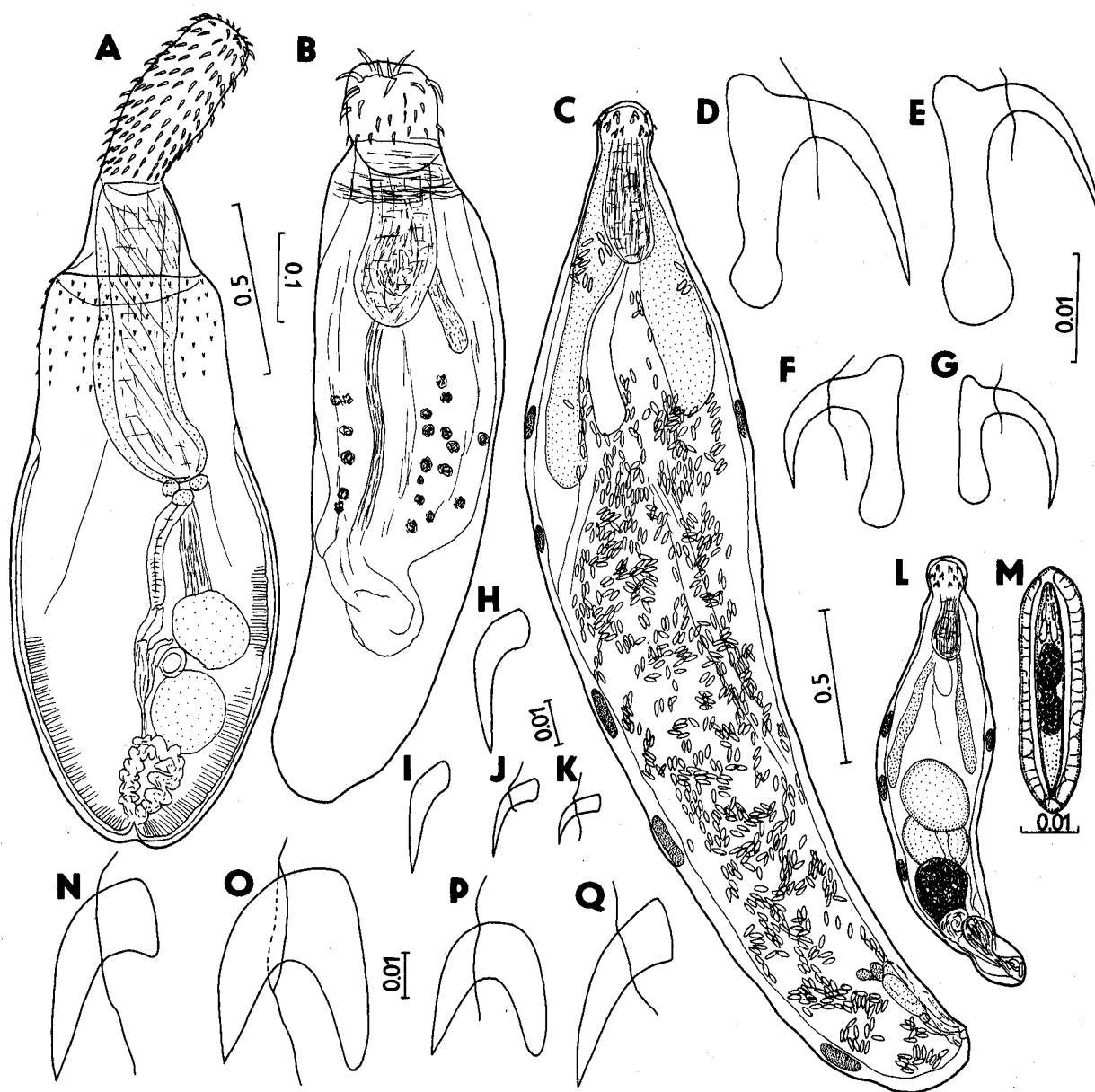
Host and locality: *Cichlasoma friedrichstahli* – Cenote Azul (Puerto Aventuras) (geographical position not measured; 23 February 1994) – 1/3; 5.

Site of infection: middle part of intestine.

Material studied: 2 males and 3 females from *C. friedrichstahli*.

**Description:** Body small; trunk short, maximum width at level of ventral giant cell, posterior end slightly curved ventrally. Giant hypodermic nuclei 5 dorsal and 1 ventral. Proboscis short, spherical, armed with three circles of 8 hooks in each (total of 24 hooks). Hooks slender, sharply pointed, with prominent, posteriorly directed roots and stubby anterior manubria. Lemnisci almost equal, slender.

**Male** (N = 2): Trunk 1.08–1.17 mm long, 309–382 wide. External presoma 91–121 long and 101–130 wide; proboscis measuring 65–86 × 85–119; proboscis receptacle 169–343 long and 104 wide. Apical hooks with blade 16–18 long and 3 wide, roots 14 long; median hooks 15–16 long and 3 wide, roots 12; basal hooks with blade 13 and roots 9.5 long. Neck 117. Lemnisci two times longer than proboscis. Testes double, overlapping one another; anterior testis



**Fig. 5.** *Polymorphus brevis* (Van Cleave, 1916) larv. from *Cichlasoma synspilum* (A, N-Q); Echinorhynchidae gen. sp. larv. from *Astyanax fasciatus* (B, H-K); *Octospiniferoides chandleri* Bullock, 1957 from *Cichlasoma friedrichstahli* (C-G, L-M). A-C, L - total views; D, H, N - apical hooks; E, I, O-P - median hooks; F-G, J-K, Q - basal hooks; M - egg (inner shell with embryo). Scale bars in millimetres (mm).

130-238 × 169-178; posterior testis 208 × 149-215. Cement gland syncitial, overlapping posterior testis, 122-260 × 95-234.

**Female** (N = 3): Trunk 1.10-2.70 mm long and 314-592 wide; external presoma measuring 103-129 × 109-159; proboscis 81-103 long and 104-148 wide; proboscis receptacle measuring 282-330 × 97-117. Apical hooks with blade 21.5-22.5 and root 21-21.5 long; median hooks 16-18 and 20-21.5; basal hooks 12-13 and 14-16 long; width of blade 3.

Neck 72 long and 104-160 wide. Genital pore subterminal. Eggs slender, 39-45 × 10-14 in size (in permanent mounts - Fig. 5M).

**Remarks:** The specimens studied resemble *Octospiniferoides chandleri* by the size of sharply pointed hooks with prominent roots on the globular proboscis and arranged in three circles of a total of 24 hooks. This acanthocephalan was described by Bullock (1957) from *Fundulus grandis* and redescribed by the same author (Bullock 1966) from cyprinodontiform fish (*Gambusia*

*affinis*, *Lucania parva*, *Heterandria formosa* and *Chirops affinis*) from Florida and Louisiana (USA). There is only a slight difference between Bullock's specimens and those from Yucatan in the size of proboscis, which is somewhat smaller in the former specimens (41–61 in males and 43–90 in females after Bullock 1966). Bullock (1966) reported eggs of *O. chandleri* to measure 78–95 × 11–16, which is much more than in the present material. However, it is apparent that outer membrane (thin-walled outer shell) covering fluid-filled space was not preserved in the specimens from Yucatan and it was probably destroyed during processing (staining and dehydration). Bullock (1966) measured the eggs in saline or in formalin before their processing. The size of inner shell is almost identical between worms from *C. friedrichstahli* (39–45 × 10–14 – Fig. 5M) and those measured by Bullock (1966) (38–48 × 8–14).

Salgado-Maldonado (1991) reported the occurrence of *O. chandleri* in *Heterandria bimaculata* from Mexico. DeMont and Corkum (1982) studied the life cycle of *O. chandleri* and found the ostracods, *Cypridopsis vidua* and *Physocypria pustulosa*, to serve as intermediate hosts. The cichlid *Cichlasoma friedrichstahli* is a new definitive host of *O. chandleri*.

## 2. *Neoechinorhynchus golvani* Salgado-Maldonado, 1978

Host and locality: *Cichlasoma urophthalmus* – Chen-há (20°54'06"N; 88°44'50"W; 27 June 1994) – 3/41; 1.

Site of infection: intestine.

Material studied: 3 specimens from *Cichlasoma urophthalmus*.

**Remarks:** The specimens from *C. urophthalmus* morphologically correspond to those of *Neoechinorhynchus golvani*, a species described from the intestine of *Cichlasoma aureum* from south-eastern Mexico (Salgado-Maldonado 1978, 1985). Consequently, neither description nor figures of the specimens found in cenote fish are provided in the present paper.

Salgado-Maldonado, Pineda-López and Vidal-Martínez (unpubl. data), reviewing helminth parasites of cichlid fish in Mexico, reported 12 species of *Cichlasoma* and *Petenia splendida* as definitive hosts of *N. golvani*.

Family Echinorhynchidae Cobbold, 1876

## 3. *Echinorhynchidae* gen. sp. larva Fig. 5B, H–K

Host and locality: *Astyanax fasciatus* – Gran Cenote (25 April 1994) – 2/18; 1.

Site of infection: mesentery.

Material studied: 1 specimen from *A. fasciatus*.

**Description:** (N = 1) Body covered with thin-walled, hyaline sheath; cyst 720 long and 218 wide; trunk elongate, in posterior part contracted, measuring 552 × 218. Proboscis short, spherical, partly invaginated, 108 long and 106 wide, armed with probably 12 irregular rows of 4 fine hooks each (proboscis partly invaginated). Hooks slender, slightly curved; length of hooks as follows (from presumably apical hooks to basal hooks): 23–24; 21.5–22.5; 15.5–17; 11–13.5 long. Proboscis receptacle elongate, 186 long and 77 wide; lemnisci and other internal organs difficult to observe.

**Remarks:** The morphology of the larva, mainly a large number of hooks and their rows (12) as well as their shape, indicates its probable appurtenance to a species of the family Echinorhynchidae Cobbold, 1879. However, more precise identification is not possible due to the fact that the larva does not possess well developed organs. In addition, the proboscis is partly invaginated, which makes impossible to precisely count the number of hooks and their arrangements in the anterior end of files.

Family Polymorphidae Meyer, 1931

## 4. *Polymorphus brevis* (Van Cleave, 1916)

Fig. 5A, N–Q

Syn.: *Arhythmorhynchus brevis* Van Cleave, 1916 – see Amin (1992).

Host and locality: *Cichlasoma synspilum* – Los Cuates (17°55'00"N; 88°53'00"W; 5 April 1994) – 1/1; 1.

Site of infection: intestinal wall.

Material studied: 1 specimen from *C. synspilum*.

**Description:** (N = 1). Trunk cylindrical, wider posteriorly, 2,416 long and 750 wide, covered with thick tegument, finely striated in posterior third. Trunk elongate, 1,870 long, with single anterior field of small tegumental spines, arranged in irregular rows of mostly 4–6 (maximum 8) spines each spines decreasing in size posteriorly, from 8.5 long in neck region to 5.5 posteriorly. Neck 186 wide; proboscis cylindrical, 520 long and 240 wide, armed with 18 longitudinal rows of at least 14 hooks (distal part of proboscis invaginated). Observed anterior hooks slender, slightly curved; medial hooks (6 in each row) more massive, with strongly developed roots; posterior hooks (6 in number) less developed, subtle, without roots. Size of hooks (listed from posterior hooks) as follows: 37–49; 43–46; 43–48; 44–50; 48–49; 46–48; medial hooks: 36–37 (length of blade) and 35–40 (length of root); 44–48 and 43–48; 46–49 and 41–45; 46 and 40; 49 and 40. Proboscis receptacle elongate, 853 long and 240 wide.

Primordia of gonads located in posterior part of trunk weakly developed.

**Remarks:** The larva (cystacanth) found in the intestinal wall of *Cichlasoma synspilum* corresponds in its morphology, including the shape and size of the proboscis, and the arrangement and size of hooks, to the species *Polymorphus brevis* (Ryzhikov et al. 1985, Amin 1992). This species was originally described as *Arhythmorhynchus brevis* but Amin (1992) transferred it to the genus *Polymorphus* Lühe, 1911.

This acanthocephalan is a parasite of fish-eating birds, e.g. *Botaurus lentiginosus*, *Egretta intermedia*, *Ardea herodias*, *Nycticorax nycticorax*, *Bubulcus ibis* and *Pandion haliaetus*; it occurs in North America and China (Petrochenko 1958, Ryzhikov et al. 1985). In Mexico, *P. brevis* (reported as *Arhythmorhynchus brevis*) seems to be a rather common parasite. Pérez-Ponce de León et al. (1992) found cystacanths of *P. brevis* in the mesentery of the bagre *Rhamdia guatemalensis* from Lago de Catemaco, Veracruz; the authors also reviewed unpublished findings of *P. brevis* larvae and adults in Mexico and reported five species of fish and two species of amphibians to harbour larvae of this acanthocephalans. Two bird species, namely *Nycticorax nycticorax* and *Egretta thula* from Lago de Pátzcuaro, were found as definitive hosts of this parasite (Salgado-Maldonado 1980, Osorio-Sarabia et al. 1986, Pérez-Ponce de León et al. 1992). In addition to these data, Peresbarbosa-Rojas et al. (1994) found *A. brevis* larvae in the mesentery and musculature of *Allophorus robustus* and *Neophorus diazi* (Goodeidae) from Pátzcuaro (Michoacán).

## DISCUSSION

The study on fish parasites from cenotes in the Yucatan Peninsula revealed the presence of six species of cestodes and four species of acanthocephalans. Of these, five species (three cestodes and two acanthocephalans) parasitized fish as adults, five species (three tapeworms and two acanthocephalans) as larvae. The number of species found is fairly low compared with the richness of the fauna of nematodes (9 species of adults and 9 of larvae) and, in particular, that of trematodes (10 species of adults and 22 of metacercariae). Nevertheless, similar proportion of endohelminths with dominance of trematodes and nematode species has also been reported in Mexico, e.g., by Osorio-Sarabia et al. (1986, 1987), Pérez-Ponce de León et al. (1992), Salgado-Maldonado (1993), Peresbarbosa et al. (1994). In addition to a low number of species found, both tapeworms and acanthocephalans occurred only sporadically, which contrasts with nematode and trematode infections, where prevalence was high in several species and values of intensity of infection reached up to hundreds of

parasites, as it was in some trematode metacercariae in cenote fish (see Scholz et al. 1995b).

With the exception of *Bothriocephalus acheilognathi*, which was found in *Gambusia yucatana*, all other tapeworms were recorded in the bagre, *Rhamdia guatemalensis*. The species *Bothriocephalus* sp. may well represent a new, hitherto undescribed species, limited in its occurrence to cenotes in the central zone of the Yucatan Peninsula. Dilepidid larvae, found in the gall bladder of the bagre, are wide-spread parasites, which do not seem to exhibit a narrow specificity to their fish intermediate hosts.

Of acanthocephalans, only *Neoechinorhynchus golvani* can be considered as a specific parasite of cichlid fish (Salgado-Maldonado 1978). Other species parasitize fish as larvae or they occur in fish of different families.

From the zoogeographical point of view, the fauna of cestodes and acanthocephalans of cenote fish is composed of different components. The species found can be considered as cosmopolitan parasites (*B. acheilognathi*, *Dendrouterina papillifera*), or they are distributed in central and northern Mexico and southern USA (*Octospiniferoides chandleri*, *N. golvani*, *Polymorphus brevis*); Neotropical elements are represented by the tapeworms *Nomimoscolex* sp., and *Dendrouterina pilherodiae*. Zoogeographical distributions of *Bothriocephalus* sp. and proteocephalidean larvae remain unclear due to uncertain taxonomy of these taxa. Compared with the fauna of nematodes and trematodes (Moravec et al. 1995a,b, Scholz et al. 1995a,b), the proportion of Neotropical compounds in the fauna of cestodes and acanthocephalans is considerably lower.

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