

## Some helminth parasites from Morelet's crocodile, *Crocodylus moreletii*, from Yucatan, Mexico

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**Abstract.** An examination of three specimens of the Morelet's crocodile, *Crocodylus moreletii* Duméril et Bibron, from the Lagoon of Celestún, Yucatan, Mexico revealed the presence of the following eight helminth species: *Acanthostomum americanum* (Pérez Vigueras, 1956), *Pelaezia loossi* (Pérez Vigueras, 1956), *Telorchis* sp. juv., *Pseudoneodiplostomum groschafii* sp. n. (all trematodes), *Dujardinascaris helicina* (Molin, 1860), *Contracaecum* sp. Type 2 larvae, *Micropleura* sp. and *Paratrichosoma recurvum* (Solger, 1877) (all nematodes). *Pseudoneodiplostomum groschafii* sp. n. is established by indication based on the description of specimens from *Crocodylus rhombifer* from Cuba, given by Groschaf and Baruš (1970). *Acanthostomum acuti* Caballero et Brennes, 1959 is considered a synonym of *A. americanum*. *A. americanum* and *D. helicina* are recorded for the first time from Mexico and *Micropleura* sp. is the first American representative of the genus recorded outside South America. Findings of *A. americanum*, *Telorchis* sp., *P. groschafii*, *D. helicina* and *Micropleura* sp. in *C. moreletii* represent new host records. Some observations on the early development of *D. helicina* are provided. All species, except for *P. recurvum*, are briefly described and illustrated and some problems concerning their morphology, taxonomy and geographical distribution are discussed.

The Morelet's crocodile, *Crocodylus moreletii* Duméril et Bibron, is one of the two *Crocodylus* species occurring in the tropical zone of Mexico. It is distributed at low elevations on the Gulf and Caribbean slopes in Guatemala, Belize and southeastern Mexico (Yucatan Peninsula), primarily inhabiting freshwater lakes, rivers and ponds, but also entering brackish waters (Lee 1996); the geographical distribution of the second species, the American crocodile *C. acutus* Cuvier, is wider.

The helminth fauna of crocodiles in Mexico is poorly known and only few data on the helminth parasites of *C. moreletii* have been published to date (Caballero 1948, Thatcher 1964); the most recent study is that by García-Reynoso (1991), who examined six *C. moreletii* from Veracruz and Tabasco, but her thesis has remained unpublished. Salgado-Maldonado and Aguirre-Macedo (1991) used a small *C. moreletii* specimen originating from Celestún, Yucatan for their successful experimental infection with the metacercariae of *Pelaezia loossi* (Pérez Vigueras, 1956) from naturally infected fish, *Cichlasoma urophthalmum* (Günther).

In 1994, three specimens of *C. moreletii* collected from the Lagoon of Celestún, Yucatan were examined for the presence of metazoan parasites and the results of the study of helminths are presented below.

### MATERIALS AND METHODS

During September and November of 1994, three young Morelet's crocodiles, *Crocodylus moreletii* Duméril et Bibron, 1851 (total body length 101-119 cm), were collected by local fishermen from the coastal lagoon of Celestún (Ría Celestún Special Biosphere Reserve; 20°51'N, 90°23'W), Yucatan, Mexico, on the basis of permission [number A00.-700.-(2) 03300] given to the author by the Dirección General de Aprovechamiento Ecológico de los Recursos Naturales, Instituto Nacional de Ecología, SEDESOL, Mexico. The animals were transported alive to the Laboratory of Parasitology, CINVESTAV-IPN, in Mérida, where they were immediately anaesthetised with chloroform in barrels and subsequently killed and examined for metazoan parasites.

Helminth parasites were fixed in 4% formalin. Trematodes were stained in carmine, dehydrated through an ethanol series and mounted in Canada balsam as permanent slides. For examination, nematodes were cleared in glycerine. Drawings were made with the aid of a Zeiss microscope drawing attachment. For scanning electron microscopy (SEM), the nematodes were post-fixed in 1% osmium tetroxide, dehydrated through an ethanol series and acetone, and then subjected to critical point drying. The specimens were coated with gold and examined with a JSM-6300 scanning electron microscope at an accelerating voltage of 15 kV. All measurements are given in millimetres. The specimens have been deposited in the National Helminthological Collection of the Institute of Biology, National Autonomous University of Mexico (UNAM), in Mexico City and in the Helminthological Collection of the Institute of Parasitology, Academy of Sciences of the Czech Republic (ASCR), in České Budějovice.

## RESULTS

### TREMATODA

#### Fam. Acanthostomidae Poche, 1925

*Acanthostomum americanum* (Pérez Vigueras, 1956) Fig. 1 A-E  
Syn. *Acanthochasmus americanus* Pérez Vigueras, 1956; *Acanthostomum acuti* Caballero et Brenes, 1959.

**Description** (based on 20 specimens): Body of gravid specimens elongate, 1.589-3.371 long, maximum width 0.517-0.666. Surface of body covered with fine spines, these being more distinct and more numerous on anterior portion of body; spines appearing to be absent from posterior quarter of body. Oral sucker terminal, funnel-shaped, 0.245-0.313 long and 0.299-0.340 wide. Outer surface of sucker armed with row of 20 large, simple peribuccal spines 0.063-0.072 long. Ventral sucker circular, size 0.150-0.190 × 0.150-0.204, situated approximately at 1/3 of body length. Ratio of oral and ventral suckers 1 : 0.55-0.63. Prepharynx present, very short, sometimes indistinct due to state of worms during fixation. Pharynx large, oval, strongly muscular, 0.163-0.177 long and 0.150-0.190 wide. Oesophagus relatively short and wide, measuring 0.122-0.136 in length. Intestinal branches run along body to caudal end, opening there to body surface by two distinct sublateral anal pores; intestinal bifurcation in front of ventral sucker. Seminal vesicle posterior to ventral sucker. Small slit-like ventral pit present. Testes tandem or slightly diagonal, located near posterior end of body and with smooth outline, being of irregular rounded shape, usually oval or transversely oval. Size of anterior testis 0.150-0.231 × 0.313-0.354, that of posterior testis 0.190-0.299 × 0.299-0.326. Ovary transversely oval, smaller than testes, measuring 0.122-0.177 × 0.190-0.299, situated just anterior to anterior testis. Seminal receptacle near posterior margin of ovary. Uterus filling space delimited by ovary, ventral sucker and vitellaria. Genital pore median, just in front of ventral sucker. Mature eggs yellow-brown, oval, measuring 0.027-0.033 × 0.012-0.015. Vitellaria follicular, situated on sides of posterior half of body, initiating just posterior to end of seminal vesicle and extending posteriorly to anterior part of anterior testis. Excretory vesicle opening by median pore on posterior end of body.

**Site of infection:** Anterior part of intestine.

**Prevalence and intensity:** In all 3 crocodiles (100%), 1-182 (mean 61) specimens.

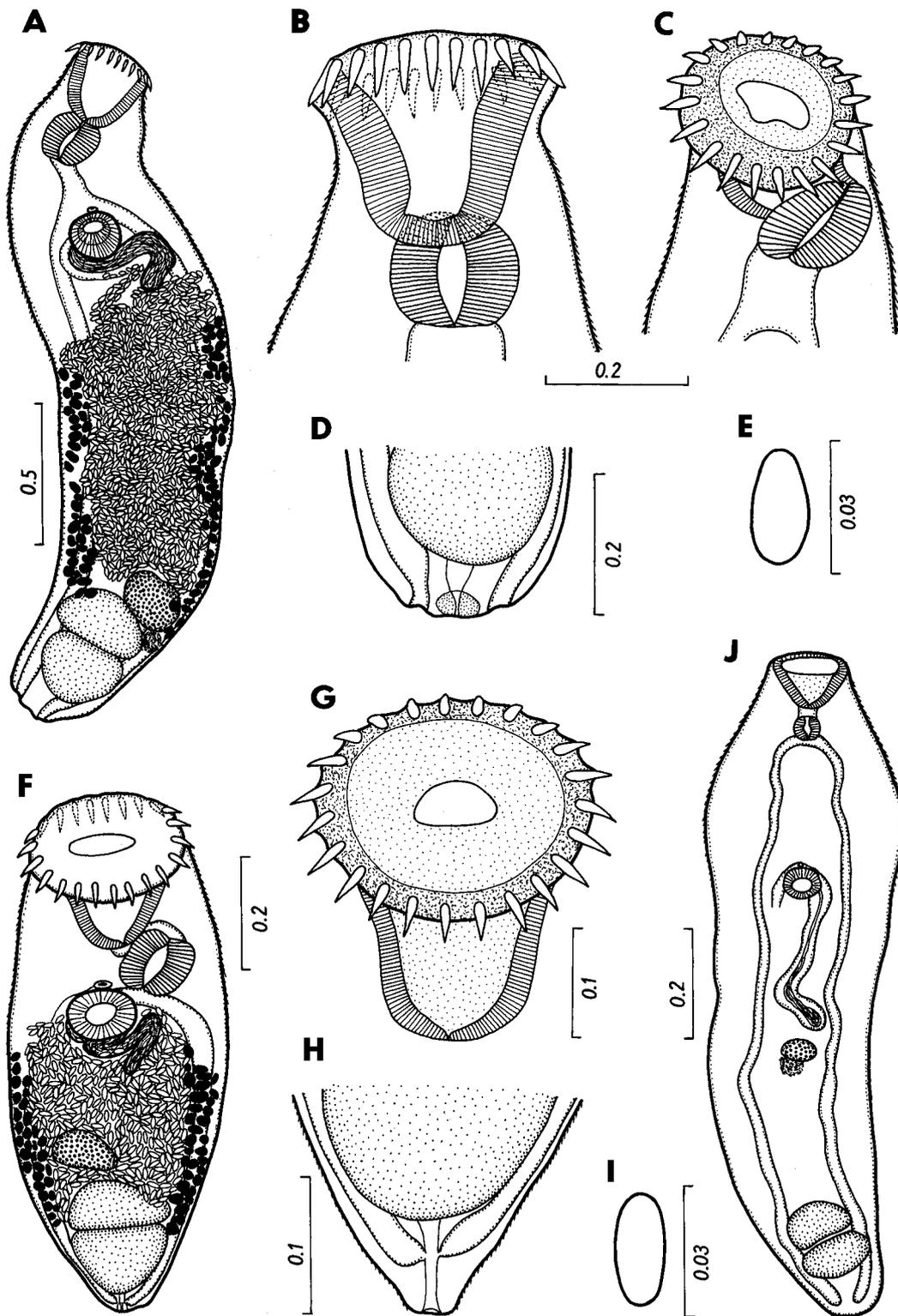
**Comments:** The taxonomy of acanthostomatid trematodes seems to be rather confused, especially as to the delimitation of genera. Although there were several attempts to solve this problem (e.g., Yamaguti 1971, Nasir 1974, Brooks 1980, Lamothe-Argumedo and Ponciano-Rodríguez 1986), the unsatisfactory situation in this group of trematodes remains to date.

The type genus of the Acanthostominae, *Acanthostomum*, comprising intestinal parasites of fishes and reptiles (mainly crocodilians), was created by Looss (1899) for the species *A. spiniceps* (Looss, 1896) and *A. coronarium* (Cobbold, 1861) and the former was designated as its type species. According to the generic diagnosis, the intestinal branches of these trematodes were bluntly ended. However, it is apparent that the anal pores at the posterior extremity of *A. spiniceps* were overlooked by Looss (1899), because subsequent studies (Khalil 1963, Fischthal and Kuntz 1963, Moravec 1976) showed their presence. Moravec (1976) mentioned the presence of intestinal pores as a possible generic feature of *Acanthostomum*.

But many authors (e.g., Caballero 1955, Yamaguti 1971, Nasir 1974, Brooks 1980) did not pay attention to the structure and the character of intestinal branches in acanthostomines and Nasir (1974) not only listed all these forms with differently structured intestines in a single genus *Acanthostomum*, but he even incorrectly reduced the number of *Acanthostomum* (*Acanthostomum*) species to *A. imbutiforme* (Molin, 1859) in the Old World and *A. scyphocephalum* (Braun, 1899) in the New World. Brooks (1980) made a detailed analysis of the Acanthocephalinae, recognising and re-diagnosing several genera in it, but he used evidently unsuitable morphological characters to distinguish the genera (see also Lamothe-Argumedo and Ponciano-Rodríguez 1986).

The most recent attempt to revise acanthostomine trematodes is that by Lamothe-Argumedo and Ponciano-Rodríguez (1986), who based their system of eight genera principally on differences in the structure of the digestive tract. Unfortunately, in contravention of the International Code of Zoological Nomenclature, they transferred the type species of *Acanthostomum*, *A. spiniceps*, to another genus *Proctocaeum* Baugh, 1956, and determined *A. imbutiforme* (Molin, 1859) as a new type species of *Acanthostomum* (!), by which the species without anal pores were again incorrectly listed in the latter. Nasir (1974) considered *A. spiniceps* a synonym of *A. imbutiforme*, but these are evidently two different species (Moravec 1976).

The purpose of this paper is not a revision of the Acanthostominae, but it is clear that the above-described trematodes from *C. moreletii* belong to the genus *Acanthostomum*. Their morphology shows that they can be assigned to the species *A. americanum*, as was described for example by Groschaft and Baruš (1970) (reported as *Atrophecaecum americanum*) or Brooks (1980). *Acanthostomum acuti* Caballero et Brenes, 1959, reported from *Crocodylus acutus* Cuvier in Costa Rica and *C. rhombifer* Cuvier in Cuba, is undoubtedly its junior synonym. Brooks (1980) re-erected, based evidently on unsuitable features, the genus *Caimanicola* Freitas et Lent, 1938 (now considered a synonym of *Acanthostomum*) and regarded *A. acuti* a synonym of the South American species *C.* (= *A.*)



**Fig. 1.** A-E – *Acanthostomum americanum* (Pérez Viguera, 1956) (A – general view; B, C – oral sucker, lateral and subapical views; D – region of posterior end; E – shape of egg). F-I – *Pelaezia loossi* (Pérez Viguera, 1956) (F – general view; G – oral sucker, subapical view; H – region of posterior end; I – shape of egg). J – *Telorchis* sp. juv.

*marajoara* Freitas et Lent, 1938. However, until a new detailed comparison of *A. americanum* from Central American crocodiles and *A. marajoarum* from South American caimans is available, both forms should be considered independent species.

*Acanthostomum americanum* was originally described by Pérez Viguera (1956) from *C. acutus* from Cuba (Zapata Peninsula) from where it was later reported as *Atrophecaecum americanum* and *A. acuti* by Groschafft and Baruš (1970) from *C. rhombifer*, a Cuban endemic, kept in a crocodile farm in the Peninsula of Zapata. The same species (partly under the synonym *Acanthostomum acuti*) was recorded from *C. acutus* from Costa Rica, Honduras and El Salvador (see Brooks 1980). In Mexico, this species has been reported as *Proctocaecum* (= *Acanthostomum*) *acuti* in the thesis by García-Reynoso (1991) from *C. moreletii* in Frontera, State of Tabasco.

Scholz et al. (1995a) reported encysted *Atrophecaecum* (= *Acanthostomum*) cf. *astorquii* (Watson, 1976) metacercariae possessing 20 peribuccal spines from a number of fish species from many cenotes (= sinkholes) in the Peninsula of Yucatan, Mexico. The species identification was based principally on the fact that one of the intestinal branches seemed to be somewhat reduced, as in adult *A. astorquii*, a parasite of the catfish *Rhamdia nicaraguensis* (Günther) in Nicaragua. However, it may well be that these metacercariae belong to *A. americanum*; although they frequently occur in Yucatanese cenote fishes, conspecific adult forms have never been recorded from cenotes in Yucatan (Scholz et al. 1995b), whereas *A. americanum* is probably an abundant and widely distributed parasite of Yucatanese crocodiles (*C. acutus* and *C. moreletii*), which acquire *Acanthostomum* infection by feeding on fish.

***Pelaezia loossi*** (Pérez Viguera, 1956) Fig. 1 F-I  
Syn. *Acanthochasmus loossi* Pérez Viguera, 1956.

**Description** (based on 20 specimens): Body of gravid specimens small, somewhat narrowed at posterior part, 0.830-1.224 long, maximum width 0.422-0.558. Surface of whole body covered with fine spines, these being more distinct on anterior part of body. Oral sucker terminal, funnel-shaped, 0.231-0.326 long and 0.272-0.326 wide. Outer surface of sucker armed with row of 23 large, simple peribuccal spines 0.045-0.072 long. Ventral sucker circular, size 0.095-0.136 × 0.122-0.190, situated near middle of body. Ratio of oral and ventral suckers 1 : 0.43-0.50. Prepharynx rather long. Pharynx oval, large, strongly muscular, 0.163 long and 0.095-0.122 wide. Oesophagus almost absent. Intestinal bifurcation just anterior to or at level of ventral sucker. Intestinal branches run along body to caudal end, opening there into excretory vesicle at short distance anterior to body end (forming so-called uroproct). Seminal vesicle posterior to ventral sucker or partly at

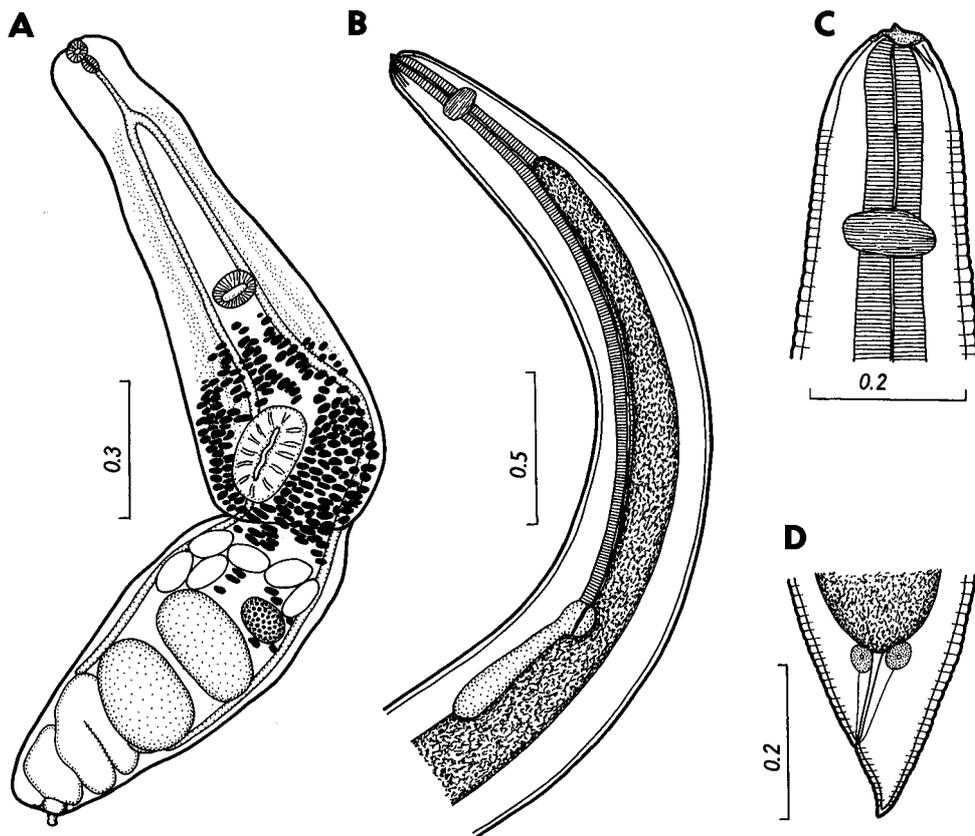
its level. Testes tandem, with smooth outline, located near posterior end of body, being of irregular shape, usually transversely oval. Size of anterior testis 0.082-0.136 × 0.163-0.258, that of posterior testis 0.095-0.163 × 0.150-0.245. Ovary transversely oval, submedian, smaller than testes, measuring 0.082-0.095 × 0.136-0.150, situated just anterior to anterior testis. Seminal receptacle indistinct. Uterus filling space delimited by anterior testis, ventral sucker and vitellaria. Genital pore median, just in front of ventral sucker. Mature eggs yellow-brown, oval, size 0.027-0.030 × 0.012-0.015. Vitellaria follicular, situated on sides of posterior half of body, initiating slightly posterior to ventral sucker and extending posteriorly to posterior border of anterior testis. Uroproct opening by median pore on posterior end of body.

**Site of infection:** Posterior part of intestine.

**Prevalence and intensity:** In 1 out of 3 crocodiles examined (33%), 97 specimens.

**Comments:** Morphology of the present specimens closely resembles that of *P. loossi* as described by Pérez Viguera (1956), Groschafft and Baruš (1970), Brooks and Overstreet (1977) and Salgado-Maldonado and Aguirre-Macedo (1991) and, therefore, they are considered to belong to this species. Both Pérez Viguera (1956) and Groschafft and Baruš (1970) described 24 peribuccal spines in *P. loossi* (reported in genera *Acanthochasmus* and *Acanthostomum*, respectively) from Cuba, but a recent re-examination of specimens from the latter authors' material showed the presence of only 23 spines; the same number (23) of peribuccal spines was reported by Salgado-Maldonado and Aguirre-Macedo (1991) in conspecific trematodes from *C. moreletii* from Yucatan, Mexico, whereas Brooks and Overstreet (1977) observed only 20-22 spines in specimens from *Alligator mississippiensis* Daudin from Louisiana, USA, mentioning that subsequent life-cycle studies might show Louisiana specimens to represent a distinct species.

*Pelaezia loossi* was originally described by Pérez Viguera (1956) from *C. acutus* from Cuba, from where it was later reported by Groschafft and Baruš (1970) from *C. rhombifer*. In Mexico, it was recorded by Salgado-Maldonado and Aguirre-Macedo (1991) from *C. moreletii* from Celestún, Yucatan; morphologically identical and undoubtedly conspecific trematodes, reported as *Acanthostomum* sp., were found by García-Reynoso (1991) from the same host species in the Tabasco State. *Pelaezia loossi* was also reported from *A. mississippiensis* from the southern USA (Brooks and Overstreet 1977, Scott et al. 1997) and adults of this species were obtained from *Caiman crocodilus* and *Crocodylus intermedius* experimentally infected with metacercariae from fish in Venezuela (Ostrowski de Núñez 1984).



**Fig. 2.** A – *Pseudoneodiplostomum groschafti* sp. n., a non-type specimen from *C. moreletii*. B-D – *Contracaecum* sp. Type 2 larva from mesentery (B – anterior part of body; C – cephalic end; D – tail).

Encysted metacercariae of *P. loossi* occur in many fish species and in Mexico they have been reported by Salgado-Maldonado and Aguirre-Macedo (1991) and Scholz et al. (1995b) and Scholz and Vargas-Vázquez (1998).

Fam. *Telorchidae* Lühe, 1899

*Telorchis* sp. juv.

Fig. 1 J

**Description** (1 specimen): Body 1.782 long, maximum width 0.517. Tegument on anterior half of body densely covered with small spines; spination on posterior half of body indistinct. Oral sucker subterminal, size  $0.144 \times 0.171$ . Very short prepharynx 0.015 long. Pharynx muscular, oval, measuring  $0.063 \times 0.069$ . Oesophagus indistinct. Caeca simple, narrow, extending to posterior extremity. Ventral sucker median, distinctly smaller than oral sucker, measuring  $0.078 \times 0.120$ , situated approximately at border of first and second thirds of body length. Ratio of oral and ventral suckers 1 : 0.63. Testes transversely oval, tandem, intercaecal, near posterior extremity; anterior testis  $0.048 \times 0.084$ ; posterior testis  $0.048 \times 0.078$ . Genital pore median, just anterior to ventral sucker. Cirrus sac

long, narrow, extending posteriorly to short distance anterior to ovary; its length 0.408. Ovary transversely oval, median, size  $0.027 \times 0.045$ , situated approximately in midway between ventral sucker and anterior testis. Seminal receptacle just posterior to ovary. Uterus and vitellaria indistinct. Metraterm slightly outlined.

Site of infection: Intestine.

Prevalence and intensity: In 1 out of 3 crocodiles (33%), 1 specimen.

**Comments:** Since the only available specimen is immature, its species identification is impossible. The genus *Telorchis* Lühe, 1899 includes many species parasitic in turtles, rarely in snakes and amphibians (Yamaguti 1971); many species were described from North American freshwater turtles, some being reported also from Mexico, but most of them can be considered dubious (Moravec and Vargas-Vázquez 1998a). No *Telorchis* species has so far been described from crocodylians; the only representatives of the family *Telorchidae* parasitising crocodylians are the two species of *Pseudotelorchis* Yamaguti, 1971 recently described from *Caiman crocodylus yucare* (Daudin) from Brazil (Catto and Amato 1993).

It is not clear whether *C. moreletii* serves as a true definitive host of *Telorchis* sp. or only as a para-definitive host of a *Telorchis* species currently parasitic in turtles.

Fam. Proterodiplostomidae Dubois, 1936

***Pseudoneodiplostomum groschafti* sp. n.** Fig. 2 A  
Syn. *Pseudoneodiplostomum* sp. Groschaft et Baruš, 1970

This species is established by indication based on the description of *Pseudoneodiplostomum* sp. from *Crocodylus rhombifer* (type host) from Cuba, published by Groschaft and Baruš (1970) (holotype collected from the intestine of *C. rhombifer* from Ciénaga – Zapata, Cuba on 12 March 1968; types deposited in the Institute of Parasitology, ASCR, in České Budějovice, cat. no. D – 441).

**Description** (1 specimen from *C. moreletii* from Mexico): Body divided into two segments, its total length 2.298. Anterior segment 1.292 long and 0.449 wide, posterior segment 1.006 long and 0.408 wide. Length ratio of posterior segment to anterior one 1 : 1.1. Oral sucker small, size 0.051 × 0.048. Ventral sucker (acetabulum) transverse oval, 0.075 × 0.105, situated approximately in middle of anterior segment, 0.707 from anterior extremity. Size ratio of oral sucker to ventral sucker 1 : 2.6. Prepharynx absent. Pharynx muscular, 0.042 long and 0.036 wide. Length of oesophagus 0.150. Narrow intestinal caeca extending posteriorly to posterior border of posterior testis. Tribocytic organ in lower portion of anterior segment, 0.270 long and 0.150 wide, margins of its cavity with numerous papillae. Ovary transverse oval, 0.090 × 0.120, submedian, situated in anterior portion of posterior segment. Vitellaria follicular, extending mainly in region of tribocytic organ, reaching anteriorly nearly to ventral sucker and posteriorly to anterior part of anterior testis. Ootype, Mehlis' gland and vitelline reservoir situated between testes. Uterus runs from ootype to region of ovary, returning from there through middle of posterior segment to posterior extremity. Termination of uterus as well as ductus ejaculatorius indistinct. Uterus containing six oval, yellow-brown eggs 0.114-0.120 long and 0.066-0.069 wide. Testes postovarian, intercaecal, transversely oval, tandem, much larger than ovary; size of anterior testis 0.159 × 0.291, of posterior testis 0.201 × 0.285. Seminal vesicle well developed, forming several loops.

**Site of infection:** Middle part of small intestine.

**Prevalence and intensity:** In 1 out of 3 crocodiles (33%), 2 specimens.

**Comments:** In 1970, Groschaft and Baruš described *Pseudoneodiplostomum* sp. based on several specimens collected from *Crocodylus rhombifer* from Cuba. The authors considered it to be morphologically close to *P. thomasi* (Dollfus, 1935), a species described from the

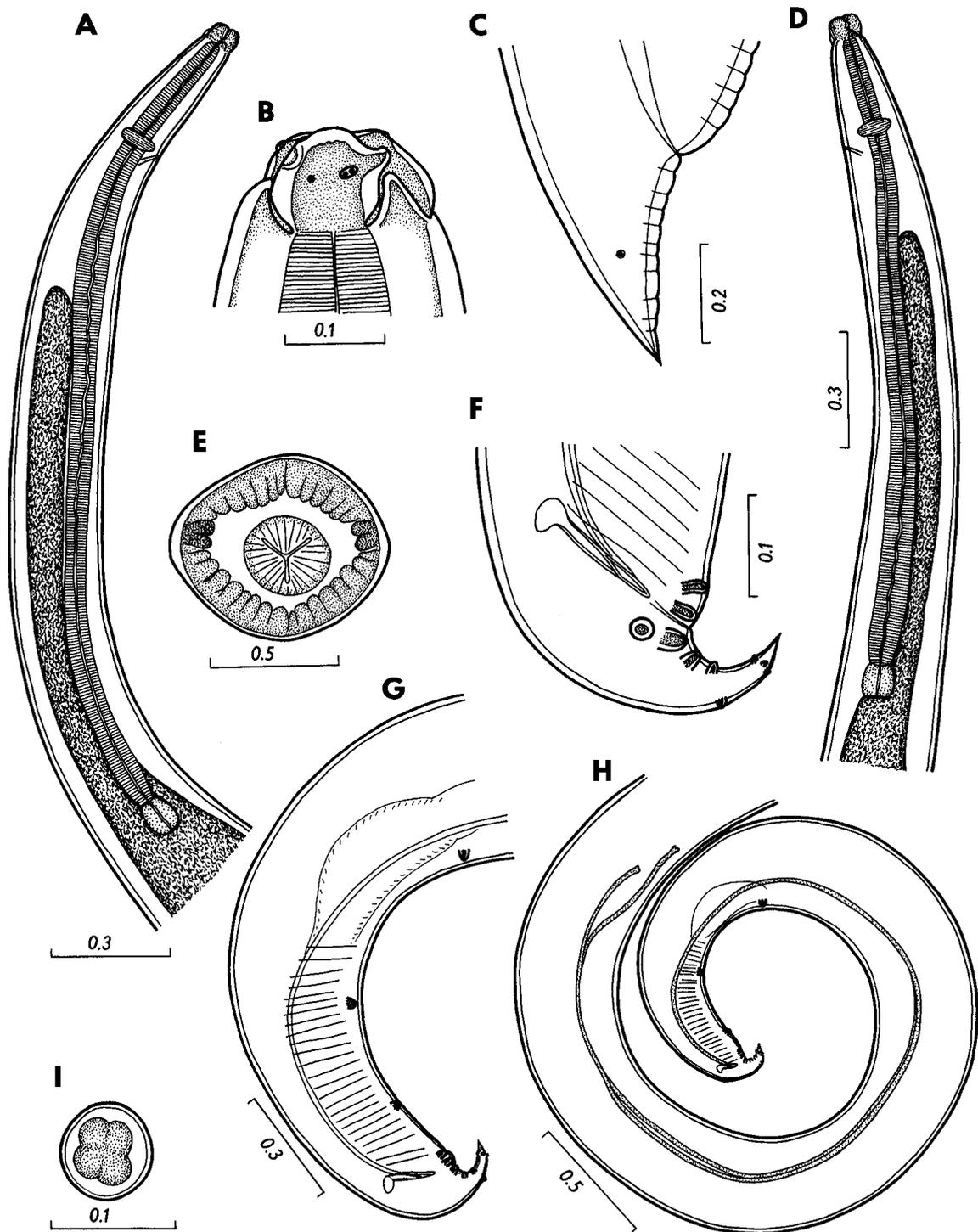
crocodile *Osteolaemus tetraspis* Cope from the Congo, but differing from it in a more elongate tribocytic organ, a shorter posterior body segment, a different length ratio of both segments and in its geographical distribution. A recent re-examination of ten specimens of the original Cuban material of this species studied by Groschaft and Baruš (1970), now deposited in the Institute of Parasitology, ASCR, in České Budějovice, confirmed these differences and, moreover, showed that in contrast to *P. thomasi* the vitellaria never extended posteriorly below the level of the posterior testis.

The Cuban trematodes also differ from the two other congeneric species: from *P. bifurcatum* (Wedl, 1861) in the situation of the ventral sucker near the middle of the anterior segment, in having the posterior segment distinctly shorter than the anterior one, and in the shape of the posterior extremity (not bifurcated); from *P. siamense* (Poirier, 1886) in the much smaller body size and a smaller number of papillae on the tribocytic organ (20 vs. 25-40); moreover, *P. bifurcatum* and *P. siamense* are parasitic in crocodiles in Africa and South Asia, respectively.

Since the trematodes described by Groschaft and Baruš (1970) as *Pseudoneodiplostomum* sp. differ distinctly morphologically from all its congeners, they are considered to represent a new species, *P. groschafti*; this is named in honour of my late fellow-worker Dr. Jindřich Groschaft, who was the first to describe these trematodes. The type specimens have been deposited in the Institute of Parasitology, ASCR, in České Budějovice (cat. no. D – 442). *P. groschafti* is the first *Pseudoneodiplostomum* species known from the American continent.

The two trematode specimens (one was later destroyed) of the present material, collected from *C. moreletii* from Yucatan, Mexico are morphologically identical with *P. groschafti* and are considered to belong to this species. In Mexico, morphologically identical and undoubtedly conspecific trematodes, reported as *Pseudoneodiplostomum* sp., have also been recorded by García-Reynoso (1991) from *C. moreletii* from Veracruz.

In 1948, Caballero recorded another proterodiplostomid trematode, identified as *Crocodicola pseudostoma* (Willemoes-Suhm, 1870), from *Crocodylus moreletii* in Mexico; conspecific progenetic metacercariae were reported from the catfish *Rhamdia guatemalensis* (Günther) in Mexico by Pérez-Ponce de León et al. 1992. However, Sudarikov (1960) analysed Caballero's description of this species and concluded that, in fact, it was *Herpetodiplostomum caimancola* (Dollfus, 1935). Since *C. caimancola* somewhat resembles *P. groschafti*, it cannot be excluded that Caballero's species from *C. moreletii* might belong to *P. groschafti* too. In addition to some inconspicuous structures, *Herpetodiplostomum* Dubois, 1936 should differ from *Pseudoneodiplostomum* Dubois, 1936 in



**Fig. 3.** *Dujardinascaris helicina* (Molin, 1860). **A** – anterior end of male; **B** – cephalic end, sublateral view; **C** – female tail; **D** – anterior end of young female; **E** – transverse section through body at oesophagus region; **F** – male tail; **G** – posterior end of male; **H** – posterior part of body of male; **I** – egg.

having an unsegmented body; however, the division into segments is not quite clear in some *P. groschaffi* specimens from Cuba.

#### NEMATODA

Fam. *Ascarididae* Baird, 1853

***Dujardinascaris helicina*** (Molin, 1860) Figs. 3-5  
Syn. *Ascaris helicina* Molin, 1860.

**Description:** Robust nematodes of brownish colour. Cuticle with dense transverse striations. Fixed specimens usually tightly coiled in spiral. Lips shield-shaped, with relatively large interlocking processes (Fig. 4 C, D). Middle anterior region of lips semicircular, provided with row of prominent, anteriorly oriented teeth (Fig. 4 E, F); surface of pulp just posterior to teeth forming four distinct lobes (Fig. 4 E, F). Interlabia well developed, triangular, reaching anteriorly mid-length of lips (Fig. 4 B). Cervical alae absent (Fig. 3 E). Oesophagus rather long, ventriculus small, almost spherical. Long anterior, dorsal intestinal caecum present. Nerve ring encircling oesophagus approximately at 1/5-1/6 of its length. Excretory pore approximately at level of nerve ring, deirids at short distance posterior to it.

**Male** (1 specimen): Length of body 14.185, maximum width 0.571. Lips and interlabia 0.066 and 0.039, respectively, long. Length of oesophagus 2.217; ventriculus 0.095 long and 0.082 wide. Both nerve ring and excretory pore 0.462 from anterior extremity. Intestinal caecum 1.496 long. Deirids not located. Preanal papillae: 5 subventral pairs present, last 2 pairs being close together just anterior to cloaca. Adanal papillae: 1 lateral pair of large papillae. Postanal papillae: 6 pairs, 3 of them being subventral and 2 dorsolateral. Moreover, lateral pair of minute papilla-like outlets of phasmids present between last subventral and last dorsolateral pairs of postanal papillae (Fig. 3 F). Precloacal ventral body surface with slightly outlined oblique muscle bands. Non-alate spicules equal in length, 5.889 long, very narrow; their proximal ends slightly expanded, distal ends pointed. Gubernaculum 0.571 long, its proximal end expanded to form marked dorsal lobe, distal end pointed. Tail conical, 0.168 long, with sharply pointed tip.

**Female** (4 gravid specimens; measurements of 3 immature specimens in parentheses): Length of body 19.176-41.480 (10.363-10.758), maximum width 0.938-1.727 (0.299-0.394). Lips and interlabia 0.109-0.136 (0.060-0.075) and 0.068-0.082 (0.030-0.042), respectively long. Length of oesophagus 1.918-4.148 (1.564-1.795); ventriculus 0.109-0.217 (0.082-0.109) long and 0.095-0.177 (0.082) wide. Nerve ring and excretory pore 0.585-0.680 (0.299-0.340) and 0.653-0.707 (0.326-0.367), respectively, from anterior extremity. Intestinal caecum 1.455-2.258 (1.020-1.210) long. Deirids in smallest gravid specimen 0.816 from anterior end. Vulva 9.979-20.190 (5.163-5.236) from anterior end,

situated at 49-50% (49-51%) of body length. Vagina directed posteriorly. Eggs almost spherical, thin-walled, with smooth surface, size 0.075-0.083 × 0.063-0.075; thickness of wall 0.002-0.003. Content of eggs mostly uncleaved (Fig. 5 A) or cleaved at most into four blastomeres (Fig. 3 I). Tail conical, 0.250-0.408 (0.177-0.249) long, with sharply pointed tip; pair of distinct papilla-like outlets of phasmids present approximately at mid-length of tail (Fig. 3 C).

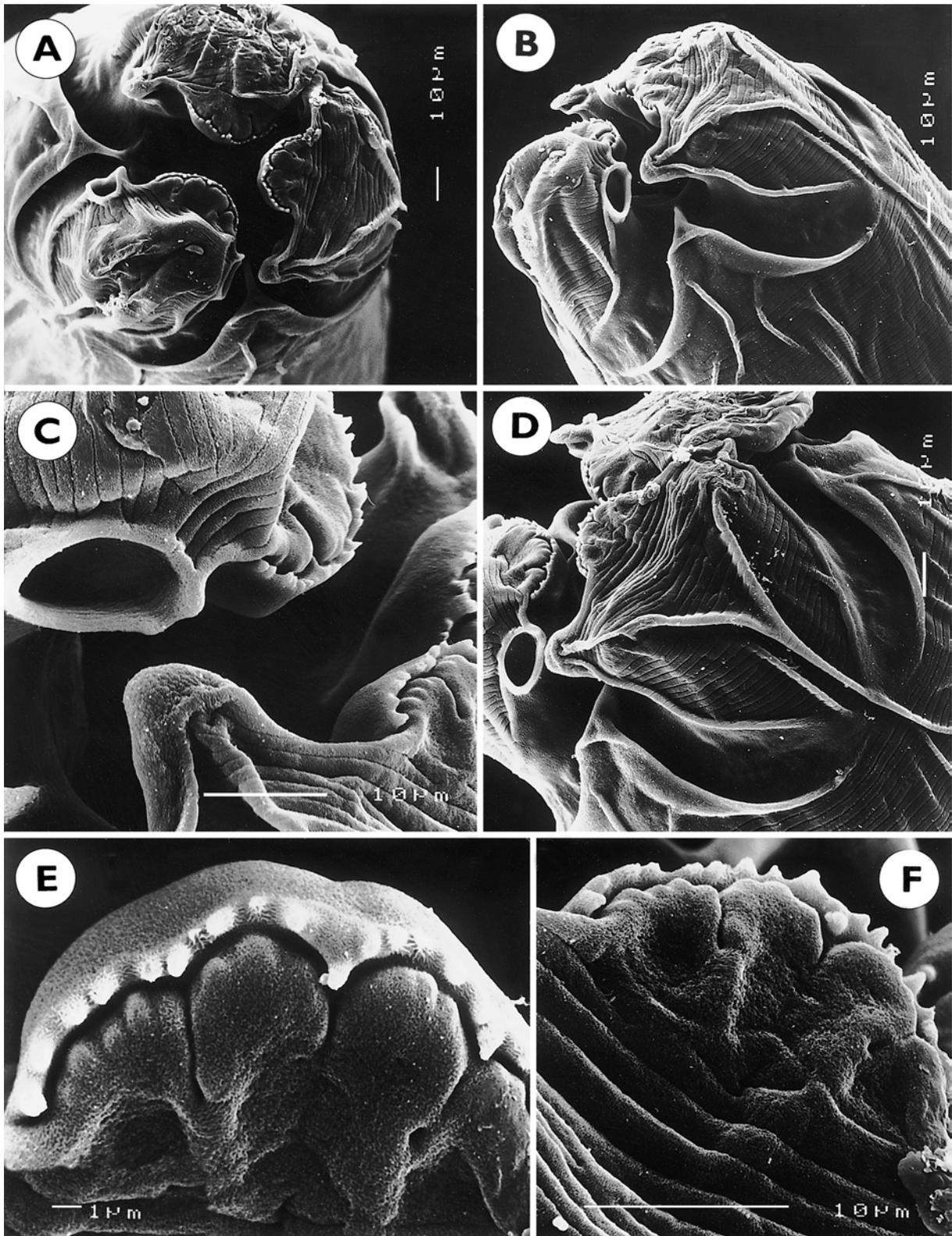
**Site of infection:** Stomach.

**Prevalence and intensity:** In all 3 crocodiles examined (100%); 2-17 (mean 10) nematodes.

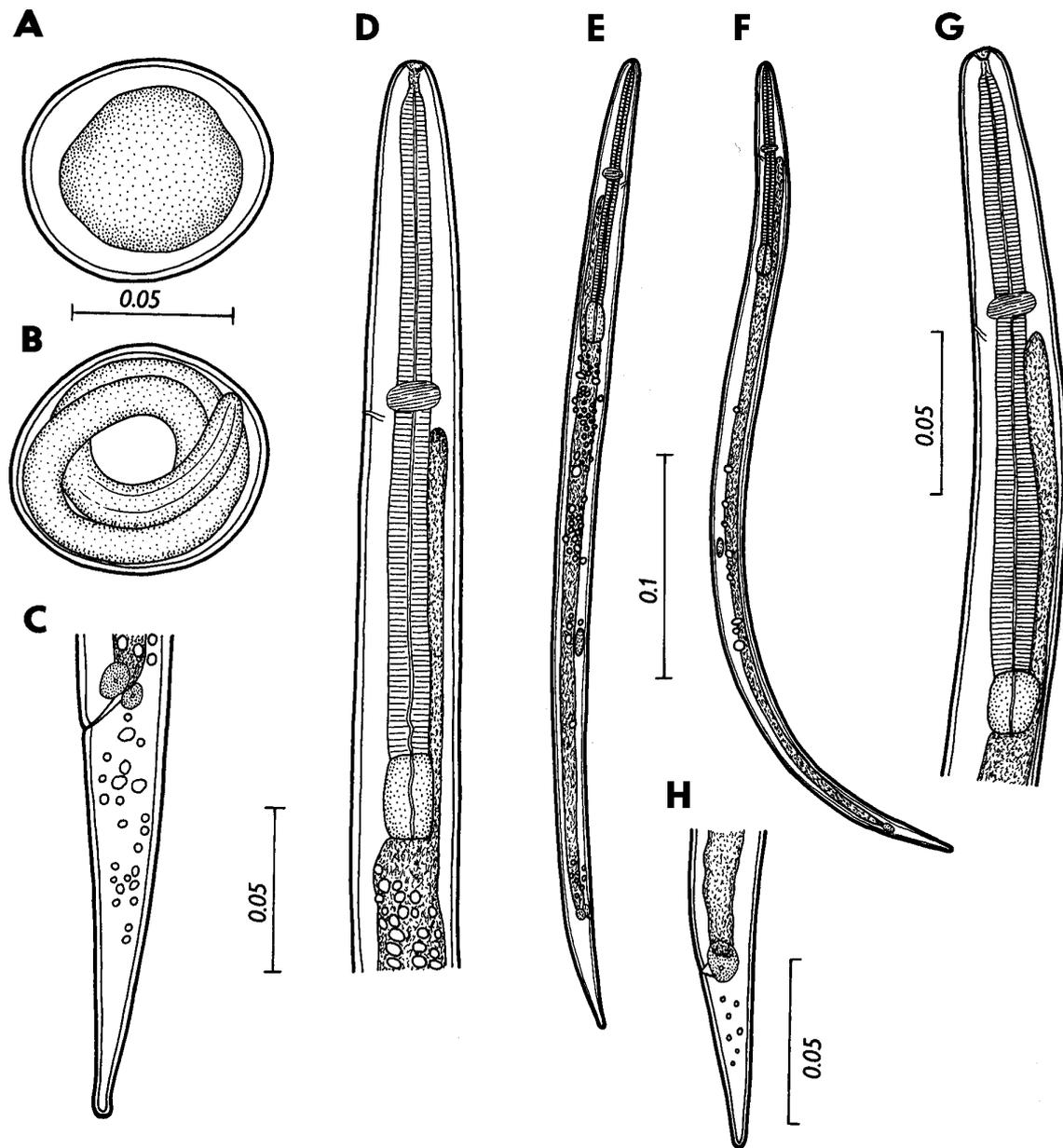
**Comments:** This species was originally described by Molin (1860) as *Ascaris helicina* from an American crocodile *Crocodylus acutus* from museum specimens from an unknown locality. In his revision of *Dujardinascaris* Baylis, 1947, Sprent (1977) pointed out that many later records of this nematode species from different crocodiles, including those from Africa and Asia were, in fact, misidentifications. Sprent (1977) examined the type specimens (only females) of *A. helicina* and also the nematodes from *C. acutus* from the British Museum (females from crocodiles from the Amsterdam Zoo) and from the U.S. National Parasite Collection (one male and several females from crocodiles from the San Diego Zoo), and briefly mentioned some characteristic features of this species. *Dujardinascaris helicina* was previously reported and redescribed also by Groschafft and Baruš (1970) from the stomach of *C. acutus* and *C. rhombifer* Cuvier from Cuba; as Sprent (1977) mentions, the morphology of these nematodes, as described by these authors, corresponds closely with Sprent's species description, but the spicules were only 1.14 mm long in a single available specimen of comparable length.

Even though the morphology of *D. helicina* has been insufficiently described, the specimens of the present material can be assigned to this species because of the following reasons: their morphology corresponds, more or less, to the description and illustrations given by Sprent (1977); they originate from the Neotropical Region from where this nematode was first described; the host, *C. moreletii*, is closely related with *C. acutus*, a type species of *D. helicina*, and both these crocodiles frequently occur in the same Yucatanese localities (Lee 1996, Stafford and Meyer 2000).

The SEM examination, used for the first time in this species, showed details in the structure of the cephalic end, which are otherwise difficult to observe under the light microscope. Some differences found in the distribution of male caudal papillae, as compared to the descriptions given by Groschafft and Baruš (1970) and Sprent (1977), may be ascribed to some inaccuracies due to difficulties in observing these structures, and probably also to some degree of intraspecific variability. The male of the present material was distinctly larger than those examined by the above mentioned authors.



**Fig. 4.** *Dujardinascaris helicina* (Molin, 1860), scanning electron micrographs of cephalic end. **A** – apical view of lips; **B** – interlabium between dorsal and subventral lips, lateral view; **C** – interlocking process of dorsal lip; note anteriorly oriented teeth on lips; **D** – dorsal lip; **E**, **F** – marginal teeth and four-lobed pulp on lips, different views.



**Fig. 5.** *Dujardinascaris helicina* (Molin, 1860), early larval development. **A** – unembryonated egg from uterus; **B** – egg containing motile larva after 3 days of cultivation in water; **C-E** – hatched second-stage larva (**C** – tail; **D** – anterior end; **E** – general view); **F-H** – second-stage larva from abdominal cavity of experimentally infected *Poecilia reticulata* 1 day p.i. (**F** – general view; **G** – anterior end; **H** – tail).

In her unpublished thesis, García-Reynoso (1991) reported another ascaridoid species, *Dujardinascaris antipini* Mozgovoy, 1950, from *C. moreletii* from Veracruz, Mexico. This intestinal parasite species is characterised principally by the presence of well-developed lateral alae and the absence of teeth on lips

(Groschaft and Baruš 1970, Sprent 1978) and it was transferred by Sprent (1978) from *Dujardinascaris* to a newly established genus *Ortleppascaris* Sprent, 1978. None of the above features are mentioned by García-Reynoso (1991); on the other hand, the shape of the illustrated gubernaculum is typical of *D. helicina* and

also the accompanying, incomplete description is in agreement with the latter; moreover, the specimens were not collected from the intestine but from the stomach, which is a typical site of *D. helicina* infection. This shows clearly that the nematodes reported by García-Reynoso (1991) from *C. moreletii* from Veracruz were, in fact, *D. helicina*.

**Notes on the development:** Eggs of *D. helicina* expressed from the uteri were cultivated in a Petri dish filled with water at a laboratory temperature of 21-22°C. Their content quickly embryonated and already after 24 hr some eggs contained mobile larvae. Within three days, most larvae hatched from egg shells. These larvae (Fig. 5 C-E), representing undoubtedly second-stage larvae, were 0.433-0.450 mm long and 0.015 mm wide. The structure of their digestive tract was already similar to that in adults. The oesophagus and the ventriculus were 0.133-0.138 mm and 0.013 mm, respectively, long. The nerve ring was 0.070-0.073 mm from the anterior extremity. The intestinal caecum was 0.030 mm long and reached nearly to the nerve ring level. The tail was conical, 0.058-0.063 mm long, with a rounded tip. A small, oval genital primordium was situated 0.178-0.183 mm from the posterior end of the body. The body contained numerous reserve granules. These larvae survived in water without any further development for up to 22 days after their hatching from the eggs.

Ten-day-old second-stage larvae were fed to fishes (10 *Cichlasoma synspilum* Hubbs and 5 *Poecilia reticulata* Peters) and small frogs (*Rana catesbeiana* Shaw), which were examined on days 1, 11, 25 and 33 post infection. Only one *P. reticulata*, examined on day 1, harboured 11 *Dujardinascaris* larvae (7 in intestine and 4 in abdominal cavity) morphologically identical with those of the free-living larvae in culture; the larvae from the abdominal cavity (Fig. 5 F-H) were slightly smaller (body length 0.385-0.410 mm, width 0.013 mm) and the reserve granules almost disappeared from their bodies. All other experimental vertebrates did not become infected. An attempt was also made to infect copepods *Diaptomus albuquerquensis* Herrick with free second-stage larvae of *D. helicina*, but no infection was found in them after 12 days.

The only experimental study on the life cycle of a *Dujardinascaris* species is that by Mahmoud (1999) in *D. dujardini* (Travassos, 1920), a parasite of *Crocodylus niloticus* in Egypt; he found fishes (*Tilapia* sp.) to act as experimental intermediate hosts and copepods (*Cyclops* sp.) as preintermediate paratenic hosts. Third-stage larvae probably belonging to *Dujardinascaris* spp. were earlier found in the mesenteries and the body cavity of naturally infected fishes (mainly *Lates* spp.) in Africa and frogs (*Rana catesbeiana* and *R. sphenoccephala* Cope) in the USA (Baylis 1928, Brandt 1936). It is probable that subsequent studies will show that fishes, frogs and other food animals serve as intermediate hosts for *D. helicina*.

According to Mahmoud (1999), the first-stage larvae of *D. dujardini* moult inside the eggs after 6-8 days from the beginning of incubation, they retain the shed cuticle of the first-stage larva, and hatch spontaneously within 2-3 days; after 1-2 days the larvae start to leave the old cuticle of the first stage. In contrast to this, the hatching of *D. helicina* second-larvae is distinctly earlier and no hatched larvae were observed to retain the cuticle of the first-stage; the first moult probably occurred inside the egg.

Fam. Anisakidae Railliet et Henry, 1912

***Contraecaeum* sp.** (Type 2 larvae of Moravec et al. 1993)

Fig. 2 B-D

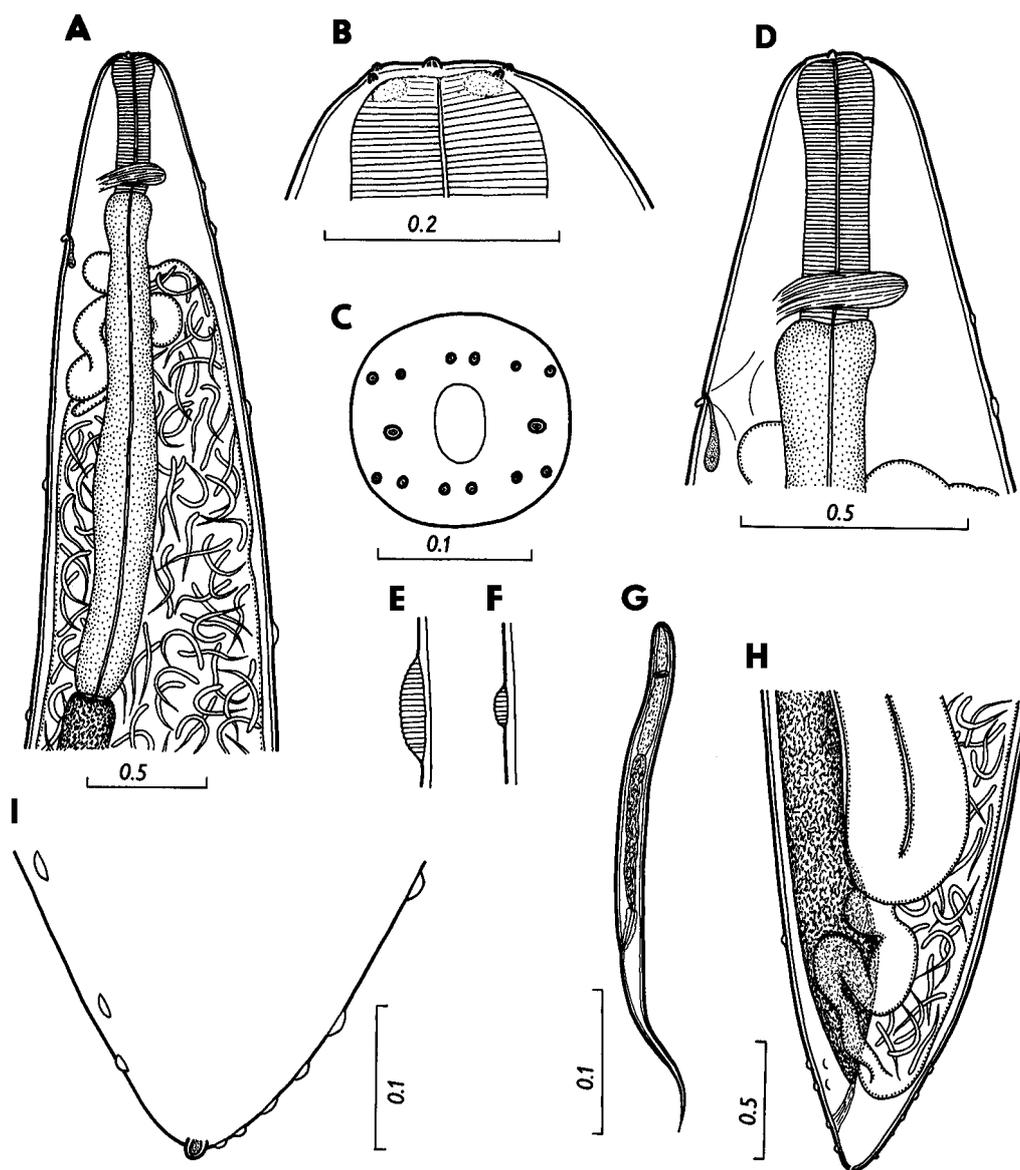
**Description** (1 specimen): Body 20.264 long and 0.762 wide. Cuticle with distinct transverse striations. Cephalic end rounded, bearing small ventral cuticular tooth; anlagen of lips little developed. Excretory pore near ventral cephalic tooth. Oesophagus narrow, 2.448 long. Ventriculus small, rounded, 0.109 in diameter; posterior ventricular appendix short, measuring 0.490. Nerve ring 0.326 from anterior extremity. Intestine brownish, dark. Intestinal caecum very long, extending anteriorly almost to nerve ring; its length 1.904. Genital primordium indistinct. Rectum short hyaline tube; three small unicellular rectal glands present. Tail conical, 0.082 long.

**Site of infection:** Mesentery (encapsulated).

**Prevalence and intensity:** In 1 of 3 crocodiles (33%); 1 larva.

**Comments:** The presence of the cephalic tooth shows that this larva is at the third stage. Adults may belong to the morphological group of species represented by *C. microcephalum* (Rudolphi, 1819), *C. multipapillatum* (Drasche, 1882), *C. micropapillatum* (Stossich, 1890), *C. caballeroi* Bravo Hollis, 1939, *C. plagiaticum* Lent et Freitas, 1948 among others, parasitising mainly fish-eating birds. Larvae of this type occur mainly in fishes, having been reported, for example, as frequent parasites of freshwater fishes in Brazil, Argentina, Venezuela, Cuba and southern Mexico (Baruš and Moravec 1967, Moravec and Baruš 1971, Moravec et al. 1993, 1995, 1997, Ramallo and Torres 1995, Moravec 1998). In crocodiles, larvae of this type were found in *Crocodylus rhombifer* in Cuba (Groschaft and Baruš 1970) and in *C. moreletii* in Mexico (Veracruz) (García-Reynoso 1991). Crocodiles may apparently serve only as paratenic hosts.

In addition to the encapsulated larva from the mesentery, which is considered to be the true parasite of crocodiles, morphologically identical larvae, mostly dead and partly digested, were found in the stomach of 2 of 3 crocodiles examined (prevalence 66%), with the intensity 2 and 8 nematodes. Apparently, these *Contraecaeum* larvae from the stomach remained there after their original fish hosts were digested by the crocodiles.



**Fig. 6.** *Micropleura* sp., gravid female. **A** – anterior end of body, lateral view; **B**, **C** – cephalic end, lateral and apical views; **D** – anterior end, lateral view; **E**, **F** – cuticular inflations, lateral views; **G** – first-stage larva from uterus; **H** – posterior end of body, lateral view; **I** – caudal end with marked cuticular ornamentation and terminal papilla-like process.

*Contracecum* sp. Type 2 larvae occur frequently in *Cichlasoma urophthalmus* and some other fish species in this locality (Vidal-Martínez et al. 1994, Moravec, unpubl.).

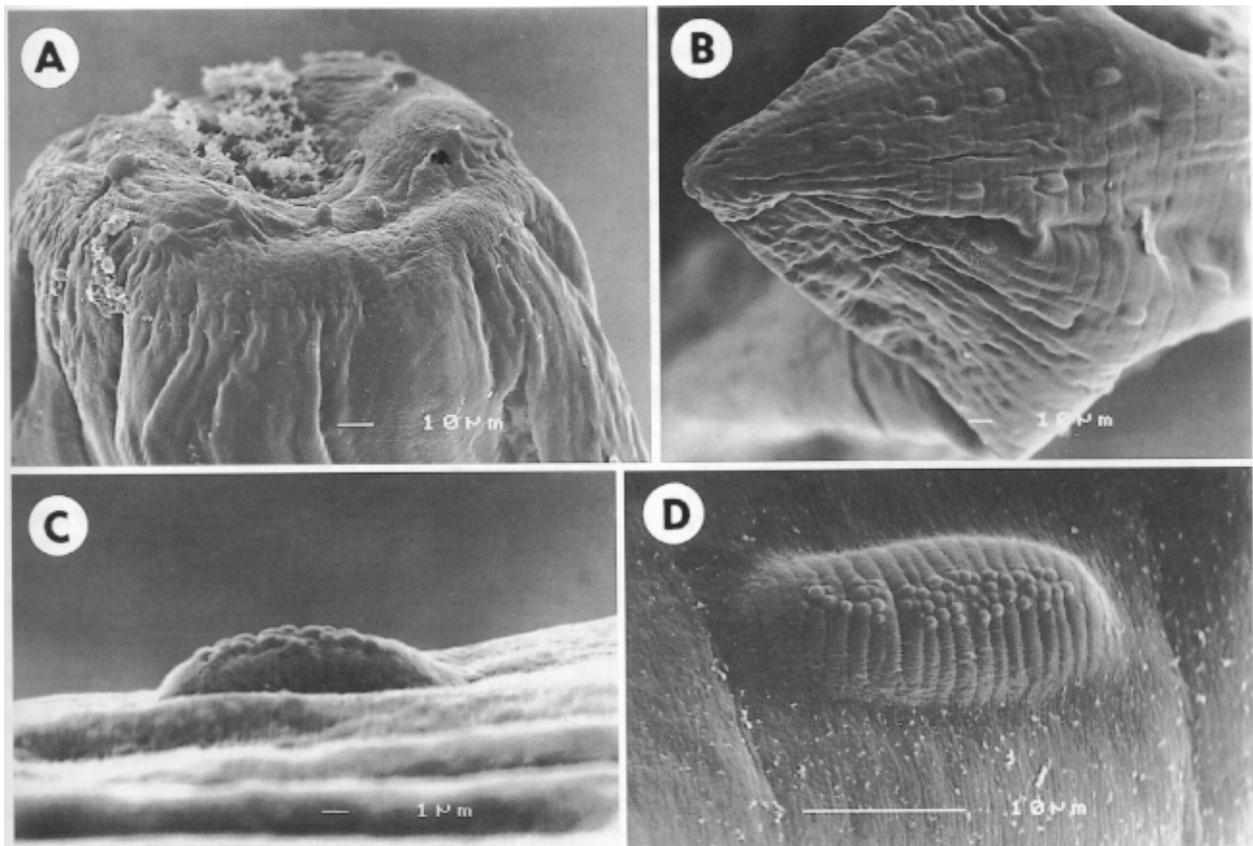
Fam. *Micropleuridae* Baylis et Daubney, 1922

*Micropleura* sp.

Figs. 6, 7

**Description of female** (1 gravid specimen): Body white, elongate, tapering to both ends, 31.824 long, maximum width 1.972. Cuticle thin, with very fine transverse striations; body surface bearing numerous small, elongate cuticular inflations or bosses (Figs. 6 E,

F, I and 7 B-D) with minute papilla-like formations on their upper side (Fig. 7 D); majority of inflations in middle and posterior parts of body. Inflations rather small, papilla-like, only 0.006-0.009 high at anterior part of body and in caudal region, and more prominent, more elongate and distinctly higher (0.018) in middle region of body. Anterior end rounded. Oral aperture oval, somewhat laterally depressed, surrounded by four submedian pairs of cephalic papillae of outer circlet, four single papillae of inner circlet forming one dorsal and one ventral pairs, and a pair of larger lateral amphids (Fig. 6 B, C). Oesophagus 3.209 long, distinctly divided into short anterior muscular portion



**Fig. 7.** *Micropleura* sp., gravid female, scanning electron micrographs. **A** – cephalic end, dorsoventral view; **B** – dorsal view of caudal end with distinct cuticular ornamentation; **C**, **D** – cuticular inflation bearing papilla-like formations, lateral and apical views.

and much longer glandular portion; muscular oesophagus 0.625 long and 0.204 wide, glandular oesophagus 2.584 long, its maximum width 0.313. Length ratio of muscular and glandular portions of oesophagus 1 : 4. Nerve ring encircling base of muscular oesophagus, being situated 0.571 from anterior extremity. Small excretory pore slightly posterior to anterior end of glandular oesophagus; minute digital cuticular protrusion present just posterior to excretory pore (Fig. 6 D). Intestine straight, relatively narrow, light-coloured. Anus appearing to be absent; rectum atrophied, reduced to short ligament attached to body wall. Caudal end rounded, with two terminal papilla-like protrusions. Amphidelphic. Ovaries short, anterior ovary coiled at level of anterior half of glandular oesophagus, posterior ovary near posterior end of body. Uterus extends from approximately anterior end of glandular oesophagus to intestinal end, occupying almost whole space of body cavity and containing numerous first-stage larvae. Vagina and vulva not found (probably considerably atrophied). Larvae from uterus 0.306-0.360 long, their maximum width 0.015-0.018; oesophagus 0.090-0.105 long, forming 25-32% of body

length; tail slender, sharply pointed, 0.093-0.132 long, forming 30-40% of body length.

**Male:** Unknown.

**Site of infection:** Body cavity.

**Prevalence and intensity:** In 1 out of 3 crocodiles (33%), 1 nematode.

**Comments:** The general morphology of the only available specimen shows that it belongs to the dracunculoid genus *Micropleura* Linstow, 1906. At present the genus comprises five little-known species parasitic in the body cavity and serous membrane of reptiles; four species are known from crocodiles (*Gavialis gangeticus*) and turtles (*Lissemys punctata* and *Trionyx gangeticus*) from India, whereas only one, *Micropleura vazi* Travassos, 1933 is known from the New World, parasitising South American caimans (Ivashkin et al. 1971, Baker 1987). The latter was originally described from *Caiman crocodilus crocodilus* (L.) from Brazil (Travassos 1933) and from the same host species in Brazil it was later reported by Vicente and Jardim (1980); apparently *Micropleura* sp. reported from the same host species in Brazil by Travassos et al. (1939) and Travassos and Freitas (1941) also belonged

to the same species. From *Caiman crocodilus yacare* Daudin, *M. vazi* was subsequently reported from Paraguay (Goldberg et al. 1991) and Argentina (Troiano et al. 1999). No *Micropleura* species has so far been reported from North and Central America.

Although the morphology of the Mexican female specimen resembles that of *M. vazi* and it may belong to this species, the absence of males does not enable its species identification. This is the first *Micropleura* species studied by SEM, which made it possible to determine the exact number and arrangement of cephalic papillae in this genus and to study a detailed structure of cuticular protrusions. This is the first record of a *Micropleura* species from New World crocodiles (*Crocodylus* spp.) and from North America.

Fam. Capillariidae Railliet, 1915

***Paratrichosoma recurvum*** (Solger, 1877)

Syn. *Trichosoma recurvum* Solger, 1877.

Site of infection: Abdominal skin.

Prevalence and intensity: Adult nematodes: in 1 out of 3 crocodiles (33%), 4 specimens; tunnels containing *P. recurvum* eggs in 2 out of 3 crocodiles (66%), 12 and 60 tunnels per crocodile.

**Comments:** This species has already been dealt with by Moravec and Vargas-Vázquez (1998b).

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In addition to helminths, two crocodiles harboured unidentified adult pentastomids (prevalence 66%, intensity 6 and 4 specimens).

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