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Observations on the development of *Syncuaria squamata* (Nematoda: Acuariidae), a parasite of cormorants, in the intermediate and paratenic hosts

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Abstract. The development of the nematode *Syncuaria squamata* (Linstow, 1883), a gizzard parasite of cormorants, was experimentally studied in the ostracod *Notodromas monacha*. After the eggs of this nematode have been swallowed by the ostracod, the toothed first-stage larvae of the parasite are released and penetrate through the intestinal wall into the haemocoel of the crustacean. Before attaining the infective third stage, the larvae moult twice in the body of the intermediate host (9–11 and 13–15 days after infection at water temperatures of 20–22° C). The fishes *Alburnoides bipunctatus, Noemacheilus barbatulus, Oncorhynchus mykiss* and *Poecilia reticulata* were for the first time recorded as suitable experimental paratenic hosts of *S. squamata* third-stage larvae in which a slight growth of larvae may occur. The first recorded natural paratenic host of this nematode was tench, *Tinca tinca*, originating from a South-Bohemian pond where cormorants occur. Paratenic hosts are apparently the main source of *S. squamata* infection for cormorants.

The nematode *Syncuaria squamata* (Linstow, 1883) is a common gizzard parasite of cormorants in various parts of the world (see Baruš et al. 1978, Wong et al. 1986, Anderson 1992). From former Czechoslovakia, it was only recorded by Moravec (1990) from *Phalacrocorax carbo* (L.) from three South-Bohemian and South-Moravian localities, but recent studies on the helminth fauna of cormorants in Czech Republic, carried out by the Institute of Parasitology, ASCR, have revealed its frequent occurrence in this part of Central Europe.

Although the genus now includes at least nine valid species (Wong et al. 1986), some data concerning the development and transmission are available only for *Syncuaria squamata*. Kurochkin (1958), working with these nematodes (reported as *Skrjabinocara squamata*) from *Phalacrocorax carbo* from Astrakhan in the River Volga Delta in Russia was the first to study the nematode development in the intermediate host. The author tried to infect with *S. squamata* eggs various planktonic and benthic crustaceans including cyclopid and diaptomid copepods, cladocerans, ostracods, gammarids and others, but he succeeded in infecting only one species of ostracod, *Cypris pubera*. Kurochkin (1958) briefly described partial larval development in this intermediate host up to the 8th day p.i., when the larvae attained the length of 0.73 mm, but he failed to observe moulting and he could not finish these observations because of the death of experimental ostracods. Although he fed the infected ostracods (8th day p.i.) to several species of fish (*Alburnus alburnus*, *Blicca bjoerkna*, *Scardinius erythrophthalmus*, *Cobitis taenia*, *Cyprinus carpio*) and obtained negative results, he presupposed, in view of the biology of feeding of cormorants, the involvement of fish paratenic hosts in the transmission of *S. squamata* to the definitive host.

Additional data on the biology of *S. squamata* were published by Wong and Anderson (1987) nearly thirty years later. Not mentioning the previous observations by Kurochkin (1958), these authors described the development of *S. squamata* from double-crested cormorants, *Phalacrocorax auritus auritus* (Lesson), in Canada. They experimentally infected two species of ostracods, *Cyclocypris ovum* and *Cypridopsis vidua*, with the eggs of *S. squamata* and followed the nematode development to the infective third-stage larvae. The infected ostracods were used for experimental infection of cormorants (*P. auritus auritus*). Wong and Anderson (1987) experimentally infected goldfish with *S. squamata* third-stage larvae in which the larvae were later found in granulomas on the intestinal serosa; they also experimentally demonstrated that infected goldfish (paratenic host) may be the source of infection for cormorants.

Since the existing data on the biology of *S. squamata* in Europe are fragmentary and those by Wong and Anderson (1987) concern the North-American population of this nematode parasitizing a different species of cormorants and showing some morphological differences as compared with Palaearctic populations, the present authors carried out some experimental studies on the development of *S. squamata* originating from *Phalacrocorax carbo* from Czech Republic. The results obtained, supported by field observations, are presented in this paper.

MATERIALS AND METHODS

The nematodes *Syncuaria squamata* were recovered from the gizzard of common cormorants, *Phalacrocorax carbo* (L.), shot around nest colonies in South Bohemia (pond Ženich near Třeboň) and South Moravia (ponds near Pohořelice and water reservoir Nové Mlýny), Czech Republic, between 1987 and 1992 (according to Hudec and Černý (1972), the only subspecies of *Phalacrocorax carbo* occurring in former Czechoslovakia, is *P. c. sinensis* (Shaw et Nodder, 1801)). All experiments were performed during the period May–September 1991. The gravid female nematodes containing large numbers of fully mature eggs were placed individually in petri dishes (diameter 10–15 cm) filled with water, their bodies were torn by fine needles and the eggs were released from the uteri. Each dish contained 100 or 200 ostracods or copepods, or 50 specimens of gammarids or aquatic isopods. The following species of invertebrates were tested as possible intermediate hosts of *Syncuaria squamata*: *Notodromas monacha* Müller (Ostracoda), *Cyclops strenuus* Fischer, *Macrocyclops albidus* (Jurine) and *Eucyclops serrulatus* (Fischer) (all Copepoda), *Gammarus fossarum* Koch (Amphipoda), and *Asellus aquaticus* L. (Isopoda). The experimental ostracods originated from a periodical pool near České Budějovice. A small amount of detritus and plant remnants were then added into each petri dish which were kept at the laboratory temperatures of 20–22°C. The invertebrates were examined for the presence of nematode larvae at intervals of 2–3 days.

Feeding experiments were carried out in small aquaria in the laboratory where fishes were allowed to feed spontaneously on the infected ostracods harbouring the parasite's third-stage larvae. Afterwards, the fishes were fed with tubificids and commercial pellet food. The following fishes were used: 6 guppies, *Poecilia reticulata* (Peters), (body length 2–4 cm) from a laboratory culture; 3 eels, *Anguilla anguilla* (L.), (9–11 cm) originating from Italy and kept at low temperature (10°C) in the laboratory in České Budějovice for one year before the experiment; 6 carps, *Cyprinus carpio* L., (4–6 cm) and 2 rainbow trout, *Oncorhynchus mykiss* (Walbaum), (5–6 cm), both from fish hatchery; 2 perch, *Perca fluviatilis* L., (7 cm), 1 gudgeon, *Gobio gobio* (L.), (9 cm), 2 minnows, *Phoxinus phoxinus* (L.), (3–4 cm), and 1 spirlin, *Alburnoides bipunctatus* (Bloch), (7 cm), all from the localities (pond Mácha Lake in North Bohemia and the Rivers Rokytná and Jihlava in South Moravia) where cormorants do not occur.

The nematode larvae obtained from ostracods and fishes were fixed so that they were immobilized by heating them in a drop of water on a glass slide over a flame for several seconds. Ultimately, the killed larvae were examined with a light microscope. Drawings were made with the aid of a Zeiss microscope drawing attachment.

RESULTS

A. Experimental infections

Experimental infections of intermediate hosts

Of the aquatic invertebrates tested as possible intermediate hosts of *Syncuaria squamata* (see Materials and Methods), only the ostracod *Notodromas monacha* was successfully infected with the parasite's eggs.

The mature eggs of *S. squamata* contain a fully

Table 1. Survey of experimental infections of fishes.

Fish host	No. of fish in experiment	No. of fishes infected	Intensity	Localization	No. of days p. i. when fishes were examined (no. of fishes)
Poecilia reticulata	6	1 (41 DPI)	2	abdominal cavity (1 free, 1 encysted)	30 (1); 41 (5)
Phoxinus phoxinus	2	0	–	–	3 (1); 8 (1)
Cyprinus carpio	6	0	–	–	72 (6)
Alburnoides bipunctatus	1	1 (35 DPI)	2	intestinal surface (unencysted)	35 (1)
Gobio gobio	1	0	–	–	17 (1)
Noemacheilus barbatulus	2	1 (17 DPI)	1	intestinal surface (unencysted)	17 (1); 24 (1)
Anguilla anguilla	3	0	–	–	3 (3)
Oncorhynchus mykiss	2	2 (8 DPI)	1	abdominal cavity (unencysted)	8 (2)
Perca fluviatilis	2	0	–	–	2 (2)

formed first-stage larva at the time of deposition. The ostracod becomes infected when swallowing the nematode eggs. The larvae of the parasite hatch in the digestive tract of this host, with the help of their dorsal boring tooth penetrate through the intestinal wall into the haemocoel and there they continue to develop. Exceptionally the larvae were found inside the inner segments of antennae. The larvae undergo two moults (the first 9–11 days p.i. and the second one 13–15 days p.i. at 20–22°C) before reaching the third stage, which is already infective for the definitive or paratenic hosts. First fully developed third-stage larvae liberated from the cuticle of the second moult were recovered in experimental ostracods 18 days p.i. These larvae remain spirally coiled in the haemocoel of the intermediate host, but no capsule develops around them. The rate of development of *S. squamata* larvae was asynchronous in individual ostracods. After attaining the third stage, the larval development ceases in the body of the intermediate host. During the development from the first to the third stage the length of larvae increases approximately seven times.

During our experiments, the percentage of infected ostracods in individual petri dishes ranged from 60–100% and the intensity of infection was 1–9 (mean 3) larvae per ostracod. The rate of mortality of ostracods was high during the experiment and only small numbers of these crustaceans survived the period required by *S. squamata* larvae to complete their development.

Experimental infections of paratenic hosts

Experimental fishes were individually placed in small aquaria to which 15–20 live ostracods containing various numbers of third-stage larvae of *S. squamata* in their body (18, 21 or 22 days p.i.) were added and the fishes were allowed to feed on them. A survey of these feeding experiments is given in Table 1. Of a total of 9 fish species used in these experiments, small numbers of *S. squamata* larvae were later recorded only from *Poecilia reticulata* (fam. Poeciliidae), *Alburnoides bipunctatus* (Cyprinidae), *Noemacheilus barbatulus* (Cobitidae) and *Oncorhynchus mykiss* (Salmonidae). All these larvae represented the third stage and their size was similar or slightly greater to those from ostracods. The larvae were found free in the body cavity of experimental fishes, mostly on the outer surface of intestine. Only one of the two larvae recorded from *P. reticulata* on day 41st p.i. was encapsulated by host's tissue; this larva was inside a small, round, thin-walled whitish

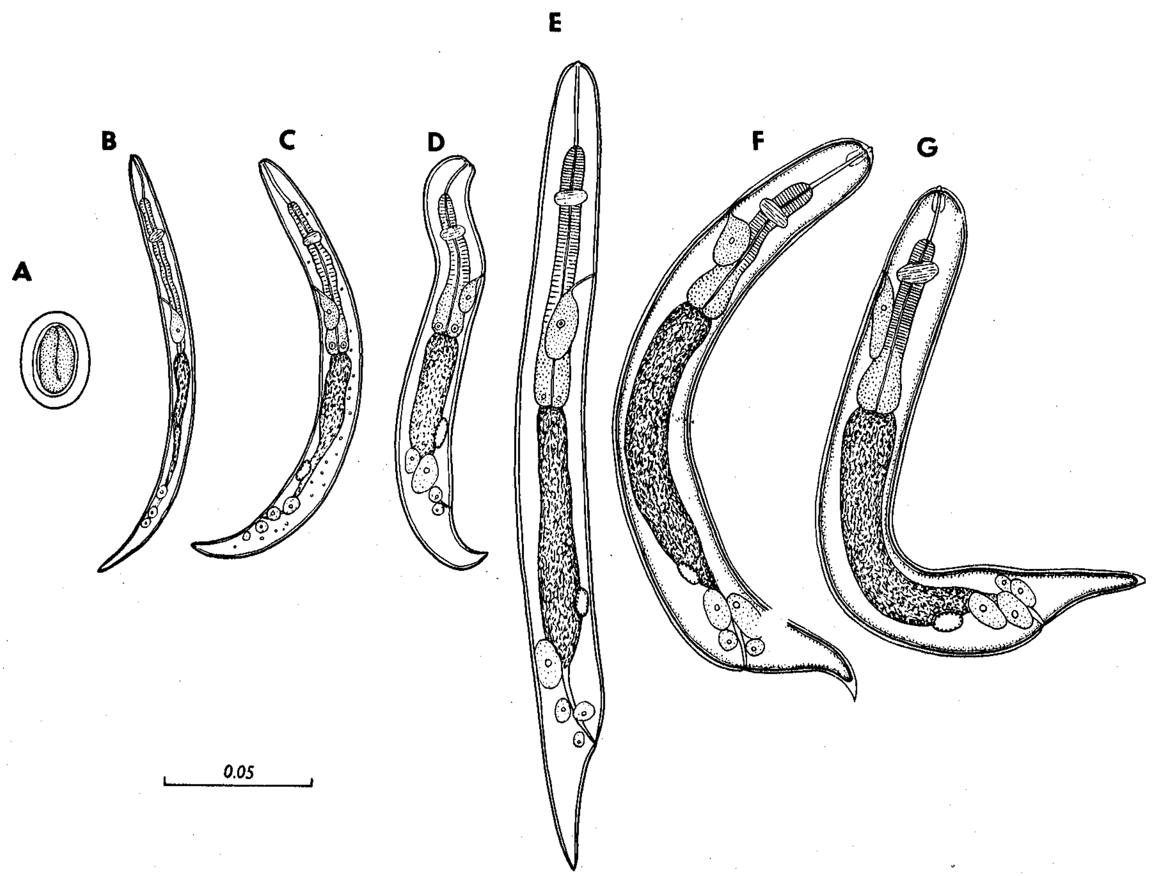

Fig. 1. *Syncuaria squamata* (Linstow, 1883). **A** – mature egg; **B – G** – first-stage larva from the intermediate host (**B** – 2 days p.i.; **C, D** – 5 days p.i.; **E** – 7 days p.i.; **F, G** – larva undergoing first moult 9 days p.i.).

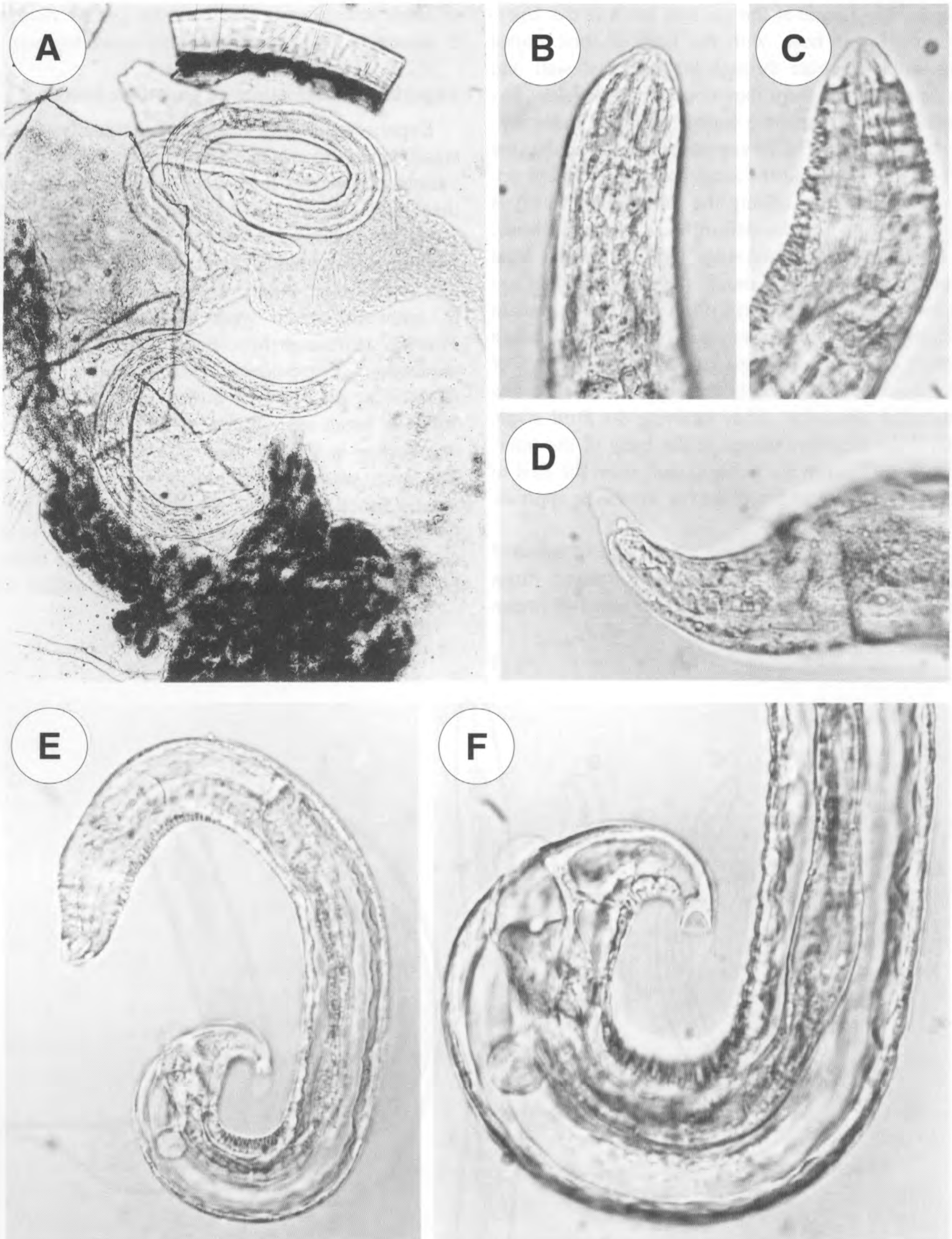

Fig. 2. *Syncuaria squamata* (Linstow, 1883) – second-stage larvae from ostracods. **A** – two larvae in broken body of an ostracod on day 11th p.i. (x 140); **B** – cephalic end of larva 11 days p.i. (x 670); **C** – cephalic end of larva 15 days p.i. (x 670); **D** – tail of larva undergoing first moult on day 11th p.i. (x 670); **E** – larva undergoing second moult on day 15th p.i. (x 340); **F** – posterior end of body of larva undergoing second moult on day 15th p.i.; note the bifurcated tip of newly formed tail (x 670).

capsule firmly attached to the intestinal surface. All larvae from fishes were living which indicates that they are capable of surviving in their fish paratenic hosts for more than a month.

B. Morphology and larval development

a) Eggs Fig. 1A

The eggs are oval, thick-walled, with almost smooth surface. The mature eggs measure 0.036–0.039 x 0.024–0.027 mm and they contain a first-stage larva.

b) First-stage larva Fig. 1

The larvae recovered from ostracods on 2nd day after infection are fine, with light, transparent body measuring 0.156–0.165 mm in length and 0.009 mm in width. The cuticle is very thin and smooth. The cephalic end of body is provided with a small boring tooth (Figs. 1B, C); cephalic papillae are indistinct. The inner organization of the body is rather obscure. The digestive tract starts as a narrow, slightly sclerotized tube (vestibule) covered with fairly large cells. The oesophagus appears to be undivided, extending posteriorly approximately to mid-length of body. The nerve ring encircles the oesophagus at the border of its first and second quarters. The excretory cell is hardly visible at this stage, being located at a short distance anterior to the oesophagus end; the excretory pore is distinct. The intestine is thin-walled, somewhat vesicular at its anterior part. Three distinct unicellular rectal glands are present around the rectum. The anal opening is distinct, the tail is conical and pointed at its distal tip.

During the following three days the body of larvae widens, their internal organization is more distinct and they become less active. Their cuticle becomes somewhat thicker and in living larvae it is possible to observe a small but conspicuous, highly refractile drop-like formation at the cephalic end. The posterior end of the oesophagus becomes distinctly wider than its anterior part and appears to have a glandular structure. A small oval genital primordium becomes visible near the posterior end of intestine. Seven-day-old larvae are stouter, mostly immobile, with a thick cuticle. Their body length

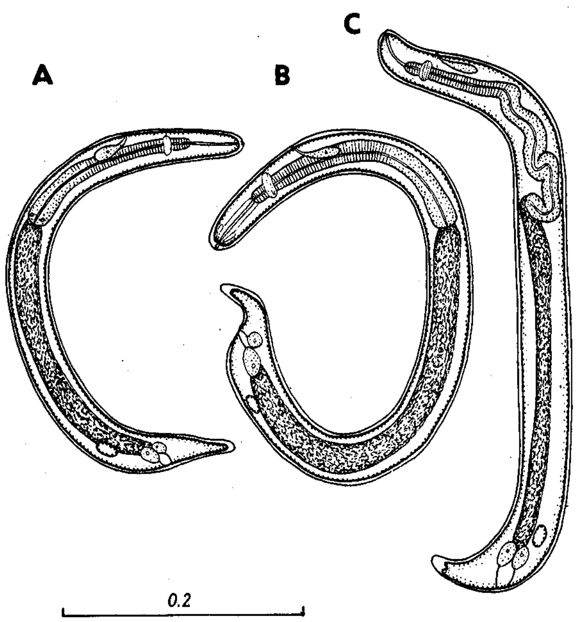

Fig. 3. *Syncuaria squamata* (Linstow, 1883) – larval development from the second to the third stage. **A, B** – second-stage larvae inside the cuticle from the first moult 11 days p.i.; **C** – transitory-stage larva undergoing second moult on day 13th p.i.

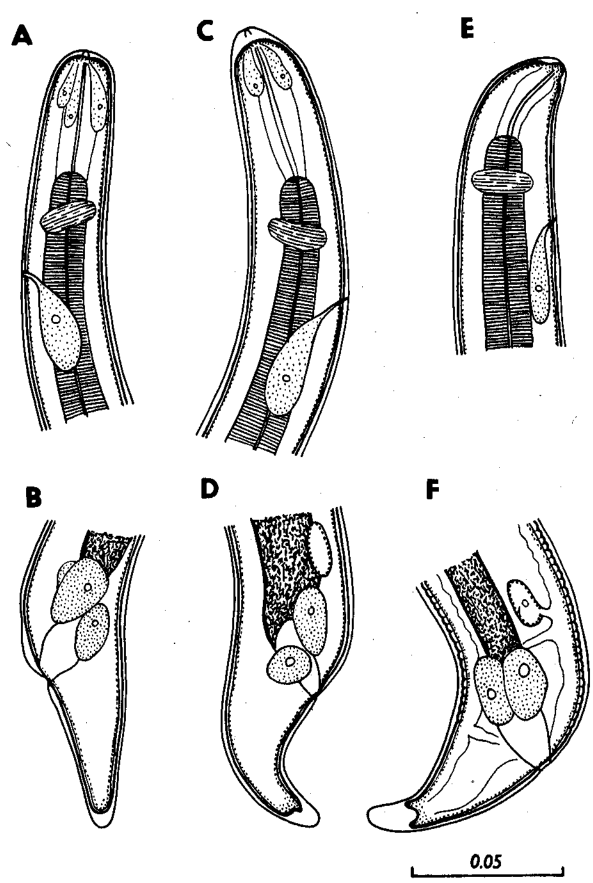

Fig. 4. *Syncuaria squamata* (Linstow, 1883) – anterior and posterior ends of larvae during first and second moults. **A, B** and **C, D** – larvae undergoing first moult 11 days p.i.; **E, F** – larva during second moult 13 days p.i.

Table 2. Growth of *S. squamata* larvae in the intermediate host.

	First-stage larvae			
				First moult
	2 days p.i.	5 days p.i.	7 days p.i.	9 days p.i.
Length of body	0.156–0.165	0.153–0.180	0.201–0.300	0.237–0.285
Width of body	0.009	0.012–0.021	0.015–0.027	0.030
Length of oesophagus including vestibule	0.057–0.063	0.069–0.078	0.123–0.132	0.090–0.096
Length of vestibule		0.015	0.033	0.024
Distance of nerve ring		0.036	0.039–0.045	0.036–0.045
Distance of excretory pore	0.039–0.054	0.054	0.075–0.081	0.045–0.057
Length of tail	0.027–0.030	0.018	0.048	0.015–0.045
Genital primordium from anterior end			0.195	0.180–0.198

	First-stage larvae	Second-stage larvae		Third-stage larvae
	First moult	Second moult		
	11 days p.i.	13 days p.i.	15 days p.i.	18 days p.i.
Length of body	0.450–0.654	0.354–0.600	0.330–0.846	1.122–1.170
Width of body	0.036–0.045	0.033–0.042	0.039–0.045	0.048–0.063
Length of oesophagus including vestibule	0.165–0.240	0.138–0.180	0.135	0.669–0.792
Length of vestibule	0.036–0.054	0.027–0.033	0.039	0.063–0.066
Distance of nerve ring	0.060–0.075	0.060	0.066	0.084–0.093
Distance of excretory pore	0.090–0.105	0.090–0.105	0.090–0.105	0.114–0.123
Length of tail	0.042–0.063	0.048–0.060	0.045–0.060	0.054–0.063
Genital primordium from anterior end	0.330–0.519			
Genital primordium from rectum		0.054–0.063	0.039	0.060–0.075

(0.291–0.300 mm) is almost twice as long as that of the early first-stage larvae and their body width attains 0.027 mm. The maximum width of body is at the rectal region. A small terminal papilla-like formation is visible on the cephalic end (Fig. 1E). These larvae are sensitive to osmotic pressure and their body bursts in the water when removed from the ostracod.

The larvae recovered 9 days p.i. are slowly moving, plump, somewhat shorter than those 7 days p.i. They undergo the first moult and the sheathed cuticle is best visible on both ends of the body. Their general morphology is similar to that of younger larvae.

c) Second-stage larva Figs. 2–4

The second-stage larvae still inside the cuticle from the first moult are found 11 days p.i. They are 0.450–0.654 mm long and 0.036–0.045 mm wide. The larvae are almost immovable. Their morphology is similar to that of older first-stage larvae. The cephalic end is rounded and a few distinct elongate cells are situated around the anterior end of the vestibule. The oesophagus is relatively long, but still undivided, representing about one third of the body length. The nerve ring encircles the oesophagus near its anterior end, the excretory pore is situated at short distance posterior to the nerve ring level. The intestine is straight, relatively wide. The rectum is a short, wide hyaline tube, surrounded by three large oval unicellular rectal glands. The tail is conical, with a rounded tip. The small oval genital primordium is located ventrally at a short distance anterior to the rectum.

The second moult of the larvae starts apparently immediately after the first one. Larvae undergoing the second moult were recovered 13 and 15 days p.i. These were 0.501–0.846 mm long and 0.039–0.045 mm wide. In contrast to younger larvae, their body is more transparent and their inner organs clearly visible. The oesophagus is not yet divided, but its posterior glandular part is conspicuously elongated. The intestine becomes markedly narrow in diameter. The tail is short, with a bifurcated tip in lateral view. A newly formed, densely transversely striated cuticle is visible beneath the old cuticle of the second moult.

d) Third-stage (infective) larva from the intermediate host Figs. 5, 6

The third-stage larvae, without the sheathed cuticle from the second moult, were first recovered on the 18th

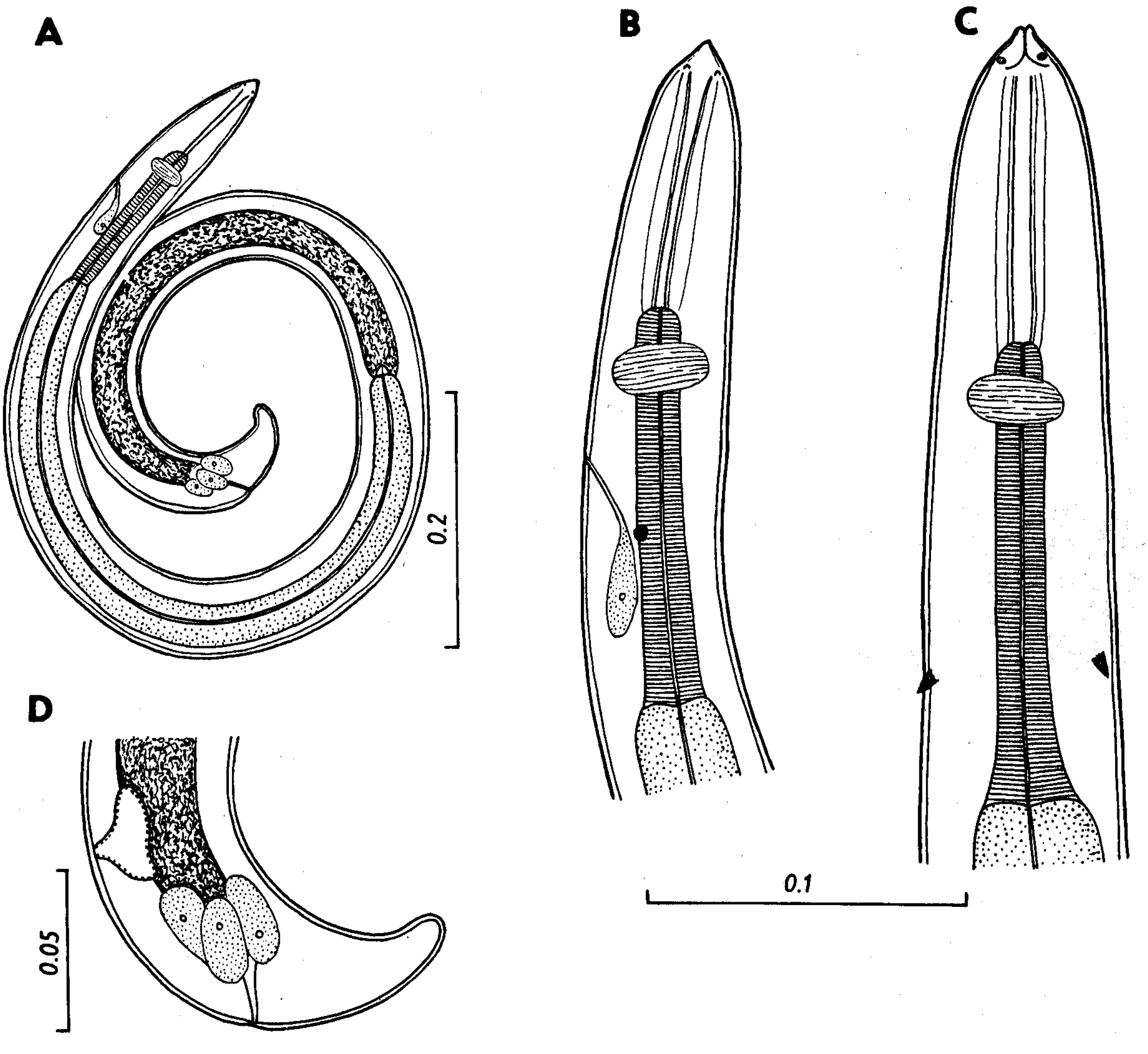

Fig. 5. *Syncuaria squamata* (Linstow, 1883) – third-stage larva from the intermediate host 18 days p.i. **A** – general view; **B, C** – anterior end, lateral and dorsoventral views; **D** – tail.

day p.i. These larvae, which measure 1.12–1.17 mm in length and 0.048–0.063 mm in width (for other measurements see Table 2), now resemble the adult nematodes in their morphology. They are light coloured, with an almost smooth cuticle (a dense, fine transverse striation of cuticle is hardly visible). The cordons are absent. The pseudolabia are well developed, triangular, with prominent apices. Four cephalic papillae are located immediately posterior to pseudolabia. The vestibule (buccal capsule) is narrow, elongated. The oesophagus is divided into a short and narrow anterior muscular part and a much longer and wider glandular one. The nerve ring encircles the muscular oesophagus near its anterior end. The excretory pore is situated posteriorly to the nerve ring level. The comparatively large deirids with pointed tips are located at some distance behind the level of the excretory pore. The intestine is narrow, light in colour. The rectum is a short hyaline tube surrounded by three large, oval unicellular rectal glands. The tail is conical, with smooth rounded tip. A small genital primordium is located just anteriorly to the rectum.

These larvae are spirally coiled and rest in the haemocoel of the intermediate host, but no capsule develops around them. The tendency to coil up the body is evident even when fixing such larvae. This phenomenon is apparently connected with the fact that larvae of this type are infective larvae, infecting passively their paratenic or definitive hosts.

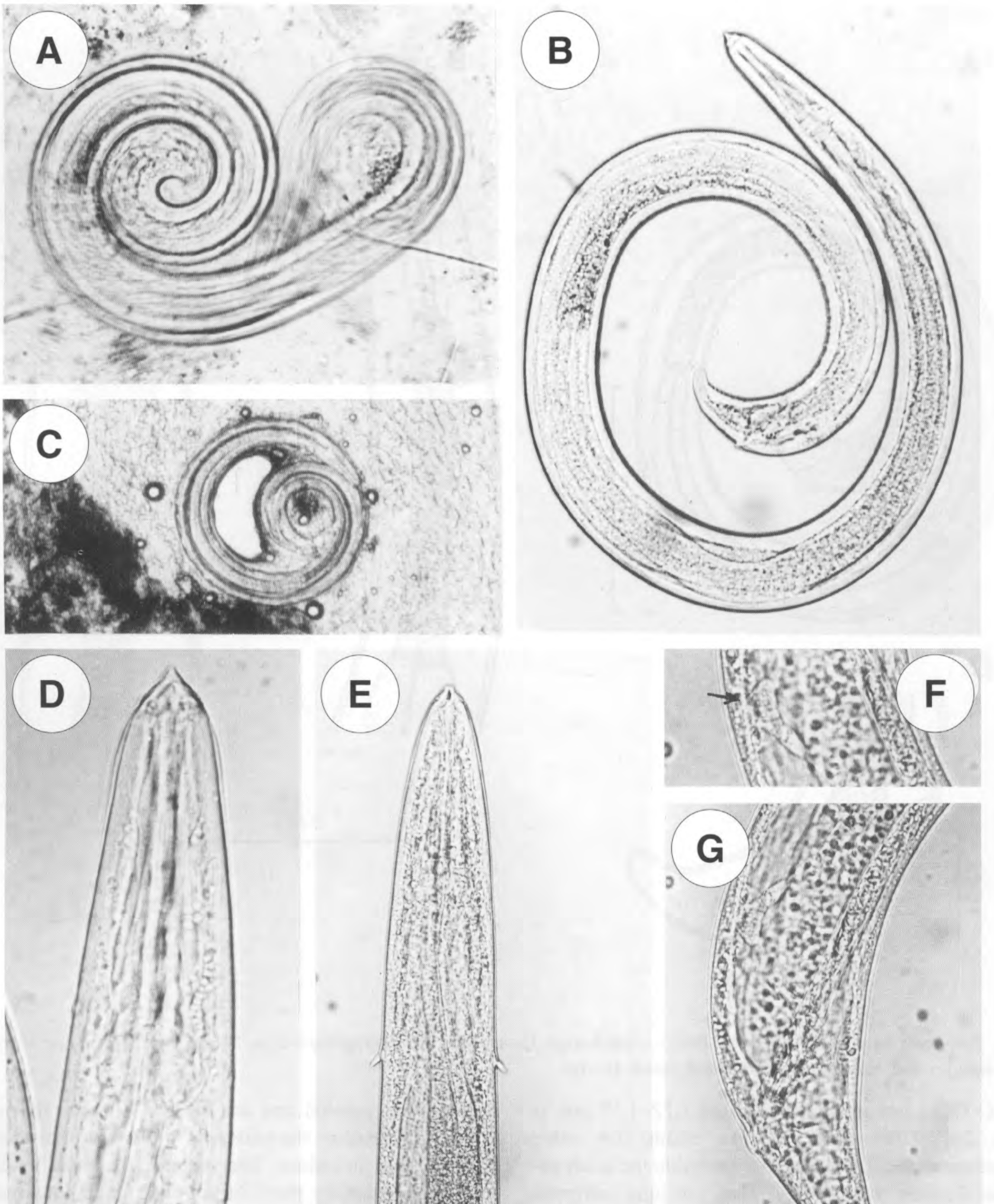

Fig. 6. *Syncuaria squamata* (Linstow, 1883) – third-stage larvae. **A** – third-stage larva in tissue of ostracod intermediate host (x 290); **B** – larva liberated from ostracod 18 days p.i. (x 290); **C** – larva on liver surface of experimentally infected guppy (*Poecilia reticulata*) 41 days p.i. (x 125); **D** – anterior end of larva from ostracod 18 days p.i., lateral view (x 750); **E** – anterior end of larva from naturally infected tench (*Tinca tinca*), dorsoventral view (x 340); **F** – region of genital primordium (arrow) of larva from naturally infected tench (x 570); **G** – posterior end of larva from naturally infected tench (x 520).

e) Third-stage larvae from experimental paratenic hosts Figs. 6C

The third-stage larvae recovered from experimentally infected fish paratenic hosts (see Tables 1 and 3) were morphologically identical with the third-stage larvae from ostracods. The measurements were also very similar, although the length of body in some larvae from *Oncorhynchus mykiss* and *Noemacheilus barbatulus* was somewhat greater (Table 3).

f) Third-stage larvae from natural paratenic hosts Fig. 6E–G

The third-stage larvae of *Syncuaria squamata* were found in 2 out of 10 tench, *Tinca tinca* (L.), (body length 20 and 22 cm) examined from the pond Ženich near Třeboň, South Bohemia, in April 1991; a single larva was present in each fish. The larvae were located on the surface of the host's intestine and were inside a thin-walled whitish envelope produced by the host tissue. The larvae were morphologically identical (Fig. 7) but somewhat larger than those from the ostracod intermediate host (see Table 3). In addition to tench, 25 fishes of eight other species were examined from the same locality but no larvae of *S. squamata* were found in them.

DISCUSSION

The species under study was originally described by Linstow (1883) as *Filaria squamata* from females obtained from the common cormorant (*Phalacrocorax carbo*) from Central Asia and the male was later described by Saidov (1954) from *P. carbo* in the Caspian Sea. Kurochkin (1958) redescribed the species (reported as *Skrjabinocara squamata*) and he synonymized with it *S. schikhobalovi, S. skrjabini, S. timofejevi* and *S. viktori*. Wong et al. (1986) transferred this species to the genus *Syncuaria* Gilbert, 1927 and redescribed it on the basis of nematodes collected from *Phalacrocorax auritus auritus* from Canada (Ontario). Although Kurochkin (1958) reported that the shape of deirids was rather variable in this species, these being mostly three-peaked but, exceptionally, two- or many-peaked, Wong et al. (1986) mention and illustrate only bifurcated deirids in this species. Our recent SEM studies of *S. squamata* adults from Czech Republic (unpublished) have revealed the presence of three-peaked deirids in all specimens examined. In addition, the shape of mature eggs of *S. squamata* as illustrated by Wong et al. (1986) is different (markedly narrow) as compared to that of eggs in European specimens (see e.g., Kurochkin 1958; present study). Consequently, it may well be that the above mentioned morphological differences reflect certain

Table 3. Measurements of *S. squamata* third-stage larvae from ostracods and fishes.

	From intermediate hosts	From paratenic hosts			
	Notodromas monacha (18 days p.i.)	*Oncorhynchus mykiss* (8 days p.i.)	*Poecilia reticulata* (41 days p.i.)	*Noemacheilus barbatulus* (17 days p.i.)	*Tinca tinca* (natural inf.)
Length of body	1.122–1.170	1.014–1.455	1.032	1.440	1.537–1.564
Width of body	0.048–0.063	0.045–0.054	0.048	0.051	0.054
Length of pseudolabia	0.009	0.006–0.009	0.006	0.009	0.008
Length of oesophagus including vestibule	0.669–0.792	0.600–0.831	0.660	0.825	0.816–0.864
Length of vestibule	0.063–0.066	0.054–0.075	0.060	0.072	0.072–0.075
Muscular oesophagus: length	0.111–0.114	0.093–0.096	0.096	0.090	0.108–0.117
width	0.012	0.012–0.015	0.015	0.015	0.015–0.018
Glandular oesophagus: length	0.492–0.609	0.450–0.600	0.591	0.587	0.624–0.684
width	0.027–0.030	0.024–0.030	0.024	0.027	0.030
Distance of nerve ring	0.084–0.093	0.075–0.093	0.078	0.090	0.090–0.096
Distance of excr. pore	0.114–0.123	0.105–0.132	0.108	0.129	0.126–0.132
Distance of deirids	0.165	0.153–0.186	0.153	0.180	0.174–0.180
Length of tail	0.054–0.063	0.048–0.066	0.039	0.060	0.045–0.051
Genital primordium from rectum	0.060–0.075	0.090	0.060	0.060	0.060–0.081

genetic differences between the Nearctic and the Palaearctic populations of this parasite.

Kurochkin (1958) was the first to find that ostracods serve as the intermediate hosts for *Syncuaria squamata*. He not only successfully infected *Cypris pubera* with *S. squamata* eggs but, at the same time, he found naturally infected conspecific ostracods from the shallow, drying up water reservoirs at places with cormorant colonies at the Astrakhan Natural Reserve. The ostracods (*Cyclocypris ovum* and *Cypridopsis vidua*) were experimentally proved to be suitable intermediate hosts of *S. squamata* also by Wong and Anderson (1987) in Canada. Results of the present study show that another ostracod species, *Notodromas monacha*, can serve as the intermediate host of this parasite. The intermediate hosts of other *Syncuaria* species are unknown. *Syncuaria squamata* is the second acuarioid species known to utilize ostracods as an intermediate host, in addition to *Desportesius invaginatus* (see Chabaud 1950). However, dragon-fly larvae of the genus *Anax* (Insecta) have been reported as an intermediate host for another *Desportesius* species, *D. brevicaudatus*, by Mozgovoy et al. (1965).

Kurochkin (1958) mentions that the first moult of *Syncuaria squamata* larvae in ostracods occurs apparently 3–4 days p.i., but the author did not observe this moulting. According to Wong and Anderson (1987), the first moult occurred only 11 days p.i. and the second moult 18 days p.i. at room temperatures of 19–21°C. The rate of larval development in ostracods in our experiments, carried out at 20–22°C, was similar to that observed by Wong and Anderson (1987), only the first moult occurred as early as on day 9th p.i.

Although Kurochkin (1958) predicted the role of fish paratenic hosts for the transmission of *Syncuaria squamata* to cormorants, he did not succeed in experimental infecting some fishes with larvae from ostracods. Now it is apparent that it was due to the fact that his 8-day-old larvae (0.73 mm long) used in these experiments were not infective third-stage larvae but only advanced second-stage larvae. Wong and Anderson (1987) found goldfish (*Carassius auratus*) to be a suitable experimental paratenic host of *S. squamata* in which the larvae were located in granulomas on the intestinal serosa; no information was given how long these larvae can survive in this host. Our experimental infections have indicated that four other species of fish belonging to the families Cyprinidae, Cobitidae, Salmonidae and Poeciliidae (*Alburnoides bipunctatus, Noemacheilus barbatulus, Oncorhynchus mykiss* and *Poecilia reticulata*) can serve as the paratenic hosts of *S. squamata*, in which they can survive more than a month. Tench, *Tinca tinca*, has been found as the first known natural paratenic host of this parasite. In our opinion, the fish paratenic hosts are the principal source of *S. squamata* infection for cormorants, although a direct transmission from infected ostracods is also possible (Wong and Anderson 1987).

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