FOLIA PARASITOLOGICA 46: 205-215, 1999

On the development and life cycle of *Camallanus anabantis* (Nematoda: Camallanidae), a parasite of the climbing perch, *Anabas testudineus*

Nimai C. De

Helminthology Laboratory, Zoology Department, Kalyani University, Kalyani, West Bengal, 741235, India

Key words: Nematoda, *Camallanus*, *Mesocyclops*, Copepoda, *Anabas*, fishes, development, life cycle

Abstract. The developmental stages and life cycle of the nematode *Camallanus anabantis* Pearse, 1933 an intestinal parasite of *Anabas testudineus* (Bloch) are described. The copepod *Mesocyclops leuckarti* (Claus) was used as experimental intermediate host. After being ingested by the copepods the nematode first-stage larvae enter its haemocoel, where they moult twice, 4 d.p.i. and 11 d.p.i., at 21-26°C, respectively to become the infective third-stage larvae. The definitive fish hosts become infected when feeding on copepods harbouring infective larvae. In the fish host's intestine the larvae undergo two more moults, the third on day 15 p.i. The fourth moult of "male" larvae occurred on day 68 p.i. and that of "female" larvae on day 86 p.i. at water temperatures 24-36°C. A female with eggs and few larvae in the uteri was first observed on day 187 p.i.

The nematode *Camallanus anabantis* Pearse, 1933 is the common intestinal parasite of *Anabas testudineus* (Bloch) (type host) and also reported to be harboured by many other fishes such as *Clarias batrachus* (Linnaeus), *Channa gachua* (Hamilton), *C. punctatus* (Bloch), *Puntius filamentosus* (Valenciennes), *Betta unimaculata* (Popta), *Mastacembelus armatus* (Lacepede) and *Trichogaster trichopterus* (Pallas) (see Soota 1983). Examinations of the larvae, particularly the third and fourth stages, have been found useful in determining species in the genus (see De and Ghosh 1989). De (1993) studied the seasonal dynamics of *C. anabantis* in the type host but the development and larval morphogenesis of this nematode are still unknown. The life cycles of only six *Camallanus* species from fishes (Kupryanova 1954, Campana-Rouget 1961, Moravec 1969, 1971a, b, Monchenko 1972 on *C. lacustris* (Zoega, 1776), Kupryanova 1954 on *C. truncatus* (Rudolphi, 1814), Stromberg and Crites 1974 on *C. oxycephalus* Ward et Magath, 1917, Stumpp 1975 on *C. cotti* Fujita, 1927, Campana-Rouget et al. 1976 on *C. fotedari* Raina et Dhar, 1972 and De and Maity 1995 on *C. xenentodoni* Khan et Yaseen, 1969) have been studied so far. The present communication deals with the results of the studies on the development of *C. anabantis* in the intermediate copepod host and the definitive fish host.

MATERIALS AND METHODS

Specimens of *Camallanus anabantis* were collected from intestines of *Anabas testudineus* purchased from the local fish market in Kalyani, West Bengal, India in February 1997. The collected worms were rinsed thoroughly in 0.85% saline. Gravid females with motile first-stage larvae in their uteri were sorted out and transferred to small Petri dishes (4 worms in each) containing filtered tap water and kept overnight at room temperature to permit the release of larvae. The spent females were taken out and the content of each Petri dish was poured into a 250 ml glass beaker containing filtered pond water up to one third and in which fifty previously starved, laboratory reared copepods, *Mesocyclops leuckarti* (Claus) had been added earlier. After being exposed for two hours the copepods from each beaker were transferred to separate 500 ml beakers, three-fourth of which had been previously filled up with filtered pond water. A few algal filaments were added to each beaker, kept at 21-26°C. Twenty-five copepods from each beaker were examined under low magnification to determine infection of the copepods. To study larval development, copepods from each beaker were teased by fine needles on glass slides and examined by light microscopy at 2 hour intervals after 24 hours of infection period. Later, the intervals were gradually increased. For experimental infection a total of 60 fishes, *A. testudineus* reared in the laboratory and fed dry food only were used. To infect the fishes five infected copepods (each harbouring 4 third-stage larvae on average) were forcibly pushed into the stomach of each fish by means of a long-nozzled dropper. The fishes were kept at normal temperatures 24-36°C. The fishes were killed and examined at intervals, between 9 and 187 d.p.i. All larvae i.e. those obtained from the haemocoel of the cyclops and caeca and intestine of the fishes were killed by gentle heating and fixed in 4% formaldehyde. After being cleared in 2% glycerol the larvae were examined by light microscopy. All measurements are in micrometres.

RESULTS

Experimental infections of copepod intermediate hosts

Larvae released by the gravid females, when transferred to pond water in the experimental beakers, tended to hover near the bottom of the water column.

Address for correspondence: N.C. De, Zoology Department, Kalyani University, Kalyani, West Bengal, 741235, India. Phone: ++91 33 582 8750; Fax: ++91 33 582 8282; E-mail: ncde@klyuniv.ernet.in

They show considerable motility and become ingested by copepods, and migrate from its digestive tract to the haemocoel of the cephalothorax, where they develop further. The first-stage larvae increase in size, both the cuticle and wall of the oesophagus become thickened and consequently, the spacious oesophageal cavity narrows. The oesophageal gland cells with distinct nuclei appear at the posterior end of the oesophagus. At 21-26°C almost all larvae become ensheathed between days 3 and 4 p.i. The first moult occurred on day 4 p.i. at 21-26°C. The second moult, to attain the third infective-stage, occurred on day 11 p.i. at 21-26°C. The fully developed third-stage larvae were, however, first recovered from the copepod hosts on day 14 p.i. They remain in the haemocoel of the cephalothorax of the copepod intermediate host as coiled third-stage larvae and their further development ceases.

In the present series of experiments the prevalence of infection of copepods was 67%, intensity range 1-10, and mean intensity 4.

Experimental infection of fish definitive hosts

In the present series of experiments sixty fishes, selected for experimental use, were forcibly fed experimentally infected copepods harbouring third-stage larvae. Only 34 out of 60 fishes examined on different days p.i. were found to harbour larvae and/or adults of *C. anabantis.* The nematodes were found located in the caecum (third- and fourth-stage only) and anterior and middle parts of the host's intestine. Morphological data of the nematodes recovered from the fishes revealed that the third moult occurred on day 15 p.i. The fourth i.e. final moult occurred at different times for the "male" and "female" larvae, on day 68 p.i. in "male" larva but on day 86 p.i. in "female" larva. A female with few larvae in the uteri was recovered on day 187 p.i.

Morphology and larval development

First-stage larvae

First-stage larvae from female uterus (n=14) Figs. 1,6

Body translucent, 231-300 long and 13-15 in maximum width (see Table 1 for other measurements). Body cuticle transversely striated. Head rounded, with a small dorsal cuticular tooth; oral papillae indistinct. Short buccal tube. Oesophagus thin-walled and with spacious lumen occupies 15-19% of body length. Nerve-ring encircles oesophagus at its posterior third. Excretory pore anterior to nerve-ring. Intestine wide, light-coloured and with fine granules; posteriorly with large cuboidal cells. Tail conical, elongate with pointed tip, 13-19 % of body length.

First-stage larvae from cyclops (n=19) Fig. 2

After penetration into the haemocoel of the copepod, the dimensions of first-stage larvae changed only a little (Table 1) but the oesophagus differentiated into a thick-walled anterior moiety and a posterior glandular moiety with distinct cell nuclei.

Second-stage larvae

Moulting first-stage larva (n=1) Fig. 3

The first larval moult occurred in the haemocoel of copepod on day 4 p.i. At this stage larva measures 435 long and bears no dorsal cephalic tooth. Oesophagus indistinctly divided into anterior muscular (58 long) and posterior glandular (21 long) parts. Intestine straight and wide, a short posterior part with large cuboidal cells and narrow lumen. Small oval ventral genital primordium near midintestine. Tail relatively short, 14% of body length.

Developed second-stage larvae (n=17) Figs. 4, 5, 9, 10

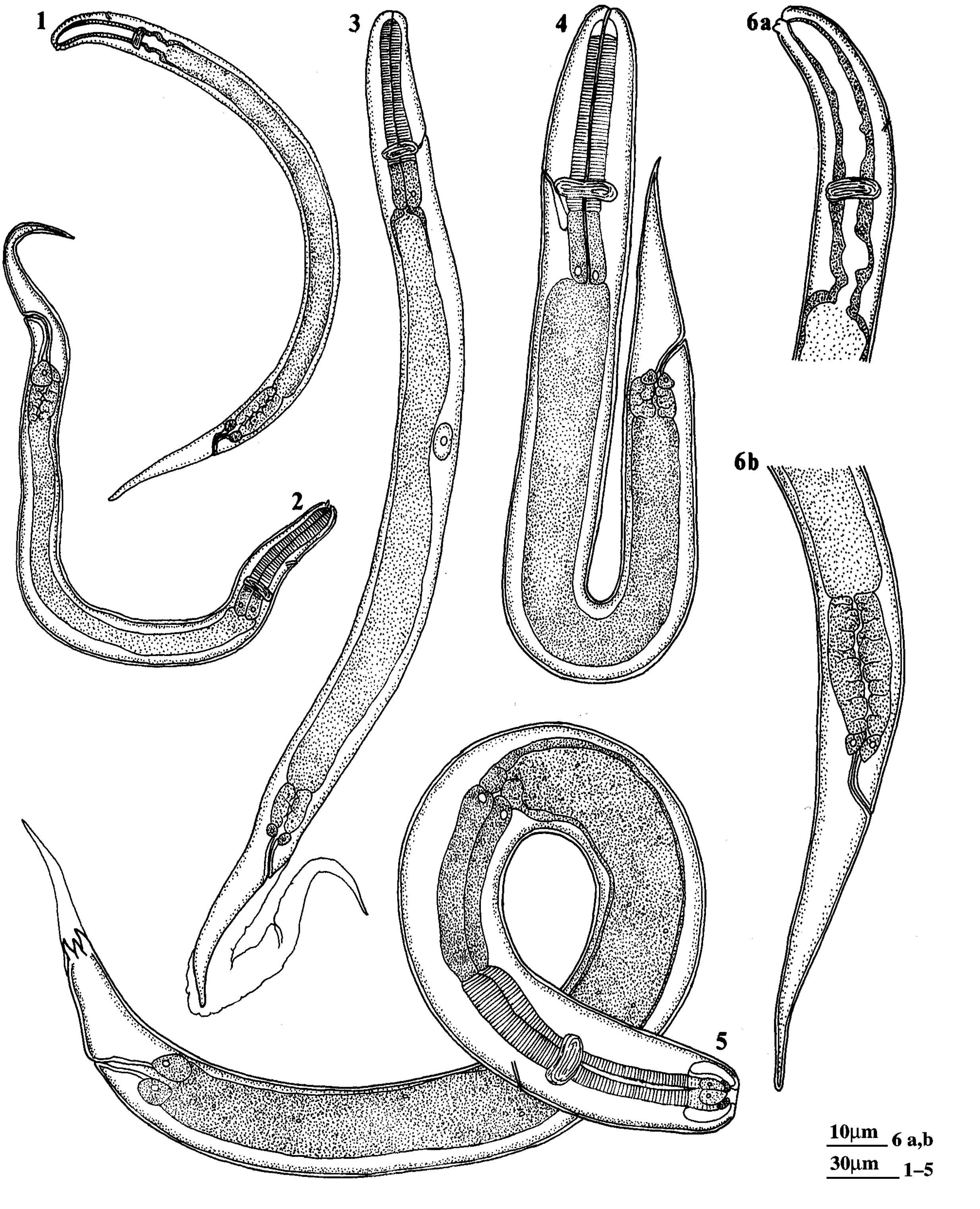
Second-stage larvae were first recovered on day 7 p.i. Body more stout, tail relatively short. Cuticle transversely striated. Cephalic end rounded and without dorsal cuticular tooth; buccal tube short. Oesophagus with anterior long muscular and posterior short glandular moieties. Straight, wide intestine with short posterior zone bearing large cuboidal cells.

The larva recovered on day 10 p.i. was found preparing for its second moult, best visible at tail end. The typical third-stage tail visible below larval cuticle. Anterior end of oesophagus with a hyaline bell-shaped structure, two small bead-like structures and two large cells with distinct nucleus also visible. Oesophagus with anterior muscular moiety longer than posterior glandular one. Nerve-ring near middle of muscular oesophagus. Excretory pore slightly posterior to nerve-ring. Intestine straight, wide and with coarse granules.

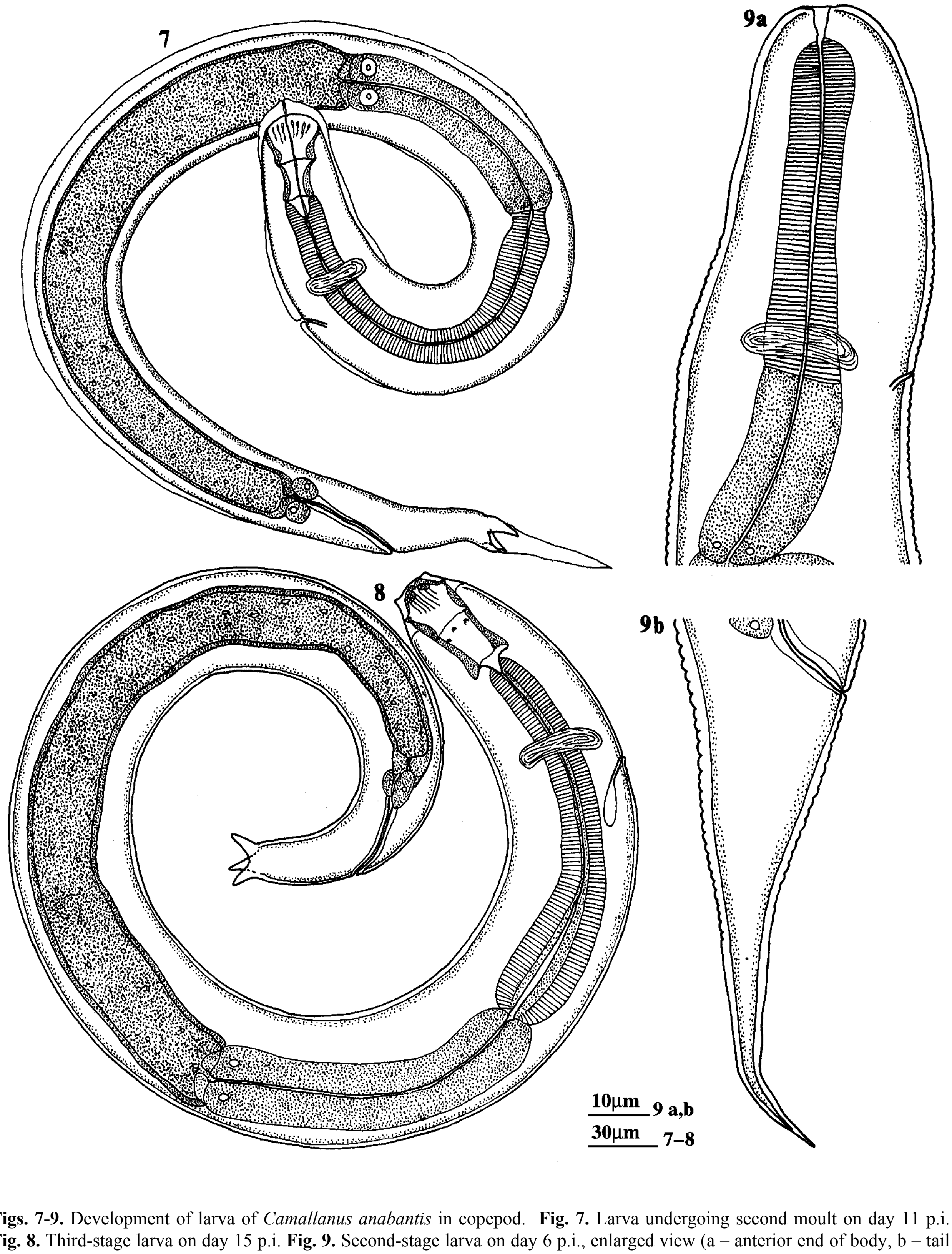
Third-stage larvae from copepods

Moulting second-stage larvae (n=2) Fig. 7

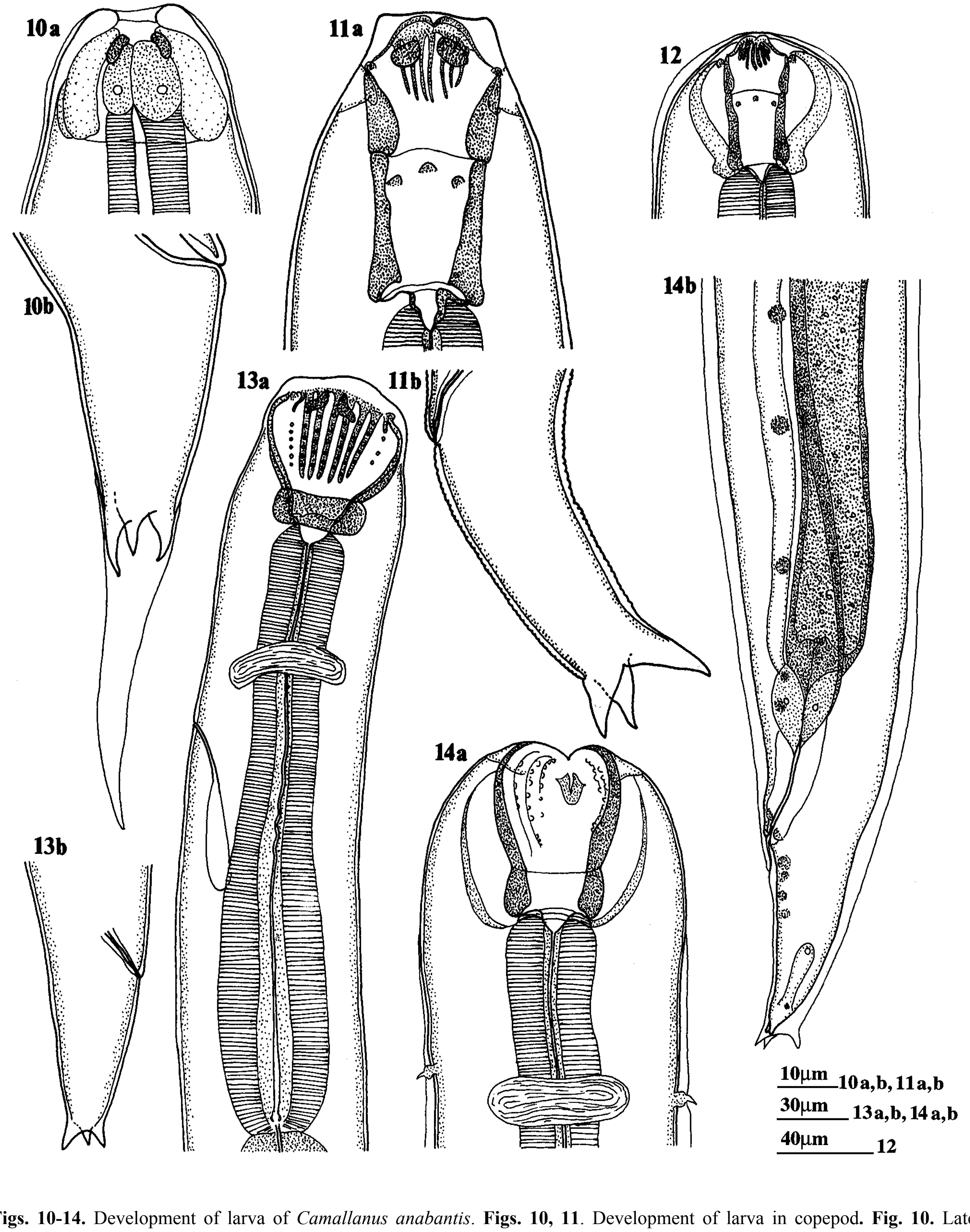
The two larvae undergoing the second moult were recovered from the copepod haemocoel on day 11 p.i. During moulting, old cuticle becomes loosened at both ends, particularly on tail. Larval body light-coloured and covered with thin cuticle. Oral opening dorsoventrally elongate. Buccal capsule, typical camallanid type, already formed and contains two parts; anterior part bivalved, each valve reinforced with 7 sclerotised longitudinal ridges on inner surface and posterior part simple leading posteriorly to an oesophageal cup. Sclerotised inner lining of anterior part of oesophagus seen to pass out through buccal capsule. Oesophagus with longer anterior muscular and short posterior glandular parts, Nerve-ring at about 1/4 of oesophagus length. Excretory pore slightly posterior to nerve-ring. Glandular oesophagus opens into intestine through valvular apparatus. Intestine wide, light orange in colour and posteriorly joins short, narrow rectum; three small unicellular rectal glands present at their junction. Tail ends in one dorsal and two subventral mucrones.



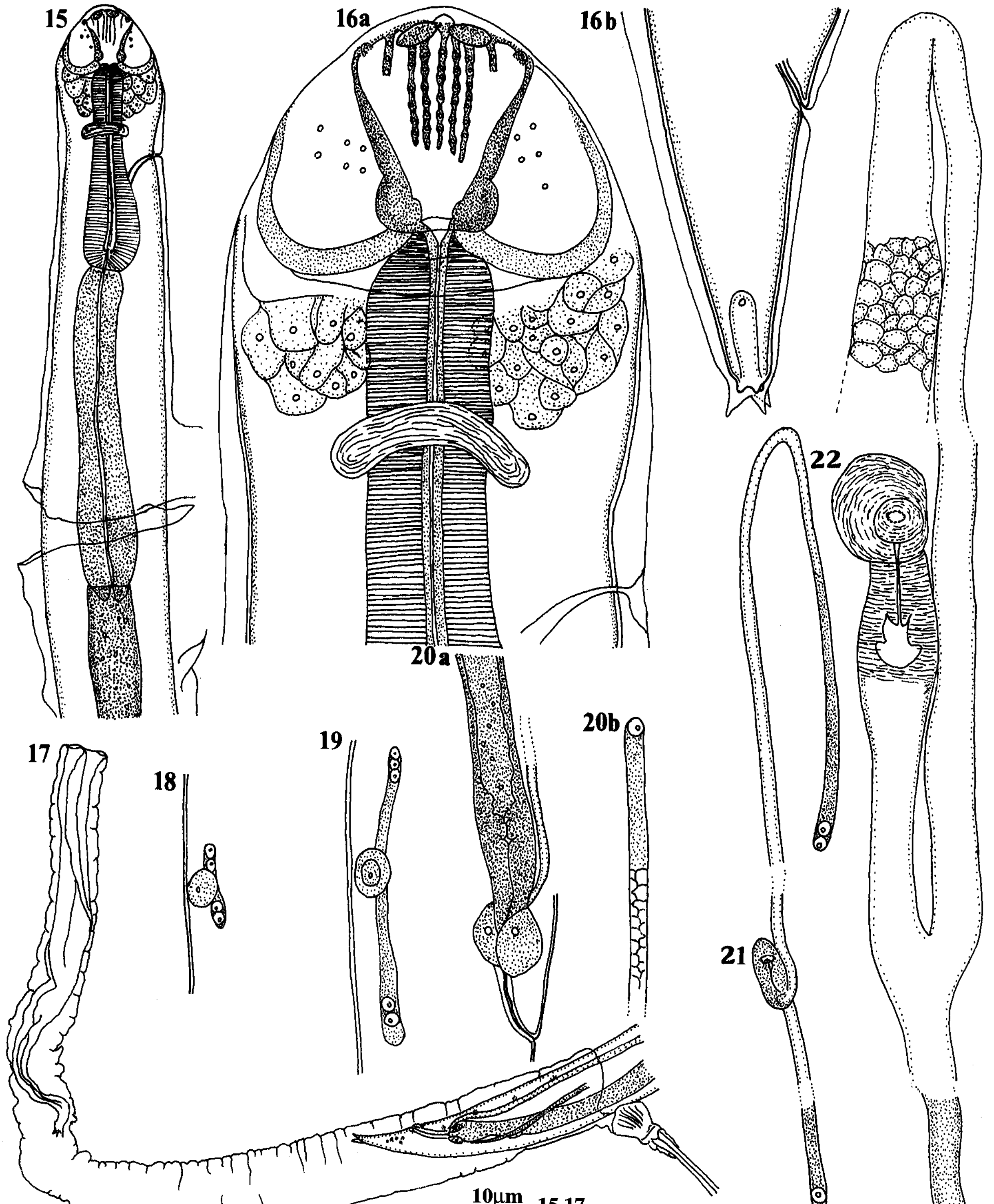
Figs. 1-6. Development of larva of *Camallanus anabantis.* **Fig. 1.** Free first-stage larva. **Figs. 2-6.** Development of larva in copepod. **Fig. 2.** First-stage larva on day 2 p.i. **Fig. 3.** Larva during first moult on day 4 p.i. **Fig. 4.** Second-stage larva on day 7 p.i. **Fig. 5.** Late second-stage larva on day 10 p.i. **Fig. 6.** Free first-stage larva, enlarged view (a – anterior end of body, b – tail end).



Figs. 7-9. Development of larva of *Camallanus anabantis* in copepod. **Fig. 7.** Larva undergoing second moult on day 11 p.i. **Fig. 8.** Third-stage larva on day 15 p.i. **Fig. 9.** Second-stage larva on day 6 p.i., enlarged view (a – anterior end of body, b – tail end).



Figs. 10-14. Development of larva of *Camallanus anabantis*. **Figs. 10, 11**. Development of larva in copepod**. Fig. 10.** Late second-stage larva on day 10 p.i., enlarged view (a – anterior end of body, b – tail end). **Fig. 11**. Third-stage larva on day 15 p.i., enlarged view (a – anterior end of body, b – tail end). **Figs. 12-14**. Development of larva in *Anabas testudineus*. **Fig. 12.** Anterior end of larva undergoing third moult on day 15 p.i. **Fig. 13.** Fourth-stage larva on day 15 p.i. (a – anterior end of body, b – tail end). **Fig. 14.** "Male" larva preparing for final moult on day 60 p.i. (a – anterior end of body, b – tail end).



Figs. 15-17. Development of larva of *Camallanus anabantis* in *Anabas testudineus*. **Fig. 15.** "Female" larva undergoing fourth moult on day 86 p.i., anterior end. **Fig. 16.** "Female" larva undergoing fourth moult on day 86 p.i., enlarged view (a – anterior end, b – tail end). **Fig. 17.** Tail end of "male" larva undergoing fourth moult on day 68 p.i. **Figs. 18-22.** Development of genital primordium in larvae of *C. anabantis* from *A. testudineus*. **Figs. 18, 19.** In third-stage larva on day 15 p.i. **Fig. 20.** In fourth-stage "male" larva on day 33 p.i. (a – distal end, b – proximal end). **Fig. 21.** In fourth-stage "female" larva on day 69 p.i. **Fig. 22.** In fourth-stage "female" larva on day 84 p.i.

Third-stage (infective) larvae (n=4) Figs. 8, 11

Third-stage larvae were first recovered on day 14 p.i. at water temperatures 21-26°C. Their development in the copepod hosts was studied up to 15 days p.i. Larvae measure 735-813 in length. Cuticle immediately after second moult appears smooth but later transverse striations appear. Two submedian cephalic papillae seen in lateral view but amphids not discernible. Buccal capsule with bivalved anterior part, each with 6-7 smooth longitudinal ridges on inner surface and simple posterior part bearing three denticles anteriorly and leads posteriorly to a distinct oesophageal cup. Two small weakly sclerotised plates lie near anterior margin of each buccal valve. Oesophagus' anterior muscular moiety remains longer than posterior glandular one. Nerve-ring at about 1/3 of muscular oesophagus' length. Excretory pore posterior to nerve-ring. Small oval genital primordium near midintestine. Tail elongate, 7-8 % of body length with three distinct mucrones at tip.

Third-stage larvae from experimental fishes (n=12) Figs. 18, 19

Third-stage larvae of *C. anabantis* were obtained from the caeca and intestine of experimentally infected *A. testudineus* between days 14 and 33 p.i. Morphologically they resemble infective-stage larvae from copepods but their body dimensions are larger (Table 2). The glandular oesophagus exceeds anterior muscular part in length. The genital primordium starts to develop as a short rod with terminal nuclei.

Fourth-stage larvae

Moulting third-stage larva (n=1) Fig. 12

The single larva undergoing the third (first in the definitive host) moult was recovered from an experimentally infected fish on day 15 p.i.; its body longer than third-stage larvae from copepods (Table 2). Cuticle thin and indistinctly striated. Apart from the buccal capsule, typical of the third stage, a new buccal capsule seen. Newly formed buccal capsule weakly sclerotised, wider and not divided into anterior and posterior chambers. Longitudinal ridges on inner surface of new buccal capsule not seen. Tail conical with three mucrones, one large dorsal and two smaller subventral.

Developed fourth-stage larvae (n=25) Figs. 13, 14, 20-22

Fourth-stage larvae were also first obtained on day 15 p.i. being slightly larger than moulting third stage (Table 2). Cuticle thin and transversely striated. Oral opening dorsoventrally elongate. Two pairs of submedian cephalic papillae present, but amphids not discernible. Buccal capsule with two well sclerotised lateral valves, each valve bears on inner surface 7-8 beaded ridges of variable length. A pair of sclerotised plates present near anterior margin of each valve. One small weakly sclerotised knob-like body, anlage of trident, present at dorsal and ventral edges of buccal valves. Anterior muscular oesophagus shorter than posterior glandular part. Intestine straight and brown-coloured. Conical tail with three mucrones. Genital primoridia in both "male" and "female" form long slender rods, "male" with single, "female" with two opposed rods. Fourth-stage larva (male) preparing for final moult was recovered on day 60 p.i. At this stage new wider buccal capsule appears bellow the old one but buccal ridges yet to appear. Within sheath tail bears two mucrones, caudal papillae and indistinct spicules.

Young adult, fifth stage

Moulting fourth-stage "male" larvae (n=2) Fig. 17

The fourth moult of "male" larvae first occurred on day 68 p.i. at water temperature 24-36°C. Body cuticle thin. Both old, typical of fourth stage, and new wider and weakly sclerotised buccal capsule with faint beaded ridges in each valve seen. Dorsal and ventral aggregation of large cells found below newly formed buccal capsule. Muscular oesophagus shorter than posterior glandular one. Nerve-ring at about 1/3 of muscular oesophagus. Excretory pore just posterior to nerve-ring. Intestine straight and wide. Tail conical, bears two mucrones. Single genital anlage differentiated into testis and vas deferens. Spicules indistinctly visible but caudal papillae seen clearly.

Moulting fourth-stage "female" larvae (n=3) Figs. 15, 16

Fourth moult of "female" larvae occurred on day 86 p.i. At moulting body cuticle remains thin, and morphology of anterior end, including buccal capsule resembles that of corresponding "male" larva. Anlage of trident not located in lateral view. Female genital system well differentiated. Tail conical, bears three comparatively small mucrones.

Young males and females of *C. anabantis* were first recovered on day 69 and day 87 p.i., respectively. A female with eggs and few larvae in the uteri was recovered on day 187 p.i. Morphology and dimensions of the males and females obtained in the present series of experiments conform to those of Roy (1987).

DISCUSSION

The course of development of *Camallanus anabantis* follows that known in other camallanid genera. The first two moults take place in the intermediate copepod host, and the next two, i.e. third and fourth moults, in the definitive host. The morphology of the first- and second-stage larvae of *C. anabantis* is found to be almost identical to that of corresponding larval stages so far de-scribed in other *Camallanus* species as well as in genera *Procamallanus, Spirocamallanus, Paracamallanus* and *Neocamallanus*. An interesting feature of the present first- and second-stage larvae is that the intestinal wall at its distal part is made up of large cuboidal cells and therefore, the lumen is narrow there.

Table 1. Dimensions of *Camallanus anabantis* larvae in the copepod intermediate host (in µm).

	First-stage larvae				First moult	
	Free larvae	2 days p.i.	3 days p.i.	4 days p.i.	5 days p.i.	4 days p.i.
Length of body	231-300	314-319	312-367	359-382	363	435
Diameter of body	13-15	21	19-21	21-25	30	28
Length of oesophagus	38-47	42-58	42-54	54-68	66	79
Oesophagus (% body length)	15-19	13-18	13-15	15-18	18	18
Anterior – nerve-ring	32-36	34-43	17-38	38-49	38	55
Anterior – excretory pore	19-23	25	25-34	40-47	30	52
Length of tail	32-47	59	62-68	57-72	76	60
Tail (% body length)	13-19	19	18-20	16-19	21	14

	Second-stage larvae				Second moult	Third-stage larvae	
	5-6 days p.i.	7-8 days p.i.	9-10 days p.i.	11-15 days p.i.	11 days p.i.	14 days p.i.	15 days p.i.
Length of body	374-423	446-679	450-682	410-822	699-714	622	735-813
Diameter of body	32-34	32-41	36-53	23-43	42-46	34	49-59
Length of buccal capsule	-	-	-	-	35	38	44-48
Length of oesophagus	72-91	100-168	146-231	77-278	253-273	229	272-302
Oesophagus (% body length)	22-34	22-27	25-39	19-34	36-38	37	37-38
Muscular oesophagus	40-55	66-92	89-137	45-170	163-169	132	155-170
Glandular oesophagus	32-36	28-76	57-108	32-108	91-104	97	117-132
Anterior – nerve-ring	47-62	53-66	51-74	32-110	66-71	85	76-85
Anterior – excretory pore	30	54-72	57-93	25-130	79-81	83	95-106
Length of tail	68-74	53-76	46-79	56-62	52-54	49	51-60
Tail (% body length)	11-18	8-16	8-14	7-14	7-8	8	7-8

The larvae at their third stage, however, show some differences, particularly in the structure of the buccal capsule. Like the present third-stage larvae the corresponding larval forms of some other *Camallanus* spp. and other genera like *Neocamallanus*, *Serpinema* and *Paracamallanus* possess a buccal capsule with a spacious posterior portion and a few sclerotised teeth present at or near its junction with anterior portion (Campana-Rouget 1961, Moravec 1969, 1974, De et al. 1984, Bartlett and Anderson 1985). A similar divided buccal capsule is reported to occur in the third-stage larvae of some *Spirocamallanus* species e.g., *Spirocamallanus cearensis* Pereira*,* Vianna Dias et Azevedo, 1936, *Spirocamallanus pimelodus* (Pinto, Fabio, Noronha et Rolas, 1974)*, Spirocamallanus cricotus* Fusco et Overstreet, 1978 and *Spirocamallanus neocaballeroi* Caballero-Deloya, 1977 (Pereira et al. 1936, Fusco 1980, Moravec et al. 1993, Moravec and Vargas-Vázquez 1996). On the other hand the third-stage larvae of *Camallanus xenentodoni*, *Procamallanus laeviconchus* (Wedl, 1962), *Procamallanus spiculogubernaculus* Agarwal, 1958*, Spirocamallanus fulvidraconis* (Li, 1935), *Spirocamallanus mysti* (Karve, 1952)*, Spirocamallanus rebecae* Andrade-Salas, Pineda-Lopez et Garcia Magana, 1994 and *Onchocamallanus bagarii* (Karve et Naik, 1951) possess buccal capsule without distinct separation into anterior and posterior portions (Li 1935, Moravec 1975, De et al. 1986, De 1995, Moravec et al. 1995, De and Maity 1995, 1999). The third-stage larvae start to grow and develop further after reaching the caeca and intestine of the fish host. In the caeca, however, only the third- and fourth-stage larvae were found. The fourth-stage larvae of *C. anabantis* differ from the third-stage larvae mainly in their larger body size (Table 2) and in the structure of the buccal capsule, genital primordia and smaller tail mucrones.

Table 2. Dimensions of *Camallanus anabantis* larvae and young adults in the definitive fish host (in µm).

	Third-stage larvae				Third moult	Fourth-stage 'male' larvae				Fourth moult
	14 days p.i.	15 days p.i.	17-20 days p.i.	33 days p.i.	15 days p.i.	15 days p.i.	33 days p.i.	59-67 days p.i.	69 days p.i.	68 days p.i.
Length of body	786-855	1036-1544	885-1011	1045-1213	1578	1731	1862	1770-3395	2922	3815-3937
Diameter of body	43-47	47-76	57	59-79	64	76	83	66-152	129	114-168
Buccal capsule length	47	46-49	49-51	47-49	51	57	62	64-76	74	61
Length of oesophagus	266-272	338-440	289-346	331-374	445	491	501	578-711	658	778-816
Oesophagus (% body length)	31-35	27-33	33-35	31-32	28	28	27	20-33	23	20-21
Muscular oesophagus	130-136	157-208	142-166	159-163	212	242	236	270-321	274	320-336
Glandular oesophagus	130-142	181-232	147-180	172-211	231	249	265	308-416	384	458-480
Anterior – nerve-ring	79-81	87-96	85-87	89-91	98	104	113	83-142	123	137-145
Anterior – excretory pore	95-96	104-132	96-113	113	132	146	-	144-195	163	175
Length of tail	53	58-70	56-60	49-56	66	71	50	70-84	74	92-96
Tail (% body length)	6-7	4-6	6-7	5	4	4	3	2-4	3	2

	Fourth-stage 'female' larvae				Fourth moult	Young males	Young females
	15 days p.i.	69-77 days p.i.	80-84 days p.i.	88 days p.i.	86 days p.i.	69-86 days p.i.	87-104 days p.i.
Length of body	2724-2762	2884-4517	4425-5410	5426	5448-6051	3540-4320	5861-6583
Diameter of body	112-113	113-183	170-204	180	168-221	120-172	172-237
Buccal capsule length	85-104	64-85	76-85	112	103-111	66-78	89-113
Length of oesophagus	671-696	593-822	822-850	825	820-938	780-840	824-924
Oesophagus (% body length)	25	16-25	16-19	15	14-17	19-22	14
Muscular oesophagus	284-293	253-325	302-350	319	290-374	320-353	314-387
Glandular oesophagus	387-404	340-446	488-522	506	477-595	460-487	510-534
Anterior – nerve-ring	161	123-142	129-161	188	168-206	130-148	178-208
Anterior – excretory pore	183-185	164-189	202-221	248	213-252	174-185	219-254
Length of tail	88	80-128	103-125	114	114-125	90-100	114-136
Tail (% body length)	3	2-3	2-3	2	2	2-3	2

In the host's intestine the fourth-stage larvae grow considerably and their gonads develop further.

The present data reveal that the first-, second- and third-stage larvae recovered from the experimental copepod hosts possess muscular oesophagus longer than posterior glandular moiety (Table 1) but the third- and fourth-stage larvae as also the adults from fish hosts possess anterior muscular oesophagus shorter than posterior glandular one (Table 2). This indicates change in the relative sizes of muscular and glandular oesophageal moieties during development, i.e. allometric growth. Likewise, the relative position of nerve-ring and excretory pore also changes during growth.

As to the experimental studies to determine the rate of development of fish nematodes in the definitive hosts very little work has been done so far. Li (1935) presumed that it lasted up to four months in *S. fulvidraconis*. De (1995) observed that the last (fourth) moult of "male" and "female" larvae of *S. mysti* in the definitive host occurred on day 37 p.i. and day 67 p.i., respectively (water temperature not mentioned). Moravec et al. (1995) reported that in *S. rebecae* adults (both males and females) developed in about 42 days at 25-32°C. In *S. neocaballeroi* the fourth moult in the male was supposed to occur on day 14-15 p.i. at 25-32°C (Moravec and Vargas-Vázquez 1996). The "male" larvae of *C. lacustris* undergo their last moulting 35 days p.i. at the earliest, but even as late as 69 days p.i., whereas the last moulting of "female" larvae occurrs on day 65 p.i. and later (Moravec 1969). The prepatent period of *C. lacustris* was three months (Moravec 1969). Stromberg and Crites (1974) observed that at 26°C, the final moulting of the "male" and "female" larvae of *C. oxycephalus* occurred on the 17th or 18th and 24th day after infection, respectively. In *C. anabantis* the development in the definitive host was found to be more slow. The final moult of "male" and "female" larvae occurred on day 68 and 86 p.i., respectively, at 24-36°C. Female with eggs and only a few larvae in the uteri was recovered from the fish host for the first time on day 187 p.i. at 24-36°C. De (1993) studying the seasonal dynamics of *C. anabantis* infection in the climbing perch, *A. testudineus*, observed that in the natural populations third-stage larvae and females with larvae in the uteri occurred in maximum number during the months of May and November, respectively, i.e., six months elapsed between presence of third-stage larvae in the fish host and appearance of females with larvae, and with that the present observations conform.

REFERENCES

BARTLETT C.M., ANDERSON R.C. 1985: Larval nematodes (Ascaridida and Spirurida) in the aquatic snail, *Lymnaea stagnalis*. J. Invertebr. Pathol. 46: 153-159.

CAMPANA-ROUGET Y. 1961: Remarques sur le cycle évolutif de *Camallanus lacustris* (Zoega, 1776) et la phylogenie des Camallanidae. Ann. Parasitol. Hum. Comp. 36: 425-434.

CAMPANA-ROUGET Y., PETTER A.J., KREMER M., MOLET B., MILTGEN F. 1976: Présence du nématode *Camallanus fotedari* dans la tube digéstif de poissons d'aquarium de divérses provenances. Bull. Acad. Vet. France 49: 205-210.

DE N.C. 1993: Seasonal dynamics of *Camallanus anabantis* infections in the climbing perch, *Anabas testudineus* from the freshwater swamps near Kalyani town, West Bengal, India. Folia Parasitol. 40: 49-52.

DE N.C. 1995: On the development and life cycle of *Spirocamallanus mysti* (Nematoda: Camallanidae). Folia Parasitol. 42: 135-142.

DE N.C., GHOSH S.P. 1989: Larval and adult morphology of *Camallanus anabantis* Pearse, 1933 and *C. kulasirii* (Yeh, 1960) (Nematoda: Camallanidae) from freshwater fishes, with notes on the validity of some related forms. Syst. Parasitol. 14: 227-236.

DE N.C., MAITY R.N. 1995: Redescription and development of a little known nematode *Camallanus xenentodoni* (Nematoda: Camallanidae) with a note on a related form. Folia Parasitol. 42: 211-219.

DE N.C., MAITY R.N. 1999: Larval development of *Onchocamallanus bagarii* (Nematoda: Camallanidae) in copepods. Folia Parasitol. 46: 53-58.

DE N.C., SAMANTA P., MAJUMDAR G. 1984: Aspects of the developmental cycle of *Neocamallanus singhi* Ali, 1957 (Nematoda: Camallanidae). Folia Parasitol. 31: 303-310.

DE N.C., SINHA R.K., MAJUMDAR G. 1986: Larval development of *Procamallanus spiculogubernaculus* Agarwal, 1958 (Nematoda: Camallanidae) in copepods. Folia Parasitol. 33: 51-60.

FUSCO A.C. 1980: Larval development of *Spirocamallanus cricotus* (Nematoda: Camallanidae). Proc. Helminthol. Soc. Wash. 47: 63 - 71.

KUPRYANOVA R.A. 1954: On the biology of the fish nematodes *Camallanus lacustris* (Zoega, 1776) and *Camallanus truncatus* (Rudolphi, 1814) (Nematoda: Spirurida). Dokl. Akad. Nauk SSSR 97: 373-376.

LI H.C. 1935: The taxonomy and early development of *Procamallanus fulvidraconis* n. sp. J. Parasitol. 21: 102-113.

MONCHENKO V.I. 1972: Study of the life cycle of *Camallanus lacustris*. Tr. VII nauchn. konf. parazitologov USSR. Pt. 2. Kiev, pp. 43-44. (In Russian.)

MORAVEC F. 1969: Observations of the development of *Camallanus lacustris* (Zoega, 1776) (Nematoda: Camallanidae). Acta Soc. Zool. Bohemoslov. 33: 15-33.

MORAVEC F. 1971a: On the problem of host specificity, reservoir parasitism and secondary invasions of *Camallanus lacustris* (Nematoda: Camallanidae). Helminthologia 10: 107-114.

MORAVEC F. 1971b: Some notes on the larval stages of *Camallanus truncatus* (Rudolphi, 1814) and *Camallanus lacustris* (Zoega, 1776) (Nematoda: Camallanidae). Helminthologia 10: 129-135.

MORAVEC F. 1974: The development of *Procamallanus cyathopharynx* (Baylis, 1923) (Nematoda: Camallanidae). Folia Parasitol. 21: 333-343.

MORAVEC F. 1975: The development of *Procamallanus laeviconchus* (Wedl, 1862) (Nematoda: Camallanidae). Acta Soc. Zool. Bohemoslov. 39: 23-38.

MORAVEC F., KOHN A., FERNANDES B.M.M. 1993: Nematode parasites of fishes of the Paraná River, Brazil. Part 3. Camallanoidea and Dracunculoidea. Folia Parasitol. 40: 211-229.

MORAVEC F., MENDOZA-FRANCO E., VARGAS-VÁZQUEZ J., VIVAS-RODRIGUEZ C. 1995: Studies on the development of *Procamallanus* (*Spirocamallanus*) *rebecae* (Nematoda: Camallanidae), a parasite of cichlid fishes in Mexico. Folia Parasitol. 42: 281-292.

MORAVEC F., VARGAS-VÁZQUEZ J. 1996: The development of *Procamallanus* (*Spirocamallanus*) *neocaballeroi* (Nematoda: Camallanidae), a parasite of *Astyanax fasciatus* (Pisces) in Mexico. Folia Parasitol. 43: 61-70.

PEREIRA C., DIAS M.V., AZEVEDO P. 1936: Biologia do nematode "*Procamallanus cearensis*" n. sp. Arq. Inst. Biol. São Paulo 7: 209-226.

ROY R. 1987: Some aspects of piscine nematodes and transcuticular absorption. Ph.D. thesis. Burdwan University, Burdwan, 106 pp.

SOOTA T.D. 1983: Studies on the nematode parasites of Indian vertebrates. I. Fishes. Rec. Zool. Surv. India, Misc. Publ., Occas. Pap. 54, 352 pp.

STROMBERG P.C., CRITES J.L. 1974: The life cycle and development of *Camallanus oxycephalus* Ward et Magath, 1916 (Nematoda: Camallanidae). J. Parasitol. 60: 117-124.

STUMPP M. 1975: Untersuchungen zur Morphologie und Biologie von *Camallanus cotti* Fujita, 1927. Z. Parasitenkd. 46: 277-290.

Received 3 September 1998 Accepted 25 January 1999