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PARASITES OF SOUTH AFRICAN FRESHWATER FISH. I. SOME NEMATODES OF THE CATFISH [*CLARIAS GARIEPINUS* (BURCHELL, 1822)] FROM THE HARTBEESPOORT DAM

J. BOOMKER, Department of Parasitology, Faculty of Veterinary Science, University of Pretoria, P.O. Box 12580, Onderstepoort, 0110

ABSTRACT

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A seasonal study of the parasites of fish in the Hartbeespoort Dam was undertaken in 1979. This paper deals with 4 nematode species recovered from catfish, namely, *Paracamallanus cyathopharynx* (Baylis, 1923), *Procamallanus laeviconchus* (Wedl, 1862), *Contracaecum* sp. and *Skrjabinocara* sp. Total numbers of parasites recovered are tabulated and their seasonal variation illustrated diagrammatically. *Paracamallanus cyathopharynx* was recovered from 23 out of 43 catfish examined and *Procamallanus laeviconchus* from 13, while *Contracaecum* sp. larvae were present in all the catfish. *Skrjabinocara* sp. was recovered from 1 catfish only, but it is not regarded as being parasitic in fish, as it was also recovered from 1 out of 4 cormorant examined. *Paracamallanus cyathopharynx* and *Procamallanus laeviconchus* are illustrated and the measurements of the Hartbeespoort Dam material compared with those given by various authors who recovered the same parasites from other fish species elsewhere in Africa.

INTRODUCTION

Although the parasites of freshwater fish in Africa have already received considerable attention (Khalil, 1969, 1971), those of South African freshwater fish have not been studied in any great detail. Khalil (1971) lists *Contracaecum* sp. larvae as the only nematodes occurring in catfish. Ortlepp (1935), Price, McClellan, Druckenmiller & Jacobs (1969) and Lombard (1968) mention some parasites they found in fish, and Prudhoe & Hussey (1977) list a few species of parasites found in fish in the Transvaal, South Africa. Mashego (1977) recorded *Paracamallanus cyathopharynx* (Baylis, 1923), *Procamallanus Laeviconchus* (Wedl, 1862) and *Contracaecum* sp. larvae in catfish in Lebowa, South Africa, for the first time.

This paper deals with some nematodes found in catfish from the Hartbeespoort Dam, as well as their seasonal variation during 1979.

MATERIALS AND METHODS

The site

All the catfish utilized in this study were collected from the Hartbeespoort Dam, which is situated about 40 km to the west of Pretoria, Transvaal (S25°43′, E27°51′). The dam is 1167 m above sea level and has a total surface area of 2 000 ha when full (Dept. of Water Affairs, 1964, cited by Steijn, Toerien & Visser, 1975). The dam is highly eutrophic (Steijn *et al.*, 1975), nitrogen and phosphorus entering the dam mostly through the Crocodile River (Fig. 1).

Fish were collected from areas which, by a number of trial nettings, they were known to frequent (Fig. 1). Site No. 2 yielded most of the catfish, but some were also caught at sites Nos. 1 and 3.

Collection of fish

Usually fish were caught with seine nets, except in those cases when the quota could not be met. In such cases additional fish were caught with handlines.

An attempt was made to collect 5 specimens on each collecting trip over 13 consecutive months. During the coldest months, June and July, however, no fish were caught, because they moved to water that was too deep to be netted, and attempts to catch them with handlines also failed.

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Collection of parasites

Immediately after being landed, fish were examined macroscopically for ectoparasites. All visible parasites were then collected in 70% ethyl alcohol and their sites of attachment noted.

Large fish were transported alive to the laboratory, where they were killed and smears were taken from the blood, gills and body. The fish were then scrubbed with a bristle brush under running water, and the washings sieved onto a sieve with apertures of 150 μm. The residue was collected and preserved in 10% formalin.

Small fish were killed at the collection sites and, after smears of the blood, gills and body were taken, they were placed individually in 50% ethyl alcohol. At the laboratory they were transferred to another container, scrubbed with water, and this water, together with the 50% alcohol in which they were transported, was sieved. The residue was preserved in 10% formalin.

The fish were opened ventrally with scissors, and the entire digestive tract, together with the liver and spleen, was removed. After the mesenterium, liver and spleen had been removed, the stomach and intestines were opened separately and thoroughly washed in normal saline. The washings were heated to 60 °C in a waterbath, after which they were sieved (38 μm aperture) and the residue fixed in 10% formalin.

The mucosae of the stomach and intestines of the large fish were removed by scraping with a knife or a glass slide and digested as described by Reinecke (1973).

In the case of small fish, or those with thin-walled stomachs and intestines, the entire organs were digested in pepsin and HCl (Reinecke, 1973).

As large numbers of *Contracaecum* larvae were found in all the catfish, the entire mesenterium was digested for ½–1 hour at room temperature. This resulted in the liberation of live larvae, which were then fixed in boiling alcohol-glycerine (approximately 60 °C) and preserved in alcohol-glycerine.

Blood smears were made according to standard techniques (Wintrobe, 1947). Gill smears were made by scraping the surface of the gills and smearing the resulting epithelium onto pre-cleaned glass slides. Body smears were made in the same way. Impression smears of the spleen and kidney were made according to the technique described by Ashley & Smith (1964). The various smears were fixed and stained, as described in an earlier paper (Boomker, 1980).

The livers of all the fish were examined macroscopically for parasites and thereafter cut into 0,5 cm cubes. These were kept in normal saline at 40 °C for 1–2 hours, after which the tissue was thoroughly washed and discarded. The saline and washings were sieved through a sieve with 38 μm apertures and the residue preserved in 10% formalin.

In addition to the above procedures, the gills, swim bladders, abdominal cavities and reproductive organs were examined macroscopically and then washed. The washings were sieved through a sieve with 38 μm apertures and fixed in 10% formalin.

Where organs showed distinct pathological lesions, tissue blocks were collected in 10% neutral buffered formalin for histological examination.

The various collections and residues were examined in a counting chamber with the aid of a stereoscopic microscope. Total counts were made, except in the case of very large fish or large volumes, when 1/10 aliquots were prepared and counted. In all cases, total counts of the *Contracaecum* larvae were done.

To determine the monthly incidence, the mean number of a parasite species was calculated by dividing the total number of that parasite collected during a month by the number of hosts caught during the same month.

Additional nematodes of the genera *Paracamallanus* and *Procamallanus* from Looss' collection from Egypt and Mashego's collection from Lebowa were loaned from the British Museum (Natural History) and compared with the Hartbeespoort Dam material.

For identification purposes, nematodes were cleared and examined in lactophenol. Drawings were made with the aid of a Nikon Optiphot microscope with Nomarski differential interference contrast illumination and a Sankei drawing tube.

RESULTS

Only 4 species of nematodes were recovered from the 43 catfish examined. They were *Paracamallanus cyathopharynx* (Baylis, 1923) and *Procamallanus laeviconchus* (Wedl, 1862) (Camallamidae), *Contracaecum* sp. larvae (Anisakidae) and *Skrjabinocara* sp. (Acuariidae). Of the last-named genus, only 1 female and 3 larvae were recovered.

The numbers of parasites recovered from each catfish are given in Table 1, and in Fig. 2–5 variation in their prevalence is graphically illustrated.

Paracamallanus cyathopharynx was found in the intestines, especially near the rectum of 53,5% (23) of the fish examined. *Procamallanus laeviconchus* occurred in the stomachs of only 30,2% (13) of the catfish while *Contracaecum* sp. larvae were found in the mesenterium of 100%. Some *Contracaecum* sp. larvae were also recovered from the stomach mucosa. *Skrjabinocara* sp. was found in the stomach of 1 catfish only.

The configuration of the buccal capsule and pharynx of *Paracamallanus cyathopharynx* (Fig. 6 & 7) sets it apart from other nematodes of fish. The spicules and tail of the male of the Hartbeespoort Dam material are illustrated in Fig. 8–10, and the female tail and vulvar region in Fig. 11 & 12, while the morphology of *Procamallanus laeviconchus* of catfish from the Hartbeespoort Dam is illustrated in Fig. 13–18. The 4th larval moults of both species are illustrated in Fig. 19–21.

Mashego (1977), who was the first to record *Paracamallanus cyathopharynx* and *Procamallanus laeviconchus* from catfish in South Africa, does not provide any measurements of the nematodes he collected. In Table 2 the measurements of 7 male and 8 female *Paracamallanus cyathopharynx* from the Hartbeespoort Dam catfish are compared with those of specimens identified by Baylis (1 male, 1 female ex coll. Looss, on loan from British Museum), as well as with measurements given by Baylis (1923) for material from *Clarias anguillaris* from Egypt, and that given by Moravec (1974) from material from *Clarias lazera* and *C. anguillaris,* also from Egypt.

The principal measurements of 6 male and 5 female *Procamallanus laeviconchus* of the Hartbeespoort Dam material are compared with those given by Baylis (1923) in Table 3, as well as those of 2 females from *Bagrus bayad* which Baylis identified as *Procamallanus laeviconchus*.

DISCUSSION

Yorke & Maplestone (1926) created the genus *Paracamallanus* for nematodes found in the clariid fish *Clarias anguillaris* (syn. *Heterobranchus anguillaris*) from Egypt. These nematodes were originally described as *Camallanus cyathopharynx* by Baylis (1923). Since then the parasites have been recorded from a number of clariid fishes from various countries (Vassiliades, 1970; Khalil, 1971; Moravec, 1974; Mashego, 1977).

Moravec (1974) redescribed *Paracamallanus cyathopharynx* and suggested that *Camallanus longitridentatus* Fernando & Furtado, 1963 from *Clarias batrachus* be transferred to the genus *Paracamallanus*. He also regarded *Paracamallanus senegalensis* Vassiliades, 1970 from *Clarias senegalensis* as synonymous with *Paracamallanus cyathopharynx* (Moravec, 1974).

The data in Table 2 indicate that the Hartbeespoort Dam material is considerably larger than the material from Looss' collection. However, the measurements given by Baylis (1923) and Moravec (1974) correspond well with those of the Hartbeespoort Dam material. From Table 2 it is also apparent that there is a considerable variation in the size of this nematode, a fact which could be attributed to the influence of the host in which it occurs.

Procamallanus laeviconchus (Wedl, 1862) was originally recorded from *Synodontis schaal* from Egypt and described as *Cucullanus laeviconchus* Wedl, 1862, but was subsequently transferred to the genus *Camallanus* (Railliet & Henry, 1915). Baylis (1923) compared material from *Bagrus bayad* from Egypt with that of Wedl (1862) and erected a new genus, *Procamallanus,* to which he assigned his own material as well as *Cucullanus laeviconchus* Wedl, 1862.

Moravec (1975) stated that *Procamallanus laeviconchus* is one of the most prevalent nematodes of fish, and that it has been recorded from fish belonging to the families Clariidae, Mormyridae, Characidae, Siluriidae, Tetraodontidae and Cichlidae. Until 1971, *Procamallanus brevis* (Kung, 1948) and *Procamallanus slomei* (Southwell & Kirschner, 1937) were the only species recorded in South Africa, and both occur in frogs (Ivashkin, Sobolev & Khromova, 1971). Mashego (1977) recorded *Procamallanus laeviconchus* from the catfish, *C. gariepinus* from Lebowa, South Africa, for the first time.

The *Procamallanus* sp. recovered from the Hartbeespoort Dam catfish resembles *Procamallanus laeviconchus* but differs from it in that only 1 spicule could be found, and that there is an additional pair of sub-lateral papillae on the tail of the male. Material collected by Mashego (1977) from the Olifants River was examined and found to be similar to that from Hartbeespoort Dam. Despite the differences mentioned above, the Hartbeespoort Dam material is assigned to *Procamallanus laeviconchus*.

Moravec (1974, 1975) studied the life cycle of *Paracamallanus cyathopharynx* and *Procamallanus laeviconchus* in Egypt and found that *Mesocyclops leukarti* (Copepoda) harbours the first 3 larval stages of both these nematodes. The copepod must then be ingested by the catfish to continue the life cycle. The only immature stages that were found in this study were the 4th stage larvae and 4th larval moults. The latter are illustrated in Fig. 19–21. This confirms the observations of Moravec (1974).

The numbers of *Paracamallanus cyathopharynx* and *Procamallanus laeviconchus* collected on a montly basis are given in Fig 2 & 3. In the case of *Paracamallanus cyathopharynx* a seasonal variation in parasite burdens seems to occur. Peak worm burdens were seen in February and again in November, which are 2 of the hottest months in this country. Between these 2 months the numbers of nematodes in the fish declined but were not completely absent. The surviving adult nematodes acted as source of infection for the copepods, which are more abundant during the summer months, thereby creating favourable conditions for the transmission of the parasites.

From Fig. 2 it can be seen that 4th stage larvae of *Paracamallanus cyathopharynx* were recovered from catfish that were caught during the warmer months, with the exception of November 1979 and January 1980. This indicates that the intermediate host is more abundant during these months and that catfish are seasonally infested.

Procamallanus laeviconchus seems to be non-seasonal in its infestation rate, as can be seen from Fig. 3. Although some 4th stage larvae were recovered (Table 1), their numbers were too small for any conclusion to be made as regards their life cycle and seasonal occurrence. The adult worms, however, were more often recovered during the summer months, and especially late summer (January to March). During these months more adults were collected than during all the other months together (Table 1). This is in agreement with the observations of Imam (1971) and Moravec (1975).

TABLE 1 The total worm burdens recoverd from *Clarias gariepinus* from Hartbeespoort Dam for the period January, 1979–January, 1980

				Contracaecum sp.		*Paracamallanus cyathopharynx* (Baylis, 1923)			*Procamallanus laeviconchus* (Wedl, 1862)			Total recovered
Fish No.	Date collected	Sex	Length (cm)	L_2	L_3	L_4	M	F	L_4	M	F	
A	Jan. '79	?	?	4	107			1			1	113
B*	Jan. '79	?	?	2	53							57
1	Jan. '79	M	73		169	1	4	4	1	3	4	186
2	Feb. '79	F	62,5	1	173	1		1				176
3	Feb. '79	M	88,5		270		4	9			3	286
4	Mar. '79	M	80,5		375						1	376
5	Mar. '79	M	86		342	2						344
6	Mar. '79	F	67		285						1	286
7	Mar. '79	M	82	3	354			1		1	2	361
8	Mar. '79	M	79,5	1	225	1	4	5		1		237
9	Apr. '79	M	89	2	443	2		1				448
10	Apr. '79	F	79		216							216
11	Apr. '79	M	115		117			3			1	121
12	Apr. '79	M	81	1	395		3	2	1	2		404
13	May '79	M	82		614							614
14	May '79	M	79	1	258							259
15	May '79	F	70		456		3					459
16	May '79	M	81		323		1	1				325
17	May '79	M	83		392		2					394
18	Aug. '79	F	70		392					1	1	394
19	Aug. '79	M	91		474		2	2				478
20	Sept. '79	M	73		279		1	1		1		282
21**	Sept. '79	M	82	1	422		4	1				433
22	Sept. '79	F	75		268	1						269
23	Oct. '79	M	72,5		334	1	2					337
24	Oct. '79	?	70,5		261	1	1			1		264
25	Nov. '79	M	86		407		5	2				414
26	Dec. '79	M	92		229							229
27	Dec. '79	M	80		144		2	3				149
28	Dec. '79	M	81		696	2						698
29	Dec. '79	M	95		721			5			1	727
30	Dec. '79	M	93		407	1		2				410
31	Dec. '79	M	107		364		11	11				386
32	Dec. '79	F	82		344							344
33	Dec. '79	M	102		691							691
34	Dec. '79	M	90		374		1					375
35	Dec. '79	F	88		605							605
36	Dec. '79	F	84		231							231
37	Jan. '80	M	110	8	775		1				1	785
38	Jan. '80	M	115	1	552		2	1				556
39	Jan. '80	F	87	2	330							332
40*	Jan. '80	M	77	1	313			6				322
41	Jan. '80	M	62	4	113			3				120

M=Male
L_2=2nd stage larvae
L_3=3rd stage larvae
L_4=4th stage larvae
F=Female

*Two unidentifiable nematodes found in each catfish
**One adult *Skrjabinocara* female, 3 fourth stage larvae and 1 unidentifiable nematode found in this catfish

TABLE 2 Comparative measurements of *Paracamallanus cyathopharynx from different hosts*+

Author	Baylis, 1923		Moravec, 1974		Specimens ex coll. Looss, this paper		This paper	
Host	*C. anguillaris*		*C. anguillaris* and *C. lazera*		*Host not given*		*C. gariepinus*	
	M	F	M	F	M	F	M	F
Length (mm)	5,9	9,2	2,04–6,54	5,81–13,75	3,76	4,93	4,13–5,45	11,42–12,52
Width	120	180	82–122	122–190	68	84	106,6–135,2	163,8–192,4
Oesophagus, length of muscular part	440–560	650–670	381–465	510–680	336	448	384,8–5,07	572–657,8
length of glandular part	490–540	630–650	420–681	525–844	444	564	587,6–780	863–977
Buccal capsule, length	*	*	60–69	81–99	46	—	57,2–65	72,8–83,2
width			63–75	90–162	52	—	52–67,6	70,2–88,4
Pharynx, length	*	*	33–42	54–69	34	—	39–46,8	59,8–65
width			51–60	72–87	48	—	49,4–62,4	72,8–83,2
Distance of nerve ring from anterior end	130–150	170–180	135–183	186–249	126	168	145,6–168,2	192,4–208
Distance of cervical papillae from anterior end	behind nerve ring		129–156	162–210	124	—	135,2–184,6	187,2–202,8
Trident, length of lateral part	—	—	51–66	69–99	28	—	41,6–57,2	59,8–70,2
length of median part	—	—			32	—	44,2–57,2	52–62,4
Distance of vulva–anus (mm)	—	—	—	—	—	—	—	4,25–4,86
Distance of anus–tail	—	350–430	—	228–570	—	230	—	395,2–496,6
Distance of vulva–tail (mm)	—	4,3	—	2,45–7,41	—	2,16	—	4,65–5,32
Right spicule, length	—	—	240–309	—	—	—	239,2–300,8	—
Left spicule, length	—	—	33–48	—	—	—	28,6–31,2	—
External spicular sheath, length	—	—	—	—	—	—	28,6–33,8	—
Distance of tail–cloaca	50–70	—	63–78	—	48	—	75,4–91	—

+ All measurements given as µm unless otherwise stated

* Combined length given as 100–130 µm by Baylis, 1923

M=Males

F=Females

TABLE 3 Comparative measurements of *Procamallanus laeviconchus* from different hosts*

Author	Baylis, 1923		Specimens ex collection Looss, this paper		This paper	
Host	*B. bayad*		*B. bayad*		*C. gariepinus*	
	M	F	M+	F	M	F
Length (mm)	3,65	15,5		11,37–15	3,77–5,38	7,02–8,93
Width	110	350		208–416	97,9–123,6	181–216
Buccal capsule length		67,5–70		96–104	67,6–72,8	83,2–96,2
width		42,5–60		60–88	44,2–50	59,8–70,2
Oesophagus, length of muscular part	400	470		376–492	309,4–413,4	410,8–491,4
length of glandular part	600	780		764–812	603,2–793	774,8–927
Distance of nerve ring from anterior end		175–200		208–220	169–200,2	208–226,3
Distance of cervical papillae from anterior end	—	—		116–232	201–221	252,8–262,2
Distance of vulva–anus (mm)	—	—		3,8–4,5	—	3,0–3,5
Distance of anus–tail	—	150		120–160	—	117–137,8
Distance of tail–vulva (mm)	—	—		3,9–4,6	—	3,1–3,6
Right spicule, length	150	—		—	106,6–137,8	—
Left spicule, length	50	—		—	not found	—
Caudal alae, length	—	—		—	182–243,2	—
Distance of tail–cloaca	37	—		—	52–59,8	—
Preanal papillae, No. of pairs	9 (8–10)	—		—	8 (9)	—
Post-anal papillae, No. of pairs	4–5	—		—	3+1	—
Adanal papillae, No. of pairs	1	—		—	1	—

* All measurements given in µm unless otherwise stated

M=Males

F=Females

+ No males available

During the warmer months, the intermediate hosts are also expected to increase, especially in an eutrophic dam such as the Hartbeespoort Dam. This increase usually takes place in the warmer, shallow water which catfish frequent during their spawning activities (Holl, 1968; Van der Waal, 1974) and where they no doubt also become infested by ingesting infested copepods. The species of copepod that acts as intermediate host for *Paracamallanus cyathopharynx* and *Procamallanus laeviconchus* in this country has yet to be determined.

Larval *Contracaecum* spp. were collected from all of the catfish examined, and the numbers recovered are given in Table 1. As it is impossible to assign the larvae to a species, a number of piscivorous birds have been collected and their intestinal parasites identified.

Thomas (1937) described some aspects of the life cycle of *Contracaecum spiculigerum*, under experimental conditions. He found that eggs were laid in a morulated stage and that the larvae moulted twice within the eggs without shedding their sheaths. Upon hatching they attach to the substrate by means of the loose anterior ends of the sheaths (Thomas, 1937). The larvae lost the sheaths only when ingested by a suitable fish host (Thomas, 1937).

Sprent (1954) postulated that the Ascarididoidea evolved through the marine arthropods and vertebrates. Because of a lack of host-specificity the 2nd stage larvae may enter the tissues of a wide variety of invertebrate and vertebrate hosts and may remain there for an indefinite period without any further development (Sprent,

FIG. 1 Schematic representation of the Hartbeespoort Dam and the sites at which the catfish were caught

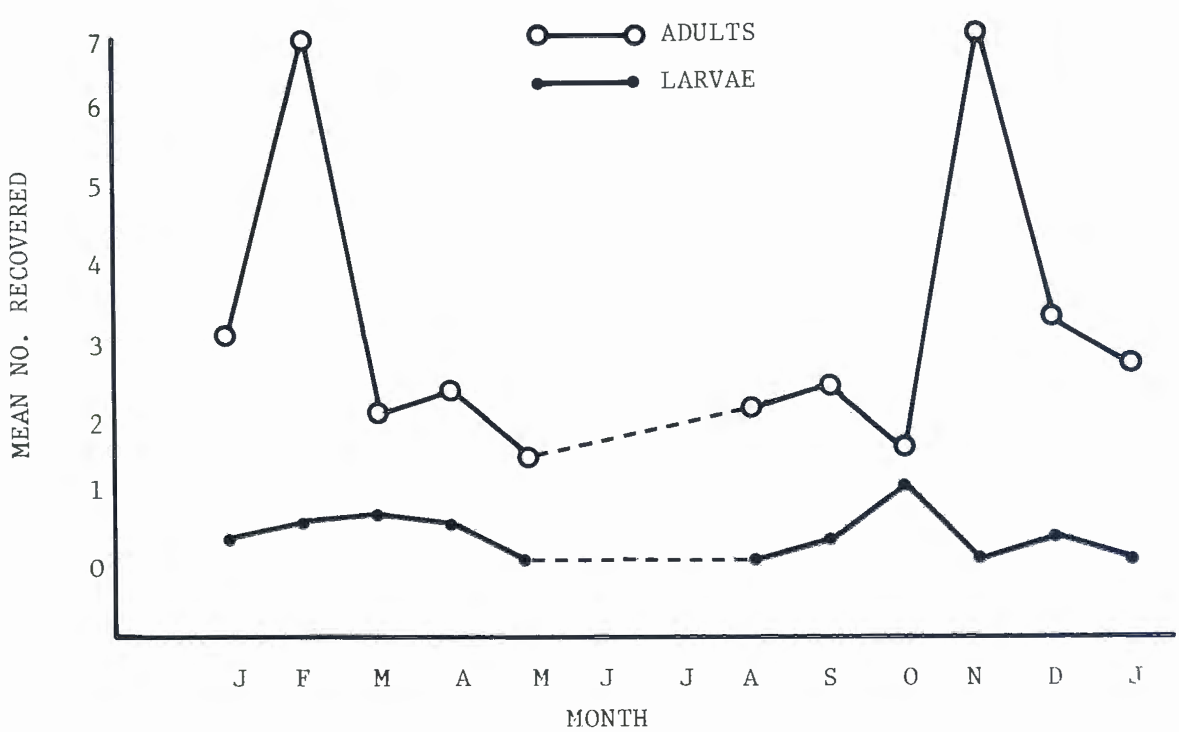


FIG. 2 Mean number of *Paracamallanus cyathopharynx* recovered each month

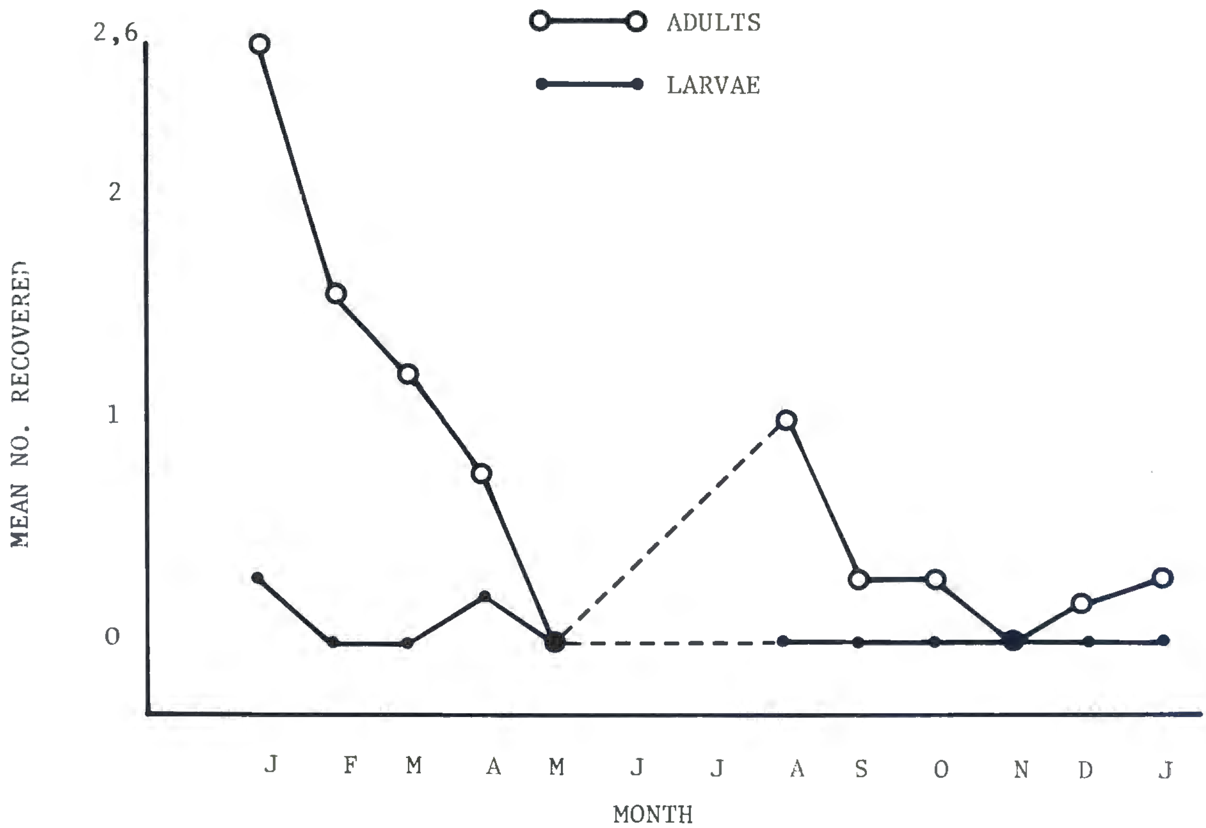


FIG. 3 Mean number of *Procammallanus laeviconchus* recovered each month

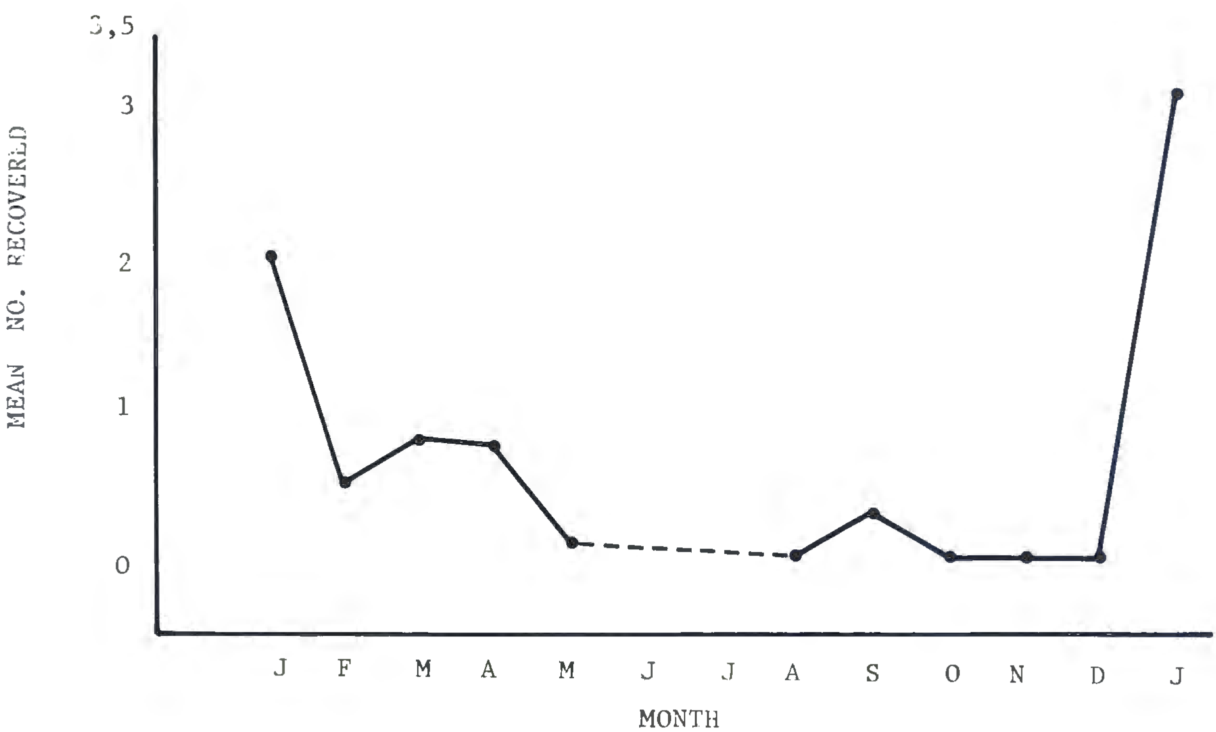


FIG. 4 Mean number of 2nd stage *Contracaecum* larvae recovered each month

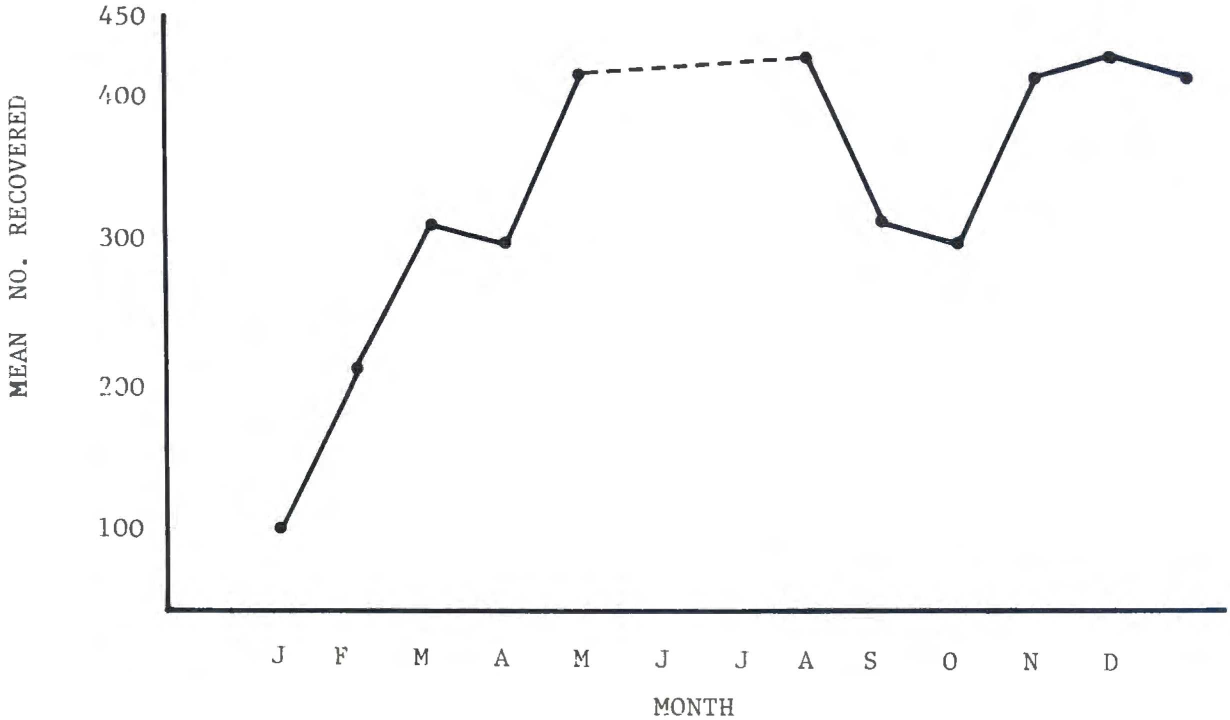


FIG. 5 Mean number of 3rd stage *Contracaecum* larvae recovered each month

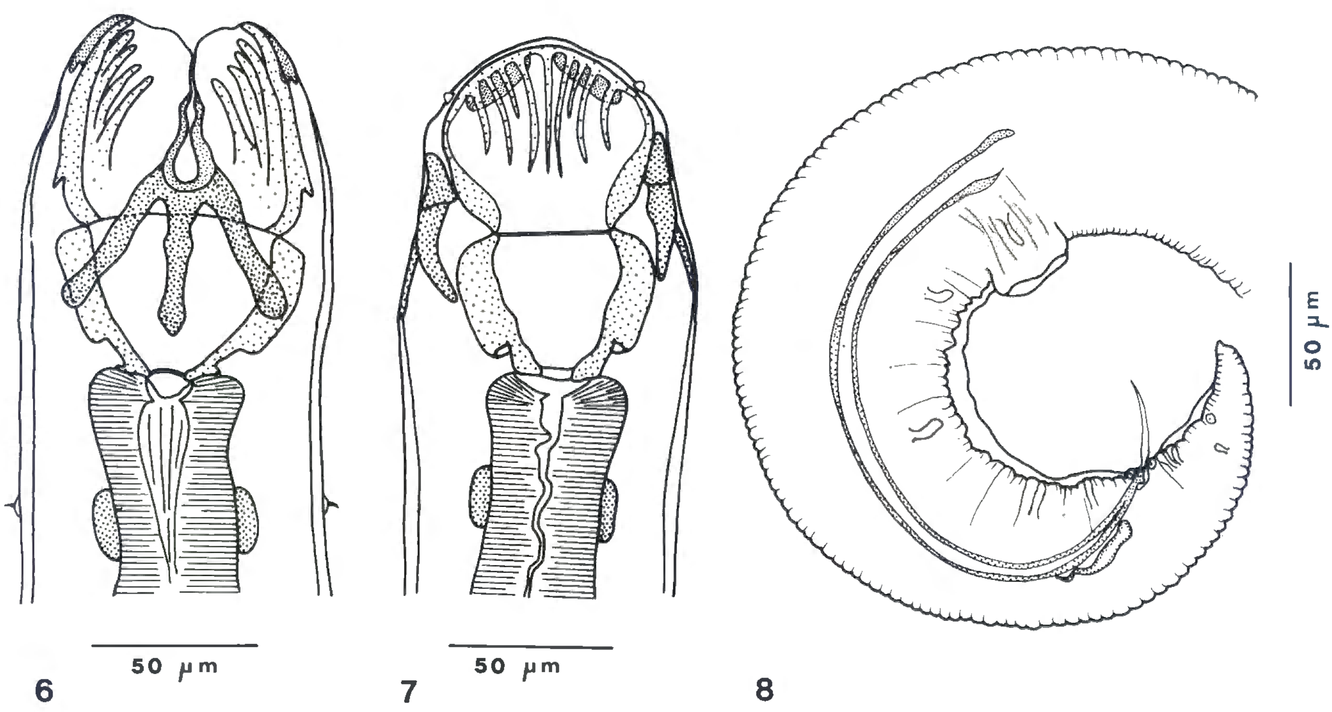
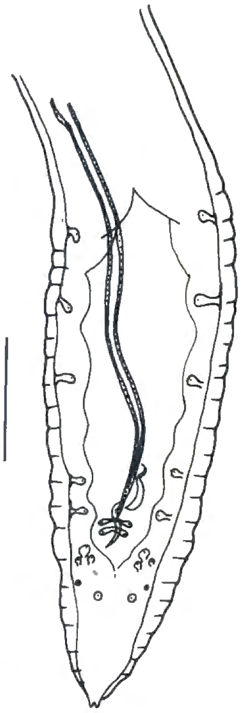


FIG. 6 Anterior extremity of *Paracamallanus cyathopharynx*, ventral view
FIG. 7 Anterior extremity of *Paracamallanus cyathopharynx*, lateral view
FIG. 8 Posterior extremity of *Paracamallanus cyathopharynx* male, lateral view



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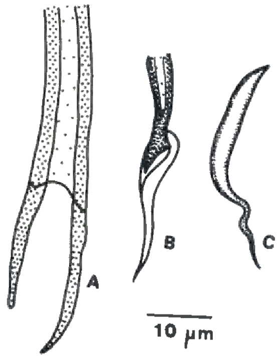

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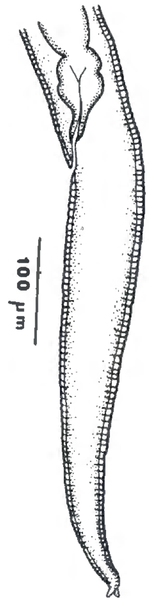

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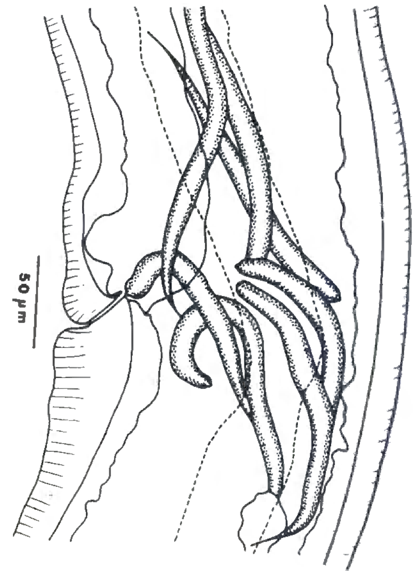

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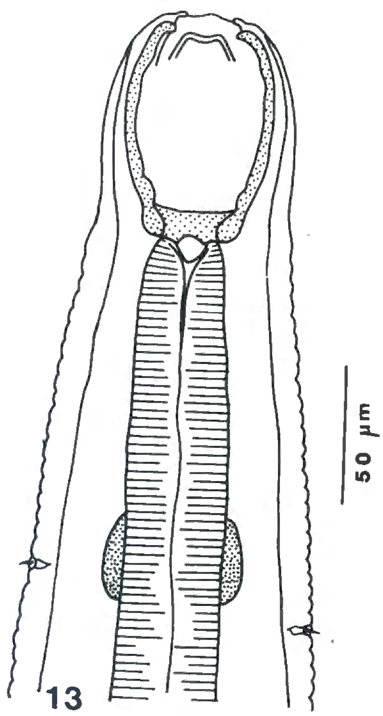
FIG. 9 Posterior extremity of *Paracamallanus cyathopharynx* male, ventral view

FIG. 10 *Paracamallanus cyathopharynx*, spicules; (A) proximal end of right spicule, (B) distal end of right spicule, (C) left spicule

FIG. 11 *Paracamallanus cyathopharynx*, posterior end of female

FIG. 12 *Paracamallanus cyathopharynx*, vulvar region of female



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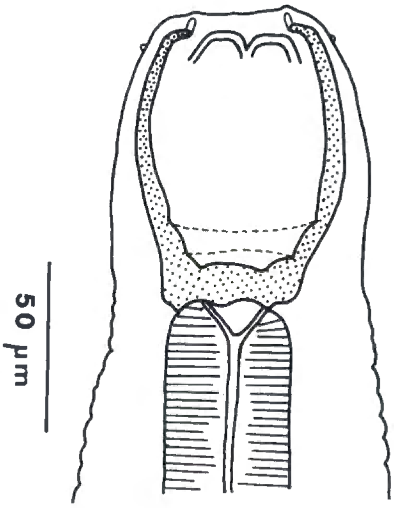

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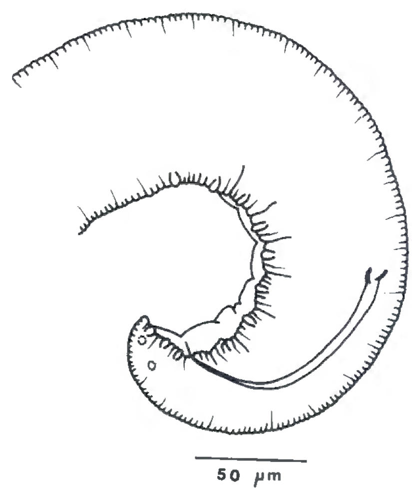

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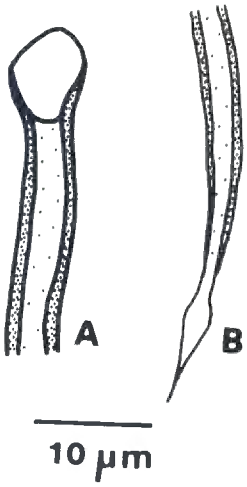
FIG. 13 Anterior extremity of *Procamallanus laeviconchus*, ventral view

FIG. 14 Anterior extremity of *Procamallanus laeviconchus*, lateral view

FIG. 15 Posterior end of *Procamallanus laeviconchus* male, lateral view



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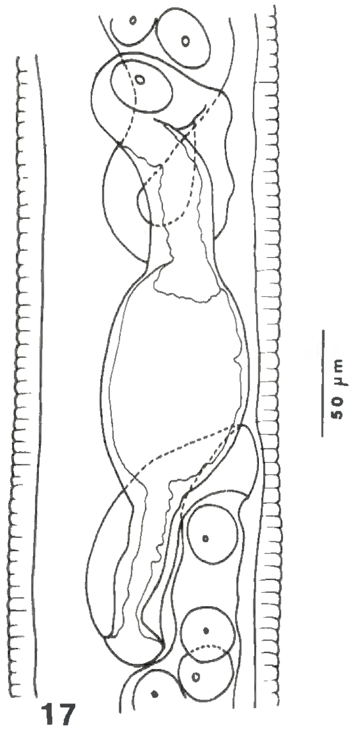

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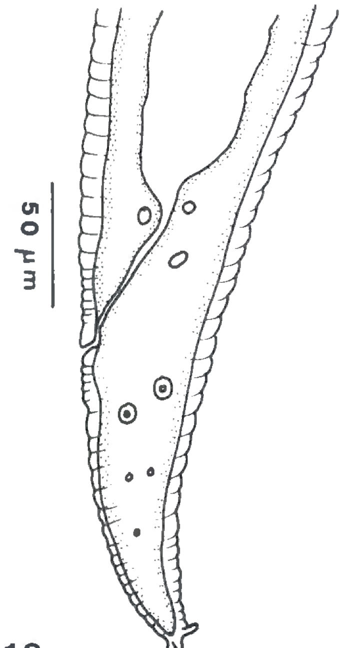

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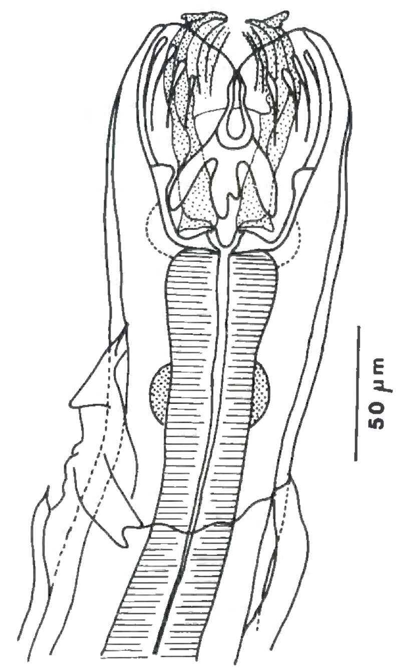
FIG. 16 *Procamallanus laeviconchus,* right spicule, (A) proximal and (B) distal ends
FIG. 17 *Procamallanus laeviconchus,* female uterus
FIG. 18 *Procamallanus laeviconchus,* tail of female, lateral view



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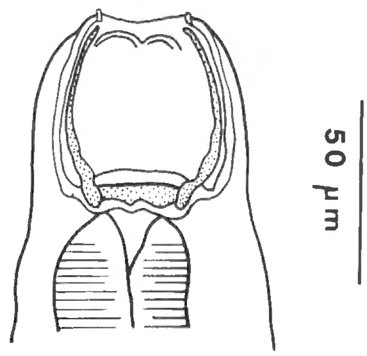

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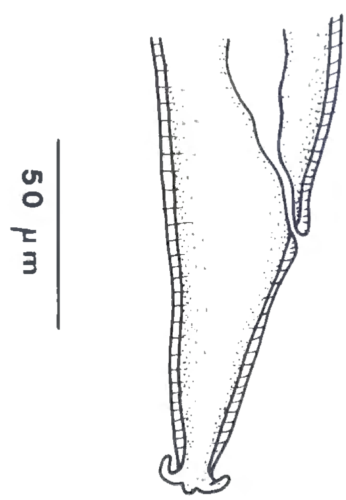

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FIG. 19 *Paracamallanus cyathopharynx,* 4th moult; shaded part is the buccal capsule of 4th stage larva, dorsal view
FIG. 20 Anterior end of *Procamallanus laeviconchus,* dorsal view of 4th moult. Shaded part is the buccal capsule of the 4th stage larva
FIG. 21 *Procamallanus laeviconchus,* tail of 4th moult, lateral view

1962). However, Thomas (1937) showed that domestic ducks and fowl are not susceptible to infection with *Contracaecum spiculigerum*, thereby implying a degree of host specificity where the final host is concerned.

A tentative scheme for life cycle patterns in the Ascarididoidea was given by Sprent (1954). He stated that larvae after hatching are ingested by an intermediate host, which in turn has to be eaten by the final host and used the life cycle of *Contracaecum spiculigerum* as an example of this type. A second type of life cycle involves the ingestion of embryonated eggs by an intermediate host. The larvae that hatch from these eggs remain in the tissues of the intermediate host until they are eaten by a second intermediate host or by the final host. It is only in the final host that the larvae will develop into 4th stage larvae and adult nematodes (Sprent, 1954). A nematode that has this type of life cycle is *Contracaecum microcephalum* (Sprent, 1954).

Hartbeespoort Dam supports a large number of water birds of which the white-breasted cormorant (*Phalacrocorax carbo*), the reed cormorant (*Phalacrocorax africanus*) and the darter (*Anhinga rufa*) are the most prevalent predators of fish. Various species of heron, egrets and occasionally the fish eagle (*Haliaetus vocifer*) also prey on fish, but these are regarded as being of lesser importance in the transmission of *Contracaecum* because they do not consume the same quantities of fish as the cormorants and are also not as numerous on Hartbeespoort Dam. A possible exception is the cattle egret (*Bubulcus ibis*) and the little egret (*Egretta garzetta*), which are found in large numbers. McLachlan & Liversidge (1978) record the food of both species as including fish, especially the smaller fish, such as Canary kurper (*Chetia flaviventris*), from which *Contracaecum* spp. larvae have also been recovered (Boomker, unpublished data). Egrets may therefore also play a role in the transmission of *Contracaecum*. This assumption is strengthened by observations of the feeding habits of catfish. During the summer months, large numbers of both species of cormorants and egrets mentioned above breed in the trees which stand in shallow water along the banks of the dam. Catfish move into the shallow water and avidly consume the bird droppings as well as bird eggs and chick that fall out of the nests. Sometimes as many as 20 birds nest in the same tree and on numerous occasions up to 8 catfish have been caught beneath these trees. During the months that the birds are not breeding, catfish will move in at night under the trees where the birds roost and consume their droppings (Boomker, unpublished data).

Malvestuto & Ogambo-Ongoma (1978) are of the opinion that the first intermediate host, usually a crustacean, is not needed in the life cycle of *Contracaecum*. The above-mentioned feeding behaviour of catfish seems to support their opinion, but because the eggs of the nematodes are shed in the faeces of the birds in a morulated stage, they must embryonate and hatch in the stomach of the fish intermediate host. Such a process has as yet not been shown to occur in the case of *Contracaecum*. One must also remember that the bird droppings are very fluid and disperse immediately after falling into the water. Catfish ingest only a small amount, that is sieved by the gill rakers which hold back only the larger undigested pieces. Therefore, most of the *Contracaecum* eggs are lost and the majority of the 3rd stage larvae probably result from the ingestion of either the crustacean intermediate host or the ingestion of smaller fish that harbour the parasites.

The presence of the large numbers of 3rd stage larvae is attributed to the constant intake of small numbers of either embryonated nematode eggs or infested intermediate hosts. As all the catfish examined in this study were large fish, over 60 cm long (Table 1), they have conceivably been exposed to infestation for a number of years. However, the numbers of larvae are probably not directly proportional to the number of infective stages ingested, as not all the larvae will develop into dormant 3rd stage larvae. One must consider that the immune mechanisms of the catfish, albeit slow in developing, may cause inhibition and later destruction of the infective stages in the stomach mucosa in a way similar to that seen with *Haemonchus* spp. in ruminants (Reinecke, personal communication, 1980). This mechanism, if present in catfish, will account for the few 2nd stage larvae recovered. Furthermore, the mortality rate of encapsulated 3rd stage larvae must also be considered, although very few dead larvae were recovered in this study. The method employed to liberate the larvae from their protective capsules worked very well, and 30 minutes after the infested mesenteria had been placed in the digesting fluid, larvae could already be seen moving about freely inside the container. This method resulted in the liberation of 100% of the larvae.

Ortlepp (1938) described *Contracaecum carlislei* from the oesophagus and stomach of *Microcarbo africana africanides* (= *Phalacrocorax africanus africanus*). Prudhoe & Hussey (1977) state that 3 species of *Contracaecum* commonly occur in African fish-eating birds, namely, *Contracaecum micropapillatum* (Stossich, 1890) in cormorants and pelicans, and *Contracaecum microcephalum* (Rudolphi, 1809) and *Contracaecum spiculigerum* (Rudolphi, 1809) usually in cormorants, pelicans and herons. The latter 2 parasites have been recorded from white pelican (*Pelecanus onocrotalis*) and white-breasted cormorants from lake St Lucia, Natal, by Whitfield & Heeg (1977). In the course of this study, 3 reed cormorants and 1 white-breasted cormorant were also examined and numerous adult *Contracaecum* spp. were recovered. Preliminary studies indicate that they are *C. spiculigerum* and *C. carlislei*. It therefore seems reasonable to assume that the *Contracaecum* larvae found in catfish belong to the species found in the birds.

Three 4th stage larvae and 1 female of a nematode belonging to the genus *Skrjabinocara* were found in 1 catfish only. Their occurrence in catfish seems to be erratic, as none of the 7 species of *Skrjabinocara* listed by Yamaguti (1961) occur in fish. *Skrjabinocara squamatum* (Von Linstow, 1883) has the widest distribution and has not only been found in *Phalacrocorax carbo* in Turkestan, the Volga Delta and Adelaide (Australia), but also in *Phalacrocorax auritus* from Cuba and *Phalacrocorax cristatellus* from Indochina (Yamaguti, 1961). One species, *Skrjabinocara buckleyi* Ali, 1957, has been found in *Phalacrocorax niger* from India and the others from various fish-eating birds in Russia (Yamaguti, 1961).

The fact that these nematodes have been found in only 1 of the 43 catfish examined has led to the opinion that they were ingested by the catfish after accidental regurgitation by white-breasted cormorant whilst feeding the chicks, and that they are not normally parasitic in fish. This view has been confirmed by the finding of adult male and female *Skrjabinocara* sp. from the gizzard and stomach of the white-breasted cormorant examined.

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