The Occurrence and Treatment of Bothriocephalosis in the Common Carp, *Cyprinus Carpio* in Fish Ponds with Notes on its Presence in the Largemouth Yellowfish *Barbus Kimberleyensis* from the Vaal Dam, Transvaal

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Abstract

Pseudophyllidean cestodes provisionally identified as belonging to the genus *Bothriocephalus* were found in the Aischgrund common carp *Cyprinus carpio* in fish ponds, and in largemouth yellowfish *Barbus kimberleyensis* from the Vaal Dam in the Transvaal. The cestocide Lintex (2', 5-dichloro-4'-nitrosalicylanilide), a Bayer niclosamide preparation proved successful in eradicating parasites from infected fish. The cestocide was administered as medicated fish pellets at a dosage level of 50 mg active ingredient per kg fish per day for seven days. Routine measures to eradicate the parasite from infected fish farms are proposed.

Introduction

Relatively little is known about the cestode parasites of indigenous and cultivated pond fish species in South Africa. Lombard (1961) recorded adult stages of unidentified tapeworms from various *Barbus* species. The records of Khalil (1971) on the presence of plerocercoids of *Ligula intestinalis* Gmelin from *Barbus pineomaculatus, B. longicauda* and *B. paludinosus* from Zimbabwe, as well as that of Prudhoe and Hussey (1977) on the occurrence of this parasite from the intestine of the cormorant *Phalacrocorax africanus,* collected by B.C.W. van der Waal at the Marble Hall Fisheries Research Station in 1970, suggest that Lombard possibly may have referred to *L. intestinalis.* In addition to this species, Prudhoe and Hussey (1977) also recorded *Paradilepis delachauxi* (Fuhrmann) from the intestines of the cormorant. Cestodes collected from the catfish *Clarias gariepinus* in Lebowa by Mashego (1977) include *Polyonchobothrium clarias* (Woodland, 1825) and *Proteocephalus glanduliger* Janichi, 1928.

In autumn 1978, Mr B.S. Koch of the Department of Nature Conservation of the Transvaal Provincial Administration collected largemouth yellowfish *Barbus kimberleyensis* in the Vaal Dam for the purpose of induced spawning experiments. In addition to studies on the ripeness and gonad development of females, the gut contents of the fish were also investigated to determine the feeding habits of this fish in Vaal Dam. Amongst the food items Mr Koch found numbers of intestinal cestodes which he provisionally identified as belonging to the Pseudophyllidea. The parasites, which occurred in numbers ranging from one to more than a thousand per fish, were found to be small, usually less than 35 mm in length. Of the twenty-five fish analysed, only one did not contain the cestode.

Recently Pseudophyllidean cestodes were also discovered during routine investigations for parasites and diseases amongst common carp pond fish used in intensive production experiments at the Marble Hall Fisheries Research Station, northern Transvaal. As a result of the severity of the infection, which in some ponds reached an incidence of 45%, steps were immediately taken to work out a treatment to eradicate the parasite from infected fish. An electron microscopic study of the preserved material revealed two types of Pseudophyllidea which were both provisionally identified as belonging to the genus *Bothriocephalus.* When the formalin preserved cestode material collected by Mr Koch from *B. kimberleyensis* was compared with that from the Marble Hall common carp material, it was also found to contain two different types of tapeworm closely resembling, and possibly the same, as those of the carp.

The results reported in this paper include a brief reference to the external morphological features of the parasites based on scanning electron microscope studies, as well as a description of the effective treatment of fish with the aid of cestocides applied in fish feed. Reference is also briefly made to the experience with Bothriocephalosis in Europe and elsewhere as a problem in fish culture.

External Morphological Features of the Parasites

Specimens of the parasites from both localities were studied with the aid of a scanning electron microscope at the Department of Zoology of the University of Potchefstroom. Bouin's and formalin preserved specimens were dehydrated with alcohol and transferred to amyl acetate for one hour after which the material was critically point dried with liquid CO_2. Scolexes and strobilae of specimens were then sputter-coated with a gold layer of approximately 20 nm, and studied at 10 and 20 kW with the

scanning electron microscope.

According to Rudolphi (1808) cited by Cooper (1918), Yamaguti (1959) and Bykhovskya-Pavlovskya *et al.* (1964), the genus *Bothriocephalus* is defined *inter alia* on the basis of the following external morphological features: elongated scolex with prominent terminal disc; well developed segmentation with secondary segmentation of proglottids of strobila distinct.

Preserved specimens of both types of the parasites of the Marble Hall common carp material fit the description of *Bothriocephalus,* in that they possess elongated scolexes and a well developed strobila segmentation with a distinct secondary segmentation of the proglottids (Figs. 1a and b). One, called type 1 for the purpose of this paper, clearly showed the presence of the prominent terminal disc characteristic of this genus. The other (type 2) of which the scolex is more rounded apically (Figs. 2a and b) shows in some electron micrographs signs of a ridge which might suggest the weak development of a terminal disc (Fig. 3). Although this Bothriocephalid therefore does not entirely fit the description of the genus *Bothriocephalus*, it is provisionally placed with this genus, subject to confirmation based on detailed morphological studies of the external and internal microscopic morphology of the material presently being undertaken.

According to the original description of *Bothriocephalus gowkongensis* by Yeh (1955) neither of the two types fit the description of this species, which has mature proglottids of more or less equal width and length with gravid proglottids being longer than they are broad. In both types 1 and 2 the proglottids appear clearly shorter than they are broad (Figs. 1c, d and 2c, d).

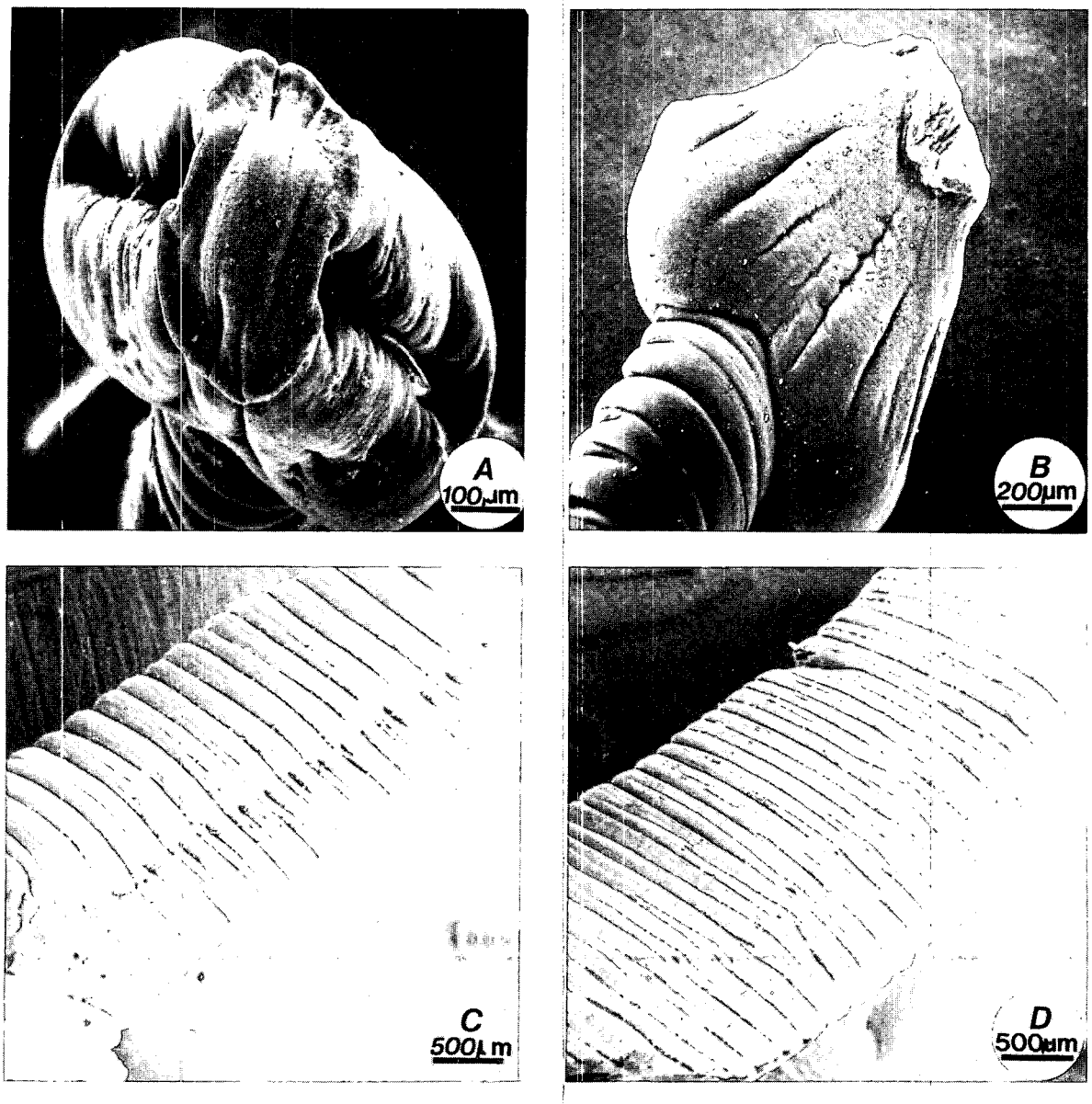

Figure 1
Scolex and strobila of Bothriocephalus *type 1, collected from the Dinkelsbühl Aischgrund variety of the common carp,* Cyprinus carpio *from fish ponds at Marble Hall, Transvaal.*
A – Scolex anterior view showing terminal disc and lateral grooves;
B – dorsal view of scolex;
C – dorsal view of stobila showing dorsal groove with genital atria;
D – ventral view of stobila.

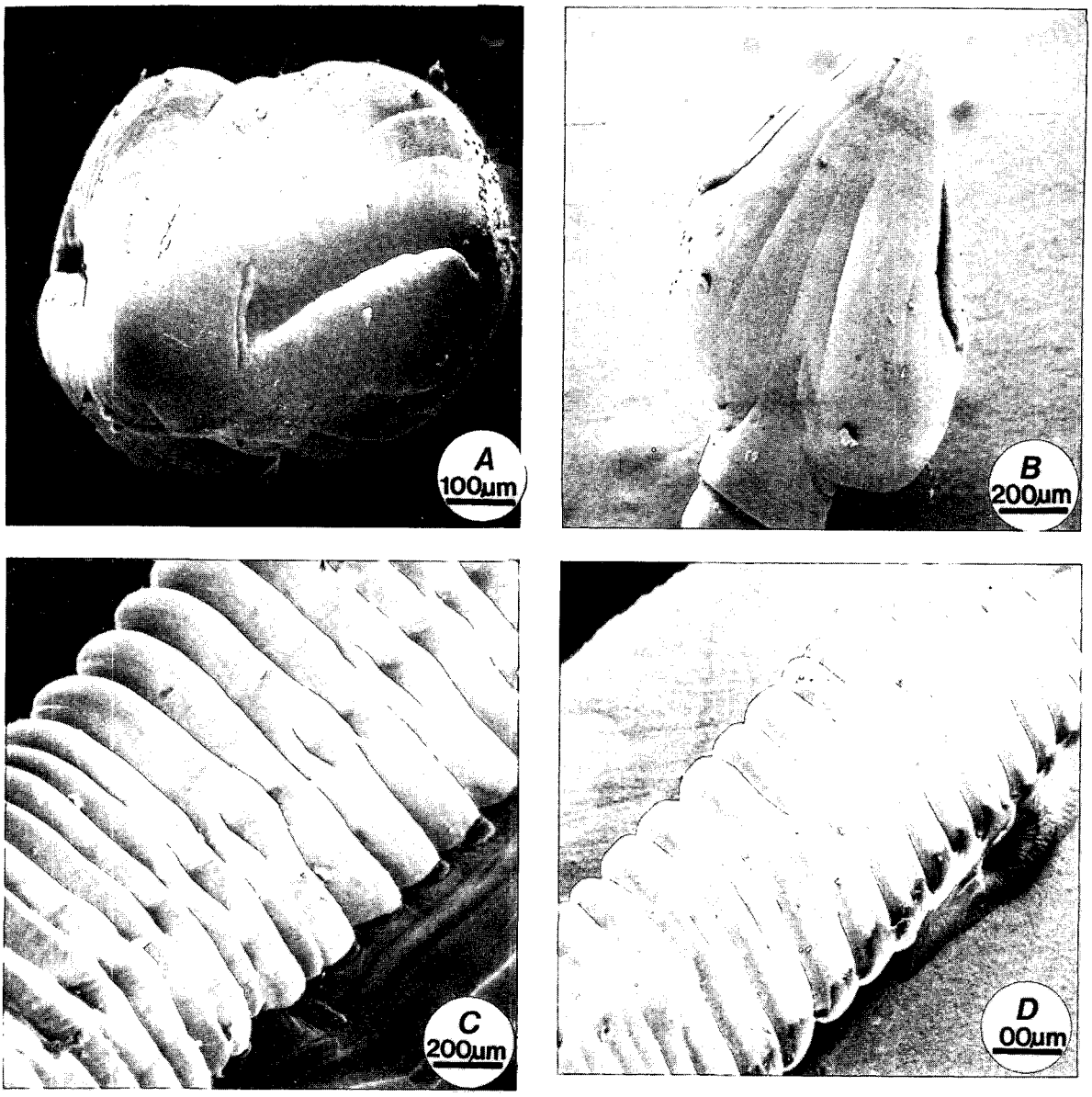

Figure 2
Scolex and strobila of Bothriocephalus *type 1, collected from the Dinkelsbühl Aischgrund variety of the common carp,* Cyprinus carpio *from fish ponds at Marble Hall, Transvaal.*
A — Scolex anterior view lacking terminal disc;
B — dorsal view of scolex;
C — dorsal view of strobila showing genital atria but absence of groove found in type 1;
D — ventral view of strobila.

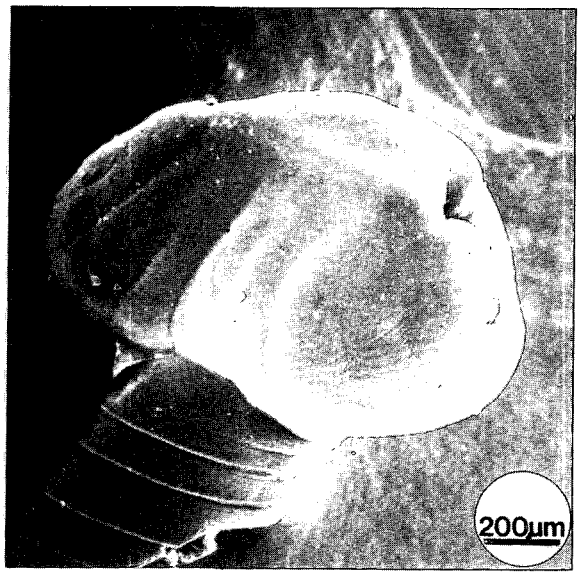

Figure 3
Scolex of Bothriocephalus *type 2 in contracted form showing signs of presence of terminal disc*

Electron micrographs of the scolexes of the specimens collected from *B. kimberleyensis* in the Vaal Dam are illustrated in Figures 4a—d. The close resemblance of these two types with those from Marble Hall can clearly be seen (compare Figs. 1, 2 and 4).

Recently pseudophyllidean cestodes were collected from *Barbus trimaculatus* Peters 1852 from a fish pond at Marble Hall after the above electron microscope study was completed. A microscope investigation of the live specimens revealed that the parasite has the ability to contract and relax considerably (Figs. 5a—h). In the relaxed or protruded form the scolex is heart-shaped, and pointed apically. In this condition no terminal disc on the scolex is noticeable, while the proglottids are clearly longer than they are broad. In the contracted form, however, the scolex is fist-shaped and also shows little or, at most, a weakly developed apical disc. (Electron micrograph, Figure 3, resembles this stage). During contraction of the worm the proglottids become shorter than they are broad, resembling Figures 2c, 2d, 4c and d. It is only between the extremes of the contracted and expanded conditions that the apical disc is prominent, as it appears in Figures 1a and 1b.

From observations on the live parasites it appears that types 1 and 2 as separated in the text may well represent forms of the same species, fixed at different stages of contraction. The possibility that we may in fact deal with *B. gowkongensis* can therefore not be excluded. The phenomenon of contraction in

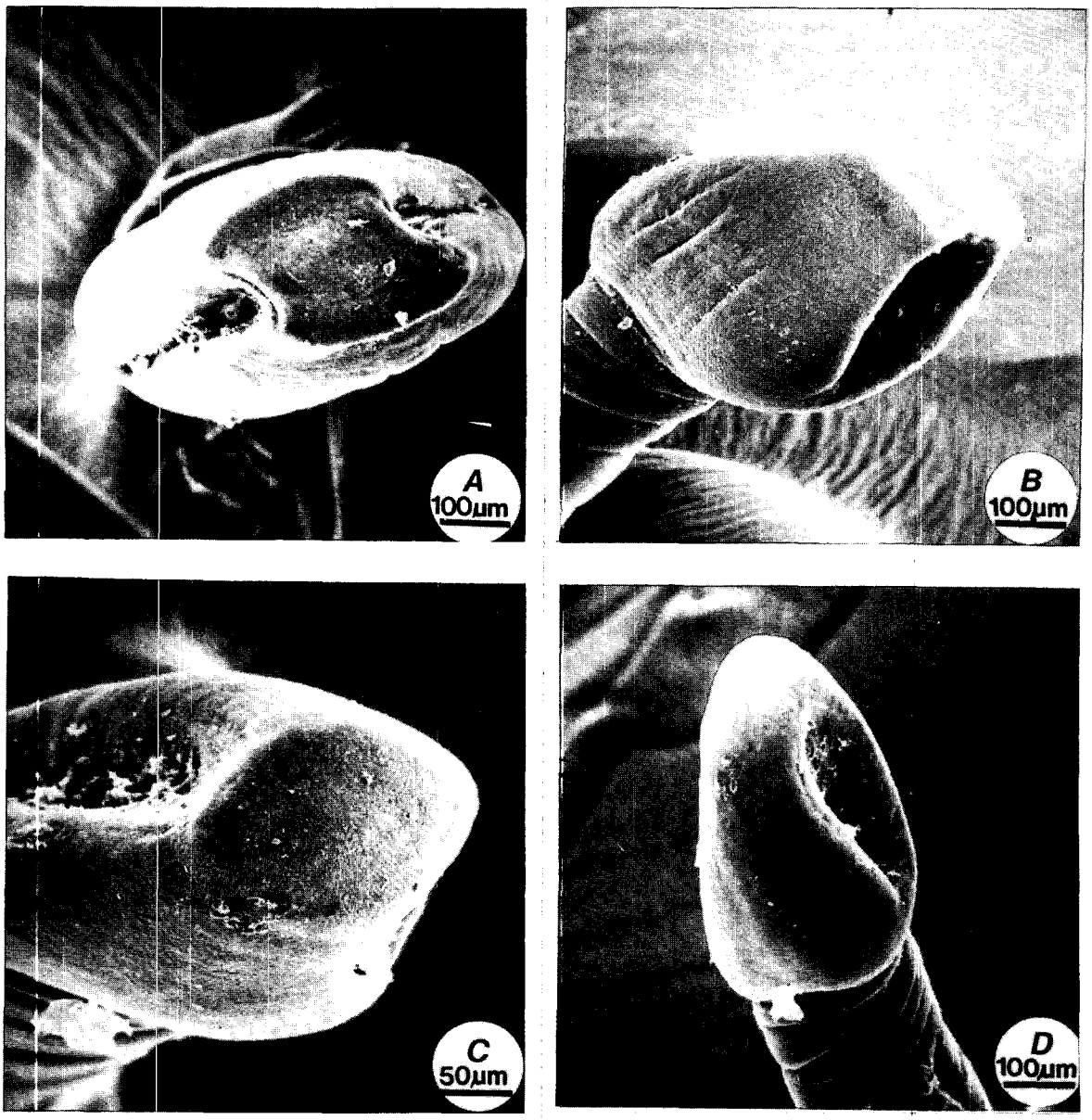

Figure 4
Scolex of Bothriocephalus *collected from* Barbus kimberleyensis *in Vaal Dam; A, B resemble* Bothriocephalus *type I and C, D* Bothriocephalus *type 2 of the Marble Hall material*

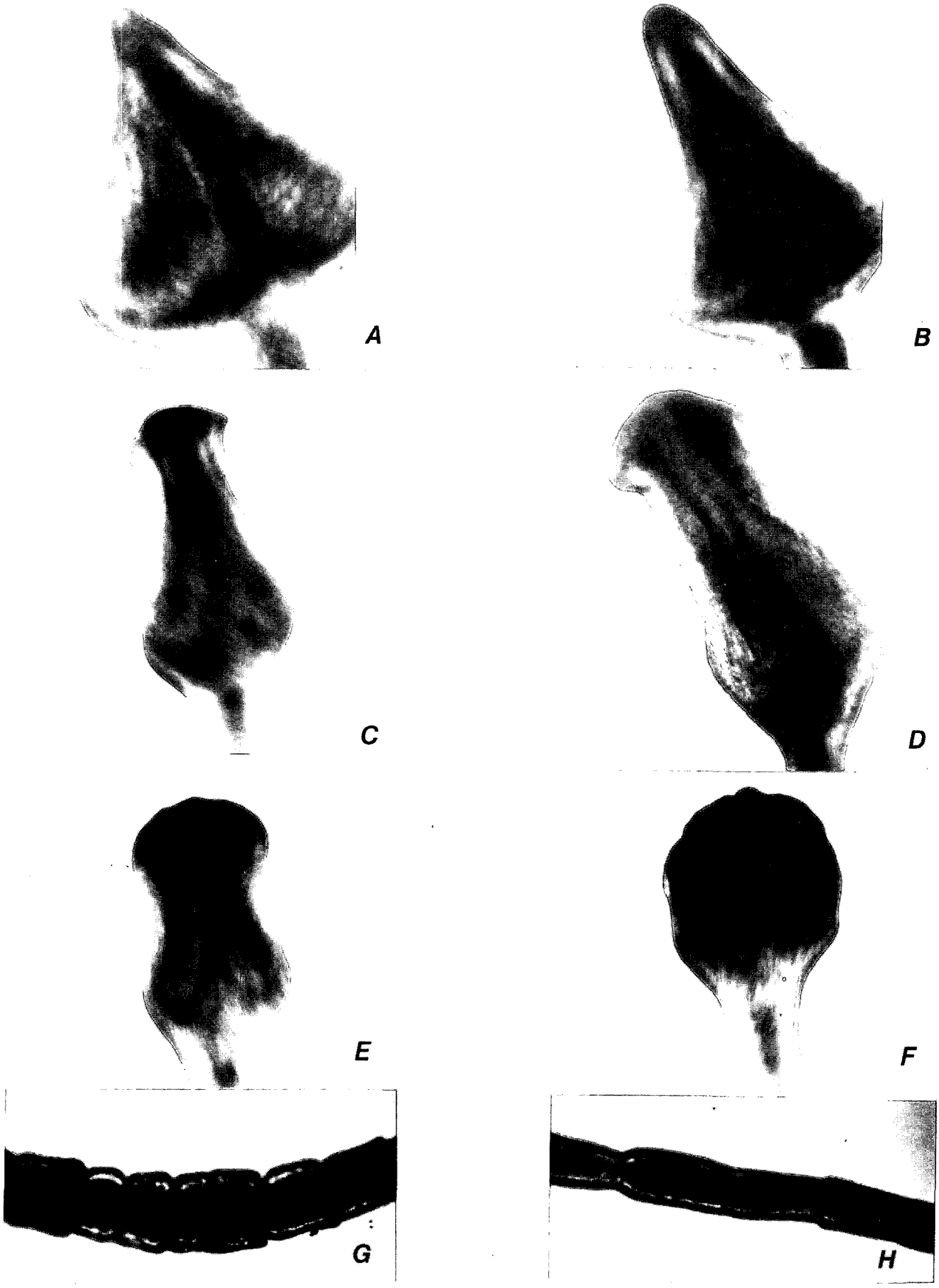

Figure 5
Series of microscope photographs of live Bothriocephalus *in the process of contraction. A—F sequence of scolex contraction; G — strobila contracted; H — strobila extended*

Pseudophyllids must therefore be taken into account in taxonomical studies, and will be considered in the morphological study that is at present being undertaken.

The Problem of Bothriocephalosis

Species of the genus *Bothriocephalus* Rud. 1808 has been recorded in both marine and freshwater fish species. It has been reported from Japan (Yamaguti, 1934), Western Europe (Cooper, 1917), United Kingdom (Kennedy, 1974), USA and Canada (Linton, 1941; Jilek and Price, 1978), Egypt (Meggit, 1930; Amin, 1978) as well as China (Yeh, 1955) and the USSR (Bykhovskaya-Pavlovskaya *et al.*, 1964). The species *B. (Clestobothrium) kivuensis* is described by Baer and Fain (1957–58) occurring in *Barbus a. altianalis* from Lake Kivu, Africa. Parasites belonging to the genus *Bothriocephalus*, which cause diseases amongst pondfish at fish farms of the USSR, include *B. gowkongensis* (Musselius and Strelkov, 1966). Antalfi and Tölg (1971) reported this species to have been present in Rumanian carp in previous years. Bykhovskaya-Pavlovskaya *et al.* (1964) showed this parasite also to occur in *Cyprinus carpio, Hypophthalmichthys molitrix* and other Cyprinids in the USSR as early as 1958. The infestation of fish farms in Hungary, Austria and Germany with *B. gowkongensis* is ascribed by Bykhovskaya-Pavlovskaya *et al.* (1964) and Körting (1974) to be mainly the result of the introduction of the grass carp *Ctenopharyngodon idella*, imported from the Amur River Basin into the Ukraine and Moscow as pond fish, and which appeared to be responsible for the *B. gowkongensis* infection amongst the fingerlings of the common carp in that region. In Central Europe this parasite is reported to be responsible for heavy mortalities of the common carp in pond hatcheries (Körting, 1974, 1975). According to Hoffman (1976) this tapeworm has also been found in the South Eastern USA in grass carp, the golden shiner, *Notegeminus crysoleucas* and the fathead minnow, *Pimephales promelas*. The *B. gowkongensis* infected grass carp was apparently in this case distributed from Arkansas (Scott and Grizzle, 1979).

Possible Route of Entry of Bothriocephalus into South Africa

As a result of the eutrophication of several South African rivers and impoundments (Steÿn *et al.*, 1975 and 1976), algal blooms and excessive growths of certain noxious aquatic weeds occurred which posed a threat to the effective management of such water bodies and required expensive remedial action to rid the Hartbeespoort Dam, for instance, of the water hiacinth, *Eichhornia crassipes*, with the aid of herbicides. Chinese grass and Silver carps were imported and investigated for their possible effective utilization of the aquatic weed problem and algal blooms, respectively, which resulted from the eutrophication of river systems (Kruger and Brandt, 1975; Schoonbee *et al.*, 1978). The silver carp was introduced into the Transvaal from the fish farm of the Kibbutz Gan Shmuel at Hadera in Israel whilst the grass carp (of Hungarian stock) was obtained from West Germany. Both species were subsequently spawned artificially with the aid of hormones at the Fisheries Research Station at Marble Hall (Schoonbee *et al.*, 1978; Brandt and Schoonbee, 1980) and can now be produced on a large scale. Earlier, in 1967, the Natal Parks Board also imported the grass carp from Malaysia (Pike, 1974). In 1977 a number of silver carp fingerlings were also imported by the Natal Parks Board from the Kibbutz Hazorea, Israel.

Although the possibility cannot be excluded that these parasites might have been introduced with the Chinese carps into South Africa, the discovery of what seems to be the same parasite from the yellowfish *B. kimberleyensis* from the Vaal Dam, dispells this possibility to a certain extent as no fish from the Marble Hall Fisheries Research Station were introduced into the Vaal River System, at least not since the introduction of the grass and silver carps to Marble Hall in 1975. Until such time therefore that the identification of these parasites are confirmed, and that it can be shown to be a species associated with the Chinese carps, the possibility that the parasites might have been imported with the common carp, *Cyprinus carpio* (which is originally from China) into South Africa as early as 1859 (Maar, 1960) or even with the Dinkelsbühl Aischgrund variety of the common carp in 1952 into the Transvaal (Lombard, 1961) cannot be excluded. One other possibility which has to be considered is that this Pseudophyllidean cestode is an endemic species associated with local Cyprinids. Of interest is the fact that none of more than 30 dissections of grass and silver carps (which are kept in separate ponds at Marble Hall) have at this stage been found to reveal the presence of these parasites.

In view of the problems encountered in Europe and elsewhere with *B. gowkongensis*, and also as a result of the severity of infection recorded in pond fish such as the common carp (Körting, 1974, 1975), it was immediately decided upon the discovery of *Bothriocephalus* among the Aischgrund common carp in ponds at Marble Hall, to take the necessary steps to eradicate this parasite from the fish and ponds at the research station with the aid of cestocides.

Control Measures for Parasites with 2', 5-Dichloro-4'-Nitrosalicylanilide (Lintex)

In the light of the success obtained elsewhere with the treatment of infected fish with niclosamide preparations (Körting, 1974), Lintex (2', 5-Dichloro-4'-nitrosalicylanilide) was incorporated in fish pellets and applied at a dosage strength of 50 mg active ingredient per kg fish per day for seven days. This cestocide was mixed into fish pellets and fed at a dosage concentration of 5% food per fish biomass per day. For the purpose of the experiment, 50 fish were originally taken from a stock of common carp (mean biomass 200 g) known to be heavily infected with the parasites (dissection revealed a 45% infection incidence). Fifteen fish from the infected stock were then transferred to an aquarium tank and treated for seven days as prescribed, after which none of the treated fish were found to contain any parasites. A repetition of the experiment yielded the same results. The prescribed dosage for Lintex was thus considered effective to eradicate this parasite from the pond fish. This step was then followed by a large scale treatment of pond fish with the same Lintex treated pellets but, instead of handfeeding, use was then made of demand feeders. More than 14 000 carp kept at the research station were allowed to feed freely on the Lintex treated pellets. Feeding was done for two days with an interruption of another two days without feed, in order to enable the fish to clear their stomachs, after which another three active feeding days were allowed. A total of one hundred fish were then killed and dissected for the parasite. None of the parasites were found in any of these fish nor in any other of the Lintex treated fish dissected at a later stage.

Discussion and Recommendations

The present investigation reveals that a species of *Bothriocephalus* occurs in South Africa which may pose a threat to its still infant freshwater fish farming industry if the necessary precautionary measures are not taken to prevent the parasites from entering fish farms. It is therefore considered a matter of urgency to bring this problem to the attention of the fish farmer, especially those who raise the carp, *C. carpio*, as pond fish.

On the information available it cannot be assumed with certainty that the parasites discovered in fish at Marble Hall and Vaal Dam are indigenous or were imported with either the common carp, or the Chinese grass carp and/or silver carp. The final species identification of the cestode material will throw more light on the actual origin of the parasites.

At this stage the Chinese grass and silver carp, held as broodstock at the Marble Hall Fisheries Research Station in ponds separate from the Aischgrund common carp do not appear to be infested with the parasites. The possibility that they may become infected is, however, good seeing that they are known to be hosts for *B. gowkongensis*.

Bothriocephalus has a life cycle in which its larval form, a procercoid, normally invades a cyclopoid copepod, which naturally occurs as a zooplankter in ponds. The infected copepod, with a second larval stage, a plerocercoid must then be ingested by a fish as final host for the parasite to complete its adult tapeworm stage.

There are therefore certain steps which can be taken to eradicate the parasite from infested fish ponds. In view of the nature of the problem and the positive results obtained with the cestocide Lintex, the following recommendations are made for consideration by local, private and provincial hatcheries where and when this problem is encountered:

1. The systematic prophylactic treatment with medicated feed of all carp species prior to the overwintering period, in order to avoid the continuation of the life cycle of the parasite in copepods during early spring, when algal blooms and zooplankton begin to appear. This should be followed by an early spring treatment just before the onset of the natural spawning season of the common carp. Thirdly, all fry and fingerlings should be treated with medicated feed in specially disinfected ponds before release to fish farmers.

2. A programme of draining and lime disinfecting of ponds must be made in such a way that reinfection of such ponds will not occur (Huet, 1970).

3. Alternatively, and to be on the safe side, disinfected spawners of all carp species should, as an interim measure, be artificially spawned on a large scale so that the risk of providing parasite infected fish to the farmer can be avoided. This alternative is virtually the only means of guaranteeing that fry and fingerlings will be free of this specific type of parasite.

Bothriocephalus specimens has so far been recorded from two localities in the Transvaal. At this stage it not only occurs in the common carp, but has been found in *Barbus trimaculatus, Barbus kimberleyensis,* and lately, in *Barbus mattozzi*. It therefore appears that this parasite may readily infest indigenous cyprinids which are at some stage feeding on zooplankton serving as intermediate host for this parasite. The most recent information indicates that we may be dealing with one species only, possibly *Bothriocephalus gowkongensis*.

New Information on the Parasite

Since the completion of this manuscript, new information concerning the possible origin of the parasite has been obtained which virtually implies that it may have been introduced in 1975 with the grass carp.

Formalin preserved specimens of the grass carp fingerlings originally imported from Mindelaltheim, Günzburg, West Germany were dissected and *Bothriocephalus* was found in some of them. A reply to inquiries to the supplier of the grass carp fingerlings confirmed that *B. gowkongensis* was already present there at the time when the fingerlings were supplied to the Marble Hall Fisheries Research Station.

Acknowledgements

The authors hereby wish to thank the departments of Zoology of the Potchefstroom and Rand Afrikaans Universities for facilities which made this study possible. Our thanks are also due to the Department of nature Conservation of the Transvaal Provincial Administration for permission to publish the results. We also wish to thank Mr. Don Curle for his help in the collection of the material and Professor M Leighton for his much appreciated editorial comments.

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