Occurrence of *Atractolytocestus huronensis* Anthony, 1958 (Cestoda: Caryophyllaeidae), in Hungarian pond-farmed common carp

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Summary

In 2001, a caryophyllidean tapeworm, *Atractolytocestus huronensis* was detected in the intestine of pond-farmed common carp in Hungary. Within two years the cestode spread throughout Hungary and its presence has been demonstrated in several pond farms. The parasite commonly occurred in the gut of market sized common carp imported from the Czech Republic. The cestode can infect some weeks old common carp fry and older age groups alike. *A. huronensis* specimens measuring 0.7–1.5 cm occurred in the most proximal segment of the common carp foregut, where they were firmly attached to the gut wall by their scolex. By its characteristically low number of testes *A. huronensis* is well distinguishable from the species *A. sagittatus* known from East Asia and from the Astrakhan territory of Russia.

Introduction

Over a long period of time, economically important cestodes parasitising the gut of the European subspecies of common carp (*Cyprinus carpio carpio*) in adult form were represented solely by the species *Caryophyllaeus laticeps* (Pallas) (Schäperclaus, 1954). Later on, Russian authors (Bauer *et al.*, 1969) suggested that the common carp was also parasitised by a species well distinguishable from *C. laticeps*, i.e. *Caryophyllaeus fimbriceps* Annenkova-Chlopina. From the gut of the Far Eastern common carp subspecies (*Cyprinus carpio haematopterus*) another caryophyllidean cestode species, *Khawia sinensis* Hsü was known, the European appearance of which was reported by Kulakovskaya and Krotas (1961). *Khawia sinensis* soon became widespread in the European common carp stocks (Mattheis and Spangenberg, 1974; Panczyk and Zelazny, 1974; Scholz, 1991), driving out the native *C. fimbriceps* species from the pond farms. The appearance of this parasite in Hungary and its differentiation from *C. fimbriceps* were reported by Molnár and Buza (1975) as well as Murai and Molnár (1975). Until quite recently, the cosmopolitan species *Bothriocephalus acheilognathi* Yamaguti, brought into Europe by introduction of the grasscarp (*Ctenopharyngodon idellus*), was the cestode most commonly found in the gut of common carp in Hungary, in addition to the common carp specific *K. sinensis* (Malevitzkaya, 1958; Musselius, 1962).

This paper reports that a new caryophyllidean cestode hitherto unknown in Europe has appeared in the Hungarian pond-farmed common carp stocks, which causes intensive infection in some ponds and can be identified anatomically with the cestode *Atractolytocestus huronensis* Anthony, 1958 described in North America.

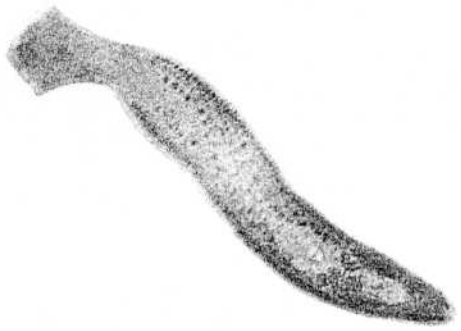

Fig. 1. *Atractolytocestus huronensis* Anthony, 1958 from *Cyprinus carpio*. A fixed specimen stained with carmine. x 5.

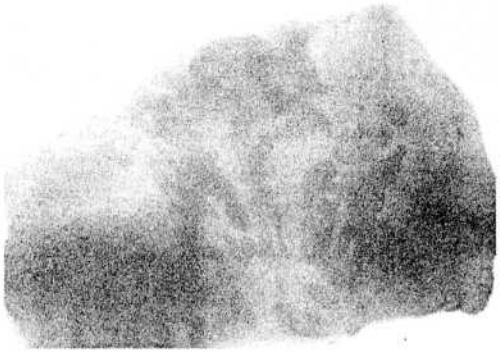

Fig. 2. Native *Atractolytocestus huronensis* Anthony, 1958 cestodes in the foregut of a common carp (*Cyprinus carpio*). x 5.

Materials and methods

Veterinarians of the Central Veterinary Institute regularly screen the fish stocks of large pond farms for diseases every year. They first noticed the tiny cestodes in common carp specimens of a pond farm located on the Great Hungarian Plain on the occasion of an on-site fish dissection. Subsequently the specialists looked for such cestodes in the gut of all pond-farm fish specimens submitted for laboratory examinations.

The cestodes found were placed into 0.65% isotonic saline solution after collection, freed from the adhering mucus by gentle shaking, and measured. Some of the cestode specimens were rendered transparent with lactic acid during slight compression between slides while others with methyl salicylate after dehydration, and then examined in toto. Some of the cestodes were fixed in 70% ethanol solution or 10% hot formalin solution, stained with borax carmine or alum-carmine and embedded into Canada balsam without sectioning after dehydration. Five specimens were fixed under coverslip in Bouin's solution in slightly flattened condition for 4 hours, then embedded in paraffin, and sectioned longitudinally. The 5–8 µm thick sections were stained with haematoxylin and eosin solutions. The cestode specimens examined in their entirety and the sections were photographed with a digital camera mounted on an Olympus BH2 microscope.

Results

On 28 July 2001 unknown small caryophyllidean tapeworms were found in the gut of two-summer common carp submitted for routine examination from an Eastern Hungarian pond farm (Figs 1 and 2). On detailed examination, on the basis of their morphological characteristics these cestodes could be identified with the species *Atractolytocestus huronensis* Anthony, 1958. In the following months further infected fish were found in the above fish farm and also a farm in the western part of Hungary (Table 1).

In the spring of 2002, specimens of this parasite were detected in the same stock of the previous farms as well as from the overwintered fry stock of further two farms. The parasite was detected on several occa-

	Date of exam	Age of fish	No fish	Fish farms	No. inf. spec.	Prev. %	Intensity	Remarks
1	2001 July	2+	6	I EH	6	100	4-20	
2	August	1+	100	I EH	11	11	1-22	
3	October	1+	100	II WH	100	100	4-31	
4	2002 February to June	3+	108	CZR	81	75	1-42	
5	April	2+	20	II WH	8	40	1-6	
6	May	2+	10	III WH	7	70	4-11	
7	May	2+	10	IV EH	4	40	1-4	
8	July	6 weeks	20	I EH	18	90	1-16	Pond I
9	July	6 weeks	100	I EH	0	0	0	Ponds II to VI
10	July	6 weeks	20	II WH	14	70	1-32	Pond I
11	July	6 weeks	20	II WH	3	15	1-30	Pond II
12	July	6 weeks	20	II WH	0	0	0	Pond III

Table 1. Occurrence of *A. huronensis* in common carp (*Cyprinus carpio*) during veterinary screening in 2001 and 2002. EH = East Hungary, WH = West Hungary, CZR = Imported food fish from the Czech Republic

sions in market sized common carp imported from the Czech Republic and not placed out into ponds.

Infection of the fry was first detected in 1.5-month-old common carp in mid-July 2002. In the intestine of these fish mature *A. huronensis* specimens not yet containing eggs were detected. Among the fry, infection was usually found in the biggest individuals. Among the 534 fish examined for *Atractolytocestus* infection 252 specimens (47 %) proved to be infected during investigations. The prevalence of infection varied by ponds within a given fish farm. During the fishing-off in the autumn of 2002, *A. huronensis* was detected in 11 other fish farms located in different geographic regions of Hungary.

During the routine diagnostic examination of common carp it was a conspicuous finding that *Khawia sinensis* and *Bothriocephalus acheilognathi* infection, which had been commonly diagnosed in earlier years, was detected much less often in 2002. About 3% of the examined common carp fry were infected with *K. sinensis* and 7% with *B. acheilognathi*. These two cestode species could only exceptionally be detected in fish infected with *A. huronensis* specimens.

The cestodes could be detected exclusively in the gut of common carp (*Cyprinus carpio*), and were never found in the intestine of gibel carp (*Carassius auratus gibelio*), grasscarp (*Ctenopharyngodon idellus*) and silver carp (*Hypophthalmichthys molitrix*), even if these fish shared a pond with common carp specimens.

Major morphological data of the parasite identified as the species *Atractolytocestus huronensis* Anthony, 1958 are compiled in Table 2. Additional data are as follows:

Without any muscular contraction the scolex is arrowhead shaped (Fig. 3A). The live worm can stretch the scolex out to two or three times its original length or contract it into a broad roundish shape. Therefore, after fixation the scolex may have narrow spearhead or mushroom shape. The vitelline follicles start below

the neck and are located continuously alongside the body down to the caudal end. On the medial part they start slightly lower than on the lateral part, and extend to the upper end of the cirrus sac and then postovarially to the caudal end.

So far testes have been found in four specimens only. The number of testes may be 3 to 5. They stain pale with haematoxylin or carmine and, therefore, are poorly visible among the vitelline follicles, apical to the cirrus sac. Testes were not discernible in the majority of cestode specimens found. Cirrus well developed (Fig. 3B). The male genital pore is located anterior to the female genital pore and they open into a joint atrium. The vas deferens running toward directions of the testes disappears above the cirrus sac and cannot be followed among the vitelline follicles. The ovary is H shaped. The space among the projections of the ovary is occupied by the convolutions of the uterus filled with eggs. The vagina is a tube. At the ovary the end of the vagina forms a receptaculum seminis which, however, contains only irregularly arranged fibrous material instead of clusters of cumuliform mass of paralell arranged allosperm. The initial part of the joint vitelline duct is slightly dilated (Fig. 3C). The operculate eggs are oval shaped.

Examination of the worm in cross section revealed that in addition to the vitelline follicles located in the cortical parenchyma a few follicles occurred also in the medullary parenchyma. The place of testes was occupied mainly by parenchymatous tissue. The testes contained round chromatin granules measuring 1–2 µm; however, the expected spermatozoites having elongated, straight or

Length in fixed stage	3 to 9	n = 35
Width in fixed stage	0.5 to 1.2	n = 35
Length in live stage	7 to 15	n = 20
Scolex	No hooks or bothridia	
Neck	Narrow, muscular	
Vitelline follicles	More than 500	
Testes	0.05	n = 4
Muscular cirrus sac	0.35 to 0.45	n = 5
Ovary width	0.6 to 0.9	n = 5
Lateral arms' length	0.8 to 1.1	n = 5
Diameter of vagina tube	0.02 to 0.05	n = 2

Table 2. Morphological data of *A. huronensis* specimens found in Hungary with measurements in mm.

undulating nucleus were not observed. The efferent seminiferous ductules (vasa efferentia) could not be recognised, and no bundles of spermatozoa having an intact head could be observed in the cirrus either. No allosperm having a dark-staining nucleus were found in the female genital duct. The cirrus and the receptaculum seminis contained a fibrous material staining pink with eosin.

The live worms could evert their cirrus long (Fig. 3D), especially in contracted state. Copulating specimens were not observed.

Discussion

As a result of fish movements and poorly controlled fish transportations that are being carried out all over the world today, the transcontinental translocation of parasites to a new biotope has become a common event (Bauer and Hoffmann, 1976; Molnár, 1987a). Introduction of a given parasite into a new continent is especially likely in the case of fish species bred as ornamental fish. The European common carp (*Cyprinus carpio carpio*) is particularly at risk in this respect, as it has an ornamental variation known as 'koi', which has been bred from the Asian subspecies

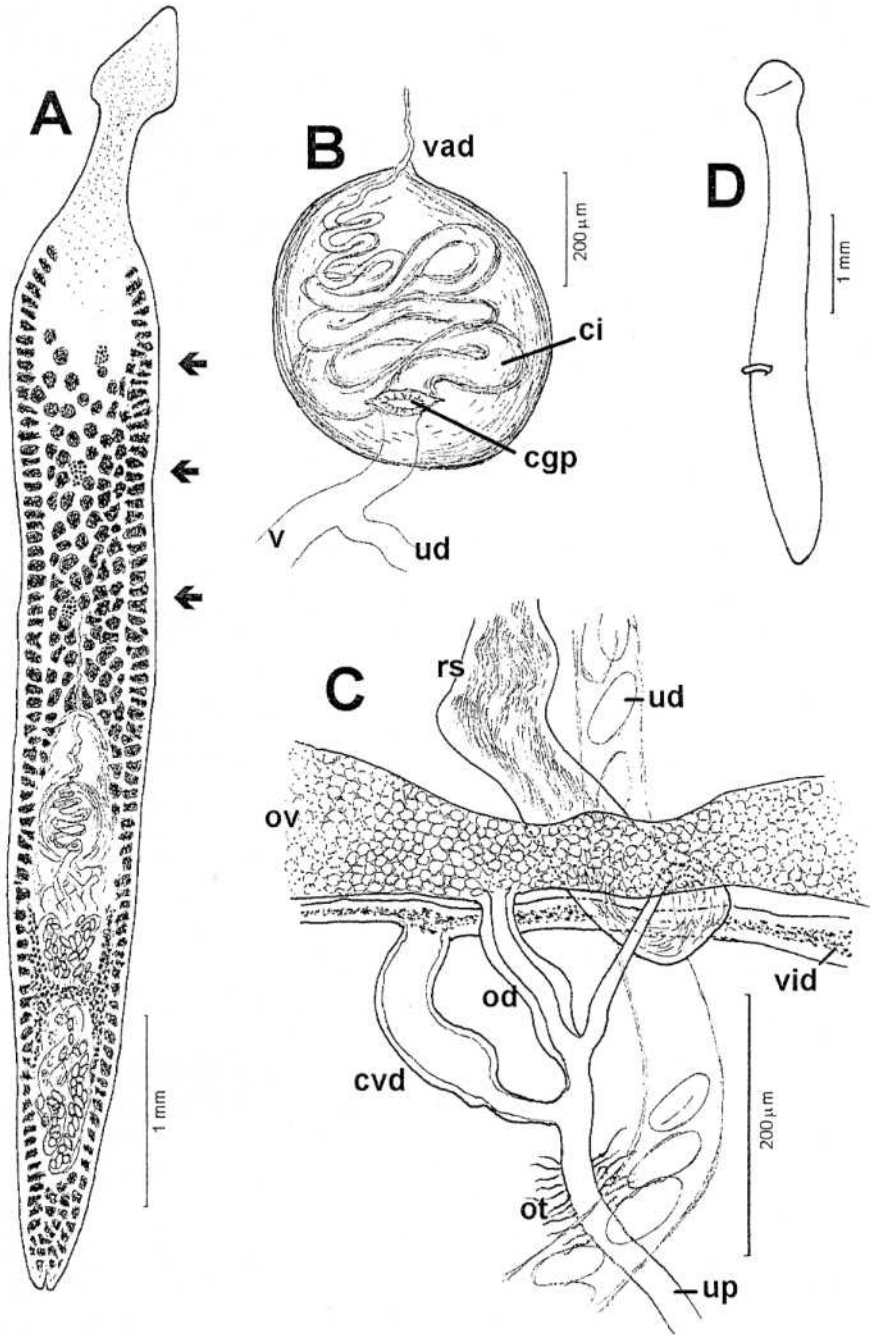

Fig. 3. *Atractolytocestus huronensis* Anthony, 1958 from *Cyprinus carpio*: A – a relaxed specimen with inner organs, slightly dorsoventrally compressed. The positions of testes are marked by arrows; B – cirrus sac; C – postovarian complex of genital ducts; D – a contour of a contracted specimen with everted cirrus. Abbreviations: ci –cirrus; cpg – common genital pore; cvd – common part of vitelline duct; od – oviduct; ot – ootype; ov – ovary; rs – receptaculum seminis; ud – distal part of uterus; up – proximal part of uterus; v – vagina; vad – vas deferens; vid – vitelline duct.

(*Cyprinus carpio haematopterus*). In the 1950s, Soviet fish breeders introduced into the European part of the Soviet Union substantial numbers of Amur wild carp because of their assumed resistance to diseases. By that fish transfer numerous new parasites were brought into these areas. The introduction of *Philometroides cyprini* (syn. *Philometra lusiana*) with the Amur wild carp has been demonstrated (Vismanis, 1964). For the monogeneans *Dactylogyrus achmerovi* and *D. molnari* and for the myxosporeans *Thelohanellus nikolskii* and *T. hovorkai* Molnár (1976, 1982, 1987b) as well as Molnár and Kovács-Gayer (1981–1982) have also indicated the Amur wild carp as the source of infection. However, the appearance of new common carp parasites like *Khawia sinensis*, *Dactylogyrus sahuensis* and *D. molnari* indicates that the transcontinental spread of common carp parasites may also be due to the increased imports of ornamental carp. Koi consignments from the Far East arrived in Hungary on numerous occasions in the past few decades (Pénzes and Tölg, 1986). Although these consignments were accompanied by valid veterinary certificates, they failed to meet the conditions necessary for preventing the transcontinental spread of parasites.

In the light of the above facts, the appearance of a new parasite species in the intestine of common carp bred in Europe was not unexpected at all. At the same time, the diagnosis itself was rather surprising, as *Atractolytocestus huronensis* known from North America, rather than *A. sagittatus* already having become established in the eastern region of Europe, appeared in the Hungarian common carp population.

The species *Atractolytocestus huronensis* was described by Anthony (1958) from common carp (*Cyprinus carpio*) in North America. Subsequently Amin (1986) detected it also in sucker (*Catostomus commersoni*). European occurrence of this parasite has briefly been mentioned by Chubb et al. (1996), and Kirk et al (2003) in Symposium abstracts, while by Hoole et al. (2002) in their book on the diseases of cyprinid fishes reported, that the worm was first detected in Britain in 1993. The morphology of the parasite was studied in detail by Jones and Mackiewicz (1969), who established that this cestode characterised by a triploid chromosome set had an unusually low number of testes, and assumed that parthenogenesis was involved in its reproduction. Already the above authors suspected the close relatedness of *A. huronensis* and *Markewitschia sagittata* known from the Amur wild carp, but classification of the latter species into the genus *Atractolytocestus* was first considered justified by Scholz et al. (2001).

The species *Markewitschia sagittata* was described by Kulakovskaya and Akhmerov (1965) from the river Amur. Subsequently the occurrence of the parasite was reported by Demshin and Dvorjadkin (1981) who detected *M. sagittata* in Amur wild carp transferred to the Astrakhan area of the Soviet Union. Studying the anatomic and developmental features of the parasite, the latter authors indicated the species *Limnodrilus hoffmeisteri* and *L. udekemianus* as intermediate hosts. Following the entry of the parasite into the water system of the river Volga the westward spread and appearance in Central Europe of *Atractolytocestus (Markewitschia) sagittata* were expected; however, instead of that species

possessing numerous testes the species *A. huronensis* having very few testes has been detected in Hungary and its common occurrence has been established.

The tapeworm specimens found in this study either have no testes at all or have only 3–5 testes, i.e. even fewer than reported for the American *A. huronensis* specimens. We agree the opinion of Chubb et al. (1996) and Kirk et al. (1993) that the species found by us has directly evolved from the tapeworm originally described as *Markevitschia sagittata*, in the same way as *A. huronensis* may also have evolved from the species *M. sagittata*, as its principal host, the common carp is not indigenous in America. Since, however, there is no major anatomical difference between the cestodes found by us and the tapeworms described as *A. huronensis*, on the basis of our morphological studies we can only establish the identity of the two tapeworms.

Presumably the parasite has become widespread in the Czech Republic in addition to Hungary. This is supported by its frequent detection during the routine examination of market sized common carp imported from that country. The parasite can colonise, and develop in, practically all common carp having adopted feeding on benthos, i.e. capable of consuming the intermediate host species *Tubifex* and *Limnodrilus*. With the appearance of *A. huronensis* in Hungary a new parasite has been added to the parasite fauna of cultured common carp, and in the short time that has elapsed since its detection the spread of this tapeworm in the Hungarian fish farms could be demonstrated. So far this parasite has been detected in common carp only. Since, however, in the United States and Canada *A. huronensis* can infect fish belonging to the genus *Catostomus* taxonomically more distant from the common carp, its appearance in other cyprinid fish may be expected. The type of reproduction and site of colonisation of the parasite are identical with those of the already naturalised *K. sinensis*. Only time can tell whether an antagonism like that observed between *K. sinensis* and *Caryophyllaeus fimbriceps* will develop between the two parasites, or rather a combined damage-causing effect of the two cestodes will have to be reckoned with. Namely, according to our unpublished observations, since the appearance of *K. sinensis* in Hungary it has almost completely displaced the previously common species *C. fimbriceps*, which can now be detected only in fish stocks living in natural waters.

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