

## NOTE

# Occurrence of *Atractolytocestus huronensis* (Cestoda, Caryophyllaeidae) in German pond-farmed common carp *Cyprinus carpio*

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**ABSTRACT:** Up to now, the caryophyllid cestode *Atractolytocestus huronensis* Anthony, 1958, a parasite of common carp, has attracted little attention in Germany. Based on recent publications from the Czech Republic and Hungary, it appears probable that this cestode may be increasingly common in Germany. There is a strong connection between the occurrence of *A. huronensis* and imports of common carp from the Czech Republic and southern Germany. Although in most cases no clinical alterations in parasitized carp have been observed, care should be taken to avoid further dissemination and to prevent possible losses in commercial pond farming.

**KEY WORDS:** Caryophyllaeidae · *Atractolytocestus* · Morphology · Prevalence · Common carp · Germany

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## INTRODUCTION

Cyprinids are a major group of freshwater fish which serve as a source of food, and are used for sport fishing. They are also appreciated for their ornamental appeal and as experimental models for research. Cyprinids are hosts to a variety of parasites including caryophyllid cestodes. In addition to other parasite genera, caryophyllid cestodes are widely distributed among common carp worldwide. They are unique among the Cestoidea in having a monopoleuroid body plan (i.e. they have no internal or external proglottidization and have a single set of reproductive organs). These morphological features are also seen in the Cestodaria. However, the lycophora of Cestodaria have 10 hooks and the Caryophyllidea possess an oncosphere with 6 hooks, characteristic of the eucestodes. There are about 42 genera and 137 spe-

cies in 4 families grouped within the order Caryophyllidea. They are widely distributed intestinal parasites of benthic-feeding siluriform and cypriniform freshwater fishes. As a member of the family Lytocestidae, *Atractolytocestus huronensis* Anthony, 1958 is characterized by inner longitudinal muscles that separate the cortical vitellarium from the medullary testes. As a result of this configuration, the testes generally appear in whole mounts as a narrow central core with lateral or annular vitelline follicles arranged close to the tegument. Unlike the Pseudophyllida (i.e. the genera *Bothriocephalus* and *Diphyllobothrium*) the scolices of members of the Lytocestidae lack loculi, bothria, or acetabula (Khalil et al. 1994). Species of *Atractolytocestus* differ most markedly in the number of testes. They do not appear to be site specific within the gut and can be found throughout the intestine (Scholz et al. 2001).

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Table 1. *Cyprinus carpio*. Summary of common carp in the present study distinguishing age, sample site and season. K<sub>0</sub> = carp fry, K<sub>1</sub> = 1 yr old carp, K<sub>2</sub> = 2 yr old carp. One group was examined continuously from stage K<sub>0</sub> to K<sub>2</sub>

Locality	Preliminary sample of K <sub>1</sub> 2003		Same group K <sub>0</sub> to K <sub>2</sub>								Next generation K <sub>1</sub> autumn 2004		Total			
	(n)	(%)	Spring 2003 (n)	Spring 2003 (%)	Early summer 2003 (n)	Early summer 2003 (%)	Autumn 2003 (n)	Autumn 2003 (%)	Spring 2004 (n)	Spring 2004 (%)	Late summer 2004 (n)	Late summer 2004 (%)	(n)	(%)	(n)	(%)
Cunersdorf	0	0.0	10	18.9	10	18.9	10	18.9	10	18.9	3	5.7	10	18.9	53	100.0
Kleinbeucha	10	14.1	10	14.1	10	14.1	10	14.1	10	14.1	8	11.3	13	18.3	71	100.0
Torgau	10	20.0	0	0.0	10	20.0	10	20.0	10	20.0	10	20.0	0	0.0	50	100.0
Koselitz	5	9.1	10	18.2	10	18.2	10	18.2	10	18.2	10	18.2	0	0.0	55	100.0
Grüngräbchen	5	7.8	10	15.6	10	15.6	10	15.6	10	15.6	19	29.7	0	0.0	64	100.0
Königswartha	15	21.7	11	15.9	10	14.5	10	14.5	10	14.5	2	2.9	11	15.9	69	100.0
Uhyst	5	8.8	11	19.3	11	19.3	10	17.5	10	17.5	0	0.0	10	17.5	57	100.0
Kreba	5	11.1	10	22.2	10	22.2	10	22.2	10	22.2	0	0.0	0	0.0	45	100.0
Hammerstadt	5	9.6	10	19.2	10	19.2	10	19.2	10	19.2	0	0.0	7	13.5	52	100.0
Petershain	5	10.9	11	23.9	10	21.7	10	21.7	0	0.0	10	21.7	0	0.0	46	100.0
Mühlau	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	5	100.0	5	100.0
Total	65	11.5	93	16.4	101	17.8	100	17.6	90	15.9	62	10.9	56	9.9	567	100.0

The occurrence of *Atractolytocestus huronensis* in Europe has briefly been mentioned by Chubb et al. (1996), and Kirk et al. (2003). The parasite infects young fry of a few weeks of age and older age groups alike and causes deprivation of the host's nutrients. In addition to the destructive mechanical effects caused by the scolex, it is suspected that the digestive enzymes released by the worm damage the local tissue (Molnar et al. 2003).

The present work attempts to identify the parasite, and assess its effect on common carp and the prevalence of infestation concomitant with age of common carp and different seasons.

## MATERIALS AND METHODS

The study was carried out at Fish Health Service, Saxonia and the Institute of Parasitology, Faculty of Veterinary Medicine, University of Leipzig, Germany. Common carp of different ages (194 carp fry, K<sub>0</sub>; 221 1 yr old carp, K<sub>1</sub>; and 152 2 yr old carp, K<sub>2</sub>) were submitted from different fish farms in Saxony, Germany, within the framework of health surveys and maintained in the laboratory in large glass aquaria until examination (Table 1).

External and internal examinations of all 567 carp were carried out using methods described by Noga (1996). Morphological terms proposed by Khalil et al. (1994) and Mackiewicz (1994) were used for the description of scolices.

Preparation of the collected cestodes was made as follows. Cestodes were cleaned in cold tap water, stained with lactic acid carmine for up to 1 h and after-

wards washed repeatedly in fresh tap water until their color turned blue. After fixation in hot, 70% ethanol and dehydration in ethanol at ascending concentrations the specimen were mounted in Canada balsam for permanent storage.

Methods of analysis focused on the prevalence of infestation of *Atractolytocestus huronensis* in relation to origin and age of the host (common carp) and the respective season. Statistical analysis was conducted with SPSS 11.5. Chi-square, Kendal-Tau-b and a post-hoc ANOVA corrected by Bonferroni were calculated.

## RESULTS

### Clinical and post-mortem finding

All worms were located in the foregut, which is characterized by the presence of numerous intestinal folds. Tissue swelling and inflammation induced by the piercing of the cestode scolex into the deep layers of the mucous membrane were not observed. Since infections with a small number of cestodes are asymptomatic, as seen in our survey (1 to 5 specimen per fish), pathomorphological alterations were not expected and were thus not further analysed.

### Prevalence of *Atractolytocestus huronensis*

The results shown in Tables 2 & 3 reveal no significant variations of *Atractolytocestus huronensis* infection among different age groups or seasons. None of the 2 yr old carp were infected with *A. huronensis*,

Table 2. *Atractolytocestus huronensis* infecting *Cyprinus carpio*. Prevalence of infestation in common carp of different age groups infecting *Cyprinus carpio*: K<sub>0</sub> = carp fry, K<sub>1</sub> = 1 yr old carp, K<sub>2</sub> = 2 yr old carp, nd = not done

Locality	K <sub>0</sub>		K <sub>1</sub>		K <sub>2</sub>		Total	
	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Cunersdorf	6	30.0	9	30.0	0	0.0	15	28.3
Kleinbeucha	3	15.0	4	9.3	0	0.0	7	9.9
Torgau	1	10.0	1	3.3	0	0.0	2	4.0
Koselitz	0	0.0	0	0.0	0	0.0	0	0.0
Grüngräbchen	0	0.0	0	0.0	0	0.0	0	0.0
Königswartha	0	0.0	0	0.0	0	0.0	0	0.0
Uhyst	0	0.0	2	5.7	nd		2	3.5
Kreba	3	15.0	4	16.0	nd		7	15.6
Hammerstadt	0	0.0	3	9.4	nd		3	5.8
Petershain	1	4.8	1	6.7	0	0.0	2	4.3
Mühlau	nd		0	0.0	nd		0	0.0
Total	14	2.5	24	4.2	0	0.0	38	6.7

whereas prevalences of 2.5% (K<sub>0</sub>) and 4.2% (K<sub>1</sub>) were seen in younger carp. There was also no significant difference in *A. huronensis* distribution among seasons. Highest cestode prevalences were seen during summer to autumn (2.3 and 2.5%). The geographical distribution of *A. huronensis* revealed no clear tendencies as the farms with the highest prevalences were located in different areas.

**Identification of *Atractolytocestus huronensis***

The tapeworms found in pond-farmed common carp possessed characteristics typical of *Atractolytocestus huronensis* (Tables 4 & 5, Fig. 1). The whole body

length of the examined specimen was 5.1 to 7.9 mm (n = 17), whereas the body width was 0.9 to 1.3 mm (measured at half body length). Due to the movement and the shrinking caused by fixation, the scolices were of variable shape. They appeared bulbate to bulboacuminate with a distinct neck and had a diameter of 500 to 900 µm. The H-shaped ovary measured 500 to 850 µm in width and was located in the very posterior part of the cestode. The cirrus sac measured 325 to 575 µm in length and 275 to 375 µm in width. The poorly contrasting testes, varying in number from 2 to 14, were oval to spherical and were usually found in the vicinity of the oval cirrus sac (Fig. 2).

**DISCUSSION**

It can be assumed that *Atractolytocestus huronensis* occurs throughout continental Europe, mainly due to the fact that carp from southern Bohemia are exported to many countries including Germany (Majoros et al. 2003, Oros et al. 2004).

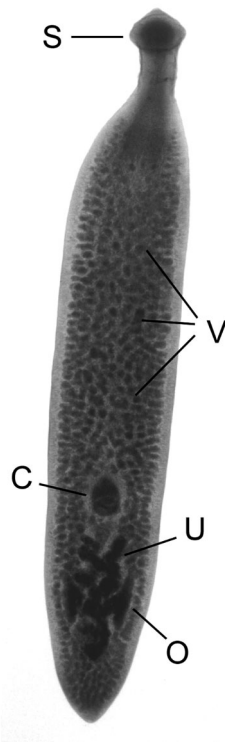
Personal observations (G. Bräuer) indicate that natural infections may be correlated with poor physical condition and intestinal inflammation. In our study infection intensities were generally low. It appears probable that increased infection pressure may alter health and productivity. Greater losses during winter should also be taken into consideration.

Table 3. *Atractolytocestus huronensis* infecting *Cyprinus carpio*. Prevalence of infestation in common carp during different seasons. K<sub>0</sub> = carp fry, K<sub>1</sub> = 1 yr old carp, K<sub>2</sub> = 2 yr old carp, nd = not done. One group was examined continuously from stage K<sub>0</sub> to K<sub>2</sub>

Locality	Preliminary sample of K <sub>1</sub> 2003		Same group K <sub>0</sub> to K <sub>2</sub>						Next generation K <sub>1</sub> autumn 2004		Total			
	(n)	(%)	Spring 2003	Early summer 2003	Autumn 2003	Spring 2004	Late summer 2004	(n)	(%)	(n)	(%)	(n)	(%)	
Cunersdorf			0	0.0	6	40.0	6	40.0	3	20.0	0	0.0	15	28.3
Kleinbeucha	0	0.0	0	0.0	3	42.9	3	42.9	0	0.0	1	14.3	7	9.9
Torgau	0	0.0			1	50.0	1	50.0	0	0.0	nd		2	4.0
Koselitz	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	nd		0	0.0
Grüngräbchen	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	nd		0	0.0
Königswartha	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	nd		0	0.0
Uhyst	0	0.0	0	0.0	0	0.0	1	50.0	0	0.0	nd		2	3.5
Kreba	0	0.0	0	0.0	3	42.9	2	28.6	2	28.6	nd		7	15.6
Hammerstadt	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	nd		3	5.8
Petershain	0	0.0	1	50.0	0	0.0	1	50.0	nd		0	0.0	2	4.3
Mühlau	nd		nd		nd		nd		nd		nd		0	0.0
Total	0	0.0	1	0.2	13	2.3	14	2.5	5	0.9	0	0.0	38	6.7

Table 4. *Atractolytocestus huronensis*. Measurements of cestodes (n = 17)

	Minimum	Maximum	Average	Deviation
Body length (mm)	5.05	7.88	5.98	0.68
Body width (mm)	0.90	1.33	1.03	0.12
Scolex width ( $\mu\text{m}$ )	500	900	622.6	106.6
Testes number	2	14	4.9	3.2
Cirrus sac length ( $\mu\text{m}$ )	325	575	444.2	75.8
Cirrus sac width ( $\mu\text{m}$ )	275	375	321.2	30.4
Ovary width ( $\mu\text{m}$ )	500	850	623.3	87.4

Fig. 1. *Atractolytocestus huronensis*. Whole mount showing scolex (S), cirrus sac (C), ovaries (O), uterus (U) and vitelline follicles (V). Testicles are not visible

According to the results of our studies, health or productivity seem not to be significantly altered in infected common carp. As described by Mackiewicz et al. (1972), *Atractolytocestus huronensis* cause some epithelial loss adjoining the detachment zone. The worm does not disrupt the basement membrane which forms an eosinophilic interface layer surrounding the scolex and only few defense cells are present (Molnar et al. 2003).

Concerning the prevalence of *Atractolytocestus huronensis*, our results are in accordance with those of Molnar et al. (2003). They reported that this cestode can infect young fry of a few weeks of age but also common carp which are several years old. Thus the infection is obviously not age dependant, which is probably due to a poor immune response to the parasite. Fish trade and poorly controlled shipments of fish contribute to the wide distribution of *A. huronensis* in common carp. The statistical analysis related to seasonality and locality is probably of low explanatory power due to the limited amount of available data.

The cestodes investigated in the current study are similar in their morphology and dimensions to those of *Atractolytocestus huronensis* Anthony, 1958. The present findings are consistent with the findings of Mackiewicz (1994), Scholz et al. (2001), Majoros et al. (2003) and Oros et al. (2004). *A. huronensis* and *A. sagittata* differ most markedly in the number of testes, which is 6 to 20 in *A. huronensis* (Anthony 1958) versus 80 on average in *A. sagittata* (Anthony 1958, Jones & Mackiewicz, 1969) and may reach 200 (Protasova et al. 1990) or more (Scholz et al. 2001).

The number of testes did not exceed 14 with most of the specimen exhibiting on average 4.9 testes. Some specimens did not have any testes at all as previously reported by Majoros et al. (2003). According to Oros et

Table 5. *Atractolytocestus* infecting *Cyprinus carpio*. Comparison of cestodes from farmed carp from different localities

	Eastern Germany (Present study) (n = 17)	Slovakia (Oros et al. 2004) (n = 15)	Czech Republic (Oros et al. 2004) (n = 16)	Hungary (Majoros et al. 2003) (n = 5)	USA (Anthony 1958) <sup>a</sup> (n = 10)
Body length (mm)	5.1–7.9	5.0–8.0	4.0–9.0	3.0–9.0	5.0–18.0
Body width (mm)	0.9–1.3	0.5–0.8	0.5–0.9	0.5–1.2	0.9–2.0
Scolex width ( $\mu\text{m}$ )	500–900	516–741	415–938	–	–
Testes number	2–14	16–20	9–14	0–5	6–18
Cirrus sac length ( $\mu\text{m}$ )	325–575	506–617	350–555	350–450	256–457
Cirrus sac width ( $\mu\text{m}$ )	275–375	299–374	214–347	–	–
Ovary width ( $\mu\text{m}$ )	500–850	421–574	297–482	600–900	–

<sup>a</sup>Common carp from natural source

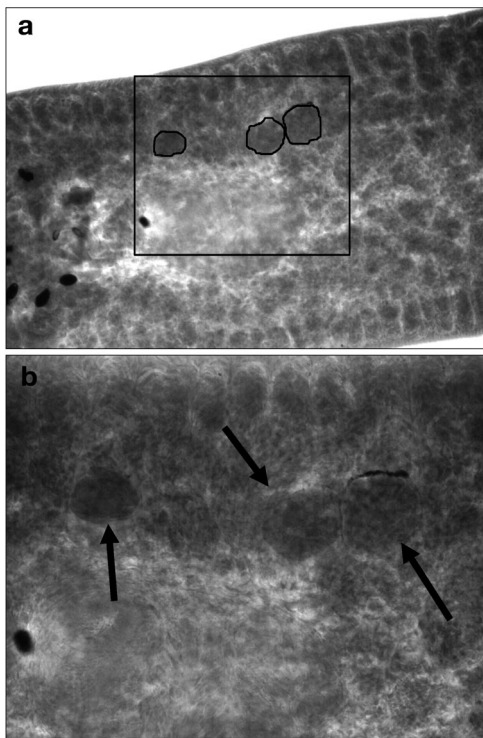


Fig. 2. *Atractolytocestus huronensis*. (a) Testes surrounding the cirrus sacs (outlined). (b) Additional detailed view of box in (a). Cirrus sacs marked with arrows

al. (2003), this could be due to a triploid genome as supposed by Jones & Mackiewicz (1969) but is more likely due to an inadequate staining technique. In our experience some testes may be difficult to identify because of deformation or overlapping of vitelline follicles which is related to the quality of staining, and thus the actual number of testes is probably underestimated.

The present data indicate that natural infections with *Atractolytocestus huronensis* have no significant consequences on health and productivity of common carp. Furthermore, it appears that this parasite does not currently have a major impact on commercial pond fisheries in Saxony. Nonetheless, due to its exclusive biological niche in the foregut, which is not occupied by other cestodes (*Khawia sinensis* or *Bothriocephalus acheilognathi*), *A. huronensis* will proba-

bly establish itself as a significant parasitic helminth of carp in Europe.

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