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## Description of the development of the attachment and copulatory apparatus of *Dactylogyrus extensus* from *Cyprinus carpio* var. *koi*

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### Summary

In July 2005 a Koi carp from a private pond in Bavaria was investigated. The aim of the presently reported study was to determine the composition of the monogenean fauna of Koi carp, *Cyprinus carpio* var. *koi* and to observe the development of *Dactylogyrus extensus*, under natural conditions, on the fish gills. A total of three species were recovered, namely: *Dactylogyrus extensus* Müller et Van Cleave, 1932, *Dactylogyrus minutus* Kulwieć, 1927, and *Gyrodactylus cyprini* Diarova, 1964. The dominant species was *D. extensus*, while the remaining monogeneans were not abundant. Six developmental stages of *D. extensus* were defined and they were compared with those previously observed by Prost (1963), under experimental conditions. The differences observed in size of the sclerotised structures of the haptor and the copulatory apparatus were discussed.

Keywords: *Cyprinus carpio*; Koi carp; monogenea; development; *Dactylogyrus extensus*; Germany

### Introduction

The monogenean fauna of carp in commercial fishponds near Lausitz and in Wolzig Lake, situated South-West of Berlin was studied by Lux (1987, 1990). He found 4 species of *Dactylogyrus* (*D. extensus*, *D. vastator*, *D. minutus* and *D. anchoratus*) and 7 species of *Gyrodactylus* (*G. stankovici*, *G. kherulensis*, *G. shulmani*, *G. sprostoniae*, *G. khatarinieri*, *G. cyprini*, and *G. mediuss*). Kappe (2004) studied Monogenea in commercial carp ponds near Leipzig and he found 3 species of *Dactylogyrus* (*D. vastator*, *D. extensus*, and *D. anchoratus*). No data on the monogenean fauna of carp from Bavaria are available. Fragmentary studies on postembryonic development of *D. extensus* were carried out, under laboratory conditions, by Bauer (1951, 1959) and Bauer & Nikolskaja (1954), but no illustrations of the developmental stages were provided. Prost (1963)

studied the development and pathogenicity of *D. extensus* on carp, under experimental conditions. She also monitored the development of the sclerotised structures of the haptor and the copulatory apparatus.

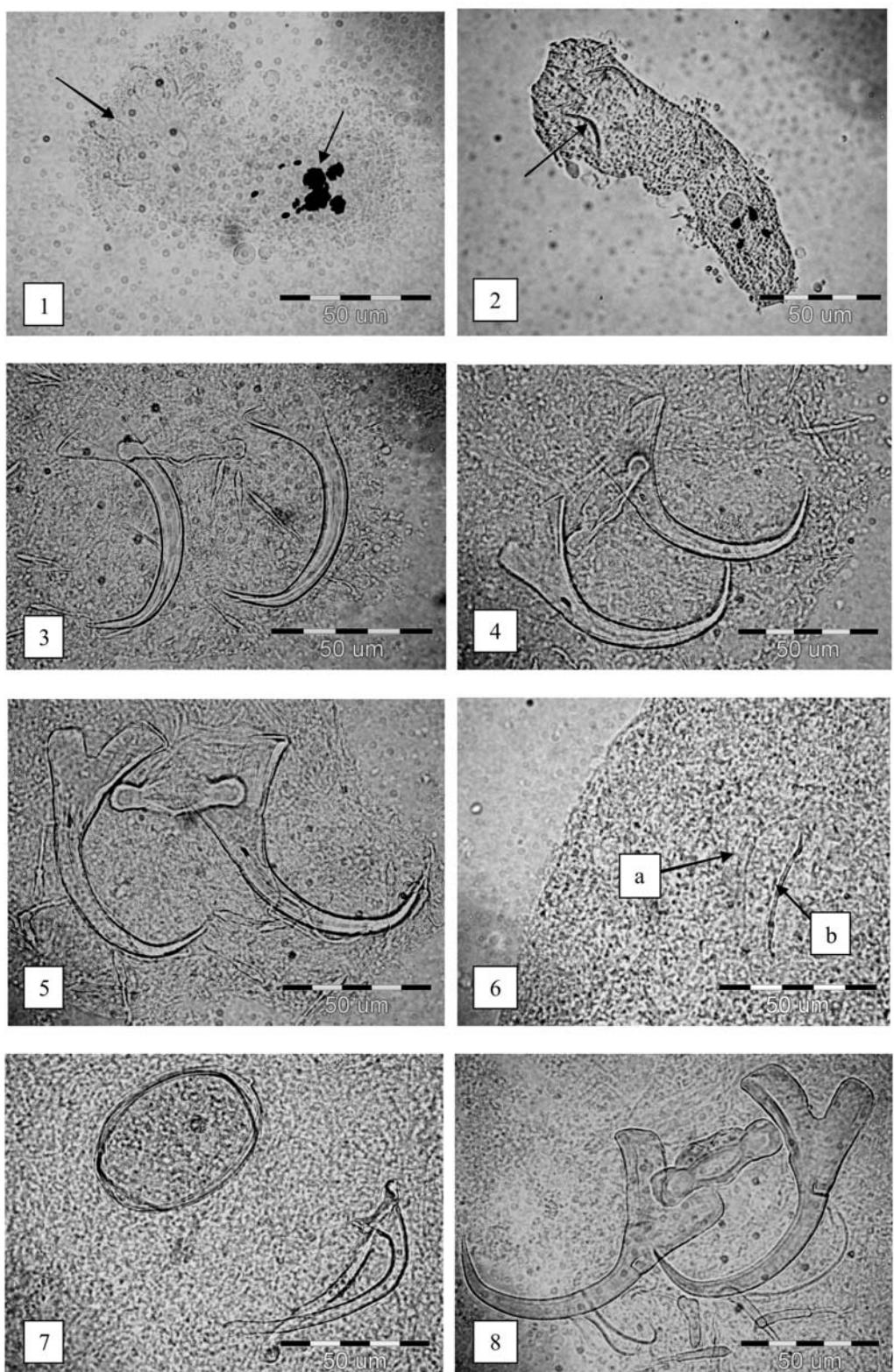
The aim of the present study was to determine the specific composition of the monogenean fauna of a Koi carp (*Cyprinus carpio* var. *koi*) from a private fish pond in Bavaria and to observe the development of *D. extensus*, under natural conditions, providing measurements of sequential developmental stages, including sclerotised structures of the haptor and the copulatory apparatus. These are the first studies of this kind, concerning Monogenea from Koi carp.

### Materials and methods

The host fish came from a private hobby pond in Bavaria, its volume was about 25 m<sup>3</sup>, containing about 12 koi carp, length between 20 – 45 cm long. The fish was transported to the laboratory, immediately after death. At this time the water temperature was about 22 °C. The fish (5 years of age, total length 43 cm, total weight 1180 g) was necropsied on 12 July 2005. The gills from one side and all fins were dissected. The parasites collected were fixed and preserved in GAP (Malmberg, 1970). The sclerotised structures of the attachment apparatus and the copulatory apparatus were measured and photographed under an Olympus compound (light) microscope, using the phase contrast and the Multiscan v. 4.2 image processing software. The monogenean species found were determined based on their sclerotised structures, i.e., the haptor and the copulatory apparatus - following Gusev (1985; Moravec 2004).

### Results

The bacteriological and virological examinations were negative. At necropsy, massive mucus aggregation was



Figs. 1. *Dactylogyrus extensus*; oncomiracidium with eyes and marginal hooks (arrows) (stage I): scale bar 50  $\mu\text{m}$

Fig. 2. *Dactylogyrus extensus*; juvenile specimen with point of anchors (arrow) (stage II): scale bar 50  $\mu\text{m}$

Fig. 3. *Dactylogyrus extensus*; juvenile specimen with anchors without processes and with loose dorsal bar (stage III): scale bar 50  $\mu\text{m}$

Fig. 4. *Dactylogyrus extensus*; juvenile specimen with small processes and dorsal bar (stage IV): scale bar 50  $\mu\text{m}$

Fig. 5. *Dactylogyrus extensus*; juvenile specimen with longer processes and connected dorsal bar (stage IV): scale bar 50  $\mu\text{m}$

Fig. 6. *Dactylogyrus extensus*; juvenile specimen with copulatory apparatus, a – cirrus tube, b – cirrus accessory (arrows) (stage V): scale bar 50  $\mu\text{m}$

Fig. 7. *Dactylogyrus extensus*; adult specimens with eggs and fully developed copulatory apparatus (stage VI): scale bar 50  $\mu\text{m}$

Fig. 8. *Dactylogyrus extensus*; adult; anchors with fully developed inner and outer processes and dorsal bar (stage VI): scale bar 50  $\mu\text{m}$

found on gills, showing the beginning of destruction. Microscopically massive invasion by *Ichthyophthirius* and monogeneans was found. A total of 873 specimens of monogeneans were collected. The infection intensity on a single gill arch almost reached 400 individuals. The genus *Dactylogyrus* was represented by 2 species: *D. extensus* (847 specimens) (Fig. 1 – 8) and *D. minutus* (8 specimens) (Fig. 9, 10). These two *Dactylogyrus* species differs in shape and size of anchors, dorsal bar and copulatory apparatus. The third species found was *Gyrodactylus cyprini* (18 specimens) (Fig. 11). Of all *Gyrodactylus* species previously described on carp, only *G. cyprini* has an oval plate belonging to anchors. All *Dactylogyrus* individuals were found on the gills, while *Gyrodactylus* preferred the fins.

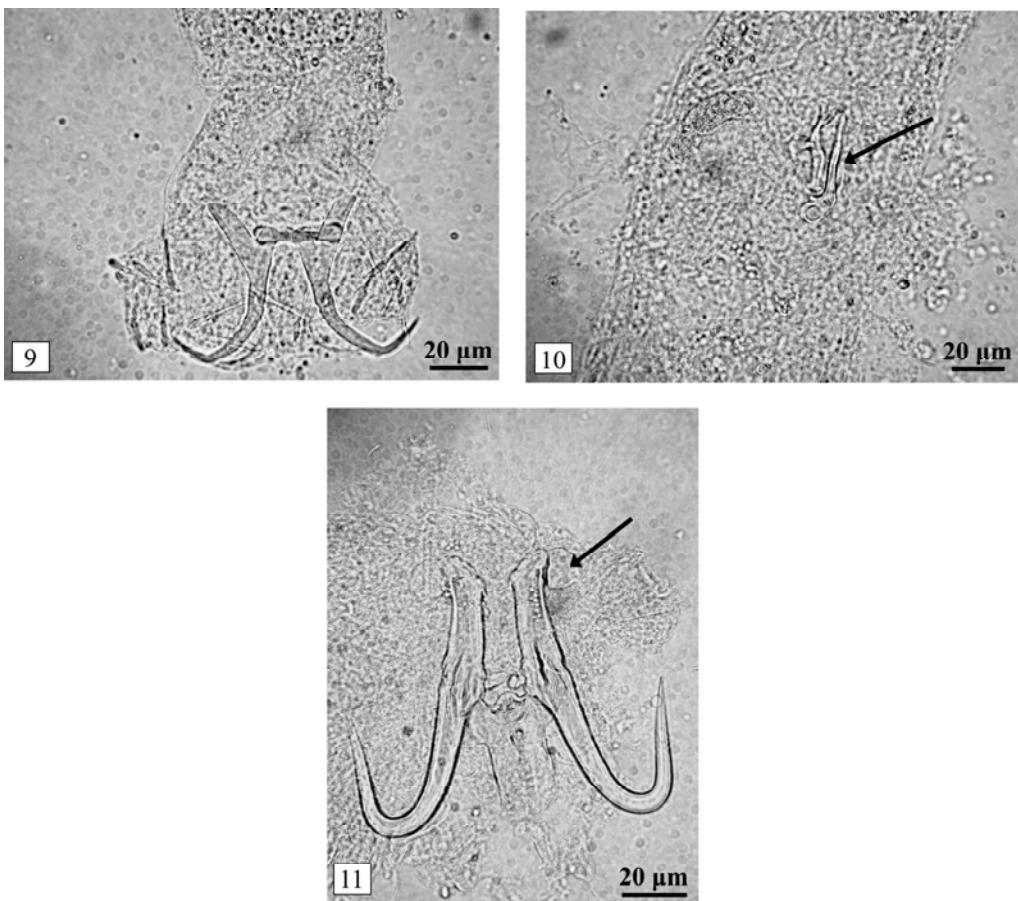


Fig. 9. *Dactylogyrus minutus*; haptor: scale bar 20  $\mu\text{m}$

Fig. 10. *Dactylogyrus minutus*; copulatory apparatus (arrow): scale bar 20  $\mu\text{m}$

Fig. 11. *Gyrodactylus cyprini* - haptor - anchors with oval plate (arrow): scale bar 20  $\mu\text{m}$

#### *Development of D. extensus under natural conditions*

Six developmental stages, in the life cycle of *D. extensus*, were defined by Prost (1963). All the stages (I – VI), from oncomiracidium (I) to the adult stage (VI) were found on the gills of the fish. The stage I - oncomiracidium with eyes and marginal hooks (Fig. 1) represented 13 specimens (1.5 %), stage II - juvenile specimen with point of anchors - 26/ 3.1 % (Fig. 2), stage III - juvenile specimen with anchors without processes and with loose dorsal bar - 73/ 8.6 % (Fig. 3), stage IV - juvenile specimen with small and longer processes and dorsal bar 68/ 8.1 % (Fig. 4, 5), stage

V - juvenile specimen with copulatory apparatus - 112/ 13.2 % (Fig. 6). The most prevalent was stage VI - adult specimens with fully developed anchors, dorsal bar and copulatory apparatus - 555/ 65.5 % (Fig. 7, 8) were found. The measurements of the sclerotised structures are presented in Table 1.

#### Discussion

Comparing the parasitic fauna of the presently studied Koi carp with the parasite fauna reported from carp by other authors, it is evident that there are differences in their specific composition. The smaller number of the monogenean species found on Koi carp was probably related to the fact



that this study was based only on a single fish, whereas the data of other authors were based on multiple host fishes. Furthermore, in a small pond with only a few fish individuals, only a few parasite species can be present. Moreover, the structure of parasite communities depends on the local conditions and the number of species in a defined ecosystem is always lower than the number of parasite species recorded within the species range (Kennedy & Guegan, 1994). In our study *D. extensus* was the dominant species. Paperna (1994a) showed under experimental conditions, that *D. vastator* excluded *D. extensus*. However, in

Table 1. A comparison of measurements (in  $\mu\text{m}$ ) of sequential stages of development of *D. extensus* into adult

Distance measured	Experimental conditions (24–25°C) (Prost 1963)						Natural conditions (present study 2005)					
	Developmental stage						Developmental stage					
	I n = 13	II n = 26	III n = 73	IV n = 68	V n = 112	VI n = 555	I n = 13	II n = 26	III n = 73	IV n = 68	V n = 112	VI n = 555
Body length	—	—	—	—	—	—	98.7–132.2	139.9–238.9	244.5–341.8	346.3–470.3	482.5–744.7	824.1–1496.2
Body width	—	—	—	—	—	—	35.4–49.4	52.2–68.6	68.8–88.9	87.9–110.0	113.3–144.3	146.9–294.6
Length of anchors	absent	22–38	39–56	56–64	59–65	60–69	absent	33.1–59.1	60.5–64.7	64.9–68.8	68.4–71.2	71.3–86.8
Root length of anchors	—	—	—	—	—	—	—	—	—	63.5–65.7	65.8–67.8	67.9–77.6
Length of inner processes	—	—	—	—	—	—	—	—	—	10.6–17.4	17.5–19.5	22.5–30.7
Length of outer processes	—	—	—	—	—	—	—	—	—	4.5–8.2	8.3–10.4	11.0–19.0
Length of marginal hooks	15–16	15–20	17–22	19–24	10–28	23–33	14.2–15.9	16.6–22.2	22.3–24.4	24.6–26.4	26.5–28.6	28.7–36.4
Width of dorsal bar	absent	absent	31–34	32–34	33–35	33–39	absent	absent	absent	37.3–41.1	40.6–41.7	41.9–43.0
Length of dorsal bar	—	—	—	—	—	—	1.2–2.8	8.0–11.3	11.4–13.0	13.1–17.7	—	—
Length of copulatory apparatus	absent	absent	absent	absent	35–42	55–68	absent	absent	absent	51.3–66.5	68.7–84.7	—
Length of copulatory tube	—	—	—	—	—	—	—	—	—	71.8–99.6	—	—

\* number ( $n$ ) of collected and measurement specimens

the study of Pojmańska (1995) *D. extensus* and *D. vastator* were recorded together in carp from fish ponds in Zabieńiec. She concluded that perhaps low intensity of occurrence of both species is the reason for lack of competition between them. Additionally, environmental conditions may be of influence. Paperna (1964b) described adaption of *D. extensus* infecting carp reared in artificial ponds in Israel to temperature between 24 and 28 °C under experimentally controlled conditions. He concluded that the behaviour *D. extensus* under different temperature and oxygen tensions in Israel may indicate a relatively rapid effect of natural selection and the establishment of a strain of *D. extensus* well adjusted to local ecological conditions. Our study may confirm these results of Paperna. Thus, the host immune response could be involved in interaction between the two species, and this factor is clearly temperature dependent. A possible competition between *D. extensus* and *D. minutus* could not be excluded, but this phenomenon should be proved under experimental conditions.

Prost (1963) studied the development and the pathogenicity of *Dactylogyurus extensus* on three-week-old immature carp, cultured under experimental conditions. In the present study on the development of *D. extensus*, under natural conditions on large adult fish, we observed, as did Prost (1963), that the primordial point of the anchors first appeared at stage II (Fig. 2) and the dorsal bar at stage III (Fig. 3). Stage IV marks the appearance of the processes (outer and inner) of the anchors, which enlarge at further stages of development (Figs. 4, 5). The copulatory apparatus appears at stage V (Fig. 6), while stage VI represents the adult phase (Figs. 7, 8) (Table 1). The results of measurements in this study, substantially differ from those provided by Prost (1963), regarding both the haptor and the copulatory apparatus. This could be caused by the different size of the studied fish. It is considered, that monogeneans are highly host specific in comparison to other parasitic groups of fish species (Sasal *et al* 1999). They also found a good relationship between host body size and parasite body size for specialist parasites. According to Šimková *et al.* (2001) the attachment organs are considered to be important for the determination of host specificity. On the other hand, the development of the attachment organs depends to a great extent on the host specificity. It have been established that there is correlation between host body size and the size of sclerotized parts of the haptor in case of species infecting only one host species. *Dactylogyurus extensus* infects exclusively the gills of the common carp. In our study was the most abundant species. In case of species with lower host specificity that sort of correlation has not been observed. However parasite living on larger hosts have to adopt their hooking system to gill filament diameter in they do not want to be removed by their host. Our results support the study Karaivanova *et al* (2003) who showed the presence of positive relationship between the host body size and two morphometric characters of anchors of the haptor of *D. extensus* on carp in a natural reservoir. This may be due to the necessity of more steadily attachment of parasites to hosts with a more active way of life.

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