

Goussia carpelli (Apicomplexa, Eimeriorina) from cyprinid fish: Field observations and infection experiments

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Since the original description of *Goussia carpelli* from common carp, *Cyprinus carpio* (by LÉGER & STANKOWITCH 1921) many fish species were reported to be hosts of this parasite. Until now, the host spectrum is estimated to comprise at least 17 cyprinid fishes from Europe, North America and Asia (SHULMAN 1984, JASTRZEBSKI 1984, ALVAREZ-PELLITERO & GONZALES-LANZA 1986). Almost all studies dealing with pathology, life cycle and ultrastructure of *Goussia carpelli* were performed on infections of common carp. In carp populations, this ubiquitous coccidium is transmitted either directly by oocyst ingestion (ZMERZLAYA 1964, STEINHAGEN & KÖRTING 1988) or with tubificid oligochaetes acting as paratenic hosts (STEINHAGEN & KÖRTING 1990).

Although several authors supposed cross transmission of *Goussia carpelli* among different fish species (ZMERZLAYA 1964, MUSSELIUS et al. 1965, IVASIK & KULAKOVSKAYA 1959, JASTRZEBSKI 1984), there is only a single paper describing such a successful transmission from common carp to silver crucian carp, *Carassius auratus* (ZMERZLAYA 1964).

In the present communication natural infections of various fish species with *Goussia carpelli* oocysts, and the results of several interspecific transmission experiments are reported.

Materials and Methods. Field observations: Bleak (*Alburnus alburnus*), dace (*Leuciscus leuciscus*), gudgeon (*Gobio gobio*), roach (*Rutilus rutilus*), tench (*Tinca tinca*), silver crucian carp (*Carassius auratus gibelio*), koi carp (*Cyprinus carpio koi*), stone moroco (*Pseudorasbora parva*), and *Leucaspis delineatus* from several hatcheries and ponds in South Bohemia were brought to the laboratory. Here the fish were dissected, the intestine removed and opened lengthwise. Wet mount preparations of intestinal tissue were examined for the presence of coccidian oocysts. Measurements of oocysts were taken from fresh material by the aid of calibrated eyepieces. Small pieces of intestinal material was fixed with 4% formaldehyde solution, dehydrated in a series of ethanol, embedded in paraffin wax, and 5 µm sections were Giemsa-stained.

Transmission experiments: Fish: Common carp in this study were laboratory reared either from fertilized eggs (obtained from the Department of Experimental Animal Morphology and Cell Biology, Agricultural University, Wageningen, The Netherlands) or from one day old fry (obtained from South Bohemian carp fisheries). Minnows (*Phoxinus phoxinus*) and nase (*Chondrostoma nasus*) were artificially bred and raised in the laboratory (Landesanstalt für Fischerei Nordrhein-Westfalen, Albaum, West Germany). Chub (*Leuciscus cephalus*), goldfish (*Carassius auratus*), and golden orphe (*Leuciscus idus*) were raised in the laboratory from fertilized eggs, obtained from ponds of a hatchery in South Bohemia and in North West Germany. Roach (*Rutilus rutilus*), gudgeon (*Gobio gobio*), European bitterling (*Rhodeus amarus*), *Leucaspis delineatus*, and goldfish were brought to the laboratory as juveniles (30–50 mm body length, age up to 6 months) from hatchery populations in South Bohemia and North West Germany. All fish were maintained in aquaria in aerated tap water at 21 to 24°C and were fed once or twice a day on *Artemia salina* larvae or on pelleted dry fish food. Before the fish were used in infection experiments the intestines of 5 fish of each source were examined for the presence of *Goussia carpelli* oocysts.

Infection experiments: It was attempted to infect nase, minnow, golden orphe, and *Leucaspis delineatus* with *Goussia carpelli* obtained from laboratory infected carp by fecal contamination. Intestinal tissue and feces, containing *G. carpelli* oocysts were introduced into aquaria stocked with up to 15 experimental fish

and 5 to 11 carp as controls. Two to 4 days post initial exposure (PE) the fish were removed from the contaminated aquaria, transferred to clean tanks, and the degree of infection was determined 14 to 21 days PE. The fish were dissected, the digestive tract was removed and opened lengthwise. Wet mount preparations of intestinal tissue were examined for the presence of *G. carpelli* oocysts. Smear preparations were air dried, methanol fixed and Giemsa stained. It was attempted to infect chub, nase, minnow, golden orphe, roach, gudgeon, goldfish, *Leucaspis delineatus*, and bitterling with *G. carpelli* obtained from carp using tubificid oligochaetes (*Tubifex tubifex* and *Limnodrilus hoffmeisteri*) as paratenic hosts. Tubificids were fed on intestinal tissue and mucosal scrapings of carp containing sporulated oocysts of *G. carpelli*. One or 2 of these tubificids were inoculated orally into each of the experimental fish using a polyethylene tubing fitted to the needle of a 1 ml disposable syringe. The degree of infection of the experimental fish and of the control carp was determined 2 to 3 weeks PE.

Furthermore, it was attempted to transmit *Goussia carpelli* recovered from naturally infected silver crucian carp (*Carassius auratus gibelio*) to goldfish and common carp as described above.

Results. Field observations: In wet mount and histological preparations of intestinal tissue from bleak, dace, gudgeon, roach, tench, silver crucian carp, koi carp, stone moroco (*Pseudorasbora parva*), and *Leucaspis delineatus*, coccidian oocysts and developmental stages were detected. Morphology and measurements of fresh oocysts resembled those of *Goussia carpelli* from common carp. Koi carp, silver crucian carp, dace, and stone moroco were infected regularly, while bleak, gudgeon, roach, tench, and *Leucaspis delineatus* only occasionally harboured *G. carpelli* oocysts. The infection intensity, however, was low in all cases.

Infection experiments: In our experiments it was not possible to infect gudgeon, roach, nase, golden orphe, minnow, bitterling, and *Leucaspis delineatus* with *Goussia carpelli* recovered from experimentally infected carp. In both types of experiments (direct transmission and tubificids as paratenic hosts) none of the above mentioned fishes acquired an infection, while almost all control carp, treated in the same way harboured high numbers of oocysts. Attempts to infect goldfish with *G. carpelli* from carp using tubificids as paratenic hosts resulted in weak infections in 4 out of 15 goldfish used. All fish exposed to *G. carpelli* oocysts recovered from silver crucian carp, remained uninfected.

The full details of the infection experiments are given in tab. 1, 2 and 3.

Discussion. Eimerian parasites from homoiothermic vertebrates in general were found to be strictly host specific (JOYNER 1982). Most researchers, while reviewing the literature on fish coccidia (e.g. DYKOVÁ & LOM 1981, BALL et al. 1989), suppose that the degree of host and tissue specificity is less developed in fish coccidia. This is supported by a high number of recordings of coccidian species from a variety of different host species. *Goussia carpelli* for instance was reported from 17 different fishes (SHULMAN 1984, ALVAREZ-PELLITERO & GONZALES-LANZA 1986, this study). The identification of the species was based on measurements and morphology of the fresh oocyst and sporocyst. Transmission experiments, even though highly needed, were not performed, mainly due to the complicated life cycles of piscine coccidia which often include obligatory invertebrate organisms as intermediate hosts (DESSER 1980, PATERSON & DESSER 1982, FOURNIE & OVERSTREET 1983). To determine the host range of piscine coccidia, up to present infection experiments were undertaken with *Calyptospora funduli* (SOLANGI & OVERSTREET 1980, UPTON & DUSZYNSKI 1982) and with *Goussia iroquoina* (PATERSON & DESSER 1982). These experiments showed that *G. iroquoina*, originally isolated from golden shiner (*Notropis cornutus*) also was able to infect fathead minnows (*Pimephales promelas*). *Calyptospora funduli*, which was isolated from *Fundulus grandis* also developed in *Fundulus similis* (SOLANGI & OVERSTREET 1980, HAWKINS et al. 1984) and in *Fundulus heteroclitus* (UPTON & DUSZYNSKI 1982). In experimentally infected *Rivalus marmoratus*, which is not a natural host of *Calyptospora funduli*, abnormal development was observed (VOGELBEIN et al. 1987). Furthermore, ZMERZLAYA (1964) found *Goussia carpelli* from silver crucian carp to be infective for carp. Our attempts to infect a variety of cyprinid fishes from pond environments of Central Europe with *Goussia carpelli* isolates

Tab. 1. Infection experiments of cyprinid fishes with *Goussia carpelli* recovered from carp: contamination

Fish species	Number of fishes		control carp	
	used	infected	used	infected
<i>Chondrostoma nasus</i>	10	0	5	5
	6	0	11	9
<i>Leuciscus idus</i>	14	0	5	5
<i>Phoxinus phoxinus</i>	10	0	5	5
<i>Leucaspis delineatus</i>	10	0	5	5
<i>Carassius auratus</i>	8	0	14	3

Tab. 2. Infection experiments of cyprinid fishes with *Goussia carpelli* recovered from carp: tubificids as paratenic hosts

Fish species	Number of fish		Number of controls	
	used	infected	used	infected
<i>Chondrostoma nasus</i>	10	0	5	4
<i>Leuciscus cephalus</i>	4	0	13	7
<i>Leuciscus idus</i>	4	0	5	5
<i>Phoxinus phoxinus</i>	10	0	5	4
<i>Leucaspis delineatus</i>	10	0	9	9
<i>Rhodeus amarus</i>	10	0	10	10
<i>Rutilus rutilus</i>	10	0	10	10
<i>Gobio gobio</i>	10	0	10	10
<i>Carassius auratus</i>	10	4	10	8
	5	0	13	7

Tab. 3. Infection experiments of cyprinid fishes with *Goussia carpelli* recovered from *Carassius auratus gibelio*

Fish species	Transmission route	Fish number	
		used	infected
<i>Carassius auratus</i>	direct	17	0
	<i>Tubifex</i>	6	0
<i>Cyprinus carpio</i>	direct	14	0
	direct	11	0
	<i>Tubifex</i>	5	0

failed, but only gave positive results with goldfish. These results may reflect the isolates' high degree of adaptation to common carp, but also show its ability to infect goldfish and so might support the concept of a less developed host specificity in piscine coccidia than in eimerian coccidia from higher vertebrates. Our field observations also revealed infections with *G. carpelli*-like coccidia in fishes other than common carp in low intensities and low prevalences, often in early spring, when the fishes were in bad shape due to the winter condition. From North American goldfishes, however, KENT & HEDRICK (1985) reported heavy infections with a coccidian parasite which caused serious losses among hatchery populations of goldfishes. From oocyst morphology, this parasite was identified as *G. carpelli*, but the authors failed to

establish laboratory infections. A clear identification of this organism and *G. carpelli*-type oocysts from cyprinid hosts other than carp as *Goussia carpelli* always should include transmission experiments of these isolates to common carp.

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Summary. Intestinal tissue samples of 9 cyprinid and gobiid fish species from several hatcheries and ponds in South Bohemia were found to harbour *Goussia carpelli*-like coccidian oocysts. Furthermore, laboratory transmission of *Goussia carpelli*, obtained from common carp, was attempted to 9 cyprinid fish species, both laboratory reared and obtained from pond environments. Infection experiments, carried out by fecal contamination (direct transmission) and by using tubificid oligochaetes as paratenic hosts resulted in weak infections in 4 out of 15 *Carassius auratus* used, but it was not possible to infect any of the other fishes used.

Zusammenfassung. *Goussia carpelli* (Apicomplexa, Eimeriorina) aus Cypriniden: Feldbeobachtungen und Infektionsexperimente. — In Darmproben von 9 verschiedenen Cypriniden und Gobiiden aus südböhmischen Fischzuchten und Teichen konnten Coccidien-Oocysten nachgewiesen werden, die morphologisch *Goussia carpelli* entsprachen. Außerdem wurde versucht, im Labor 9 verschiedene Cypriniden mit *Goussia carpelli*, die von Karpfen isoliert wurden, zu infizieren. Einige Versuchsfische waren im Labor erbrütet, und einige Arten wurden aus Fischteichen entnommen. Es wurde versucht, die Fische sowohl direkt durch Kontamination des Aquarienwassers als auch durch Verfüttern von tubificiden Oligochäten, die als paratenische Wirte agieren können, zu infizieren. In 4 von 15 *Carassius auratus* ließ sich eine leichte Infektion feststellen. Es war jedoch nicht möglich, einen der übrigen Cypriniden zu infizieren.

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