SEASONAL OCCURRENCE AND MATURATION OF *BATHYBOTHRIUM RECTANGULUM* (CESTODA: AMPHICOTYLIDAE) IN BARBEL *BARBUS BARBUS* (PISCES) OF THE JIHLAVA RIVER, CZECH REPUBLIC

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Summary:

Seasonal dynamics of the tapeworm *Bathybothrium rectangulum* (Bloch, 1782), a parasite of barbel *(Barbus barbus)*, was studied from April 1992 to June 1993 in the Jihlava River (the Danube basin), Czech Republic. Although the cestodes occurred in fish throughout the year, their maturation exhibited a marked seasonality with new infections (recruitment) in summer (July), growth and maturation in autumn and winter; worms with ripe eggs left the fish hosts from May to July. Smaller fish (size ≤ 35 cm) were more frequently infected with cestodes than larger ones, although mean intensity reached its maximum in 35.5-40 cm long fish.

KEY WORDS : *Bathybothrium rectangulum*, *Barbus barbus*, seasonal patterns, maturity, host-size dependence.

Résumé : INCIDENCE SAISONNIÈRE ET MATURATION DE *BATHYBOTHRIUM RECTANGULUM* (CESTODA : AMPHICOTYLIDAE) CHEZ LE BARBEAU, *BARBUS BARBUS* (PISCES), DE LA RIVIÈRE JIHLAVA, RÉPUBLIQUE TCHÈQUE

L'évolution saisonnière de l'helminthe Bathybothrium rectangulum *(Bloch, 1782), parasite du barbeau* (Barbus barbus), *a été étudiée d'avril 1992 à juin 1993 dans la rivière Jihlava (bassin du Danube), République tchèque. Bien que les cestodes soient présents chez le poisson tout au long de l'année, leur maturation est marquée par un net caractère saisonnier — nouvelles infestations (recrutement) en été (juillet), croissance et maturation en automne et hiver ; les vers porteurs d'œufs mûrs quittent le poisson-hôte de mai à juillet. Les poissons les plus petits (taille ≤ 35 cm) ont été plus souvent infestés par les cestodes que les plus grands, encore que le pic d'intensité soit maximal pour les poissons longs de 35,5 à 40 cm.*

MOTS CLÉS : Bathybothrium rectangulum, Barbus barbus, *modes saisonniers, maturation, taille-dépendance.*

INTRODUCTION

The tapeworm *Bathybothrium rectangulum* (Bloch, 1782) (Pseudophyllidea: Amphicotylidae) is a specific intestinal parasite of barbel (*Barbus* spp.) and related genera of cyprinid fish, occurring in Palaearctic Region (Lühe, 1910; Joyeux & Baer, 1936; Protasova, 1977; Moravec & Amin, 1978; Van Maren, 1979; Dubinina, 1987; Scholz, 1989*a*). Despite its relatively common occurrence, there are only very limited data on the occurrence and life history of this parasite (see Chubb, 1982). With the exception of brief information about the occurrence of this tapeworm in barbel from Poděbrady, Bohemia (Šrámek, 1901) and Central and Eastern Balcan Mountains (Kakacheva-Avramova, 1973), the only data describing the seasonal periodicity of occurrence and maturation of *B. rectangulum* were provided by Kulakovskaya (1959). The same author (Kulakovskaya, 1963) also reported copepods *Macrocyclops albidus* and *Megacyclops viridis* as experimental intermediate hosts of this tapeworm.

However, data by Kulakovskaya (1963) originated from a different geographical region. It is known that seasonal patterns in the occurrence and maturation of helminths of freshwater fish can be influenced by local ecological conditions and can differ even in relatively close localities (see Chubb, 1982 for review).

Considering the specificity of *B. rectangulum* and the fact that barbel has become endangered or even extinct fish species in most localities in Central Europe, more detailed data on the ecology of this cestode parasite appear to be of more than regional importance. In this paper, data on the occurrence and maturation of *B. rectangulum* from barbel *(Barbus barbus)* in the Jihlava River, South Moravia, Czech Republic, are presented.

MATERIALS AND METHODS

Samples of barbel, *Barbus barbus* L., were taken monthly by electrofishing from the Jihlava River near the village of Biskoupky (near Rosice u

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Brna; the Danube River system) in South Moravia, Czech Republic (see Moravec and Scholz, 1994, 1995). A total of 177 barbel, ranging between 14-51 cm in total length (age 1-7 years) was examined monthly from April 1992 to June 1993 (Table I); in addition, a sample of 18 barbel (size 12-47 cm) was examined in May 1994.

The fishes were transported live to the Institute of Parasitology in České Budějovice and 1-2 days after their capture were examined by routine helminthological examination as outlined by Bykhovskaya-Pavlovskaya (1969).

Planktonic invertebrates were sampled monthly from July to December 1992 and in May 1994 to search for larvae of *B. rectangulum*. The invertebrates examined were as follows: *Candona candida, Cypridopsis vidua, Cyclocypris globosa* and *Hepretocypris reptans* (Ostracoda, 263 specimens), *Macrocyclops albidus* (445), *Eucyclops serrulatus* (1,329), *Acanthocyclops vernalis* (7), *Paracyclops affinis* (4), *Ectocyclops phaleratus* (1), *Megacyclops gigas* (1) (Copepoda, 1,787), and *Paracantha truncata* (Cladocera, 132). Survey of other benthic invertebrates, which were examined for the presence of helminth larvae and were free of *B. rectangulum* infection, is given by Moravec & Scholz (1994).

The tapeworms found were fixed under slight coverslip or slide pressure with 4 % formaldehyde. In order to evaluate seasonal changes in maturation, the worms were stained with Schuberg's carmine and divided into the following groups: group I: juvenile worms (only scolices or unsegmented worms); II: maturing worms (segmentation present, genitalia developing); III: mature worms (genitalia developed, no eggs present); IV*a*: gravid worms, without ripe eggs, uterus small, oval in shape; IV*b*: gravid, with ripe eggs, uterus large, lobate; IV*c*: destrobilized worms. A total of 1,315 worms was evaluated (Fig. 2). The material has been deposited in the helminthological collection of the Institute of Parasitology, ASCR, in České Budějovice (Coll. No. C-17).

RESULTS

Occurrence of *B. rectangulum* in barbel

Out of 195 barbel *(Barbus barbus)* examined, 98 (prevalence 50.3 %) were infected with a total of 1,690 worms (mean intensity 17.3, range 1-222; abundance 9.1).

A survey of prevalence, intensity and mean intensity of *B. rectangulum* infection in individual month samples is given in Table I and Figure 1. *Bathybothrium rectangulum* occurred in barbel throughout the year with prevalence reaching its maximum in summer 1992, declining to lowest values in winter and

Year and month	No. of barbel examined	No. of barbel infected	Prevalence (%)	Intensity of infection (mean, range)	Body length of barbel in cm (mean, range)	Abundance
1992						
April	12	6	50	11 (2- 32)	34 (22-50)	5.3
May	14	10	71	4 (1- 16)	32 (19-43)	2.6
June	11	6	55	5 (1- 16)	37 (24-47)	2.4
July	12	9	75	21 (1- 46)	30 (21-35)	15.4
August	12	9	75	6 (1- 23)	28 (22-36)	4.3
September	12	4	33	16 (3- 33)	26 (21-35)	5.2
October	13	7	54	27 (1- 69)	29 (18-49)	14.4
November	12	8	67	22 (3- 93)	29 (19-47)	14.8
December	15	7	47	38 (1-222)	33 (28-46)	17.8
1993						
January	13	5	38	22 (4- 77)	37 (28-51)	8.4
February	10	5	50	24 (1- 82)	35 (30-51)	12.1
March	10	3	30	27 (15- 44)	35 (24-45)	8.0
April	10	6	60	9 (1- 18)	29 (14-35)	5.6
May	10	4	40	9 (1- 26)	35 (30-40)	3.7
June	11	3	27	66 (10- 96)	30 (16-42)	18.0
1994						
May	18	7	39	8 (1- 25)	32 (12-48)	3.1
Total	195	98	50	17 (1-222)	28 (14-51)	9.1

Table I. — Survey of *Barbus barbus* examined from the Jihlava River and their infection with *Bathybothrium rectangulum*.

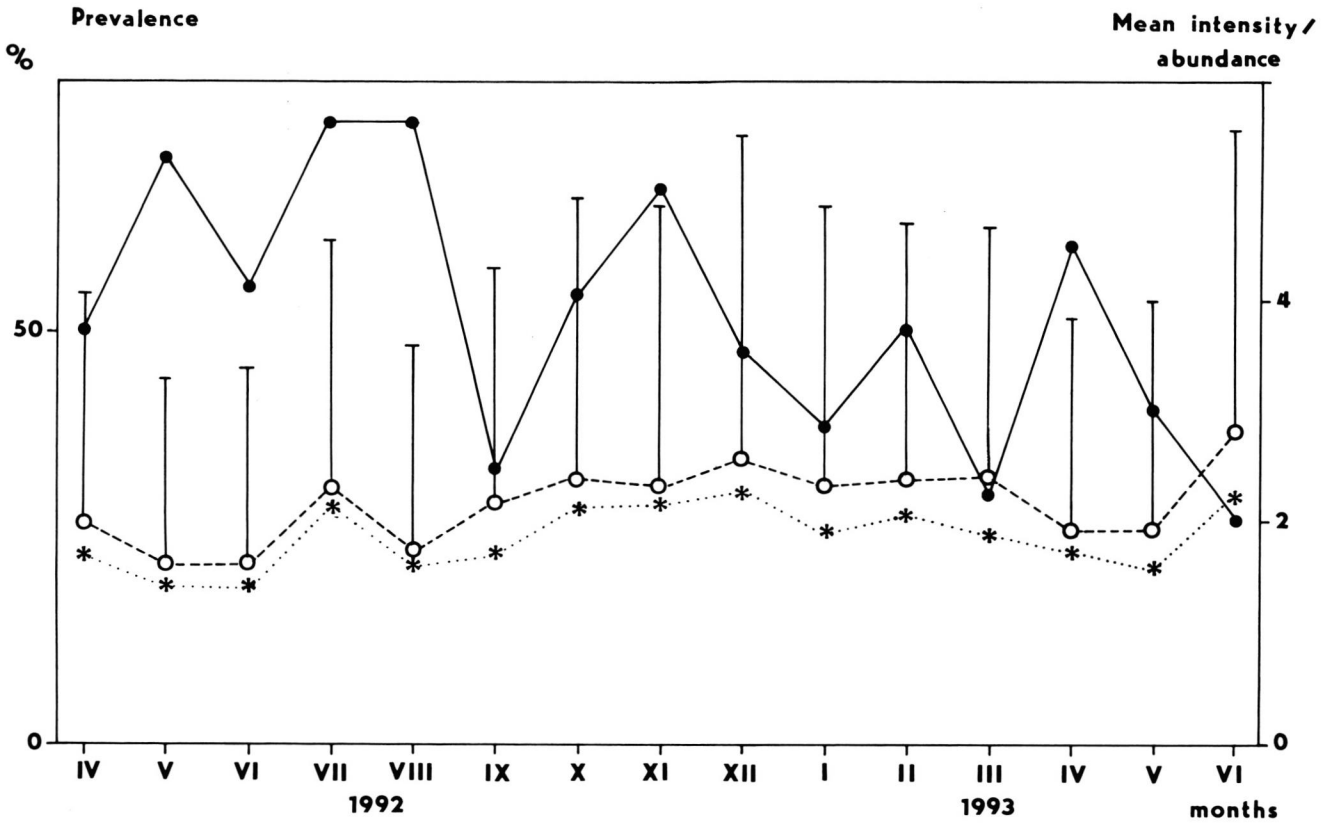

Fig. 1. — Seasonal variation of prevalence (points), mean intensity (circles) and abundance (asterisks) of infection of barbel with *Bathybothrium rectangulum* in the Jihlava River. Mean intensity and abundance expressed as log (x + 1). Vertical bars around mean intensity data are standard deviations.

early spring (March). Mean intensity of infection and abundance fluctuated irregularly without any distinct seasonal pattern (Fig. 1) with the exception that lowest values occurred in late spring (May) and early summer (June).

SEASONALITY OF MATURATION

Proportion of worms in different states of maturity in monthly samples indicated the existence of a pronounced seasonal cycle in the maturation of *B. rectangulum* (Fig. 2). Juvenile worms (group I), which represented 9.0 % of worms evaluated, occurred exclusively in July. Maturing worms were recovered from July to March with the highest proportion (79-100 %) from August to January (Fig. 2). Mature worms were found in October, from January to April and in June, with higher proportions (98 %) only in March. Gravid worms of different states of maturity (groups IV*a-c*) occurred only from April to July in each years (1992, 1993 and additional sample in 1994), with the exception of eight tapeworms containing immature eggs (group IV*a*) found in October. Worms with fully developed, ripe eggs containing motile oncospheres were observed only from May to July, with the highest frequency in June (Fig. 2).

SITE OF LOCATION

The anterior third of the intestine was found to be the preferred site of location of *B. rectangulum* tapeworms. A total of 1,021 of 1,089 specimens evaluated (93.8 %) were localized in this part of the gut; 48 and 20 tapeworms (i. e. 4.4 and 1.8 %, respectively) were found in the middle and posterior thirds. The anterior third of the gut harboured a majority of tapeworms in all month samples (from 78 % in November up to 100 % in September and December), with the exception of June when 73 % of tapeworms, represented by gravid tapeworms occurred in the posterior third of the intestine.

RELATIONSHIP BETWEEN INFECTION OF *B. RECTANGULUM* INFECTION AND HOST SIZE

The infection of *B. rectangulum* was influenced by the size of fish (Fig. 3). Prevalence was highest in smaller barbel (size 20.5-25 cm) and its value decreased in larger fish specimens. Mean intensity increased from fish smaller than 20.5 cm to fish 21-25 cm long. In larger fish, its value fluctuated without any significant pattern, reaching its maximum in fish 35.5-40 cm long. The smallest barbel infected was 18 cm long (age 3 years); the largest one measured 50 cm (age 7 years).

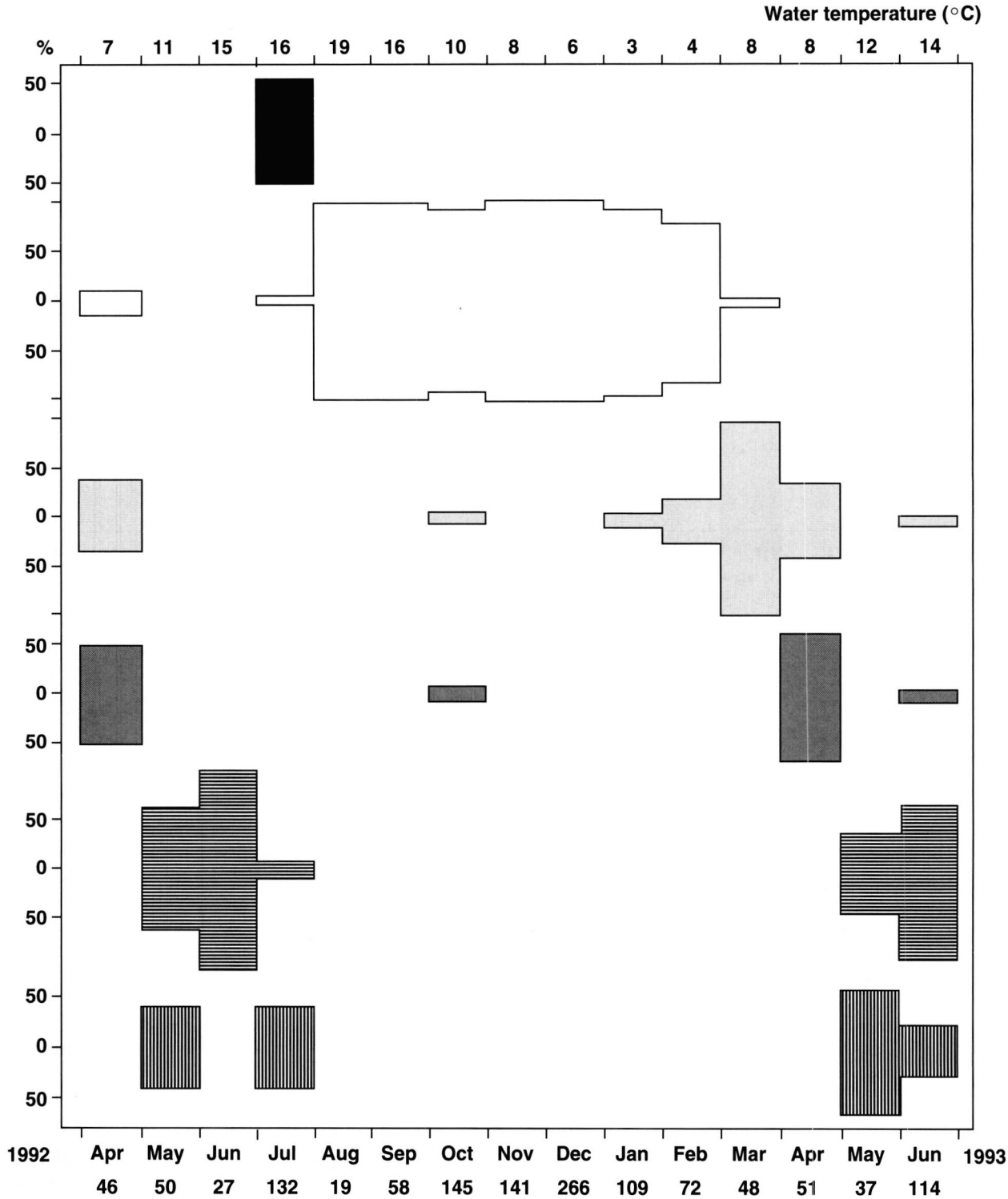

Fig. 2. — Seasonal cycle of maturation of *Bathybothrium rectangulum* in barbel in the Jihlava River. Data are expressed as percentages of the total number of tapeworms found per month: I: scolices (black); II: maturing worms (white); III: mature worms (stippled, small points); IV*a* - gravid worms with infertile eggs (stippled, large points); IV*b*: gravid worms with ripe eggs (horizontally hatched); IV*c*: destrobilized gravid worms (vertically hatched). Numbers below axis x represent numbers of tapeworms evaluated.

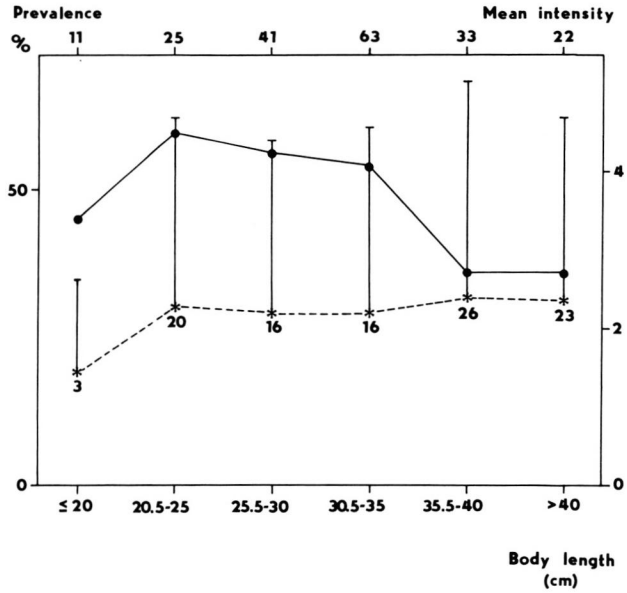

Fig. 3. — Relationship of prevalence (points) and mean intensity of infection (asterisk) with *Bathybothrium rectangulum* to body length of barbel from the Jihlava River. Mean intensity expressed as log (x + 1), with vertical bars representing a standard deviation. Figures on the top represent number of fish in individual size groups; figures below intensity curve represent absolute values of mean intensity (mean number of worms per infected fish).

EXAMINATION OF PLANKTON

Out of 2,182 planktonic invertebrates, only one female of the copepod *Macrocyclops albidus*, examined in October 1992, was found to be infected with one procercoid, which morphologically corresponds to the larvae of *Bathybothrium rectangulum* as described by Kulakovskaya (1963).

The procercoid measured 429 × 166 µm. It possessed a rectangular scolex, 134 µm wide, with shallow laterally situated bothria, numerous calcareous corpuscles (about 12-19 µm in diameter) filling the body and an elongate cercomer containing six embryonal hooks.

DISCUSSION

In the Jihlava River, *Bathybothrium rectangulum* exhibited a pronounced annual cycle of maturation with the recruitment in summer (July), growth and maturation in the autumn and winter months, and production of eggs at the late spring and at the beginning of summer (May-July). Due to overlapping of old generation and newly acquired tapeworms in July 1992, the parasite occurred in barbel throughout the year.

Kulakovskaya (1959) observed very similar seasonal patterns in the occurrence and maturation of *B. rectangulum* in *Barbus barbus* and *B. meridionalis petenyi* in different localities of the ex-USSR with the recruitment taking place in summer (June-August) and gravid worms being released from the hosts in May-June. Differences between individual localities were thought to depend on their geographical position; lower water temperatures were considered to have delayed maturation (Kulakovskaya, 1959). In some localities, the recruitment occurred when gravid worms were still present, similarly to the situation in the Jihlava River in July 1992.

Finding several gravid worms in barbel sampled in October 1992 indicates the possibility of accelerated growth and sexual development of some specimens in the same year of their recruitment. The decrease of water temperature in November and December made it impossible for these worms to complete their sexual maturation.

Seasonal patterns in maturation have also been found in other tapeworms parasitizing freshwater fish in mid-latitude regions of Europe (almost all continental Europe and Ukraine according to Chubb, 1982). In pseudophyllideans, seasonality in the occurrence and maturation have been reported in *Bothriocephalus acheilognathi, B. claviceps, Triaenophorus nodulosus, Eubothrium crassum* and *E. rugosum* (for extensive review see Chubb, 1982). In Czech Republic, seasonality in maturation has been found in *Bothriocephalus claviceps* (Moravec, 1985), *Triaenophorus nodulosus* (Ergens, 1966; Moravec, 1979), *Proteocephalus percae* (Moravec, 1979; Scholz, 1986), *P. torulosus* (Scholz, 1989*b*; Scholz & Moravec, 1994). In most cases worms became gravid in late spring and early summer.

The finding of one procercoid, which resembles those of *B. rectangulum* as described by Kulakovskaya (1963), in the copepod *Macrocyclops albidus* demonstrated that they may serve as intermediate hosts of this tapeworm. This copepod species has already been proved to serve as an experimental intermediate host of *B. rectangulum* (Kulakovskaya, 1963).

Higher prevalence of *B. rectangulum* tapeworms in smaller fish from the Jihlava River compared to larger barbel might indicate that smaller fish consume more plankton, including copepods. Heavier intensity of infection in some larger barbel might be explained by larger amount of food consumed, including planktonic animals; piscivory does not seem to play an important role in the parasite transmission and accumulation of parasites in larger fish specimens since forage fish represent only a negligible component of barbel diet (Losos *et al.*, 1980; Moravec & Scholz, 1995).

Evaluation of the distribution of tapeworms in the digestive tract of fish showed that *Bathybothrium rectangulum* preferred the anterior part of the intestine as its site of location. Although the value of these data

may be limited by the fact that the fish were examined 1-2 days after their capture, the presence of tapeworms firmly attached with their scolex in the intestinal epithelium does not support the assumption about unnatural migration of the worms in captivity. In addition, similar patterns in the site of location (preference for the anterior part of the digestive tube) has been reported in other fish tapeworms.

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