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Seasonal occurrence of *Dollfustrema vaneyi* (Digenea: Bucephalidae) metacercariae in the bullhead catfish *Pseudobagrus fulvidraco* in a reservoir in China

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ABSTRACT: The seasonal population dynamics of metacercariae of the bucephalid *Dollfustrema vaneyi* (Tseng, 1930) Echmann, 1934 in the bullhead catfish *Pseudobagrus fulvidraco* (Richardson) were investigated in Jiangkou reservoir, Jiangxi Province, east China, during the period from April 1990 to August 1991. In total, 523 fish were obtained, and the overall prevalence of the metacercariae was 89.87% and mean abundance 136.25 ± 308.09 (mean ± SD). A pattern of seasonal changes in prevalence and mean abundance was observed, with higher levels of metacercariae infection in late spring and summer. An analysis of the distribution of *D. vaneyi* in different organs of *P. fulvidraco* suggested that the eyes might be a suitable location for the parasite. Furthermore, the possible role of metacercariae in bullhead catfish was discussed in relation to the life cycle of this parasite.

KEY WORDS: Bucephalid · *Dollfustrema vaneyi* · Metacercariae · Bullhead catfish · *Pseudobagrus fulvidraco* · Seasonal occurrence · Reservoir

INTRODUCTION

The population ecology and seasonal occurrence of bucephalid digeneans have so far received little attention, even though parasite ecology has been the focus of studies over the past few decades (Chubb 1979, Esch & Fernández 1993, Bush et al. 1997). The only available literature is related to the seasonality of 2 species, *Rhipidocotyle fennica* and *R. campanula*, in their bivalve and fish hosts in Finland (Taskinen et al. 1991, 1994, Taskinen & Valtonen 1995).

In freshwater fish in China, the bucephalid *Dollfustrema vaneyi* (Tseng, 1930) Echmann, 1934 has been found to be a common parasite (Chen 1973, Zhang et al. 1999). Its life cycle has been clearly demonstrated, with the first intermediate host being a bivalve, *Limnoperna lacustris*, and several species of cyprinid and silurid fish as second intermediate hosts (Komiya & Tajimi 1941, Long & Lee 1964, Tang & Tang 1976, P. Wang 1985, Wang & Wang 1998). The metacercariae are found in several organs and/or cavities of fish intermediate hosts, while worms mature in the intestines of piscivorous fish of the genus *Siniperca* (Tang & Tang 1976, P. Wang 1985, X. Wang 1985, Wang & Wang 1998). However, apart from the life cycle, relatively little research has been carried out on this parasite.

The bullhead catfish *Pseudobagrus fulvidraco* is often very abundant in lakes, reservoirs and even in rivers, and despite its small size, is important in the fishing industry in China (Anonymous 1976, Cheng & Zheng 1987). The abundance of this fish thus ensures the availability of hosts for examination. In addition, the fish has commonly been reported with *Dollfustrema vaneyi* infection (Long & Lee 1964, Wu et al. 1991). The present study was therefore designed to investigate

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the seasonal population dynamics of *D. vaneyi* in its second intermediate host, bullhead catfish, in a reservoir in Jiangxi province, east China.

MATERIALS AND METHODS

The Jiangkou reservoir (27.6° N, 114.8° E) is located in Jiangxi province, east China. It was built on the upper reaches of the Ganjiang River, which connects with the Yangtze River. The reservoir is 340 km^2, with an average depth of about 10 m.

The bullhead catfish *Pseudobagrus fulvidraco* was either netted or angled from the reservoir during the period from April 1990 to August 1991. In total, 523 fish were obtained in 12 samples, with the number of fish examined indicated in Fig. 2 ('Results'). Fish were brought back alive to the laboratory, where they were examined within 48 h. The body length of each fish was measured. Preliminary investigations had shown that the parasites were present in connective tissues surrounding the eyeballs, and in the kidney and liver. Thus, the eyes, kidney and liver of each fish were dissected out. The eye-socket and body cavity were washed with saline (0.65%) more than 5 times to ensure maximum collection of the parasite. The outside membrane of the eyeballs was broken into pieces and then washed. The metacercariae which had been washed into dishes were counted under a microscope. To examine the parasite in the kidney and liver, the organs were pressed between 2 pieces of glass and observed under a microscope. The number of parasites recorded from the surrounding tissue of the eyes and eye-socket were added together and expressed as the number of parasites in the eyes. However, all metacercariae found from different organs and body cavities were recorded separately.

The correlation between the length of hosts and the number of metacercariae per host was analyzed for all samples pooled by using the correlation matrices on the computer program STATISTICA, and the difference in the mean abundance of different length groups of the fish was compared using a 2-sample *t*-test. The total number of metacercariae in each individual fish was also counted and prevalence and mean abundance calculated, as defined by Bush et al. (1997). In addition, changes in prevalence were analyzed statistically by using a *G*-test of heterogeneity to determine if the changes were seasonal (Sokal & Rohlf 1981). Abundance was analyzed using a 1-way ANOVA on STATISTICA. The number of metacercariae was also added up for each organ and/or body part in each sample, and then the seasonal changes in proportional distribution of the parasite in the different organs were analyzed.

RESULTS

The overall prevalence of *Dollfustrema vaneyi* metacercariae in all bullhead catfish sampled was 89.87% (n = 523), and 81.26, 62.91, 51.43 and 6.88% of the total number of fish sampled had infections in the eyes, kidney, liver and body cavity, respectively. The overall mean abundance was 136.25 ± 308.09 (±SD), and the mean number of parasites for the eyes, kidney, liver and body cavity of all fish examined was 114.67 ± 279.85, 17.70 ± 39.25, 5.72 ± 16.51 and 0.15 ± 0.73, respectively. The body cavity was thus not included in the further analysis of the proportional distribution of the parasite in different organs. In addition, a significant positive correlation was found between fish length and the number of metacercariae per fish ($r_{x,y}$ = 0.2427, $p <$ 0.001). The relationship between fish length and the number of metacercariae per fish is shown in Fig. 1. The prevalence levels were almost the same for all length groups. However, fish in the 14 < Length (L) ≤ 16 and 20 < L ≤ 22 cm length groups had the highest abundance levels. The abundance in the 14 < L ≤ 16 group was significantly higher than of those fish in lower length groups (*t*-test, $p < 0.05$; but p = 0.061 when compared with the lowest length group). The highest level was found in the highest length group (*t*-test, $p < 0.05$, but not with the 18 < L ≤ 20 length group).

Monthly changes in the proportional distribution of metacercariae in the bullhead catfish are shown in Fig. 2. In 11 out of 12 samples, more than 70% of the metacercariae were found in the eye sites. Even in November 1990 when the proportion in the eye was minimal, 65% were found at this site. The proportion of parasites in the kidney was higher than in the liver except on 1 occasion in June 1991. The eyes of *Pseudobagrus fulvidraco* are thus major sites for the parasite, while the body cavity contains few parasites.

When the investigation started, high levels of *Dollfustrema vaneyi* prevalence in the bullhead catfish

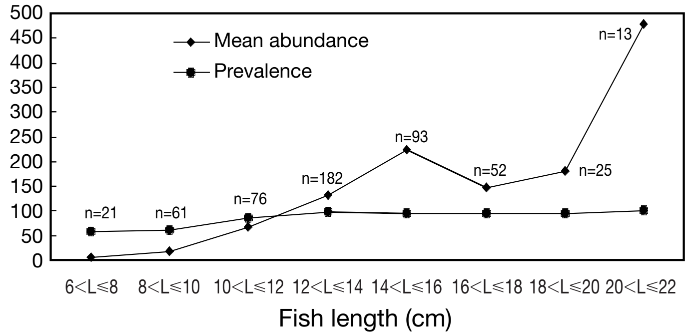

Fig. 1. Relationship between the length (L) of the bullhead catfish *Pseudobagrus fulvidraco* and the prevalence and mean abundance of the metacercariae of the bucephalid *Dollfustrema vaneyi* in Jiankou reservoir, east China

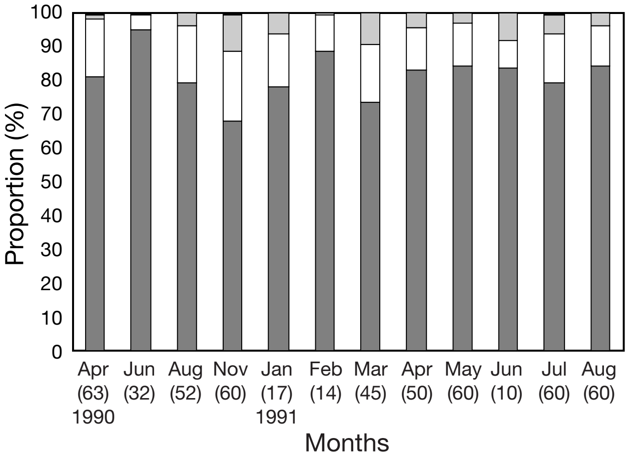

Fig. 2. Proportional distribution of metacercariae of the bucephalid *Dollfustrema vaneyi* in the eye sites (■), kidney (□) and liver (▨) of the bullhead catfish *Pseudobagrus fulvidraco* in Jiankou reservoir, east China. Numbers in parentheses indicate fish sample size

were observed, with values of 95.24 and 96.88% in April and June 1990 respectively (Fig. 3a). The prevalence then declined gradually, with the lowest level (64.29%) being recorded in February of the following year. The rise in prevalence began in spring and prevalence remained relatively high in late spring and throughout the summer. However, in late summer a decrease in prevalence occurred. Statistical analysis revealed that changes in prevalence were significantly seasonal ($G = 64.09 > \chi^2_{0.005[11]} = 26.80$).

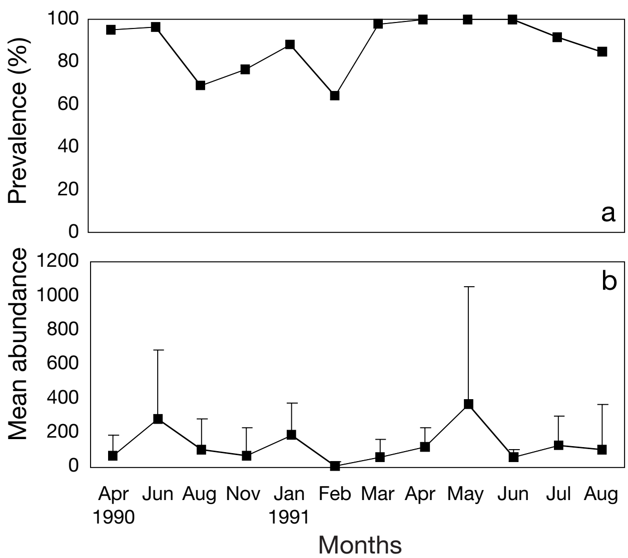

Fig. 3. Monthly changes in (a) prevalence and (b) mean abundance of metacercariae of the bucephalid *Dollfustrema vaneyi* in the bullhead catfish *Pseudobagrus fulvidraco* in Jiankou reservoir, east China. Bars indicate standard deviations

Similar to the seasonal pattern of changes in prevalence, higher levels of abundance were recorded in late spring and in the summer of 1990. It decreased in late summer and remained low in autumn and winter (Fig. 3b). Abundance started to rise again in the following spring, and reached its highest level in summer, followed by a decrease from June onwards. Statistical results showed that changes in abundance of *Dollfustrema vaneyi* metacercariae in bullhead fish were significantly seasonal ($F = 5.57$, $p < 0.001$).

DISCUSSION

Freshwater digeneans often show seasonal changes in prevalence and intensity of infection (Chubb 1979), and the emergence of cercariae is generally related to the rise in water temperature (e.g. Stables & Chappell 1986, Taskinen et al. 1994, Lyholt & Buchmann 1996). For *Rhipidocotyle fennica* and *R. campanula*, the 2 bucephalid species whose life cycle and seasonal occurrence have been well studied, the emergence of their cercariae occurs at elevated water temperature (Taskinen et al. 1994). In a lake in Finland, the emergence of *R. fennica* cercariae started at a water temperature of 20.3°C (range 18.0 to 24.0°C), and ceased at 11.6°C (range 10.4 to 13.4°C). In another lake, also in Finland, where *R. campanula* occurred, the water temperatures on the date of the first and last observations of the cercariae emergence were 16.8 and 18.0°C, respectively (Taskinen et al. 1994). The 2 species may be considered to have a similar pattern of seasonality, but the range of temperatures for the emergence of cercariae varies slightly and this may also be the case for other species, especially those in different climates. Although the exact temperature range for *Dollfustrema vaneyi* cercariae shedding is unknown, the emergence of the cercariae has been observed from April to June at water temperatures ranging from 15 to 20°C (authors' unpubl. data). The release of the free-swimming cercariae of *D. vaneyi* in warm seasons may thus result in higher infection levels of *D. vaneyi* metacercariae in fish, as observed in *Pseudobagrus fulvidraco* in the Jiankou reservoir in the present study.

Cercariae of bucephalids penetrate the body surface of their fish host, and then migrate to a suitable location in that host. It has been demonstrated in the laboratory that fish become infected directly by the cercariae of *Dollfustrema vaneyi* (Tang & Tang 1976), and within a few days metacercariae may be found in the organs of fish hosts (Wang & Wang 2000). The way that *D. vaneyi* cercariae penetrate the fish surface and then migrate towards a suitable site in a fish host is unknown, but the occurrence of relatively higher numbers of metacercariae in the connective tissues of the eyes of *Pseudobagrus fulvidraco* may imply that the eye sites of the fish are the most suitable location for the parasite, and further investigations on other intermediate hosts may clarify the present finding.

The definitive hosts, fish in the genus *Siniperca*, feed mainly on fish, and the bullhead catfish has been recorded as one of the most important items in the diet of these definitive hosts (Chang et al. 1995). The bullhead catfish is abundant in various water bodies and the infection levels of *Dollfustrema vaneyi* in this fish may be high. Therefore, metacercariae in *Pseudobagrus fulvidraco* may play an important role in the life cycle of this parasite. However, further investigations are needed to clarify this.

Larval digeneans are generally long-lived in fish hosts (Chubb 1979) and their numbers correlate well with fish length (Poulin 2000). Several factors, such as density-dependent regulation of parasite numbers and pathogenicity of parasites causing parasite-induced host mortality and removing large and heavily infected fish from the population, have been shown to influence the fish length and parasite number relationship (Poulin 2000). Larger and older *Pseudobagrus fulvidraco* have a bigger surface area and thus there is a greater chance that cercariae can penetrate, and due to the fact that these fish are older, they have had more time to accumulate parasites. Higher infection levels of *Dollfustrema vaneyi* metacercariae with increasing host size should be expected even though the life-span of metacercariae of *D. vaneyi* is unknown. The highest abundance level in the biggest length group could also be a reflection of small sample size of the oldest fish, as suggested by Kennedy (1984). However, the higher abundance level in the $14 < L \leq 16$ length group and the lower levels in smaller and the next 2 bigger length groups may indicate the removal of heavily infected fish, as recognized by several authors (Anderson & Gordon 1982, Kennedy 1984, Rousset et al. 1996). Heavily infected fish may have a higher probability of being preyed upon (Kennedy 1984), and larger fish may also be fishing targets. On the other hand, Kennedy (1984) considered that such age or size parasite abundance curves may be also due to the death of parasites within hosts; however, dead metacercariae of *D. vaneyi* were not observed in the catfish, and this may not be the case for the present study.

In the Jiankou reservoir, the infection level of *Dollfustrema vaneyi* in *Pseudobagrus fulvidraco* was and still is high (authors' unpubl. data). The parasite's effects on the host or the host response to the infection certainly requires further investigation, although haemorrhage has been commonly observed in the eye sites of heavily infected fish. Further studies should also be conducted to examine the interactions between the fish and the parasite.

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