Transmission strategies of model trematodes from first intermediate snail hosts

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Trematodes represent a large, entirely parasitic group of helminths distributed in aquatic ecosystems worldwide that infect a wide range of definitive and second intermediate hosts, but the first intermediate host is almost always a mollusk. A number of transmission strategies have evolved among trematode species to enhance changes in completing their life cycle, including the synchronized emergence of large numbers of larvae, the cercariae, from snail hosts. In addition, trematodes can affect the reproduction, growth, shell shape, and locomotory activity of the snail by diverting its energy resources to better meet the needs of the parasite, which can lead to a reduced lifespan of infected snails.

The main aims of the present study were: i) to monitor cercarial emergence patterns and daily output rates from snails of three model species with different life cycle characteristics, and ii) to investigate the effect of trematode infection on snail host longevity. Emergence of cercariae was monitored over main day-time intervals (sunrise, day, sunset and night) for three consecutive days under natural light/dark and controlled temperature conditions. The effect of trematode infections on snail survival was studied under laboratory conditions using naturally infected and putatively uninfected control snails.

Snails with trematode infections were sampled in 2021 and 2022 in four lakes in the Czech Republic. The eye fluke, *Tylodelphys clavata*, showed a nocturnal pattern of emergence, peaking at sunset, while there were marked differences in output rates between seasons. The mean daily emergence rate was 207 cercariae $snail^{-1}day^{-1}$ in August and 1,469 cercariae $snail^{-1}day^{-1}$ in September. This trematode uses three hosts: snail, fish and bird. The emergence of *Sanguinicola inermis* peaked at night, and the daily emission rate was 4,205 cercariae $snail^{-1}day^{-1}$. *Sanguinicola inermis* has a two-host life cycle, with cercariae emerging from the snail to infect the fish definitive host. Emergence of *Plagiorchis* sp. occurred during periods of low or total light deficiency (sunrise, sunset, and peaked at night), while it was nearly arrested during daytime. This trematode species had a mean daily cercarial output rate of 4,029 cercariae $snail^{-1}day^{-1}$. *Plagiorchis* sp. exhibits the lowest host specificity of the species studied, using a wide range of second intermediate and definitive hosts. Laboratory survival experiments showed that snails infected with *Plagiorchis* sp. had a 45 % shorter life span (7.3 days) than uninfected control snails (16.1 days).

While it is commonly reported that cercarial emergence is triggered by high light intensity, the three investigated trematode species showed the highest emergence during periods of low or no light intensity. The clear peaks in cercarial emergence correspond to the periods of the highest activity of the most common next hosts of *T. clavata* (perch) and *S. inermis* (carp). In lake Medard (*T. clavata* sampling site) most abundant fish species were whitefish, bleak and roach, while perch was the most abundant benthic species. In lake Otakar (*S. inermis* sampling site), carps make the majority of the fish population. Because *Plagiorchis* sp. is generalist, the cercarial emergence is probably not coordinated with the activity of a particular host, but rather with avoiding high predatory pressure during daytime. Although it is beneficial for parasites to keep their hosts alive as long as possible, they can induce significant damage by shortening the host's lifespan by nearly half. However, due to the long co-evolution of both organisms, trematodes are well adapted to compensate for countable

losses via numerous sophisticated transmission strategies, such as the timing of cercarial emergence with the next host's occurrence.

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