


Toxicity of formalin for fingerlings of *Cyprinus carpio* var. *koi* and in vitro efficacy against *Dactylogyrus minutus* Kulwicz, 1927 (Monogenea: Dactylogyridae)

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Abstract The toxicity of formalin on *Cyprinus carpio* var. *koi* and its anti-parasite effects against *Dactylogyrus minutus* (Monogenea) in in vitro tests is analyzed. Specimens of *D. minutus* were submitted to eight concentrations of formalin: 50, 75, 100, 125, 150, 175, 200, 250 mg L⁻¹, in triplicate. Concentrations of formalin 100, 150 and 200 mg L⁻¹ were then tested to determine the median lethal concentration of 50% of the fish per immersion bath. Fish behavior was also observed during the first 6 h of exposure. The 200 mg L⁻¹ concentration was the most rapid efficacy for *D. minutus*, killing all parasites in 16 min. All parasites were killed in 47 min at concentration 100 mg L⁻¹. Concentration 200 mg L⁻¹ was the most lethal for fish in less than 24 h exposure, with 24 h LC₅₀ at 135.44 (119.78–153.14) mg L⁻¹. The therapeutic index was 2.05–30 min and 1.15–16 min. A short bath (1 h) is recommended in koi carp with a minimum concentration of 75 mg L⁻¹ of formalin, not exceeding 100 mg L⁻¹ for treatment against *D. minutus*.

Keywords *Cyprinus carpio* · Treatment · Formalin · Therapeutic index · Monogenea · *Dactylogyrus* sp.

Introduction

The koi carp *Cyprinus carpio* (Linnaeus, 1758) is an ornamental fish with high market demand due to its ease in breeding and to its great variation in color patterns (Hussain et al. 2014, 2015). It is a fast-growing species (Hashem et al. 1997) and very tolerant to variations in water quality parameters and stocking density (Carneiro et al. 2015). However, its cultivation has been affected by ectoparasite Monogenea *Dactylogyrus* Diesing 1850, featuring 900 species (Gibson et al. 1996; Santos et al. 2016).

Carp are usually infected by more than one species of *Dactylogyrus*, some of them highly pathogenic, especially for fingerlings (Kritsky and Heckmann 2002; Jalali and Barzegar 2005), causing massive mortality rates and high liabilities to producers (Buchmann et al. 1993; Bretzinger et al. 1999; Kritsky and Heckmann 2002). Several studies investigated the biology and mechanisms of infestation of these parasites (Ergens and Dulmaa 1969; Dzika et al. 2009; Mhaisen et al. 2013), pinpointing the species *D. achmerowi* Gussev 1955, *D. anchoratus* Dujardin, 1845, *D. arcuatus* Yamguti, 1942, *D. difformis* Wegener, 1857, *D. extensus* Mueller & Van Cleave, 1932, *D. formosus* Kulwicz, 1927, *D. intermedius* Wegener, 1910, *D. vastator* Nybelin, 1924 and *D. minutus* Kulwicz, 1927 as the most prevalent (Gibson et al. 1996; Jarkovský et al. 2004; Kohn et al. 2006; Stojanovski et al. 2008; Molnár 2012).

Outbreaks of Monogenea parasites occur due to their life cycle in a specific host, temperature and culture densities (Turgut and Akin 2003). Monogenea are included among parasites with higher dispersion, epizootic impact and control difficulties in tanks (Pereira et al. 2006). Koi carp fingerlings were devastated in Israel by a severe infestation of *Dactylogyrus vastator* Nybelin, 1924, during the spring and early summer (Paperna 1963).

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