



Changes in microcystin production in cyanobacteria exposed to zooplankton at different population densities and infochemical concentrations

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ABSTRACT: We investigated microcystin (MC) production by four cyanobacterial strains (three *Microcystis aeruginosa* and one *Planktothrix agardhii*) in response to different grazer densities (direct exposure: zero, two, four, or eight individuals per 300 mL) and infochemical concentrations (indirect exposure: 0%, 10%, 25%, and 50%) of *Daphnia magna* and *Moina macrocopa*. MC production increased after direct exposure to both zooplankton species and was higher with increasing concentration of infochemicals. This MC production was significantly different among the control and three zooplankton treatment levels. Upon direct and indirect exposure of cyanobacteria to zooplankton, intracellular MC peaked on days 3 and 4. In most cyanobacterial strains, the peak MC contents were significantly higher in direct treatment with the highest zooplankton density and in indirect treatment with the highest concentration of zooplankton culture media filtrate than with treatments with the lowest density and concentration, respectively. Extracellular MC concentrations were much lower than intracellular ones, but both showed similar temporal patterns over the course of the experiment. Cyanobacteria directly exposed to *Daphnia* released greater amounts of extracellular MC than those exposed to *Moina*. This is the first study to provide evidence of an induced defense of increased MC production by cyanobacteria in response to increasing zooplankton grazer density and increased concentrations of infochemicals released by zooplankton. In addition to the induction of tolerance in *Daphnia* to toxic *Microcystis*, we discuss how these reciprocal defenses may explain the coexistence of zooplankton and toxic cyanobacteria in eutrophic freshwaters.

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