

Littoral zone structures as *Daphnia* refugia against fish predators

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Abstract

The assumption that macrophytes can provide zooplankton a daytime refuge against fish predation is central to the diel horizontal migration hypothesis. However, previous observations and experiments have shown that large-bodied zooplankton avoid macrophytes. To directly test these contrasting roles of macrophytes, we measured the reaction of *Daphnia pulex* to macrophytes (*Elodea canadensis* or plastic) in the presence and absence of chemical cues from two commonly occurring European fishes, roach (*Rutilus rutilus*) and perch (*Perca fluviatilis*). In the same series of laboratory experiments, we then tested the ability of different densities of *E. canadensis* and plastic macrophytes to reduce predation by roach or perch. In the absence of fish, only 27% of daphnids occurred in the macrophytes. However, 70–80% of daphnids occurred in the macrophytes when either roach or perch occurred. In addition, significantly more daphnids occurred in plastic versus real macrophytes, indicating that some chemically mediated avoidance of real macrophytes by *Daphnia* occurred. In the presence of fish chemical cues from either roach or perch, the differences between real and plastic macrophytes quickly disappeared as daphnids moved into macrophytes. However, this behavior decreased mortality only from roach predation, because perch spent significantly more time than roach foraging among macrophytes. Thus, although daphnids sought macrophyte refuge in the presence of both fishes, the effectiveness of the refuge depended on macrophyte density and predator identity. These results support the idea that macrophytes can increase survival of *Daphnia* populations in shallow lakes, depending on the fish species present.