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Diel horizontal migration of zooplankton: costs and benefits of inhabiting the littoral

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SUMMARY

1. In some shallow lakes, *Daphnia* and other important pelagic consumers of phytoplankton undergo diel horizontal migration (DHM) into macrophytes or other structures in the littoral zone. Some authors have suggested that DHM reduces predation by fishes on *Daphnia* and other cladocerans, resulting in a lower phytoplankton biomass in shallow lakes than would occur without DHM. The costs and benefits of DHM, and its potential implications in biomanipulation, are relatively unknown, however.
2. In this review, we compare studies on diel vertical migration (DVM) to assess factors potentially influencing DHM (e.g. predators, food, light, temperature, dissolved oxygen, pH). We first provide examples of DHM and examine avoidance by *Daphnia* of both planktivorous (PL) fishes and predacious invertebrates.
3. We argue that DHM should be favoured when the abundance of macrophytes is high (which reduces planktivory) and the abundance of piscivores in the littoral is sufficient to reduce planktivores. Food in the littoral zone may favour DHM by daphnids, but the quality of these resources relative to pelagic phytoplankton is largely unknown.
4. We suggest that abiotic conditions, such as light, temperature, dissolved oxygen and pH, are less likely to influence DHM than DVM because weaker gradients of these conditions occur horizontally in shallow lakes relative to vertical gradients in deep lakes.
5. Because our understanding of DHM is rudimentary, we highlight potentially important research areas: studying a variety of systems, comparing temporal and spatial scales of DHM in relation to DVM, quantifying positive and negative influences of macrophytes, focusing on the role of invertebrate predation, testing the performance of cladocerans on littoral versus pelagic foods (quantity and quality), investigating the potential influence of temperature, and constructing comprehensive models that can predict the likelihood of DHM. Our ability to biomanipulate shallow lakes to create or maintain the desired clear water state will increase as we learn more about the factors initiating and influencing DHM.

Keywords: *Daphnia*, food quality, macrophytes, predation, shallow lakes