Toward a more comprehensive theory of zooplankton diel vertical migration: Integrating ultraviolet radiation and water transparency into the biotic paradigm

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ABSTRACT: The current prevailing theory of diel vertical migration (DVM) of zooplankton is focused largely on two biotic drivers: food and predation. Yet recent evidence suggests that abiotic drivers such as damaging ultraviolet (UV) radiation and temperature are also important. Here we integrate current knowledge on the effects of abiotic factors on DVM with the current biologically based paradigm to develop a more comprehensive framework for understanding DVM in zooplankton. We focus on "normal" (down during the day, up at night) DVM of holoplanktonic, primarily herbivorous zooplankton. This new *transparency-regulator hypothesis* differentiates between *structural drivers*, such as temperature and food, that vary little over a 24-h period and *dynamic drivers*, such as damaging UV radiation and visual predation, that show strong variation over a 24-h period. This hypothesis emphasizes the central role of water transparency in regulating these major drivers of DVM. In less transparent systems, temperature and food are often optimal in the surface waters, visual predators are abundant, and UV radiation levels are low. In contrast, in more transparent systems, vertical thermal gradients tend to be more gradual, food quality and quantity are higher in deeper waters, and visual predator abundance is often lower and damaging UV radiation higher in the surface waters. This transparency-regulator hypothesis provides a more versatile theoretical framework to explain variation in DVM across waters of differing transparency. This hypothesis also enables clearer predictions of how the wide range of ongoing transparency-altering local, regional, and global environmental changes can be expected to influence DVM patterns in both inland and oceanic waters of the world.

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