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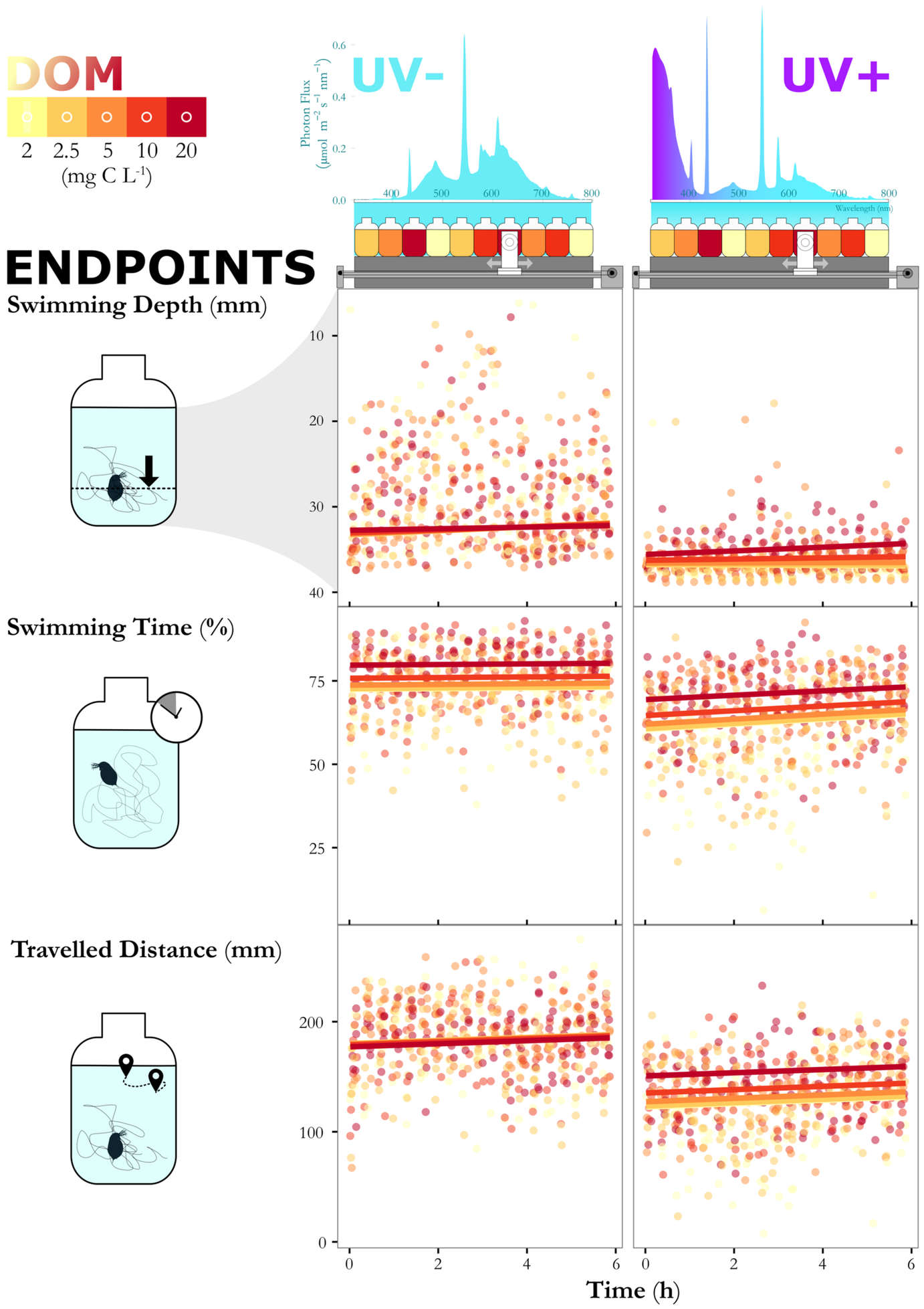
Analyzing Zooplankton Swimming Behavior with Robots and Data Science

Idea

Behavior is an essential yet underestimated proxy to assess the effects of stressors. While behavior is easy to observe, it can be difficult to quantify and analyze. We set out to assemble a toolbox capable of quantifying multiple endpoints of zooplankton swimming behavior. We tested the effects of multiple stressors on zooplankton in an environmentally relevant scenario. As a model system, we chose the common freshwater crustacean *Daphnia magna* and exposed it to ultraviolet (UV) radiation. To simulate water browning, we used different concentrations of dissolved organic matter (DOM). The full factorial design allowed us to investigate interactive and subtle effects of UV and DOM on behavior.



Methodology

We built the imaging system (aka robot) using a Raspberry Pi microcomputer at its core, which controlled a camera and motors to change camera positions using a Python script. We repeatedly filmed individuals for one minute every 19 minutes over six hours. Particle tracking algorithms in OpenCV allowed us to extract the coordinates of individual *Daphnia* over time, from which we calculated swimming characteristics.

Data Analysis

We analyzed the tracking data with the statistical software R. Linear mixed-effect (LME) models were chosen to reflect the potentially different behavioral trajectories of *Daphnia magna* individuals. Raw data and results of the LME models for swimming depth, swimming time, and swimming distance are shown in the figure to your left.

Findings

The swimming behavior revealed that DOM buffers the effects of UVR. At high DOM concentrations and UV exposure, the swimming behavior resembled the one without UV. This is likely due to the attenuation of UVR by DOM. Interestingly, DOM also raised the overall swimming activity independent of UVR exposure.

Importance

We succeeded in providing a low-cost and open-source solution to investigate behavioral patterns in zooplankton. We encourage fellow researchers and citizen scientists to make use of our methodology, scripts, and data. Our system is easily scalable and adjustable to host a range of model organisms, and thus can be used to investigate a multitude of questions in behavioral ecotoxicology.

Wolf & Heuschele. 2018. Water browning influences the behavioral effects of ultraviolet radiation on zooplankton. *Frontiers in Ecology and Evolution: Behavioral Ecology* **6**, 26 p. DOI: 10.3389/fevo.2018.00026

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