Does environmental flow speed affect the local relative abundance of Vorticella convallaria?

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Relative abundance of the sessile microorganism

Vorticella convallaria in differing flow speeds

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Introduction

- Vorticella convallaria are microscopic sessile suspension feeders (MSSFs) ubiquitous in aquatic ecosystems (Figure 1) [1].
- MSSFs attach to surfaces and consume bacteria and detritus using a self-generated feeding current (Figure 2) [1, 2].
- As highly prevalent filter feeders, MSSFs serve as biological indicators of ecosystem health and are heavily involved in nutrient and carbon cycling [1].
- Vorticella and other MSSFs are integral to clarifying effluent in wastewater treatment and have been shown to decrease heavy metal concentrations (Figure 3) [3, 4]. However, the conditions in which they collectively thrive and feed most effectively are not well known.

- Vorticella are pushed downstream towards orientations shown to have reduced feeding rates in higher flows (Figure 4) [5, 6]. Vorticella experience a wide range of free-stream flow speeds from ~1 mm/s (sinking aggregate) to ~100 cm/s (e.g., river bed), and are more commonly found in slower flows, though this has not been studied systematically [7].
- Unfavorable conditions can cause Vorticella to develop into a free-swimming form, indicating they may have some autonomy over where they settle and feed [1].

Methods

- Four distinct regions of flow were created by inserting a custom laser-cut stair-step obstacle into a flume (Figure 5).
- The velocity profile of the area of interest was characterized using Particle Image Velocimetry (PIV), resulting in shear rates ranging from 0.4 s⁻¹ to 2.8 s⁻¹. Vorticella can swim upstream in this range.
- A motor driven propeller maintained a circulating flow throughout the flume (Figure 6).
- Vorticella fully colonized the flume, which contained a diluted wheat-grass culture solution for food.
- Vorticella colonized a thin plastic slip marked with standardized transects and were counted from photographs every 12 hours for 72 hours. The slip was cleaned and replaced between each trial.
- The obstacle was reversed so that organisms were exposed to flows of increasing speed as well as flows of decreasing speed.

Preliminary Results

- Example trials in which Vorticella were exposed to four flow speeds in both increasing and decreasing orders. Error bars represent ±15 organisms.
  - The population of Vorticella experienced less growth overall when exposed to faster flow speeds first.
  - No significant difference was found between the two fastest flow speeds.
  - Organisms in two fastest flows remained pushed over in the direction of flow during observation in still water.
  - When exposed to increasing flow speeds, Vorticella were significantly more abundant in the slowest flow speed. They remained more abundant over time and became more abundant when the obstacle was reversed, indicative of selective preference.

Research Question:
Does the relative abundance of Vorticella convallaria vary based on environmental flow speed?

Hypothesis:
Vorticella will be most abundant at slower flow speeds, where the flow does not push them towards orientations with a reduced feeding rate.

Objectives

- Contextualize results from summer 2021, which introduced Vorticella convallaria in still conditions into flows with shear rates of 0 s⁻¹, 0.5 s⁻¹, 1.0 s⁻¹, and 1.5 s⁻¹ and compared their 3D orientations finding that organisms became increasingly pushed over as flow speed increased.
- Begin observational investigation into secondary questions:
  - Can Vorticella actively select the location in which they settle?
  - Are there morphological differences between Vorticella exposed to different flow speeds? (ex. body angle, stalk length)

References & Acknowledgements

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Future Directions

- Take further trials, especially ones in which the obstacle is reversed part way through data collection for better comparison between increasing and decreasing flow conditions.
- Measure average Vorticella body and stalk angles in each flow speed.
- More complex flow fields could be studied using the flume, such as by introducing rivets or pebbles.
- Observe Vorticella in the wild to better understand the conditions in which they thrive.