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

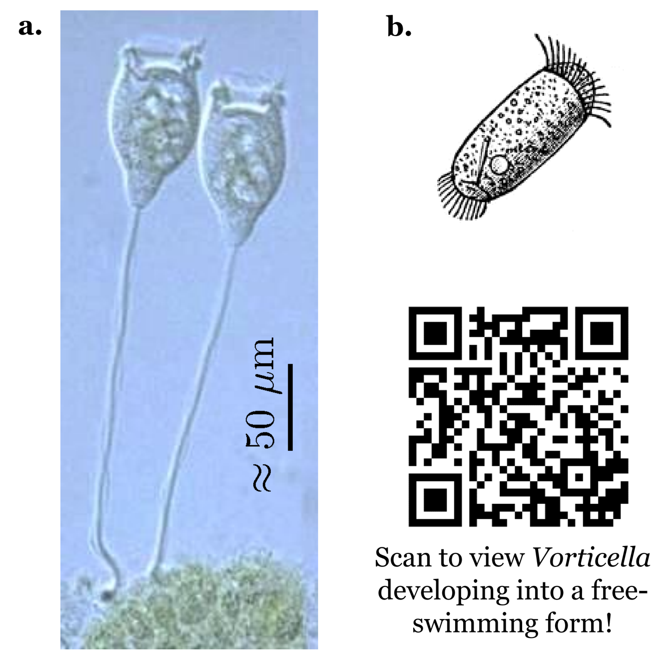
Tia S. Bottger

Relative abundance of the sessile microorganism *Vorticella convallaria* in differing flow speeds

Tia S. Böttger, Brett Klaassen van Oorschot, Rachel E. Pepper; University of Puget Sound, Department of Physics

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.



Scan to view *Vorticella* developing into a free-swimming form!

Fig. 1: *Vorticella convallaria*
a. Sessile stalked trophont.
b. Diagram of free-swimming teletroph.

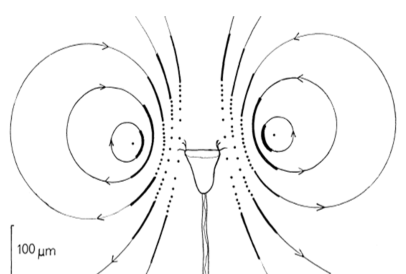


Fig. 2: *Vorticella* feeding current in still water [2].

- 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].

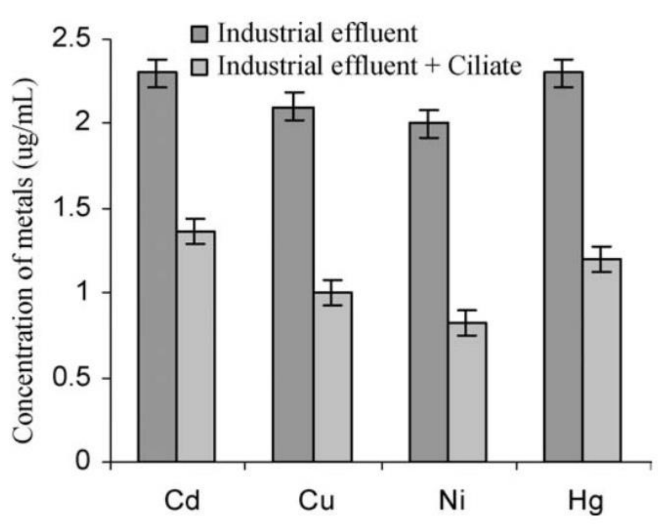


Fig. 3: Metal ions in 10 L of industrial effluent with and without *Vorticella microstoma* after 6 days [3].

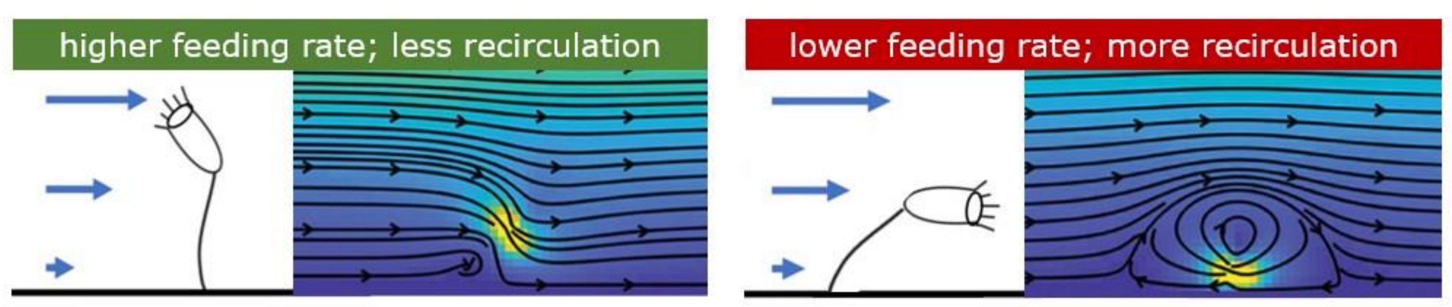


Fig. 4: *Vorticella* oriented downstream have reduced feeding rates [6]. Flows calculated modeling *Vorticella* as a point force above a plane boundary, color indicates flow speed (0 to 200 μm/s).

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* raised 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)

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**.

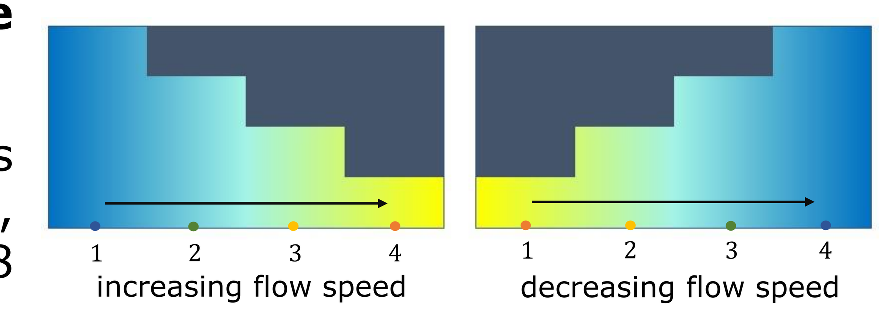


Fig. 5: A reversable stair-step obstacle creates four regions of differing flow speeds.

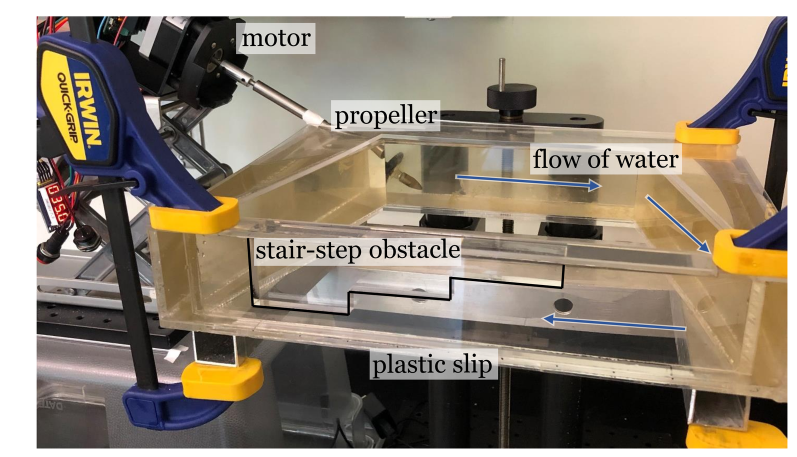


Fig. 6: A motor-driven propeller maintains circulating flow throughout the flume.

Preliminary Results

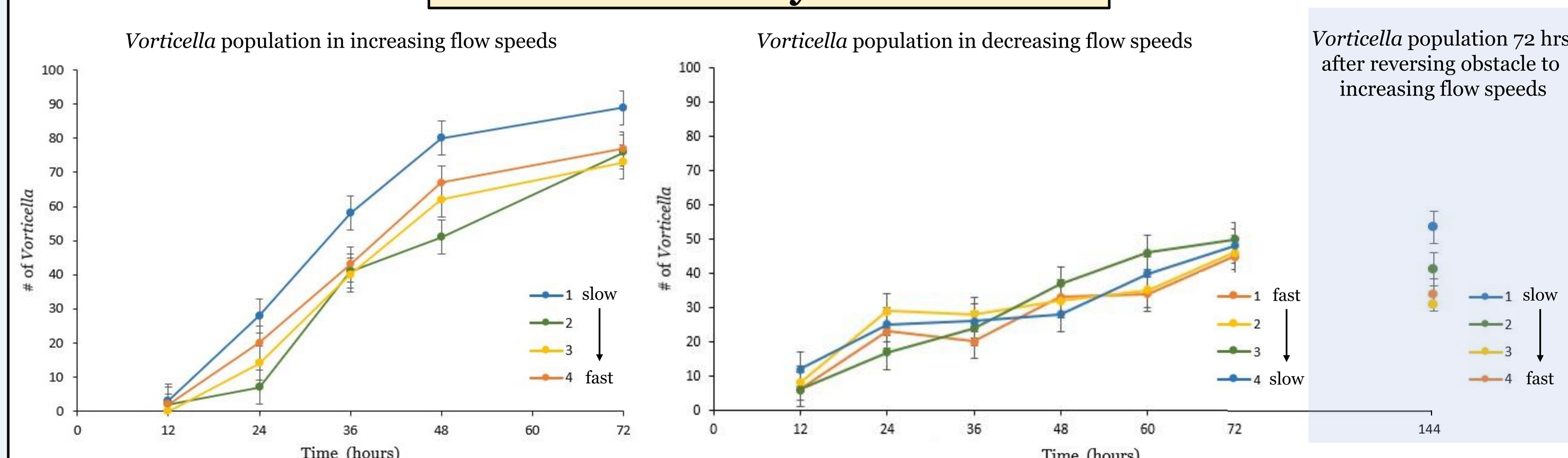


Fig. 7: Example trials in which *Vorticella* were exposed to four flow speeds in both increasing and decreasing orders. Error bars represent ±5 organisms.

- 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.

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.