symmetry of green algal coenobia resulting from adaptive phenotypic plasticity under planktonic life history

1. INTRODUCTION

Phenotypic plasticity is the ability of an organism to produce different phenotypes and change its observable traits in response to environmental factors (DeWitt et al., 1998). It allows organisms to adapt to varying conditions to optimize their survival ability (Morales & Trainor, 1997).

Desmodesmus is a genus of green algae from the family Scenedesmaceae (Chlorophyta) (Guiry & Guiry, 2023). The vast majority of specimens have been described from freshwater plankton, particularly from eutrophic waters (Johnson et al., 2019). *Desmodesmus* species are generally found in nature as coenobium - a simple colony with a defined number of cells with little or no specialization (Chung et al., 2018). These colonies are most often made up of four cells, but one, two, eight, or sixteen cells can also be found, usually if a predator is nearby (Lürling, 2003). Coenobia are typical in their rectangular shape with one or more spines growing from the four apexes (Dragoș et al., 2019)

The coenobia of *Desmodesmus* are biradially symmetric, which implies that their symmetry can be observed along several axes, in two planes only. In this case, we observe left-right, vertical, and transversal symmetry (Martindale & Henry, 1998). In a state of ideal symmetry, the *Desmodesmus* coenobia should be as similar to itself as possible after a set of transformations is applied to it (Savriama & Neustupa, 2010). However, in nature, these coenobia may also display a significant level of asymmetry, particularly in the region of the apical spines.

This thesis focuses on the asymmetry of the species *Desmodesmus communis* as a result of phenotypic plasticity influenced by factors such as water flow, disturbance of the aquatic environment, and planktonic life history. While past studies have explored asymmetry in response to grazing pressure or the presence of indole-3-acetic-acid (a plant hormone), the impact of planktonic life history on asymmetry remains unstudied (Chung et al., 2018; Lürling, 2003). This thesis introduces a novel approach to understanding asymmetry in *Desmodesmus communis*, simulating conditions in disturbed aquatic environments and using geometric morphometrics to analyze changes in cenobia shape in depth.

The analysis was based on separating one culture of *Desmodesmus communis* into three equally sized units. All three units were subjected to three levels of disturbance ranging from none to constant for 14 days. In these units, a close observation of changes in the shape of each coenobium was carried out. The hypothesis was that to protect against sinking pressure, coenobia should form as symmetrically as possible in the environment with the most significant disturbance. Utilizing a geometric-morphometric analysis involving four symmetry transformations, we assessed the degree of asymmetry within a single coenobium and compared the degree of asymmetry between differently disturbed units (Savriama & Neustupa, 2010). The main objective was to understand how coenobia phenotypes change under different conditions and whether adaptation to the planktonic lifestyle indeed promotes greater symmetry.

This thesis further describes how coenobia shifted in shape and whether the hypothesis was confirmed. Using a particular geometrical-morphometric analysis, we were able to decompose the asymmetry of coenobia along each axis and determine in which axis coenobia are most often asymmetric. These findings allowed for further development of the hypothesis with results described in this thesis.

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