Introduction

The most widely studied movement modality in diatoms is gliding. Models of the propulsion mechanism include secretion of extracellular polymeric substances (EPS) through the raphé. Few reports of non-gliding movements include rolling, shuffling, rocking, and pirouette. Whether these movements are characteristic of diatom species subjected to fluctuations in changing environments or if certain modalities are exhibited as a response to a discrete stimulus is not yet fully understood.

In the mudflat species, *C. closterium* has features that relate to its migration in the sediments. The movement forms that are adapted for survival in the prevailing conditions in the mud are not yet known.

The purpose of this study was to examine the modalities of movement of *C. closterium* and determine how they were affected by varying salinity and nutrient concentrations and with varying acclimation to these environmental stresses.

Materials & Methods

Cultures were maintained in 100 µmol m⁻² s⁻¹ (irradiance), 18 °C, 12:12-h light:dark photoperiod (5 & 15 days). Salinities of 5 & 20 practical salinity units (psu) were obtained by simple dilution of 35-psy growth medium with distilled water. 70 & 140 psu were obtained by NaCl addition to 35-psy. 2F media = 4x 35-psy. Salinity was measured with an optical refractometer.

Randomly chosen cells mounted on a flow-through stage chamber were tracked for movement modality changes at different salinity levels for 60 min at 30 °C under constant illumination. Movements with the desired salinity was produced using a sterile reservoir containing 500 µM 1M NaCl. The percent cells exhibiting different movement modalities over a 5 min period in the 5- and 15-day cultures was computed. Speed of actively gliding cells from each treatment was determined by tracking 20 cells for 30 sec intervals using 3D Studio Max software.

Results

- Table 1 lists characteristic movement modalities. (Figs. 2A & B show the position of the cell during movement relative to the x-, y- and z-axes.)
- In addition to a “smooth” gliding (Figs. 1A & B), *C. closterium* exhibited “corkscrew” gliding motion with the gliding axis as evidenced by lateral displacement of cells (Figs. 1C & D).
- Gliding or stationary cells were capable of pirouetting with one tip attached and the other moving without cell displacement along the X-axis.
- Speed increased during corkscrew but no clear pattern in transition from corkscrew to gliding or vice versa was related to reversals was observed (Fig. 3).
- Pivot, rollover and “rock & roll” (Fig. 4) movement has been commonly observed in *C. closterium*. Tip flexion was observed when tips of gliding cells became lodged against debris (Fig. 5).
- In 5-psy cells showed continuous gliding and corkscrew gliding. A salinity increase or decrease resulted in an increase of various modalities with shorter periodicity of change. In 35-psy, cells re-established normal gliding after 20 min of “rock & roll”, while 140-psy cells did not resume gliding (Fig. 6).
- Cells in 5-psy exhibited more gliding than those in other salinities. After 5 days in 35, 50 & 50 psu, gliding increased, rock & roll & non-motility increased. In 2F-35, gliding was reduced and cells exhibited other modalities in equal proportions. Pirouette cells re-established normal gliding after 10% after 5 days to 75% after 15 days in all salinities for 2F-enriched media (Fig. 7).
- Gliding speed of cells in 2F-35 was greater than those in 35-psy after 5 days of acclimation. Speed decreased in cells acclimated to altered salinity levels. 2F-35 gliding speed increased (Fig. 8).
- In 2F-35, cells spent 90% of the time gliding which increased in 20, 50 & 70 & 140 psu with a concomitant increase in other modalities. In 2F-70, cells were either non-motile or exhibiting rock & roll 96% of the time (Fig. 9).

Discussion

The various movement modalities of *C. closterium* represent adaptation to the mudflat habitat (Apoya-Horton et al. 2006). Considering the cohesive nature of the mudflat sediment (Bellingham et al. 2005), corkscrew gliding may assist in passage through the layer of fine particles. Pirouette and pivot movements may represent a response to chemical gradients and directed taxis under suboptimal conditions. These responses may be due to cell tips having a sensory detection system (Colin et al. 2004) that is not only used for light but with other environmental cues as well. Pirouette movement was observed to the encountering stressful conditions (Harrower 1977).

Acknowledgements

We thank MTU for a Graduate Fellowship to MDH and support from the National Science Foundation (Grant IBN 0110875 to MRAH and GJCU).

Literature Cited


