Defining optimum: growth conditions affect heat stress resistance in the Antarctic extremophile *Chlamydomonas* sp. UWO241

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Introduction

Optimal growth:
- **Simple definition**: fastest growth rate is optimal [1]
- **Extended definition**: fastest growth rate & most resistant to stress [2]

Chlamydomonas sp. UWO241:
Antarctic psychrophile [3]

Lake Bonney, Antarctica: [3]
Permanent ice coverage
Highly stratified
Conditions at 17 m, where UWO241 lives
- ~5°C (cold)
- <11 µmol/m²s¹ light intensity (low)
- blue-green light
- 700 mM salinity (high)

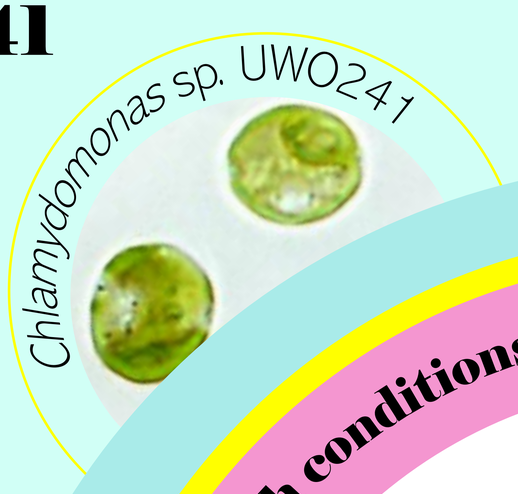
Glycerol: [4]
Compatible solute
- Osmoregulant & cryoprotectant
- Salinity dependant

Triacylglycerides (TAGs): [5]
Lipid storage
- 3 lipids on a glycerol backbone
- Increase in heat stress response

Hypotheses

Algae grown under conditions that mimic Lake Bonney will exhibit greater stress resistance.

Lipids act as a protective molecules during heat stress.



High light + Low salt = Cell death

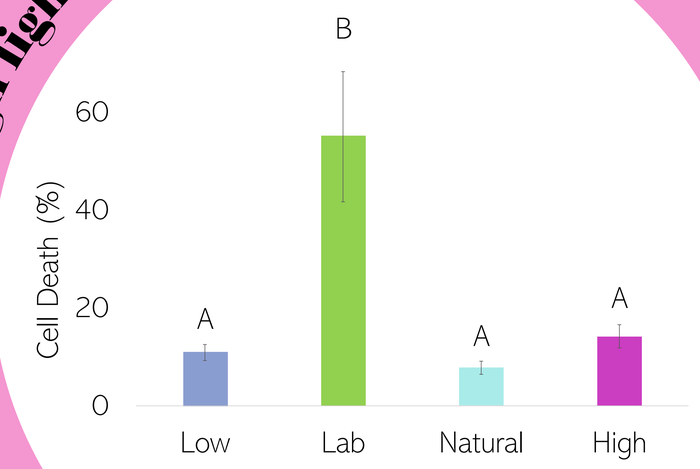


Figure 2. Cell death (% ± SD) indicated with SYTOX by treatment condition pre-stress: N = 3. ANOVA: ($F(3,8) = 31.58$, $p = <0.0001$). Tukey's differences indicated by letters.

Natural growth conditions most resistant to heat stress

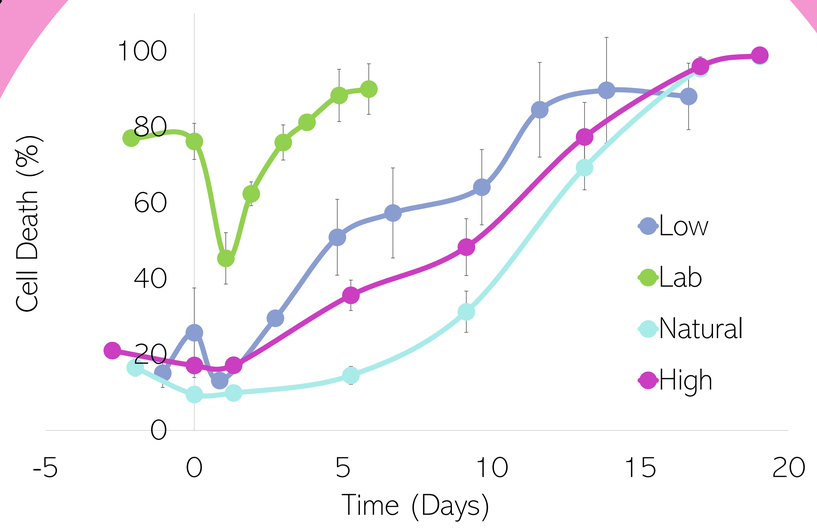


Figure 3. Heat shock responses by treatment condition: N = 4 except for lab where N = 3. **(A)** Total chlorophyll (% ± SD). Multi-way ANOVA: light intensity ($F(1,26) = 43.353$, $p = <0.0001$) and salinity ($F(1,26) = 75.901$, $p = <0.0001$). **(B)** Dead cells indicated by SYTOX staining (% ± SD). Multi-way ANOVA light intensity ($F(1,26) = 4.644$, $p = 0.041$) and salinity ($F(1,26) = 44.397$, $p = <0.0001$).

High light + Low salt = Fast growth

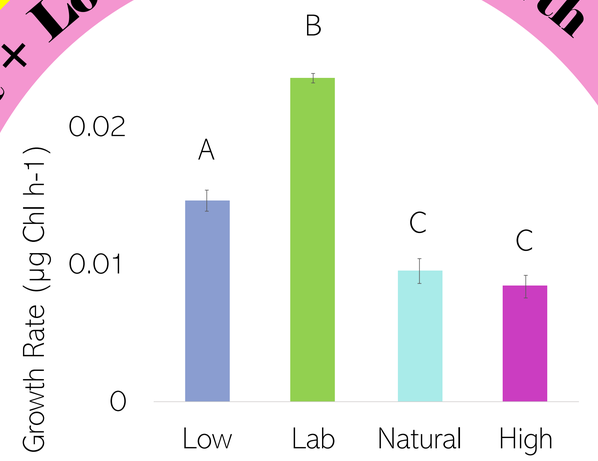


Figure 1. Growth rate (µg Chl h-1 ± SD) by treatment condition pre-stress; N = 3. ANOVA: ($F(3,8) = 165.3$, $p = <0.0001$). Tukey's differences indicated by letters.

Glycerol & TAGs increase in heat stress

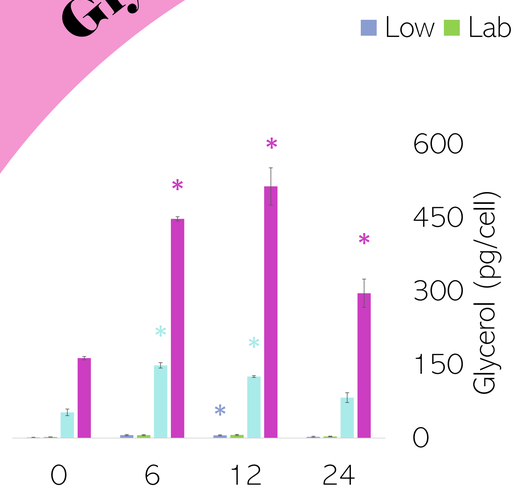


Figure 4. Glycerol (pg/cell ± SD) by treatment; N = 3. Statistical comparison by treatment compared to unstressed cells (0h), significance ($p < 0.05$) indicated by *.

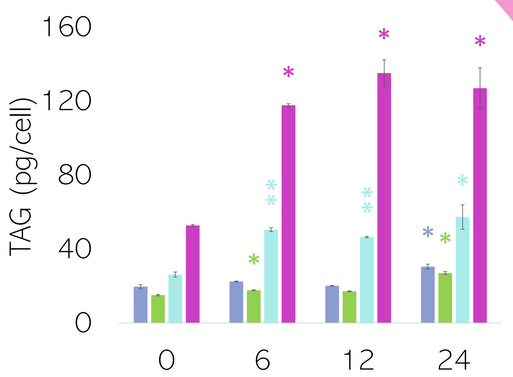
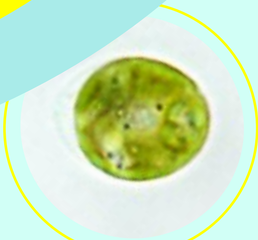


Figure 5. TAG (pg/cell ± SD) by treatment; N = 3. Statistical comparison by treatment compared to unstressed cells (0h), significance ($p < 0.05$) indicated by *.



Methods

Growth: 4°C → heat stress: 24°C

Measure:
- Viability
- Growth rate
- Glycerol levels
- TAG levels

Table 1. Experimental treatment conditions.

Treatment	Salinity (mM)	Light (µmol/m²s¹)
Low	10	13
Lab	10	130
Natural	700	13
High	700	130

Conclusions

Optimum conditions for UWO241
- Closest to Lake Bonney
- Slow growth rates & highest stress resistance

Glycerol synthesis during heat stress
- Novel response in algae & plants

TAGs increase during heat stress

References

1. Pocock et al. (2011). *Journal of Experimental Botany*, 62(3): 1169–1177.
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3. Cvetkovska et al. (2017). *Polar Biology*, 40(6): 1169–1184.
4. Raymond et al. (2020). *Front. Plant Sci.*, 11.
5. Légeret et al. (2016). *Plant, Cell and Environment*, 39: 834–847.