Reactive Oxygen Species are Linked to the Toxicity of *Alexandrium* to Heterotrophic Protists

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**Issue:** Harmful algal blooms (HAB) are widespread

- Some species produce toxins – Public health risk
- Disrupt food webs
- Economic impacts – $82 million/yr; fisheries, tourism
Alexandrium spp.

- Toxic dinoflagellates (neurotoxins)
- Paralytic Shellfish Poisoning (PSP)
- Toxins can be transferred through food web
- Blooms from Gulf of Maine to Long Island Sound
- Intense blooms in Long Island Sound since 2006
Heterotrophic Protists

- Single-cell eukaryotes
- Widespread & abundant (100 – 200,000 cells L\(^{-1}\))
- Consume 60 – 70 % primary production
- Important food for animals
So What?

• What mechanisms control HAB dynamics?

• Grazing must be an important factor!

• Agents of bloom control and toxin transfer

• But, toxic *Alexandrium* may poison protist grazers
Lab studies: *Alexandrium* kills heterotrophic protists, but mortality not related to PSP toxins!

**Problem:** Is there an alternative mechanism of toxicity?

**Ho:** Reactive oxygen species (ROS)

**H1:** Protein-like compound
Solutions: Experiments conducted to examine effect of *Alexandrium* sp. on a ciliate, *Tiarina fusus* and a heterotrophic dinoflagellate, *Polykrikos kofoidi*.

Questions

1) Are PSP toxins responsible for the toxicity?

2) Is physical contact, or actual ingestion required for toxicity?

3) Are reactive oxygen species (ROS) involved?
Approach: Lab assays

Protists exposed to:

“High PSP” = 23-30 pgSTXeq/cell
“Low PSP” = 9 – 16 pgSTXeq/cell
“No PSP” = 0 pgSTXeq/cell

Controls

- 12 well tissue culture plates
- 15 ciliates/well
- Triplicate
Are PSP toxins responsible?

- Survival independent of PSP
- Survival dependent on prey concentration

![Graphs showing ciliate and dinoflagellate survival across different PSP concentrations and density levels.](image)
Are the toxins extracellular?

- Significant mortality without contact or ingestion
- Extracellular compounds involved in toxicity
Are ROS involved?

- Survival increased in presence of ROS-scavengers
- Effectiveness varies with ROS-scavenger species
- Protein enzyme also increases survival
**Conclusions**

- Novel mechanism of toxicity to protists
  - Toxicity not related to PSP toxin content
  - ROS linked to the toxicity
  - Toxic protein-like compound(s) also produced by No-PSP strains

- Toxicity is cell concentration-dependent
- Contact/ingestion not required for toxicity
Benefits

• Progress toward characterizing the mechanism of toxicity to protists

• New conception of *Alexandrium* defense system important for:
  
  Modeling and predicting HAB formation and termination
  Toxin transfer up the food web,
  Arm races between predators and prey
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