Salinity tolerance of *Artemia* and *Ephydra*: uncertainty and discrepancies

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Brine shrimp  
(*Artemia franciscana*)

- 5-10mm length
- Filter algae
- Several generations per year
- Winter die-off
- Produce resting eggs (cysts)

Doyle Stephens, USGS
Brine flies (genus *Ephydra*)

- Inhabit lake bottom
- Bioherms/stromatolites
- Larvae feed on detritus and algae
- Adults emerge onto lake surface and shore
Small organisms, large role

- Energy transfer up the chain (bird food)
- Nutrient cycling

Brine shrimp (*Artemia franciscana*)

Brine fly (*Ephydra cinerea*)

Kerry S. Matz—Bugguide.net
Small organisms, large biomass

At peak 2008 densities:
- 5.8 shrimp/liter
- 94,000 tons in lake
- 13,400 bull African elephants
- 1.3 million people

- Est. 370 million per linear shoreline mile
- Up to 5700 larvae per m$^2$ of suitable lake bed
Salinity as habitat

• Biodiversity declines as salinity increases
• A few well-adapted species remain
Effects of salinity

- Increased energy cost for osmoregulation
- Lowered $O_2$ levels may be a stress
- Reduced hatching success (brine shrimp)
- Leaves less resources for growth, reproduction
Ecologic thresholds

- Even tolerant species have their limits
- Response can be abrupt
Threshold response

African jewelfish

Crop yield

J.N. Langston and P.J. Schofield
U.S. Geological Survey

M.H. McCallum et al.
Australian Society of Agronomy
GSL Elevation

- Dec 2009: 4194.4 ft
- Historic average: 4200 ft.
- Historic low: 4191.4 ft in 1963
- Snowpack in GSL basin is 58-67% of normal
When is salinity too high?

• We need to know effects on:
  – Survival, short and longer term
  – Life span
  – Growth
  – Reproduction
  – Food resources

• Existing studies are not sufficient for GSL
Consult the literature

- Little information on GSL shrimp at high salinities
Artemia franciscana

Cady et al. 1999—UDWR report

• Tested short term survival and hatching
• Poor survival above 15% salinity
• Can hatch in 8-9% maximum salinity

• Low sample sizes and salinities
• Leaves out long term effects
• Suggests GSL currently borderline
Artemia franciscana

VanHaecke et al. 1984

• GSL strain
• 9 day survival from 0.5-12% salinity
• Temperature tolerance
• High survival and temperature tolerance

• Salinity range too low to be applicable now
Artemia franciscana

Wear and Haslett 1987

- New Zealand strain
- Temperature interaction

- Threshold between 20 and 26%?
- Same species, very different habitat
- Contrasts w/ Cady et al. 1999
**Artemia franciscana**

Triantaphyllidisis et al. 1995
- San Francisco Bay strain

- Reproduction threshold between 10 and 14%?
- 26 d survival dropped at 18%
- Contrasts w/ other studies
Mono Lake *Artemia*

- Tolerates up to 16-18%
- No thresholds detected
- Habitat and species very different from GSL
GSL Field Data
Field Data

2000-2009
• Salinity 9% - 18%
Salinity not related to:
• # of adults
  \( r^2 = 0.1 \)
• Brood size
  \( r^2 = 0.1 \)
• Cyst densities
  \( r^2 = 0.2 \)
What we know

- Survival, reproductive output, and body size decrease in high salinities
- Response may or may not be abrupt
  - Could occur at 10-26% salinity
  - 15% may be the optimum
- North Arm is too saline
- Salinity in early 1960s 23-28%
- Temperature makes this worse
Ephydra cinerea

• Research on this species is lacking
• Collins 1980: ecology & habitat, but no salinity
• Herbst et al. 1988: salinity tolerance of Mono Lake species (E. hians)
• More difficult to sample and keep in laboratory
What we know

• Mono Lake species tolerates up to 20% – Signs of osmotic dehydration
• Great Salt Lake population may tolerate up to 26%
• Eggs can tolerate up to 30%
• North Arm is too saline
What we need to know

- Detailed response of GSL population to high salinities (>16%)
  - Long term survival
  - Reproductive output
  - Growth & development

- Threshold or linear response?
  - Identify salinities at which populations are considered impaired
What we need to know

- Interacting effect of temperature
- Effects on phytoplankton communities
- Once we know what salinity is too high, how likely are we to get there?
Context & Conclusions

• Not charismatic, but important
• Primary pathway for lake nutrients to reach waterfowl
• We do not know the upper salinity tolerances

\[ \text{NH}_4^+ \quad \text{PO}_4^{3-} \]
Context & Conclusions

- Extinction is not a concern
- Functional impairment is
- What will periodic declines do to dependent waterfowl and industry?
- Determine minimum acceptable lake level