HCO₃⁻ UTILIZATION POTENTIAL OF SUBMERSED AQUATIC VEGETATION AND ITS IMPLICATIONS FOR NATIVE PLANT RESTORATION IN A SPRING-FED CENTRAL TEXAS RIVER

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Study Location: Comal River

Edwards Aquifer Hydrogeologic Dip Section

Adapted from Klett, Knowles, Elder, and Sieh, 1979
Texas Dept. of Water Resources Report 252
Endangered Species of the Comal River and associated Springs

Fountain Darter (*Etheostoma fonticola*)

Comal Springs Riffle Beetle (*Heterelmis comalensis*)

Comal Springs Dryopid Beetle (*Stygoparnus comalensis*)

Peck’s Cave Amphipod (*Stygobromus pecki*)

Comal Springs Riffle Beetle (*Heterelmis comalensis*)
Threats to Endangered Species:

1. Non-native, Nuisance & Invasive Species
   • Plants & animals

2. Diminished Springflow and Water Quality
   • Municipal, Agricultural, Industrial and Recreational Use
   • Urban & Agricultural Runoff
   • Drought

3. Habitat degradation
   • Loss or shifts in aquatic vegetation
Non-Native, Nuisance & Invasive Species

Malaysian trumpet snail (*Melanoides tuberculatus*),

*Figure 8.* Ventral view of a fountain darter (*Etheostoma fonticola*) with massive infection of *Centrocestus formosanus* and an uninfected fish (lower). Opercula flared outward by deformed and hyperplastic gill tissue (each division of scale = 1 mm).
Non-Native, Nuisance & Invasive Species

Giant ramshorn snail (*Marisa cornuarietis*), Red swamp crayfish (*Procambarus clarkii*), Armored catfish (*Pterygoplichthys anisitsi*), Tilapia (*Oreochromis spp*), Indian waterweed (*Hygrophila polysperma*)
Municipal, Agricultural, Industrial, Recreational Use & Runoff
Drought of mid-1950's

Daily flow volume from Comal Springs
January 1928 to June 2013

Data from: USGS Water Resources Division, San Antonio

Drought Impact on Texas Surface Water
March 18, 2014

Drought Severity Index
- Normal
- Abnormally Dry
- Drought - Moderate
- Drought - Severe
- Drought - Extreme
- Drought - Exceptional

Sources
- H2OC
- USDA
- NOAA
- TCEQ Office of Water

Drought Monitor image developed by the National Drought Mitigation Center (NDMC)
National Drought Mitigation Center, University of Nebraska-Lincoln
USGS 08169000 Comal Rv at New Braunfels, TX

Daily discharge, cubic feet per second -- statistics for Nov 12 based on 83 years of record

<table>
<thead>
<tr>
<th></th>
<th>Min (1957)</th>
<th>Most Recent Instantaneous Value Nov 12</th>
<th>25th percentile</th>
<th>Mean</th>
<th>Median</th>
<th>75th percentile</th>
<th>Max (1974)</th>
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<tbody>
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<td>242</td>
<td>288</td>
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<td>345</td>
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</table>
Aquatic Vegetation:
*Hygrophila polysperma* vs. *Ludwigia repens*
E. Fonticola Habitat Quality

The diagram illustrates the comparison between native and exotic vegetation types for Fountain Darter density (number/m²). vegetation types include:
- Open
- Ceratopteris
- Sagittaria
- Vallisneria
- Hygrophila
- Cabomba
- Ludwigia
- Algae
- Bryophytes

Native vegetation types generally support higher densities of Fountain Darters compared to exotic types.
What happens to *E. fonticola* habitat under extremely low-flow conditions?
**HCO₃⁻ Utilization Potential**

**Objective:** To determine which aquatic plant & bryophyte species are capable of using bicarbonate as a Dissolved Inorganic Carbon (DIC) source for photosynthesis (Ps)

**Rationale:** Under low-flow conditions, temperature and pH likely to increase, making CO₂ scarce

**Approach:** Assay plants under closed-system conditions and see how high they can drive pH.

- CO₂ obligates: Ps stops when CO₂ depleted
- HCO₃⁻ users: Ps continues to higher pH
HCO$_3^-$ Utilization: pH Drift Method

- DIC is pH-dependent
- PS $\downarrow$ CO$_2$ (H$_2$CO$_3$) $\uparrow$ pH
- Synthetic culture solution w/known alkalinity & carbon composition
- Initial pH $\sim$8.3 (not much CO$_2$ in solution)
- CO$_2$ depletion lowers total inorganic carbon (C$_T$) only modestly.
- HCO$_3^-$ use lowers C$_T$ more conspicuously.
- Loss of CO$_2$ and HCO$_3^-$ does not change alkalinity as (OH$^-$) replaces alkalinity lost.
- C$_T$:Alk ratio sensitive measure of HCO$_3^-$ utilization potential.
Methods: $\text{HCO}_3^-$ Utilization Potential of Aquatic Vegetation from the Comal River
Analyses

• Focus on major Comal species:
  o Non-native: *Hygrophila polysperma*
  o Native: *Ludwigia repens, Cabomba caroliniana, Vallisneria americana, Sagittaria platyphylla* & bryophytes

• Key response focus = final pH & C$_T$:$\text{Alk}$ ratio
  o The more proficient use of HCO$_3^-$, the higher they can drive (drift) pH resulting in a lower C$_T$:$\text{Alk}$ ratio

• One-way ANOVA will allow comparison among species & culture conditions.
### Results: Relationship between pH and Ps

<table>
<thead>
<tr>
<th>Mean pH during interval</th>
<th>Net Photosynthesis (mg O₂ mg dry mass⁻¹ h⁻¹)</th>
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<tbody>
<tr>
<td>8.0</td>
<td>-0.5</td>
</tr>
<tr>
<td>8.5</td>
<td>0.0</td>
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<td>9.0</td>
<td>0.5</td>
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<td>2.0</td>
</tr>
<tr>
<td>11.0</td>
<td>2.5</td>
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</table>

- **Cabomba (4/26/2013)**: [Data points shown in the graph.]
- **Vallisneria (7/16/2013)**: [Data points shown in the graph.]

**Figure 1.** Comparison of prototypical CO₂ obligate (*C. caroliniana*) and HCO₃⁻ user (*V. americana*).
Results

Figure 2: C_{\text{t}}:Alk for 6 major species.

- There is no evidence for HCO_{3}^{-} use for bryophytes, C. caroliniana or S. platyphylla.
- HCO_{3}^{-} use not typical but potentially inducible L. repens and H. polysperma.
- V. americana readily uses HCO_{3}^{-}.
Results: One-way Analysis Of Variance

Figure 3. One-way ANOVA showing: a) bryophytes, *C. caroliniana* & *S. platyphylla* are not HCO$_3^-$ users. b) *H. polysperma* & *L. repens* HCO$_3^-$ utilization induced by CO$_2$ stress and c) *V. americana* strong HCO$_3^-$ user & gets stronger under stress.
Conclusions

- Study determined HCO$_3^-$ utilization potential for six key species within the Comal River system
  - 3 species (bryophytes, C. caroliniana & S. platyphylla) are not using HCO$_3^-$ now and show no evidence that utilization can be induced.
  - 2 species (H. polysperma (non-native) & L. repens (native)) do not use HCO$_3^-$ under normal conditions but evidence that utilization can be induced by CO$_2$ stress
  - 1 species (V. americana) is a strong HCO$_3^-$ user and gets even stronger under CO$_2$ stress

- Implications for vegetation choice in E. fonticola habitat restoration?
Conclusions

Implications for choice of vegetation in *E. fonticola* habitat restoration?

1. *L. repens*
2. *C. caroliniana*
3. *V. americana*
4. *S. platyphylla*
5. Bryophytes
   (colonize)
Special Thanks!