Effects of the nuisance alga *Didymosphenia geminata* on benthic community resource use

Natalie E. Knorp and Justin N. Murdock
School of Environmental Studies and Department of Biology
Tennessee Tech University, Cookeville, TN

Introduction

- *Didymosphenia geminata* is a diatom that has reached nuisance biomass levels in streams worldwide.[1] It can form mats that blanket stream bottoms (Fig. 1), which may reduce food availability to all parts of the stream food web.[2]
- Stable isotopes are used in food web analyses to asses which food resources are being assimilated into consumer tissues. Organism tissues are generally similar in their ^{13}C values compared to their food resources, while ^{15}N values tend to increase in a predictable pattern from food to consumers.[3]
- Additional food web information can be gained from lipid (fatty acid) analysis. Consumers obtain fatty acids directly from their food sources[4], so consumer lipid composition should match their food resources.

Figure 1. *Didymosphenia geminata* mats in the South Holston River, TN.

Purpose

- Determine whether *D. geminata* influences food resource use by stream macroinvertebrates and fish.
- Assess whether or not consumers utilize *D. geminata* as a food resource.

Methods

Sample collection

- "High" and "low" *D. geminata* biomass sites were sampled in the Clinch, South Holston, and Watauga rivers, TN.
- Major food web components were collected in the summer of 2014 and 2015. These included fine benthic organic material (FBOM), suspended particulate organic material (SPOM), algal biofilms, macrophytes, filamentous algae, coarse particulate organic matter (CPOM), *D. geminata*, and abundant macroinvertebrates.
- Fin, liver, and muscle tissue from rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) were collected in 2015.

Stable Isotope Analysis

- All food web components were dried, ground to a homogenized powder, and analyzed for carbon and nitrogen isotopic ratios by Washington Stable Isotope Laboratory.
- Data were analyzed with SIAR, a Bayesian mixing model in Program R.

Lipid Analysis

- Macroinvertebrates and fish muscle tissue were ground with a mortar and pestle, suspended in methanol, and analyzed for ω3:ω6 fatty acid ratios and diatom-specific markers.
- Data were analyzed with t-tests or the non-parametric equivalent.

References

1) Spaulding, S.A. and L. Elwell. 2007. Increase in Nuisance Blooms and Geographic Expansion of the Freshwater Diatom *Didymosphenia geminata*. U.S. Geological Survey Open-File Report 2007-1425.
2) Tennessee WildlifeResources Association. 2007. Management of the Clinch River Trout Fishery. http://www.state.tn.us/twra/fish/StreamRiver/tailtrout/clinch_trout_07.pdf
3) Vander Zanden, J. and J.B. Rasmussen. 2001. Variation in d15N and d13C trophic fractionation: Implications for aquatic food web studies. Limnology and Oceanography 46: 2061-2066.
4) Dalsgaard, J., M. St. John, G. Kattner, D. Müller-Navarra, and W. Hagen. 2003. Fatty acid trophic markers in the pelagic marine environment. Advances in Marine Biology, 46:225−340

Acknowledgements: Tennessee Tech, Trout Unlimited, NPS, and USFWS provided financial support. Thanks to K. Henderson, L. Hix, A. Engle, K. Dunham, and K. Catignani for assistance in the field and lab, and to J. Perkin for assistance with statistics.

Results

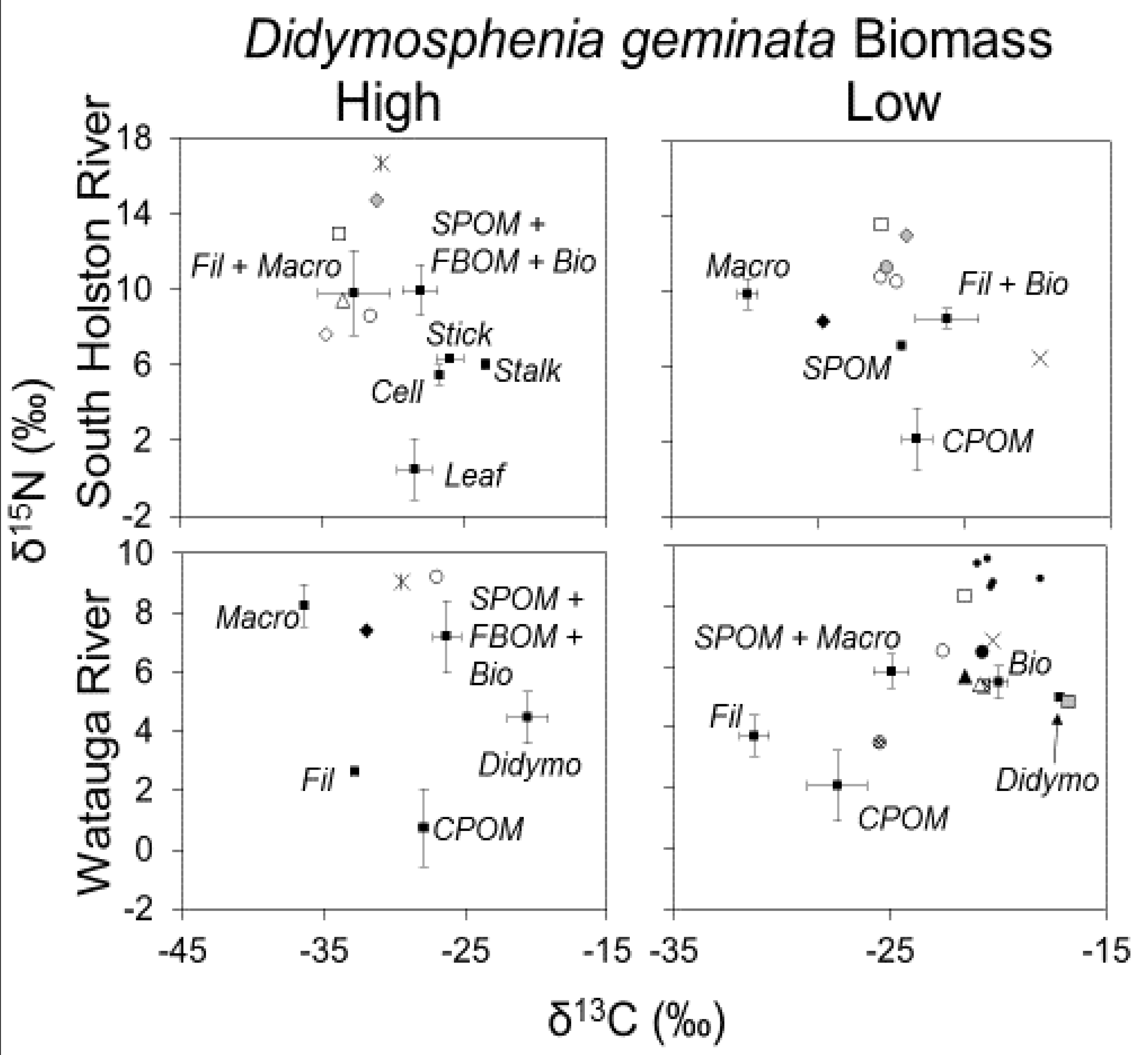

Figure 2. Stable isotope biplots for macroinvertebrates (data points) and their food resources (black squares with bars) in the South Holston and Watauga Rivers in 2014. Mixing models from these data suggest food resource switching at high versus low *Didymosphenia geminata* sites.

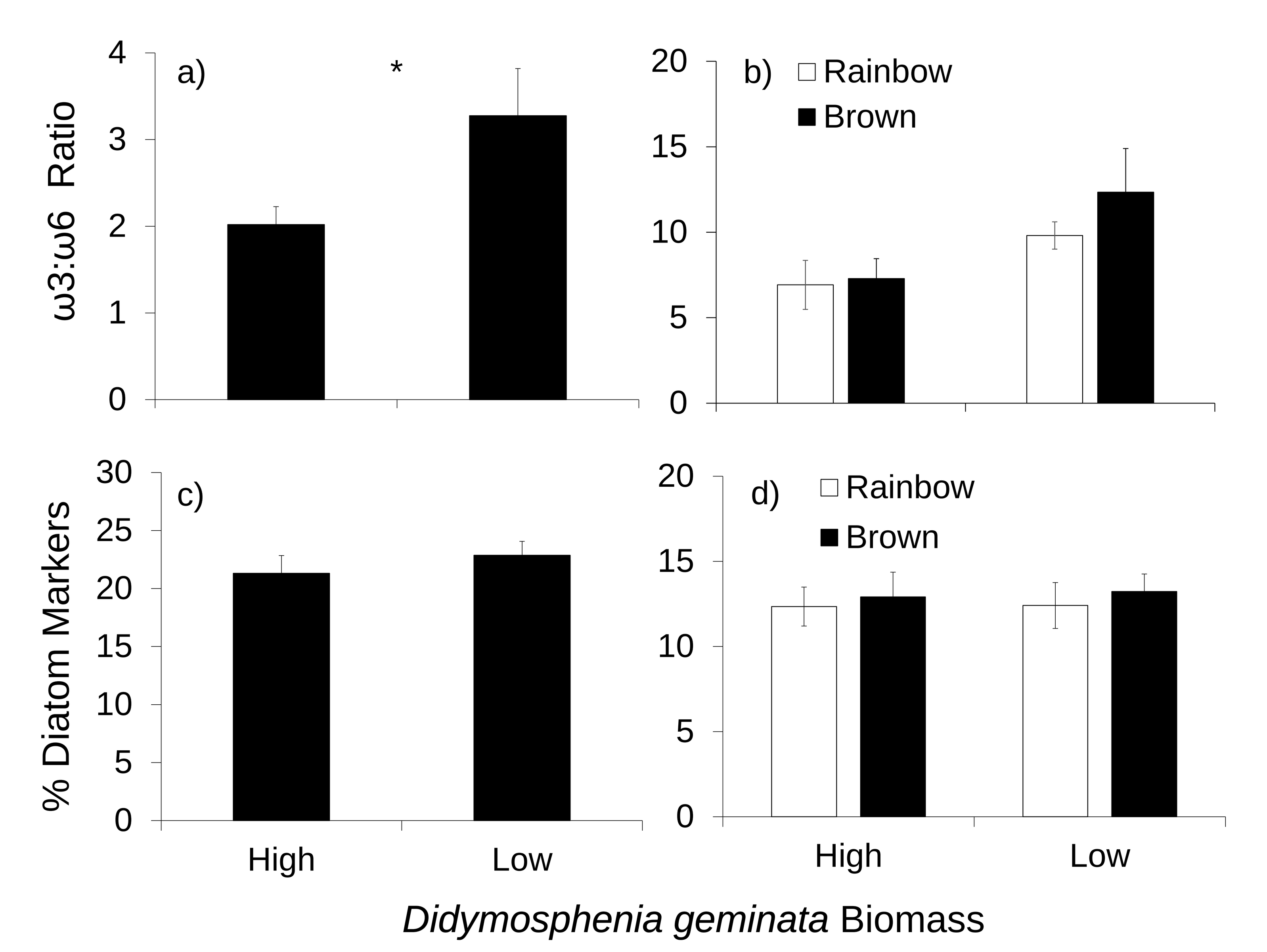

Figure 3. ω3:ω6 fatty acid ratios (a, b) and percent diatom markers (c, d) in macroinvertebrates (a, c) and fish (b, d). Bars represent mean ± 1 SE. Statistically significant differences at α=0.05 are marked with an asterisk.

Results

Stable Isotope Analysis

Macroinvertebrates

- In 2014, macroinvertebrates in the South Holston and Watauga Rivers were switching from a variety of food resources at low *D. geminata* biomass sites to filamentous algae or macrophytes at high biomass sites. Resource switching was not observed in the Clinch River where overall biomass was low (Fig. 2).
- Resource use patterns were harder to distinguish in 2015. Most macroinvertebrates were feeding on a variety of food resources.
- In both years, macroinvertebrate groups from both high and low biomass sites were assimilating *D. geminata* cells and/or stalks.

Fish

- Both trout species mainly consumed amphipods and turbellarians, but also *D. geminata* at all sites sampled.

Lipid Analysis

Macroinvertebrates

- Macroinvertebrates from high *D. geminata* biomass sites had lower ω-3:ω-6 fatty acid ratios than from low biomass sites (U=64, p=0.048; Fig. 3a).
- Percent diatom markers were not significantly different in macroinvertebrates between high versus low biomass sites (t=0.78, df=28, p=0.44; Fig. 3c).

Fish

- Fish from high and low *D. geminata* biomass sites had similar ω-3:ω-6 fatty acid ratios (Brown: t=1.77, df=8, p= 0.12; Rainbow: t=1.72, df=8, p= 0.12; Fig. 3b) and similar percent diatom markers (Brown: t=0.17, df=8, p=0.87; Rainbow: t=0.031, df=8, p=0.98; Fig. 3d).

Discussion and Conclusions

- *Didymosphenia geminata* can affect food resource use in some taxa. Food switching occurred in several macroinvertebrate groups, and this conclusion was supported by both isotope and lipid data. On the other hand, fish appeared to be feeding on the same food resource at high and low biomass sites.
- Both macroinvertebrates and fish will utilize *D. geminata* as a food resource when it is present.
- My study also highlights the necessity of combining stable isotope analyses with other approaches, such as lipid analyses.

Future Work

- Gut content analyses of both fish and macroinvertebrates would clarify whether these taxa are consuming *D. geminata* or small diatoms that attach themselves to *D. geminata* stalks (Fig. 4).

Figure 4. *Didymosphenia geminata* cells and stalks with attached (epiphytic) diatoms. Figure modified from Spaulding and Elwell 2007.