Mary Coyle

Student Corner

Your Ugly Algae Neighbor: Rock Snot, A Native Nuisance

Appearing in rivers like an alien invader, *Didymosphenia geminata* has garnered universal disgust, frustration and the worst nickname of all algal species, "rock snot." This stalked diatom is notorious for unsightly, grayish-brown mats that form along the bottom of oligotrophic rivers and streams (Figure 1).These mats range from small tufts along the apical surface of substrate to mats that cover the entire stream or river bottom to depths exceeding 20 cm. Due to the physical structure of the stalks, *D. geminata* mats have a significant impact on the aesthetic and biological characteristics of river systems.

Beyond its unsightly appearance, *D. geminata* nuisance mats snag fishing gear and alter macroinvertebrate community structure and near-substrate hydrology. Sections of rivers that have heavy mat coverage have decreased densities of taxa of large-bodied macroinvertebrates of Ephemeroptera (mayflies), Plecoptera (stone flies), and Trichoptera (caddis flies), known as EPT taxa, while the density of small-bodied taxa such as Chironomidae (midges) increased. This could alter the composition of local fisheries by reducing prey abundance for those species that key in on large EPT taxa. However, while the appearance of these infuriating mats may mimic an invasion, this diatom may, in fact, be a red flag of changes in the environment at a global scale.

Figure 1. Didymosphenia geminata *on stream bottom rock (A) and nuisance mat (B) in the Kootenai River, Libby, MT.*

Background

Counter to the typical occurrence of nuisance algae in systems with high nutrients, *D. geminata* forms nuisance mats in winter in cold rivers with low nutrient concentrations (especially phosphorus – P), high light availability, and stable bedrock. These habitat conditions are commonly found below dams, leading to a high prevalence of nuisance mats in the tailwaters of impounded systems. While predominantly a lotic (flowing water) issue, nuisance mats have been known to occur at lake outlets and along shorelines that have significant wave action.

Historically, the occurrence of *D. geminata* mats has been observed throughout Europe since the mid-19th century. However, these mats generally persisted for a short period of time resulting in little public attention. The current *D. geminata* mats that are receiving attention throughout the United States and other parts of the world are of a different nature. These "nuisance mats" are defined as those that extend >1km that persist for several months of the year (Spaulding and Elwell 2007). The Kootenai River in northwest Montana, USA has mat coverage over 70 percent of the river bed that extends at least 32 river kilometers downstream of Libby Dam, while patchy mat coverage continues for another 49 km downstream and persists for 10 months out of the year (Figure 2). Impounded by Libby Dam, the tailwaters of the Kootenai River, where mat coverage is greatest, has an average soluble reactive phosphorus (SRP) concentration below detection (0.5 µg/L) and nitrate + nitrite concentrations >200 µg/L. Nitrogen concentrations in the Kootenai River have steadily increased over the past nine years and are predicted to continue to rise as a result of upstream anthropogenic activities in the watershed.

Native Nuisance vs. Invasive Status

As a microscopic member of the aquatic community, a shift to a highly noticeable macroscopic state is noteworthy. However, without a historical reference of *D. geminata* as part of the periphyton, the occurrence of mats results in a public perception that an

Figure 2. Photograph of the Kootenai River bottom with >80% Didymosphenia geminata*, nuisance coverage (A). Close up of nuisance mat,"rock snot"(B).*

invasion is underway. Unfortunately, this misconception has led to the widespread belief that the species is an invasive in the United States. Historically, *D. geminata* was described as a rare diatom located only at northern latitudes and it was not considered an invasive until extensive nuisance mats were recorded from New York to Montana in the 1990s and 2000s.

In 1989, persistent, nuisance mats were first recorded throughout central Vancouver Island, Canada, in pristine river systems and an association was made between the presence of mats to popular fishing locations (Bothwell et al. 2009). Further tests showed that *D. geminata* cells could remain viable in damp felt-soled waders for 50 days (Kilroy et al. 2007), confirming the plausibility that anglers and other recreationists were moving this diatom among rivers. However, as mats have continued to appear and research has matured, patterns have begun to emerge and the concept of this species being an invasive in the northern hemisphere is being refuted, especially given historical recorded dating to 1866 confirming its presence in Montana. Rather, changes in water quality conditions are being linked to the presence of nuisance mats. To investigate this hypothesis throughout a *D. geminata* mat affected region, I examined the commonality of this diatom and its prevalence for nuisance mats throughout the intermountain northwest.

Regional Distribution

Algal scrapings were collected from sites across Montana and Idaho with an emphasis on areas with records of visual sightings of mats. To increase the area sampled, I enlisted the assistance of federal (USFS, EPA, USGS) and state agencies (Montana Fish, Wildlife and Parks and Idaho Department of Fish and Game), private individuals (e.g., fly fishers or interested citizens), and personnel from non-governmental organizations (NGOs) such as Trout Unlimited (TU), Kelly Creek Fly Casters (KFC), and the Federation of Fly Fishers (FFF). PowerPoint presentations were given to several of the larger organizations (TU Libby, KFC, and IDFG) to disseminate information about the ecology of *D. geminata*, methods to collect samples, and how to identify *D. geminata* mats.

Volunteers were asked to collect a scraping of algae from various depths and rocks at one location to provide a diverse sample. The sample was placed in a 15 ml centrifuge tube at least ¼ to ½ full, labeled with the name of the river, date, and location. Other information such as the presence of a mat, amount of shade and size of the water body were also recorded on data sheets accompanying each tube. Tubes with samples preserved with Lugol's iodine and the data sheet were then mailed to me at the University of Idaho for analysis.

To analyze the samples, I examined multiple subsamples from each sample by placing approximately 5–8 mL onto a glass microscope slide, covering it with a cover slip and examining them with the aid of a compound microscope at 120×. If 5 or more cells of *D. geminata* were found, a positive detection was recorded. A digital photograph (Figure 3) was taken of the cell and the remaining algae scraping was dried on an index card to create a voucher for that sample. Photograph number, stream characteristics, and coordinates were all recorded on the envelope that held the algae scraping. Characteristics viewed in the subsample such as presence of stalk material from the *D. geminata* cells were also recorded. All data were then entered into a Microsoft Access database that will be available online to researchers or interested parties within the next year.

D. geminata detections from this study and Tait (2010) were plotted on a GIS map with ArcMap v. 10.2.2. This map provides a reference of *D.geminata*

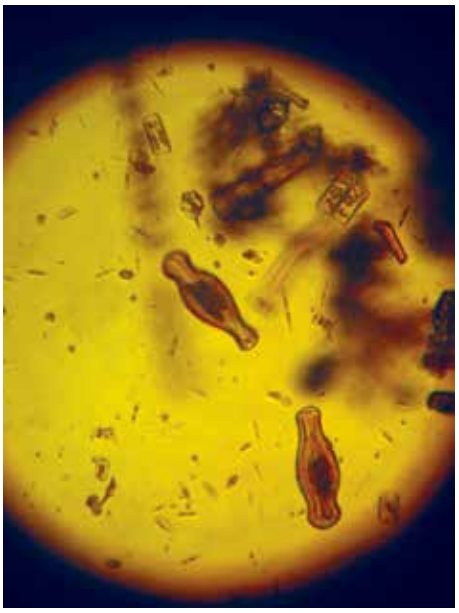

Figure 3. Didymosphenia geminata *cells in an algae scraping from Cedar Creek in northwest Montana 2014.*

presence throughout the U.S. in 2014. From the algae scrapings and sequential mapping of *D. geminata* cells, the commonality of this algal species in the region has been clarified (Figure 4). Of the 127 creeks and rivers surveyed in Idaho and Montana, 52 percent had *D. geminata* as part of the algal community. Of those with *D. geminata*, only 32 percent had visible mats, while 68 percent of the rivers had *D. geminata* as a normal member of the periphyton community (Figure 4). This survey clearly demonstrated that *D. geminata* is common throughout the region and usually occurs in a "well-behaved," non-nuisance/non-mat phase. Data collection and synthesis will continue throughout 2015 to increase our understanding of the species throughout the United States.

A Native Nuisance

As this study has shown, *D. geminata* is common throughout the intermountain northwest. Supporting the historical records of *D. geminata* as native species in Idaho and Montana, the question remains, what shifts in the environment, including possible changes in water quality, causes *D. geminata* to move into a nuisance mat-forming phase from a well-behaved member of the periphyton community? What threshold is the trigger? And finally, what, if anything, can be done to reverse this trend across the landscape?

Limiting Nutrients

Phosphorus limitation (< 2 µ/L) has been strongly linked to nuisance mat growth (Kilroy and Bothwell 2012). Given phosphorus concentrations have remained relatively stable in the Kootenai River, a potential mechanism increasing P limitation may be increases in nitrogen from atmospheric and terrestrial sources. Globally, nitrogen production for agriculture, from the consumption of fossil fuels, and from other human activities has reached all-time highs within the last decade (Gu et al. 2013). This massive shift has had wide-reaching effects on the nitrogen cycle, including increased wet and dry nitrogen deposition. This increase of nitrogen within lentic and lotic systems has the potential to affect the N:P ratio, resulting in phosphorus limitation.

To evaluate this hypothesis, I conducted mesocosm studies near Libby Dam, Montana, investigating phosphorus enrichment as a management strategy study in March to September, 2013 and January to May, 2014. Results from these studies clearly showed that P enrichment suppressed the stalk growth of *D. geminata* at all concentrations (0.5, 1.5, 2, 3, 5 and 8 µg/L) of P added, and that algal diversity and biomass increased significantly.

To provide a complete story, a mesocosm study investigating the response of mats to changes in the nitrogen to phosphorus ratio is currently underway. This study will help determine if increasing nitrogen in an already phosphorus limited system will continue to lead to increasing nuisance mats or if

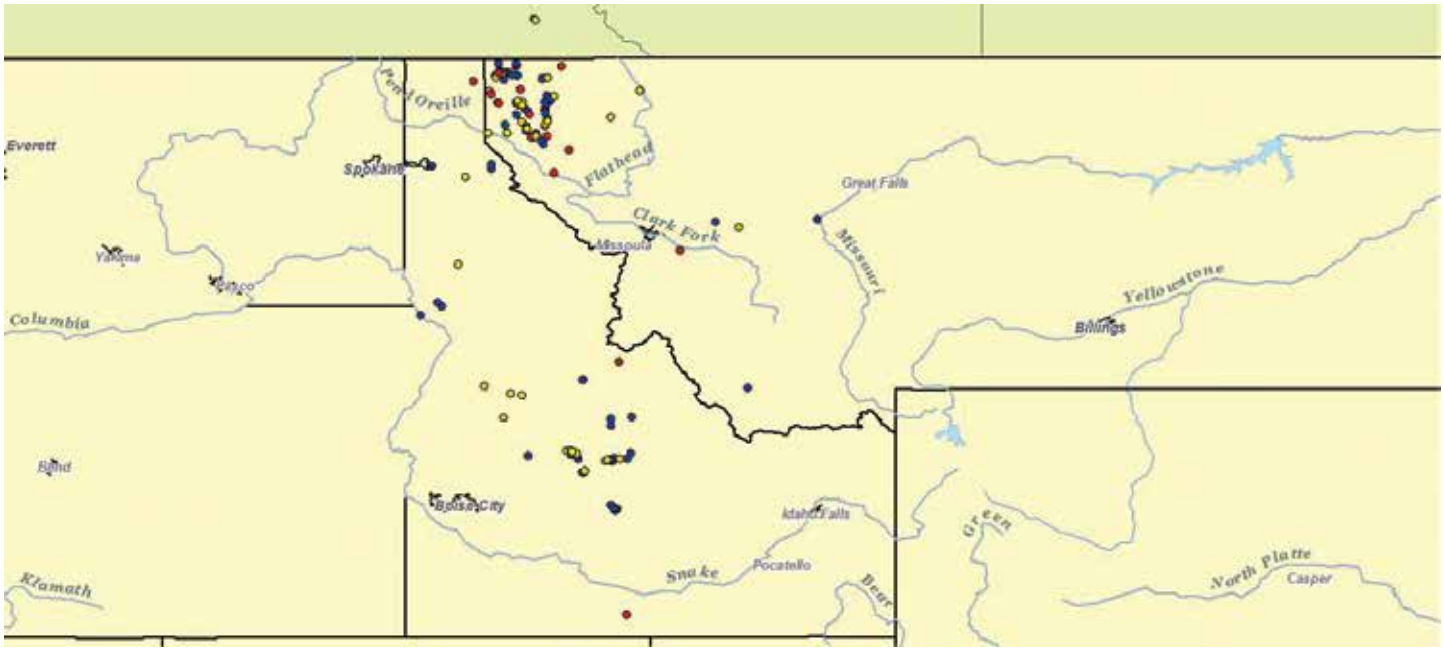

Figure 4. Didymosphenia geminata *distribution throughout Idaho and western Montana collected by authors and volunteers. Yellow dots are confirmed presence of* D. geminata *cells with no mat presence. Red dots are confirmed presence of cells and mats of* D. geminata *and blue dots are algal scrapings that were negative for* D. geminata.

the threshold has already been reached. At the conclusion of these studies, my goal is to be able to make recommendations for the management of *D. geminata* mats in the Kootenai River.

Conclusion

D. geminata is an unsightly nuisance that many wish would just wash away. However, this diatom may be an indicator of a much larger environmental issue. Understanding the driving mechanism behind the dramatic shift of the microscopic native diatom to the ugly macroscopic nuisance is essential to identify viable management strategies and understand ecosystem health. While the Kootenai River has an extensive water quality dataset, for most river systems with significant *D. geminata* nuisance mats, long-term water quality data are patchy or non-existent, making it difficult to detect consistent and widespread regional trends. To further understand this complex issue, efforts to compile mat (nuisance or otherwise) locations, cell locations, and related water quality data are imperative. Understanding global environmental health trends is an enormous undertaking but by working to understand this perplexing diatom, I aim to gain valuable insights.

If you are interested in providing algae scrapings for *D. geminata* detections and the Didymo Database, please contact Mary Coyle at rocksnotresearch@gmail.com.

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Mary Coyle is a Ph.D. student of natural resources at the University of Idaho. A native of McCall, Idaho, and a fly fishing enthusiast, she is passionate about restoring and protecting water resources throughout the Pacific Northwest. Her graduate research is focused on developing management strategies for Didymo nuisance mats in the Kootenai River of Libby, MT.

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