

Benthic macroinvertebrate survey of Oaks Creek, Otsego County, NY, during the initial stages of zebra mussel (*Dreissena polymorpha*) colonization

Lee Hingula¹

INTRODUCTION

An increasingly prevalent problem in New York State is the further dispersal of *Dreissena polymorpha*, the exotic zebra mussel from central Europe. Steps have been made to control, monitor and minimize the spread of this species. In spite of efforts to prevent its spread, the zebra mussel has increased its range throughout the state. While the economic impacts of *D. polymorpha* are well documented, its impact on biodiversity is not well understood. Information on the effect of zebra mussels on fast flowing streams is particularly scarce. It has been suggested that such streams not particularly prone to heavy infestations (i.e., Horvath et al. 1996). However, in the past two years, researchers have noted the increasing presence of zebra mussel veligers in fast flowing streams (i.e., Gray 2005).

In 2002, adult zebra mussels were collected from Canadarago Lake, Otsego County, NY (Horvath and Lord 2003). The lake is drained by Oaks Creek which joins the Susquehanna River approximately 22 Km from its source. The goal of this research is to establish a record of the macrobenthic invertebrate community found on rocks in Oaks Creek prior to zebra mussel colonization in order to provide future researchers with preliminary data for comparison should zebra mussels become well established there. While some adult mussels were documented in the stream during summer 2004, their densities were well below that which were expected to impact the existing benthic fauna.

BACKGROUND

Zebra mussels (*Dreissena polymorpha*) are bivalves that can approximate the size of a thumbnail. They have light and dark stripes across their shells and are highly genotypically and phenotypically plastic, as suggested by the specific epithet, *polymorpha*. Adults attached to hard objects release gametes into the water column that, following fertilization, become free swimming larval trochophores (Maxwell 1992). Trochophores gradually metamorphose into veligers and finally settle on the bottom as juveniles. Larval stages are free floating for two to three weeks and can develop from egg to adult in less than three months (Maxwell 1992). Adults attach to any hard substrate by means of byssal threads which are protein fibers. Zebra mussels can clog water pipes and boat engines thereby costing millions of dollars in control and removal.

¹ SUNY Oneonta Faculty Research Grant and Summer Fellowship Program intern, summer 2004. Present affiliation: Vassar College.

Zebra mussels are capable of altering the ecology of aquatic ecosystems through their high fecundity, feeding habits and high densities. Once introduced into an area, zebra mussels can reach densities of several thousand adults per m². In the western basin of Lake Erie, populations of adults and juveniles approached 400,000/m² in 1990 (Griffiths 1993). The resultant filter feeding habits clarify the water, increasing the depth of the photic zone, allowing macrophytes to grow at greater depths and changing the ecology of water bodies (Griffith 1993). Zebra mussels outcompete native bivalves which are far less fecund. They also can directly attach to the hard shells of native unionids. Once attached, zebra mussels can impede water flow through their siphons resulting in the starvation of the host. In one study, infested unionids exhibit higher ammonia excretion rates, lower respiration to nitrogen excretion ratios and lower carbohydrate to protein contents, indicating that the unionids were starving (Baker and Hornbach 2000). Even when zebra mussels are attached in low numbers or not attached at all, unionid mortality rates can be high, suggesting that reduced food levels are responsible (Baker and Hornbach 2000). It is assumed by many researchers that zebra mussels increase the overall biomass of macrobenthic invertebrates; Wiktor (1969) noted that biomass of chironomids and amphipods doubled near zebra mussel colonies. Many species are negatively impacted, which suggests that while biomass increases, species richness and diversity will likely decrease in infested waters.

Oaks Creek is a fast flowing stream located in Otsego County, NY. It flows from Canadarago Lake southeast into the Susquehanna River, a distance of approximately 22 km (13.8 miles). Oak Creek's width varies from about 8 m to 15 m. The substrate is rocky in the fast flowing water and muddy in pools and at its beginning in Canadarago Lake. There is limited submerged vegetation, save some periphyton, and what little emergent vegetation is in the creek is located near its headwaters (personal observation). water quality data collected in Oaks Creek (Fickbohm 2003) implies that conditions are well within the ranges suitable for zebra mussel infestations.

I hypothesized that organisms found on the rocks would mostly be in the orders Ephemeroptera, Plecoptera and Trichoptera, in concert known as EPTs, which are indicative of clean, fast flowing water. I assumed that there were likely to be few organisms found from other orders such as Odonata, Hemiptera or Coleoptera since they prefer lentic water with submergent or emergent vegetation. Zebra mussels will likely have the greatest impact on the EPTs because they are also found primarily on hard substrata. Whether zebra mussels will increase EPT populations by increasing the surface area of suitable EPT substrate or whether they will cause decreases in EPT populations by changing the food web has yet to be examined and is one of the aims of this study.

METHODS AND MATERIALS

Nine sites were selected on Oaks Creek in Otsego County based on proximity to Canadarago Lake, depth, water current speed, accessibility and substrate composition.

Sites were no more than 1 meter deep and had rocky substrates. At each site, a transect was plotted across the stream. Transects were plotted at runs and riffles, but pools were not sampled due to their soft bottoms, though otherwise would be ideal water conditions for zebra mussel colonization. Each site was sampled three times during the summer of 2004. On 21 June, sites 1-4 were sampled and 5-9 were sampled in 22 June. On 6 July, sites 1-4 were sampled and on 7 July, sites 5-9 were sampled. Sites 1-5 were sampled on 19 July and sites 6-9 on 20 July.

Samples of macrobenthic invertebrates were collected from ten rocks across each transect. After a rock of suitable size was selected, a kick net with a diameter of 27 cm was placed at the most downstream part of the rock. The rock was lifted into the net and gently rubbed so that organisms would be dislodged and flow into the net. Samples were bagged in Whirl Paks[®] and treated with 70% ethanol for preservation. Rock size and transect location were recorded on each bag.

In the laboratory, organisms from each sample were identified according to Merritt and Cummins (1996) and Peckarsky et al. (1990). Each sample's contents were put into 6 or 8 dram vials and preserved in 70% ethanol. Mean density was determined for each transect. Surface areas were calculated from measurements of length x width x height by assuming rocks were rectangular cubes using the formula of $2x(\text{length} \times \text{width}) + 2x(\text{length} \times \text{height}) + 2x(\text{width} \times \text{height}) = \text{total surface area}$.

An Excel[®] spreadsheet was used to calculate the Brillouin Index for each transect of each sampling date. The index was calculated using the formula $H = \frac{1}{N} \log\left(\frac{N!}{n_1!n_2!n_3!..}\right)$ where H is the Brillouin's Index, N is the total number of individuals in the transect, $n_1!$ is the number of individuals belonging to species 1, $n_2!$ is the number of individuals belonging to species 2, and so on (Maxwell 1992).

Transect #	GPS location	Description
1	N 42° 40.240' W 75° 00.768'	Shallow stream site on Keating Rd.
2	N 42° 43.947' W 75° 00.274'	Steep embankment on southern part of Keating Rd.
3	N 42° 43.838' W 75° 00.135'	Bridge at intersection of Hoke and Keating
4	N 42° 43.335' W 75° 00.292'	Bridge on Route 28 in Oaksville
5	N 42° 42.368' W 74° 59.156'	Private residence on Bissel Rd.
6	N 42° 42.127' W 74° 58.522'	Bridge over Fork Shop Rd.
7	N 42° 41.283' W 74° 57.453'	Steep embankment at intersection of Routes 59 & 26
8	N 42° 40.967' W 74° 57.476'	Closed bridge on Lower Toddsville Rd
9	N 42° 39.993' W 74° 57.548'	Bridge on Route 28 in Index

Table 1. Location and description of each transect.

RESULTS

A total of 3,615 organisms were processed. There were representatives from 47 genera in 34 families in 13 orders. Tables 2, 3, and 4 describe the average number of organisms per dm² of rock surface area for date sampled, respectively. Tables 5, 6, and 7 give the Brillouin Index values for each transect during each of the three sampling periods, respectively. These values are an index of diversity, which provide insight into the sensitivity to changes of the rare species in the creek (Maxwell 1992).

Transect	Date	Density (organisms/dm ²)
1	6/21/2004	1.66
2	6/21/2004	0.572
3	6/21/2004	0.402
4	6/21/2004	3.10
5	6/22/2004	1.73
6	6/22/2004	3.35
7	6/22/2004	3.17
8	6/22/2004	1.85
9	6/22/2004	1.59

Table 2. Densities of benthic macroinvertebrates from Oaks Creek on 21 June and 22 June. Surface area is calculated as $2x(\text{length} \times \text{width}) + 2x(\text{length} \times \text{height}) + 2x(\text{height} \times \text{width})$, under the assumption that rocks are shaped like rectangular cubes.

Transect	Date	Density (organisms/dm ²)
1	7/6/2004	3.96
2	7/6/2004	2.98
3	7/6/2004	1.32
4	7/6/2004	2.04
5	7/7/2004	1.54
6	7/7/2004	3.05
7	7/7/2004	3.13
8	7/7/2004	1.86
9	7/7/2004	2.20

Table 3. Density of benthic organisms from Oaks Creek on 6 July and 7 July. Surface area is calculated as $2x(\text{length} \times \text{width}) + 2x(\text{length} \times \text{height}) + 2x(\text{height} \times \text{width})$, under the assumption that rocks are shaped like rectangular cubes.

Transect	Date	Density
----------	------	---------

		(organisms/dm ²)
1	7/19/04	0.396
2	7/19/04	1.04
3	7/19/04	0.71
4	7/19/04	1.38
5	7/19/04	1.23
6	7/20/04	1.83
7	7/20/04	1.65
8	7/20/04	1.86
9	7/20/04	1.59

Table 4. Density of benthic organisms from Oaks Creek on 19 July and 20 July. Surface area is calculated as $2 \times (\text{length} \times \text{width}) + 2 \times (\text{length} \times \text{height}) + 2 \times (\text{height} \times \text{width})$, under the assumption that rocks are shaped like rectangular cubes.

Transect	Date	Brillouin's Index
1	6/21/04	0.426
2	6/21/04	0.851
3	6/21/04	0.139
4	6/21/04	0.367
5	6/22/04	0.633
6	6/22/04	0.549
7	6/22/04	0.698
8	6/22/04	0.884
9	6/22/04	0.847

Table 5. Brillouin Indices for the benthic communities collected on 21 June and 22 June in each transect.

Transect	Date	Brillouin's Index
1	7/6/04	0.630
2	7/6/04	0.554
3	7/6/04	0.554
4	7/6/04	0.433
5	7/7/04	0.576
6	7/7/04	0.542
7	7/7/04	0.699
8	7/7/04	0.817
9	7/7/04	0.826

Table 6. Brillouin Indices for the benthic communities collected 6 July and 7 July.

Transect	Date	Brillouin's Index
1	7/19/04	0.572

2	7/19/04	0.757
3	7/19/04	0.403
4	7/19/04	0.566
5	7/19/04	0.653
6	7/20/04	0.745
7	7/20/04	0.846
8	7/20/04	0.797
9	7/20/04	0.782

Table 7. Brillouin Indices for the benthic communities collected 19 July and 20 July.

Table 8 shows where each taxon was found over the date Oaks Creek was sampled. Order, family and genus are listed taxonomically and a “+” indicates transects where those taxa were located.

DISCUSSION

The data suggest a macrobenthic invertebrate community in Oaks Creek composed mostly of mayflies (Ephemeroptera) and caddis flies (Trichoptera). Other taxa found (Decapoda, Megaloptera, Plecoptera, Diptera) were rare, and some taxa (Odonata, Hemiptera) were extremely rare. Consistently high densities were observed at transect 1 for all three samplings and low densities at transect 3, but nothing significant was found to suggest a pattern of increasing or decreasing density among transects. Statistical data suggest a relatively high species richness in most of the transects sampled. Brillouin Index values always fall between 0 and 1, with 1 being the highest species richness possible (where all species occur in equal numbers), and 0 being the lowest, and all but three values exceed 0.5. The high number and diversity of ETPs attests to Oaks Creek’s high biodiversity. Overall, the findings are congruent with the original hypotheses and there is nothing in the data to suggest abnormalities in the communities surveyed.

Order	Family	Genus	1	2	3	4	5	6	7	8	9
Ephemeroptera	Baetidae	<i>Baetis</i>	+								
Ephemeroptera	Baetidae	<i>Heterocloeon</i>						+	+	+	+
Ephemeroptera	Ephemerellidae	<i>Drunella</i>									+
Ephemeroptera	Ephemerellidae	<i>Ephemerella</i>								+	+
Ephemeroptera	Heptageniidae	<i>Epeorus</i>		+		+	+	+	+	+	+
Ephemeroptera	Heptageniidae	<i>Stenacron</i>	+	+	+		+			+	+
Ephemeroptera	Heptageniidae	<i>Stenonema</i>	+	+	+	+	+	+	+	+	+
Ephemeroptera	Oligoneuriidae	<i>Isonychia</i>		+	+	+	+	+	+	+	+
Ephemeroptera	Siphonuridae	<i>Ameletus</i>				+					
Odonata	Coenagrionidae	<i>Argia</i>				+	+				
Plecoptera	Chloroperlidae	<i>Utaperia</i>									
Plecoptera	Perlidae	<i>Acroneuria</i>				+	+	+	+	+	+
Plecoptera	Perlidae	<i>Neoperia</i>					+	+	+	+	+
Hemiptera	Veliidae	<i>Microvelia</i>					+				
Hemiptera	Veliidae	<i>Rhagovelia</i>					+				+
Trichoptera	Hydropsychidae	<i>Cheumatopsyche</i>	+	+	+	+	+	+	+	+	+
Trichoptera	Hydropsychidae	<i>Hydropsyche</i>	+	+	+	+	+	+	+	+	+
Trichoptera	Polycentropodidae	<i>Cyrnellus</i>		+							
Trichoptera	Polycentropodidae	<i>Neureclipsis</i>		+	+	+		+	+	+	+
Trichoptera	Polycentropodidae	<i>Paranyctiophalax</i>								+	+
Trichoptera	Psychomyiidae	<i>Psychomyia</i>	+						+		
Trichoptera	Lepidostomatidae	<i>Lepidostoma</i>								+	
Trichoptera	Limnephilidae	<i>Apatania</i>	+	+	+	+	+	+	+	+	+
Trichoptera	Limnephilidae	<i>Pychnopsyche</i>		+						+	+
Trichoptera	Glossosomatidae	<i>Glossosoma</i>		+				+	+	+	+
Trichoptera	Rhyacophilidae	<i>Rhyacophila</i>			+				+	+	+
Coleoptera	Curculionidae	Unknown				+					
Coleoptera	Elmidae	<i>Ancyronyx</i>	+	+	+		+	+	+	+	+
Coleoptera	Elmidae	<i>Stenelmis</i>									+
Coleoptera	Psephenidae	<i>Ectopria</i>					+				
Coleoptera	Psephenidae	<i>Psephenus</i>	+	+	+	+	+	+	+	+	+
Megaloptera	Corydalidae	<i>Nigronia</i>	+	+			+	+		+	+
Diptera	Ephydriidae	<i>Ephydra</i>	+								
Diptera	Pelecorhynchidae	<i>Glutops</i>							+		
Diptera	Chironomidae	Unknown	+	+	+	+	+	+	+	+	+
Diptera	Simuliidae	<i>Prosimulium</i>	+								
Diptera	Tipulidae	<i>Antocha</i>	+	+				+		+	+
Diptera	Unknown	Unknown		+				+	+		+
Amphipoda	Gammaridae	<i>Gammarus</i>	+		+						
Decapoda	Cambaridae	<i>Orconectes</i>		+	+	+	+	+		+	
Isopoda	Asellidae	<i>Caecidotea</i>	+								
Basommatophora	Ancylidae	<i>Laevapex</i>					+				
Basommatophora	Physidae	Unknown					+				
Basommatophora	Pleuroceridae	<i>Elmia</i>					+	+			
Veneroidea	Dreissenidae	<i>Dreissena</i>	+	+	+	+	+			+	+

Table 8 Taxa list. Each taxon is listed phylogenetically according to Peckarsky (1990). A “+” indicates the presence of the named species in each of the transects, labeled 1-9.

Certain factors may have skewed the data slightly. Of note is the assumption that rocks were shaped like rectangular cubes. This technique provides units of statistical significance and facilitates the measurement process. It does not take into account that there may have been crevices in the rocks to increase suitable habitat, and that the rocks were mostly ovoid in shape, decreasing the surface area. This may add a margin of error, and for consistency's sake the same procedure should be used for future studies on Oaks Creek. The paucity of organisms collected during on 19 July and 20 July is probably due to the high amount of rain that fell just prior to sampling. The water level was observed to be at least 10 cm higher and the water was faster. Organisms on the rocks were likely swept off in the current due to the change in conditions.

It is yet to be determined the extent to which zebra mussels will colonize Oaks Creek. Should they successfully colonize, this report provides baseline information on benthic communities, allowing for the assessment of the zebra mussel's impact in such an environment. Studies will likely show that such streams are important conduits for zebra mussel dispersal (see Gray in prep.; Armstrong 2005). Even if only a small fraction of veligers are able to withstand the mechanical challenges of fast flowing water their near constant introduction by even small numbers of adults make downstream dispersal almost inevitable.

REFERENCES

- Armstrong, S. 2005. Survey of veliger and adult zebra mussels (*Dreissena polymorpha*) in Goodyear Lake. In 37th Ann. Rept. (2004). SUNY Oneonta Bio.Fld. Sta., SUNY Oneonta.
- Baker, S.M. and D.J. Hornbach. 2000. Physiological status and biochemical composition of a natural population of unionid mussels (*Amblema plicata*) infested by zebra mussels (*Dreissena polymorpha*). Amer. Midl. Nat.143(2):443-452.
- Fickbohm, S. 2003. Summary of water quality monitoring of the Otsego Lake watershed:1998-2003. Addendum to Tech. Rept. #17. SUNY Oneonta Bio. Fld. Sta., SUNY Oneonta.
- Gray, M.S. 2005. Natural and human-mediated dispersal of zebra mussels (*Dreissna polymorpha*) in the upper Susquehanna River basin of New York. Masters thesis. SUNY Oneonta Biol. Fld. Sta., SUNY Oneonta.
- Griffiths, R.W. 1993. Effects of zebra mussels (*Dreissena polymorpha*) on the benthic fauna of Lake St. Claire. In T.F. Nalepa and D.W. Schloesser (eds.) Zebra Mussels Biology, Impacts and Controls. Lewis Publishers. Boca Raton.
- Horvath, T.G. and Lord P. 2003. First report of zebra mussels in Canadarago Lake. In 35th Ann. Rept. SUNY Oneonta Biol. Fld. Sta., SUNY Oneonta.

- Horvath, T.G., K.M. Martin and G.A. Lamberti. 1999. Effect of zebra mussels, *Dreissena polymorpha*, on macroinvertebrates in a lake-outlet stream. Amer. Midl. Nat. 142(2):340-347.
- Maxwell, L. 1992. The biology, invasion and control of the zebra mussel (*Dreissena polymorpha*) in North America. SUNY Oneonta Bio. Fld. Sta., Occas. Pap. 24. SUNY Oneonta Bio. Fld. Sta., SUNY Oneonta.
- Merritt, R.W., K.W. Cummins. 1996. An introduction to the aquatic insects of North America. 3rd Ed. Kendall/Hunt Publishing Company. Dubuque.
- Peckarsky, B.L., P.R. Frassinetti, M.A. Penton and D.J. Conklin Jr. 1990. Freshwater macroinvertebrates of northeastern North America. Cornell University Press. Ithaca.
- Wiktor, J. 1969. The biology of *Dreissena polymorpha* (Pall.) and its ecological importance in the Firth of Szczecin. Stud. Mat. Morsch. Inst. Ryb. Gdynia, Ser. A, 5:1-88.