Feeding interactions between native freshwater mussels (Bivalvia: Unionidae) and zebra mussels *(Dreissena polymorpha)* in the Ohio River

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Abstract: The effects of zebra mussel infestation on the feeding of native unionids in the Ohio River were evaluated through gut contents and available food in the water column. In 1996, heavily infested *Amblema plicata* (Say, 1817) and *Quadrula pustulosa* (I. Lea, 1831) had significantly less ($p < 0.01$) organic matter in their guts (1.4 and 0.6 mg ash-free dry weight [AFDW], respectively) than lightly infested specimens (4.6 and 1.8 mg AFDW, respectively), and heavily infested *Q. pustulosa* had a significantly lower ($p < 0.05$) mean algal cell number (1.8×10^4) in the guts than lightly infested specimens (3.9×10^5). However, mean algal cell numbers in the guts of heavily infested and lightly infested *A. plicata* (5.7×10^5 versus 9.1×10^5, respectively) were not significantly different ($p = 0.17$). In 1997, significant reductions ($p < 0.05$) in total algal cells and organic matter in gut samples again occurred for heavily versus lightly infested individuals of both species. In addition, gut contents of individual *A. plicata* from one of two sites contained significantly less ($p < 0.05$) organic matter (0.92 versus 4.55 mg AFDW) and fewer algal cells (9.4×10^4 versus 2.3×10^5) than the combined gut contents of all zebra mussels (18-33 mm in length) attached to their shells. Gut analyses also revealed significant diet overlap between native unionids and infesting zebra mussels. Water samples collected from just above the mussel beds in 1997 showed that algal densities and total suspended solids at the heavily infested site (> 360 zebra mussels/m^2) were reduced by more than 50%, when compared to samples collected from the surface. Thus, competitive interactions or interference by zebra mussels likely reduced the availability of algal and detrital food resources for consumption by unionids.

Key words: algae, zebra mussels, unionids, Ohio River, competition

Since its introduction into Lake St. Clair, the zebra mussel, *Dreissena polymorpha* (Pallas, 1771), has greatly reduced phytoplankton and bacterioplankton levels in the Great Lakes (Wu and Culver, 1991; MacIsaac *et al.*, 1992; Cotner *et al.*, 1995; Fanslow *et al.*, 1995; Heath *et al.*, 1995). Phytoplankton levels in Lake Erie, for example, dropped 62-92% (Leach, 1993), and planktonic diatoms decreased 85% despite sufficient nutrients for growth (Holland, 1993). Consequently, Secchi disk transparencies in Lake Erie have increased 85% (Leach, 1993). Phytoplankton grazing by zebra mussels also can alter the composition of the phytoplankton community. In Lake Huron, for example, zebra mussel feeding has shifted dominance from diatoms to filamentous green algae (Lowe and Pillsbury, 1995), and recent studies show selective rejection of the nuisance bluegreen alga *Microcystis* by zebra mussels, such that *Microcystis* becomes dominant in the plankton (H. Vanderploeg, NOAA, pers. comm.)

Zebra mussel colonization of the Great Lakes also has caused dramatic declines in the survival and fitness of native freshwater mussel populations (Hebert *et al.*, 1991; Hunter and Bailey, 1992; Haag *et al.*, 1993; Gillis and Mackie, 1994; Nalepa, 1994; Schloesser and Nalepa, 1994). By attaching to the shells of unionids, zebra mussels can directly affect unionid survival by interfering with feeding, respiration, balance, burrowing, and locomotion (Mackie, 1991; reviewed by Schloesser *et al.*, 1996). Large densities of zebra mussels, however, also can affect unionid survival indirectly by reducing or removing food resources from the water column (Lewandowski, 1976; Hebert *et al.*, 1991; Mackie, 1991; Haag *et al.*, 1993). A large gill-area to body-dry-weight ratio, and a large number of gill cirri in individual zebra mussels, allow for increased filtration efficiency and filtration rate relative to those of native unionids (Silverman *et al.*, 1995). Filtration rates of the freshwater mussel, *Lampsilis siliquoidea* (Barnes, 1823), for example, were found to be only one-tenth the filtration rate of individual zebra mussels (Heath *et al.*, 1995). In laboratory experiments, Baker and Hornbach (1997) reported that *Amblema plicata* (Say, 1817) filtered 74 ml/hr, while the 28 infesting zebra mussels filtered 130 ml/hr as a group. Thus, relatively small populations of zebra mussels can affect the feeding of unionids.

Zebra mussel populations in the lower Ohio River

have achieved densities comparable to those in the Great Lakes (350,000/m^2; A. Miller, USACOE, pers. comm.). Because of documented impacts to the phytoplankton communities and native mussel populations of the Great Lakes, large populations of zebra mussels in the Ohio River could have similar consequences for native mussel populations. Strayer and Smith (1996) found that low zebra mussel infestation rates in the Hudson River were associated with high unionid mortality and hypothesized that reduced food resources might be the cause. No studies, however, have directly confirmed whether zebra mussels affect the feeding of unionids in a riverine environment where organic materials are continually supplied from upstream. Thus, the objective of this study was to determine whether zebra mussels reduce unionid ingestion of phytoplankton and organic matter by (1) ingesting similar food resources, and (2) reducing food resources at the sediment-water interface.

METHODOLOGY

On 23 July 1996, ten specimens each of the threeridge, *Amblema plicata,* and the pimpleback, *Quadrula pustulosa* (I. Lea, 1831), were collected from a lightly infested site on the Ohio River near Parkersburg, West Virginia, which had a mean density of 0.3 zebra mussels/m^2, and a maximum of one zebra mussel/unionid (P. Morrison, USFWS, pers. comm.). On 16 August 1996, ten specimens of *A. plicata* were collected from a heavily infested site near Paducah, Kentucky, which had 3,600 zebra mussels/m^2 (A. Miller, USACOE, pers. comm.). Specimens of *Q. pustulosa* were difficult to find at this site, so on 21 August 1996, ten specimens were collected from another heavily infested site near Maysville, Kentucky, which had 360 zebra mussels/m^2 and a maximum of 92 zebra mussels/unionid (P. Morrison, USFWS, pers. comm.). In the field, mussel bodies were removed from shells, weighed, preserved in 95% ethanol, and transported to the laboratory for analysis.

In 1997, ten specimens each of *A. plicata* and *Q. pustulosa* were collected from a highly infested (370 zebra mussels/m^2) and a lightly infested (< 1 zebra mussel/m^2) site on the Ohio River for gut content analysis. In addition, all zebra mussels, 18-33 mm in length, attached to the shells of *A. plicata* were removed and preserved in 95% ethanol for gut content analysis. Zebra mussels 18-33 mm in length were chosen, because it is difficult to remove the entire gut contents of smaller individuals. At each collection site, water samples with algae were collected from the the surface and overlying the mussel bed, fixed with acid Lugol's solution (Saraceni and Ruggiu, 1969), and placed in settling chambers to compare the density and relative abundance of algal genera using inverted microscopes. Aliquots of 100 ml were then filtered through pre-ashed Whatman GF/F filters, dried (100°C), and ashed (500°C) to determine the ash-free dry weight (AFDW) of seston.

Gut contents of unionids and of zebra mussels attached to *Amblema plicata* were individually removed from each specimen, pooled, then suspended in 3 ml of water, and fixed with 50 µl of acid Lugol's solution for analysis. A 50 µl aliquot of the gut contents was placed on a microscope slide. Ocular grids divided the field of view into 59 transects, and algal cells were counted and identified to genus from two transects using an Ausjena/Nomarsky microscope at 400X. The variability of this semi-quantitative method (± 20%, $\alpha = 0.05$) was determined using ten counts from the same sample. The remaining gut contents were collected on pre-ashed Whatman GF/F filters, dried (100°C), and ashed in a muffle furnace (500°C) overnight to determine AFDW. Mean algal cell numbers and mean AFDW values in the gut samples of each species were compared by ANOVA.

RESULTS

In 1996, significant differences in total algal cells and organic matter were observed in guts of lightly and heavily infested unionids (Table 1). While mean algal cell numbers in guts of lightly and heavily infested *Amblema plicata* (5.7 x 10^5 versus 9.1 x 10^5 cells) were not significantly different ($p = 0.17$), the gut contents of lightly infested *A. plicata* had significantly more ($p < 0.01$) organic matter (4.6 mg AFDW) than heavily infested specimens (1.4 mg AFDW). Heavily infested *Quadrula pustulosa* showed significantly lower ($p < 0.05$) organic matter and mean algal cell number (0.6 mg AFDW and 1.8 x 10^4 cells, respectively) than lightly infested specimens (1.8 mg AFDW and 3.9 x 10^5 cells, respectively).

In 1997, significant reductions in organic matter content and total algal cells also were observed in guts of heavily infested unionids (Table 2). Organic matter content and total algal cells were significantly lower ($p < 0.05$) in the guts of heavily infested *Amblema plicata* (0.9 mg

Table 1. Mean algal cell number and ash-free dry weight (AFDW; ± SD) in guts of *Amblema plicata* and *Quadrula pustulosa* heavily infested (H) and lightly infested (L) with zebra mussels, July-August 1996.

Species	N	Algal Cell Number	AFDW (mg)
A. plicata (L)	11	9.1 x 10^5 ± 6.0 x 10^5	4.6 ± 0.9
A. plicata (H)	10	5.7 x 10^5 ± 4.9 x 10^5	1.4 ± 0.7
Q. pustulosa (L)	10	3.9 x 10^5 ± 2.8 x 10^5	1.8 ± 1.0
Q. pustulosa (H)	10	1.8 x 10^4 ± 9.2 x 10^3	0.6 ± 0.3

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