

The Effects of *Dreissena polymorpha* on *Campeloma decisum*'s Righting Ability and Lateral Movement

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Abstract

The introduction of the zebra mussel (*Dreissena polymorpha*) has had major economic and ecological implications, fouling pipes and exacerbating the declines of native freshwater mollusks. This study examines the effects of *D. polymorpha* biofouling on the fitness of *Campeloma decisum*, using lateral movement and righting ability, as proxies for fitness. We collected *C. decisum* from Douglas Lake in Cheboygan County, Michigan, and tested them in aquaria filled with sand and lake water. We found that *D. polymorpha* significantly aided snail righting ability. Also, *D. polymorpha* was shown to both hinder and assist lateral movement, with inhibiting effects being stronger and more prevalent. To test the effect of captivity on snail behavior, an additional sample set was tested using the same methods. We found captivity did have an effect on righting ability, but did not have a significant effect on lateral movement. Our findings support previous research suggesting *D. polymorpha* can have positive and negative effects on *C. decisum* fitness (Albalak & Lamb 2005, Tucker 1994, Stewart & Haynes 1994).

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The introduction of the zebra mussel (*Dreissena polymorpha*) has had major economic and ecological implications, fouling pipes and exacerbating the declines of native freshwater mollusks. This study examines the effects of *D. polymorpha* biofouling on the fitness of *Campeloma decisum*, using lateral movement and righting ability, as proxies for fitness. We collected *C. decisum* from Douglas Lake in Cheboygan County, Michigan, and tested them in aquaria filled with sand and lake water. We found that *D. polymorpha* significantly aided snail righting ability. Also, *D. polymorpha* was shown to both hinder and assist lateral movement, with inhibiting effects being stronger and more prevalent. To test the effect of captivity on snail behavior, an additional sample set was tested using the same methods. We found captivity did have an effect on righting ability, but did not have a significant effect on lateral movement. Our findings support previous research suggesting *D. polymorpha* can have positive and negative effects on *C. decisum* fitness (Albalak & Lamb 2005, Tucker 1994, Stewart & Haynes 1994).

Introduction:

The transformation of the Laurentian Great Lakes into a major shipping route has brought with it many unintended consequences, most notably in the form of invasive species. Introductions of invasive species such as the sea lamprey (*Petromyzon marinus*), round goby (*Neogobius melanostomus*) and zebra mussel (*Dreissena polymorpha*), have come with great economic costs. Annual losses to the region have recently been projected to be over \$200 million (Lodge and Finnoff 2008). Of these invaders, *D. polymorpha* has been particularly successful, spreading throughout the Great Lakes region, Mississippi River drainage, and parts of the Southwestern United States via commercial and recreational watercraft (Benson and Raikow 2009). Research in the Great Lakes region suggests that *D. polymorpha* presence may severely decrease or eliminate snails and other fauna (Ricciardi et al. 1997)

The life history of *D. polymorpha* makes it well adapted to anthropogenic dispersal. Gametes are released into the water column for fertilization, and the free-swimming larvae, or

veligers, remain suspended for 1-9 weeks while developing. Once this pelagic phase is complete the veligers settle out and attach to hard surfaces, such as rocks, macrophytes, and various benthic organisms, with byssal threads. Thus, *D. polymorpha* may be transported in its larval stage in ballast or live-well water, or in the adult stage on the hulls of vessels (Strayer 1999). Large populations of *D. polymorpha* have been shown to decimate populations of phytoplankton and small zooplankton (Nichols and Hopkins 1993) and substantially change composition and abundance of benthic communities by doubling some species while halving the quantities of others (Stewart and Haynes 1994). Although many studies have demonstrated the negative impacts of *D. polymorpha* biofouling on native freshwater unionids, only a handful of studies have documented their effect on native freshwater gastropods.

D. polymorpha biofouling has been shown to increase abundances of native snail species (Stewart and Haynes 1994), likely due to increases in benthic food sources in the form of feces and pseudofeces (Stewart et al. 1998). However, snail fitness may be negatively impacted as zebra mussels foul snails, possibly increasing stress and mortality (Tucker 1994). In 2005, Albalak and Lamb found that *D. polymorpha* had a significant negative impact on growth rate and burrowing depth of *Campeloma decisum*, a detritivorous viviparid snail that plays an important role in cycling matter and nutrients through the ecosystem (Townshend, Begon and Harper 2008). However, other effects of *D. polymorpha* on *C. decisum* fitness have yet to be studied. Biofouling may decrease a snail's ability to right itself if upended, wasting energy that may have been spent on foraging and perhaps leading to increased vulnerability to predation. *D. polymorpha* biofouling may also decrease snail fitness by limiting lateral movement. This study seeks to examine whether fouling by *D. polymorpha* significantly affects aspects of *C. decisum* locomotion. This is accomplished by testing the mussels' impact on righting abilities, as well as lateral movement.

Materials and Methods

Campeloma decisum that were biofouled with at least one zebra were collected from flats on the eastern shore of South Fishtail Bay on Douglas Lake in Cheboygan County, Michigan. The collection area was 26° C, less than a meter in depth and consisted of sand and silt substrate. Both *C. decisum* specimens on the surface and buried below were collected, in order to achieve a random sample. All snails were placed in a bucket filled with sand and lake water to minimize

stress. Fifty-five *C. decisum* in total were collected. Following collection, specimens were marked with an identification number using white Testor's paint. Shell length and width as well as aperture length and width were measured with calipers. The number of individual *D. polymorpha* on each snail was noted in order to aid with identification. Specimens were then put into four 10-gallon aquariums filled with lake water and sand retrieved from Douglas Lake. Natural ambient light was used to replicate typical conditions. The temperature of the water in each tank was noted during each trial and remained between 14° - 16° Celsius.

To see whether *D. polymorpha* affected *C. decisum* righting ability, 12 snails were placed equidistant from each other in a tank with a thin layer of sand. Snails were placed with their apertures facing up. After 10 minutes elapsed, each specimen's righting performance was noted. This trial was repeated for all specimens.

To address our question of whether *D. polymorpha* affected *C. decisum* lateral movement, 12 *C. decisum* were placed equidistant from each other with their apertures facing down in a tank filled with lake water and a thin layer of sand to prevent burrowing. Noting their starting positions, *C. decisum* were then left for one hour. After one hour elapsed, the horizontal distance traveled by each *C. decisum* was measured by placing a string along the length of each snail's trail. String length was measured with a ruler. The same process was conducted again until all snails were tested.

After preliminary trials were completed, all *D. polymorpha* were removed from *C. decisum* shells using a razor blade. The wet weight of each *C. decisum* and all *D. polymorpha* previously attached to the snail was taken. The righting time and distance-traveled was retested on all 55 snails.

After recognizing that the conditions of captivity may have contributed to snail behavior, a trial focusing on captivity effects was performed. An additional sample set was collected and measured using the same procedures as before. These biofouled specimens were put through both the righting ability trial and the lateral distance trial. The specimens were left in the tanks for four days and then retested for both trials. *D. polymorpha* were not removed in these trials in order to test how captivity, rather than biofouling, affects *C. decisum* behavior.

Results

Righting Ability

To examine *D. polymorpha*'s effects on righting ability, a McNemar's test was used to determine whether or not zebra mussels had a significant effect on this proxy of *C. decisum* fitness.

Table 1: *C. decisum*'s righting ability before and after *D. polymorpha* removal

Flip Test		Flip Without Mussels	
		Flip	Fail to Flip
Flip With Mussels	Flip	9	18
	Fail to	4	6
	Flip		

Table 2: *C. decisum*'s righting ability on 1st and 4th day of captivity

Flip Test		Flip Without Mussels	
		Flip	Fail to Flip
Flip With Mussels	Flip	0	12
	Fail to	3	28
	Flip		

Eighteen *C. decisum* that were successful at righting themselves while biofouled, did not right themselves once *D. polymorpha* were removed (Table 1), suggesting that the mussels aided *C. decisum*'s righting ability (McNemar p= 0.004, N =37). However, the weight ratio of mussels to snails did not have a significant effect on righting ability (Mann-Whitney p=0.699, N= 37). Furthermore, twelve of the snails in the captivity trials that had righted themselves initially did not turn over in the second trial, indicating that time spent in captivity affected snail righting ability (McNemar p = 0.035, N = 43) (Table 2).

Lateral Movement

To assess *D. polymorpha*'s possible effect on *C. decisum*'s lateral movement a Mann-Whitney test was performed. The Mann-Whitney test assessed the differences between positive (aiding) and negative (hindering) effects on *C. decisum*'s lateral movement caused by *D. polymorpha*.

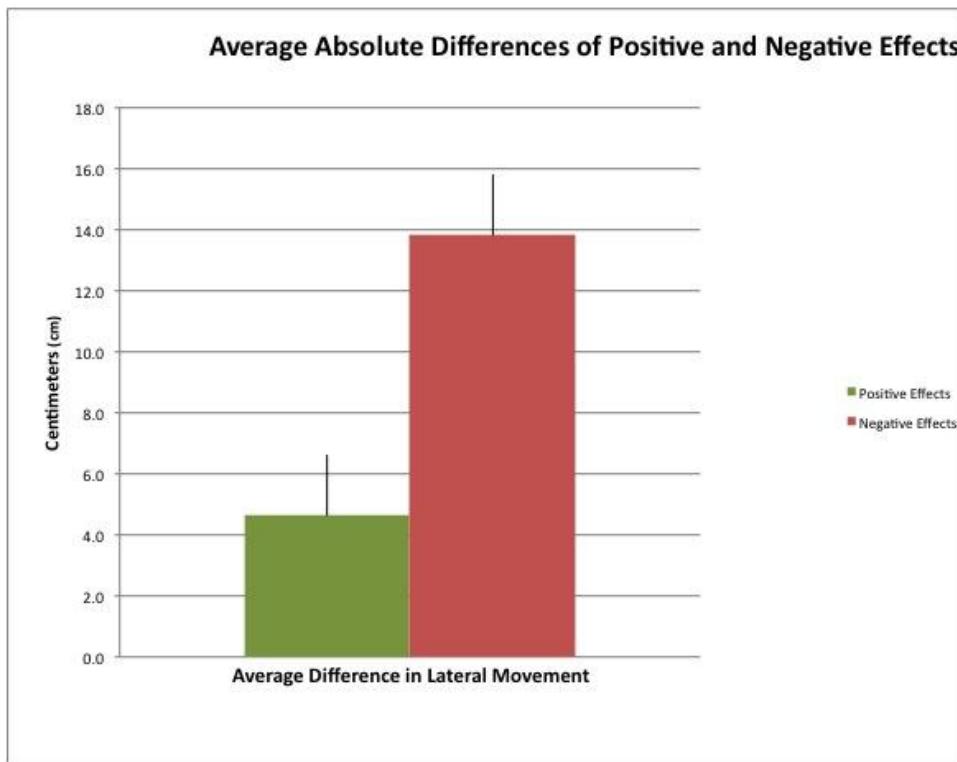


Figure 3: The average distance traveled by *C. decisum* in the presence and absence of *D. polymorpha*

On average, *D. polymorpha* tended to inhibit *C. decisum*'s lateral movement more often and to a greater extent (Mann-Whitney $p=0.013$, $N=44$) (Figure 3). However, there was no significant correlation between weight ratio and difference in lateral movement ($p\text{-value}=0.829$, $R^2 = 0.001$, $N=43$). Furthermore, the captivity sample set did not indicate that the four-day captive period significantly affected snail behavior (Mann-Whitney $p=0.421$, $N=33$).

Discussion

The rapid colonization of *D. polymorpha* throughout North America has altered lake community structures thereby contributing to the decline of benthic species (Lauer and McComish 2001). More specifically, biofouling has been shown to impose physical limitations on gastropods and unionids (Van Appledorn et al. 2007). Our study sought to examine whether *D. polymorpha* has a significant effect on two proxies of *C. decisum* fitness: lateral movement and righting ability.

We found that zebra mussels may have aided the righting abilities of *C. decisum*. However, it is unlikely that weight ratio played a role in this result, as the Mann-Whitney test did not show a significant trend. Perhaps, the placement and size of *D. polymorpha* on the shell could be attributed to this effect. If a large congregation of *D. polymorpha* was attached to the shell opposite the aperture, they may raise the snail's center of gravity enough to make righting easier. However, the effects of captivity may have played a role in our results. Perhaps in natural surroundings, wave action plays an important role in righting capacity. Even though our results demonstrate that *D. polymorpha* aided *C. decisum* in righting, it may be possible that biofouled snails are more prone to being flipped over, due to an increase in surface area. Hence, this hindrance associated with zebra mussels may nullify the benefit.

Our results demonstrate that even though zebra mussels aided and hampered lateral movement, biofouling more often impeded locomotion and to a greater extent. Similarly, zebra mussel biofouling has been shown to limit the lateral movement of another freshwater snail, *Eliminia livescens* (Van Appledorn & Bach 2007). However, weight ratio did not provide a significant explanation of the trends we saw in our results, but Van Appledorn & Bach (2007) found that snail lateral movement had a significant negative correlation with weight ratio of mussels to snail. A possible explanation for varying effects of *D. polymorpha* on lateral movement may be that mussel placement is effecting the hydrodynamics of snail movement. Mussels aligned parallel to the direction of travel could create less of a hindrance than those oriented broadside. Although, we found that captivity did not have a significant effect on our results, research has shown that freshwater snail locomotion is driven by the availability of food (Calow 1974). Our experimental design did not account for resource patchiness in the sediments, which may have influenced our results.

Although our study yielded significant results, it was conducted within aquaria, which does not accurately represent the dynamic littoral zone of the lake ecosystem. Thus, in order to increase the applicability of our results, a field component of this study is suggested. This would also remove possible impacts from testing 12 snails per aquarium. Furthermore, we do not recommend Testor's paint as a method for marking gastropods, as the numbers occasionally rub away or smudge leading to the exclusion of data. This reduction in sample size may have reduced our statistical power and the resolution of data. Thus, it would have been advantageous to collect a larger sample. As discussed previously, noting size and placement of zebra mussels on the shell may provide further insight into how *D. polymorpha* is affecting righting ability.

Our results demonstrated that *C. decisum* benefitted from the zebra mussels in terms of righting ability, but their lateral movement was hindered by biofouling. Other research has indicated that *D. polymorpha* can benefit and harm benthic invertebrates, helping by increasing organic matter in the sediments (Stewart et al. 1998), but creating locomotive problems through biofouling (Albalak & Lamb 2005). Thus, it may be beneficial to find the threshold of zebra mussel density at which benefits to the benthic community are outweighed by harm. This would allow the creation of effective zebra mussel control strategies that optimize benefits to the benthos. These types of questions are pertinent to understanding and conserving freshwater ecosystems, as they are increasingly exposed to new invasive species. Comprehending how invasive species affect native communities will allow for the development of appropriate conservation strategies and efficient responses as new species are introduced to areas.

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