Thermal Tolerance and Reproductive Responses of Northern and Southern *Dreissena polymorpha* Populations

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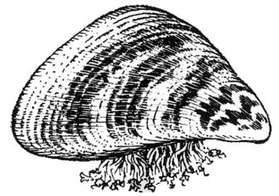


Abstract

The Dreissena polymorpha (zebra mussels) and Dreissena bugensis (quagga mussels) are invasive, freshwater species native to Eastern Europe. Since their introduction to the Great Lakes region of the United States in the 1980s, both dreissenid mussels have quickly expanded throughout inland waterways and caused significant economic impacts and ecological changes. Both zebra and quagga mussels have greatly exceeded the expansion range of predicted models, spreading throughout North America and south into warmer waters including Texas. The mechanism facilitating this expansion is a topic of great interest. Understanding differences between cold-water and warm-water adapted mussels may help us to better predict their spread into Texas. In my project, I investigated the differences in temperature tolerance by analyzing survival rates of adult mussels in varying degrees of water. Furthermore, I analyze differences in spawning of egg and sperm and resultant fertilization success between the two groups. Together, these findings provide insight into the temperature-related survival and reproductive strategies that may enable these mussels to continue expanding beyond their predicted range into warmer freshwater environments.

Introduction

Zebra mussels are an invasive, cold-water species that have spread throughout most of the US, including Texas. Zebra mussels cause significant ecological and economic damage. They alter food webs by outcompeting native species for food and resources. Zebra mussels cost millions of dollars annually in damage and prevention efforts by clogging water pipes in industrial facilities and water treatment plants while also impacting recreational activities. Zebra mussels have greatly exceeded the expansion range of predicted models, spreading throughout North America and south into warmer waters of Texas. The mechanism facilitating this expansion is a topic of great interest. Understanding differences between cold-water and warm-water adapted mussels may help us to better predict their spread into Texas. My project focuses on comparing the biology of the two populations of mussels. One group will be northern cold-water mussels from the Great Lakes region. The other population will be from warm Texas waters. First, I will investigate differences in temperature tolerance by analyzing survival rates of adult mussels in varying degrees of water. Next, I will determine differences in spawning of egg and sperm and the resultant fertilization success between the two groups. Lastly, I will examine the reproductive cycle of northern versus Texas zebra mussels. Northern mussels live from 2-5 years and spawn annually as they become larger in size. Texas mussels live for only 1-2 years and reach a smaller maximum size. I will determine if Texas mussels are able to produce more gametes at a relatively smaller size due to shorter lifespan.

Objective

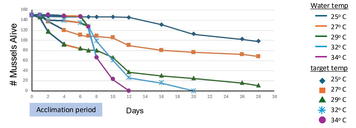
To determine the survival and reproduction of mussels adapted to warm water (TX) and cold water (WI, MI) temperatures

Experimental Design

- Mussels were obtained from a warm Texas lakes (Lake Brownwood) and two cold water lakes in Wisconsin and Michigan.
- Mussels were acclimated at 20°C for several weeks to establish a baseline.
- Mussels from each location were place groups in glass container submerged in water baths and gradually elevated to 25°, 27°, 29°, 32 °, and 35°C
- Survival of both northern and Texas mussels over these temperature range was determined based on gaping response
- Mussels from WI and TX were evaluated for their ability to spawn gametes and under fertilization at lower (25 °C and elevated 30 °C
- Mussels were quickly brought to target temperature and induced to spawn by exposure to serotonin. Gamete collection and fertilizations were performed at target temperatures.
- Reproductive output based on successful spawning, gametes produced, and several events during the fertilization process were examined.

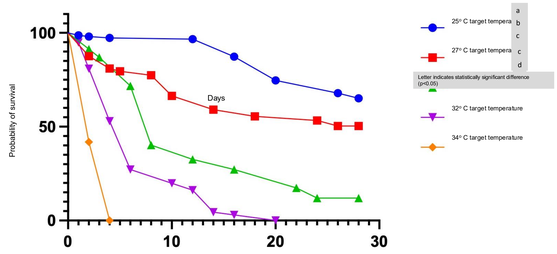
Survival of mussels under elevated temperatures

Zebra mussels were collected from colder waters (Michigan, Wisconsin) or warmer waters (Texas). Survival of mussels at various temperatures of 50 mussels from each location at each of 5 target temperatures. Upper limit is reported thermal temperature is reported to be 28 -32º C). [6,7]

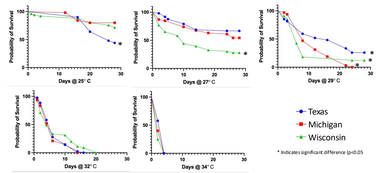


Survival of pooled mussels over 28-day period at various temperature. Mussels were gradually increased from 25º C up to a high of 34º C. Color of line indicates water temperature. Symbols represent final target temperature.

Probability of survival at target temperature of pooled mussels based on Mantel-Cox test. Data is for survival rates only after mussel reached target temperature (25 to 34º C).



Probability of survival at regional populations of mussels based on Mantel-Cox test. Data for mussels from cold-water habitats (**Michigan, Wisconsin**) and warm water (**Texas**) at the various temperatures.



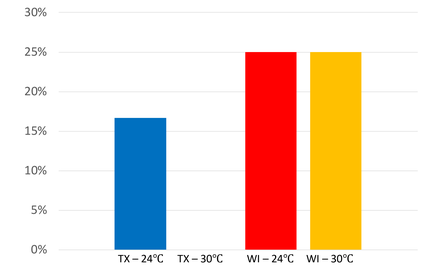
Significant mortality was observed above 32º C for all populations of mussels. Texas mussels had a significantly higher survival rate at 29º C.

Zebra mussel

Quagga mussel

Spawning under elevated temperature

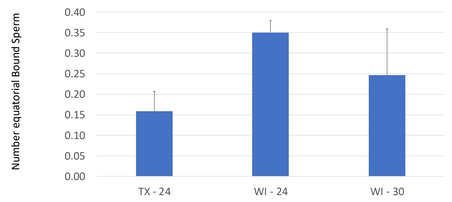
Mussels from two locations (TX, WI) were spawned at lower (24C) or elevated (30C) temperatures.



Mean number of individuals that spawned due to serotonin exposure from warmer waters (TX) and cold water (WI) mussels. Fertilization and subsequent development occurred at either 24 ℃ or elevated ℃ temperatures. 30 Bar-SE

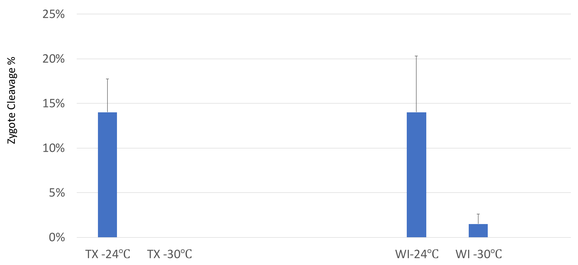
Sperm binding to eggs under elevated temperature

=Eggs and sperm of various ages postspawning were fertilized. Inseminated eggs were examined 5 min postinsemination and the number of equatorial bound was determined.



Mean number of equatorial bound sperm for fertilization from warmer waters (TX) and cold water (WI) mussels. Fertilization and subsequent development occurred at either 24 ℃ or elevated ℃ temperatures. 30 Bar-SE

Zygote Cleavage under elevated temperature



Mean number of zygotes dividing to the 2-cell stage for fertilization from warmer waters (TX) and cold water (WI) mussels. Fertilization and subsequent development occurred at either 24 ℃ or elevated ℃ temperatures. 30 Bar-SE

Conclusions

- Significant mussel mortality occurred above 32°C across all populations
- Warm-water populations (Texas) showed greater thermal tolerance at 29°C than cold-water populations (Michigan, Wisconsin), suggesting local thermal adaptation
- Wisconsin mussels had similar spawning output at 24°C and 30°C, indicating adult reproductive output is not immediately inhibited by thermal stress
- Despite successful spawning at 30°C, zygote cleavage dropped to near zero at that temperature, suggesting that warmer temperatures could severely limit successful reproduction even when adults are still able to spawn

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