

Testing for competition, facilitation, and intraguild predation between two co-dominant
detritivores: the caddisfly *Limnephilus externus* and chironomid midges

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Abstract

Most living organic material goes through the detrital pathway. Detritivores are incredibly important in ecosystems for the recycling of nutrients and energy. This project explores the inter- and intraspecies relationships between two co-dominant detritivores that inhabit the high-elevation rocky mountain ponds: the caddis fly, *Limnephilus externus*, and chironomid midges. Specifically, we are trying to determine if there is competition, facilitation, or intraguild predation between *Limnephilus externus* and chironomid midges. With climate change, the permanent and semipermanent ponds are becoming increasingly temporary. The issue this presents is that *L.externus* cannot survive in temporary ponds due to their long development time. Therefore, identifying the relationships between the two taxa can help us understand how detrital processing may change with the possible loss of *L. externus* or shifts in species abundances. For this experiment, we used a response surface design and altered the relative abundances to test for the relationships between the two taxa. Add summary sentence of findings

Introduction

Whether it is a blue lake or a green grass land, most living, organic material enters the detrital pathway (Hairston and Hairston 1993). Detrital processors are necessary for recycling organic matter and energy back into the ecosystem. This project focusses on two dominant detritivores found in the high elevation ponds near Rocky Mountain Biological Laboratory (RMBL): the caddisfly, *Limnephilus externus*, and chironomid midges. Numerous studies have focused on the role of *L. externus* and other caddisflies in detrital processing. In contrast, except for one study by Balik et al. (accepted manuscript) the effects of chironomids on detritus

processing have been overlooked. Therefore, the potential role and interactions of chironomids with other detritivores may have been overlooked in these ecosystems. *L. externus* and chironomids are the biomass dominant invertebrates in permanent and semipermanent ponds and beaver ponds near RMBL (Balik et al. 2021). Although chironomids are small-bodied aquatic insects, they are often the most numerically abundant insects in many freshwater ecosystems (REF). Furthermore, Balik et al. (accepted manuscript) showed chironomids can process similar amounts of detritus per unit biomass as the widespread caddisfly *L. externus*.

Both *L. externus* and chironomids have a larval development stage in water before they reach adulthood and emerge from the ponds. This larval development time differs greatly between the two taxa. *L. externus* has a long larval development time, and therefore only inhabits permanent and semi-permanent ponds. However, chironomids have a much shorter larval development time and can inhabit permanent to temporary ponds because they are able to emerge before the pond dries (Balik et al. accepted Oecologia). With climate change, ponds are projected to becoming more temporary. Because of this shift, it is possible that *L. externus* may be reduced in abundance or eliminated from some ponds. This possibility makes it very important to understand interspecies relationships and the detrital role that may be lost and how to what extent it may be replaced by other insects.

The question addressed in this project is: how strong is competition, facilitation, or intraguild predation between *Limnephilus externus* and chironomid midges, and how will sedge detritus breakdown change if *L. externus* biomass is reduced by pond drying and chironomids increase in dominance? My goal for this project is to understand the inter- and intraspecific relationships between *L. externus* and chironomids. Understanding these relationships may help

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us predict how the ecosystems these taxa inhabit will be impacted by the potential loss of *L. externus*.

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Competition and Facilitation

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One prediction is that the *L. externus* will facilitate chironomid growth by converting coarse sedge to finer particles that are more easily processed by chironomids. This will be tested by measuring the growth of both insects. If facilitation is present, there will be more growth of specifically chironomids in treatments with *L. externus* compared to treatments with only chironomids. Additionally, the amount of leftover sedge and the ratio of coarse to fine sedge left over after the experiment will be measured. If there is facilitation, more overall sedge will be processed in treatments containing both taxa than the taxa alone, and the ratio of coarse to fine detritus will be lower in treatments dominated by *L. externus* and higher in treatments dominated by chironomids.

On the other hand, interspecific competition will be tested by measuring growth of *L. externus* and chironomids. If interspecific competition is present, the growth of the taxon should be related to the biomass of other taxon. Some possible outcomes indicating competition are negative linear and nonlinear relationships.

No relationship (linear or nonlinear relation slope equal to zero) will indicate no compewweak interaction. Intraspecific competition is predicted to be greater between *L. externus* than chironomids (Klemmer et al. 2012). Intraspecific competition will be tested in the treatments with only *L. externus* and only chironomids. If there is intraspecific competition, it is expected that at higher densities, the two taxa will have less growth than treatments with lower abundances.

Asymmetric Intraguild Predation

Asymmetric intraguild predation will be evaluated in the varying relative abundance treatments. We predict that *L. externus* will eat some chironomids at high biomass as detritus is limiting. However, we expect this number to be low because of our preliminary trial with high biomass of *L. externus* and chironomids in which mortality was nil. In addition, diet (Balik et al. accepted Oecologia) shows that *L. externus* and chironomids have less than 2% animal chitin in their gut contents. This relationship will be measured by the number or biomass of each taxa that remain at the end of the experiment. Gut contents of *L. externus* will also be used to determine if any chironomids were eaten by *L. externus*.

Methods

We collected *L. externus* and chironomid midges from a beaver pond near Rocky Mountain Biological Laboratory. Using a response surface design (Inuoye 2001), we will test for competition, facilitation, and intraguild predation. The response surface design is a combination of a substitution and additive design where the relative densities of two organisms are varied to determine dynamics between the two taxa. There were four relative abundances of *L. externus* and chironomids. Each relative abundance was tested at three biomasses: high, normal, and low. Numerical abundance differed but similar biomass was maintained by adding 5 chironomids for every one *L. externus* to compensate for the smaller size of chironomids. Some insects of each taxa were collected prior to the experiment to get an average weight per individual to determine the ratio needed to maintain the same biomass between the two taxa and to determine average starting weight to monitor growth throughout the experiment.

Primary Experiment

For each treatment there were three replicates, with 36 microcosms total. The detritus being used is sedge (mainly *Carex aquatilis*) and was dried for three days and weighed before

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adding it to the microcosms (20 g per tank, or 147 g/m²). The sedge was incubated in pond water for four days to activate the microorganisms (e.g., bacteria, fungi, algae). Sedge was collected from the kettle ponds at RMBL. Only dead sedge from the bottom of the pond was harvested. The same amount of pond water (12 liters) was placed into each microcosm.

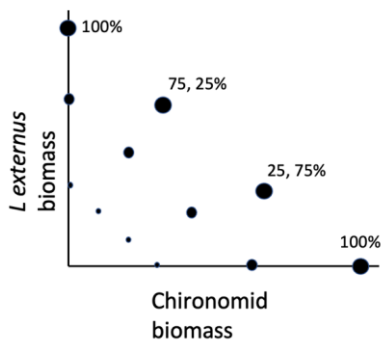


Figure 1. Response Surface Design (Inuoye 2001)

Intraspecific competition was tested in the treatments along the x-axis and the y-axis. Interspecific competition, and asymmetric intraguild predation was tested in the remaining treatments, containing both taxa.

The experiment ran for 14 days. The remaining detritus material was collected and separated into CPOM and FPOM by using a sifter. Then the detritus was dried in a drying oven at 60°C for at least 48 hours and then weighed for a final mass.

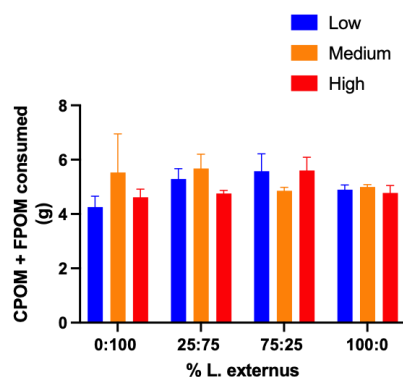
The remaining insects were collected, frozen, and dried. The final masses were collected for each taxa to determine growth. 1-15% of chironomids were recovered. This low recovery can be explained by pupation, natural death, predation, unable to find them due to small size and chironomids inhabiting the sedge.

Secondary Experiment

Due to the low recovery rate of the chironomids and multiple possible causes for it, intraguild predation was not able to be evaluated well. Another experiment was used to give better insight on intraguild predation between the two taxa. The experiment consisted of four treatments: (1) Chironomids and *L. externus* with detritus (2) Chironomids alone with detritus (3) *L. externus* alone with detritus (4) Chironomids and *L. externus* without detritus. There were six replicates for each treatment. The microcosms were 15x15cm with an same approximate amount of sedge. The sedge was collected from a pond at RMBL and placed into the microcosms. The number of individuals were kept constant for each treatment. For treatments with *L. externus*, two individuals were used, and for treatments with chironomids, 8 individuals were used. The number of individuals were kept constant because a basic rate of predation was being determined. This experiment design told us if chironomid death would change significantly with/out the presence of *L. externus* and/or sedge. The experiment ran for 48 hours, and both taxa were collected and counted. The control (chironomids alone with detritus) was used to determine normal rate of death so that the other treatments could be standardized to separate natural death from predation.

Individuals were collected at the beginning and end of the experiment to determine growth. *L. externus* was also collected at the end of the experiments to examine gut contents for the presence of chironomids, suggesting predation.

Results



References

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