

Effects of Native and Non-native Predators on Aquatic Communities

Eva Kerr

Mentor: Howard Whiteman

Full-Independent Research 2021

Keywords

Predation, *Ambystoma mavortium nebulosum*, non-native fish, aquatic invertebrates, beaver ponds

Abstract

Predators impact the ecosystem in a top-down manner; however, we are not sure how non-native predators differ from native ones. In Colorado beaver ponds, non-native trout can change aquatic communities by preying on macroinvertebrates and excluding the native predator, tiger salamanders. Beaver ponds have high macroinvertebrate density, provide habitat for tiger salamanders, and support introduced trout populations thus providing a system to study macroinvertebrate communities based on the predator present. I sampled the macroinvertebrates in 18 beaver ponds; 6 containing fish, 6 containing salamanders, and 6 with no predators within the Gunnison Valley. My analysis revealed that there is no significant difference in the aquatic invertebrate communities between beaver ponds with trout, salamanders, or no predators, although there may be differences in diversity among pond types. The other analyses are currently ongoing, but so far it appears that trout and salamanders may be complementary predators in this system.

Introduction

Non-native species have been introduced outside their native range by humans for centuries. They cause dramatic changes to their new ecosystems; however, oftentimes, little is known about the potential consequences. It is crucial to understand these consequences when making decisions about managing and protecting native species (Jeschke et al., 2014).

Losing a top predator can cause cascading effects with aquatic food webs (Boeckman & Whiteman, 2017). For example, the decline of sharks allowed for the increased predation by the cownose ray on scallops which collapsed a fishery (Meyers et al., 2007). However, it is not known how the loss of a native predator due to the introduction of a non-native predator will impact systems.

Fish have been introduced to freshwaters as non-native species to support sport fisheries. Introduced fish can shift native species' behaviors, restructure the aquatic food web present, and extirpate species (Cucherousset & Olden, 2011). For example, smallmouth bass (*Micropterus dolomieu*) have been introduced to increase recreational fishing opportunities and have subsequently altered the food web by shifting lake trout (*Salvelinus namaycush*) predation (Vander Zanden et al., 1999). Similarly, the invasive Prussian carp (*Carassius gibelio*) reduced the diversity and abundance of native invertebrates, impacting native fish populations (Ruppert et al., 2017).

Within Colorado, brown, rainbow, and brook trout (*Salmo trutta*, *Oncorhynchus mykiss*, *Salvelinus fontinalis*) are stocked to create freshwater fisheries across the state (*Colorado Fishing Atlas*). At a community level, these non-native trout have been found to influence macroinvertebrates by predation (Dunham et al., 2014). Fish, when introduced, can reduce prey density even to local extinction (Brooks & Dodson, 1965) because fish eat larger prey than other aquatic predators (Wellborn, 1994; Wellborn et al., 1996). For example, mayfly populations have been reduced in beaver ponds containing trout (Caudill, 2002; Caudill, 2003a; Caudill, 2003b; Caudill, 2005). Macroinvertebrates are important to aquatic systems because they are water quality indicators, provide food for birds and bats, and they are important to ecosystem functioning (Balik et al., 2018; Baxter et al., 2005; Gaufin, 1973).

In addition to impacting macroinvertebrates, introduced trout cause declines in the native aquatic predator, tiger salamanders, *Ambystoma mavortium nebulosum* (Herwig et al., 2013). Salamanders also impact macroinvertebrates, but potentially in different ways, making the presence of the native predator important (Wissinger et al., 1999, 2003, Boeckman and Whiteman 2017).

Within the Gunnison Valley of Colorado, beaver ponds have been observed having non-native trout, native tiger salamanders, or no predators present. Beaver ponds provide important habitat for salamanders (Karraker & Gibbs, 2009). They also support high invertebrate taxon richness, which serves as prey for predators (Bush & Wissinger, 2016). Beaver dams are important in the Gunnison Valley because they provide permanent habitat within a mosaic of semi-permanent and temporary habitats, which are drying faster due to climate change (Bush & Wissinger, 2016). It is vital to understand how predators influence the aquatic community within a beaver pond to inform the management of introduced fish as climate change influences native amphibian and invertebrate habitats. To this end, I investigated if the type of top aquatic predator present in a beaver pond affects the aquatic invertebrate community structure.

Methods

Aquatic Community Sampling

I studied 18 beaver ponds: 6 containing fish, 6 containing salamanders, and 6 with no predators within the Gunnison Valley (Fig. 1 and Fig. 2). At the ponds, I noted the presence or absence of fish and salamanders to determine the main predation pressure within the pond. I recorded the elevation, size, and temperature at each pond. I then collected, identified to the order level, and counted the aquatic invertebrates.

I collected using the stovepipe method and a D-net. I used the stovepipe method of placing the stovepipe within the bottom of the pond. The stovepipe allows for sampling of both the water column and benthic substrate within a controlled area (Washko, pers. comm). I did the stovepipe method three times at each pond. I chose where to stovepipe based on accessibility and the amount of woody debris on the pond's bottom. In addition to the stovepipe method, I used a

1-meter D-net sweep in a location where I see larger invertebrates because the stovepipe method doesn't allow for the collection of larger invertebrates.

Statistical Analysis

Non-metric multidimensional scaling (NMDS) was used to determine the community composition through the *vegan* package in R (Oksanen et al., 2019; Washko et al., 2019).

Community composition was compared between beaver ponds using a permutational multivariate analysis of variance (PERMANOVA) in the *vegan* package (Washko et al., 2019). I ran a Shapiro test for normality before running an ANOVA test to determine how environmental parameters such as pond temperature, surface area, and type of predator present affect the aquatic community (Washko et al., 2019). All statistics were completed with R studio (R Core Team 2021).

Results

Seventeen invertebrate orders were found during sampling and over 1375 individual invertebrates total from all sites. Taxa were consistent with orders mentioned in Bush & Wissinger (2016). Salamander ponds had slightly more orders per pond, on average (Table 1), although analyses are ongoing.

Ponds containing different predators were not different in terms of temperature and surface area ($p=0.85$ and $p=0.40$). There was no significant difference in the aquatic invertebrate community between beaver ponds with trout, salamanders, or no predators (Fig. 3 NMDS, $p=0.67$).

Discussion

My results indicate that aquatic invertebrate community structure does not differ whether beaver ponds have trout, salamanders, or no predators present (Fig.3). This result may be because I identified the aquatic community to the order level, decreasing the specificity of the study. Different habitat use is often not constrained at the order level of identification (Washko, pers. comm; Wellborn et al., 1996). For example, damselfly species may have shifted whether or not fish were present, but one of several damselflies might be present in both situations (Blois-Heulin et al., 1990).

However, salamander ponds appeared to have a slightly higher average number of orders than both trout and no predator ponds (Table 1). This shows that the presence of a native predator may increase diversity in the aquatic community. Further analyses, including comparing Shannon Diversity using orders instead of species, are ongoing to better evaluate this hypothesis.

I sampled semi-randomly throughout the study ponds without taking into account specific sub-habitats. Different species vary in their cover use. For example, larval dragonflies that use exposed microhabitats are more vulnerable to fish predation (Pierce, 1988). If I had sampled the same sub-habitats in each pond type, I could have tested for differences in species changing behavior in the presence of the different predators. The larval dragonfly that used the exposed microhabitat increased the use of cover in the attendance of fish. This shows a change in behavior in the presence of fish. (Pierce, 1988). Another example of behavior change within a species is a freshwater amphipod (*Hyaella azteca*) that has a smaller body size in ponds with fish and different reproductive behaviors (Wellborn, 1994). Amphipod body size was not considered in this study, but could be a factor in future projects.

The native predator and the introduced predator may be complementary in this system; however, Boeckman and Whiteman (2017) found that generally, salamanders are not complementary to salmonoids. However, the predators may be complementary in very certain size ranges (Boeckman and Whiteman 2017). Introduced predators could play complementary roles to the native predator which may play an important role as aquatic systems rapidly lose top predators (Rush et al., 2012).

Future studies should consider identifying the aquatic community to the species level or sampling multiple habitats within beaver ponds. Additionally, the effects of predation can be investigated through a controlled cattle tank experiment. However, the preliminary findings of this study provide a foundation for future work examining how top predators influence the aquatic invertebrate communities of beaver ponds.

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Tables and Figures

Table 1. An average number of macroinvertebrate orders ($\pm$ standard error) in ponds containing different top predators or no vertebrate predators.

Predator type in pond	Average Number of Macroinvertebrate Orders
Salamander	8.333
Trout	7.167
No Predator	6.5

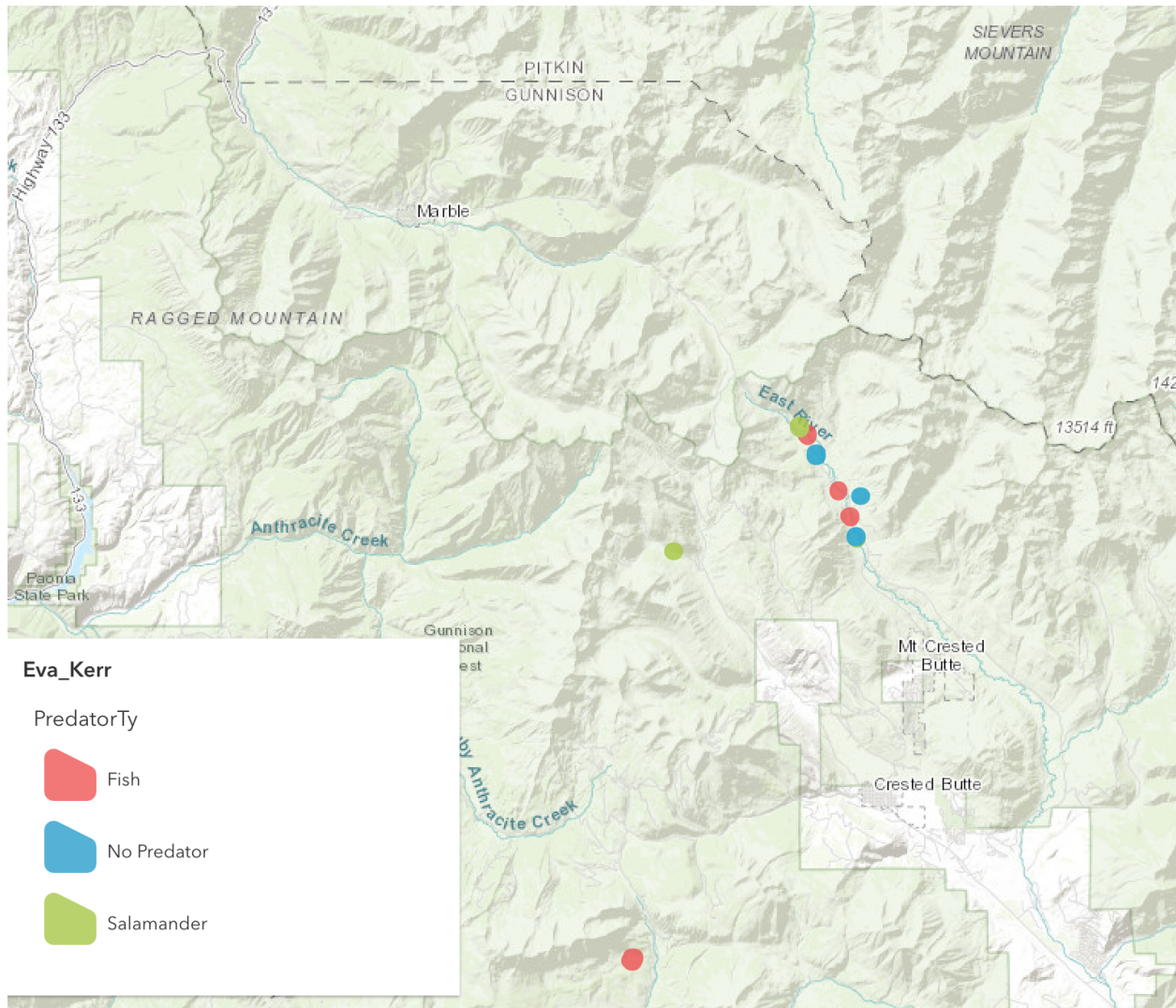


Figure 1. Overview of the location of the 18 studied ponds including the two ponds outside of the

East River Valley

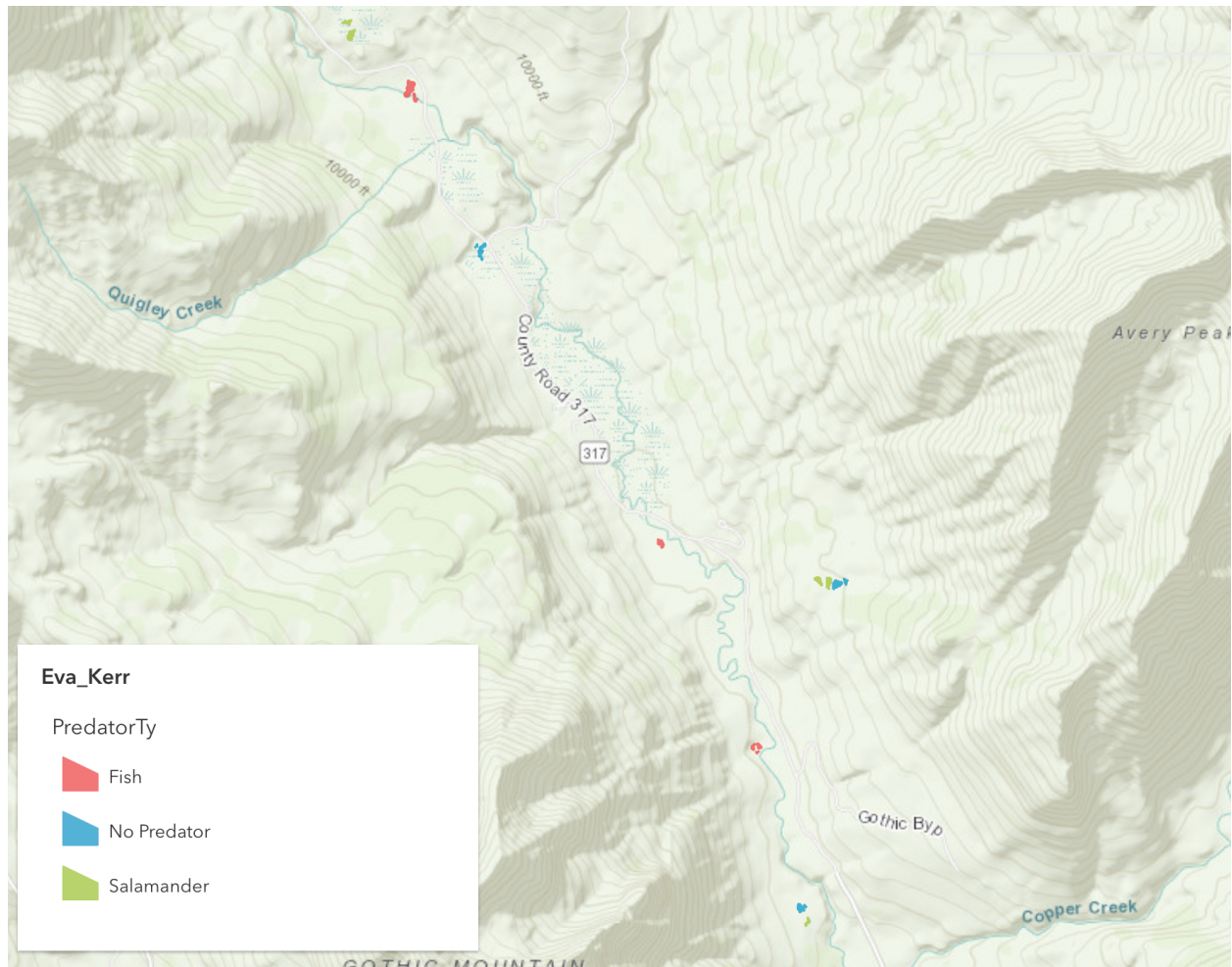


Figure 2. Close up of the ponds within the East River Valley beaver ponds

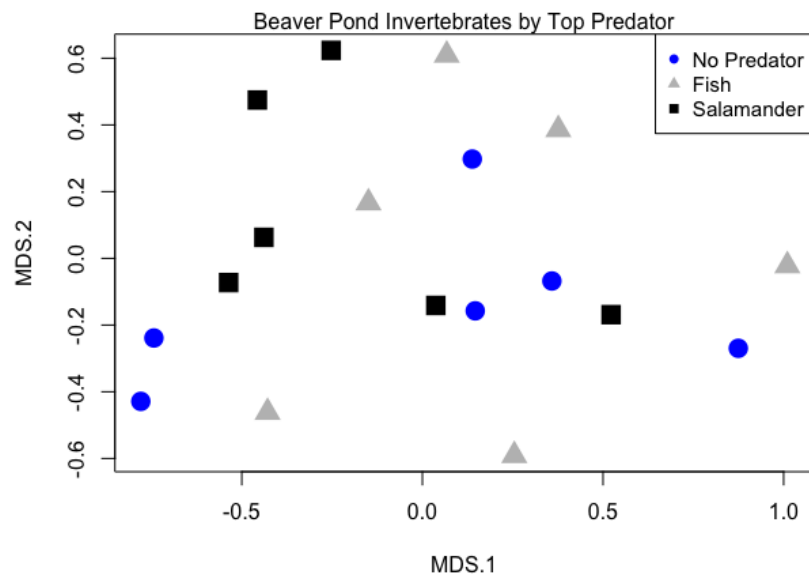


Figure 3. Differences in community structure measure by count for no predator, fish, and salamander beaver ponds. Non-metric multidimensional scaling plot showing how the aquatic communities differ between the beaver ponds. There was no significant difference between the ponds ($p=0.67$.)