

Salamanders Impact on *L. externus* Population Densities

Abstract

The caddisfly *L. externus* has been observed to have a decline in population density over the summer months as the larvae develop. However this pattern has not been formally tested, so collecting population density data is important for future research and understanding changes in densities over time. At the Mexican Cut, *L. externus* is common prey to tiger salamanders which may impact the magnitude of the density decline. This leads us to the question: How does the population number of *L. externus* decline over time in ponds with and without salamander predation? My hypothesis is the *L. externus* population density will decline at a steeper rate in ponds with salamanders than those without salamanders. Eight ponds were sampled with four being salamander and the other half being non salamander. The results found were that in the salamander ponds there was a steeper slope but a higher abundance at the beginning and in the non salamander ponds there was still a slope but significantly, statistically different ($P < 0.05$).

Introduction:

Subalpine ponds are rich with biodiversity and support balanced ecosystems. These ponds are exposed to harsh weather and short growing periods but are vital for a large range plant, invertebrate, and vertebrate species. In a pond, biotic interactions often include competition or predation which can influence the suitability of a habitat as a whole. However, considering the protection and resources, different sections of the pond can experience different observations. A common predator found in the ponds are tiger salamanders (*Ambystoma tigrinum nebulosum*) which rely heavily on aquatic insects for their nutrition. Predation can

generate common trade offs in protection mechanisms of invertebrates such as the pace of development through larval stages and emergence, physical protection, and more obscure ways to avoid threats (Anderson, Cargill, 1987). The species that offer in their position along this tradeoff will likely persist in different types of ponds depending on predator presence and the rate in which ponds dry. More specifically, caddisflies are known to create cases and this has been seen to work against predation (Wissinger, et. al. 2006). However, while these defenses can be effective, they are resource intensive, and do not guarantee complete protection from predators and the efficacy of protection varies among different species.

Subalpine ponds fall along an environmental gradient range from short (vernal) and long duration (autumnal) temporary ponds to those that are permanent, and exist with or without vertebrate predators (Greig and, Wissinger, 2010). Different microhabitats are also present within ponds; both submergent vegetation abundant on the banks of these ponds, such as quillwort, or *Isoetes bolanderi*, and wooded areas surrounding that often drop their leaves in these ponds. Although there are vegetated areas present in subalpine ponds, open habitats are also common and important for caddisfly populations, though being in open areas carries a higher risk of predation. To protect themselves from predation, caddisflies create protective cases out of multiple types of debris, such as *L. externus*, which uses sedge stems (*Carex aquatilis*), and other debris found in the water (Wissinger, et. al. 2006). While *Limnephilid* caddisflies can facilitate both ponds, temporary and permanent. In contrast to facilitating both ponds, *A. Nigriculus* are rare in permanent ponds and *L. exturnus* and *L. picturatus* are rare in temporary ponds (Wissinger, et. al. 2003). *Asynarchus* is vulnerable to predation but develops faster to withstand the harsh drying of temporary ponds. *L. exturnus*, on the other hand, develops more

slowly but invests in defensive cases. *L. picturatus* needs the protection of sage and is often beaten in competition to others. Caddisflies have multiple predators, along with the threat of cannibalism (Wissinger, et. al. 1996) but their most common predator is the tiger salamander. Salamander predation is shown to have the strongest effect on invertebrate community competition, twice the non salamander addition (Wissinger, 1999). The two most preferred caddisfly prey for the tiger salamander prey choice are *Asynarchus* and *L. picturatus* (Wissinger, et. al. 2005).

Caddisflies and salamanders bask in the sun for thermal regulation which often happens on the banks of these ponds. These microhabitats, different areas within the ponds, have the presence of different food sources and protection which are desirable factors for multiple species and are more diverse near the shorelines of these ponds. The caddisfly, *L. Externus* growth period starts early summer, growing throughout the following weeks and are found in permanent and semipermanent ponds. With their small cases, unlike *Agrypnia*, *L. externus* is vulnerable to salamander predation. *L. externus* is also vulnerable to *Asynarchus* predation although that interaction can be mediated by salamander predation, *Asynarchus* in permanent ponds. What we do not know is how these interactions influence *L. externus* density over their development in permanent ponds with salamanders vs semi-permanent ponds without salamanders.

In Gunnison, CO, the Mexican Cut Nature Preserves is a protected area of land with multiple temporary and permanent ponds that have been studied for decades. Here, there is a range of invertebrates, including caddisflies, that have different emergence times and overall

habitat sustainability. Populations of the caddisfly, *L. externus*, have been observed to diminish as the summer progresses, but there has never been a study that explicitly studies this progression over time. With this, the question is raised: How does the population number of *L. externus* decline over time in ponds with and without salamander predation? The expected outcome is that at the end of our testing period, the ponds that have salamanders will have less *L. externus* than at the beginning of the testing period, because salamanders impact caddisfly population numbers.

Methods:

This research was conducted at the Mexican Cut Nature Preserve within its pond systems. Here, eight ponds were observed encompassing four non-salamander, or low salamander density (ponds 6, 8, 10, and 11) and four salamander ponds (1, 3, 5, and 12). In these ponds, collection sites were north, east, south, and west. One meter long d-net sweeps along the base of the pond in the highest vegetative areas near the banks will be taken at these collection sites. This quantitative approach collects sufficient numbers of caddisflies in each site that is used to estimate population density (Wissinger et al 2003). The caddisflies and other debris from the area are collected in the net, this is all placed into a white rectangle bin where *L. externus* and other caddisflies were located, picked out, and categorized by their instar by comparing the larvae head to its case size. The categories are 1st through 5th instar.

Data was analyzed with regressions of density over time in each pond, with slopes to measure and compare the population density declines between the two pond types. Each pond

has a total of four slopes each for the four collection sites. ANOVA and ANCOVA tests are used to compare changes in slopes between replicate ponds. I used R studio for all analyses.

Results:

There was a significant difference between the average slope of salamander ponds ($M = -1.189$, $V = .1303$) and the average slope of non-salamander ponds ($M = -.375$, $V = .04240$) conditions; $t = -3.917$, $p = .0078$. The salamander ponds were seen significantly steeper than the non salamander ponds. Since the p-value is less than .05, we will accept the hypothesis that L. externus population densities decline at a steeper rate in salamander ponds v. non salamander ponds.

Salamander Ponds

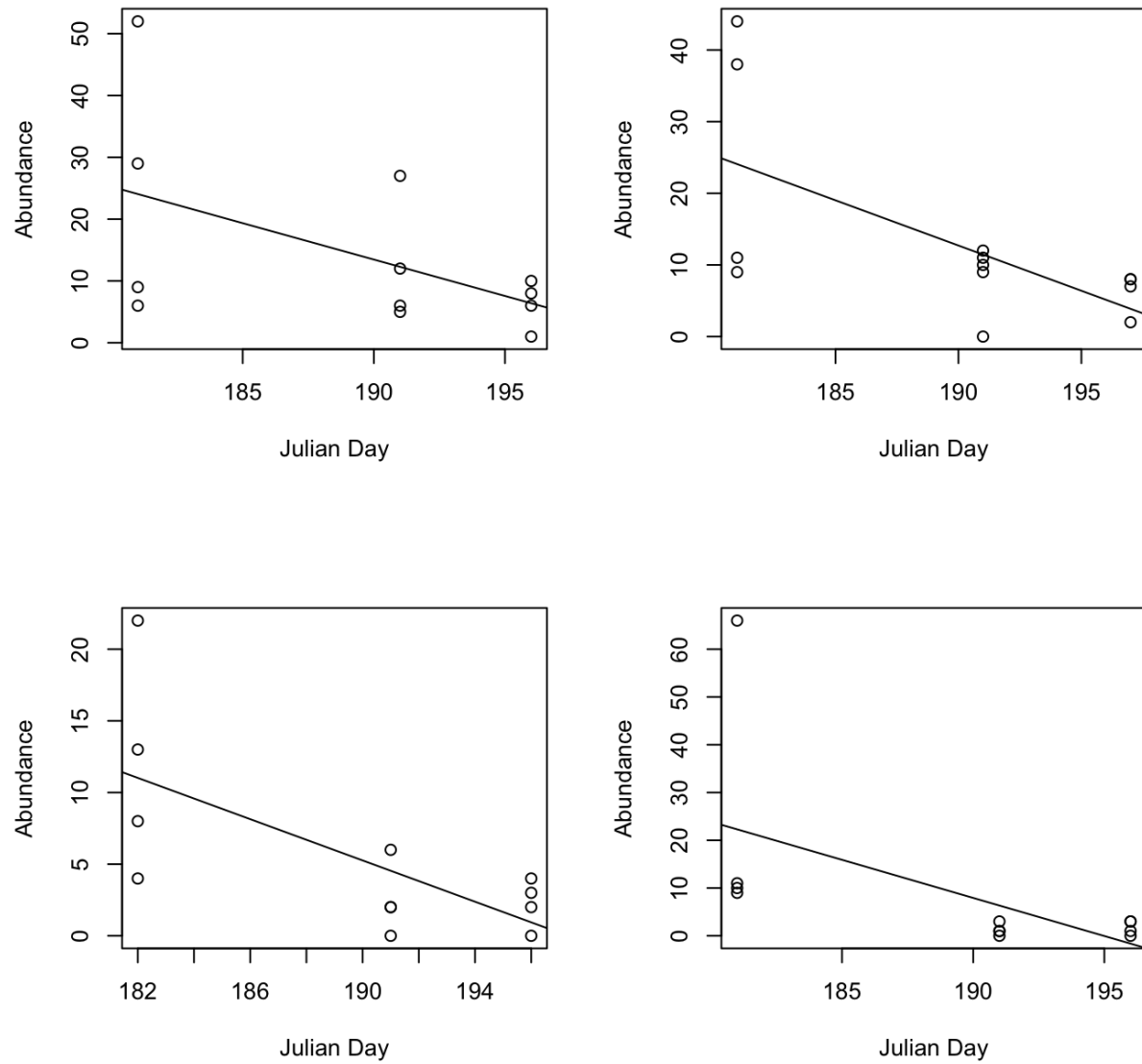


Figure 1: The four ponds with high densities of salamanders sampled. In order from right to left, pond 1 slope is -1.179, pond 3 slope is -1.262, pond 5 is -0.720, and pond 12 is -1.596.

Non-Salamander Ponds

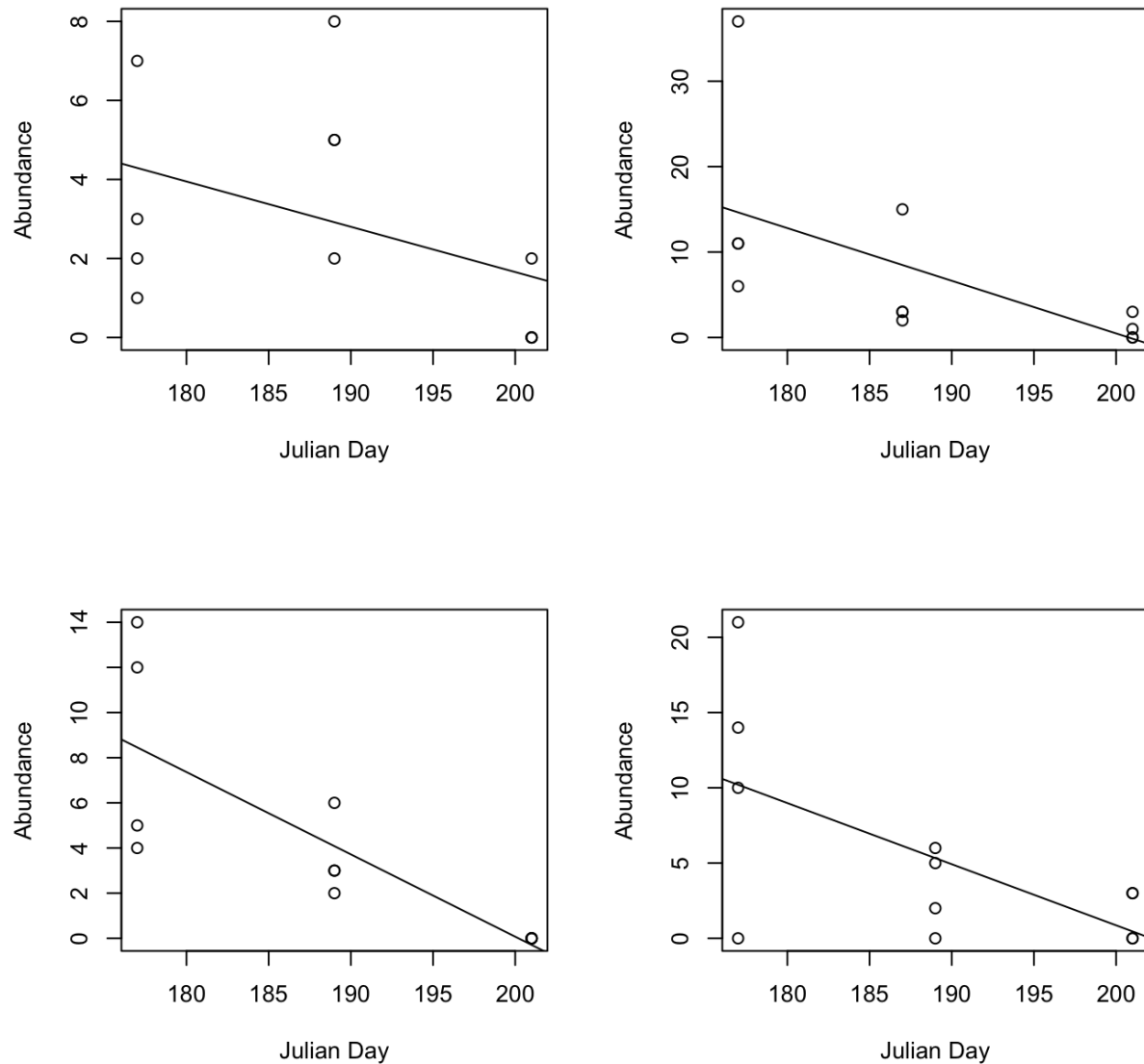


Figure 2: Four ponds with low densities of salamanders sampled. In order from right to left, pond 6 slope is -0.115, pond 8 slope is -0.616, pond 10 is -0.365, and pond 11 is -.406.

When analyzing each slope individually, all slopes have a decline but some are more significant than others. The two slopes that are not significant are ponds 1 and 12 in the

salamander ponds and pond 6 in the non salamander ponds. With these slopes, we can infer that in salamander ponds, *L. externus* population density declines at a faster rate than non salamander ponds. In the salamander ponds, most abundances start above 20 units except for pond 5 which starts under 15 units. This is the main outlier pond in this group. In the non-salamander ponds, all pond's abundance starts under 15 units. The steepest slope found was pond 12 while the least steep pond was 6. These graphs and slope numbers show there is a statistical significance between the two pond types but also, the biological significance is there too. In every graph, we can see that as time goes on, there is a decline in each pond's abundance, just some may be steeper than others supporting this idea that the abundance of *L. externus* population numbers are dependent on the time in the season.

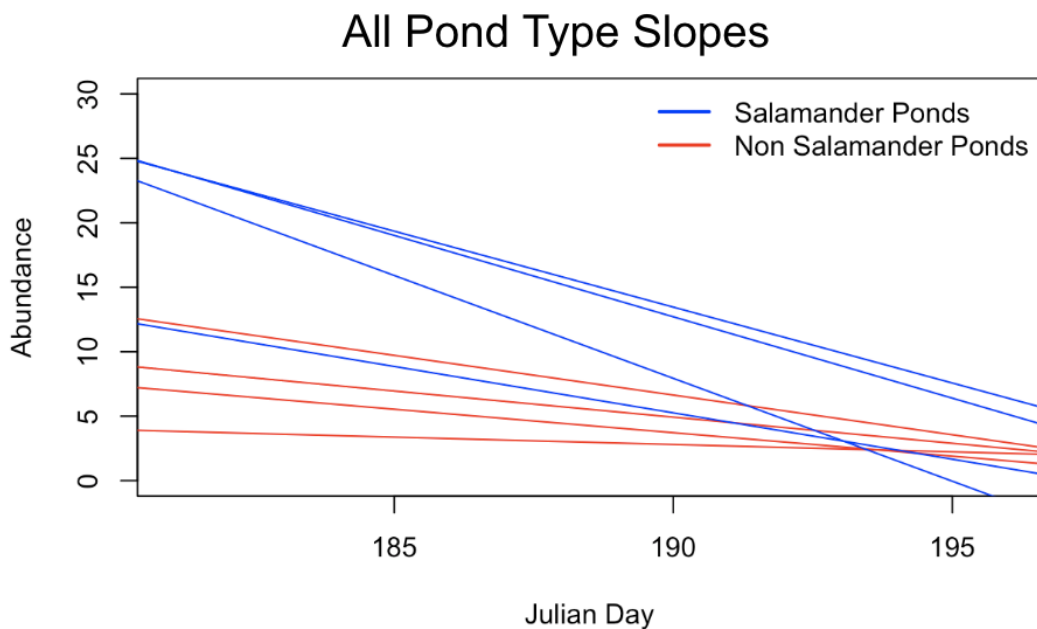


Figure 3: This graph shows all pond type slopes in reference to each other. The average slope for salamander ponds is -1.189 and the average slope for non-salamander ponds is -0.375.

Discussion

In these ponds, *L. externus* are a foundational species that not only provides nutrients for the larger insects and vertebrates, but also contribute to the continuous breakdown of sedge and detritus that when built up, can influence the pond's ecosystem health. Observations of this system, over the past 30 years, noted that there is a decline in caddisfly numbers as the summer progresses. This research is the first to quantify that decline and compare it between the two types of ponds at the Mexican Cut: semi-permanent (low density of salamanders) and permanent (high density of salamanders). After weeks of sampling, the averages of the slopes of decline in caddisfly density were significantly different between pond types. Our hypothesis is that salamander predation is the driving factor of this steeper slope because these ponds hold a significant difference in salamander density, especially large-bodied paedomorphs. Having this data is important not only for the summer but for the long term collection at the site of the Mexican Cut Nature Preserve.

Even though our hypothesis is supported with this study, other hypotheses that should be taken into consideration is the availability of different resources that could influence the decline of abundance in these ponds. The strained conditions in these semi-permanent ponds can lead to competition for resources which can be another leading factor to the steeper slopes in their population abundances. Another hypothesis could be the other predators that feed on the caddisflies, especially if they are in the more vulnerable and high populated ponds.

The hypothesis that salamander predation impacts the slope of the caddisfly population decline is consistent with other studies done at the Mexican Cut. For example, Paedamorphs have the highest direct effect on the composition of the invertebrate community as a whole. These salamanders have strong impacts on large bodied invertebrate abundances that find themselves in more vulnerable positions. (Wissinger, et al. 1999). Along with supporting this idea that salamanders are a leading factor in caddisflies general population decline, this same phenomenon has been observed in different insect species as well, like mayflies in trout streams. The slope of mayfly decline over their life history was steeper in trout streams than in fishless streams. Not only that, but the abundance started higher in these predator streams as well. They hypothesised that the reason was because these streams had a higher amount of area where the adults could lay their eggs (Peckarsky, et al. 2011) which may be the reason for the high abundance of caddisflies in the permanent ponds at the Mexican Cut also. Caddisflies lay their eggs on the sedge surrounding the ponds which varies from pond to pond depending on their morphology. Ponds with higher salamanders are seen to have more surrounding sedge which could be looked at in future using gps units and mapping the sedge, comparing the two pond types from this study to see if there is a correlation between the amount of sedge present and abundance declines.

Although salamanders are the focal predator of this research, this does not mean that they are the only predator that impacts caddisfly population abundance. Possible contributors that influenced the caddisfly mortality this summer could be from *Dytiscus* beetle larvae which are known to be overly aggressive. Future directions could be to encompass the population density of *Dytiscus* beetles, salamanders, and caddisflies to compare their abundances between each

other to see if there is a correlation or relationship between the predation in the ponds. Data on salamander abundance per pond are not yet available for this study year, therefore even just starting with those numbers when that data is present would be interesting to look at and compare as well. Caddisflies are known to show cannibalistic tendencies as well and show competitive behaviors between themselves (Wissinger, et. al. 1996) . High density salamander ponds may have a different effect on the caddisflies behaviors which was looked at by a peer of mine this summer and it was seen to have significant difference on their case sizes at the end of the trials. Knowing this, caddisfly behaviors can most likely influence their abundance slope by the high stress environment of being in a high density of predation area. Having this data is important not only for the summer but for the long term collection at the site of the Mexican Cut Nature Preserve. Having data that supports the idea that the abundances decline in general, which allows us to predict possibilities like if collections were to start later, we assume the population densities could have been higher before the collection time.

Conclusion:

In summary, *L. externus* exhibited a decrease in population densities as their instars progress throughout summer. With the addition of salamander predation, the population densities declined at a steeper rate than those without the salamanders leading to accept my hypothesis. Having this data can be useful in long term data sets to predict abundances throughout the summer as the climate changes and the Mexican Cut Nature Preserve continues to adapt to these changes. In the future, possible studies could compare the caddisfly abundance to salamander abundance to see if there is a correlation with their population fluctuations.

Citations

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