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# Habitat Selection by Three Darter Species (Genus: *Etheostoma*) in the Swannanoa River

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# Abstract

Species habitat preferences allow them to function and survive, and as habitat variables shift outside of their preferred range, it can threaten species survival. As species decline it can have negative impacts on the ecosystem. It is also important to know what habitat variables species select for because it allows us to properly monitor ecosystems. Over the course of two months during the summer of 2024, I sampled four locations along the Swannanoa River. At each site I assessed fish species diversity, distribution and association with three habitat variables (water depth, flow velocity, and substrate category). I collected six Darter species (Pisces: Family Percidae), and sufficient data were obtained to assess habitat use by three of them: Redline Darter (*Etheostoma rufilineatum*), Fantail Darter (*E. flabellare*), and Swannanoa Darter (*E. swannanoa*). Redline Darters showed significant preferences for all three habitat variables, preferring shallower, faster-moving water and relatively coarse, cobble-sized substrates. Fantail Darters showed the same pattern for depth preferring shallower sites and mid-sized substrates, however they did not show a significant preference for flow rates. Swannanoa Darters showed a significant preference for deeper and higher flow water, though they too tended to prefer cobble substrates. My results suggest that understanding habitat variables is important in efforts to conserve and maintain these darter species.

# Introduction

For species to survive and thrive they are attuned to specific variables in their habitat. As these habitat variables shift it will become harder for them to function effectively. It is important to study and understand the way that species select habitat because as our planet changes it will be imperative to be able to monitor and remediate habitats that house species of interest. As we study more species it also allows us to understand some of the possible habitat needs for related species. Stream fishes have been shown to more frequently select habitat non-randomly on smaller scales.[1] This indicates that there is something about specific habitat traits that these stream fishes select for.

Darters (Etheostomatinae) of the family Percidae are slender freshwater benthic fishes that prey mostly on macroinvertebrates.[2] Darters are a significant portion of riffle communities which suggests that they may select for faster flowing water.[3] Some Darters such as the Rainbow Darter (*Etheostoma caeruleum*) have been studied to see what sorts of microhabitats they prefer based on flow and microhabitat velocity shelters.[4] Related darter species such as Fringed Darter (*Etheostoma crossopterum*) have been found to use gravel-like substrates and rarely cobble size substrates. Bouska and Whitledge[5] also looked at Fantail Darter which is one of the species that I specifically looked at. In Illinois, the Fantail Darter selected for gravel size substrates.[5] There is also a relation between darter morphology and the habitat that they live in.[6] Their bodies are designed to work in specific environments that fit their niche.

For this research project, I examined how three darter species selected from available habitat. I tested to see if depth, flow velocity or dominant substrate type influenced the types of habitat these species selected for in a western North Carolina stream ecosystem.

# Materials and Methods

## Sampling Sites

I sampled four sites in summer 2024 on the Swannanoa River (French Broad river drainage) in western North Carolina. Each of the sites included different types of habitats, ranging from from pools to riffles. Substrate types ranged in coarseness  from silt to bedrock. At each site, I included a range of habitat and substrate types. Some of the sites had moderate to high levels of riverweed (*Podostemum* sp.) in the habitat as well.

## Sampling

On Saturday June 22nd I sampled a section of the Swannanoa River adjacent to the Walmart parking lot on Bleachery Dr. On Saturday June 29th I sampled a section of the Swannanoa River at Owen Park. On Saturday July 13th I sampled a section of the Swannanoa River near Anchors Steam Power.Finally on Saturday July 27th I sampled a section of the Swannanoa River near the Western North Carolina Nature Center downstream from the dam. Each sampling trip was done during daylight hours around midday.

Upon arriving at each site, I selected a 60-meter stretch, and placed flags every 10 meters to mark my transect points. Working upstream, I used a seine to sample a square meter at a time. In the square meter I set up the seine at the downstream portion and kicked through the square meter working closer towards it and then scoop up the seine and collect and record the fishes that were collected in that quadrat. After identifying the fishes and releasing them, I dropped a weighted marker to mark that point for habitat measurement. I then moved about a meter over and repeated until I had reached the other side or had sampled approximately 6 points along the transect. Once I finished sampling a transect I moved up to the next flag and repeated until I had covered all 60 meters of our sampling site.

Upon completion of fish sampling, I returned to the previously sampled points and recorded the depth in centimeters, the flow using a digital flowmeter, and then using a standardized substrate size chart determined the dominant substrate type of the square meter. I then moved point by point and recorded this data for every point that I had sampled. After I had completed data collection and picked up all of our equipment I recorded the turbidity, dissolved oxygen, and conductivity.

## Data Analysis

I restricted analyses to the darters that I collected more than 10 total. That left three species, Fantail Darter (*Etheostoma flabellare*), Redline Darter (*Etheostoma rufilineatum*), and Swannanoa Darter (*Etheostoma swannanoa*). Histograms were made comparing habitat use for each species of darter to unoccupied depth, flow, and substrate. Bin sizes were standardized so that the data was comparable at a glance.

Substrate sizes were graphed in order of increasing size, and bins with zero counts were omitted.

To test for significant differences between occupied and unoccupied habitats, *T*-tests were run comparing the means at points where the darters were found to the means at points where they weren't for both depth and flow. For the substrate, chi-square tests were run comparing the distribution of points in each substrate category where the darters were found to the points where darters weren't found.

# Results

I collected six species of darters: Redline Darter (*Etheostoma rufilineatum*), Banded Darter (*Etheostoma zonale*), Gilt Darter (*Percina evides*), Greenside Darter (*Etheostoma blennioides*), Swannanoa Darter (*Etheostoma swannanoa*), and Fantail Darter (*Etheostoma flabellare*). As mentioned above, I only collected enough individuals to run tests on three species: Redline Darter, Swannanoa Darter and Fantail Darter. I collected 55 Redline Darters, 30 Fantail Darters and 10 Swannanoa Darters.

Redline Darters showed significant preferences for all three habitat variables. Mean depth of occupied points was significantly less than unoccupied points ($p$ <0.0001, Figure 1). Mean flow of occupied points was significantly faster than unoccupied points ($p$ 0.0076, Figure 2). The proportion of substrate composition at occupied points differed significantly from unoccupied points ( $p$ <0.0001, Figure 3).

Fantail Darters also showed significant preferences for depth and substrate habitat variables but not for flow. Mean depth of occupied points was significantly less than unoccupied points (*p* 0.026, Figure 4). Unlike the other two species, Fantail Darters did not show a significant preference for flow rates (*p* 0.32, Figure 5).The proportion of substrate composition at occupied points differed significantly from unoccupied points ( *p* <0.0001, Figure 6).

Swannanoa Darters showed significant preferences for all three habitat variables. Mean depth of occupied points was significantly less than unoccupied points (*p* 0.00089, Figure 7). This is deeper than the other species that I looked at. Mean flow of occupied points was significantly faster than unoccupied points (*p* 0.0084, Figure 8). The proportion of substrate composition at occupied points differed significantly from unoccupied points ( *p* <0.0001, Figure 6).

Each darter's preferences for depth and flow varied slightly. They had different minimums, maximums, and means (Table 1). There was a great deal of overlap in habitat use among the three darter species.

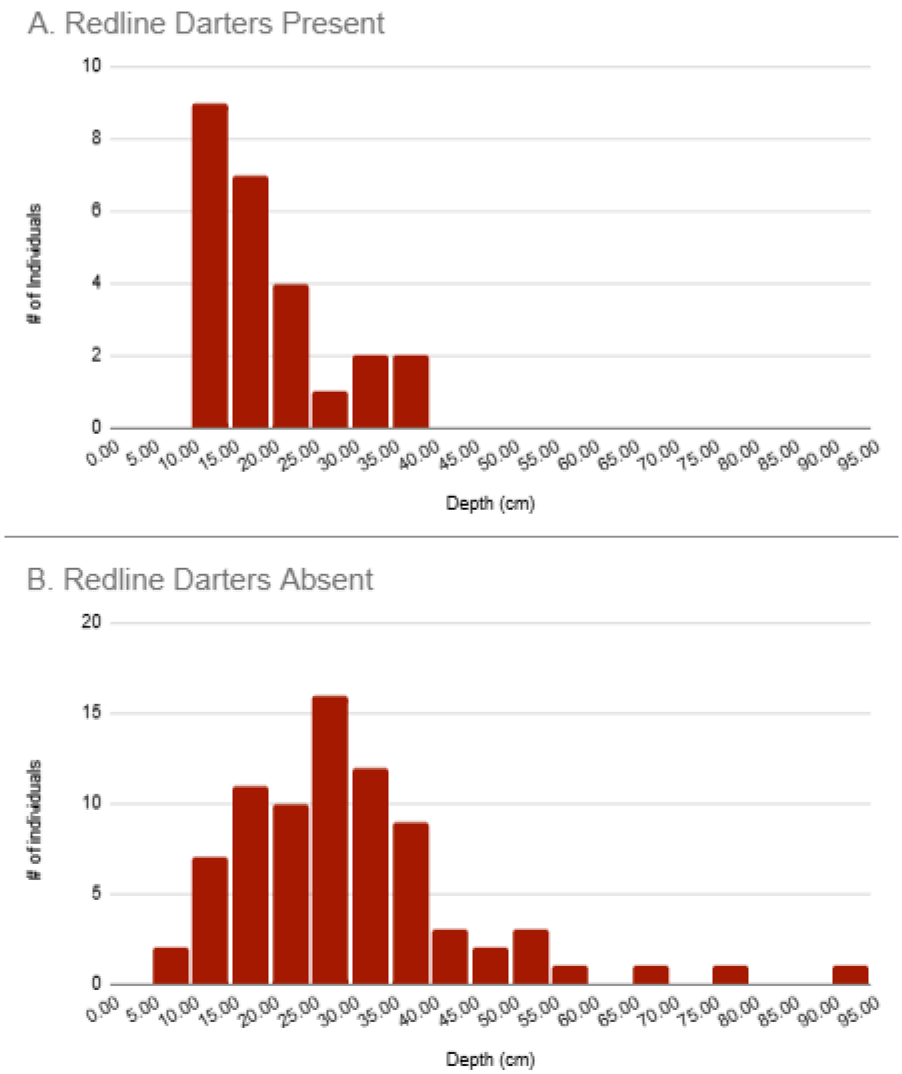


**Figure 1.** Depths at which Redline Darters were (A) and were not (B) found. The median for points with Redline Darters was 18 cm and the mean was 18.25 cm. The median for points without Redline Darters was 28 cm and the mean was 29.16 cm. The *p*-value assuming $t=0$ is $<0.0001$.

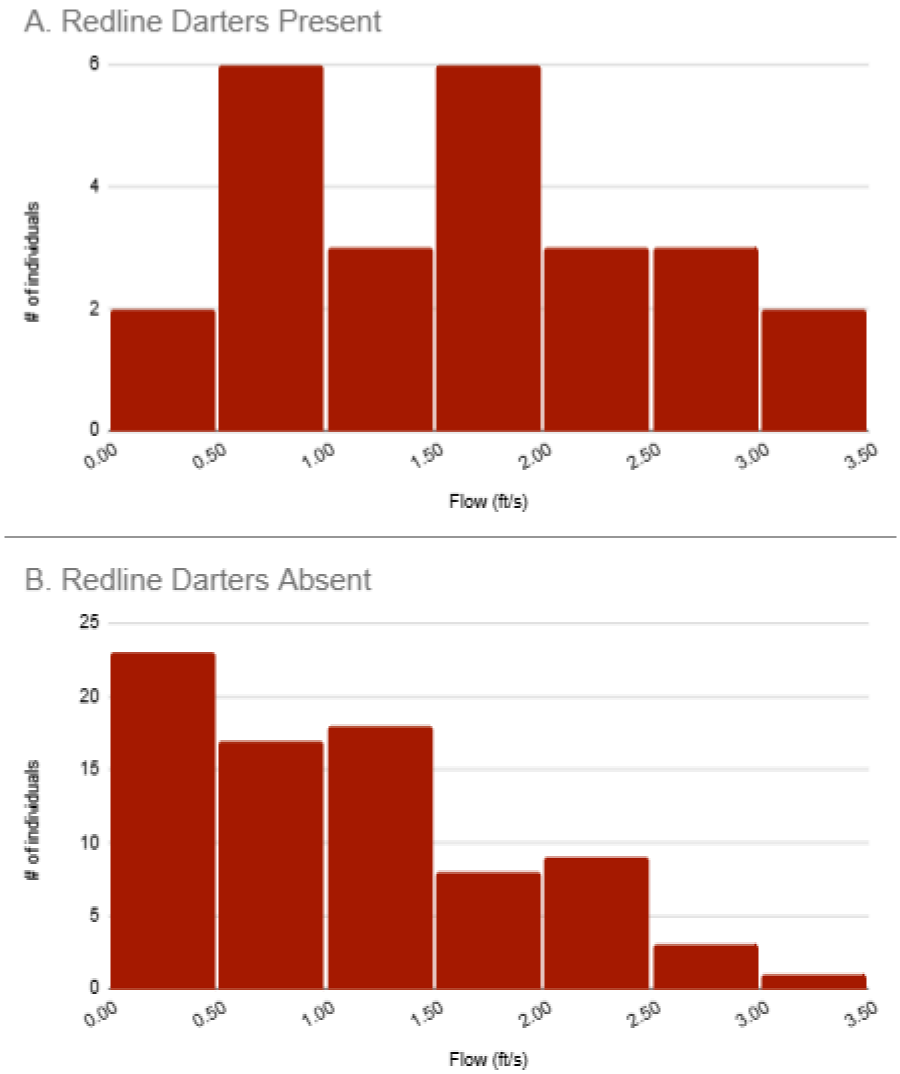


**Figure 2.** Flow at which Redline Darters were (A) and were not (B) found. The median for points with Redline Darters was 1.7 ft/s and the mean was 1.53 ft/s. The median for points without Redline Darters was 0.9 ft/s and the mean was 1.02 ft/s. The *p*-value assuming $t$=0 is 0.0076.

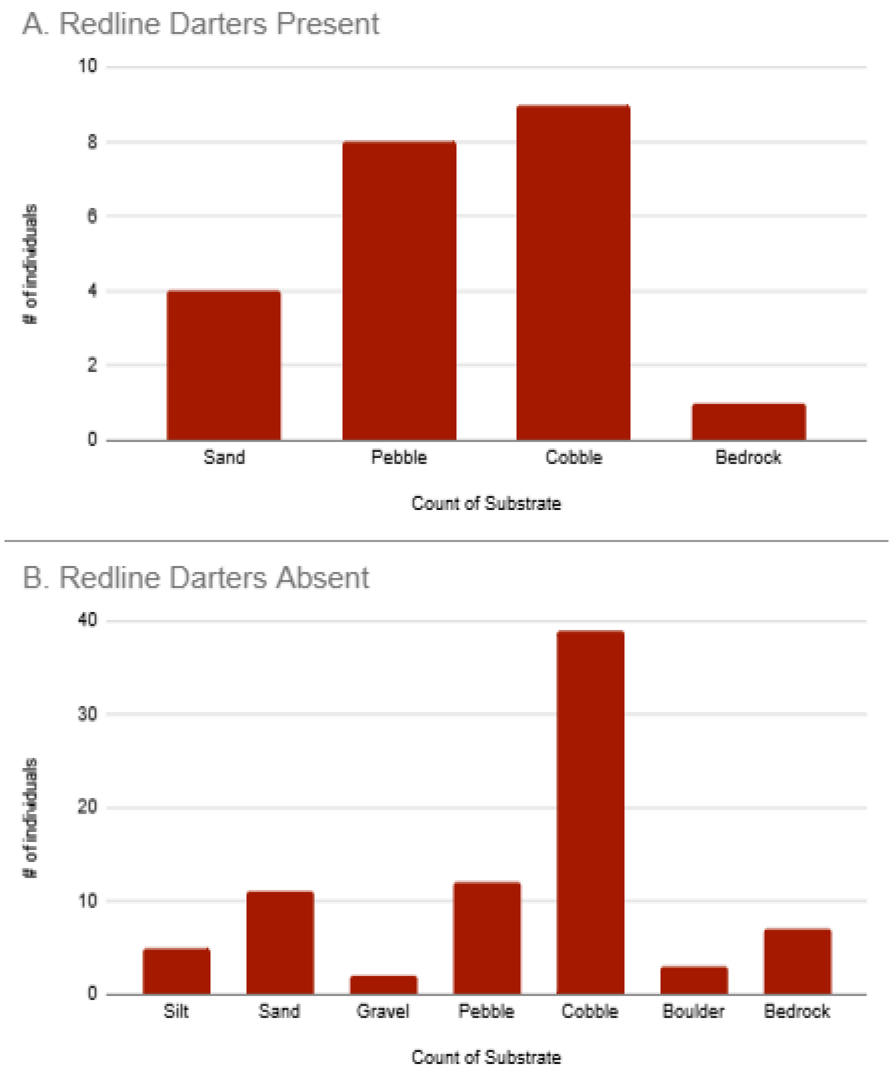


**Figure 3.** Substrate sizes where Redline Darter were present (A) and where they were not (B) present. The chi-squared value between where Redline Darter were present and where they were not present was 46.627 with 6 degrees of freedom and had a *p*-value of <0.0001.

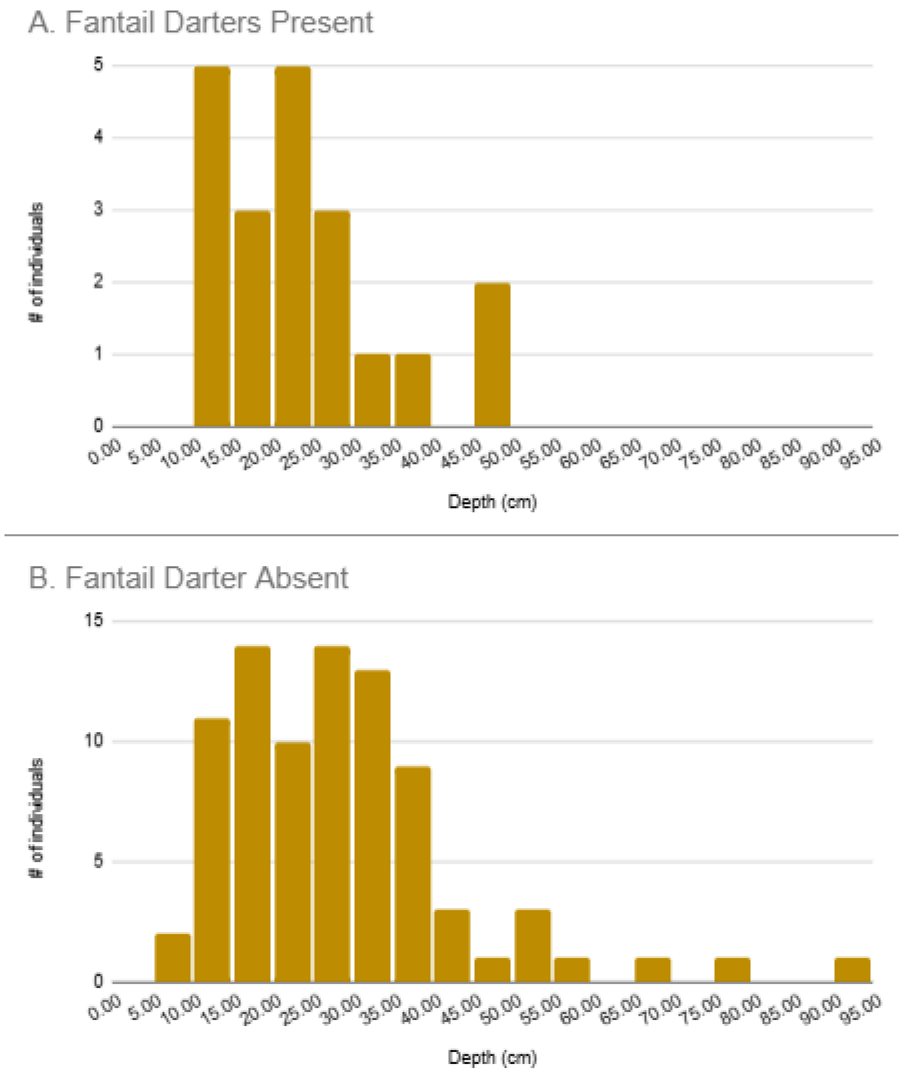


**Figure 4.** Depths at which Fantail Darters were (A) and were not (B) found. The median for points with Fantail Darters was 20 cm and the mean was 22.35 cm. The median for points without Fantail Darters was 26 cm and the mean was 27.65 cm. The *p*-value assuming *t*=0 is 0.026.

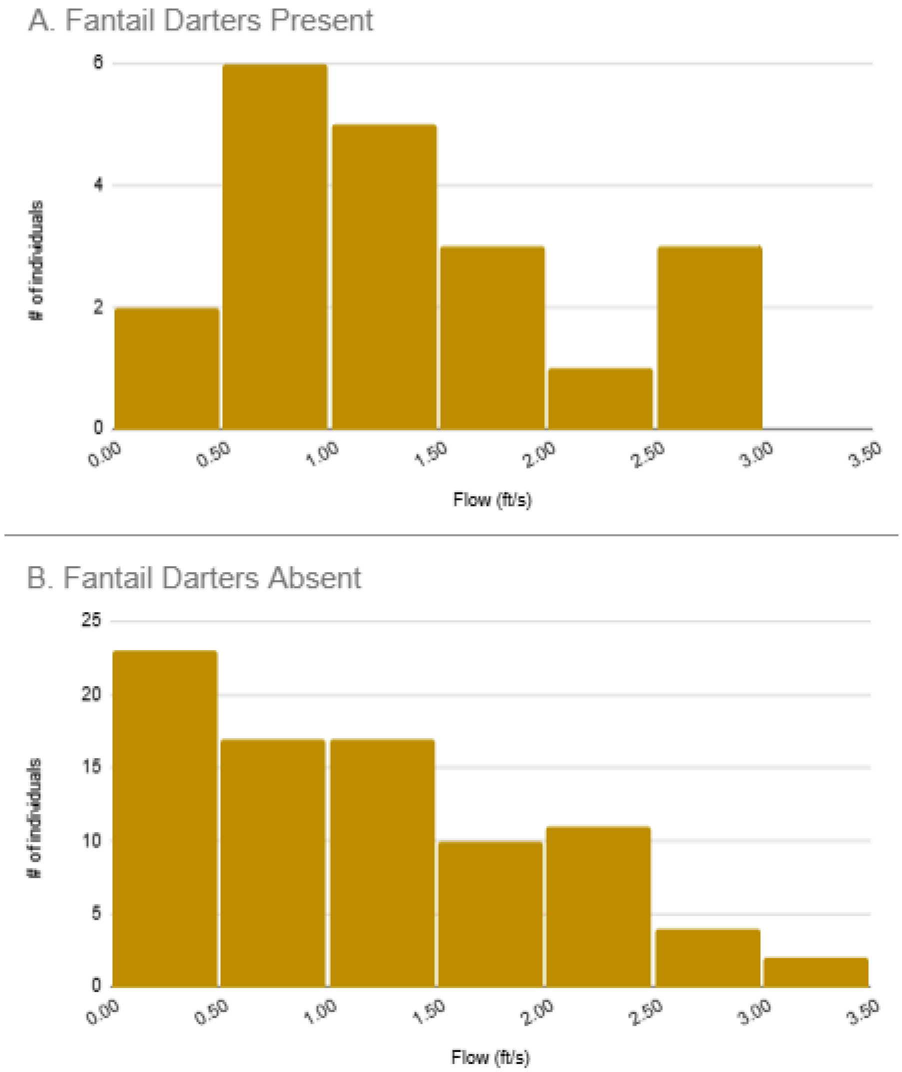


**Figure 5.** Flow at which Fantail Darters were (A) and were not (B) found. The median for points with Fantail Darters was 1.05 ft/s and the mean was 1.23 ft/s. The median for points without Fantail Darters was 1 ft/s and the mean was 1.14 ft/s. The *p*-value assuming *t*=0 is 0.32.

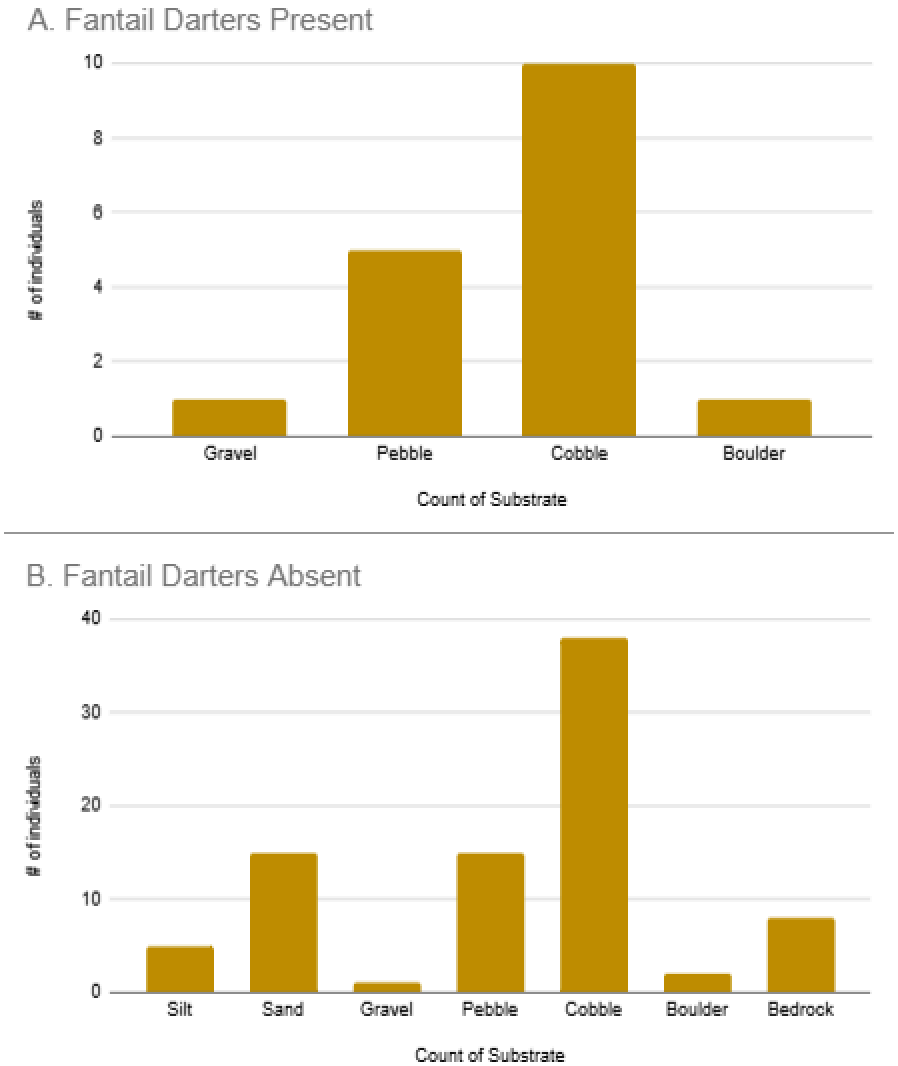


**Figure 6.** Substrate sizes where Fantail Darters were present (A) and where they were not (B) present. The chi-squared value between where Fantail Darter were present and where they were not present was 78.078 with 6 degrees of freedom and had a *p*-value of <0.0001.

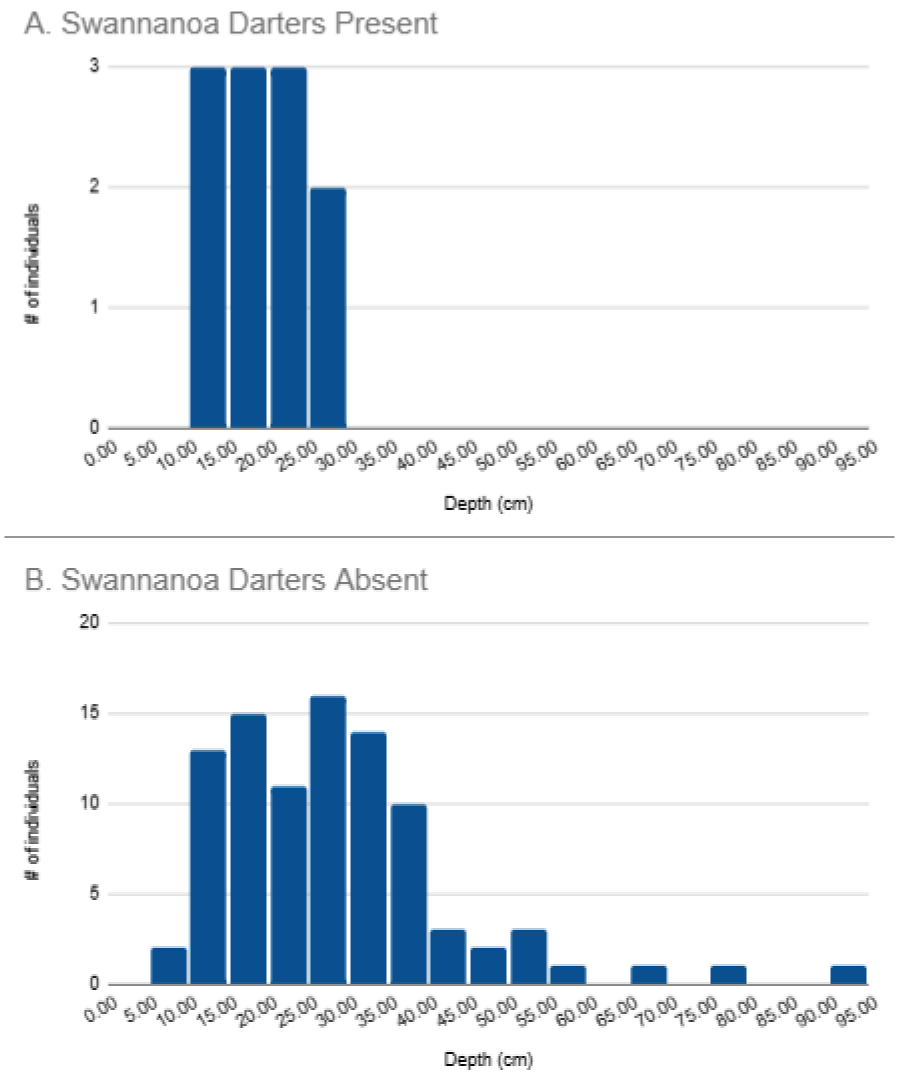


**Figure 7.** Depths at which Swannanoa Darters were (A) and were not (B) found. The median for points with Swannanoa Darters was 18 cm and the mean was 18.5 cm. The median for points without Swannanoa Darters was 26 cm and the mean was 28.17 cm. The *p*-value assuming $t$=0 is 0.00089.

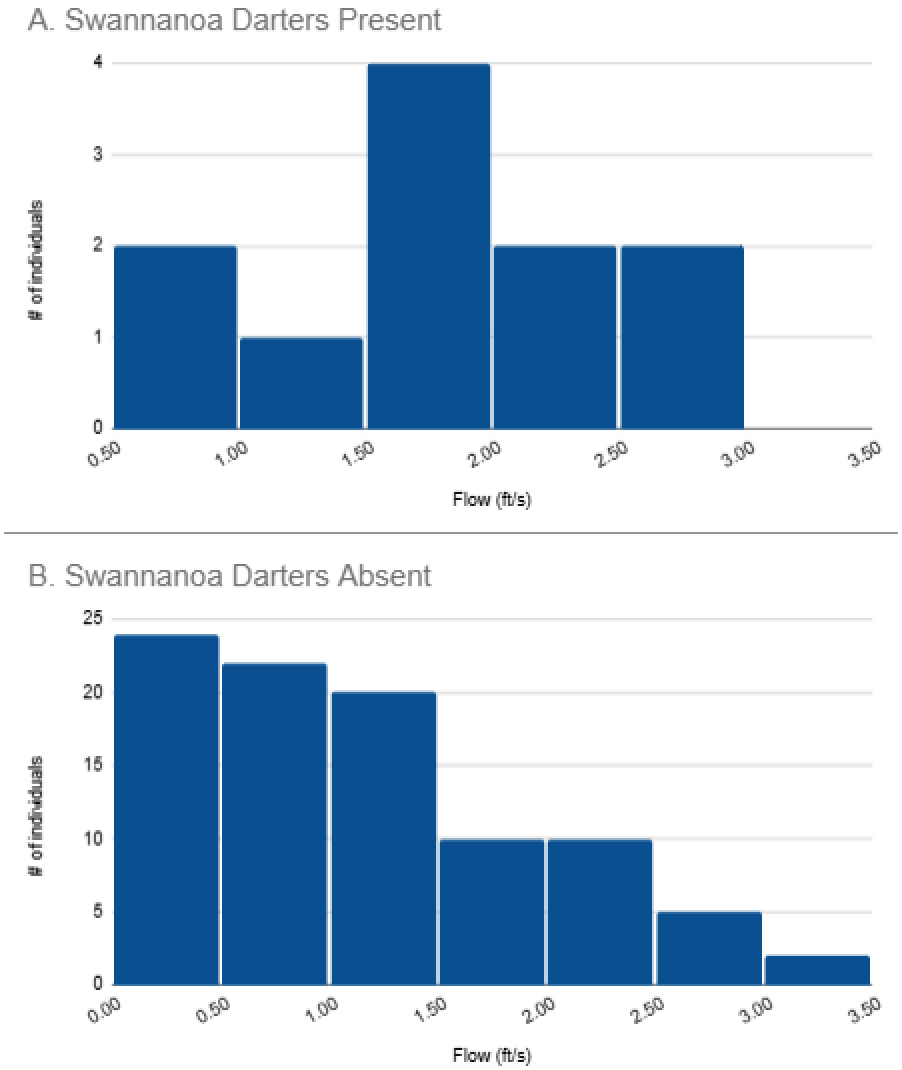


**Figure 8.** Flow at which Swannanoa Darters were (A) and were not (B) found. The median for points with Swannanoa Darters was 1.7 ft/s and the mean was 1.79 ft/s. The median for points without Swannanoa Darters was 1 ft/s and the mean was 1.1 ft/s. The *p*-value assuming $t$=0 is 0.0084.

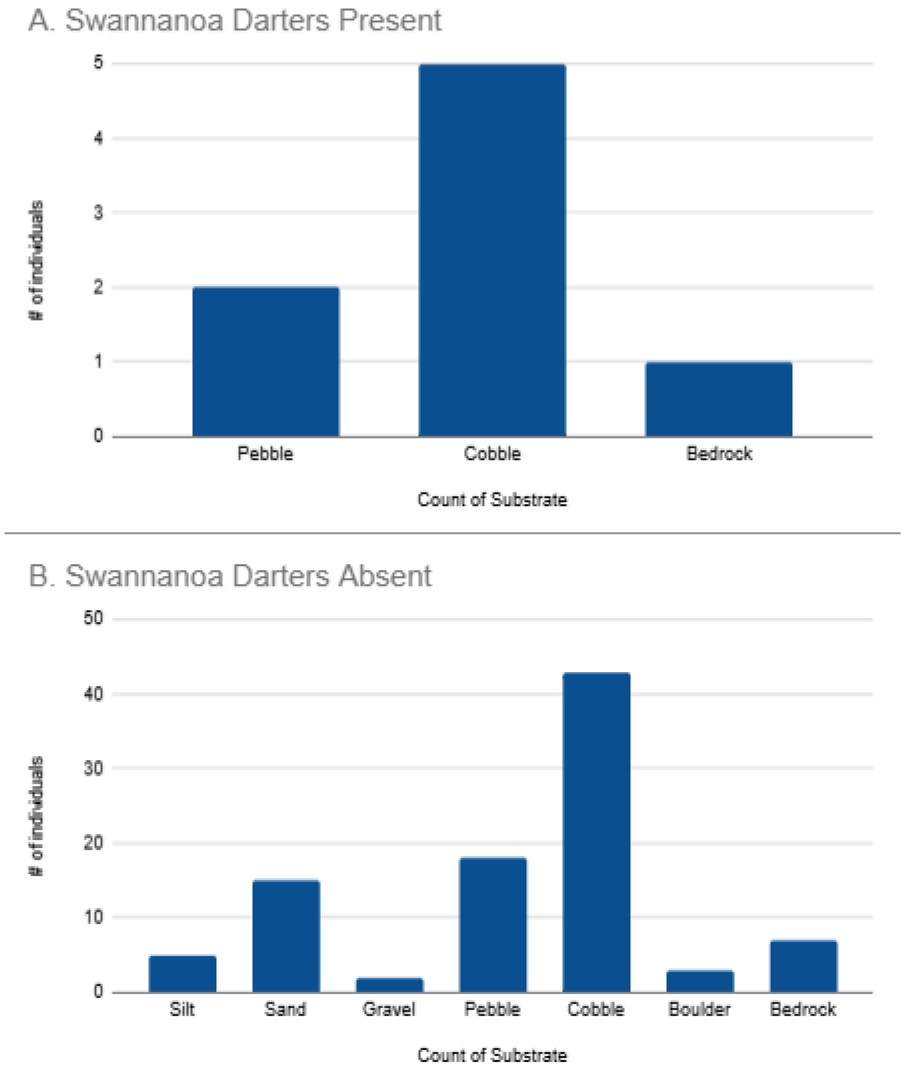


**Figure 9.** Substrate sizes where Swannanoa Darter were present (A) and where they were not (B) present. The chi-squared value between where Swannanoa Darter were present and where they were not present was 35.940 with 6 degrees of freedom and had a *p*-value of $<0.0001$.

| | Redline Darter | Fantail Darter | Swannanoa Darter |
|---|---|---|---|
| Depth Min. (cm) | 10 | 12 | 10 |
| Depth Max (cm) | 35 | 46 | 28 |
| Depth Mean (cm) | 19 | 22 | 19 |
| Flow MIn. (ft/s) | 0.2 | 0.4 | 0.9 |
| Flow Max (ft/s) | 3 | 2.6 | 2.6 |
| Flow Mean (ft/s) | 1.6 | 1.3 | 1.8 |

**Table 1.** Minimum, maximum, and mean readings in depth and flow for each of the darter types.

# Discussion

Results of my research suggest that each of the darters selected habitats non randomly. Each of the darters had slightly different preferences for habitat variables although there was a great deal of overlap among species. Fantail Darters preferred deeper water on average and also had the greatest range of tolerable depths from the species I looked at. Fantail Darters however did not have a significant preference for flow velocity like the other darters. Swannanoa Darters on average prefer the fastest flowing water. Each of these preferences in habitat variables is linked to the darter's role in their ecosystem. If these habitat variables were to shift it would make it significantly harder for these species to survive. It is important for us to have an understanding of what sorts of environments these species need so that as habitats start changing we can address changing variables that may be altered by anthropogenic environmental damage.

Our data varied a bit from what other studies have found. Bouska and Whitledge found that Fantail darters preferred gravel sized substrates and rarely cobble sized substrates,[6] however we found them to have a preference in our environment to cobble sized substrates. Pratt and Lauer found more similar results to what I found for substrates, that the Fantail Darter had a preference for larger cobble- bedrock sized substates. However they found that the fantail did have a preference for flow, which I did not find.

It would be interesting for future studies to look at what sorts of competition there may be among species because of how much overlap in habitat variables there was. It would also be interesting to run this study again now after Helene to see how the results might have shifted in a recently disturbed habitat.

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