SUBSTRATE PREFERENCE IN TWO SPECIES OF FRESHWATER DARTERS, *ETHEOSTOMA OLMSTEDI* AND *ETHEOSTOMA BLENNIOIDES*

Travis J. Deptola, Jason M. Najarian, Daniel J. Orndorf, Tyler J. Payne and Stephen M. Selego

**ABSTRACT**

The tessellated darter (*Etheostoma olmstedi*) and the green-sided darter (*Etheostoma blennioides*) are native to North America east of the Rocky Mountains. The darters usually live on the bottoms of fast-flowing streams and feed on small animals and fish eggs. The darters under study were collected in the Juniata River in Huntingdon, PA. We tested whether niche partitioning occurs between these closely related sympatric species. Significant differences in substrate preference were observed between these two species. Tessellated darters (*Etheostoma olmstedi*) appear to prefer small gravel and the green-sided darters (*Etheostoma blennioides*) appear to prefer large, flat rocks. The data demonstrates that niche partitioning occurs within the genus *Etheostoma*.

Key words: darters, *Etheostoma blennioides*, *Etheostoma olmstedi*, Juniata River, niche partitioning, substrate preference

**INTRODUCTION**

There are numerous habitats that exist in nature, all of which depend upon interactions between species. Through these interactions, organisms will inevitably affect other species that occupy the same area. In order to survive together, coexisting species must adapt to efficiently use the resources available within a particular location. According to the competitive exclusion principle, if two species dwell in the same niche and use similar resources, they will be unable to survive together indefinitely. In order to accommodate for their respective needs, niche partitioning, or dividing up resources, occurs to enable two similar species to coexist.

Two related species occupying the same habitat were collected from a stream/river environment for our research. The two coexisting species were the tessellated darter (*Etheostoma olmstedi*) and green-sided darter (*Etheostoma blennioides*). Both of these benthic-dwelling members of the order Percidae occupy the same functional guild, which is within the substrate of cold, flowing bodies of water. The research samples were collected from a stretch of the Juniata River that runs through Huntingdon, Pennsylvania (Fig. 1).
Figure 1. Aerial picture of the collection site on the Juniata River for both *Etheostoma olmstedi* (tessellated darter) and *Etheostoma blennioides* (green-sided darter).

*E. blennioides* can typically be found in deep riffle habitats, among the cobble and loose boulders within river ecosystems. These regions of the water body provide fast moving water with low turbidity that the green-sided darter prefers. This species is distinguished from other darters by several physical characteristics that include a cylindrical body with ctenoid scales, number of dorsal rays, a broad triangular head, larger body size (reaching 3 inches in length), and unique coloration pattern that contains saddle-like marks along the back of the fish (Fig. 2). The green-sided’s diet consists of immature benthic insects that are between 1 and 6 mm long, such as chironomid larvae (midges and flies), Emphemeroptera (mayflies), and Plecoptera (stoneflies). Their green color enables *E. blennioides* to blend in with the filamentous alga that covers the substrate within their habitat. The filamentous alga also serves as a resting place for the fertilized eggs of this darter species.

*E. olmstedi*, or the tessellated darter, is also found in river/stream habitats. However, this species favors slower moving, or still portions of the moving water body. This preference has enabled this species of darter to inhabit the shallower locations of lakes within its natural range. The tessellated darter is also more likely to be found in sandy/muddy-bottomed locations. *E. olmstedi* is identified by a light-sandy color that turns to white toward the underside of the fish. Tessellated refers to the fish having a checkered like pattern (X-W-shaped marks) on the back and upper sides of its body (Figure 3). *E. olmstedi* consumes small aquatic insects and crustaceans early in its life, before growing (up to 2-3 inches in length) and eating larger benthic insects once it matures. Reproduction in tessellated darters occurs in rockier locations where the adhesive eggs stick to the top and sides of rocks. Both *E. olmstedi* and *E. blennioides* live 3-4 years in nature.
Although these two fish species do share the same habitat, they have adapted to depend on different niches and resources in order to coexist, according to previous studies on these species. In the Juniata River, both *E. olmstedi* and *E. blennioides* were collected from substrate that consisted of various sized rock materials. In a controlled laboratory setting, research was conducted in an attempt to determine how these species defined their substrate niches within this particular habitat.
MATERIALS AND METHODS

A total of 40 darters were collected from the Juniata River by using seine and dip nets. Out of the 40 fish collected, 13 were determined to be tessellated darters while the other 23 were green-sided darters.

A 10-gallon fish tank was separated into four quadrants of varying substrate. The tank was divided as shown in Fig. 4. The substrate rocks were all collected from the Juniata River where the fish used in this study were caught. The rocks all had similar coloration and varied primarily in size and shape. The substrate types by area were:

- Large flat rocks that were on average 5 by 2.5cm
- Small gravel that was on average 0.5 by 0.75cm
- Large angular rocks that were on average 5 by 2.5cm
- Medium sized gravel that was on average 1.25 by 2cm

The tank was filled with water that was 10°C and occasionally cooled down through the addition of ice to maintain this temperature. The pH of the water was measured as 7.63. To minimize distractions to the fish, a black plastic bag was used to cover the outside of the tank.

The fish were individually introduced to the tank by adding them to one of the quadrants determined by a preset order (1-2-3-4-1, etc.). They were allowed to freely move around the tank for 1 minute before their position was recorded. Ending location was determined by which quadrant the fish’s pectoral fins were located in. The fish were then removed from the tank before the next trial started.

Because of the relatively lower sample size of tessellated darters, we performed 2 trials with each fish to obtain more data. For some trials four fish, selected at random, were added to the tank simultaneously. They were given 2 minutes to swim freely before the locations of all four fish were recorded.

Figure 4: 10-gallon tank divided into quadrants based on substrate.
RESULTS

A data table summarizing the substrate choice for the total number of green sided darters and tessellated darters is shown below in Table 1.

Table 1. Summary table of substrate quadrant chosen for each type of darter.

<table>
<thead>
<tr>
<th>Type of Darter</th>
<th>Quadrant Chosen</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Green-sided Darter</td>
<td>18</td>
</tr>
<tr>
<td>Tessellated Darter</td>
<td>9</td>
</tr>
</tbody>
</table>

A Chi-squared test was chosen to determine whether or not there was significance to the substrate type that was chosen for each of the darter species. To conduct this Chi-squared test, an expected value of 25% was chosen for each substrate type, which would indicate no preference for a specific substrate. The observed values for each quadrant were then also converted to a percentage by taking the number of darters that had selected this quadrant and dividing that by the total number of darters of that species. Table 2 compiles the observed versus expected values to complete the Chi-squared test for the green-sided darters, and table 3 compiles the observed versus expected values for the tessellated darters.

Table 2. Summary table of observed versus expected percentages for green-sided darters.

<table>
<thead>
<tr>
<th>Green-Sided Darter</th>
<th>Quadrant Chosen</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Observed</td>
<td>38</td>
</tr>
<tr>
<td>Expected</td>
<td>25</td>
</tr>
</tbody>
</table>

Table 3. Summary table of observed versus expected percentages for tessellated darters.

<table>
<thead>
<tr>
<th>Tessellated Darter</th>
<th>Quadrant Chosen</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Observed</td>
<td>30</td>
</tr>
<tr>
<td>Expected</td>
<td>25</td>
</tr>
</tbody>
</table>

After conducting the Chi-squared test, a Chi-squared value of 22.24 was obtained for the green-sided darters and a value of 13.52 was obtained for the tessellated darters. A third Chi-squared test was also conducted to determine significance between the substrate selection preference of green-sided darters versus the tessellated darters, using the observed values of the tessellated darters as the expected value for the green-sided darters. The Chi-squared value obtained for this test was 37.40.
DISCUSSION AND CONCLUSION

The green-sided darters generated a Chi-squared test statistic of 22.24, which is compared to 7.815, the value based on 95% confidence and 3 degrees of freedom. Our test value was considerably higher, suggesting that that strong substrate preference was exhibited by the darters. The tessellated darter test statistic of 13.52 was also compared to 7.815, and again suggested selection for specific substrate types. The final Chi-squared test, comparing the preference between the two darter species, yielding a value of 37.40, is also considerably larger than 7.815. This result indicates that although substrate selection was observed in both species, the specific preference seen varied between the species.

Our results make sense in light of the habitat each darter species prefers. Green-sided darters inhabit fast-moving water, where gravel is easily swept away. Therefore, one would expect green-sided darters to be more accustomed to larger, heavier rocks. This trend is seen in our data, as the two quadrants containing larger rocks (1 and 3) were chosen by this species over the other two quadrants. Quadrant four was especially unattractive to these darters, for unknown reasons.

Tessellated darters prefer slower-moving habitats with smaller-substrate bottoms. Therefore it comes as no surprise that these darters selected quadrant 2 (the quadrant with the smallest substrate) over the others. The tessellated darters did not show aversion akin to the green-sided darters distaste for quadrant 4, although this may be an effect of the decreased motility of the tessellated darters compared to the green-sided darters (which moved from their initial quadrants much more frequently). Further tests could be conducted using sand or mud as a substrate type to determine if the tessellated darters would select this type over the small gravel seen in quadrant 2.

Niche partitioning, as seen in the results of our study, is of extreme ecological importance. Without it, two similar species (such as the green-sided and tessellated darters) could not coexist.

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