Predation Risk and Habitat Complexity: Shoaling Behavioral Changes in *Pimephales Promelas*

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Abstract

Grouping behavior in fish is a well-understood phenomenon present in numerous species. Habitat and predation risk are two major influences on this behavior and our experiment was designed to quantify the how shoaling behavior in *Pimephales promelas* differed with an increase in complexity of environment and predation risk. We found that shoaling behavior was not different when habitat complexity increased or in the presence of a natural predator (*Perca flavescens*). While both of these factors are expected to affect grouping behaviors we were unable to quantitatively see a difference in the distances between individuals and the shoal diameter.

Introduction

Grouping behavior is common among organisms that are at risk or can gain an advantage by surrounding themselves with others that are similar to them. There are numerous influences that can alter grouping behavior, from social (Ledesma & McRobert 2007), to predatory implications (Spinozzi et al., 2009 among others). Fish are a species known to be found in groups of similar size, shape and species into groups known as schools or shoals. This behavior allows for protection

from predation through what is known as the oddity or confusion effect (Landau and Terborgh, 1986). By grouping in large numbers it becomes more difficult for a predator to single out its prey, as well protection by placing another individual between prey and predator in what is coined as the "selfish herd" (Orpwood et al., 2008). This behavior will therefore decrease the likelihood of predation on any one individual when large numbers of present and perpetuate this behavior in future generations.

Habitats and vegetation complexity in which fish are found also play a large role in influencing predation behavior of the predators (Savino & Stein, 1988). Depending on the predator, hunting strategy must be changed when there is an increase in plant density. If this altered strategy is not as effective, there will be an increased survivability in the prey. We analyzed how these two concepts (shoaling and habitat complexity) interact within fathead minnows (*Pimephales promelas*)with response to a predator (*Perca flavescens*). We hypothesized that shoaling behavior will be stronger in terms of inter-individual distances and shoal diameter in open water as well as when a predator is present, resulting in smaller distances between individuals.

Methods

Fathead minnows of approximately the same size were collected using seining nets in lake Itasca and purchased at a bait shop and placed in storage tanks. A perch of sufficient size (>10cm) was caught to serve as a predator and induce shoaling behavior. Artificial vegetation was made using polypropylene rope and

test tubes to mimic wild rice, a natural species found in Lake Itasca. Four treatment groups were used that varied in habitat and presence of a predator, all using 4 randomly selected minnows from a 50 minnow sample size. Treatments included open water and complex environment, and presence or absence of the perch predator. Shoaling behavior was quantified by distances between each individual and shoal diameter in terms of body length every 10 sec and averaged over a 5 min period using video records. Ten replicates were done for each of the four treatments that were then averaged and compared using a multiple ANOVA analysis.

Results

It was found that there was not a significant difference in the distances between individuals in terms of habitat ($f_{1,36} = 0.357$, $p = 0.742$ with interaction factor $f_{1,36} = 5.671$, $p = 0.194$) or presence or absence of a predator ($f_{1,36} = 5.671$, $p = 0.194$ and interaction $f_{1,36} = 20.308$, $p = 0.167$ also fig. 1)

There was not evidence to support that the vegetation complexity or predatory risk influenced the grouping behavior of our fathead minnows. Although statistically insignificant, minnows tended to form the tightest shoal in open water without the presence of a predator with the largest average shoal size in open water when the predator was present.

Discussion

Our results differed from our hypothesis that open water with a predator present would increase shoaling behavior. There are a number of studies that

analyze predation and habitat influence on behavior, which makes it difficult to dismiss that there is an effect on our population within our own experiment. A factor that may have played a role in complicating our results is the small density of fish used that group together. According to Rangeley & Kramer (1998), as density of schools increase there is an increase in the tendency to shoal in more favorable environments (in this case algal habitat). When a predator is introduced, there is an increase in the proportion of fish present in the favorable environment than prior to exposure. Had there been a more isolated complex region or an increase in prey density within the testing area it is likely that stronger shoaling would have been favored and our results would have varied.

Our findings do not entirely fit within the selfish herd theory that states that there would be less of a need for shoaling in a complex environment when a predator was introduced. Using this theory one would expect shoal size to be higher when there is a lowered risk of predation. However as Orpwood mentions, shoaling behavior in complex environments is not dependent on presence of a predator, which coincides with the similar distances we found in our own experiment. Shoal size was largely consistent in habitats that provided cover and did not influence the experiment as we predicted it would. In general, grouping behavior did not differ in our controlled setting, however we expect that should a similar experiment be done on a larger and more natural scale this behavior would be more evident and worthy of further study.

References

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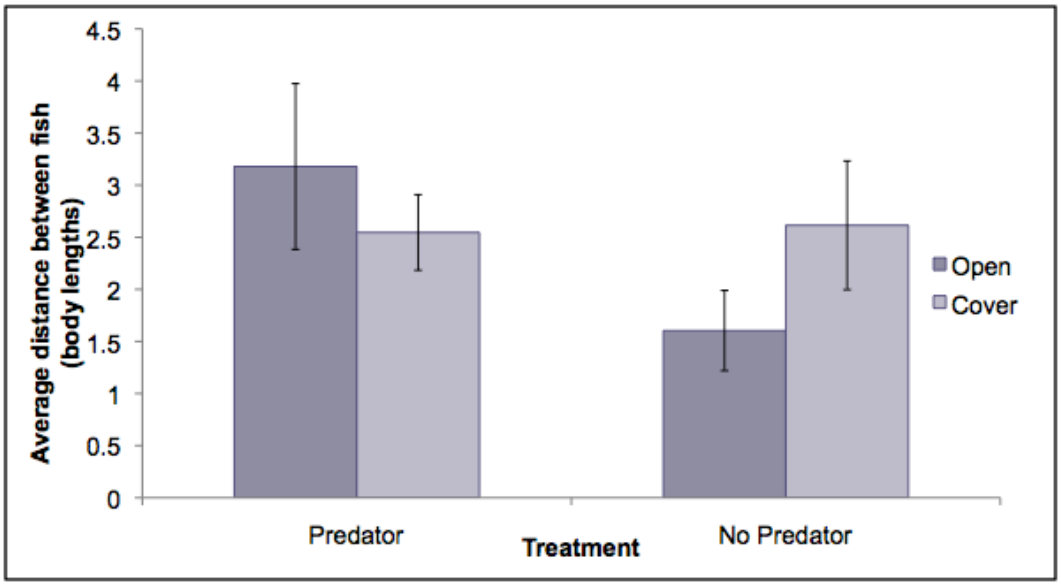

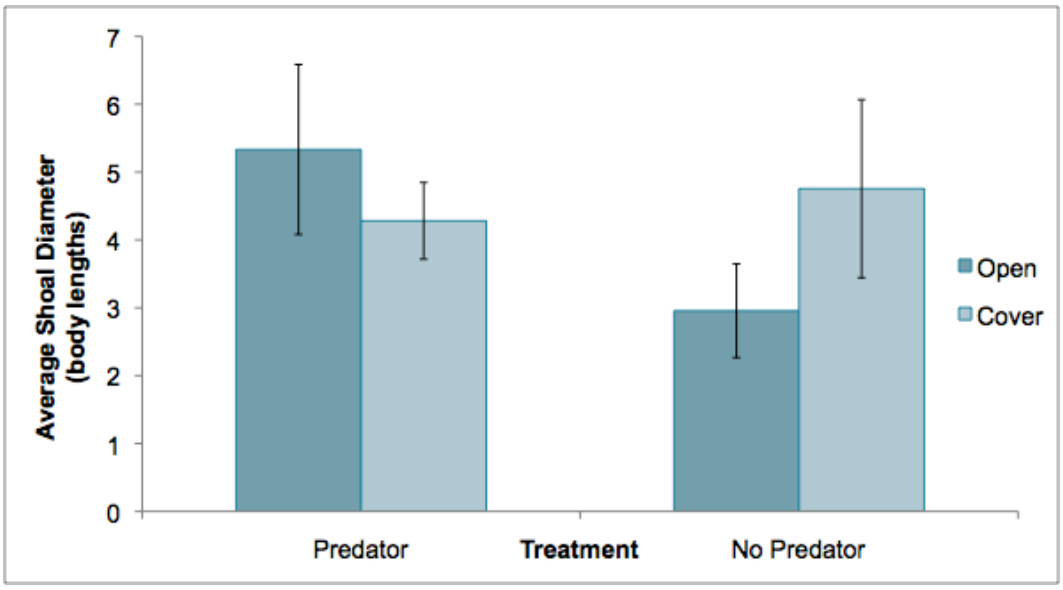

Fig. 1-Mean +/- 1 standard error of body length distances for four treatments on inter-individual distances and shoal diameter.