Smallmouth bass (*Micropterus dolomieu)* Impact on Common Shiners (*Luxilus cornutus)* Schooling Behavior

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Abstract

Small prey fish have antipredator behaviors that help them detect threats before facing them. Common shiners are part of the Cyprinidae family, which consists of small fish. When small fish want to protect themselves from possible danger, they form schools to provide better protection to each other. In this paper, I study the behavior of common shiners (*Luxilus cornutus)* in the presence of smallmouth bass (*Micropterus dolomieu).* My hypothesis was that common shiners would be closer together when the smallmouth bass was present (predator treatment). I worked with 12 schools of 10 common shiners each to run trials. Each one of them went through the treatments of control, kairomones, and predator. It is known that in the presence of predators, schools of fish become closer together to avoid the predator. Common shiners showed other antipredator techniques, like dashing and hiding from predators. Our statistical results showed no significant difference between treatments, but we saw trends of better school cohesion when common shiners were in the same tank with the smallmouth bass.

Keywords: common shiners, *Luxilus cornutus*, smallmouth bass, *Micropterus dolomieu*, behavior, schools, chemical cues, cyprinids.

Introduction

Social learning is defined as any social behavior acquired by individuals about their environment via observations or interactions with other animals (Brown and Laland 2003). One example of social learning is schooling behaviors in fish, which helps them to protect themselves from predators (Brown and Laland 2003). Fish can use their lateral line structure to sense movement or vibrations in the water, and can also use it to transfer information to nearby fish in a school. It is less dangerous for a fish to sense danger through other fish mates than getting near the predator themselves. When fish are in a school, their behavior will change depending on the menace that they are perceiving. The benefit of social-learning and schooling is that fish can be aware of the danger surrounding them though they have not had direct contact with the predator. The closer together a school, the faster is the response to threat. Swimming in school is also an advantage for fish that are predator-naïve, which can react to the nearby threat without being exposed to the predator (Brown and Laland 2013).

The common shiner is known to be a habitat generalist, but it prefers streams with gravel substrate and flowing water. They can be found in rocky pools near riffles, clear cool creeks, and sometimes in lakes. Common shiners are temperate fresh water fish. They are known for their tolerance to multiple habitats and environmental conditions resulting in a distribution from Canada to the Gulf Coast. These fish can live in places with a temperature range that goes from 0° C to 31° C (Beitinger 2000). Common shiners are successful in various environments because they can adapt to different habitats where temperature, flow, and turbidity differ. During periods of high turbidity, common shiners can even change their way of feeding. Their diet usually consists of eating small invertebrates, but turbidity makes it harder for them to see, so they rely on plant matter (NH Fish and Game Department). Their ability to tolerate warm and cold temperatures and their adaptable foraging methods are one of the reasons why these fish can inhabit environments all over North America.

Besides being very tolerant fish, common shiners are very important to the aquatic environment. Shiners are important in the food web of the fresh water ecosystems because they are the base food for many species of predatory fish (Lee et al.1994). Shiners can also have a huge role in converting the basic productivity of streams and lakes into food for larger fish and other predators. For this reason, they are frequently used as bait fish.

One known predator of the common shiner is the smallmouth bass, *Micropterus dolomieu*. Common shiners are prey upon by many large fish and that include smallmouth bass, chain pickerel, and also birds (University of Brunswick Research Institute). Fish predator can release these chemical cues that give the prey the ability to detect the proximity of a predator (Rajchard 2013). Kairomones are infochemicals that represent interspecific chemical communication between individuals in aquatic systems (Samanta et al. 2011). These are the cues prey use to detect the proximity of a predator.

In natural environments, it is important that prey fish learn to recognize diverse cues from predators to avoid risk of predation (Ferrari et al. 2005). That is why kairomones were considered to use as a treatment in this research. Predatory fish release multiply chemical cues that can be used by prey fish to detect danger (Sutrisno et al. 2013). Common shiners can respond to chemical cues of the smallmouth bass that was kept in a common shiner diet. It is documented that prey fish react better to predators that have a diet based on their species (Sutrisno et al. 2013).

The University of Notre Dame Environmental Research Center is on the border of Michigan and Wisconsin, and consists of 7500 acres of land, containing 30 lakes and bogs. Common shiners (*Luxilus cornutus*) were introduced into lakes at the University of Notre Dame Research Center (UNDERC) as bait fish. During this research, we will examine the interactions of one predator of shiners, smallmouth bass *(Micropterus dolomieu*), and its effects on common shiners' schooling behavior. This study will investigate how common shiners behave in different predator environments. Common shiners can often form schools, and it is expected that they will school closer together when there is a threat nearby. Swimming in groups makes it harder for predators to notice them (Chivers et al. 1995) and it also helps fish to have a faster response to nearby threats (Peichel 2004). We caught common shiners at Tenderfoot Creek because they can be found in rifles and slow stream waters. The fish we caught were divided in groups of ten per trial. They were observed in three different treatments: control, predator, and kairomones.

The purpose of this research is to see the impact of smallmouth bass (*Micropterus dolomieu)* on common shiners schooling behavior in Tenderfoot Creek. The hypothesis being tested is if common shiners have the same schooling interactions in the presence of predators.

Methods

Site Description

The fish used in this research were captured at the Tenderfoot Creek at the University of Notre Dame Research Center (UNDERC). This stream flows towards Tenderfoot Lake and has a slow current due to the lack of elevation. Minnow traps were set on the north side of Tenderfoot Creek at a culvert, just past the creek mouth. This area has dense vegetation, shallow waters and fish can be seen frequently.

Data Collection

Common shiners were captured using minnow traps. Due to the dense vegetation at Tenderfoot Creek, these traps were the best option, since they were easy to set and use at the creek. The traps were set every morning at 9, and every afternoon at 5. The traps were checked twice per day, and new bait was added each time. Dog food was used as bait.

Smallmouth bass was used as predator fish. This fish was fished with hook and line at Bay Lake. All fish were taken to aquariums to acclimate for a period of 24 hours before doing trials. Common shiners were kept together in a 32-gallon tank, and predator fish were kept in a different 32-gallon tank.

Before running trials, we determined the amount of fish that were going to be in each trial by running an experiment on common shiner cohesion. We started with a school of 4 common shiners, and added 2 more fish every 10 minutes. We observed the distance between them and determined that 10 fish per school seemed to have a good cohesion relationship. The 10 fish that were going to be in a school were randomized.

For the trials, 10 common shiners were put together in a 91-gallon tank and given a 3 minute long acclimation period. Then they were recorded for 2 minutes. This process was repeated two times, for a total time of 10 minutes in a trial. Each school had three treatments: control, predator, and kairomones. The camera used was set at a specific location and was not moved for the entirety of the trials. The tank where the fish were tested was cleaned after every trial to get rid of any residual hormone or factor that could modify the trials. All 12 school went through the three treatments in a random orders with an hour between treatments.

In the control treatments, I set up the fish in the 91-gallon tank and gave them 3 minutes of acclimation period. After the acclimation period was done, they were recorded for 2 minutes. While the fish were being recorded it was important to not stand around or near the tank since they would react to motion from surroundings. After the first recording session, they were given

3 more minutes of acclimation time and then were recorded for the last time in a 2 minutes period.

For the kairomone treatment, the smallmouth bass was left 24 hours in the tank where the trials were done. During the 24 hours the smallmouth bass was in the tank, it was fed and there were waste residuals. After taking the predator out, the school of common shiners were put into the tank, so they could detect the kairomones left behind. Common shiners would be able to recognize dietary cues left from the smallmouth bass. Once the common shiners were in the tank they were given a 3 minutes acclimation period followed by 2 minutes of recording. After the first recording, they were given 3 more minutes of acclimation and recorded for 2 minutes after the acclimation treatment.

For predator treatments, the school of shiners and the smallmouth bass were put in the 91-gallon together. First, the common shiners were brought into the tank followed by the introduction of the predator. Once the prey and the predator were in the tank together, they were given the first 3 minutes of acclimation period. Once the fish were acclimated, they were recorded for 2 minutes. In between recordings, they had 3 more minutes of acclimation and finished the trial with a last recording of 2 minutes. None of the fish were eaten during this trial because the smallmouth bass was fed every morning. The smallmouth must be fed before trials to guarantee that all schools stay with same number of common shiners during testing.

Statistical Analysis

Data were analyzed using One-Way ANOVA test to determine whether there was a significance difference between the three treatments (control, kairomones, predator). To run statistical tests, I used R Studio and Microsoft Excel.

Results

I tested 120 common shiners from Tenderfoot Creek at UNDERC. They were formed into 12 schools of 10 fish each. Our statistical results showed that there was no significant difference between treatments (mean ± SE; Control, 16.01 ± 1.71; Kairomones, 15.51 ± 1.53; Predator, 14.16 ± 1.27; p-value = 0.67, Figure 1). The reported f value was of 0.40 and degrees of freedom were of 35.

Discussion

Based on the statistical results, the study found no significant difference in common shiners schooling behavior. Throughout the treatments, common shiners maintain a schooling distance between each other (fish to fish) of approximatively 15.22 cm. I can confirm that common shiners do have the ability to form schools and it is more noticeable in the presence of predators. My data suggests that common shiners behave the same way when they are in a presence of a threat, chemical cues, and when they are in a control group. This research rejects our hypothesis that common shiners would have more cohesion in the presence of predators.

During the treatment of control, fish appeared to be the farther away from each other. With an average distance of 16.01 cm between fish, control groups spent much of the time wandering around and in occasion hiding under some rocks. A common occurrence observed through the trials is that in some of the schools one of the fish would keep a greater distance from the group. This distance from the focal fish at times would be greater than 25 cm. Besides having the biggest average in distance, the control group also had the greatest distance between fish in a school (26.36 cm). During this trial, there was no potential threat, and this was an opportunity for fish to wander around. Besides not having a significant distance, the control variable had the greatest distance of all treatments.

During the kairomone treatment, common shiners presented an average distance of 15.51 cm from the focal fish towards the rest of the school. There was better cohesion in comparison with the control group. This suggests that fish were able to detect some of the residual kairomones from the smallmouth bass. As said before, there are many chemical cues released by predator fish and some of them are based on their feeding (dietary cues). It is less of a risk to detect these signals from long distance, rather than having to have direct contact with the predator to be aware of danger.

Prey fish use chemical cues to detect threats, but they also use visual signals. In our trials with common shiners, the predator treatment presented the closest cohesion relation with 14.16 cm between each other. Besides forming schools, some of the mechanism the fish used to protect themselves from predators was dashing (as a group), coming to the surface, and hiding. The shortest distance between fish in a school during the trials was during a predator trial and it showed a distance between fish of only 6.50 cm. Tighter school cohesion should result in higher probability of surviving an encounter with predator (Chivers et al. 1995).

Common shiners did react to chemical and visual cues, even though the statistical tests lead to no significant difference. Albeit there was no significance difference between treatments, it is noticeable how common shiners became closer at the presence of a predator. There are some factors that could have affected the cohesion of the schools. We must consider that the size of tank might have been too small for fish to wonder to far apart. This could have impacted our results in the controls groups, since they had to keep close together because of the space. As mentioned before, one of the fish would occasionally wander further away from the others, affecting the overall average distance between fish. This behavior could be the subject of future research.

If we understand the behavior of small fish, such as the common shiner, it would be easier to understand changes in the environment. Common shiners are known to be tolerant to various habitats, and that could be used as a cue to recognize if a place is suffering an environmental change. Migration of fish is sometimes due to environmental change and modification of the community composition. Fish like the smallmouth bass have the ability to change the community of lakes in the littoral zone (Pamela et al. 2001). Understanding the importance of small fish behavior (cyprinidae) is important in all aquatic environments. It could help us understand the disappearance of native fish, and what threats could be present. Social learning fish could also have important consequences for fish conservation. If we understand fish behavior, it is easier to know their way of reproduction and schooling. Reproduction is a very important factor for fish conservation and understanding how fish choose their mates in a school can be an innovation to preserve native fish. Fish behavior could be used to understand some of threat fish have to face and what we could do to maintain their habitat.

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Figures

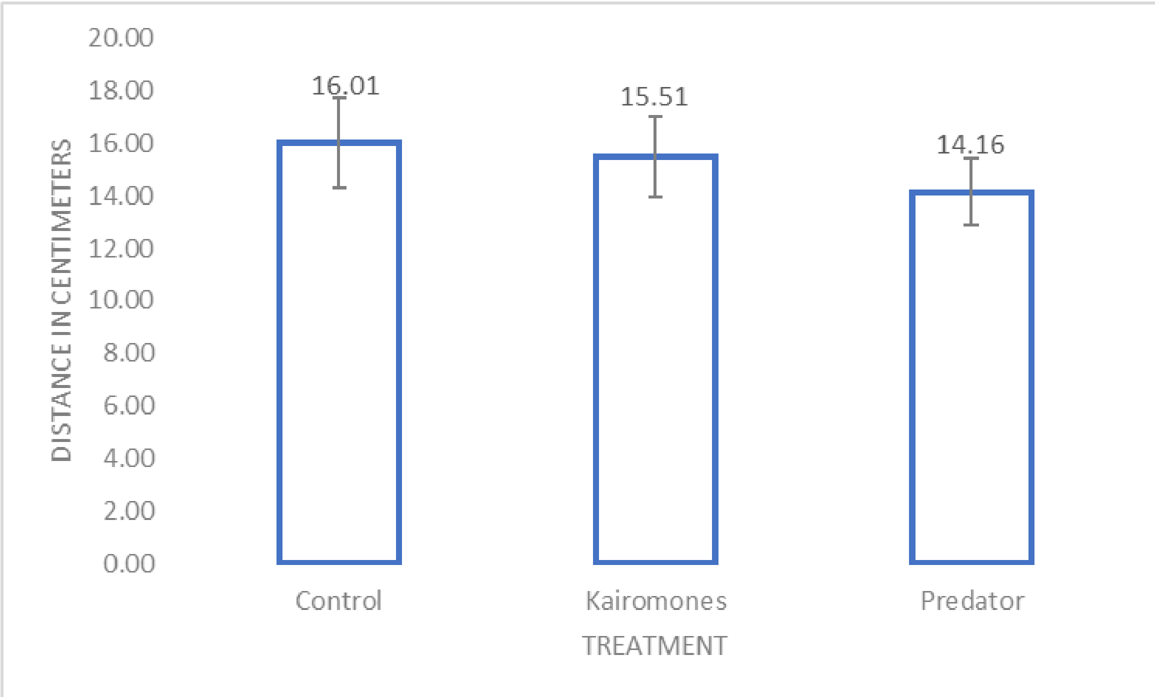

Figure 1: Average of distance between *Luxilus cornutus* in the presence of *Micropterus dolomieu.* A One-Way ANOVA comparing all three treatments and the distance between fish of each school that reveals no significant difference between variables: p-value = 0.67, df = 35, f = 0.40.