

**Visual versus kairomone response to a predator perch (*Perca*) in blacknose shiners
(*Notropis heterolepis*)**

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Abstract

Blacknose shiners (*Notropis heterolepis*) have developed many ways to detect predators and ways to react to avoid detection themselves. We wished to determine the ways in which blacknose shiners react to two such detection strategies: visual and chemical. Prey fish such as shiners can chemically detect predator fish through kairomones. These chemicals allow prey fish to detect a predator at a greater distance than vision alone would allow. We found no significant response in blacknose shiners to a visual stimulus of predator perch or from kairomones from perch. However, a trend in reduction of activity was detectable from the kairomone stimulus. This trend further supports evidence that kairomones are used as a fish's primary detection technique of predators as opposed to visual cues.

Introduction

Fish such as blacknose shiners are constantly exposed to predation from larger fish must develop many adaptations in order to avoid detection and escape. Early detection of predators is therefore critical to prey fishes' survival. Two such ways that prey fish can detect predators is visually and through chemical signals known as kairomones. Kairomones are chemicals given off by predator fish that are adaptively favorable to the prey and unfavorable to the predator (Ferri et al. 2010).

Responses to kairomones are a well documented phenomenon in many types of species. Tadpoles have been shown to respond to kairomones from predator fish by reducing activity, even without the presence of conspecific or heterospecific alarm cues (Schoeppner & Relyea 2009). *Daphnia galeata* were found to reduce size at first reproduction and reduce somatic growth rates in response to *Perca* kairomones (Weber 2003). Also, previously naïve fathead minnows (*Pimephales promelas*) were found to exhibit a fright response (reduced movement) to kairomones from juvenile pike (*Esox lucius*) after only four days of being exposed to the pike (Brown et al. 1997).

For many individuals, predator response depends on the level of experience of the prey. Predator-naïve individuals (i.e. those that have not come in contact with the predator before) often have diminished or nonexistent responses to visual and chemical cues (Ferrari et al. 2010). These fish can learn about new predators through social interactions and alarm cues (Ferrari et al. 2010).

Visual and kairomone stimuli should result in different responses in prey fish. Visual cues will only be useful for prey fish over short distances and may be manipulated by the predator, however they are also spatially reliable and information is conveyed quickly. Chemical cues such as kairomones may not be as reliable, but are conveyed over longer distances and cannot be manipulated by the predator (Brown & Magnavacca 2003). Visual cues have therefore been shown to result in dashing behavior and increased movement in glowlight tetras (*Hemigrammus erythrozonus*) (Brown & Magnavacca 2003) and larval newts (*Notophthalmus viridescens*) (Mathis & Vincent 1999), among other species. Chemical cues such as kairomones without visual cues result in freezing behavior and decreased movement in glowlight tetras

(Brown & Magnavacca 2003), fathead minnows (Ferrari et al. 2006), tadpoles (Schoeppner & Relyea 2009), and larval newts (Mathis & Vincent 1999).

We wished to determine the reaction that an individual blacknose shiner (*Notropis bifrenatus*) has to visual and kairomone stimuli from a predator fish (*Perca*) in the presence of a small shoal consisting of other blacknose shiners.

Methods

Blacknose shiners and perch used in the experiment were obtained from Lake Itasca in Itasca State Park, Minnesota. For the visual portion of the experiment, shoals of five shiners were set up in a tank to imitate a more natural environment for the minnows with a clear visual into the tank next to it. Fish were left to assimilate to the tank overnight. The behavior of one fish in the shoal was observed prestimulus for ten minutes and its movement recorded. Movement was measured based off of a grid drawn onto the tank consisting of 5cm x 5cm blocks. Each square in the grid approximated the body length of one minnow, and a minnow was considered across the line every time its eye moved across the line. Then, a perch, measuring 15.25 ± 0.25 cm, was put in the neighboring tank. Movement of the same minnow was recorded for ten minutes, with the perch remaining in the tank for the full ten minutes. The experiment was replicated five times. A control was run for each replication in the same way, but with no perch added as a stimulus.

Kairomones were obtained by leaving three perch (average size 16.2 cm) in a tank for 48 hours. Water was then removed from the tank to serve as a kairomone stimulus for the minnows. Minnows were again set up in shoals of five minnows and left to assimilate overnight. The behavior of a minnow was observed prestimulus for ten minutes and its amount of movement

recorded. Then, 180 mL of kairomones were injected into the tank. Once the injection was complete, the observational period began for another ten minutes and the movement of the same minnow was recorded. A control was set up with the same procedure and 180 mL of water from the minnow tank injected back into the tank. The experiment and control were each replicated five times. Each shoal of minnows was subjected to only one of the above treatments.

Results

A large amount of variation in the activity of individual blacknose shiners was found to exist between replications, making the median a better representation of the data than the mean. Also, the variation was not homogeneous between treatments and the data was not normally distributed. For these reasons, a non-parametric Kruskal Wallis statistical analysis was used to analyze the data. No two treatments were found to be significantly different from each other (KW=6.291, P=0.098, Fig. 1), although a trend is visible in the data. The treatment with kairomones, although not significant, did seem to result in a detectable reduction in the activity of the minnows. Visual stimulus did not appear to have an effect on the activity of the minnows.

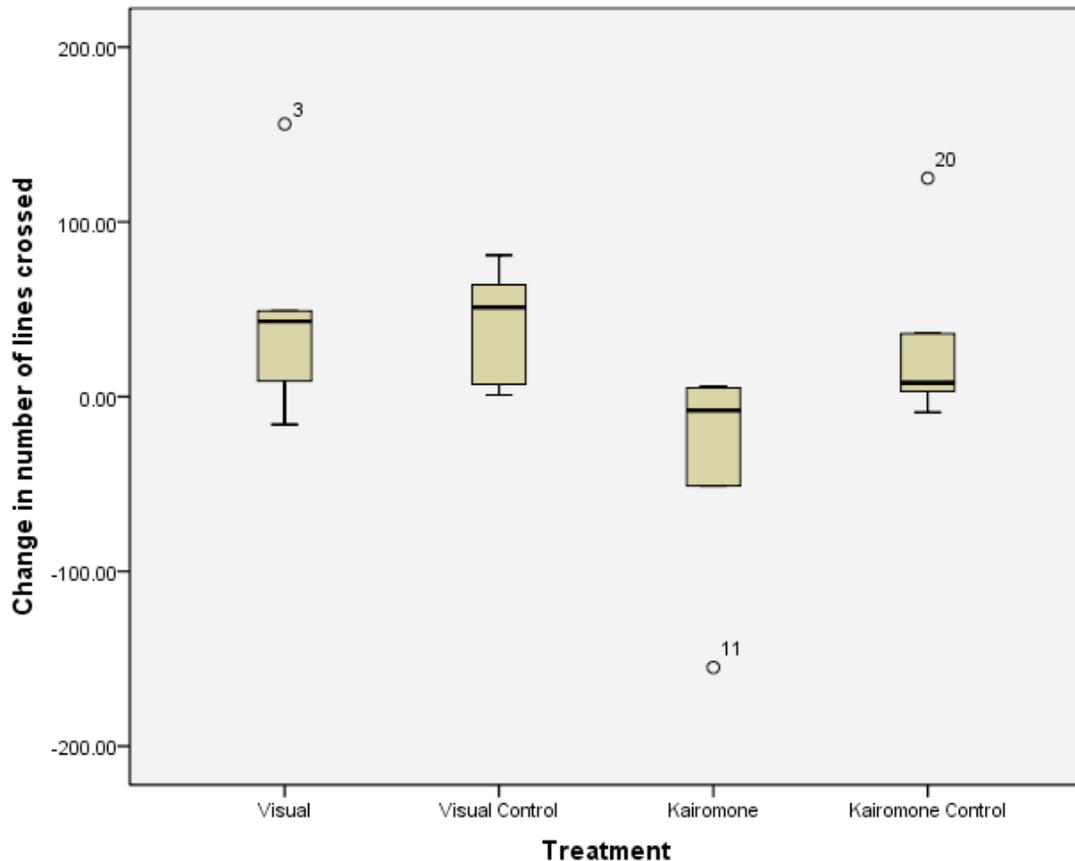


Figure 1: Shows the change in the number of lines crossed in a grid of 5cm x 5cm by blacknose minnows in response to different treatments. Visual stimulus was produced by placing a perch (approx. length 15.25 cm) in a neighboring tank. Kairomone stimulus was produced by injecting 180 mL of kairomones from perch into tank containing shiners. Kairomone control added 180 mL of water to the tank. None of the treatments were found to be significantly different from the others (KW=6.291, P=0.098). Outliers are represented by open circles, medians are represented by a solid line through the box, and whiskers show maximum and minimum.

Discussion

Lack of significance between treatments was due largely in part to the variation in fish activity between replications. However, a clear trend can be seen between control treatments and kairomone treatments. When no predator was in visible sight, it appeared the fishes' first

reaction was to reduce movement to avoid detection. Since kairomones are usually used by fish as a primary warning when predators are near, they are also normally used when predators are at a greater distance away (Brown & Magnavacca 2003). Hence, the fishes' greatest defense is to avoid detection before the predator becomes a threat. Similar results were seen by Brown et al. (1997) when fathead minnows spent greater time under cover when presented with Pike kairomones. Also, Ferarri et al. (2006) found a reduction in the number of line crosses by fathead minnows when presented with Pike kairomones, with a greater concentration of kairomones resulting in a greater reduction in line crosses.

No trend was detectable for visual stimuli. Response to visual stimuli is often dependent of the prey's assessment of the predator (i.e. posture, behavior, etc.) (Brown & Magnavacca 2003). If the fish in the study did not sense a threat from the visual presence of the predator, they would not present anti-predator responses. Since it is widely theorized and shown that visual stimuli are secondary to chemical stimuli (Brown & Magnavacca 2003), it is also possible that visual presence of a predator does not elicit a response in shiners without the presence of kairomones as well. Other studies have found in both tetras and finescale dace that a visual stimulus without presence of kairomones resulted in greater inspection behavior in closer distance to the predator than treatments with both visual stimulus and kairomones from predators fed conspecific prey (Brown & Godin 1999; Brown & Cowan 2000).

Future studies will be necessary to determine the effects that kairomone and visual stimuli combined have on blacknose shiners and also to investigate shoal reactions instead of individual reactions to visual and kairomone stimulus from predator fish. Variables such as predator density, type, size, and diet could also be manipulated.

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