Response of fathead minnows (*Pimephales promelas*) to a chemical alarm signal

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INTRODUCTION

• The fathead minnow, *Pimephales promelas*, and common shiner, *Luxilus cornutus*, are cyprinid fishes native to Minnesota (1).

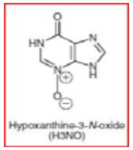
Fathead minnow

• The term fathead refers to the enlarged head of breeding males. Fathead minnows are the most common species of minnow in Minnesota with a state-wide distribution (1).

Common shiner

• The common shiner is widely distributed throughout Minnesota, but more frequently found in streams then in lakes. Both fathead minnows and common shiners consume a wide variety of plant and animal matter. The fathead minnow and common shiner can be found shoaling together in mixed species groups (1).

• Both species produce a chemical alarm signal, hypoxanthine-3-N-oxide (H3NO), in response to injury to the skin (2). The concentration of H3NO chemical has been hypothesized to provide information to potential prey about the proximity or distance of predatory fish (2, 3).



• There is evidence that the chemical pheromone or alarm signal, H3NO, that acts as an alarm cue for cyprinid fishes can also act as an attractant to some species of predatory fish that can detect the chemical and orient or move toward it (4, 5).

METHODS

• The chemical alarm signal was isolated from the skin of fathead minnows. A total of 18 to 20 cm^2 of skin was removed from five to six fathead minnows after cervical dislocation of the animals. The skin was cut into squares of less than 8 mm^2, added to 200 ml distilled water, vortexed for five minutes, and filtered through a coffee filter into 100 ml aliquots. Skin extract was stored at -20ºC. Treatments consisted of skin extract (25 ml) or distilled water (25 ml).

• Behaviors were studied under several conditions following the addition of chemical alarm signal (CAS) or distilled water: solitary fathead or solitary common shiner, single species shoals of 12 fathead or 12 common shiner, or mixed species shoals of 9 fathead and 3 common shiner minnows.

• Two synchronized digital camcorders were used to monitor the lateral and vertical movement of individuals or shoals, proximity of individuals, size of shoals, and duration of the recording and specific behaviors.

• All trials were conducted in 37-L aquaria with conditioned water. Minnows exposed to chemical alarm signal were not reused in further trials. Aquaria were carefully washed between trials.

• Data were collected by counting the total number of grid lines crossed before and after introduction of CAS, then dividing by the number of seconds of footage, and by the number of individuals in the group.

OBJECTIVES

- **Do fathead minnows display different behaviors in the presence and absence of chemical alarm signal isolated from conspecifics when solitary or in single-species shoals?**
- **Do common shiners respond to chemical alarm signal isolated from fathead minnows and exhibit anti-predator behavior when solitary or in single-species shoals?**
- **Does the shoaling behavior of mixed-species schools of fathead minnows and common shiners differ from behaviors observed among minnows in single species schools?**

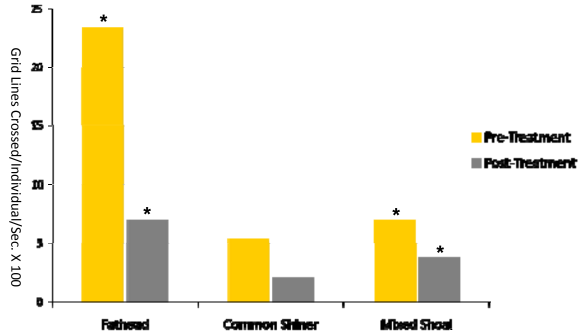


Fig. 1. Mean total lateral movement of fathead minnow shoals (12 individuals), common shiner shoals (12 individuals), and mixed species shoals (9 fathead minnows and 3 common shiners) before and after introduction of 25 ml chemical alarm signal isolated from fathead minnows (n = 4 per treatment). In all figures and tables asterisks, *****, indicate a significant difference (pre – post) (Paired *t*-test, $P < 0.05$, df = 3).

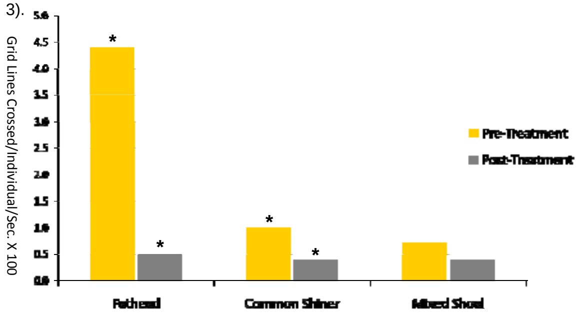


Fig. 2. Mean total vertical movement of fathead minnow shoals (12 individuals), common shiner shoals (12 individuals), and mixed species shoals (9 fathead minnows and 3 common shiners) before and after introduction of 25 ml chemical alarm signal isolated from fathead minnows (n = 4 per treatment).

Table 1. Mean total lateral and vertical movement of solitary fathead minnows and solitary common shiners before and after introduction of 25 ml chemical alarm signal (CAS) isolated from fathead minnows (n = 4 per treatment, mean ± SE).

	Lateral movement	Vertical movement
Fathead minnow (no CAS)	19.0±10.8 *	1.1±1.0
Fathead minnow (CAS)	3.4±0.3 *	0.1±0.1
Common shiner (no CAS)	0.2±0.1 **	0.0±0.0
Common shiner (CAS)	1.6±0.2 **	0.0±0.0

RESULTS

Table 2. Mean shoal cohesion of fathead minnow shoals (12 individuals), common shiner shoals (12 individuals), and mixed species shoals (9 fathead minnows and 3 common shiners) before and after introduction of 25 ml chemical alarm signal (CAS) isolated from fathead minnows (n = 4 per treatment, mean ± SE). Smaller numbers represent "tighter" shoals.

	Lateral cohesion	Vertical cohesion
Fathead minnow (no CAS)	53±1.1 *	2.5±0.6
Fathead minnow (CAS)	38±3.2 *	2.5±0.5
Common shiner (no CAS)	50±1.3 **	0.8±0.5
Common shiner (CAS)	33±0.0 **	0.8±0.3
Mixed species (no CAS)	56±2.4 ***	2.3±0.9
Mixed species (CAS)	19±1.3 ***	0.8±0.3

CONCLUSIONS

• Both solitary fathead minnows and shoals exhibited greater lateral and vertical movement than common shiners in the absence of chemical alarm signal (CAS). Solitary fathead minnows and common shiners displayed reduced lateral movement in response to CAS.

• Lateral and vertical movement of fathead shoals decreased after exposure to CAS, while only vertical movement decreased in shoals of common shiners. Mixed species shoals exhibited movement more typical of common shiners.

• Lateral cohesion of shoals decreased in single species and mixed shoals, resulting in tighter shoals with individuals in closer proximity to each other.

• Fathead minnows in shoals adopted a testing or sampling behavior. Individuals made looping motions, moving a few centimeters vertically and quickly returning to the bottom of the tank. We hypothesize that CAS did not fully disperse to the bottom of the tank during the trial, resulting in sampling behavior and aggregation of minnows near the bottom where CAS was present in lower concentration.

Fig. 3. Minnow exhibiting "sampling behavior."

LITERATURE CITED

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