Conspecific aggression of invasive crayfish, *P. clarkii*, in response to chemical cues

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Abstract

Red Swamp Crayfish, *Procambarus clarkii*, have caused vast damage to the stream ecosystem of the Santa Monica Mountains, following their invasive introduction. Through their extensive eating habits, high levels of aggression, and responsiveness to environmental stimuli, *P. clarkii* have a tremendous impact on the success of native species in the Santa Monica Mountains. With exposure to chemical cues, crayfish are able to perceive threats and react accordingly. To determine the extent of such chemoreception, pairs of *P. clarkii* were tested in the laboratory for conspecific aggression in the presence of native newt, native frog, and conspecific alarm cues. The level of aggression was measured utilizing a scale of 0-6, from acts of non-aggression to highest aggression. The addition of a native frog cue resulted in aggression levels significantly lower than conspecific alarm and native newt cues.
Through time point ten, the crayfish in the presence of the alarm cue exhibited a more sustained level of aggression than those in the other treatments.

Introduction

Procambarus clarkii are native to freshwater habitats along the southern Mississippi River. Due to their tolerance to various environmental conditions, these crayfish have successfully invaded stream ecosystems throughout southern California. As opportunistic omnivores, these crayfish impact their new habitats in various ways, reducing biodiversity and increasing biotic homogenization (Gherardi et al., 2007). For this reason, understanding crayfish behavior is essential in developing solutions to combat the environmental impacts of such invasions.
One key factor in understanding the behavior of *P. clarkii* involves their aggression in response to perceived danger. This response can be observed in a laboratory setting through the exposure of crayfish to various chemical stimuli. Sensitivity toward chemical cues is important as it provides an abundance of information pertinent to the survival of the crayfish, such as nearby predators or available resources. Previous experimentation has indicated that invasive crayfish, including *P. Clarkii*, use a broader range of predation cues than their native counterparts (Hazlett, 2003), and that their non-locomotor movements decrease in response to the introduction of predator or alarm cues (Hazlett, 1999).

Score	Criteria
0	Back away, never approach
1	Approach, but remain more than one body length away
2	Approach within one body length
3	Approach, touch
4	Approach, touch, grasp
5	Approach, touch, grasp, tug
6	Approach, touch, grasp, tug, offensive tail flip

Table 1. Aggression scale

Figure 1.1. California Newt, *Taricha torosa*

Figure 1.2. Pacific Tree Frog, *Pseudacris regilla*

Methods

The techniques employed in this investigation are based on those used in Hazlett (2000). Crayfish were selected based on size and sex. For the control treatment, 10 male crayfish and 10 female crayfish were selected, measured, and isolated in 5.7 liter plastic holding cells for 7 days at room temperature (23° C), prior to experimentation. This same isolation procedure was followed for each of the treatments. Following the acclimation period, pairs of crayfish, matched by sex and size, were transferred to 5.7 liter opaque plastic observation cells, filled with 2.0 liters of chemical cue treated carbon filtered water.
The treatment solutions included conspecific alarm, native newt (*Taricha torosa*), and native frog (*Pseudacris regilla*) cues, as well as carbon filtered water (control). Amphibian cues were prepared by rubbing the individuals and soaking in two liters of water for two hours (Zimmer et al., 2006). The conspecific cue was prepared in the same manner in order to keep the preparation procedure consistent.
An observer was assigned to each crayfish of the pair. Behavioral patterns were recorded utilizing the scale (below) for three minutes. The data was gathered as the maximum aggression score per individual per ten second interval.

Figure 2.1. *P. clarkii* in isolation container

Figure 2.2. *P. clarkii* side view

Figure 2.3. *P. clarkii* aggression trial

Results

- No significant difference in the sum of aggression values by treatment group (p>0.10)

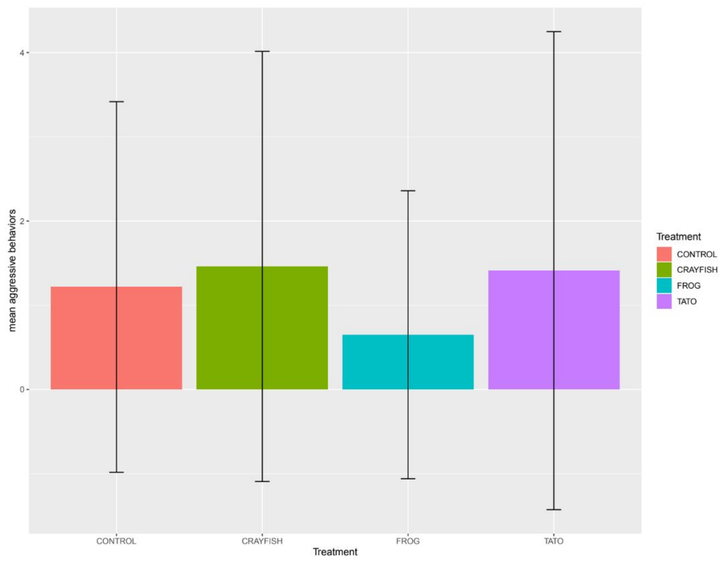

Figure 3. Mean aggressive behaviors by treatment

- There is a significant difference in aggression between treatments throughout time - repeated measures ANOVA (p=0.014)
  - Aggression with frog cues is significantly lower than crayfish and newt cues (Post-hoc test: TukeyHSD)

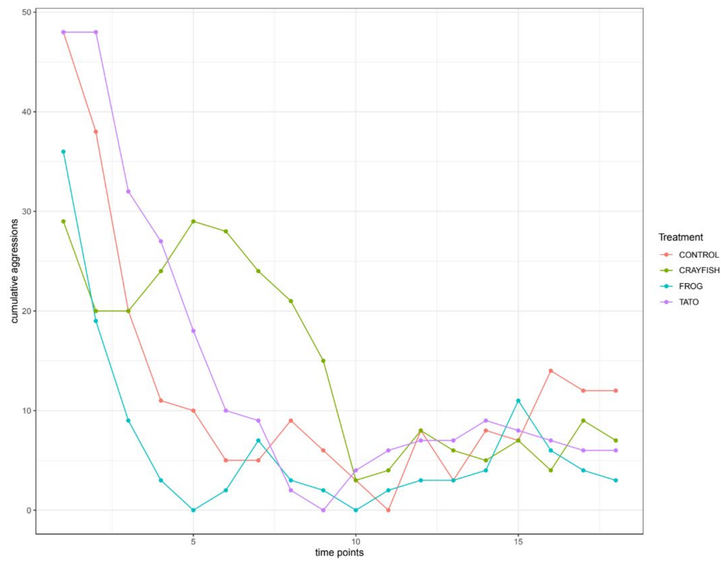

Figure 4. Cumulative aggressive behaviors vs time

Discussion

The findings of this experiment provide evidence of a behavioral response in crayfish to varied chemical stimuli. Individuals of *P. clarkii* were found to be less aggressive in the presence of a native frog cue.
There was no significant difference in the overall sum of aggression scores by treatment, due to the highly variable aggression scores over time. The crayfish exhibit higher levels of aggression during the earlier time intervals, perhaps due to the stress of being initially handled and placed into a new container. Notably, the crayfish exposed to the conspecific alarm cue exhibited a more sustained level of aggression than those in the other treatments.
Insight into the behavior and aggression of crayfish under various conditions is crucial for understanding the invasive abilities of the species. The capability of *P. clarkii* to respond to chemical cues such as the conspecific alarm cue could be a valuable contributor as to why these crayfish are able to so easily dominate the ecosystems they invade. With less aggression noted in the presence of native frog species, this highlights the potential for conservation efforts aimed at maintaining frog populations to diminish the aggression of crayfish within the streams.

Acknowledgments

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