Exotic urban crayfish and the threatened Sonoran desert pupfish: Do behavior and chemical cues mediate this predator-prey relationship?

Meghan Still, Lara Ferry & J. Chadwick Johnson.

Arizona State University at the West Campus, Division of Mathematical and Natural Sciences (2352), 4701 W. Thunderbird Rd, Glendale, AZ 85306

INTRODUCTION

Urbanization alters the structure, productivity, and composition of waterways. Such disturbance may help explain the finding that species diversity is often compromised following urbanization, at the expense of explosive population growth for a handful of urban-adapted taxa[1].

The introduction of exotic invasive species has also been shown to compromise biodiversity as invaders often outcompete native species[2]. Here, we investigate the predator-prey relationship between the Northern crayfish (*Orconectes virilis*), an invasive, omnivorous predator that has been introduced across the Phoenix valley, and the native endangered desert pupfish (*Cyprinodon macularius*).

An understanding of the predator-prey dynamics between urban exotics and threatened native species will allow us to identify the mechanisms responsible for losses in species diversity following urbanization.

Here, we test the hypothesis that the invasive Northern crayfish will adaptively respond to both familiar and novel food cues. We predict that activity and refuge use will change (increase and decrease respectively) in response to i) commercial food pellets, ii) rosy minnows, and iii) desert pupfish cues.

METHODS

All crayfish were housed individually in acrylic tanks 26.7 x 48.3 x 20.3 cm with 8.3 liters of well water. Each tank contained a refuge (half a clay pot) and a filter. Individuals were kept on a 12:12 photoperiod. All trials were conducted during the light cycle between 10:00-16:00 hours. For all trials, a baseline trial was conducted 1 day prior to the experimental manipulation. For all trials, activity and refuge use were recorded. Individuals were starved for 1 week prior to all tests.

Pellet Trials

Each individual was presented with 5 sinking pellets at the front of the tank, 20 cm away from the refuge. Crayfish behavior was scored every 15 minutes for 3 hours following the introduction of the pellets to determine foraging voracity, activity and refuge use for each individual. Each individual was tested three times.

Fish Trials

Each individual was presented with 1 rosy minnow at the front of the tank. Crayfish behavior was scored every 15 minutes for 3 hours following the introduction of fish to determine foraging voracity, activity and refuge use for each individual. Each individual was tested three times.

Pupfish Chemical Cue Trials

To obtain the pupfish chemical cue, 28 pupfish (approximately 8g) were held in 450 ml of water for 48 hours. Following the methods outlined in Hazelett (1998) each crayfish was presented with 20 ml of pupfish cue at the front of the tank. The duration of locomotory activity (i.e. walking), non-locomotory activity (i.e. grooming, feeding movements, etc) and refuge use were recorded for a 5 minute intensive observation period. Subsequently, 10 minute checks were conducted for 2 hours to determine the duration of the chemical cue stimulant.

RESULTS

Individual behavior was repeatable for all measures of refuge use during both the pellet trials (Baseline: $F_{2,38}=0.209$, $p=0.811$; Trial: $F_{2,38}=0.677$, $p=0.479$) and minnow trials (Baseline: $F_{2,18}=1.631$, $p=0.549$; Trial: $F_{2,18}=1.631$, $p=0.231$). Moreover, there was individual repeatability for the latency to eating for both the first pellet and the minnow treatments (Pellet: $F_{2,38}=1.021$, $p=0.328$; Minnow: $F_{2,18}=0.565$, $p=0.549$).

Activity measures were repeatable for all baseline trials (Pellet: $F_{2,38}=1.709$, $p=0.199$; Minnow: $F_{2,18}=0.452$, $p=0.549$; Fig. 1). However, during both foraging trials, activity levels increased after the crayfish experienced the same treatment two times (Pellet: $F_{1,9}=4.390$, $p=0.050$, Minnow: $F_{1,9}=8.208$, $p=0.019$; Fig. 1).

While refuge use and non-locomotory activity stayed consistent between the baseline and the introduction of pupfish chemical cue (Refuge use: $F_{1,19}=3.287$, $p=0.086$; Non-locomotory activity: $F_{1,19}=0.157$, $p=0.696$), locomotory activity levels increased significantly after the introduction of pupfish cue ($F_{1,19}=14.451$, $p=0.001$; Fig. 2).

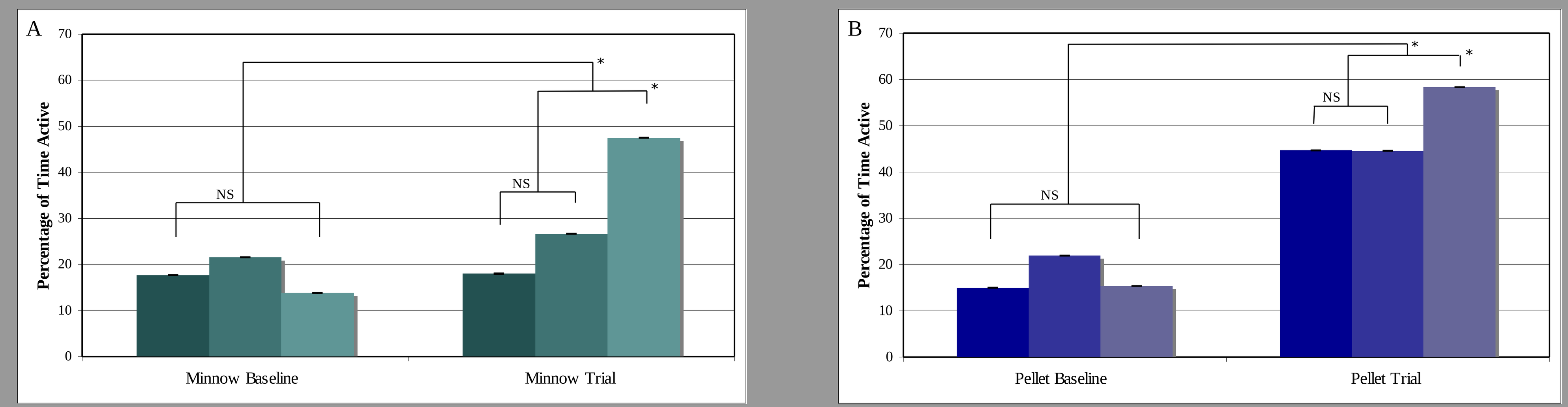

Figure 1. Repeated measures of crayfish activity in response to minnow prey and commercial pellet food. A) There is a significant difference between repeated measures 1 & 2 and 3 ($F_{1,9}=8.208$, $p=0.019$) and between the baseline and the treatment ($F_{1,9}=25.147$, $p=0.001$); B) There is significant difference between repeated measures 1 & 2 and 3 ($F_{1,9}=4.390$, $p=0.050$) and between the baseline and the treatment ($F_{1,19}=9.797$, $p=0.006$).

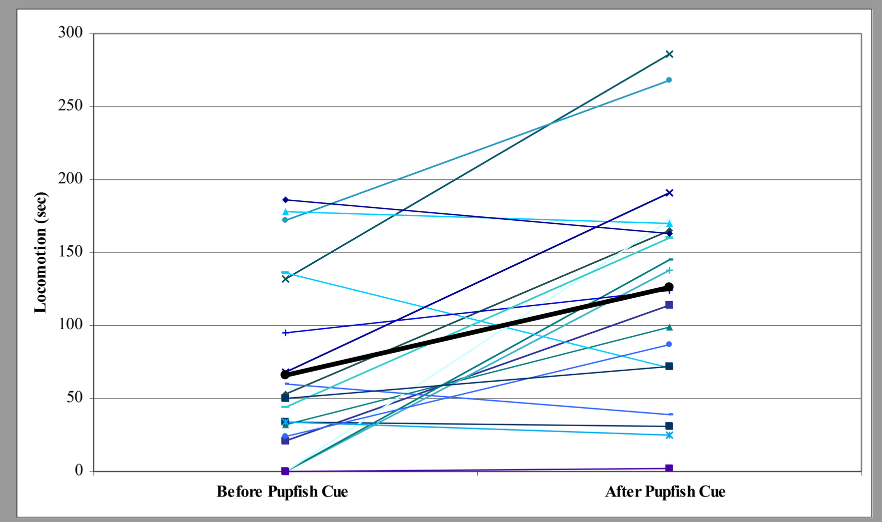

Figure 2. Individual variation in locomotory response to pupfish chemical cue ($F_{1,19}=14.451$, $p=0.001$). Bold line represents the treatment means.

DISCUSSION

Our results indicate that exotic urban predators such as the Northern crayfish recognize and respond to physical and chemical cues from novel native prey without prior experience with these cues. This is counter to reports that crayfish do not respond to the chemical cue of novel prey unless they have had previous experience with the food item[3].

Nonetheless, our crayfish do appear to alter their behavior over time[3,4]. This is illustrated by the increased activity response of crayfish during the third wave of both the pellet and minnow trials (see Fig. 1). These data support the Hazelett et al. (2002) hypothesis that invasive predators may thrive because of their flexibility in response to novel prey.

Our current focus is on the behavioral response of the endangered desert pupfish to i) exotic crayfish cues, ii) conspecific alarm cues (i.e. injured conspecifics), and iii) the combination of both predator and alarm cues. The latter treatment will allow us to look for synergistic, negative impacts of these chemical cues on the behavior of the threatened desert pupfish.

The impacts of urbanization on native species are still not well understood[1]. Moreover, few studies focus on the role of animal behavior and document the combined effect of exotic species being introduced into an urban landscape. Studies like these will provide a better understanding of how ecosystems change in response to urbanization and exotic introductions, and improve species conservation in a diversity of ecosystems.

REFERENCES

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