Differential tadpole response to pond and stream predators

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Abstract

Tadpoles have adopted different strategies to escape predators. In this study we examine tadpole response to predators. *Hyperolius spinigularis* was found in a pond and *Rana angolensis* and *Bufo brauni* were collected from a stream. All tadpoles were exposed to a pond predator (water scorpion) and a stream and pond predator (dragonfly larvae).
H. spinigularis reacted to the water scorpion by lowering its activity level whereas *B. brauni* reacted by raising its activity level. *R. angolensis* did not respond to the water scorpion.
H. spinigularis and *B. brauni* are both found in ponds with water scorpions and it is therefore no surprise that both species react to this predator. *R. angolensis* is never found in ponds and has no adaptations to the predator.
No tadpoles changed their activity level in the presence of the dragonfly larvae. It is possible that dragonflies are too common or to rare for the tadpoles to evolve any specific adaptation to this predator.

Keywords: anuran amphibians, tadpoles, predator-prey,

INTRODUCTION

It is well established that predators can induce specific avoidance response in prey (Tollrian and Harvell, 1999; Schmidt and Amezquita, 2001). Moreover, because changes in prey behavior are costly, natural selection should select for a precise response to the predator. The predation risk should therefore be a good indicator as to whether a prey response develops and how it is defined.

In many species, earlier life stages are more vulnerable to predation than adult stages. This is especially true for larval anurans, which have been shown to alter aspects of their morphology, behavior, life history and habitat use in the presence of predators (Lawler, 1989; Stauffer and Semlitsch, 1993; Warkentin, 1995; Smith and Van Buskirk, 1995). Specifically, many species of tadpoles have been shown to evade detection by living in areas of low visibility (e.g. near vegetation and pond bottom) and reducing activity level (refs). Because the costs of doing so often result in slower growth rates and foraging time, tadpoles with these changes should be able to discriminate the degree of risk for specific predators.

The aim of this study is to examine prey response in three paleotropical tadpole species found in Amani Nature Reserve, Tanzania. We measured tadpole activity level and spatial avoidance in response to predators from their own and different habitats. In doing so, we hope to determine whether predation risk is the main factor shaping antipredatory response in tadpole species.

MATERIALS AND METHODS

Study site

The study was performed in Amani Nature Reserve (ANR) Conservation Headquarters in the East Usambara Mountains of northeastern Tanzania (5.06ºS, 38.37ºE; elevation 900 m). Data were collected from 17 to 21 September 2005 in the man-made Amani Pond and a nearby stream. Amani Pond is dominated by patches of milfoil (*Myrophyllum spicatum*) and the average depth was 45 cm (Vonesh, 2005b).

Study species

Tadpoles and predators were collected one day prior to experimentation and kept in separate terrariums to prevent interactions amongst species. Based on abundance and habitat preference, three tadpole species were selected. *Hyperolius spinigularis* occurs naturally in the pond and had an average snout-vent length (SVL) of 93.8±0.2mm. *Rana angolensis*, a common stream species rarely found in groups, had an average SVL of 90.2±0.3 mm. *Bufo brauni*, had an average SVL of 70.4±0.3mm and can be found in both pond and stream environments, with higher abundance in the latter.

Based on personal observations and prior studies (Vonesh, 2005), we chose water scorpions (*Nepa* sp.) and dragonfly larvae (libellulids) as our experimental predators. Though other predators were encountered in the field, namely damselfly larvae (*Zygoptera*), diving beetles (*Dytiscus* sp.), and African clawed frogs (*Xenopus muelleri*), water scorpions and dragonfly larvae occurred in higher abundances. Water scorpions, pond predators, had an average length of 31.7±0.4mm, width of 11.3±0.1mm, and mass of 880±183mg (n=10). Libellulid larvae, found predominantly in streams and occasionally in ponds, had an average length of 15.4±0.2mm, width of 6.6±1.2mm, and mass of 145±65mg (n=14). Length and width for both predators were defined as the area from head to abdomen terminus.

Experimental design

All observations were made in a partially shaded area to reduce the effect of light and temperature on tadpole behavior. Ten tadpoles were placed in circular basins (diameter 24 in) filled with tap water to a depth of 10 cm, and allowed to acclimate for two hours. During the acclimation and observation period, tadpoles were not fed to eliminate other causes for observed behavior. Activity level, which we defined as traveling a distance of >1cm, was monitored ten minutes prior and thirty-five minutes after predator addition for a total observation period of fifty minutes. For each tadpole group, one predator was housed in a clear bag and slowly lowered into the basins. Bags were large and contained enough holes to allow transmission of visual, chemical and tactile cues from predator to prey. As a control, one group was given a bag with no predators. Number of active tadpoles per basin was recorded every five minutes for a total of twelve replicates per treatment. Water and tadpoles were replaced after each trial.

To measure spatial avoidance, the bottom of each circular basin was marked with concentric circles as inner, middle, and outer areas (radius = 4, 8, 12cm from the center, respectively). Location of individuals was recorded every five minutes during the observation period.

Statistical analysis

We tested for predator effect on tadpole activity level using unpaired T-tests (StatView v.5.0.1). A *G*-test for independence was performed to measure spatial avoidance by comparing distribution of tadpoles in control and experimental groups for each species and predator treatment.

RESULTS

Mean activity level was higher for tadpoles of *B. brauni* than any other species regardless of treatment (Fig. 1, 2). In the absence of predators, 37% of *H. spinigularis* tadpoles were active during the observation period. After addition of the water scorpion, activity was significantly reduced to 9% (T-test, $p<.0001$, Fig. 1a, Fig. 3). Tadpoles of *B. brauni* significantly increased activity from 40 to 64% in the presence of water scorpions (Fig. 1b, Fig. 3). No changes in activity level were observed for tadpoles of *R. angolensis* (Fig. 1c, Fig. 3).

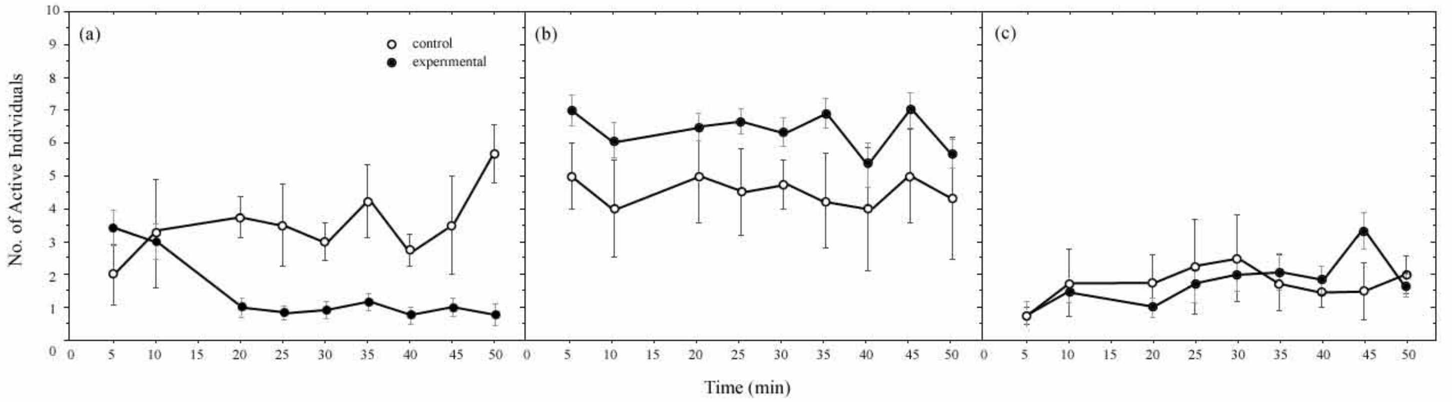

Figure 1. Number of active tadpoles (±SE) over 50 minutes for (a) *H. spinigularis* (b) *B. brauni*, and (c) *R. angolensis* in the absence (open circle) and presence (filled circle) of dragonfly larvae. Predators were added to ten minutes into observation period.

In the presence of libellulid larvae, no significant changes in activity level were observed for any of the three species (Fig. 2). Tadpoles of *R. angolensis* did show a slight reduction in activity level with the addition of dragonfly larvae, but change was only marginally significant (T-test, p=.0769, Fig. 2c, Fig. 4).

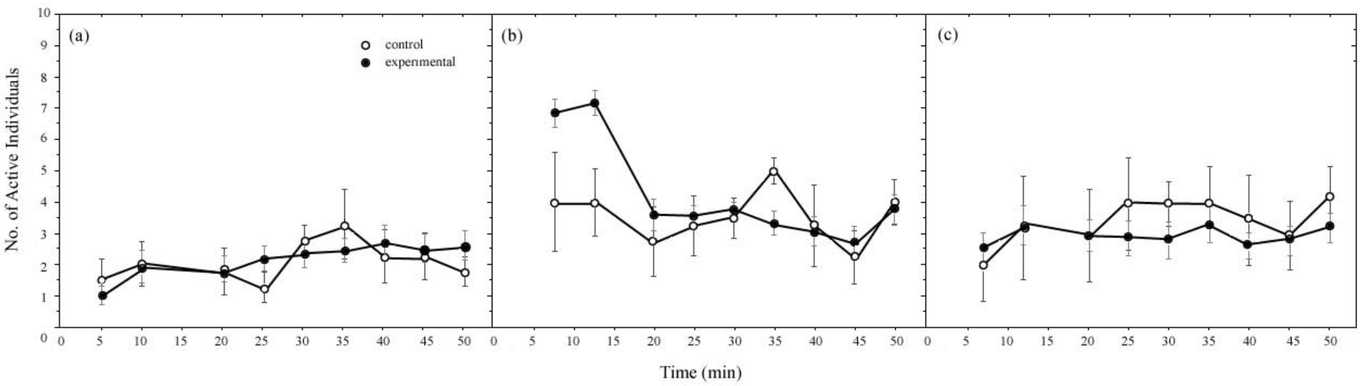

Figure 2. Number of active tadpoles (±SE) over 50 minutes for (a) *H. spinigularis* (b) *B. brauni*, and (c) *R. angolensis* in the absence (open circle) and presence (filled circle) of libellulid larvae.

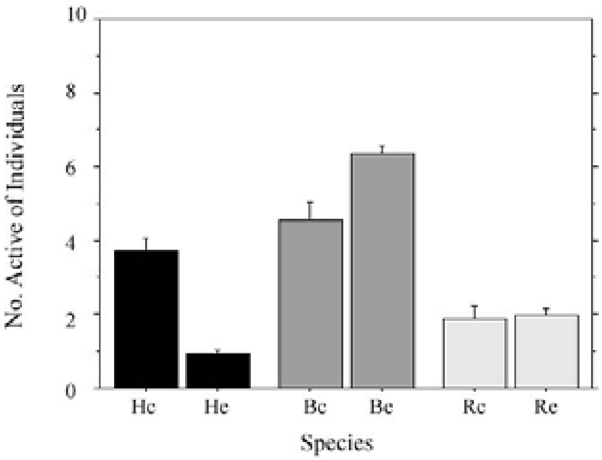

Fig. 3. Activity level (±SE) for *H. spinigularis* (H), *B. brauni* (B), and *R. angolensis* (R) in the absence (c) and presence (e) of water scorpions.

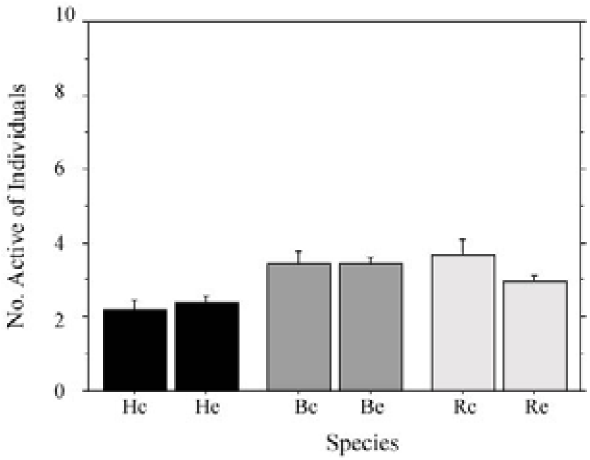

Fig. 4. Activity level (±SE) for *H. spinigularis* (H), *B. brauni* (B), and *R. angolensis* (R) in the absence (c) and presence (e) of libellid larvae.

Spatial avoidance to predators was not observed for any of the three tadpole species (*G*-test for Independence, $p>0.05$).

Discussion

Our results indicate that predator recognition is specific because tadpoles responded differentially to pond and stream predators. For tadpoles of *H. spinigularis*, activity levels were greatly reduced in the presence of water scorpions, but a lack of response to libellulid larvae. We propose that the response induced by water scorpions may be explained by the environmental conditions where both predator and prey species naturally occur, namely along pond edges of dense vegetation. As such, low visibility may be a strong selection pressure shaping predator-prey interactions. Specifically, water scorpions are sit-and-wait predators that rely on movement to detect prey. Reduced activity level in tadpoles of *H. spinigularis* would therefore be an effective survival strategy against water scorpion predation.

In contrast, tadpoles of *B. brauni* increased activity levels in the presence of water scorpions, despite the absence of these predators in streams. Because tadpoles of *B. brauni* are found in both pond and stream environments, we believe that the observed response can be attributed to their natural behavior more so than habitat preference. In particular, we noticed that *B. brauni* were smaller than other anuran amphibian species found in the stream and generally traveled in shoals. According to our results, *B. brauni* also had the highest activity levels when compared to other species. Thus, the induced predator response for this particular species is quick escape in large groups.

The other stream species, *R. angolensis*, did not alter its behavior in the presence of water scorpions. Because tadpoles of *R. angolensis* do not encounter water scorpions, there are no selection pressures to induce a response as expected.

Surprisingly, all three tadpoles species did not respond to the presence of dragonfly larvae, the most abundant and dangerous predator in Amani Pond (Vonesh, 2005). Initially, we expected tadpoles to reduce activity level in response to a sit-and-wait predator such as dragonfly larvae. However, the high abundance of libellulid larvae in both the pond and stream may have prevented such an induced response to develop. As encounter rates increased, induced responses typically do not evolve if predators are ubiquitous (De Jong, 1995). Hence, the lack of response for both pond and stream dwelling tadpoles are expected.

We did not observe spatial avoidance to predators in any of the three tadpole species. This suggests that escape behavior is not adapted by these tadpole species. Tadpoles preferred to rest on the edge of the container and on the plastic bag. This is likely to be the reason as to why most tadpoles were found away from the center. It is possible that the result could have been different, had we done more experiments in this area and arranged for more resting places in the center of the bucket.

In order to gain a better understanding of how tadpoles recognize and measure predation risk, further work is necessary. Knowledge on abundance and distribution of predators would shed insight into the relationship between induced responses and predator-prey relationships. Furthermore, future studies can explore which cues—chemical, olfactory, or tactile—are responsible for tadpole behavior.

Acknowledgements

We thank Dr. Robert Jehle for his valuable insights and Dr. Rosie Trevelyn for her support. We would also like to thank the children of Amani for their assistance in collecting tadpoles, Jessie for her creative input in the production of plastic bags, and Ellinor for her chocolate cake. The project was conducted as part of a field ecology course with the Tropical Biology Association.

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