The effects of cover on a predator-prey system: giant water bugs (*Lethocerus* spp.) and Eastern gray treefrog tadpoles (*Hyla versicolor)*

BIOS 539: Practicum in Field Biology

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Abstract

Predation poses a considerable threat for anuran tadpoles, and those tadpoles that are better equipped for their environment are more likely to survive. To survive in the presence of predators, tadpoles often exhibit phenotypic plasticity, altering behavior to better defend themselves against predators. My experiment determined if tadpoles (*Hyla versicolor)* would reduce their activity in the presence of a sit-and-wait predator, the giant water bug (*Lethocerus* spp.). I also examined the tadpoles' use of cover, both before and after addition of a predator. Conversely, I measured if cover affected the giant water bug's capture success by recording multiple water bugs activity and strike success ratio. Although tadpoles have been shown to decrease their activity in the presence of a predator, my results did not support this idea. However, the number of tadpoles surviving did differ significantly among cover treatments, with more tadpoles surviving in the two highest cover treatments (i.e. 60% and 80%). My results also showed that giant water bugs are more successful at capturing prey in a covered habitat versus a non-covered habitat. It also showed that the water bugs were less active in the covered habitat and had significantly fewer tadpole encounters.

Introduction

Predation poses a considerable risk for anuran tadpoles, and the success of predators is largely determined by their ability to detect their prey (Richards and Bull 1989). Tadpole predators can be categorized by foraging behavior, either as active foragers or sit-and-wait foragers. Active foragers can detect movement and actively search out prey whereas sit-and-wait predators attract prey and use a rapid strike method when prey approaches (Johansson 1991). One of the main predators of tadpoles is the giant water bug (*Lethocerus* spp.), which uses a sit-and-wait hunting strategy to attack. They hide in submerged plants or behind rocks; an attack is stimulated by passing movement (Venkatesan 1990).

Habitat structural complexity can affect the intensity of predator-prey interactions. Typically, the effectiveness of predators decreases in structurally complex habitats because they provide refuge for prey and may decrease predator efficiency (Babbitt and Tanner 1997); however, only limited studies have been conducted, and the results offer conflicting results. A study by Figiel and Semlitsch (1991) found that increased habitat complexity did not enhance the survival of Cope's gray treefrog tadpoles (*Hyla chrysoscelis)* exposed to crayfish (*Procambrus actus).* A study conducted by Babbitt and Jordan (1996) found significant differences in tadpole (*Bufo terrestris)* survival with increasing habitat complexity, using aquatic hemipterans (*Belostoma fluminea).* This study attempts to extend our knowledge of tadpole survivability and predator success in a structurally complex environment using giant water bugs (*Lethocerus* spp.) and Eastern gray treefrogs (*Hyla versicolor)* by examining both the predator and the prey response to cover. I will be observing giant water bugs in both a cover and a no-cover environment and will examine if their success rate and/or activity is significantly higher in one environment versus the other. I will create five degrees of cover (0%, 20%, 40%, 60%, and 80%) and observe tadpoles both before and after addition of a giant water bug. After completion of the observations, I will quantify tadpole survivorship in each of the varying treatments.

Many species of tadpoles utilize chemical cues to sense and respond to the presence of predators. These emitted chemical cues can induce a phenotypic change in the receiving species. This phenomenon, in which one genotype can produce different phenotypes when exposed to different environments, is referred to as phenotypic plasticity (Pigliucci 2005). The phenotypic response can be morphological or behavioral, or it may be manifested as an expedited growth rate. For example, McCollum and Van Buskirk (1996) showed that in the presence of predators, the tail fin of the Cope's gray treefrog became significantly larger and turned brilliant red. An alternative strategy often used by species inhabiting ephemeral sites is rapid growth during early development, which allows individuals to reach a size refuge where prey are no longer vulnerable to gape-limited predators (Sih 1987). However, trade-offs exist between rapid growth and predator avoidance because actively foraging tadpoles are more likely to be detected by predators (Woodward, 1983). For example, bullfrog tadpoles (*Rana catesbeiana)* decreased the amount of time spent swimming in the presence of dragonfly larvae (*Anax junuis*; Eklöv, 2000). This study determined if Eastern gray treefrog tadpoles decrease their activity in the presence of predators or in varying degrees of cover (i.e. 0%, 40%, 60%, and 80%).

I predicted that tadpoles would be most active in the highest degree of cover when predators were not present and that there would be a difference in survivability among the different cover treatments, with tadpoles surviving best in the highest degree of cover. I also predicted that there would be a difference in effectiveness of the giant water bug between the cover and no cover treatment. Because they are "sit-and-wait" predators, they should be more successful and less active in the cover environment.

Materials and Methods

I. *Predator behavior*

At three different vernal ponds on the UNDERC East property (Vernal Pond 5, Vernal Pond V, and Wood Duck Pond), I collected pairs of amplexed Eastern gray tree frogs (*Hyla versicolor)*. Upon returning to the lab, I placed them into wading pools. Once they laid eggs, I removed the parents and allowed the eggs to hatch. I then collected giant water bugs (*Lethocerus* spp.) at four different ponds: Wood Duck Pond, Vernal Pond 5, North Gate Pond, and Vernal Pond 9. I brought them back to the lab and placed them in covered buckets. I fed the water bugs with the previously obtained tree frogs. Once the tadpoles reached Gosner development stage 28-30, they were eligible for use in the predator behavior observation (Gosner 1960).

I constructed four separate 48.3 cm x 24.1 cm clear 37.85 liter tanks for observing predator-prey interaction, including two cover treatment tanks and two no-cover treatment tanks. I made the artificial cover by threading 56 strands of green polypropylene rope (equivalent to 60% cover) through black plastic mesh and weighted it down by placing gravel over top. The no-cover treatment consisted of the black plastic mesh weighted down by gravel.

In order to begin the experiment, food was withheld from the water bugs 24 h prior to each observation. I siphoned water into each of the four tanks to avoid disturbing the cover treatments. I then placed one water bug each into a cover tank and a no-cover tank and allowed them to acclimate for one hour; while waiting, I weighed ten tadpoles per cover treatment. After the hour acclimation time, I added in the tadpoles and began timing. I recorded the total amount of time in one hour that the water bugs moved, the number of encounters the water bugs had with tadpoles (encounter= when water bug was within 1 cm of a tadpole), the total number of strikes, the total number of successful strikes, the success rate of predators (measured as the number of captures divided by the number of strikes), and the tadpole handling time (where applicable). I conducted ten observations using 20 different predators and 20 different sets of tadpoles from July 17, 2006-July 18, 2006. All data were analyzed using SYSTAT 11.0 (SYSTAT Software, Inc.; Point Richmond, CA).

II. *Tadpole behavior*

To study tadpole behavior in varying cover treatments, I constructed five levels of cover treatment (0%, 20%, 40%, 60%, and 80%) by threading strands of green polypropylene rope through black plastic mesh (ca. 14 strands equated to 20%). Using a random numbers table, I allotted five replicates of each cover treatment across 25 separate 55-L plastic bins. I then added 10 tadpoles to each bin and let them sit outside overnight.

The next day, I conducted a scan sample of tadpole activity. I recorded the percent cover, the number of tadpoles visible, and the number of those tadpoles that were active (activity was qualified as those moving their tailfin or feeding). I then added one water bug to each bin; food had been withheld from the water bugs for 24 h. The water bugs were allowed to remain in the bins for 24 h. I then conducted another scan sample of tadpole activity. After 24 h, I removed the predators from each bin and counted the total number of survivors. The experiment was run from July 20, 2006 - July 21, 2006.

Results

I. *Predator behavior*

Before conducting any analysis on predator behavior, I used a t-test to determine if there was a difference in tadpole biomass between the cover and no-cover treatments. There was no statistically significant difference in the starting biomass between cover and no-cover treatments ($t = 0.581$; $p = 0.568$). Therefore, any difference in predator behavior may be attributed to cover treatment alone. I conducted separate t-tests comparing the effects of cover on activity and number of encounters (Figures 1 and 2). Predators were more active ($t= 3.032$; $p= 0.007$) and had more encounters with tadpoles ($t= 2.535$; $p= 0.0207$) in the no-cover treatment. In order to analyze success rate, I had to perform the nonparametric equivalent (Mann-Whitney U- Test) to an ANOVA as I could not normalize the data. The results of this test indicated that the predators in the cover treatment were more successful than those in the no-cover treatment (Mann-Whitney U test statistic= 4; $p=0.0129$; Figure 3). I also used a Mann-Whitney to compare cover treatment and handling time and found no significant trends (Mann-Whitney U test statistic= 6.00; $p= 0.327$; Figure 4).

II. *Tadpole behavior*

ANOVA's examining tadpole activity across cover classes indicated no significant difference, either before ($F= 1.067$; $df= 4$; $p= 0.398$; Figure 5) or after introduction of the predator ($F= 1.259$; $df= 4$; $p= 0.318$; Figure 6). Additionally, a paired t-test that examined whether the addition of a predator affected tadpole activity revealed no significant patterns ($t= 0.394$; $p= 0.697$; Figure 7).

In a comparison of percent cover to the number of surviving tadpoles in each treatment using a one-way ANOVA and post-hoc Tukey's test, I found that survivorship was significantly higher in the 60% and 80% cover treatments than the 0%, 20%, and 40% treatments ($F= 13.893$; $df= 4$; $p< 0.001$; Figure 8).

Discussion

I. *Predator behavior*

I began by testing whether giant water bugs were more active in cover or no-cover treatments. As expected, the predators were significantly more active in the no-cover treatment. This is presumably due to the “sit-and-wait” hunting strategy utilized by the giant water bug. In the no-cover environment, the water bugs had to actively seek out their prey as they were afforded no place to hide or rest. The cover treatment yielded less encounters with tadpoles, presumably because the tadpoles also were using the cover treatment to hide in regions distant from the water bug.

I also compared the success rate between the two cover treatments. As expected, the water bugs were more successful in the cover treatment, due to their hunting strategy. The water bugs exhibited a 100% success rate in the covered environment. A future study should be performed using varying degrees of cover to see whether there is an optimal cover percentage for water bugs.

Handling time is most likely related to tadpole density. A study by Goss-Custard (1977) showed using redshank (*Tringa totanus*) that feeding rate increased rapidly as prey density increased. If a predator senses that there are numerous prey individuals, they will capture one and selectively feed on the best parts and then capture others. If there are not many prey individuals, they will eat as much as they can when they complete a successful capture (Goss-Custard

1977). Because we used ten tadpoles in each observation and the total biomass was not significantly different among cover and no-cover treatments, there should not be a difference in average handling time.

Because of the variable nature of predators, more observations should have been performed. This would allow for the use of parametric tests to analyze the data, which would yield stronger conclusions. Future experiments might be conducted to compare cover treatment to success rate and age of predator (i.e. juvenile versus adult). Due to the limited number of water bugs and time constraints, I used both juveniles and adults in this experiment; however, I did not replicate sufficiently to test the effects of age.

II. *Tadpole behavior*

Petranka (1987) showed that Cope's gray treefrog exhibited a strong negative response to effluent tubs containing sunfish (*Lepomis cyanellus).* The experimental tadpoles spent 68% less time out of refuges than controls during the last 10 minutes of their trial (Petranka, 1987); however, I observed no significant result. A study by Warkentin (1992) showed that tadpoles' feeding rates were significantly higher at 23°C than at 20°C; therefore, depending on the temperature and the time of day of the observations, the number of active tadpoles may vary. This study should be repeated conducting multiple scan samples per day and noting the temperature in order to get an accurate representation of tadpole activity without a temperature bias. Also, because tadpoles died after addition of the predator, the total number of tadpoles decreased in each replicate, and my percent activity did not take this into account. This study should be repeated and the total number of tadpoles counted before each scan sample in order to obtain an accurate percent activity value.

Tadpoles survived better in the 60 and 80 percent cover treatments, but water bugs had a higher success rate in the cover treatment, which corresponded to 60 percent cover. This is likely because the number of encounters decreased in the cover treatment, indicating that tadpoles were harder to detect.

The validity of my results could be strengthened by increasing number of tanks used. Due to time constraints and lack of water bugs, I performed this experiment using five juveniles and twenty adults; however, at the experiment's completion, four of the five juveniles had molted. Future experiments should be performed using water bugs of all the same age.

In conclusion, it is hard to correlate the results from both parts of this experiment. The tadpoles did not exhibit phenotypic plasticity as they did not alter their activity. The tadpoles had the highest survival in the highest cover treatments, but the water bugs had a higher success rate in the cover treatment. This may indicate that cover is an important aspect of both predator and prey environment. Future studies should be performed observing both tadpoles and water bugs simultaneously, in the same cover treatment, to see if the same results are observed.

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Figures

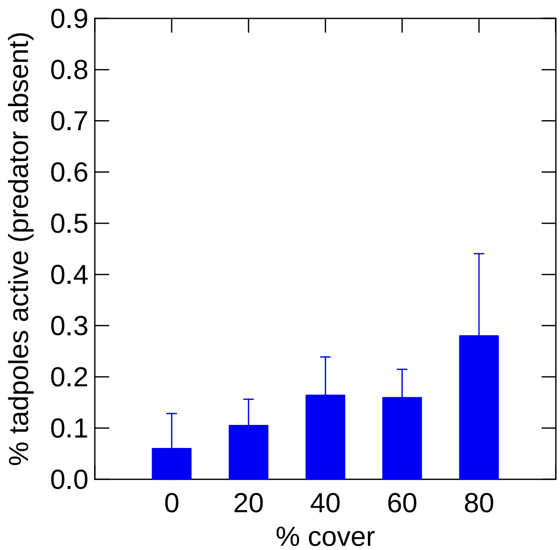

Figure 1. Tadpole activity in the 5 different cover treatments without the predator. There is no significant difference between activity in the different treatments ($F= 1.067$; $df= 4$; $p=0.398$). Error bars represent one standard error.

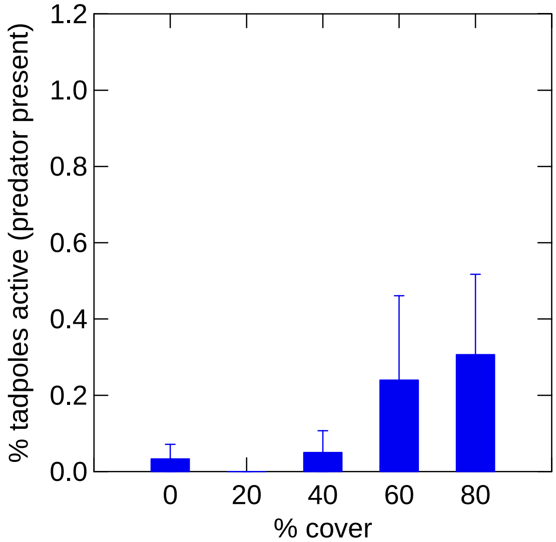

Figure 2. Tadpole activity in five different cover treatments with the predator. There is no significant difference between activity in the different treatments ($F = 1.259$; $df = 4$; $p = 0.318$). Error bars represent one standard error.

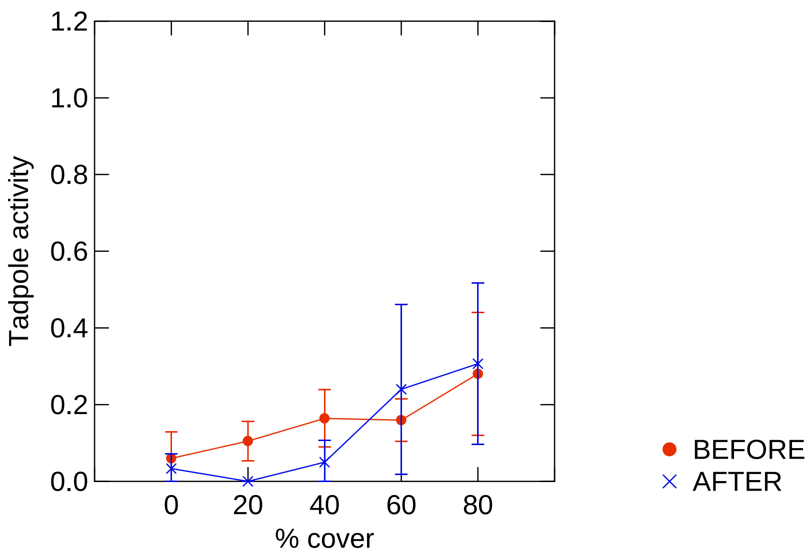

Figure 3. Effect of adding a predator on activity of tadpoles. There was no significant change in activity (t= 0.394; df= 24; p= 0.697). Error bars represent one standard error.

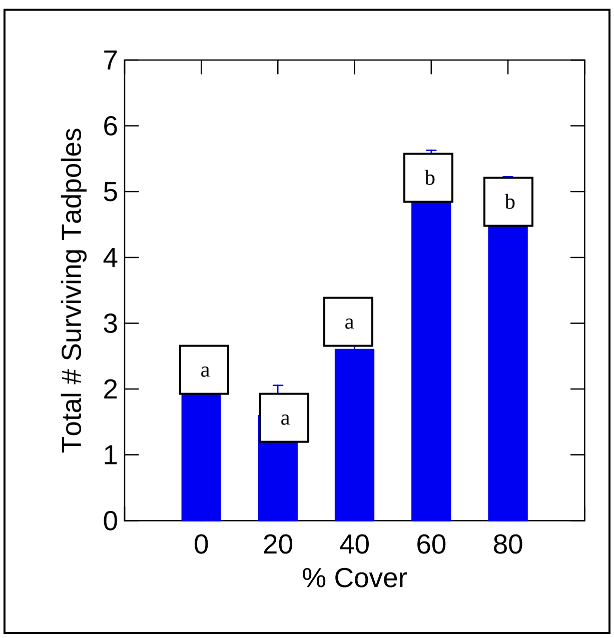

Figure 4. Number of tadpoles that survived in each cover treatment. There was a significant difference among cover treatments (F= 13.893; df= 4; p< 0.001). The

results of a post-hoc Tukey’s test are depicted as letters, where different letters represent statistical differences.