The effects of cover on diving beetle larvae (*Dytiscus spp.)* predation using wood frog (*Rana sylvatica)* tadpoles and Eastern gray treefrog (*Hyla versicolor*) tadpoles.

BIOS 35502: Practicum in Environmental Field Biology

Melinda Adams

Advisor: Matt Michel

July 22, 2006

Abstract

.Predacious diving beetle larvae (dytiscus spp.) are one of the most vicious predators of freshwater aquatic insects. They have sickle-shaped hollow jaws they use to clutch prey and funnel flesh-digesting fluids into the victim then draw out the liquid contents. Dytiscidae have a highly efficient hunting strategy that allows them to pursue prey in areas of vegetation and debris. In this study, I examined if there was a significant relationship in predator foraging behavior in response to cover and if different species of tadpoles increase or decreased predator behavior. The species of tadpoles used in this study were wood frog (*Rana sylvaatica* and Eastern gray tree frog (*Hyla versicolor).* Results showed that there were significant relationships between these three variables but also between treatment and handling time (duration of tadpole consumption). It was apparent that while the dytiscidae showed more activity in the no cover treatment and had higher efficiency in cover treatment.This study also showed that the dytiscidae took longer to consume *R. sylvatica* tadpoles over *H. versicolor* tadpoles.

Introduction

Several studies have examined the behavioral response of tadpoles in the presence of predators (Richards and Bull 1990, Babbitt and Tanner 1998, Warfe and Barmuta 2004) and have examined predator behavior in a simple environment. However there have been little to no documented experiments that concentrate on the effects of cover on predator behavior. Foraging activity has important implications within an aquatic community. If capture of potential prey is reduced this could lead to a lower foraging rate which could affect the growth and survival of a predator (Johansson 1990).

Tadpole predators can be characterized as either ‘active’ or ‘sit and wait’ foragers. Active predators are hunters that are attracted to movement and hunt for prey using various techniques. Rather than wait for the motile prey to pass by, sit and wait predators lure organisms into striking range, and rapidly attack after elongated hunting (Johansson 1991). A modification in foraging activity may depend on altered habitat structure, or in prey type as proposed by F. Johansson (1990). Furthermore, to forge efficiently members of a species with a distinct sit and wait strategy should preferably hunt in a covered habitat, while active predators should have higher success foraging in a non-covered environment (Johansson 1990). Diverse prey species could affect predator behavior because they exemplify a difference in behavior and activity (Warfe and Barmuta 2004).

Predacious diving beetle larvae (Dytiscidae) are active predators that are attracted to movement and hunt using various techniques. They are aquatic predators in both the larval and adult stages. Studies have shown they regularly attack prey much larger than themselves, such as fish and crustaceans (Lundkvist et al. 2003). They are also cannibalistic and usual prey includes tadpoles and caddisfly larvae, among dozens of other smaller water-dwelling creatures. They can be found lurking near the water surface looking for prey in and around vegetation and woody debris. Dytiscids are generalist predators that attack in an ambush strategy (Lundkvist et al. 2003). They hold perfectly still until prey passes by, then they lunge and trap the prey between their front legs and bite down with its pincers (Babbitt and Turner 1998). The sickle-shaped, hollow jaw clutches their prey and funnels flesh-digesting fluids into the victim and draws out the liquid contents (Manteifel and Reshetnikov 2001). By using this mechanism, it can eat up to 20 tadpoles a day and when food is scarce, these predacious diving beetles will also feed on carrion (Warfe and Barmuta 2004).

There are roughly 150 species of predacious diving beetles in the United States and Canada, ranging in size from about 1.5 mm to 40 mm. They can be found wherever there are ponds, sloughs, lakes, streams, rivers, billabongs and other slow-moving bodies of water (Manteifel and Reshetnikov 2001).

Diving beetle larvae have a very smooth and streamlined exoskeleton with hind legs that are covered with natatory setae (Babbitt and Tanner 1997) used to swim rapidly through the water. Their bodies are shaped like crescents, with an elongated tail covered with thin hairs (natatory setae). The head is flat and square, with a pair of long, large pincers they use to cling to grasses or pieces of wood during hunting. They require atmospheric air and adult beetles go to the surface to gather air which they store in a chamber underneath their elytra (wing covers) to enable them to increase the time they can be submerged (Pianka 1983). Larvae lack this ability, but many species use a siphon in the form of ling filaments at the end of the abdomen (Formanowicz 1987).

In this study, two species of tadpoles were used to test if there was a difference in cover and no cover predator foraging. The species used were wood frog tadpoles (*Rana sylvatica*) and Eastern gray treefrog (*Hyla versicolor*) tadpoles. Gray treefrog tadpoles are filter feeders that inhibit in areas near the water surface. This behavior makes them more vulnerable to predation. Wood frogs tend to dwell near the bottom of the body of water, putting them at a smaller risk of predator encounters.

I determined the effects of cover and no cover on predacious diving beetle larvae behavior using two species of tadpoles as prey. I examined the possibilities of significant relationships between treatment (cover and no cover) and the following: predator activity, predator/prey encounters, capture success, and predator handling time. Specifically, I hypothesized that (1) there was a significant relationship in predator foraging behavior in response to cover and (2) If different species of tadpoles increase or decreased predator behavior.

Methods

Field work

This experiment was performed separately on wood frog tadpoles and Eastern gray treefrog tadpoles. Because of differences in breeding times, wood frogs were used during the beginning of the summer, while gray tree frogs were used later in the summer. Wood frog specimens were collected from various vernal ponds on the UNDERC property in May 2006. The tadpoles were kept outside in 1m diameter wading pools until they were the ideal weight and length for predator/ prey observation. Grey treefrog tadpoles were collected while adult frogs engaged in amplexus. Pairs were then allowed to breed in plastic 18.93 liter buckets. Once the resulting eggs were placed in wading pools similar to those of the wood frogs, the breeding frogs were released back to their habitats. When the hatchlings reached Gosner stage 26 (Gosner 1960), they also were also used for observations.

Predator individuals were collected using minnow traps that were placed in small ponds that inhibited dytiscidae larvae. A total of 16 minnow traps were placed in three vernal ponds (North of Beaver Bog pond, North of Firestone Lake pond and North gate pond). Traps were set according to their location, and where dytiscidae capture would be optimum. Collected individuals were then taken to the laboratory where they were placed in collection jars filled with well water and fed one tadpole a day to maintain their predation strategies as well as their appetite.

Experimental set up

In early June, six wading pools were filled with well water and covered with black netting in order to receive heat from sunlight. This aided in setting the water temperature similar to that of a vernal pond. This water was then used to fill the 48.26 cm x 24.13 cm wide clear 37.85 liter aquarium tanks that were used for predator observation in this experiment. Six more wading pools were constructed and used as grey treefrog tadpole isolation pools. Thirty gray treefrog tadpoles were placed in each pool and fed rabbit food to ensure their survival. These wading pools lowered competition for food and increased their growth rate, making their size ideal for predator observation trials.

The cover treatment consisted of green polypropylene rope strands tested in two quantities: 0 strands of rope and 56 strands of rope. The rope was tied to a plastic black matt and gravel rocks anchored the matt and ropes to the bottom of the tank (Michel 2006).

Trials took place in 19’’ x 9 ½ ‘’ wide clear 10-gallon aquarium tanks filled with approximately seven inches of water in order to submerge the ‘cover’ (56 strands of rope), and to provide adequate water depth that allowed enough surface air so the predator could breathe. Prior to predator and prey interaction, food was withheld from the predator for 24 hours in order to increase optimum prey pursuit strategies.

Laboratory experiment

Observation of predation began when a single chosen predator was placed in the aquarium tank and allotted one hour to adapt temporarily to its artificial habitat. During each trial, two tanks were observed at one time, to compare the movement and predation techniques between cover and no cover tanks.

Twenty four tadpoles were randomly chosen and fished out with a dip net for each trial (one tank required 12 tadpoles, two from each of the 6 pools were chosen).The tadpoles were then weighed and kept in a sampling jar for the duration of the set one hour predator inhabitant time. Once the hour was up, the (12) tadpoles were added to each tank, and observations commenced once the first tadpole submerged.

Each tank was observed for one hour and I recorded data on four types of predator behavior: 1) Percent activity (the amount of time the predator moved measured as a percentage 2) number of encounters between the predator and individual prey, where an encounter is defined when the predator came within 1 cm of any tadpole 3) capture success (the number of predator attacks that result in capture divided by the total number of predator strikes 4) handling time (how long the predator spent consuming the tadpole).

Once the hour was up, the predator was fished out first to avoid and disrupt any unnecessary predation. After which, surviving tadpoles were collected, tallied and placed in a ‘dumping’ pool to assure further usage was not repeated.

Analysis

A t-test was used to compare the mean weight of the two species of tadpoles (*H. versicolor* and *R. sylvatica*): and a two-way Analysis of variance (ANOVA) was performed to determine if percent activity, number of encounters, capture success, and handling time differed among tadpole species and amount of cover.

Results

T-test results showed there was not a significant difference between tadpole mass (gray treefrog mean=0.413 SE=0.00225), (wood frog mean=0.454 SE=0.00195). Furthermore, there was not a significant relationship when comparing the weight of grey tree frogs tadpoles in cover vs. no cover (df=17.7 p=0.955), as well as the weight of wood frog tadpoles in cover vs. no cover (df=14.7 p=0.926).

The two-way ANOVA revealed that cover had a significant effect on predator activity for both wood frog and treefrog tadpoles (df=1 p<0.001). Predators that were tested in the no cover tanks showed almost double the activity of those in the no cover tanks (Fig. 1).

There was a second significant relationship between treatment and number of predator/prey encounters (df=1 p<0.001). In addition, there were a higher number of encounters recorded for the *H. versicolor* species in the no cover treatment (Fig. 4). The last significant relationship was displayed between treatment and handling time (p=0.014). Handling time was highest amongst *R. sylvatica* in the cover treatment (Fig. 6).

Discussion

A similar study was performed by Relyea (2001) that showed similar results in regards to predator-prey interactions. Relyea used similar observation tanks where predators were tested in their response to tadpole presence. A highly controlled environment was used to visually observe the capture probability, capture probability, consumption probabaility and handling time for each predator (Relyea 2001). Relyea found predators changed their behavior in response to different tadpole species. He also noted that handling time was significantly different amongst tadpole prey and capture success differed as well.

The cover treatment had a significant effect on percent predator activity, number of encounters, predator capture success, and handling time. The predators sampled in the vernal ponds on UNDERC property appear to have been more active in the no cover treatment than the cover treatment, they had a higher number of encounters in the no cover treatment, and they had a higher capture success in the cover treatment than the no cover treatment.

Based on the significant activity results, I believe dytiscidae larvae were more active in the no cover environment because it is different from their natural habitat. The larvae lurk near the water surface looking for prey in and around vegetation and woody debris that help them attack in an ambush strategy (Lundkvist et al. 2003). Perhaps withdrawing this element forced the predator to change their hunting behavior, therefore increasing the number of attacks, and lowering the number of successful captures.

The relationship between treatment and predator-prey encounters was significant, and showed that dytiscidae had a higher number of encounters in the no cover treatment than in the cover treatment. This could be because the predator was more active in the no cover treatment, therefore increasing the possibilities of encounters. But also there are minimal places that tadpoles could use as refugee, which decreases the activity of potential prey; decreasing predator efficiency (Babbitt and Tanner 1998).

There was a marginally significant relationship between treatment and capture success (f=3.853 p=0.058). Statistics support the conclusion that there was not quite a significant relationship between these two variables Initial thoughts of these factors would suggest there might be higher capture success in the covered treatment, mainly because it closely resembled that of dytiscade natural environment (Lundkvist et al. 2003). Further replicates of this experiment might yield a significant relationship between these two factors.

A marginally significant relationship was between treatment and handling time (f=3.398 p=0.077). Handling time in both tadpole species treatment varied and was higher in wood frog tadpoles. One stipulation may be that the wood frogs weighed more. However, a t-test revealed that there was not a significant relationship between the mean weight of wood frog tadpoles and gray treefrog tadpoles (gray treefrog mean=0.413 SE=0.00225), (wood frog mean=0.454 SE=0.00195). A possible suggestion that would support significance in this relationship would be individual behavior of the tadpole species. Gray treefrogs might inhabit the areas of water closest to the surface, therefore making their detection easier, where as the wood frogs may stay close to the aquatic floor, making their presence harder to detect. The more prey the predator detects, the more it will want to intake (Formanowicz 1987).

Further studies would have better success if more replications in predator capture success were made. I reported that there was not a significant relationship between capture success and treatment (wood frog/no cover =0.199 ± 0.031, wood frog/ no cover=0.079 ± 0.011).This number implies that there was a marginal significance on the affect on capture success. More replicates of this particular study could eventually signify this relationship.

Similar to results displayed by Relyea, this study showed that predators change their behavior in response to different prey, furthermore this study demonstrated predators alter their behavior (activity, capture success, encounters, and handling time). Cover enhanced predator activity, resulting a higher number of predator-prey encounters, eventually leading in a higher number of strikes, presenting the possibility of a higher capture success in both species of tadpoles. Number of encounters was greater in the no cover treatment where there were nearly the same number of encounters amongst tadpole species. Capture success was higher in the cover treatment with almost the same amount of captures within the cover treatment. This could possibly be because dytiscidae are sit and wait predators and inhibit these strategies when in their natural environment (Formanowicz 1987). Lastly, handling time was similar in both treatments, having a higher handling time amongst wood frog tadpoles. This, once again could be attributed to individual tadpole behavior. In summary, results were similar and supported those demonstrated by Relyea (2001).

Suggestions for further experimentation would be helpful in better understanding the effect of cover in dytiscade predator behavior. Replication would be primary suggestion, expanding results and making for stronger data. Also, an increase in the number of predators that are tested on would be beneficial. Instead of 20 predators, one might have stronger data testing >20. Branching from this suggestion, different predators might have similar or different behavioral changes. This data would aid in observing complex predator behavior, thus comprehending the impact and importance predator behavior has on an ecological system.

Acknowledgements

First of all, I would first like extend enormous gratitude to my mentor Matt Michel for his continuous help through out this project. I would like to thank Dr. Karen Francl for her patience and guidance throughout the summer. Dr. Gary Belovsky for his encouragement and support. Lastly I would like to thank the Bernard J. Hank family/ without their generous endowment, I would not have had experienced this fulfilling opportunity.

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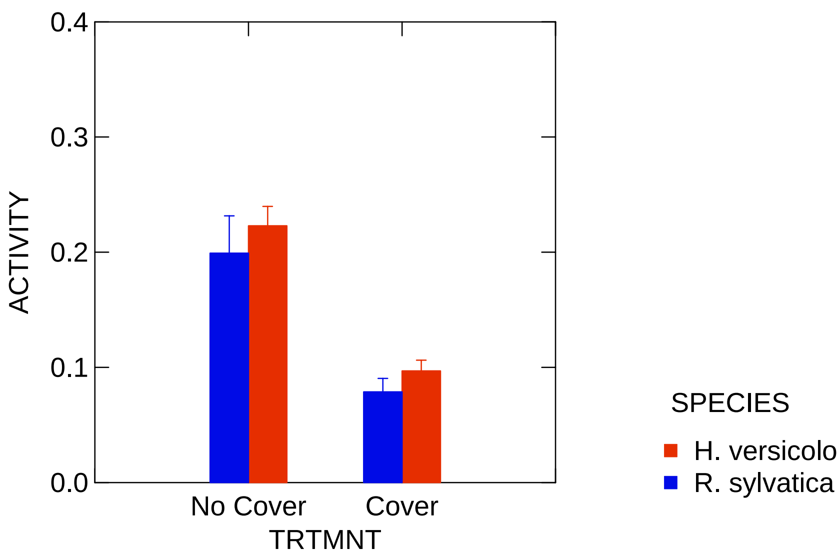

Figure 1. Percent activity. Percent activity of dytiscade larvae in the no cover and cover treatment for both tadpole species. Bars are ± standard error.

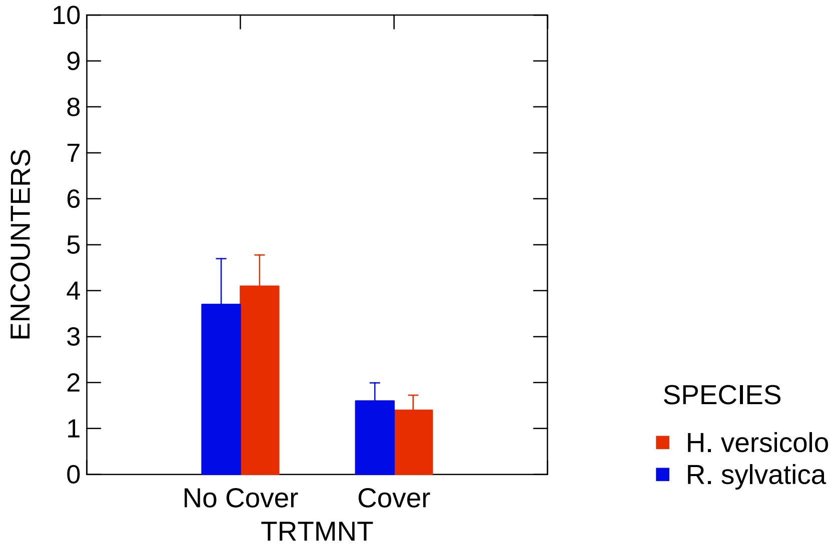

Figure 2. Predator-prey encounters. Predator/prey encounters in the no cover and cover treatment for both tadpole species. Bars are ± standard error.

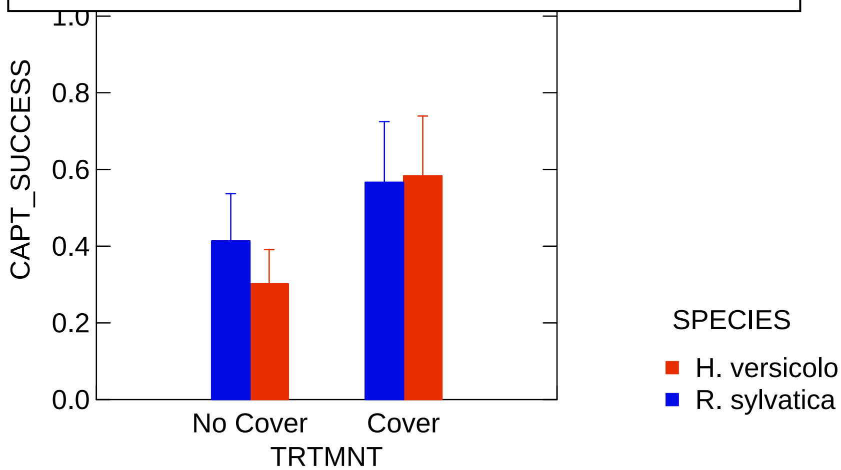

Figure 3.Predator capture success. Capture success (number of captures/ number of strikes) in cover and no cover treatment for both tadpole species. Bars are ± standard error.

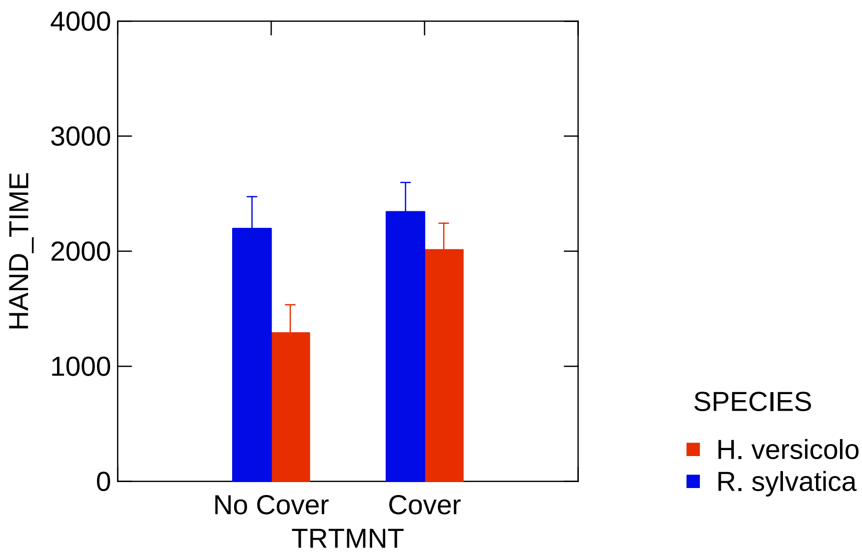

Figure 4. Predator handling time. Predator handling time in the no cover and cover treatment for both tadpole species. Bars are ± standard error. Cover had a marginal significant effect on handling time (f=3.398 p=0.077). Handling time was significantly higher in wood frogs (f=1.496 p=0.014).