Behavioral Plasticity: Belostomatid and Dytiscid Tadpole Predation in Different Amounts of Cover

Abstract:

Predator activity in certain microhabitats can influence the morphological and behavioral traits of prey. Many anuran larvae experience shifts in behavior that alter the dynamics of the population. The presence of vegetative cover in an aquatic environment can be an important factor in predator-prey interactions. Tadpoles use cover, such as aquatic stems, for protection against predators. In this study, field surveys were conducted to determine the relationship between the amount of cover and amount of predator in 10 ponds at UNDERC property and controlled laboratory experiments where done to determine the relationship between the amount of artificial cover and tadpole survival in the presence of predators. The tadpoles used in this study were *Hyla versicolor* and *Rana sylvatica;* the predators were Dytiscid larvae and Belostomatids. In the field survey, no relationship was found between stem density and predator density. In the lab experiment, it was found that the amount of cover had no effect over tadpole survival. The predators managed to capture tadpoles regardless of cover amount, indicating that they may switch behaviors from a sit and wait strategy to a more active hunting strategy. The plastic behavior of these two predators can have a dramatic impact on anuran larvae population dynamics by rendering some of their survival strategies null.

Introduction:

Habitats that present more variations can moderate predator prey interactions and can potentially decrease prey mortality. Zones with vegetative cover or areas can serve as shelter, by lessening the foraging success of predators because of decreased manoeuvrability or visual range can help in the survival of organisms(Babbit and Taner 1998). The level to which habitat complexity affects predator success may depend on the species of prey and the quality of the habitat structure in question (Babber and Babbit 2004). In amphibians, juvenile aquatic phases are more susceptible to predation. The larvae have behaviour patterns that help them defend against predation, such as remaining stationary, but vegetative cover is also an important anti-predation defence utilized by tadpoles (Swart and Taylor 2004). Studies have demonstrated that tadpoles in cover areas have higher survival rates from predators. (Babbit and Tanner 1997).

Seasonal vernal ponds in forested areas play an important role in the lifecycle of many amphibian species. Anuran and invertebrate larva develop in these bodies of water, as both groups attempting to metamorphose before the pond dries. (Skelly 1997) The canopy cover present above the ponds can create habitat variation as the increase in light exposure can foment underwater stem growth. Tadpole predators present in these environments, are larvae of the diving beetle (*Dytisicus spp*.) and giant water bugs (*Lethocercus spp*.), which are a type of diving insect that is classified as being sit-and wait predator. Both

groups are air breathers, and Belostomatids prefer to rest on aquatic vegetation while waiting for prey. (Swart 2004). When a change occurs in a given environment, alterations in predator hunting behaviour have been observed. A study done with *Dytisus verticalis* (Formanowicz 1982) documented how a switch in hunting strategies occurred when the amount of prey density changed. When prey was abundant, Dytiscus verticalis was a sit and wait predator, hunting by ambushing tadpoles. At lower prey densities however, the predator became an active hunter, constantly searching for prey.

The physical and behavioural reactions of prey individuals to predators can have significant effects on the dynamics of a community by molding the way populations develop and behave. Since these responses are directly related to predator behaviour (Altwegg 2003), I will carry out a study to observe tadpole survivability from predation in areas with different amounts of cover. I will also observe how predator density is related to stem submerged and emergent stem density in 10 vernal pools located at UNDERC. The tadpoles I plan to use are those of Eastern gray treefrog (*Hyla versicolor)* and wood frog (*Rana sylvatica),* since both species are found in these ponds. One field survey and three laboratory experiments will be conducted. I hypothesize that when tadpoles are presented with a cover-protected area and an exposed area, they will prefer areas with cover present since it offers them protection. Because the two predators utilized are typically associated with vegetation, as they perch on it, I hypothesize that areas in ponds with a higher amount of stems

will contain a higher amount of predators. Finally, in the predator-cover experiments, higher degrees of cover will have lower tadpole mortality.

Methods:

Study Site Location:

For this study, 10 vernal ponds around the UNDERC property were selected. Half of these ponds are considered to be closed canopy and half were classified as open canopy (Table 1). The other half was exposed, and contained no canopy cover. To identify sampling areas, flags were marked with a letter-number combination, and they were then placed 2m x 2m apart in each pond to create a sampling grid.

Fieldwork Surveys:

-Predator Survey:

For predator sampling, I used 238 minnow traps to capture the specimens. The traps were distributed in the 10 ponds, placed in flagged areas and were checked daily during a period of 2 weeks, and the predators found in the traps were recorded and identified to genus.

-Stem Survey:

I measured the amount of underwater stems in each of the vernal ponds by sampling each flagged area. I placed a 30cm in diameter PVC pipe on the flag, creating a circular perimeter. The amount of stems located inside each site

perimeter was manually counted and recorded.

Laboratory Experiments:

-Specimen Collection Methodology:

Rana sylvatica tadpoles and *Hyla versicolor* tadpoles were obtained from wading pools that contained sibships that had been hatched from eggs. These frog eggs had been obtained earlier, by collecting adult breeding pairs in amplexus at different vernal ponds. They were kept in captivity until the female deposited her eggs and the male fertilized the eggs. The larvae were then moved into protected wading pools and their development was monitored.

Dytiscid larvae and Belostoma adults were collected from minnow traps that had been set up in various ponds. After capture the invertebrates were deposited in containers and were fed and cared for until it was time for their usage in the experiments.

-Cover Preference test:

To observe tadpole preference to areas with cover or areas without cover, I utilized eight 48.3cm x 33cm clear plastic tanks which were filled with 17.8cm of water. The bottom of the tank was fitted with a mesh that had half of its area covered with the green polypropylene rope strands. This way, I created an environment in the tank in which one half offered cover for the tadpoles, and

the other half was exposed. Ten *Hyla versicolor* tadpoles where collected from each of the different wadding pools and I deposited each group in a different tank. After a 24 hour adjustment period, the tadpoles where observed. I recorded the amount of tadpoles both in the cover area and exposed area over 4 days.

-Tadpole Survival Test I (Dytiscid):

To test tadpole survival in a predator environment and with different amounts of cover, I arranged 30 circular 57 liter tubs into 5 x 6 rows, and filled each container with water. I then fitted each tub randomly with different amounts of cover; ten tubs with 0% (0 rope strands), ten tubs with 20% (14 rope strands) and ten tubs with 60% (42 rope strands). The cover was simulated using a mesh, with different amounts of green rope tied to it. To assure that the mats remained on the bottom of the tub, I used 4 rocks to weight them down. The 300 *Rana sylvatica* tadpoles used in this study were taken of the different wading pools that housed them. Once the tubs were prepared I deposited 10 *Rana sylvatica* tadpoles in each tub. After giving the tadpoles a 24 hour adjustment period, one Dytiscid larva was added to each tub. I avoided feeding the Dytiscid larva the day before introducing them, to standardize hunger levels among the predators. After two days, I removed the Dytiscid larvae, and surveyed the remaining tadpoles.

-Tadpole Survival Test II (Belastoma):

This experiment was organized in the same fashion as the Dytiscid experiment, only I deposited 10 *Hyla versicolor* tadpoles in each tub. Three hundred *Hyla versicolor* tadpoles were taken from each of the seven wading pools that housed them. After giving the tadpoles a 24 hour adjustment period, one Belastomatid was added to each tub. Since my predator specimens were both adults and juveniles, I used 15 adults and 15 juveniles in this experiment. I avoided feeding the water bugs the day before introducing them, to standardize hunger levels. Two days later, removed the predators and counted the remaining tadpoles.

Statistical Methods:

Results where analyzed utilizing SyStat and Excel. Stem data and predator data was analyzed in Excel, using linear regression to determine the relationship between the two variables. The tadpole cover preference experiment was analyzed in SyStat using a Paired T test. For the Dystiscid-Cover experiment, an ANOVA test was used to compare the different means of the cover groups and a MANOVA was used to conduct a multivariant analysis of variance between all three. The same approach was taken for the Belostomatid experiment, with the only difference being that a two-way ANOVA was utilized to determine the difference between adults and juveniles.

Results:

-Predator and Stem Relationships in the 10 ponds:

Belostomatids were collected only in ponds that had an open canopy, while Dytiscids where collected in both open and closed canopy ponds. Linear regressions between Belostomatids and stems in open canopies (Fig. 1) showed no pattern (R-squared=0.1391). The regression between Dytiscids and stems (Fig. 2) in open canopy ponds also had no pattern(R squared=0.0467). Another correlation with Dytiscid and stems in closed canopies (Fig. 3) and Dytisids and stems in closed and opened canopy ponds combined (Fig.4) also yielded no pattern (R-squared=0.0235 and R squared=0.0001).

-Tadpole Cover Preference Test:

The results of the Paired T test (Table 3), showed that the area with cover had a higher average of tadpoles (mean=29.3) than the area with no cover (mean=9.6). The p-value (P=0.001) rendered the difference between the two groups significant.

-Tadpole Survival Test (Dytiscid):

The results for the ANOVA (Table 4) , revealed that cover had no effect on wood frog tadpole survival from larval dytiscid predation (df = 2,22, F = 0.465, P = 0.634).

-Tadpole Survival Test (Belastoma):

The ANOVA results (Table 5), demonstrated that the relationship between tadpole survival and the amount of cover present was not significant (df=2,21, F=0.086, P=0.918). The relationship between the two predator ages (Juvenile or Adult) and tadpole survival was significant (df=1,21,F=5.133, P=0.034). Combining cover and age in relation to tadpole survival yielded no significant results (df=2,21,F=0.941, P=0.406). The analysis of variance (Fig. 6) showed that the Belostomatid juveniles consumed more tadpoles than the adults.

Discussion:

Looking at the total amount of stems in relation to ponds (Table 2.), it can be seen that the amount of stems overall was higher in open canopy ponds. Both predator groups were less abundant in closed canopy ponds. Belostomatids were only found in the open canopy ponds, suggesting these environments offered them something that closed canopy pond environments; a study devoted to this would be good for future research. As such, I rejected my first hypothesis as I was unable to prove a relationship between the stems and predators in a pond. The amount of predators I sampled might not have been enough for a proper test. More trapping would have been ideal, but this was rendered impossible as most of the ponds dried extremely quickly due to low rain fall and warm temperatures.

In the tadpole cover-preference experiment, during all my observations, the majority of the tadpoles were located in the cover indicating a preference for

these environments. Their instinctive need for protection drives them to seek cover. However from the results of the Dytiscid and Belastomatid experiments indicate that contrary to my hypothesis, different amounts of cover had no effect on tadpole survivability. The reason for this might be a shift in predator behavior; the two species can change from sit and wait predators that stalk their prey in cover-zones, to active hunters that seek out prey in areas with no cover. This change in behavior supports the study done by Formanowicz, in which it was observed a predator switched its hunting strategies. The plastic behavior exhibited by these two predator groups decreases the effectiveness of the cover protection in tadpoles, making them susceptible to predation regardless of the presence or absence of cover. In Belastomatids, a difference between adult and juvenile predatory activity was discovered. Juveniles were observed to have eaten more than the adults; this was probably due to the fact that juveniles needed to intake more nutrients to fuel their growth.

The fact that these predators seem to hunt in both cover and exposed environments means that they might have a more dramatic impact on anuran larvae communities, and their dynamics. This might pin point why I did not find a preference in habitat preference for the predators in the ponds. It could be that the predators simply did not have a habitat preference, since they could hunt effectively in different cover levels as the laboratory results show.

Belostomatids and Dytiscid larvae are not only predators that affect tadpoles; Adult Dytiscids, dragonfly larvae and certain salamanders are also important

tadpole predators. A future study could replicate the Predator-Cover experiments with some of these predators, to observe the effect that different amounts of cover had on tadpole survival in the presence of them. My study could be improved by using more replicates in all of the laboratory experiments, increasing the amount of tadpoles given and extending the observation and surveying periods. The field surveys would have benefited from more study sites and longer sampling periods, as two weeks was not enough time to trap and survey enough predators. For a future study the cover preference experiments could be repeated, only this time with

Acknowledgements:

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Tables:

Table 1. Study Sites

Vernal Pond Study Sites	
Open Canopy	**Closed Canopy**
NBB	VPGD
NFL	VPEFGH
SML	VPN
VP9B	VPJ
VP27	VP12

Table 2. Total Amount of Predator and Stems

POND	**BELASTOMATID**	**DYTISID**	**STEMS**
Closed	0	45	46
Open	66	271	1770

Table 3. Tadpole Cover Preference Results: Paired T test

Mean NOCOVER	9.6250000000
Mean COVER	29.375000000
Mean Difference	-19.750000000
95.00% Confidence Interval	-2.5070404575E+001
Standard Deviation of Difference	6.3639610307
T	-8.7777777778
Df	7
p-value	0.0000501749

Table 4. Analysis of Variance: Dytiscid Predation Experiment.

Rana sylvatica-Dytiscid Predation Experiment: Analysis of Variance					
Source	Sum of Squares	df	Mean Square	F-ratio	P
Cover	1.551	2	0.775	0.465	0.634
Error	36.689	22	1.668		

Table 5. Analysis of Variance for the *Hyla versicolor*-Belastomatid Experiment.

Hyla Versicolor-Belostomatid Predation Experiment: Analysis of Variance					
Source	Sum of Squares	df	Mean Square	F-ratio	P
Cover	0.525	2	0.262	0.086	0.918
Age	15.631	1	15.631	5.133	0.034
Cover*Age	5.729	2	2.864	0.941	0.406
Error	63.950	21	3.045		

Figures:

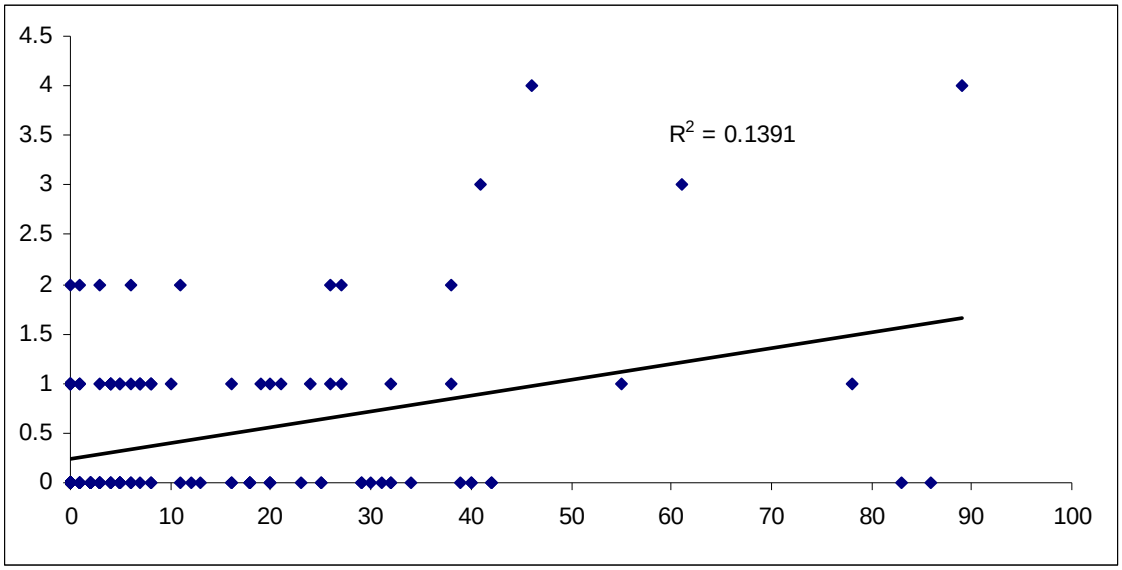

Fig 1. *Belastoma distribution across Open Canopy Ponds.* # Stems is the y value and # Belastoma is the x value. No clear pattern can be determined with the data, and the R squared value is low.

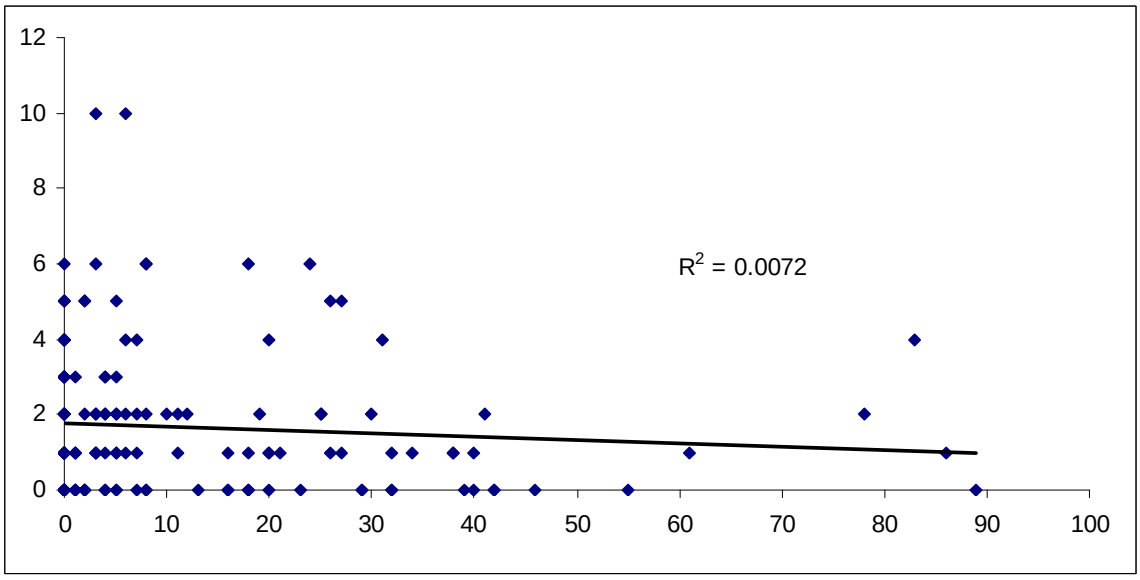

Fig 2. *Dytisid distribution across Open Canopy Ponds.* # Stems is the y value

and # Dytisid larvae is the x value. No clear pattern can be determined with t the data, and the R squared value is low.

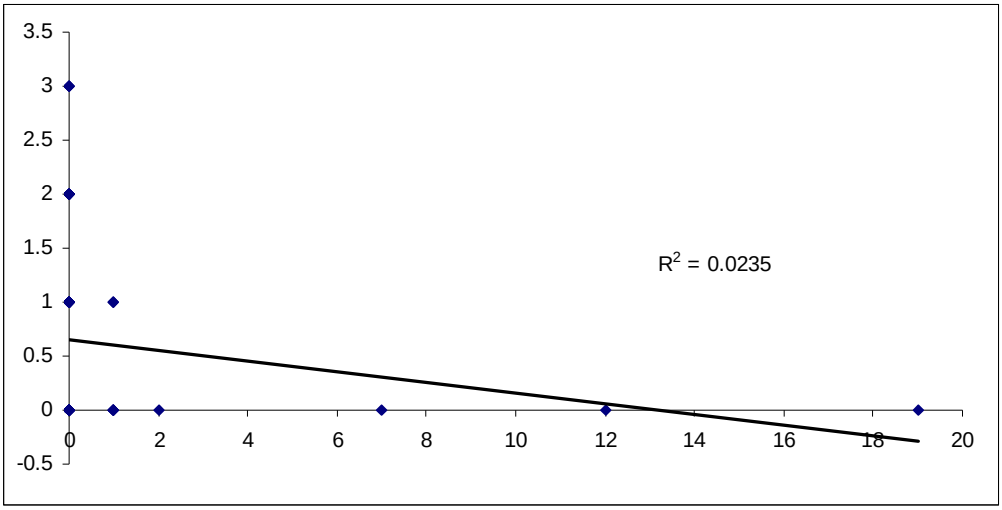

Fig 3. *Dytisid distribution across Closed Canopy Ponds.* # Stems is the y value and # Dytisid larvae is the x value. No clear pattern can be determined with the data, and the R squared value is low.

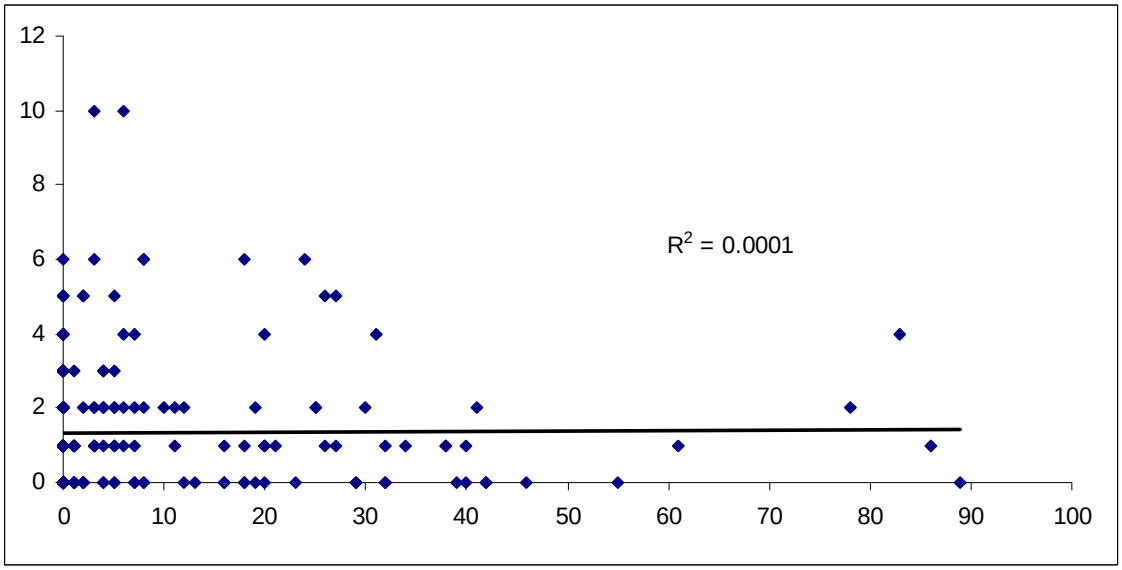

Fig 4. *Dytisid distribution across all Ponds.* # Stems is the y value and # Dytisid larva is the x value. No clear pattern can be determined with the data, and the R squared value is low.

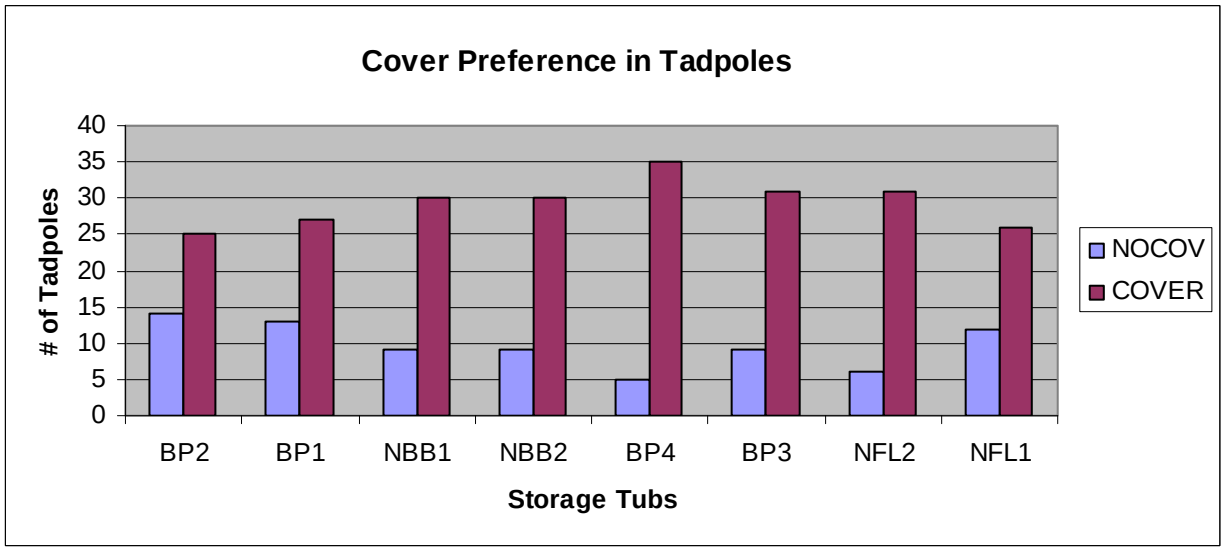

Fig 5. *Cover Preference in Tadpoles*. Tadpoles were more abundant in the area that offered cover, than in the exposed one.

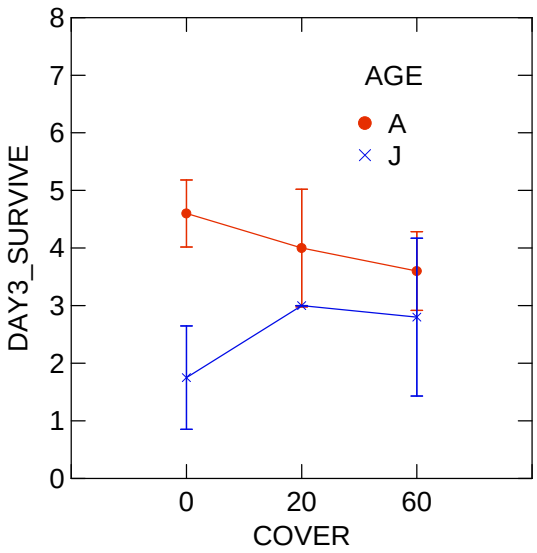

Fig.6 *Analisis of Variance between Belastoma Adults and Juveniles.* Juveniles

consumed more tadpoles than the adults.