Effects of sex and sexual maturity on intra and interspecific foraging activity between the northern crayfish, *Orconectes propinquus* and yellow perch, *Perca flavescens.*

Mia Dawn Puopolo

BIOS 33502-01

University of Notre Dame

22 July 2008

Advisor: Ashley Baldridge

ABSTRACT

Competition between northern crayfish, *Orconectes propinquus,* and yellow perch, *Perca flavenscens*, plays an important role in the success of each species. Individuals of each species prey upon and compete with each other, and thus exhibit intraguild predation. Through timed feeding trials, this study investigates the differences sex and sexual maturity play in the foraging activity of each species on an intra and interspecific level. These investigations were coupled with a field survey to assess the naturally occurring sex ratio of northern crayfish on the UNDERC property in Land O'Lakes, Wisconsin. The insignificant results of the intraspecific feeding trials suggest that crayfish are not likely to be affected by other crayfish of differing sexes and maturities while foraging. For the interspecific feeding trials the results were inconclusive. The behavior shown in both cases suggests that the crayfish's primary objective was seeking out refuge and not that of foraging. The results of the field surveys show that the natural sex ratio is favored towards females.

INTRODUCTION

Competition between crayfish and perch for food resources could play an important role in the success of each species. Like that of bass and crayfish, perch and crayfish prey upon and compete with each other, and thus exhibit intraguild predation (Bampfylde and Lewis 2007). The interactions vary by life stage such that adult perch prey on crayfish and crayfish consume perch eggs (Dorn and Wojdak 2004). Both species, in turn, also consume and compete for macroinvertebrates (Dorn and Mittelbach 1999). Additionally, there is strong intraspecific competition between juvenile and adult crayfish with both species competing for invertebrates, macrophytes and detritus associated with the cobble environment in which the animals live and forage (Lorman 1980). The success of each crayfish at each stage of life also directly affects the make up of the population in terms of the ratio between juvenile and adult and male and female crayfish within the littoral community (Dorn and Wojdak 2004).

The goal of this study was to investigate the differences in sex and sexual maturity in interspecific foraging activity between juvenile northern crayfish, *Orconectes propinquus,* and yellow perch, *Perca flavescens*. I also aimed to look at intraspecific foraging activity among young and adult northern crayfish of both sexes. Both objectives were accomplished through feeding trials observing the foraging activity between crayfish and yellow perch. These investigations were coupled with a field survey in Tenderfoot Lake to measure the naturally occurring sex ratio.

There are no significant differences in the trophic roles of male and female crayfish in littoral zones (Roth 2001). Thus, I hypothesized that there would not be differences in response to intra and interspecific foraging activity between male and female crayfish of the same age and size. However, I did expect that older and larger crayfish of either sex would be more successful in foraging than compared to young adults. Similarly, I hypothesized that juvenile and adult male and female crayfish would present lower foraging rates in the presence of yellow perch. Finally, I expected the natural ratio of males to females to be 1:1.

METHODS

My project examined the ways in which sex and sexual maturity influence foraging interactions between males and females of all ages and young and mature adults of both sexes on an intraspecific level. Additionally, the effect of sex and sexual maturity on inter-specific foraging activity between northern crayfish and yellow perch was observed. To do this, feeding trials were conducted using crayfish and fish of both sexes from various stages of life.

Firstly, a variety of crayfish were hand collected from Tenderfoot Lake on the UNDERC property using snorkeling techniques. One year old crayfish individuals [15-18 mm carapace length, approx 1.0 g body weight (Roth 2001)] were designated as the young adults, whereas larger crayfish were classified as mature adults. Yellow Perch of various sizes and maturities were harvested from Tenderfoot and Brown Lakes using seining and electro-shocking techniques. The carapace length and sex of each crayfish were recorded and they were housed in large round tub, or “wading pool”, containing shallow lake water and cobble to mimic the natural environment. Each perch was measured and housed in large flow-through holding tanks before undergoing feeding trials in separate aquaria.

The intraspecific crayfish feeding trials were setup in such a way that a young adult of each sex was tested with a mature adult from each sex as well as a young adult of the opposite sex. Additionally, a mature adult of each sex was paired with a mature adult of the opposite sex. The trial arena was a 10 gallon aquarium which was surrounded on 3 sides and the top with a black canvas so as to block out distractions from the surroundings. The tanks were filled with fresh water from Tenderfoot Lake and free of cobble substrate. After being moved to each trial tank, each pair of crayfish had a minimum waiting period of two hours to acclimate.

The feeding trial process included each pair of crayfish being offered five invertebrates, *Lestes congener*, order *Odonata*, for a trial period of five minutes. Odonates were used as they are widely available in the amounts needed for this experiment and shown to be preferred over other invertebrate species. Crayfish also do not show a significant decrease in preference for Odonate consumption when perch are present or absent (Poinsatte, unpub. data). The crayfish were free to interact with each other and compete for the invertebrates offered. At the end of each trial, the number of invertebrates eaten by each crayfish was recorded and the crayfish were moved to a separate holding tank and not used for trials again for two days or longer. Each type of trial had six replicates.

Additionally, I conducted feeding trials using perch and young and mature adult crayfish to observe the ways in which sexual maturity influences competitive interactions between males and females on an interspecific level. The feeding trials involved different pairings of young and mature males and females, such that an individual of each age and sex was paired with a single yellow perch. These feeding trials were designed to investigate how the foraging of crayfish of various stages of sexual maturity is affected by the presence of perch. The trials were conducted in a similar manner to the intraspecific trials with five Odonates offered to the fish and crayfish for a trial period of five minutes. The fish and crayfish were allowed to interact freely with each other both during the trial and during the minimum four hour waiting period before the trial. The acclimation time was longer in this case because the fish underwent a starvation period and take longer to adjust to the tank conditions.

To determine the naturally occurring sex ratio, I also conducted population surveys in Tenderfoot Lake using snorkeling techniques. Four 15 minute timed dives were conducted, in which all crayfish were collected. The primary substrate sampled was cobble with dense aquatic vegetation. The water depth was approximately three feet throughout.

ANALYSES

A set of one-way analyses of variances (ANOVAs) were run in SYSTAT 12 for each feeding trial treatment (Figs. 1-6, Table 1). Additionally, two ANOVAs comparing females of all sizes to males of all sizes and mature adults of both sexes to immature adults of both sexes were run (Figs. 7 and 8). The pairings of crayfish of different sexes and different sexual maturity did not exhibit significantly different foraging rates, with the exception of one trend. These pairings included a young male adult with mature male adult (p=0.156), young female adult with mature female adult (p=0.549), young male adult with mature female adult (p=0.496). A trend within the pairing of mature male adult and young female adult was observed (p=0.086). This trend indicates that when both are present, mature male adults consume more than that of young female adults.

For the pairings including crayfish of the same approximate age (young adult/ mature adult) and different sex, results were not significant. The observed p-value for a mature male adult paired with a mature female adult was p=0.145 and a male young adult paired with a female young adult crayfish was p=0.687.

Additionally, a trend was observed for all males (young and mature adults) versus the number of invertebrates consumed during the trials (p=0.105). Statistical significance was also observed between the number of invertebrates consumed and all females (p=0.006). This shows that as the size of the female crayfish increases, the rate of consumption also increases. Finally, for all young adults (males and females) and the rate of consumption, as well as all mature adults and the rate of consumption, there was no significance (p= 0.518 and p=0.187, respectively).

In the case of the trials involving crayfish at various stages of sexual maturity in the presence of a yellow perch, there is not enough data to analyze results in SYSTAT 12. SYSTAT 12 cites the error code “No variance in categorical predictor”, that is, in many of the trials and controls, there were no Odonates consumed and this causes an error in SYSTAT 12.

Lastly, for the field surveys, the male to female ratio was concluded for each of the four fifteen minute timed dives and an average calculated using the four survey ratios (Chart 2). In the area sampled in Tenderfoot Lake there were approximately 22.6% males and 77.4% females present per 100 crayfish.

DISCUSSION

The feeding trials provide a look into both the intraspecific competition between crayfish of both sexes at various stages of sexual maturity and interspecific competition between crayfish and perch. The insignificant results of the intraspecific feeding trials suggest that crayfish are not likely to be affected by other crayfish of differing sexes and maturities while foraging. In the cases where a young adult was paired with an adult of the same or different sex, as the statistics show, the younger crayfish was not less likely to forage than in the presence of a crayfish of the same maturity. Likewise, in the presence of young adults, the mature adults were not more likely to forage more so than in the presence of a crayfish of the same maturity. From the number of invertebrates eaten by the crayfish during the trials, it can be inferred that each crayfish of both young and mature adult status were not affected by the other’s presence. This may be because their foraging behavior is primarily affected by the presence of fish and not that of each other. As well, the size range in the trials might not have been great enough to elicit a change in behavior for the young adult crayfish. The sizes of mature adults included crayfish up to 31mm, while the young adults included crayfish up to 19mm.

In the case of the young female adult paired with a mature male adult in a trial, there is a trend showing that male adults eat more than that of their young female counterparts. This can be explained by the relatively large difference in sizes between young females and mature males. The average size of the young females was 18mm, while the average size of the mature males was 24mm. A crayfish of 6mm average difference would need more energy to sustain themselve and therefore will forage for more prey.

Unlike that of all males, there is a strong relationship in the case of the length of all the female crayfish and the number of invertebrates eaten during the trial. Among females, larger crayfish consumed a greater amount of food. This may be accounted for by the higher energetic and caloric needs of a larger female that is able to produce offspring. A gravid female, or one that has just laid eggs this summer, would need to increase their food intake in order to make up for the energy expended in offspring. Additionally, gravid females do not forage while caring for their brood, and would be likely to consume more once they are away from their offspring (Ashley Baldridge, personal comm.).

During all the feeding trials involving crayfish only, the most commonly observed behavior elicited from the crayfish was that of walking around the tank, perhaps seeking refuge. Additionally, during the trials all crayfish seemed to "passively forage". That is, they did not seem to actively seek out the invertebrates provided to them, but rather they only consumed the *Odonata* when they happened upon them while walking around the tank. This might suggest that the crayfish's primary objective was seeking out refuge within the tank instead of foraging. Since the tanks were free of cobble substrate, as is in the natural environment, the crayfish might have been uncomfortable with the foreign conditions. Their attention would likely be drawn away from foraging in this case and instead be focused on sheltering themselves from potential predators.

The results were inconclusive for the interspecific feeding trials with crayfish and perch. This was because in each of the four trial situations no *Odonata* was consumed in either the control or trial with crayfish and perch pairing which causes an error in SYSTAT 12. The data set containing four replicates does not show enough variation in the number of Odonates consumed for SYSTAT 12 to complete an ANOVA. I believe at least two more replicates with variation in the number of Odonates eaten would be necessary to run the analysis.

The results of the field surveys show that the natural sex ratio is favored towards females. With 77.4% of crayfish being females, one can see there is a majority of female crayfish in the natural habitat. This suggests that the feeding trials I conducted might not have mimicked the natural sex ratio as the trials were 1:1 male to female.

Based on my results, I suggest future research into the behavior exhibited by the crayfish, not just the total number of invertebrates consumed, in each of the different pairings to look at the effects of sex and sexual maturity on foraging. Additionally, it would be interesting to see the results of trials that mimic the naturally occurring sex ratio.

ACKNOWLEDGEMENTS

Firstly, I wish to thank the Bernard J. Hank Family Endowment for the financial support for my research this summer. Additionally, I wish to thank the University of Notre Dame Environmental Research Center staff, including Gary Belovsky, Michael J. Cramer, Heidi Mahon and our teaching assistants, Michael O'Brien and Michael McCann. Especially thank you to Ashley Baldridge, my project mentor, for providing me support and guidance. Thank you to everyone who assisted in the crayfish collecting process, particularly Tori Mork for aiding in surveying. As well, thank you to Dana Lee and Chelsea Ewen for their kindness in the form of many trips to town which saved my sanity. Also, thank you to my sister, Erica A. Scott, for reading and providing comments on this paper. Finally, thank you to my trusty lab partner, Justin Poinsatte, for being beside me through everything from mud in our waders to proofreading this paper.

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TABLES

Table 1. The p-values observed for all intraspecific crayfish feeding trial treatments.

	Mature Adult Male	Mature Adult Female	Young Adult Male
Mature Adult Male			
Mature Adult Female	p=0.145		
Young Adult Male	p=0.156	p=0.496	
Young Adult Female	p=0.086	p=0.549	p=0.105

Table 2. Survey sample data of natural sex ratio.

27mm F	20mm F	24mm F	21mm F	
22mm F	22mm F	25mm F	21mm F	
25mm F	22mm F	25mm F	19mm F	
28mm F	23mm F		22mm F	
21mm F	22mm M		22mm M	
21mm F	24mm M		23mm M	Average of all
24mm M	25mm M			Surveys
14.3% M	42.9% M	0% M	33.3% M	22.6% Male
85.7% F	57.1% F	100% F	66.7% F	77.4% Female

FIGURES

Figure 1. Male mature adults and young male adults and the number of Odonata each group consumed. The error bars show standard deviation.

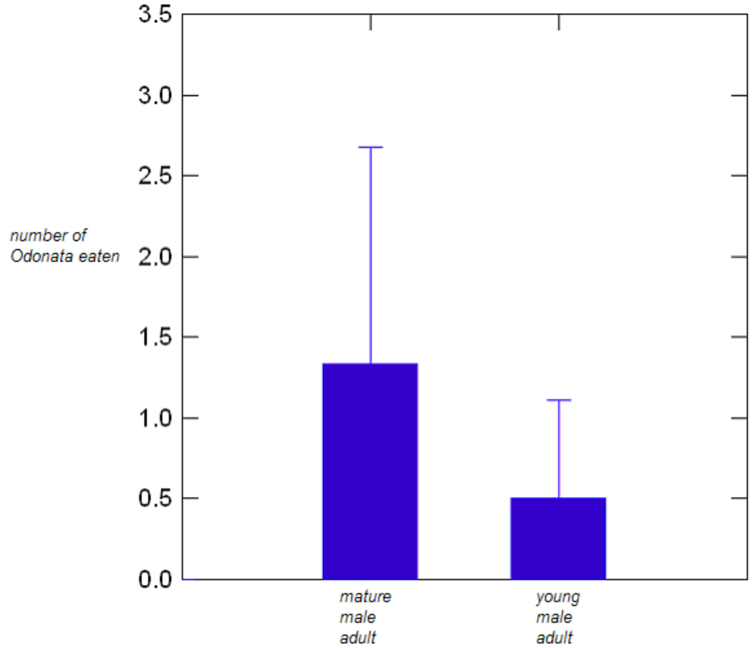


Figure 2. Male mature adults and female young adults and the number of Odonata each group consumed. The error bars show standard deviation.

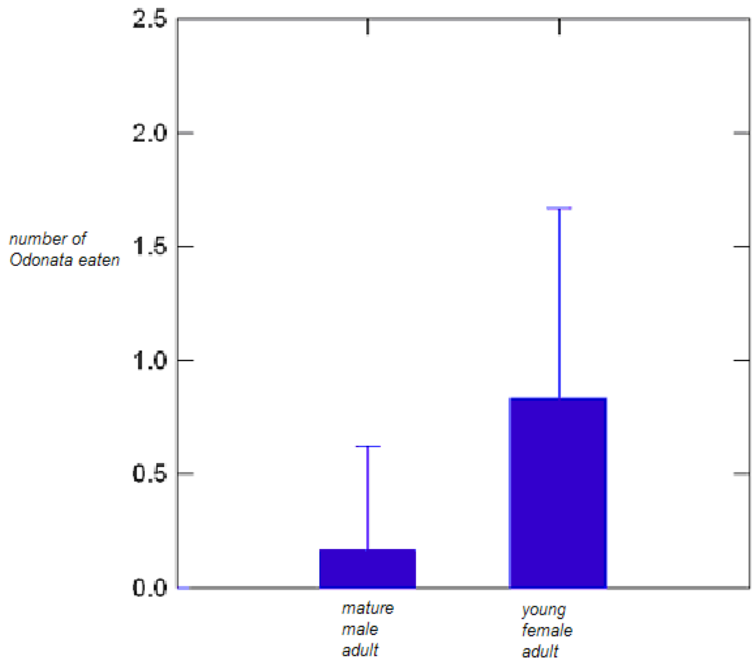


Figure 3. Mature female adults and mature male adults and the number of Odonata each group consumed. The error bars show standard deviation.

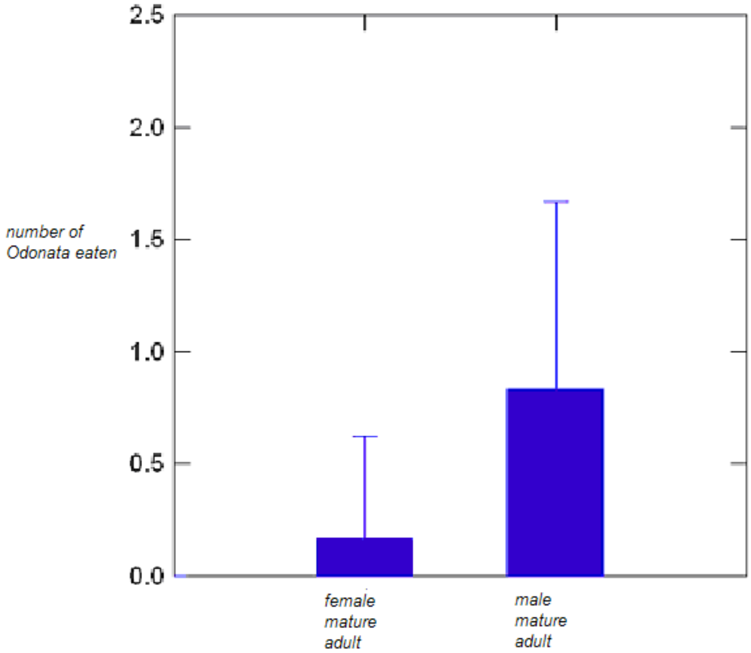


Figure 4. Female mature adults and female young adults and the number of Odonata each group consumed. The error bars show standard deviation.

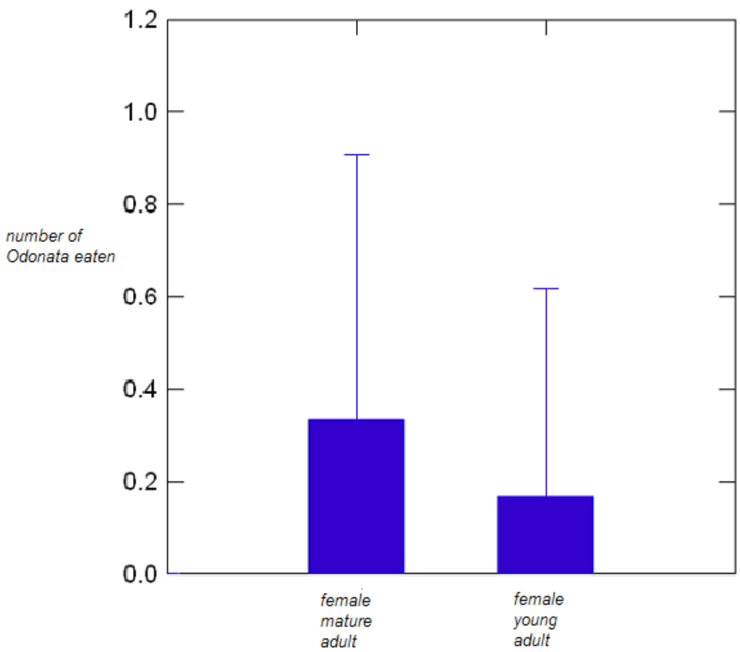


Figure 5. Female mature adults and male young adults and the number of Odonata each group consumed. The error bars show standard deviation.

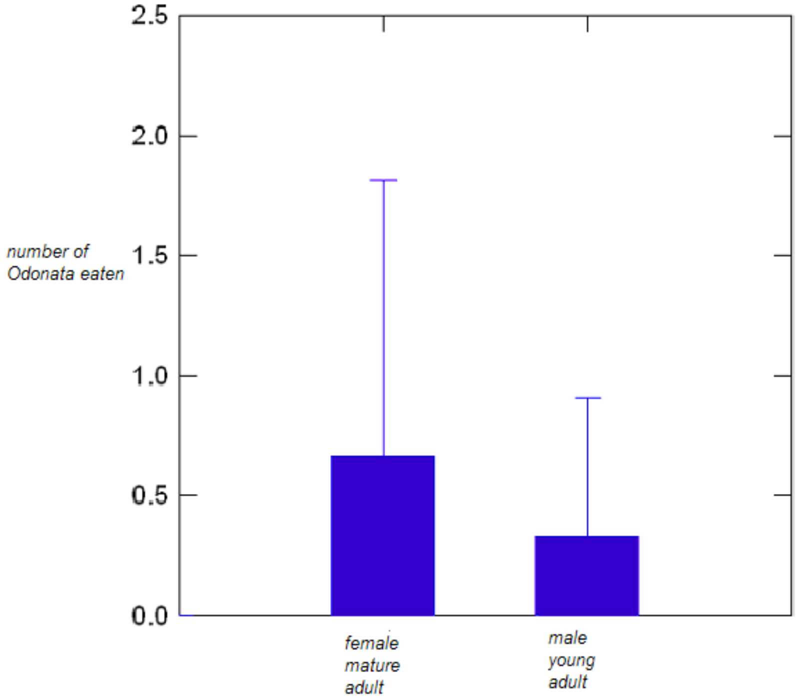


Figure 6. Female young adults and male young adults and the number of Odonata each group consumed. The error bars show standard deviation.

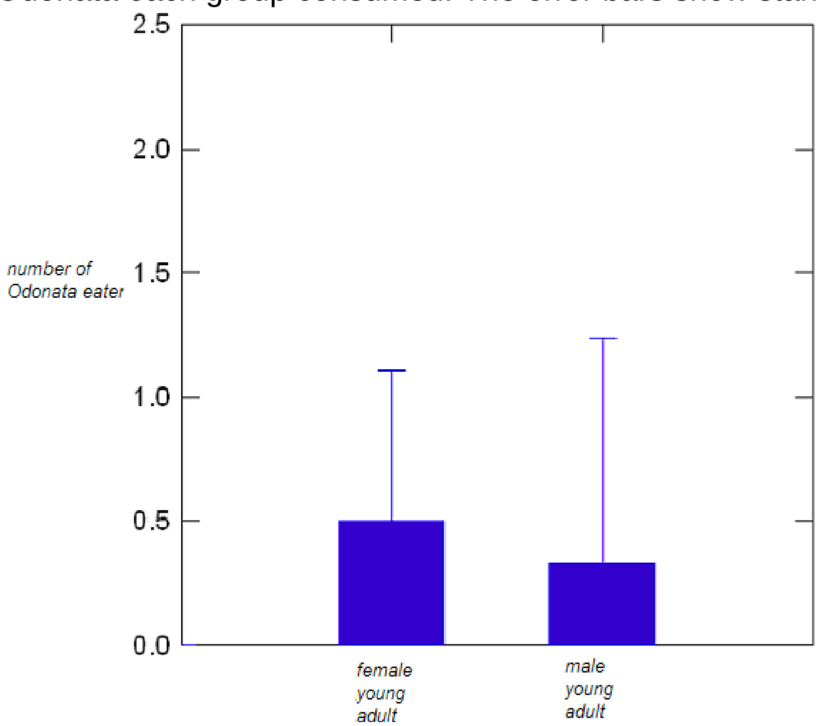
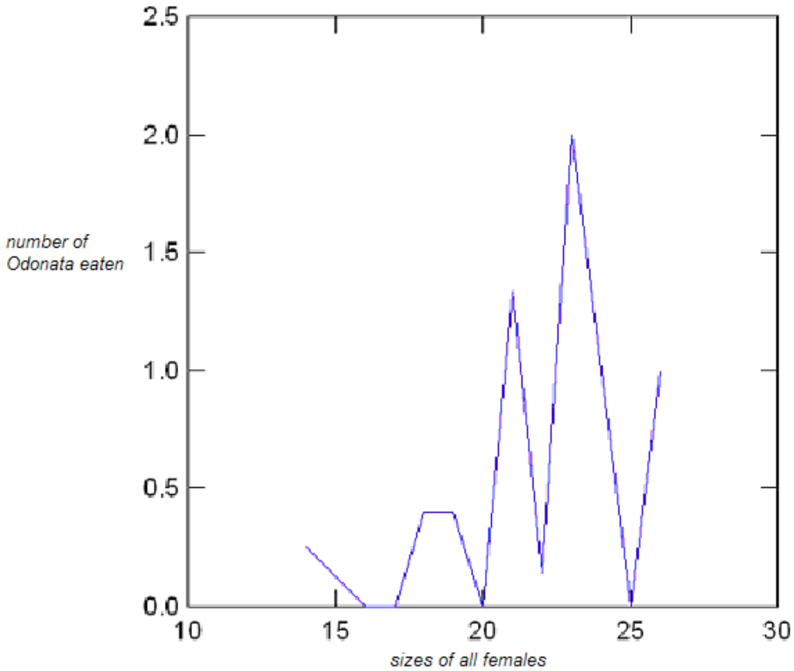


Figure 7.

A) Sizes of all females and the number of Odonata consumed.



B) Sizes of all males and the number of Odonata consumed.

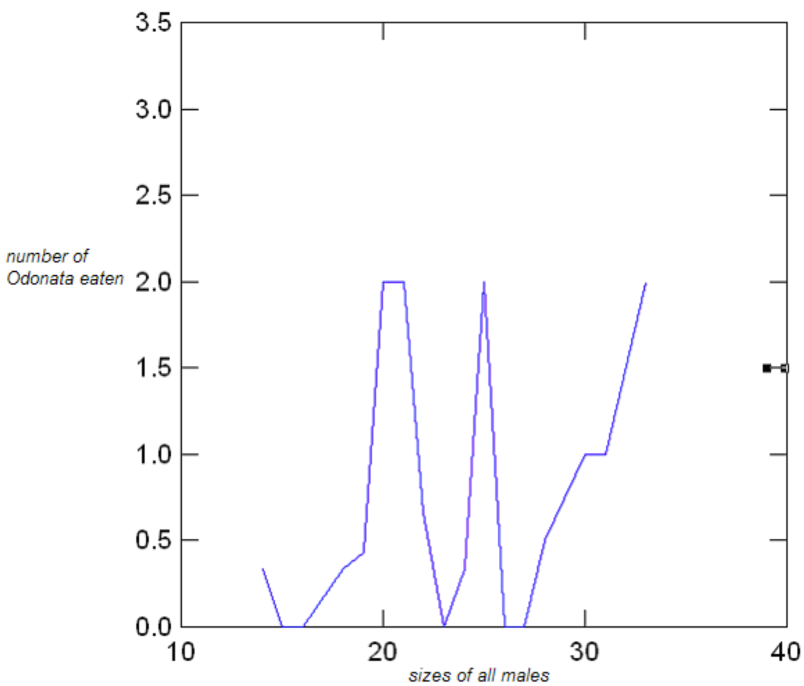
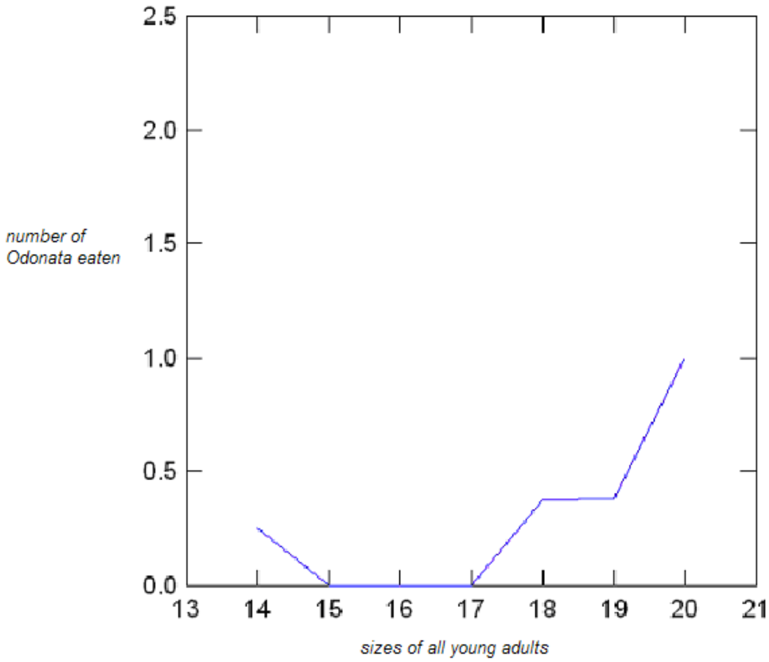
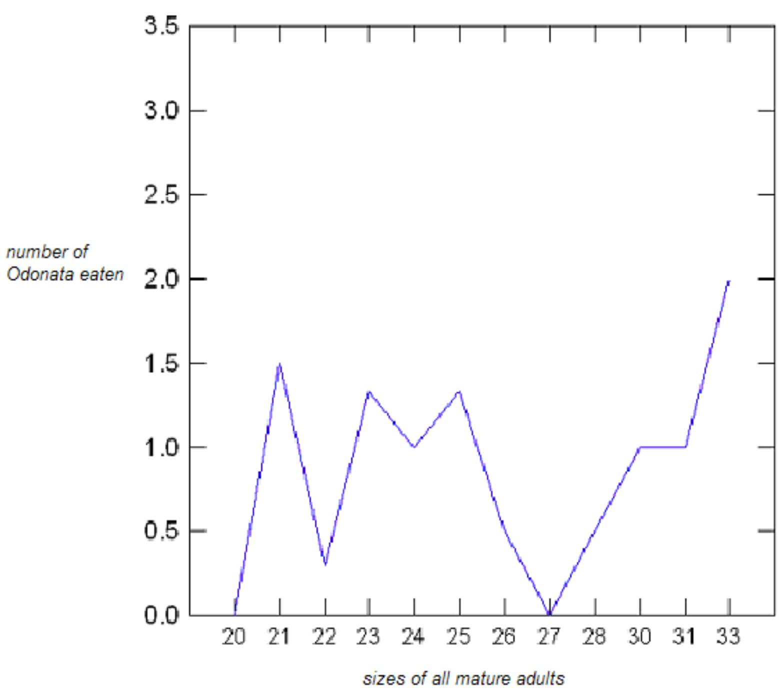


Figure 8.

A) Sizes of all young adults and the number of Odonata consumed.



B) Sizes of all mature adults and the number of Odonata consumed.



APPENDIX

Appendix 1. Map of the UNDERC property. The field survey area is circled and enlarged.