The Effects of Gender and Density on the Rate of Cannibalism in *Orconectes Propinquus*

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Abstract

Although many precautions have been taken to reduce the numbers of the invasive crayfish species *Orconectes rusticus* from North American Lakes, the populations are still stable in many areas. Density dependent mechanisms such as cannibalism may increase the impact of eradication efforts on crayfish populations. Therefore I tested for the prevalence of cannibalism in *Orconectes propinquus.* crayfish and how adult crayfish density and gender affect cannibalism rates. By placing sixty young-of-year (yoy) crayfish in each experimental tank, I evaluated juvenile mortality based on adult density as well as adult gender. After 11 days of allowing the adults to come into contact with the yoy, tanks with moderate density (only one adult) had a statistically significantly higher juvenile mortality than control tanks ($p=0.032$). Tanks with high density (two adult crayfish) fell in between control and low density for juvenile mortality, but were not statistically significant. There were no statistically significant differences for juvenile mortality and gender. These findings may indicate that interference competition was acting in tanks with more than one adult crayfish.

Introduction

The non-native crayfish species *Orconectes rusticus and O. propinquus* are well established in many Wisconsin and Michigan Lakes. At high densities *O. rusticus* crayfish reduce macroinvertebrates (Lodge et al. 1994) and decrease the density of macrophytes (Rosenthal et al. 2006). They also may pose a threat to native crayfish species by displacing them (Klocker & Strayer 2004). Although traps have been fairly successful in ridding lakes of large crayfish, the small crayfish are not easily trapped (Hein et al. 2006). The removal of only large male crayfish from the population has the

potential for stimulating population growth through compensatory mechanisms (reduction in intraspecific competition or reductions in cannibalism). The presence of density dependent mechanisms is important because they could drastically decrease the efficacy of large-scale crayfish control projects.

Cannibalism occurs in almost every large group of egg-laying animal (Polis, 1981). Cannibalism usually involves a predator that is relatively invulnerable to death and injury from its prey, explaining why cannibals are typically larger than their prey. However, it is possible for group cannibalism to occur when the larger prey is vulnerable to their much smaller but numbered predators (Polis, 1981). When cannibalism occurs under usual standards (one predator, many prey), the mortality rate tends to increase as the number of predators increase (Moksnes, 2004), creating a density-dependent population regulation mechanism. Aggression differences between female and male crayfish have not been extensively studied. However, differences in cannibalism rates between males and females is important to understand because low levels of crayfish removals via trapping removal mainly male crayfish (Hein et al. 2006)

This experiment will quantify the effect of adult crayfish density on the rate of cannibalism of young-of-year (yoy) crayfish. In addition, I will test whether male or female adult crayfish are more likely to cannibalize yoy crayfish. I hypothesize that cannibalism rates will be positively related to adult crayfish density. I also hypothesize that male crayfish will be more aggressive than female crayfish and will therefore consume greater numbers of yoy than females.

Methods

Thirty gravid *O. propinquus* females were collected from Tenderfoot Lake in early June and reared in aquaria until the young hatched in July. Nine large females and nine large male *O. propinquus* were collected for the cannibalism trial tanks. Sixty juvenile crayfish were placed in each tank.

All experiments took place in identical wading pools that were one meter in diameter, and filled with two inches of sand and rocks from Tenderfoot Lake. All tanks were filled with epilimnetic water from Tenderfoot Lake. All substrates added to the wading pools included natural invertebrates and periphyton which provided food for crayfish.

Five tank combinations included control (0 crayfish/m^2), low density male (1.3 crayfish/m^2), high density male (2.5 crayfish/m^2), low density female (1.3 crayfish/m^2), and high density female (2.5 crayfish/m^2). Each tank was replicated three times, to give a total of fifteen tanks. Each tank was stocked with 60 yoy crayfish on July 4, 2008. All of these densities are within the range, which exist naturally in lakes (*Brett Peters, personal communication*).The experiment was terminated on July 16. 2008, at which point adult crayfish were removed from the tank. YOY crayfish were recovered from the tank by thorough inspection and sieving all sediment through a 2 mm sieve. Cannibalism rate was calculated as the starting number of yoy crayfish (60 individuals) minus the number recovered at the end of the experiment. I used a one-way analysis of variance (ANOVA) to test for differences in cannibalism rates due to due to crayfish density. Gender differences were evaluated using a two-sample t-test. All analyses were conducted using SYSTAT 10.

Results

A one-way analysis of variance test showed there was a statistically significant ($p=0.032$) effect of adult crayfish density on cannibalism rate. A Tukey's post hoc test indicates that there was a statistically significantly higher number of juvenile mortality in low density tanks than in control tanks ($p=0.032$) (Figure 1). A Kolmogrov-Smirinov-Lilliefors statistical test indicated we met the assumption of a normal distribution of the residuals ($p=0.411$) from the ANOVA test. A two sample t-test showed that there was no significant between the sex adult crayfish and cannibalism mortality ($p=0.339$) (Figure 2).

Discussion

Although the data analysis rejected the hypothesis of the effects of gender on juvenile mortality, it suggests that adult density does have an effect on cannibalism rates. Specifically, the data indicate cannibalism of yoy crayfish was density-dependent; however the highest density of adult crayfish did not result in the highest cannibalism rates as I had expected.

The two forms of competition that arise in nature are exploitative competition and interference competition. The results indicate that interference competition may be occurring in crayfish populations. Interference competition among adult crayfish could explain the lower cannibalism rates in high density tanks compared to low density tanks. Unlike exploitative competition, in which organisms infer indirect negative consequences from utilizing the same limited resource, interference competition directly hinders the ability of a competing organism to obtain limited resources (Schoener, 1983). Interference competition arises from territoriality, overgrowth, undercutting, predation,

and chemical competition (Amarasekare, 2002). This kind of competition has been observed in many different species. I suspect that the adult crayfish in high density tanks were directly interfering with the other's ability to prey on yoy crayfish, either by aggressive contact or through the extra expenditure of energy used for vigilance.

Information on cannibalistic species tends to lack the nutritional history of the cannibals. However, in species that have been closely observed, cannibalism usually decreases with increasing diet quality. When food quality is low, organisms increase their foraging area, increasing the chances for intraspecific contact. This expenditure of energy to search for food leaves the organism even more deprived and weak. During this period of starvation, many species expand their diets beyond the limits of previously acceptable prey (Polis, 1981). It is possible that poor diet was positively influencing cannibalistic behaviors, however, nutritional value per tank was not recorded. In future experiments the effect of alternative food sources on cannibalism rates could be tested.

I have made the assumption that missing yoy crayfish are the result of cannibalism by adult crayfish. However, It is possible that the yoy crayfish experienced stress-induced deaths and then were consumed by crayfish (yoy or adult) or other organisms. It is also possible that other predators consumed yoy crayfish (yoy). However, because my treatments were randomly assigned to tanks and all tanks consisted of the same substrate, it is unlikely this type of mechanism would produce a significant effect of density in the ANOVA analysis.

A number of changes could be made to improve the design of this experiment. First and foremost, more replicates should be run for longer periods of time. The number of macroinvertebrates as well as macrophytes should be recorded before and after the

experiment in order to determine if the adult crayfish prefer to feed on these instead of feeding on the yoy crayfish. Also, it has been observed that juvenile and adult crayfish have preference for dark or clear cover (Alberstadt et al. 1995). In the future, cover should be measured and analyzed to determine its effect on juvenile mortality. Finally, to determine the nature of the intraspecific competition it would be interesting to conduct behavioral observations of the adult crayfish. This observation may give much more insight into the cannibalistic nature crayfish.

In conclusion it appears adult crayfish density has an effect on cannibalism rates, however, the relationship is non-linear, with intermediate densities resulting in the highest cannibalism rates. As for differences in aggression based on gender, there may not have been sufficient replicates to clearly see a trend, so we cannot draw a valid conclusion on this matter. This study suggests that the removal of crayfish from intermediate density lakes may actually stimulate population growth in some instances. However, the removal of some adults from high density populations may actually increase cannibalism and further reduce population growth by reducing intraspecific interference competition between adult crayfish.

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Figures

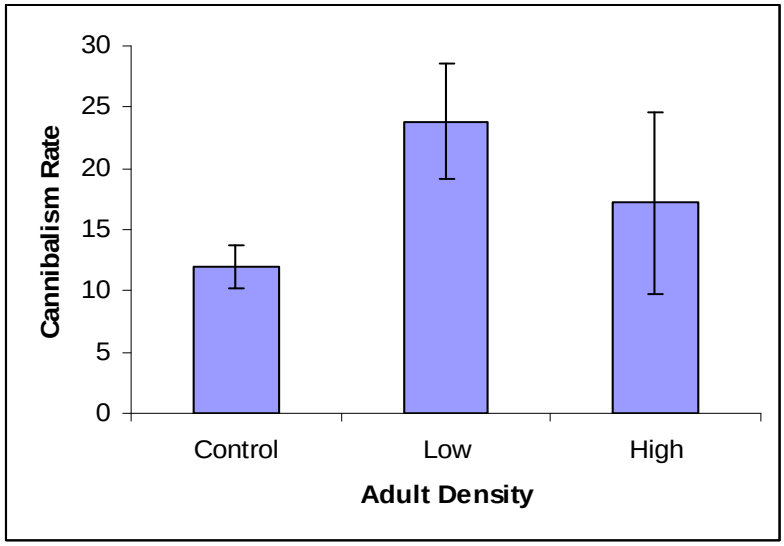

Figure 1. The effect of adult crayfish on cannibalism rate (mean±SD)

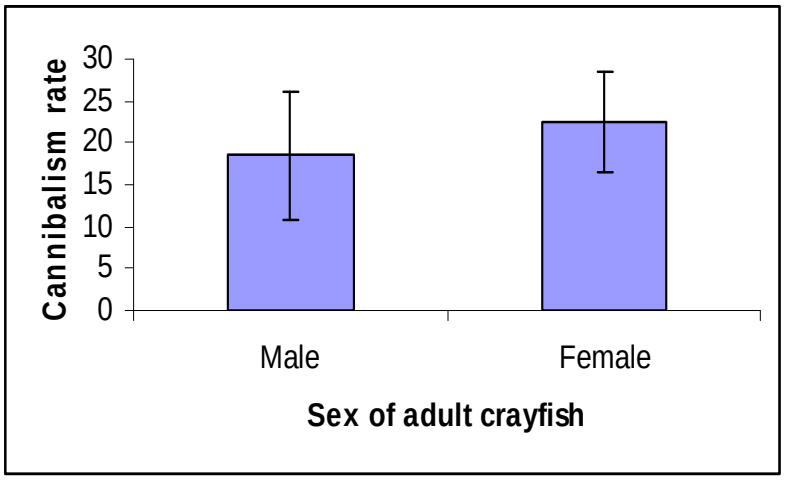

Figure 2. The effect of adult crayfish sex on cannibalism rate (mean±SD)