Catering to Crayfish: Determining the effectiveness of beef liver, northern pike (*Esox lucius)*, and dog food as bait for trapping *Orconectes propinquus* and *O. virilis* in a northern Wisconsin lake

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Abstract

Crayfish hold an important role in the freshwater ecosystems of North America and the study of them is vital to understanding many trophic interactions. Trapping is the most common method for obtaining crayfish for study and there are many different types of bait commonly used. This study tests the effectiveness of beef liver, northern pike (*Esox lucius)*, and canned dog food as bait for trapping *Orconectes propinquus* and *O. virilis* in Tenderfoot Lake. I predicted that the pike would be the most successful, and dog food would be the least. At Tenderfoot Lake, a single trap was set at six different sites. At each site, five three-day trapping periods were conducted throughout the summer. Fish proved to be a significantly more effective bait than beef liver and dog food while there was no significant difference between dog food and beef liver. Despite its inconvenience, northern pike is an effective and more successful alternative to beef liver, while dog food is a cheaper, equally effective alternative to beef liver. Selecting bait such as northern pike could prove monetarily worthwhile and could also increase trapping effectiveness. Future studies are needed to determine the effectiveness of other species of fish and other brands of dog food.

Introduction

Crayfish are the largest and longest lived crustaceans in the freshwater ecosystems of North America (Hobbs 1991). As omnivores, their diet consists of both detritus and animal material. They prey on a variety of organisms across different levels of the food chain and have direct and indirect effects on other species (Hobbs 1991). Crayfish, therefore, may have a significant impact on the ecosystems they inhabit and the study of them is essential in monitoring habitat health and change.

Trapping is one of the principle ways in which crayfish are gathered for study and it holds an essential role in many eradication efforts. Trapping commonly employs a modified minnow trap combined with bait, most often beef liver (Lodge et al. 1986). While most researchers focus on the results of the trapping, the purpose of this study is to focus on the methods. There are numerous viewpoints concerning which of the commonly used baits is most effective for catching crayfish (Brown et al. 1989, Byron and Wilson 2001, Dorn et al. 2005, Lodge et al. 1986). However, no studies have been conducted to quantitatively determine the effectiveness of each outside of a laboratory setting. Determining the most effective bait is important because more efficient trapping methods will save time, money, and resources and will yield higher returns.

The goal of this study was to measure crayfish response to three different baits by counting the number of individuals caught by each type. Multiple crayfish species tested in laboratories were shown to prefer feeding on animal material (Hess and Skurdal 1988, Lorman 1980) and freshwater invertebrates because they are high in protein (Momot 1995). Therefore, the following 3 animal based baits with high protein content were chosen for this study: store-bought beef liver, native fish (northern pike; *Esox lucius*, caught by rod and reel in Morris Lake and frozen), and canned dog food (Ol' Roy Hearty Beef in Gravy).

I hypothesized that northern pike would be the most effective bait choice because it is naturally accessible to crayfish. This species was chosen because it is very abundant on UNDERC property and is native to Tenderfoot Lake. Additionally, I predicted that dog food would be the least effective bait because it is the most processed food and thus the least natural. I also predicted that beef liver would be less effective than fish because it is not natural, but more effective than dog food, because it is not processed. Although beef liver is not a natural component of crayfish diet, it was included in this study because it has been used historically by researchers (Lodge et al. 1986).

Materials and methods

The study was conducted on Tenderfoot Lake on the University of Notre Dame Environmental Research Center (UNDERC) property in northern Wisconsin where two species of crayfish, *Orconectes propinquus* and *O. virilis*, are found. Following a study by Hazlet et al. (1974), I determined that locating sites >30m (mean roughly 60m) from each other was adequate to minimize the possibility of crayfish moving between sites. Theoretically, this also prevented the smell of one bait from interfering with the smell of another.

Six sites with depths ranging between 0.75-2 m (mean depth = 1.2m) were chosen in a bay on the west side of the lake for trapping (Figure 1). The sites had varying substrates, with four of the sites composed of a cobble substrate, one of macrophyte vegetation, and one being a 50/50 mix of cobble and macrophyte. Sites with both cobble and macrophyte substrates were used because *O. propinquus* tend to out-compete *O. virilis* in the cobble substrate and dominate trap catches there, while *O. virilis* are forced to inhabit the macrophyte (Garvey et al. 2003).

A total of five trapping sessions (each lasting three days) were conducted between 2 June and 24 June 2005. (Site 1 only had data for four trapping sessions due to a human error.) The trapping sessions consisted of the same procedure followed daily at every site for a 3-day period, during which each bait was used once. Every day, one trap baited with 100g ± 10g of bait was set out at each site. The mass was chosen following the results of Byron and Wilson (2001) and Lodge et al. (1986). Equal masses were used for all baits at all sites. Selection of the type of bait used was determined randomly or by process of elimination. Traps and bait were set daily before dusk, because crayfish are nocturnal (Bergman 2003). Traps were checked and re-baited daily. At each site, prior to re-baiting, traps were emptied of their old bait and the crayfish caught during the previous day were counted, sexed, and painted with nail polish in order to monitor recapture. Water temperature at the substrate level was recorded at each site. Once all the crayfish were counted, they were released and the trap was filled with a different kind of bait.

Statistical analyses were performed using SYSTAT 11. Analyses of variance (ANOVA) were used in order to determine if there was a statistical difference between the numbers of crayfish caught using the different baits.

Results

There was significant difference between the crayfish choice of different baits (ANOVA, $p=0.001$, $df=2$, F-ratio=7.864). A *post hoc* Tukey test showed that while there was no significant difference between beef liver and dog food (p=0.438), there was a significant difference between northern pike and beef liver (p=0.026) and between pike and dog food (p=0.001; Figure 2).

There was no species-specific bait preference (ANOVA, p=0.104, df=2, F-ratio=2.297) but there was a significant difference in the number of each species of crayfish caught (ANOVA, p<0.001, df=1, F-ratio=52.233; Figure 3).

The data also revealed a strong trend in crayfish capture and temperature (Figure 4). When temperature ranged from 19.1 - 20.8 °C, capture rate was very low, not exceeding 2 crayfish per trap. Once the temperature rose above 21°C, there was a considerable increase in capture size. However, above 24°C, the capture sizes decreased. Because the data form a bell curve, a regression line does not fit (R^2=0.0412, p=0.74). An ANOVA test revealed there was no significant interaction between day, temperature, and the amount of crayfish caught per trap (p=0.2887, df=65, F-ratio=1.25) although figure 5 shows that temperature and time in the season are strongly related (R^2=0.766; p<0.001)

Recapture monitoring showed 46 recaptures and three double recaptures out of 621 individual catches, yielding a recapture rate of 7.4%.

Discussion

My results confirm the hypothesis that native fish, such as northern pike, is more effective than non-native bait, i.e. beef liver or dog food. The use of northern pike as a bait for crayfish is also much cheaper than beef liver (estimated cost at $8,400 for 3-month trapping period, J. Murray, proposal). Additionally, northern pike was shown to be more effective to catch crayfish than beef liver and could be used in population studies where many individuals are needed (such as in Garvey et al. 2003) and in extermination efforts to eliminate invasive species, such as those described for *O. rusticus* Murray (Proposal).

However, catching northern pike is difficult since its presence is variable across and within lakes. Also, in some lakes it may not be a native part of crayfish diet. Further studies should be done to determine the effectiveness of different fish species as crayfish bait. Additionally, fishing with a rod and processing the fish (freezing, sectioning, and massing) was time consuming. While the northern pike in this study was easily obtained from the overpopulated Morris Lake on UNDERC property, such lakes are not common and its unlikely that such effortless fishing can be done in many places. The cost of the man hours required to obtain and prepare the necessary bait would most likely exceed the cost of beef liver for a large scale project. At the level of this study, the use of native fish was possible. However, as study size increases, the complications involved with using native fish would most likely increase.

In addition, the use of native fish may not be practical for large scale trapping. This study was small and did not require a great amount of pike (3.0 kg, roughly 9 small/medium fish). A large-scale project would require much more fish, the removal of which from the ecosystem may be harmful (Pierce 2003).

In this study there was no significant difference in the effectiveness of beef liver and dog food. This is important because canned dog food is cheaper, ($0.13/trap versus $0.50/trap for beef liver) easier, and safer to work with than beef liver. Further experimentation is needed in order to determine the most effective brand of dog food.

The results also showed that there was no significant difference in the effect that each bait had on the two different species of crayfish. This is consistent with the results of Lodge et al. (1994) which determined the two species had similar diets. The same baiting routine can therefore be used for both *O. propinquus* and *O. virilis* and possibly *O. rusticus.* Their similar ecology and dietary habits permits speculation that *O. rusticus* would also prefer native fish over non-native animal food but further studies of their food preference are necessary to determine if this is true (Lodge et al. 1994).

Recapture was also a factor of concern in the project design. It was possible that the crayfish could have become trap-happy with all of the food consistently available. This would have created a trap bias from day 1 through day 3 which in turn would have diminished any difference between the successes of the different baits. However, the recapture rate of 7.4% was relatively small compared to previous studies that had recaptures rates ranging from 23% (George 1965) up to 90% (Hazlett et al. 1974). These low recapture rates make the issue of trap bias negligible.

These results also showed a correlation between temperature and catch size. While this study lacked the appropriate data to find statistical significance, the bell-curve-like trend is none-the-less apparent in figure 4. The results showed below 21°C and above 24°C, trap yields of crayfish decreased. Assuming activity is directly related to capture rate, these data imply that above a certain temperature, crayfish activity may decline. These results are consistent with a study by Whitledge and Rabeni (2002), which found that for five species of *Orconectes*, including *O. virilis*, daily consumption and respiration rates decreased or stabilized above 22°C - 26°C. Researchers working in long term projects need to be conscious of this issue in order to avoid incorrectly attributing lower trap catches to reasons other than high temperatures. Because the sites in this study were blocked and independent, water temperature did not negatively effect on the results of this study.

Even though there was no statistical interaction between day, temperature, and trap yield, catch size may have decreased due to a temperature increase later in the season. Crayfish tend to prefer a high protein diet when their goal is growth and a detritus dominant diet when they want to maintain size and high energy levels later in the summer (Hobbs 1991, Paglianti and Gherardi 2004). Molting makes crayfish more vulnerable to predation and it is typically avoided when it is not necessary (Hobbs 1991). To avoid molting, crayfish may have avoided the traps baited with the high protein foods whereas they needed the high-protein animal bait at the beginning of the warm season. Because they are closely related, it is difficult to determine whether temperature or season caused the decline (Figure 5).

The major findings of this study were that northern pike is an alternative to beef liver that is more effective, though inconvenient. Additionally, canned dog food proved to be an alternative to beef liver that was equally effective and cheaper. Captured crayfish did not become trap-happy throughout the study and trap yields actually peaked between 21 and 24°C, which suggested an optimum temperature for crayfish activity.

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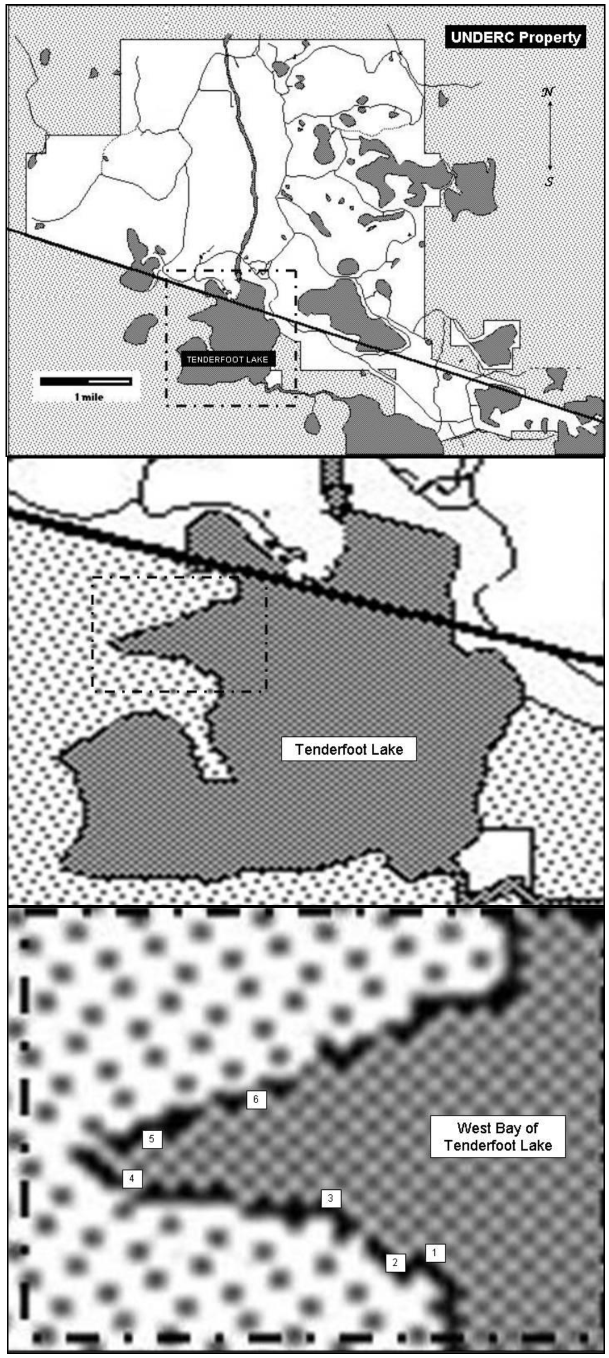

Figure 1. Map of Tenderfoot Lake, UNDERC, showing trapping site locations.

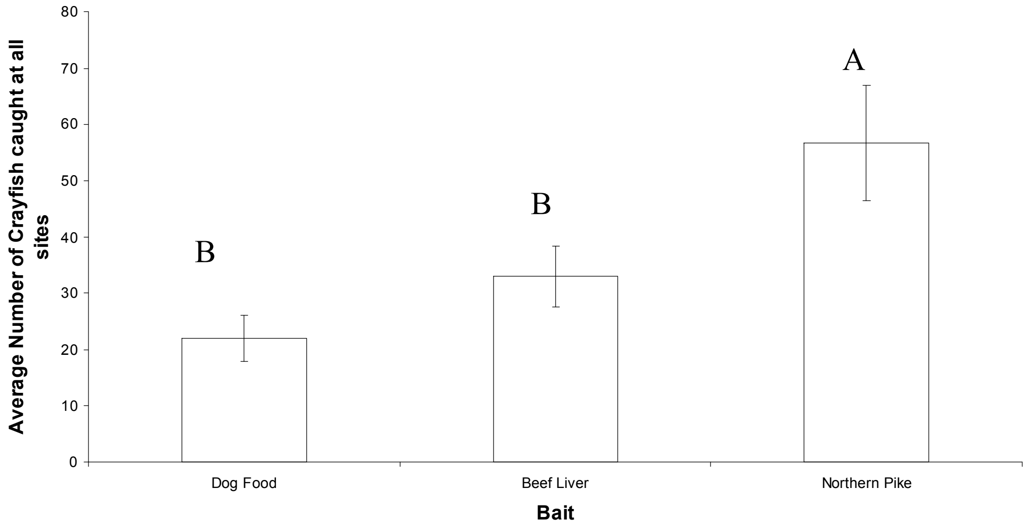

Figure 2. Average number of crayfish caught at all sites per bait type. A is significantly different from B.

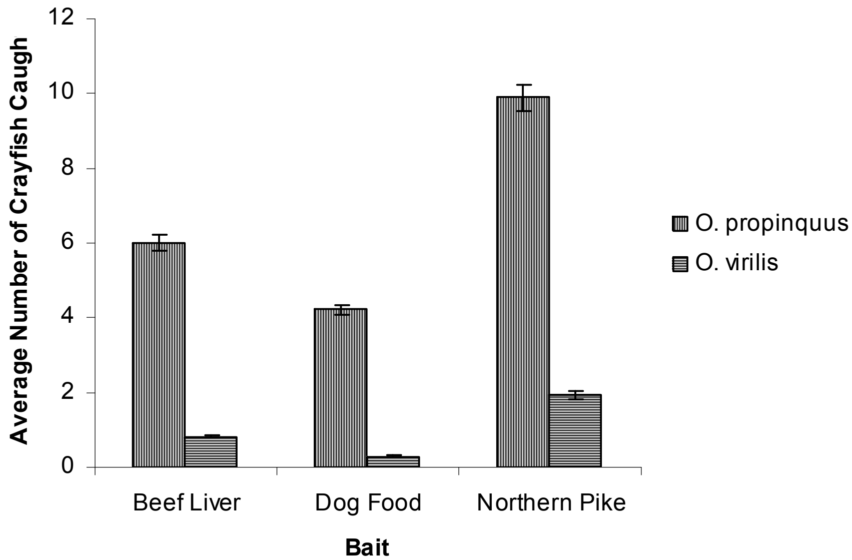

Figure 3. Comparison between the effects of each bait on different crayfish species.

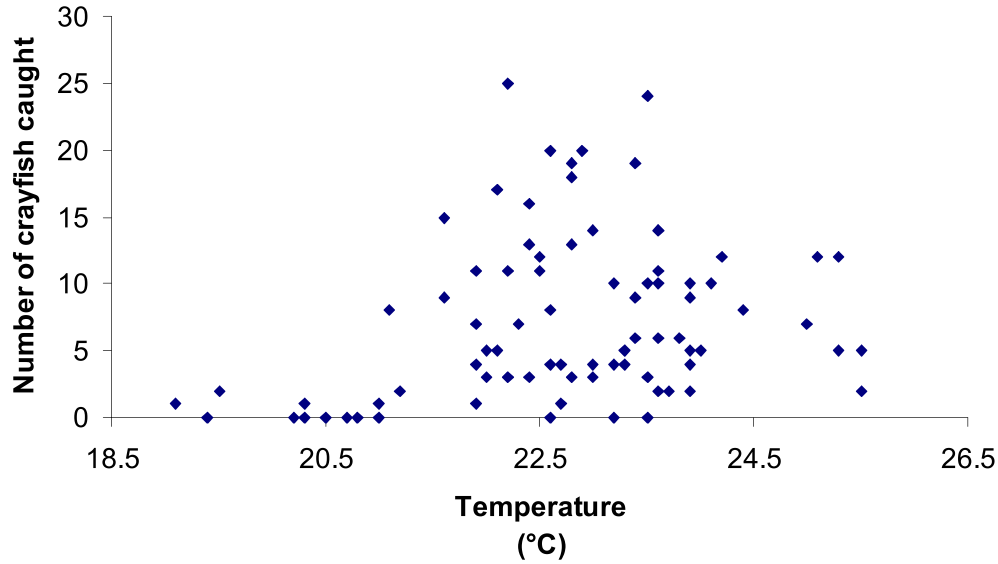

Figure 4. Relation between the numbers of crayfish caught and water temperature at substrate level. Outlier (Temp = 22.2°C, Crayfish trap catch = 49) from a single trap catch was removed to make the trend more apparent. Insignificant regression line not shown.

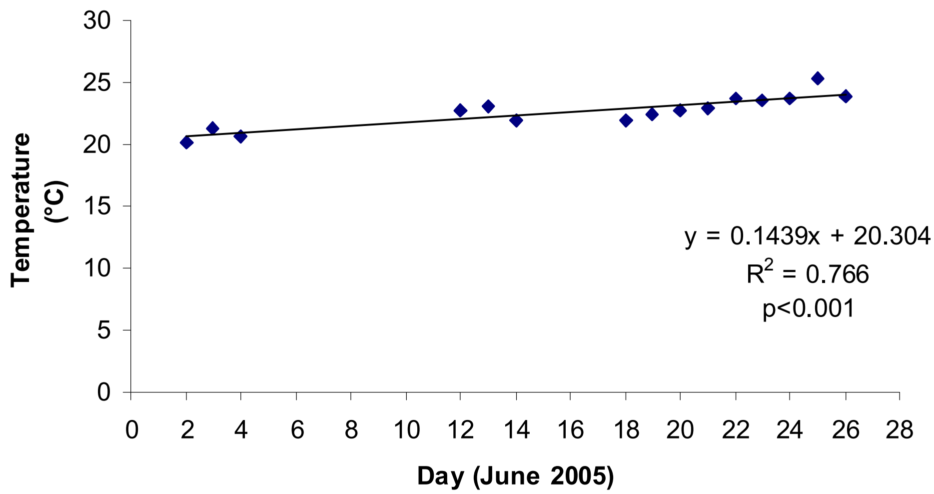

Figure 5. Relationship between day and average water temperature at the substrate level.