Population Estimate and Size Comparison of *Orconectes propinquus* in Riffle Habitats in Tenderfoot Creek

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Ashley Baca
Advisor: Dr. Todd Crowl

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Abstract: *Orconectes propinquus* is the native species of crayfish in Tenderfoot Creek at the University of Notre Dame Environmental Research Center. As a keystone species, crayfish greatly affect the stream habitat in terms of species diversity and diet selection. Tenderfoot Creek is an ideal habitat for the study of *O. propinquus* because it contains clear, rock-bottomed flowing waters. Thus, a mark recapture study was conducted for two riffle locations in Tenderfoot Creek. Crayfish were marked with a fluorescent epoxy dye on the flexor muscle, sex was determined, and carapace length was measured for each crayfish. A population estimate was made for each riffle. Our results showed that Riffle 2 has a slightly larger population of males and females compared to Riffle 1. Mean carapace length for *O. propinquus* in Riffle 1 was significantly higher, which could be explained by abiotic factors such as difference in flow rate or substrate size. A more accurate estimate could be made with greater initial capture rates to ensure consistent recapture rates once a large amount of the population is marked. Also, a greater sample size and more comprehensive analysis of habitat would help elucidate the relationship between crayfish size and habitat type.

INTRODUCTION

Recently, crayfish have reached a critical level of existence, which includes some endangered and threatened species around the world. Due to the increase in peril for crayfish species, crayfish conservation has come to the forefront of aquatic conservation (Taylor 2007). The role of crayfish in freshwater habitats is very important to community structure in that it serves as a food source for larger vertebrates as well as plays a role in litter processing, which involves grinding up leaf litter and fine particulate matter. The dual role of the crayfish in community structure renders it unique as an important keystone species. Crayfish have been described as "one of the principal components of the secondary level of productivity in aquatic ecosystems" (Momot 1967). As a keystone species and principal component, crayfish affect species diversity of predators and are an important resource for the diets of other animals.

Several species of crayfish inhabit Tenderfoot Lake and Creek. This includes *Orconectes propinquus* and *O.virilis*. However, this study focused on the native crayfish, *O. propinquus*, also referred to as the Northern Clearwater Crayfish. There are several identifying characteristics for *O. propinquus*: a broad dark mid-dorsal stripe on its abdomen and orange tips on its chela.

The creek provides ideal habitat for *O. propinquus* because it contains clear, rock-bottomed flowing waters near the riffle areas as well as sandy, rocky, and gravel substrate (Bovbjerg 1952). The rocks and woody debris found in Tenderfoot Creek provide burrowing habitat for the crayfish.

This study focused on the species size-environment relationship between two riffle sites in Tenderfoot Creek as well as looked at differences in crayfish density per site. Concurrently, the Creek was separated into two habitats based on depth, the riffles (shallow water) and the pools (deep water). There are two riffles located on the north side of Tenderfoot Creek, in which area and flow were measured. The same area was then delineated in the pool habitat so that the area in which we were catching crayfish was standardized. Crayfish sampling is important to determine population dynamics which can aide the ongoing conservation effort.

If population size is known within a respective habitat, more effective conservation efforts can be established. For example, size quotas can be established or habitat restrictions enforced. These regulations are more effective if population size has been estimated. With this in mind, we estimated the population size of northern freshwater crayfish (*Orconectes propinquus)* in Tenderfoot Creek. Additionally, we classified *O. propinquus* according to gender and carapace length (size). Based on observations in my study, the size of *O .propinquus* should increase with the size of substrate because it provides more habitat space for the crayfish to live and grow in the stream bed (Todd Crowl, personal communication).

MATERIALS AND METHODS

STUDY SITE DESCRIPTION

Tenderfoot Creek is a permanent body of water, which is important to crayfish population dynamics as demonstrated by Flinders (2003). Flinders (2003) found that crayfish may be able to better select habitats in permanent streams since the environmental variables are typically more constant**,** which likely explains the significant species-environment relationship in permanent streams.

Riffle 1 has a length of 121.3 m compared to a length of 59.5 m in Riffle 2. The average flow per riffle differed in that Riffle 1 had an average flow of 5.1125 ± 0.148 $m^3 s^{-1}$ in comparison to an average flow of 2.875 ± 0.225 $m^3 s^{-1}$ in Riffle 2.

MARK AND RECAPTURE

In order to determine the extent that the environment affects the crayfish population (physical and human-introduced factors), a mark and recapture study was conducted over a two month period. Mark and recapture sampling was conducted over two week long periods (Nowicki et al 2008). Each sample period lasted three man hours so the time at each riffle was held constant. Three collection methods were used to collect crayfish in each riffle: small net, hand collection, and liver-baited traps. There were three different traps at each trapping location (two riffles, two pool sites), totaling twelve traps in the Creek.

Once crayfish were collected, each habitat type was assigned a specific elastomer colored dye: green and purple were used for riffle 1, orange and red used for riffle 2, and blue for pool 1 (Nowicki et al 2008). The epoxy dye was injected into the flexor muscle under the tail of the crayfish (subcutaneous method). The flexor muscle of the crayfish is located on the underside of the abdomen. During recapture, an individual with the dye corresponding to the habitat in which it was caught was documented and the crayfish was then released. If there was no dye present in the flexor muscle of the captured crayfish, it was injected with the location specific dye and counted as a replicate for its respective habitat upon release. Thus, density values were determined based on the number of crayfish found with each respective dye. Crayfish that had shifted habitats from the riffles to the pools and vice versa were counted and could be used for future migration pattern studies. The mark and recapture was conducted four to five times a week for two week long trials to ensure enough replicates. In addition to marking, the sex of each crayfish was determined as well as the measurement of carapace length (from rostrum to end of carapace) in millimeters. The population size was estimated using MARK software and size comparisons were made between the crayfish captured in each riffle using a t-test.

HABITAT ANALYSIS

A rough analysis of the substrate was conducted and the type of substrate was determined using the Wentworth scale, in which percent cover and diameter measurements were made of the rocks and substrate on the bottom of Tenderfoot Creek. Four quadrants were randomly sampled along the length of the riffle. Multiple observations were taken in order to most accurately describe the habitat along the riffle. At the start of the study, flow was measured along the length of each riffle at increments of 10 meters. Measurements were taken at distances of 0.25, 0.50, and 0.75 along the width of the riffle.

RESULTS

Crayfish sampling was standardized by collecting for the same amount of man hours at each riffle location. Relatively, a greater number of crayfish were collected per total man hours at Riffle 2 (n=275) when compared to Riffle 1 (n=258).

Using the mark recapture data, a population estimate was calculated based upon the probability of capture and recapture per unit of time in each riffle. The population model [p(t), c(t)], in which probability of capture (p) and recapture (c) varied for each capture period, gives an estimation of the number of male and female crayfish in each riffle location. Riffle 2 is the upstream riffle. Riffle 2 has a slightly larger population of males (136) and females (269) when compared to Riffle 1 (M=134, F=258; Figure 1). The standard error for Riffle 2 is smaller in number for both males and females due to a larger number of recaptures in Riffle 2. The total number of recaptures was 18 crayfish with 13 being recaptured in Riffle 2 (Figure 2).

Mean carapace length was compared between Riffle 1 and Riffle 2 in order to determine any differences. There was a significant difference in the mean carapace length of *O. propinquus* in Riffle 1(24.728 ± 10.189) in comparison to Riffle 2 (22.558 ± 3.567) ($t=3.321$, $df=531$, $p=0.001$).

The mean diameter of rocks measured for each riffle fell into the pebble category of the Wentworth scale between 64-256 mm (Wentworth 1922). Substrate analysis on Tenderfoot Creek illustrated that the mean pebble size for Riffle 1 was slightly larger at 98.1± 2.93 mm than Riffle 2 at 76.5 mm ± 2.34 (Appendix 1B).

DISCUSSION

Some assumptions made during a mark recapture study include a closed population, no immigration, and no mortality. For this study, a closed population and no immigration would indicate that there is no migration between the pool and riffle habitats in Tenderfoot Creek as well as no migration between the two riffle sites. Traps were set in two different pool locations to test for migration patterns; however, no migration was observed and only one crayfish was ever captured using the trap nearest the riffle. The assumption made of no migration was then verified. The two riffle locations are separated by a significant distance of deeper water, which is not ideal for migration between the two habitats. It is not ideal because *O. propinquus* preferentially walk along the rocky and sandy substrate bottom of streams while swimming is mainly used for defense or when startled to escape a predator.

According to an ideal free distribution, one might think that a longer riffle would contain more crayfish. Since Riffle 1 is longer than Riffle 2, one might assume there is a larger population of crayfish. However, the population estimate illustrates that the two riffles have relatively similar population numbers despite the increased length of one riffle location. The standard error for the population estimate is fairly high, which is most likely caused by the low recapture rate. In order to improve recapture rate, it would be important to have bigger sampling captures at the beginning of the study in order to mark a greater proportion of the population. Also, recapture sampling should be conducted more frequently to minimize the amount of crayfish that may migrate out of the area and are thus less likely to be recaptured. A more significant population estimate could then be conducted for each riffle site.

O. propinquus in Riffle 1 have a significantly larger mean carapace length when compared to Riffle 2, which can potentially be explained by a habitat complexity hypothesis. This hypothesis suggests that as the complexity of the habitat increases, the population density or size would also increase (Kohn 1976). In order to test this hypothesis, a correlation between the size of crayfish and the size of the substrate could be evaluated. For example, larger or more complex substrate could provide more habitat for larger crayfish (Todd Crowl, personal communication). Building on the habitat complexity hypothesis, the larger pebble size observed in Riffle 1 could explain the significantly larger crayfish in the same riffle.

In order to determine if there was a species size- habitat complexity relationship present in the riffle, a more comprehensive analysis of the substrate should be conducted. Also, an analysis of riparian vegetation could help explain some of the differences in habitat complexity in terms of shaded vs. open areas, species of plants, and comparison between the two riffle sites.

Another component of habitat complexity that could be tested is the flow rate of each riffle. If the flow (current) is faster in one riffle, there may be a relationship to crayfish size. For example, because Riffle 1 had a faster flow and the crayfish there have a larger mean carapace length, it would be beneficial to test the hypothesis that faster flowing riffles necessitate the need for a larger mean carapace size, so adult crayfish can optimally survive in the complex habitat. It would be important to measure the flow rate of each riffle throughout the summer to ensure that the flow rate does not change significantly, which would affect the size correlation. Also, a larger sample size and a greater number of replicates would ensure that trends illustrate actual relationships present in the riffles of Tenderfoot Creek.

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LITERATURE CITED

Bovbjerg R. 1952. Comparative ecology and physiology of the crayfish. *Orconectes propinquus* and *Cambarus fodiens*. Physiological Zoology, 25:34-56.

Flinders CA and Magoulick DD. 2003. Effects of Stream Permanence on Crayfish Community Structure. *American Midland Naturalist* 149(1): 134-147.

Kohn A and Leviten P. 1976. Effect of habitat complexity on population density and species richness in tropical intertidal predatory gastropod assemblages. *Oecologia.* 25(3): 199-210.

McCulloch et al. 2005. Analyzing Population Structure. http://iws.collin.edu/biopage/faculty/mcculloch/2406/Handouts/population_size.pdf>

Momot W. 1967. Population Dynamics and Productivity of the Crayfish, Orconectes virilis, in a Marl Lake. *American Midland Naturalist*. 78(1): 55-81.

Nowicki P et al. 2008. Monitoring crayfish using a mark-recapture method: potentials, recommendations, and limitations. *Biodiversity and Conservation.* 17: 3513-3530.

Northwest Marine Technology. 2008. *Visible Implant Elastomer Tag Project Manual.* 1-29.

Price J and Welch S. 2009. Semi-Quantitative Methods for Crayfish Sampling: Sex, Size, and Habitat Bias. *Journal of Crustacean Biology* 29(2): 208–21.

Taylor, C. A. et al 2007. A reassessment of the conservation status of crayfishes of the United States and Canada after 10 + years of increased awareness. Fisheries *American Fisheries Society* 32: 372-389.

Wentworth CK. (1922). A scale of grade and class terms for clastic sediments. *J. Geology* 30:377–392.

TABLES AND FIGURES

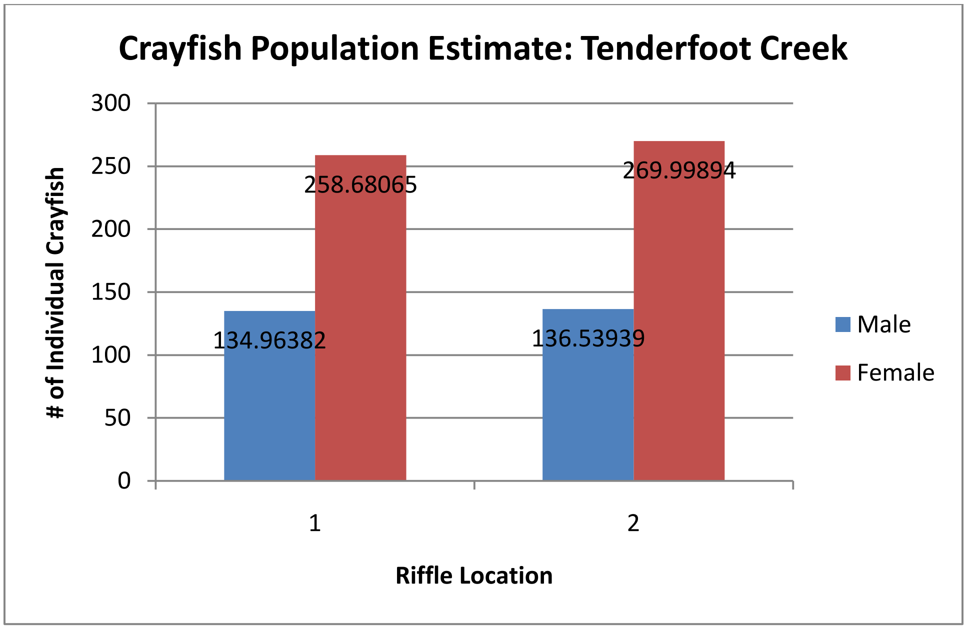

Figure 1: Population Estimate of *O. propinquus* in Tenderfoot Creek. Riffle 1: M: Std error=6085.6076, F: Std error=11664.081; Riffle 2: M: Std error=2904.4044, F: Std error=5743.2954. Riffle 2 appears to contain a slightly greater population of *O. propinquus* with a greater confidence level.

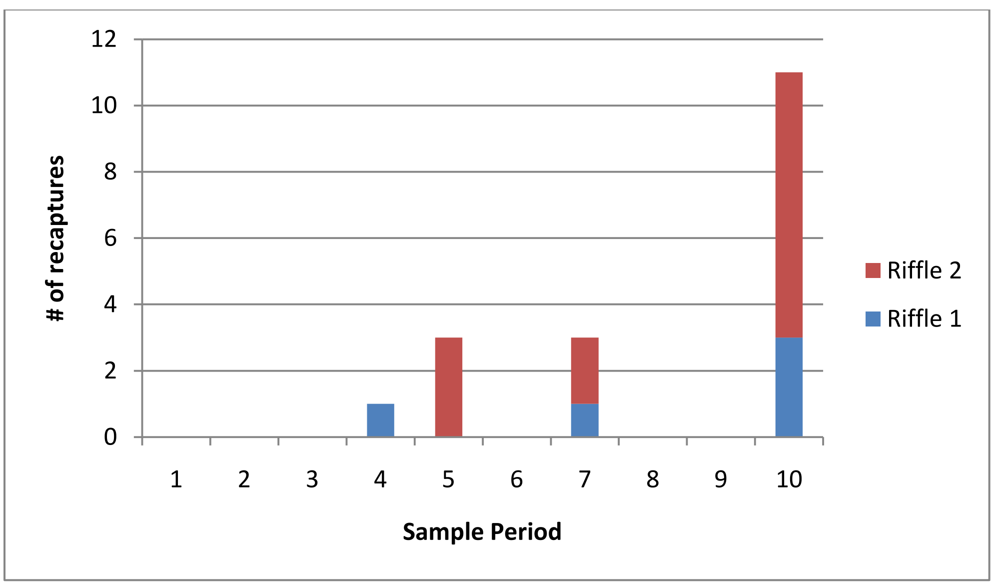

Figure 2: Number of *O. propinquus* recaptures per riffle location for each sample period. Six sampling periods rendered no recaptures. The remaining four sampling periods showed a recapture total of 18 *O. propinquus* with a greater number being recaptured in Riffle 2 (13 of 18).

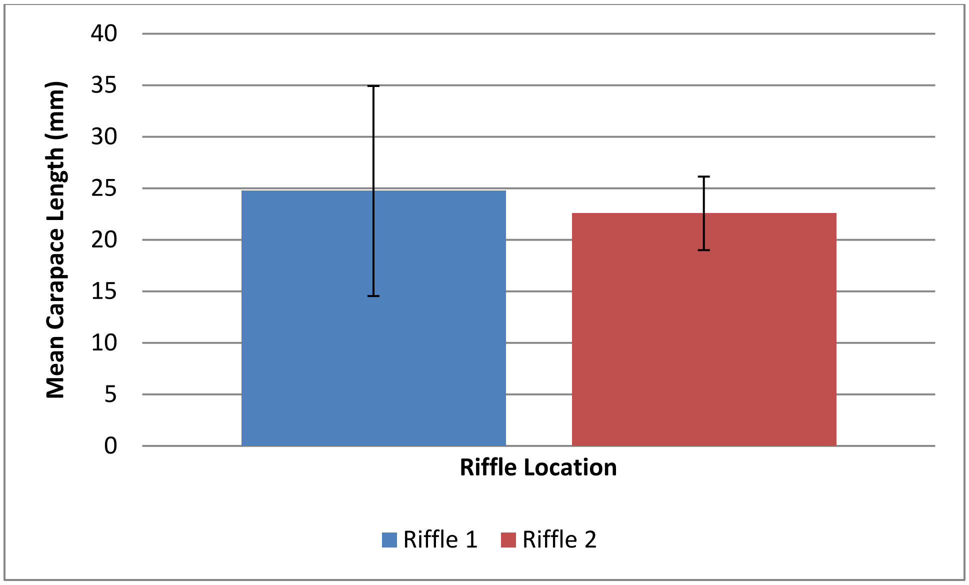

Figure 3: Mean carapace length comparison of *O. propinquus* between Riffle 1 and Riffle 2. *O. propinquus* mean carapace length in Riffle 1 is 24.728 mm, which is greater than the mean carapace length of 22.558 in Riffle 2 (p=0.001).

APPENDIX 1

A.	Average Flow				Length
	0.25	0.5	0.75	Total	(meters)
Riffle 1	5.6875 ± 1.201	5.35 ± 1.095	4.3 ± 0.661	5.1125 ± 0.148	121.3
Riffle 2	2.425 ± 0.621	3.775 ± 0.964	2.425 ± 1.402	2.875 ± 0.225	59.5

B.	Average Rock Size				
	Transect 1	Transect 2	Transect 3	Transect 4	Overall
Riffle 1	64.09091 ± 10.57	91.97727 ± 4.33	136 ± 53.42	100.5263 ± 2.96	98.14862 ± 2.93
Riffle 2	100.625 ± 8.12	43.125 ± 5.65	108.3333 ± 7.66	53.75 ± 4.01	76.45833 ± 2.34