INFLUENCE OF HABITAT COMPLEXITY ON CYPRINID FISHES IN STREAMS

BIOS 569 - Practicum in Aquatic Biology

Alisha J. Eisert

404 Lyons Hall

Dr. Martin Berg

1993

ABSTRACT: Woody debris is important in establishing stability and complexity in streams. This study examined the effect of woody debris additions on stream fish populations. The initial hypothesis was that the addition of wood to areas of a stream devoid of wood would result in increased fish populations. Bundles of white birch and white pine sticks were placed in three areas of Tenderfoot Creek, Gogebic County, Michigan. Visual observations and minnow traps were used to examine the numbers of fish in both experimental (areas with sticks added) and control (areas with nothing added) from June through July 1993. Statistical analyses indicated that fish were distributed evenly among the experimental and control sides. Although Chi square analysis found distribution to be significantly different when examining minnow trap data, stricter testing found it was not enough to be statistically significant. The bundles may have had a negative influence on fish, resulting in a preference of the control sides by fish populations. Addition of woody debris may have resulted in increased foraging time of minnows. It is documented that minnows are omnivorous and feed on algae and insect larvae, such as chironomids. Availability of crayfish habitat would increase, and they could compete for food or prey on fish eggs. Loss of substrate for fish nesting also could have contributed to decreased preference.

INTRODUCTION

Does stream complexity influence the distribution of cyprinid fishes? Recent studies have shown that water depth and current velocity play an important role for darters (Percidae) in Kentucky (Fisher and Pearson, 1987), a variety of benthic fish species in the Ozarks (Gorman, 1988), and many small-fish taxa in New England (Bain and Finn, 1988). Conflicting data have been reported, however, on the relative importance of habitat complexity and have provided little insight into its effects.

Woody debris makes several contributions to stream ecosystems. It increases conservation of fine particulate organic material (Bilby, 1981), provides refugia from predators via greater substrate complexity, provides habitat for aquatic organisms, and during decomposition, the wood acts as a site of nitrogen fixation (Melillo *et al.,* 1983) and source of food (Ward and Aumen, 1986).

Knowledge of substrate-organism relationships is becoming increasingly important as riparian habitats are continually being modified. Such measures cause immediate increases in leaf, wood, and sediment input to the stream, with delayed decreases once deforestation is complete (Gurtz and Wallace, 1984). Bilby (1981) found that the decrease in particulate matter retention resulted from the increased erodibility of the stream bed. Following deforestation, there was a two year lag before decreases in retention were found. The drastic input of logging debris initially may have a positive influence on stream benthic communities, but later effects could be deleterious. Therefore, it is essential to identify the importance of habitat complexity in lotic systems. Despite extensive damage to forest communities, it still may be possible to maintain optimal species biomass and richness, providing that the instream conditions are maintained.

In a study of habitat selection by fish in Illinois streams, Angermeier (1987) found that although areas of preferred greater complexity were preferred, depth and current were more important in influencing stream populations. Using amount of organic material and presence of woody debris as an indication of complexity, Angermeier (1987) found a higher species richness in areas of slow current than in fast. Slower current enables greater accumulation of debris and increases habitat complexity.

Bain and Finn (1988) reported that fish communities generally were influenced by habitat structure. They found that although most species preferred a certain habitat-type, a few exhibited no preference. They referred to these taxa as habitat generalists. They concluded that although fish preferred a certain habitat, they were not restricted to it. Hill and Grossman (1993) stated that it is unlikely that stream fish populations occupy a specific habitat. They believed that fish demonstrated broad habitat use.

Diehl (1992) studied yellow perch (*Perca fluviatilus*) and the effects of habitat complexity on predation. He found that invertebrate species richness and biomass were always greater in areas of greater complexity. Although invertebrates responded positively to such areas, perch did not. Despite increases in prey populations, perch foraging time increased due to more refugia for invertebrates. The negative effects of complexity outweighed the positive effects.

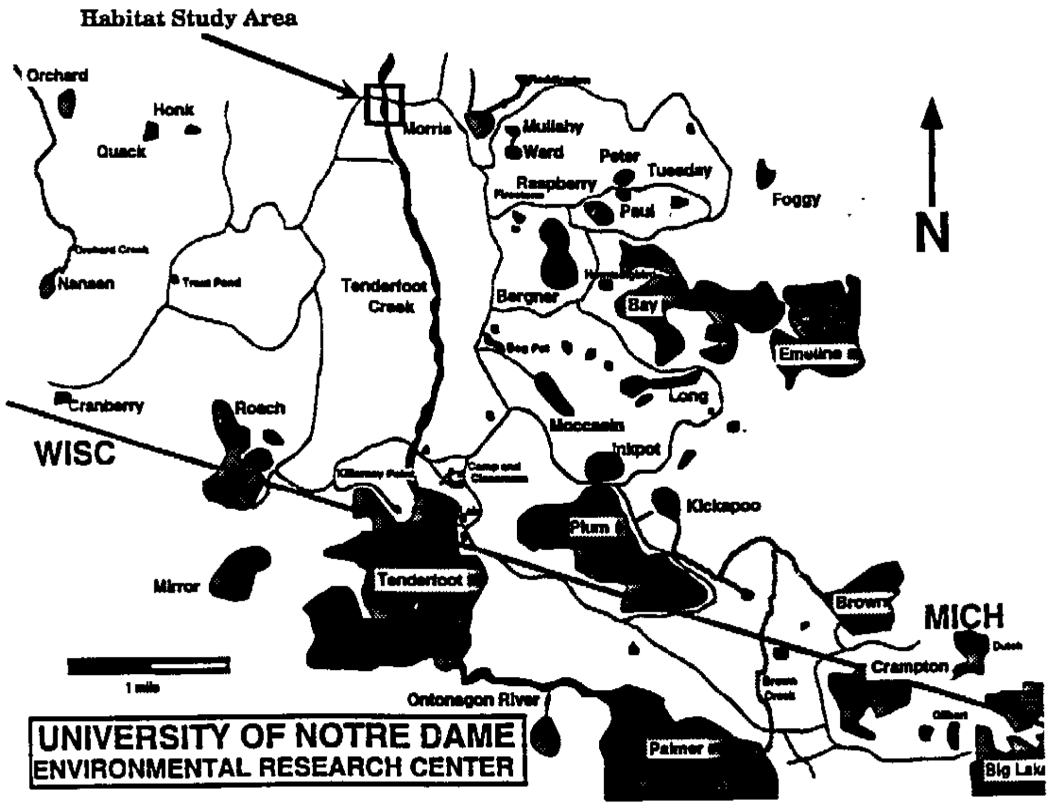
Angermeier and Schlosser (1989) studied small streams in Illinois, Minnesota, and Panama to find a relationship between species richness, habitat complexity, and habitat area. They determined that habitat complexity correlated with species richness in the Panamanian streams, but not in Illinois or Minnesota. No conclusion coud be reached to the influence of habitat complexity on fish populations.

Results from previous studies generally have been inconclusive as to whether habitat complexity has a positive or negative effect on fish populations. The present study was undertaken to examine the effect of increasing habitat complexity on cyprinid fishes. I predicted that areas with higher heterogeneity (i.e. increased complexity) would have higher fish populations. It was proposed that the addition of the woody material to a relatively uniform stream reach composed almost entirely of cobble would enhance fish populations. Results from this study can be extended to examine the long-term effects that deforestation and delayed consequential loss of complexity could have on stream fish populations.

MATERIALS AND METHODS

This study was conducted in a 30 m reach of Tenderfoot Creek, which is located in the upper peninsula of Michigan (Gogebic County) (Figure 1). To evaluate the effect of habitat complexity, three study areas (3 m long x 4 m wide) were established in 1 m of water. Each area was divided lengthwise into two sides, an experimental side (stick additions) and a control side (no stick additions). Thus, each side was 3 m long and 1.5 m wide and was marked in the four corners with metal poles. Each area was between .5 and 2 m from its stream margin. The two sides were separated by a 1 m buffer strip apart and each area was 11 m from the next. White birch *(Betula papyrifera)* and white pine *(Pinus strobus)* sticks

FIGURE 1: REGIONAL MAP



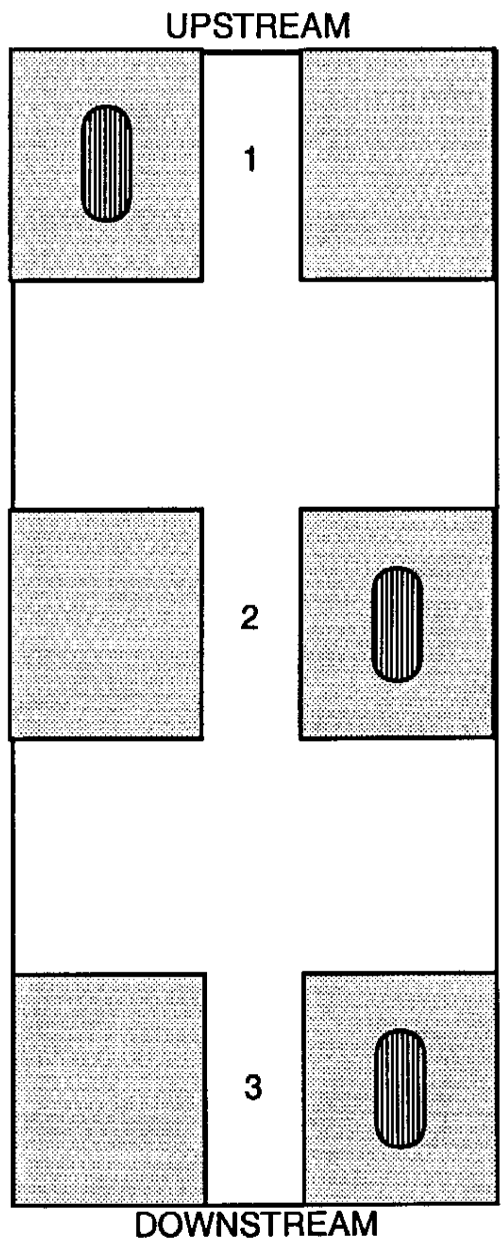
(approximately 1 m long and 6 cm wide) were collected from the ground and tied into nine bundles. Each bundle was approximately 25 cm wide and contained about 15 sticks.

Area 1 was the downstream-most site and Areas 2 and 3 were sequentially placed upstream. Treatments (experimental or control) were randomly assigned to sides in each site (Figure 2). Three bundles were added to each designated side. The bundles were equally spaced down the center of a side and weighted down with rocks and bricks.

Cyprinidae habitat preferences were based on observations while snorkeling and from minnow trap collections. Fish species present in the stream were the hornyhead chub (*Nocomis biguttatus*), common shiner (*Luxilus cornutus*), and pugnose minnow (*Opsopoeodus emiliae*). Visual observations were collected as follows:
Two observers would walk downstream along the stream margin to Area 1. They would position themselves outside each of the downstream corners of one side and lie motionless for one minute while facing upstream with their hands on the bottom. Making as little disturbance as possible, each person would crawl on their hands and count all fish seen in the area. It was previously determined that due to high turbidity, the two observers could not see enough of the area to duplicate the other's count. Counts of fish on each side took 45 seconds. The observers immediately returned to the initial position and repeated the counting process. This method was conducted for each of the six sides in the three areas. Visual observations were conducted eight times throughout the summer (18 June - 10 July 1993).

Minnow traps also were used to quantify fish habitat preference. Area 2 was chosen randomly and three traps were placed on each side. After 24 hours, the traps were collected

FIGURE 2 : PLACEMENT OF STICK BUNDLES IN STREAM



SHADED BLOCKS ARE CONTROL SIDES

BLOCKS WITH OVALS ARE EXPERIMENTAL SIDES and minnows counted. Minnow traps were set 3 times during the study.

RESULTS

Two methods of statistical analyses were used to examine the visual data. Replicated goodness-of-fit test with Chi-square and the paired difference test examined different hypotheses. The Chi-square test examined the hypothesis that fish populations were in the ratio 50:50 for the experimental and control sides. The difference test examined the hypothesis that the number of fish on the experimental side was equal to the number of fish on the control side. All statistical results were not significant at the 0.05 level. Visual observations in Areas 1 and 2 were found to be significantly different using the pooled and total Chi-square tests, but the difference test, which is more conservative, found no significant differences.

Data collected from minnow traps was found to be significantly different by the Chi-square tests, but the difference test found no differences between the experimental and control sides. Results from visual observations and minnow traps failed to reject the hypothesis. All comparisons between treatments were not statistically significant.

DISCUSSION

Results from previous studies have been inconclusive as to the influence of habitat complexity on fish populations. Results from the present provided no strong evidence for a positive or negative impact of habitat complexity. Although the hypothesis was that woody debris would have a positive impact on fish populations, the complexity could have added unexpected negative influences.

Diehl (1992) found that yellow perch (*Perca fluviatilis*) foraging efficiency for benthic organisms was reduced by habitat complexity. If this is the case for cyprinid species, then the bundles may have had a negative effect on fish populations. It is possible that invertebrates on sticks were harder to see than those on cobble. Although cyprinids also feed on algae found in the water column or stream bed, invertebrates are a part of their diet and would therefore influence foraging preference. Because cyprinids are visual feeders, it is possible that despite the increased number of invertebrates on the experimental side, invertebrates on sticks are harder to see compared to those on a cobble bottom. Thus, although "actual" food availability was higher on the experimental side, "apparent" food availability, from a cyprinid perspective, may have been higher on the control side.

Hill and Grossman (1993), in their study of stream fishes and habitat use, found that prey capture success played an important role for drift-feeding fishes. Results from the present study suggest that advantages of habitat complexity could be countered by food availability. If foraging on cobble is more energy efficient, then the control side would be preferred since the bundles in the experimental side covered a large area of stream bottom.

Persson and Greenburg (1990) also studied perch foraging efficiency and habitat use. They hypothesized that if two habitats were close together, there was no reason why the fish should forage in only one, as determined by the optimal foraging model. The optimal foraging model states that a species should forage in the area which is most energy efficient. They termed this behavior partial preferences. Many of their predictions were not supported, but with further research, resource partitioning and the optimal foraging model may be rejected in favor of a less defined manner of foraging.

The following example presented by Persson and Greenburg is applicable to the present study: "a bird foraging on the edge of a forest may also encounter prey in the grass around the forest." Therefore, the experimental side may have been too small an area to detect a treatment difference. The experimental and control sides were only 1 m apart, which may not have been enough space in relation to cyprinid foraging. It is possible that the fish could spend equal time in both experimental and control sides due to the close proximity of the two. Thus, they would not exhibit a distinguishable preference. One suggestion to avoid this problem in future studies would be to create larger areas to study. One area of great complexity amid a homogeneous area could lead to significant results. In addition, visual observations would have to be eliminated since accuracy in counting would be reduced as the area increased.

Another important factor which could explain the lack of significant differences between experimental and control sides is fish nesting. Although little data exists detailing habitat preferences of nesting fish, one might postulate that fish prefer large areas of unrestricted substrate in which to nest. Sufficient space is necessary to build an adequate spawning cup, defend the nest, and perform courtship rituals. In the present study, the bundles may have taken up too much space and left little area for nesting. In their study of habitat use by spawning bigmouth chubs (*Nocomis platyrhynchus*), Lobb and Orth (1988) determined that the fish preferred areas with no cover present within 1 m of the nesting site. Because the present study took place during peak spawning time, the negative influence of the sticks may have masked any potential benefits.

The physical effect of the presence of bundles also should be considered. Although data from the present study demonstrated that fish had no preference for habitat complexity, other organisms did, which may have deterred fish nesting in the organisms' vicinity. Experimental areas contained many more crayfish than control areas. Crayfish could compete with fish for food or prey on fish eggs. Thus, enhancing crayfish populations in experimental areas may have had a negative effect on fish populations.

Finally, the methods employed in the experiment should be reevaluated. Visual observations were difficult to make and more variable than traps. Visual observations may have biased the results since interactions between the observer and fish were inevitable. A different method of observing fish is necessary in future studies. Traps may be the most efficient method to count fish. Minnow traps also should be placed in the stream before modifying the habitat. This would determine if the modification had made an impact, whether positive or negative.

The hypothesis that the addition of woody debris to areas of a stream would increase fish populations was not supported by the present study. This could be due to the effects of wood bundles on stream benthic communities. Despite the lack of significant results from this experiment, there is enough supporting research in the literature to prevent total discarding of the hypothesis. With some modifications to the experiment, it is still quite feasible to test if woody debris is important to fish populations.

ACKNOWLEDGEMENTS

This work was funded by the Bernard J. Hank Family Endowment. I am grateful for the experience, knowledge, and memories I have gained as a result. I also thank all those who assisted me in the field: Lisa Bongiovi, R.J. Cummings, Michele DePhilip, Brian Foy, Bridget Graham, Harvey Leo, David Pruitt, and Jennifer Snodgrass. Without their help, none of my work could have been accomplished. Last, but not least, I am most grateful to Dr. Martin Berg, who was always there when I needed him.

REFERENCES CITED

Angermeier, P.L. 1987. Spatiotemporal variation in habitat selection by fishes in small Illinois streams, p.52-60. *In* W.J. Matthews and D.C. Heins (eds.). Community and evoultionary ecology of North American stream fishes. University of Oklamhoma Press, Norman.

Angermeier, P.L. and Schlosser, I.J. 1989. Species-area relationships for stream fishes. *Ecology* **70**:1450-62.

Bain, M.B., J.T. Finn and H.E. Booke. 1988. Streamflow regulation and fish community structure. *Ecology* **69**:382-92.

Bilby, R.E. 1981. Role of organic debris dams in regulating the export of dissolved and particulate matter from a forested watershed. *Ecology* **62**:1234-43.

Diehl, S. 1992. Fish predation and benthic community structure: the role of omnivory and habitat complexity. *Ecology* **73**:1646-61.

Fisher, W.L. and Pearson, W.D. 1987. Utilization among four species of darters in three central Kentucky streams, p.69-76. *In* W.J. Matthews and D. C. Heins (eds.). Community and evolutionary ecology of North American fishes. University of Oklahoma Press, Norman.

Golladay, S.W. and Webster, J.R. 1988. Effects of clear-cut logging on wood breakdown in Appalachian mountain streams. *Amer. Midl. Nat.* **119**:143-55.

Gorman, O.T. 1988. Habitat segregation in an assemblage of minnows in an Ozark stream. *Ecology* **69**:1239-50.

Gurtz, M.E. and Wallace, J.B. 1984. Substrate-mediated response of stream invertebrates to disturbance. *Ecology* **65**:1556-69.

Hill, J. and Grossman, G.D. 1993. An energetic model of micro-habitat use for rainbow trout and rosyside dace. *Ecology* **74**:685-98.

Lobb, M.D. and Orth, D.J. 1988. Bigmouth chub *Nocomis platyrhynchus* in the New River, West Virginia. *Amer. Midl. Nat.* **120**:32-40.

Melilio, J.M., R.J. Naiman, J.D. Aber and K.N. Eshleman. 1983. The influence of substrate quality and stream size on wood decomposition dynamics. *Oecologia (Berl)*, **58**:281-5.

Persson, L. and Greenberg, L.A. 1990. Optimal foraging and habitat shift in perch (*Perca fluviatilis*) in a resource gradient. *Ecology* **71**:1699-1713.

Ward G. W. and Aumen N.G. 1986. Woody debris as a source of fine particulate organic matter in coniferous forest stream ecosystems. *Can. J. Fish. Aq. Sci.* **43**:1635-42.