NESTING BEHAVIOR OF COMMON FRESHWATER CYPRINIDAE

BIOS 569 - Practicum in Aquatic Biology

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ABSTRACT

A ten week study was conducted in Tenderfoot Creek, Gogebic County, Michigan, on nest building and courting behavior of the cyprinid fishes *Nocomis biguttatus* (hornyhead chub), *Notropis cornutus* (common shiner), and *Opsopoeodus emiliae* (pugnose minnow). Observations concluded *Nocomis biguttatus* males were the main builder and guarder for nest mounds where females of the same species could drop eggs. The males protected the mound and fry from other males (of both the same and different species) who came into the guarded territory. Several inter- and intraspecific interactions were observed. *Notropis cornutus* typically swam downstream from the guarding male and assisted in defending the nest. If the hornyhead chub (the guarder) left the nest to court, the common shiner would move upstream and defend the mound. Several *Notropis cornutus* and *Opsopoeodus emiliae* were seen swimming about 0.5 meters downstream of the nest.

Nest distributions also were studied for the cyprinid species in both a pool and a riffle area. Minnows most frequently built their nests in areas of moderate current velocity, shallow depth, and principally gravel substrate. The study showed that cyprinid minnows preferred to build nests in riffle areas rather than pool areas. Thus, disappearance of the riffle habitat could severely affect the population distribution and nest building behavior of cyprinid fishes. This study supports and refines existing data on the nesting behavior of stream minnows.

INTRODUCTION

Detailed information on habitat requirements of stream fishes is important for the preservation of common freshwater fish species (Karr et al, 1985 as cited in Lobb and Orth). The nest building of fish is a phenomenon that has been frequently studied in different streams and with different fish species. Nest building fish have a distinctive sequence or behavior for nest building, courting, and spawning. It is important to understand these behaviors in order to predict the effects of stream pollution and development on freshwater minnows.

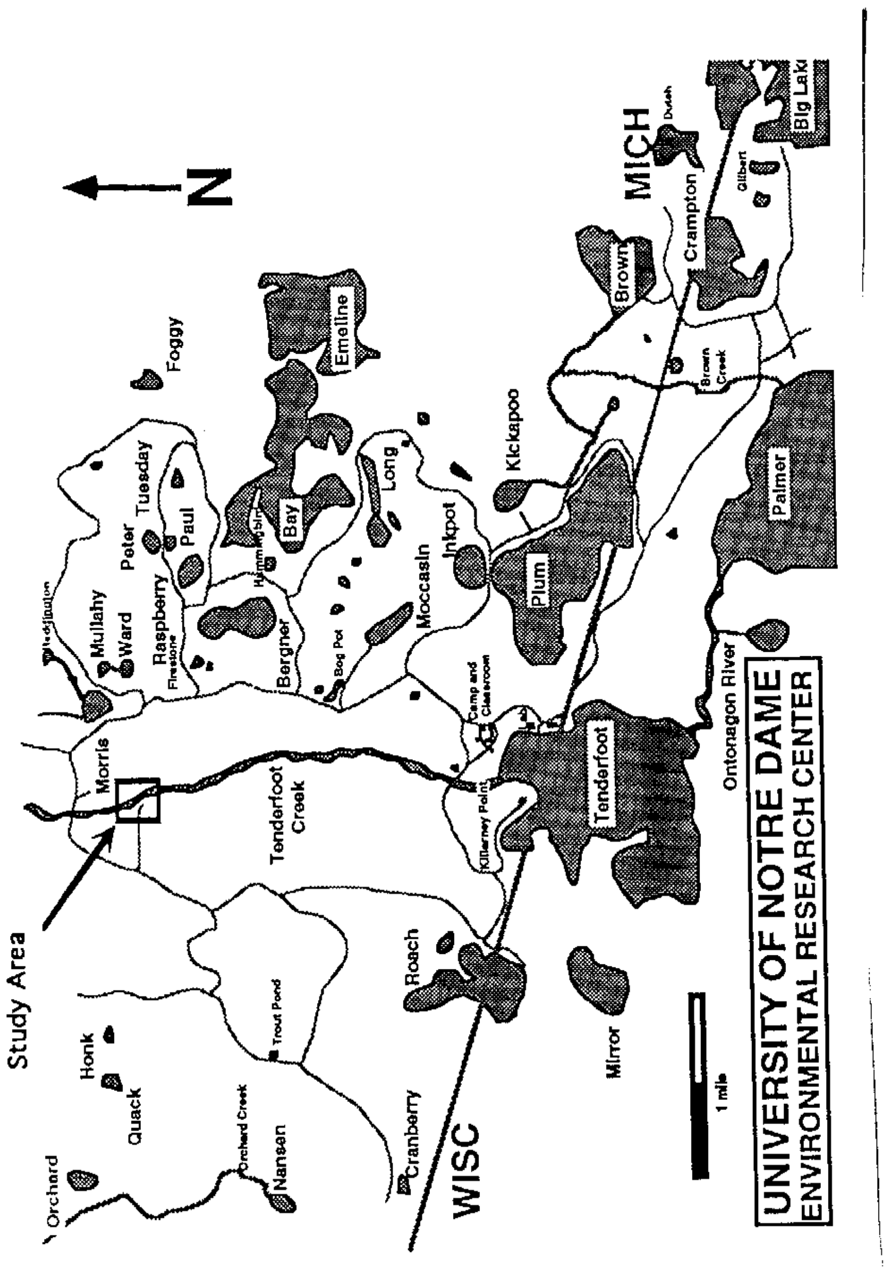
Fish nests usually are made of gravel. Nests provide protection, a clean substrate, and circulation of oxygenated water for the eggs (Vives, 1990). Nests are built and guarded by the male fish for most Cyprinid species. The male courts the female into his nest and spawning is induced. Many inter- and intraspecific interactions can affect mating. The male must guard the nest from conspecific fish and from fish of other species. In this ten week study on the nesting and spawning behavior of common freshwater minnows, the nest building and courting behaviors of the fish were observed. Also, intraspecific and interspecific interactions between minnows were noted. Observations on nest distribution and associated physical characteristics of the stream were recorded.

MATERIALS AND METHODS

This behavioral study was conducted in a 170 m (riffle=152 m; pool=18 m) reach of Tenderfoot Creek in Gogebic County, Michigan (Fig. 1). Fish nests were marked using small colored flags with an identifying number written on each. The fish were observed by snorkeling and notes were recorded either on an underwater tablet or in a journal written out of the water. The taxa observed in this study included *Nocomis biguttatus* (hornyhead chub), *Luxilus cornutus* (common shiner), and *Opsopoeodus emiliae* (pugnose minnow). Several fish of each species were collected with minnow traps for identification. To facilitate identification, fish were over-anesthetized with 2,phenoxy-ethanol. Identification in the field occurred by phenotypic characteristics (size, color, and distinguishing markings) common to the individuals observed.

The study area was mapped using tape measures, rope, and

FIGURE 1: Study area in Tenderfoot Creek, Gogebic County, Michigan.



flagging. The stream was divided into six sections. A string was extended from the downstream to the upstream end of the section. The string was marked with flagging every 3 meters. The stream bank was measured with a tape measure placed perpendicular to the string, and the measurements and angle of the string were recorded. After the nests were located and marked, they were identified by their distance horizontally from the string and their distance upstream vertically from the downstream end of the section in which they were located. Water depth, nest height, and nest width were recorded using a ruler. The current velocity of the stream was measured by floating an orange downstream and measuring the time it took to travel a known distance. All measurements were recorded in a journal.

RESULTS

Location of Nests

A map of the stream margin (Fig. 2) was constructed for the study area and divided into six sections. The sections were delineated by natural bends or fallen trees. Five of these sections were riffle areas (areas of high current velocity causing sediment transport) and one was a pool area (area of slow water where materials tend to be deposited). Nests were more abundant in the riffle than in the pool area (Table 1). Also, the nests were found in the downstream portion of the pool, immediately upstream from the head of the riffle. No trends were observed for the horizontal distribution of the nests throughout the stream. The distribution of nests is shown in Figures 3-7. No nests were found in Riffle III.

The mean nest height was 0.10 m (range = 0.04-0.28 m) and there were no significant differences in nest height in the different regions studied (Fig. 8). The mean nest width was 0.41 meters (range = 0.13-0.91 meters) (Fig. 8). Again, there were no significant differences in the widths of nests in the different areas. The average water depth in which minnows built their nests was 0.34 meters (range = 0.02-0.71 meters) (Fig. 8). The most upstream nests were constructed in deeper water, however, this may be caused by the deeper average overall depth upstream compared to that downstream. Also, because the measurements were not taken on the same day, error could be attributed to different water levels caused by precipitation. Current velocity in the stream was measured for sections I, II, V and VI (Fig. 9). Current velocity was faster in the downstream riffles than in the upstream area.

FIGURE 2: Map of stream margin.

SCALE: 1.5 mm = 1 m

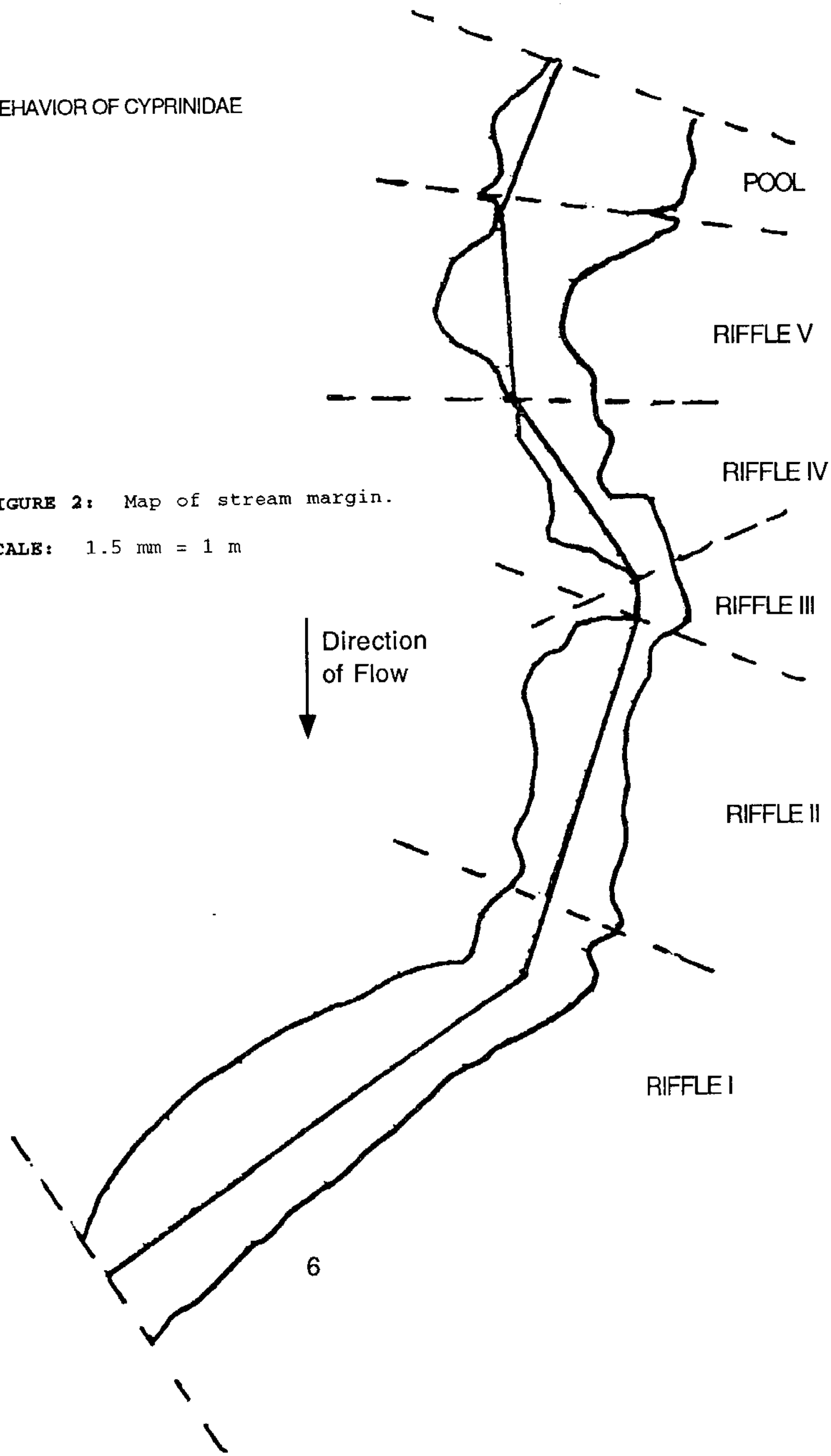


TABLE 1

Nest distribution in pool vs. riffle

	# of nests	Area (m)	nests/meter
riffle	146	124	1.18
pool	12	17.7	0.68
total	158	141.7	1.12

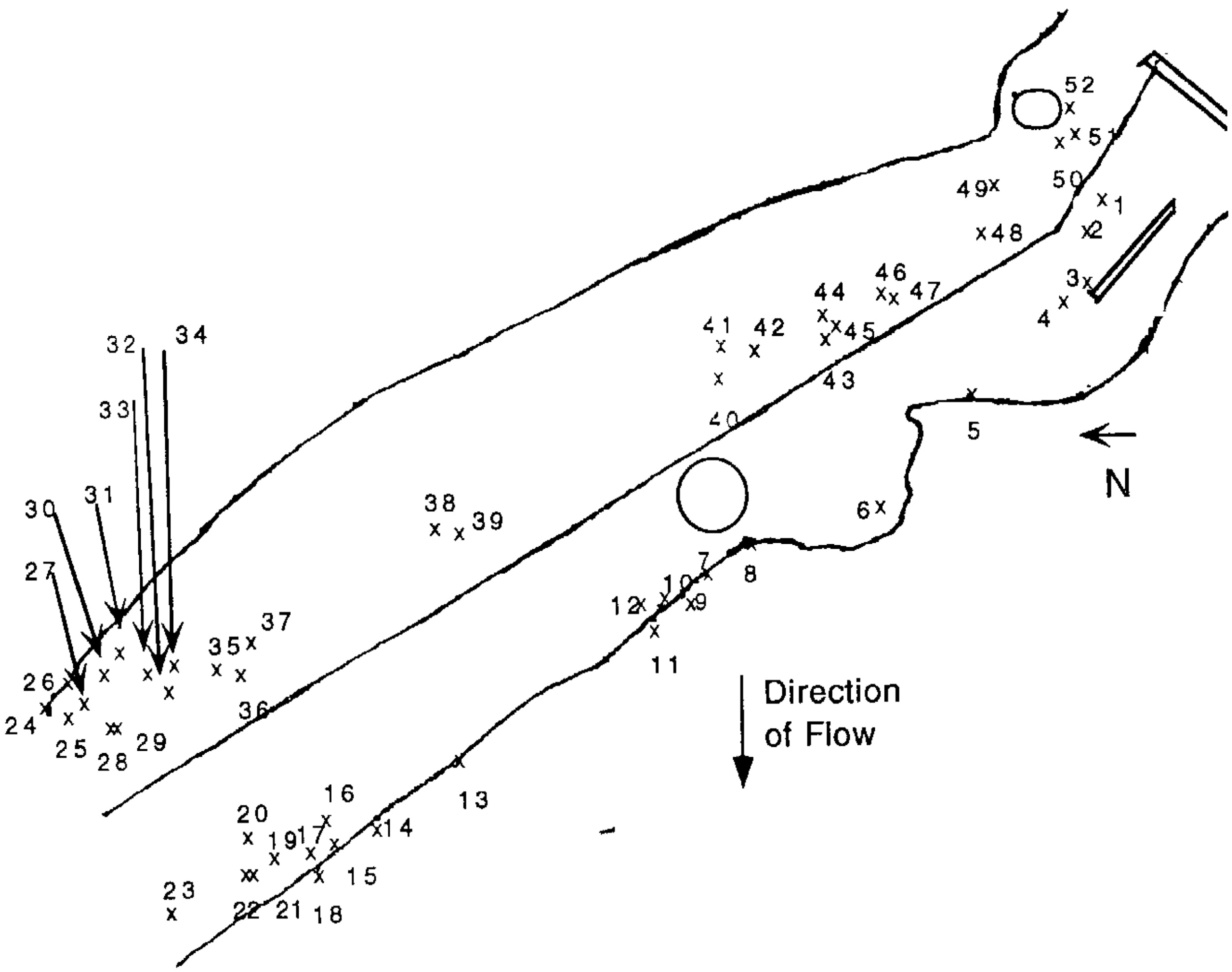
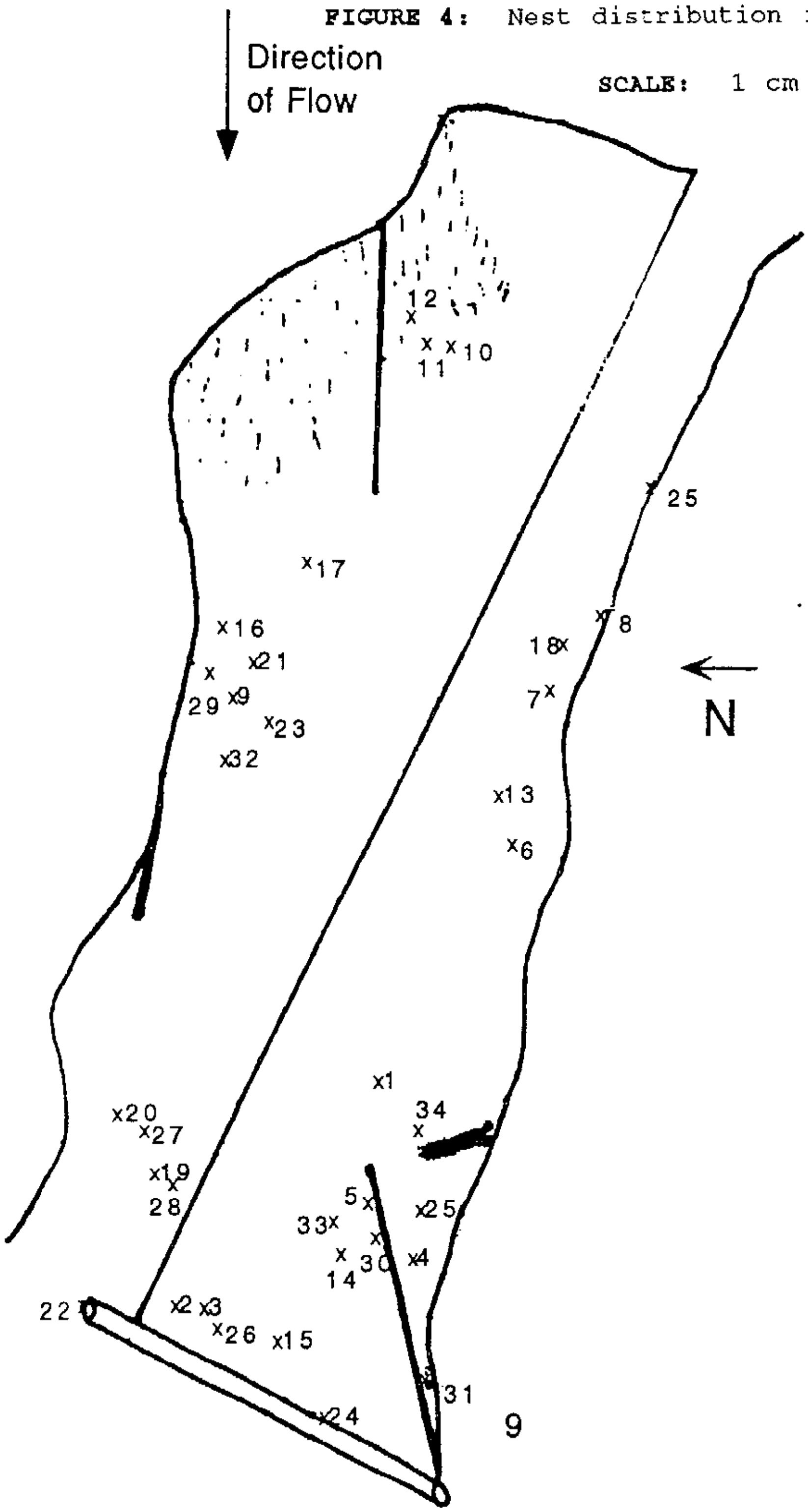


FIGURE 3: Nest distribution in Riffle I.

SCALE: 1 cm = 4 m

FIGURE 4: Nest distribution in Riffle II.

SCALE: 1 cm = 2 m



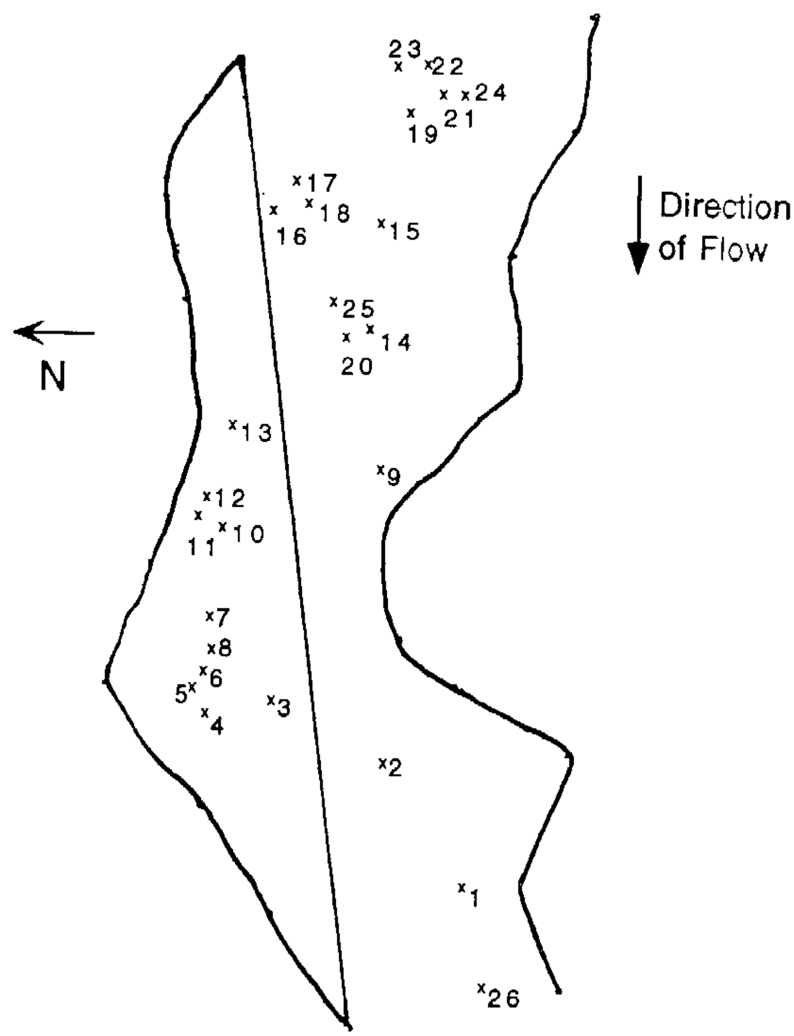


FIGURE 5: Nest distribution in Riffle IV.

SCALE: 1 cm = 2 m

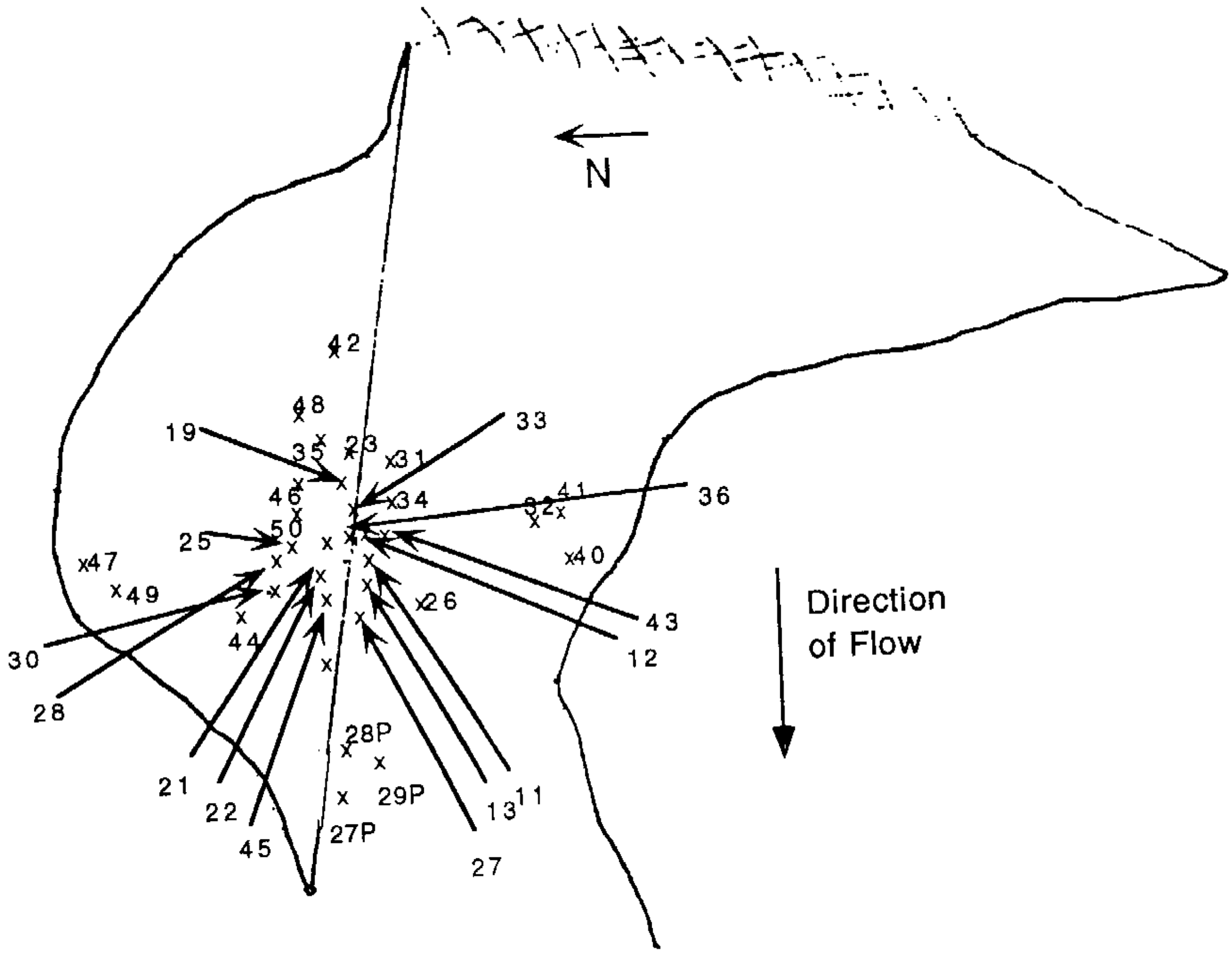


FIGURE 6: Nest distribution in Riffle V.

SCALE: 1 cm = 2 m

KEY: XXX=beaver dam

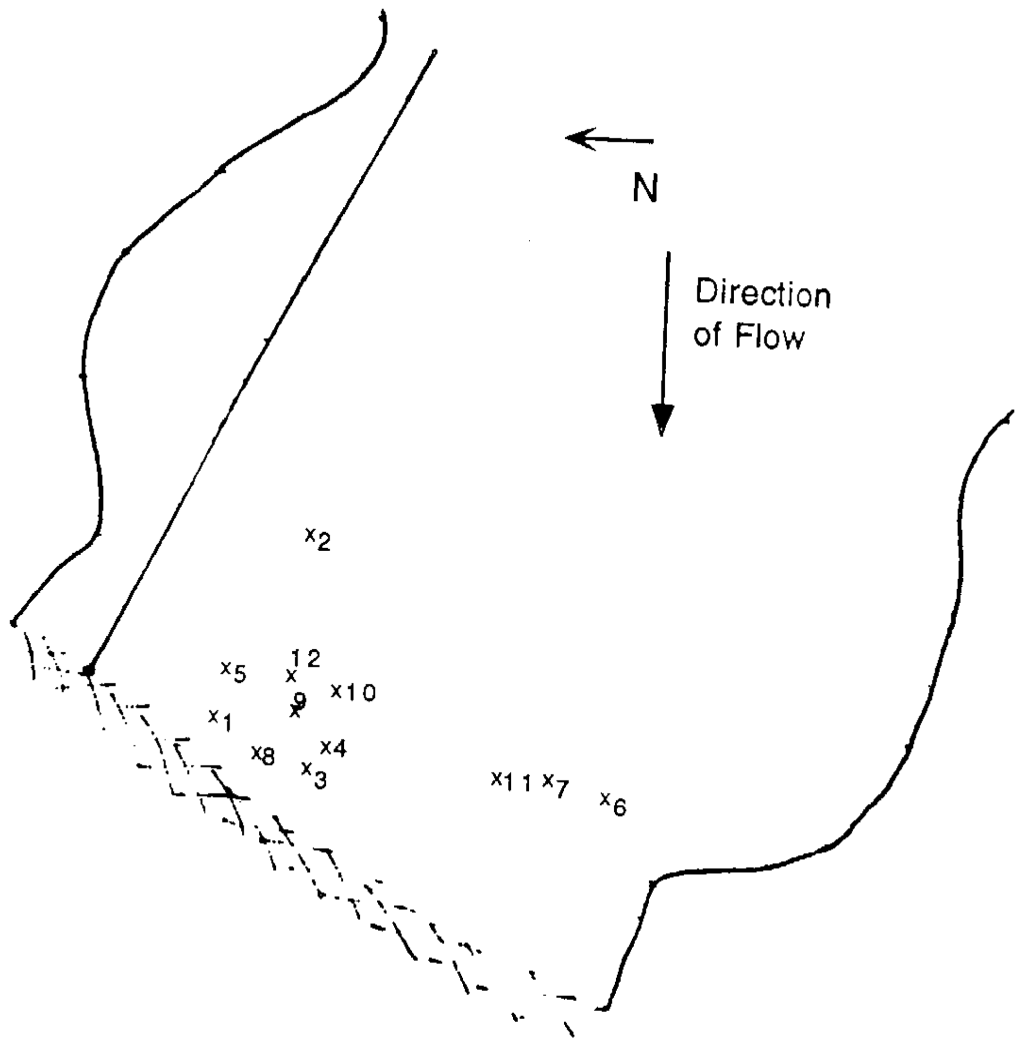


FIGURE 7: Nest distribution in Pool.

SCALE: 1 cm = 2 m

KEY: XXX=beaver dam

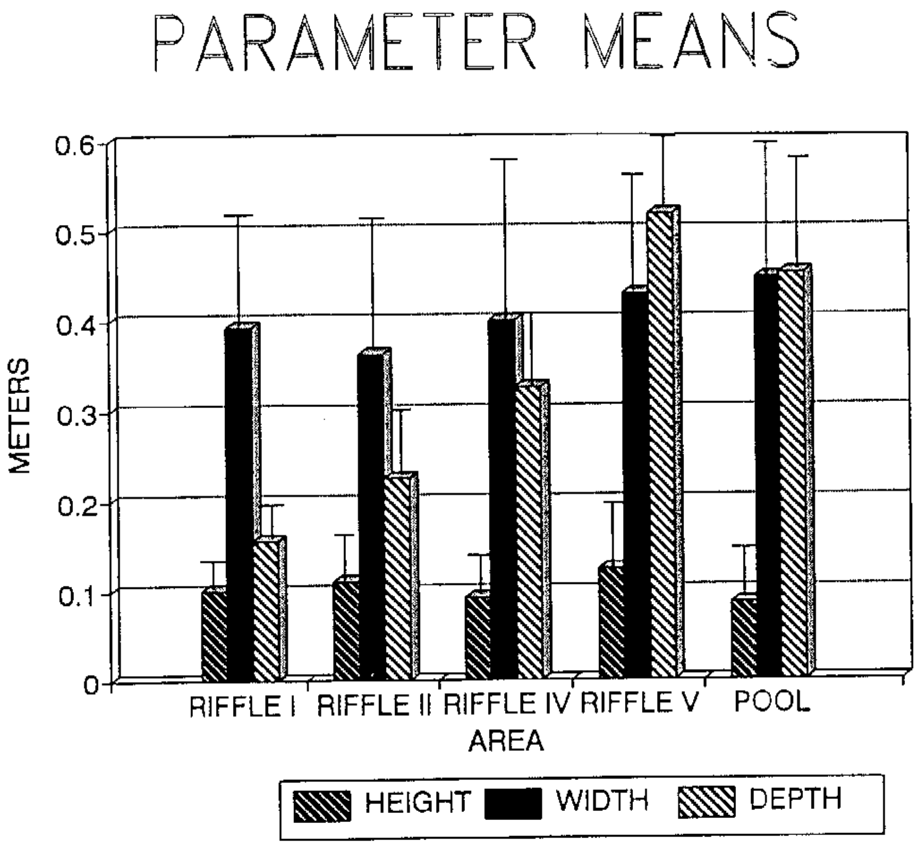


FIGURE 8:

The mean height, width, and depth for the different areas. Error bars represent +/- 1 unit standard deviation.

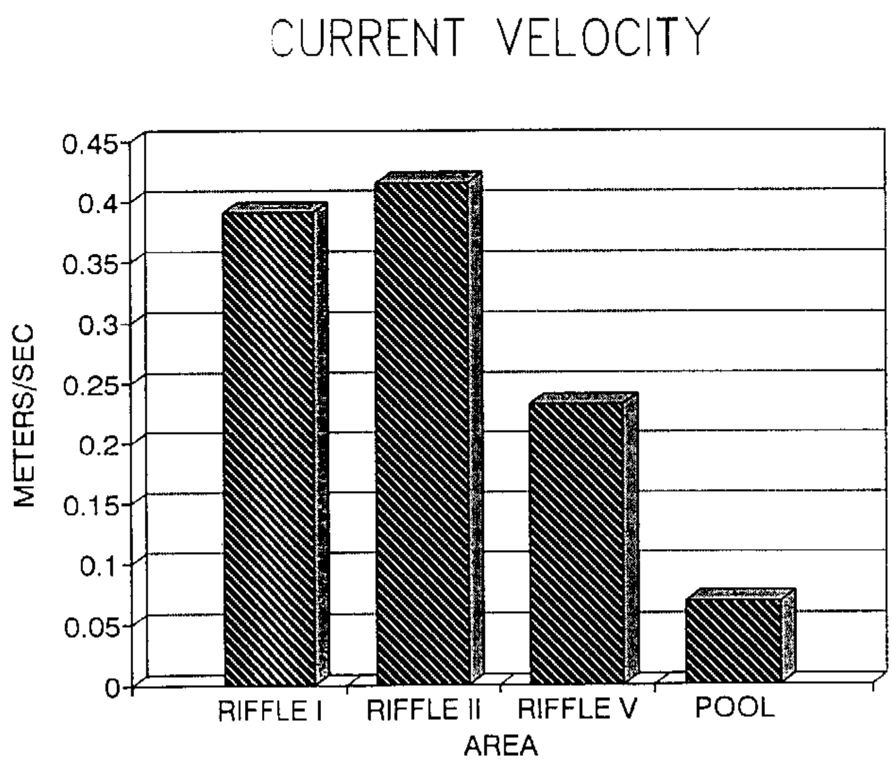


FIGURE 9: Current velocity in meters/sec.

Minnow Behavior

The nest building and courting behavior of Cyprinidae also was observed. A few black crappie (*Pomoxis nigromaculatus)* nests also were found in the stream. The Cyprinidae observed in this study were *Nocomis biguttatus*, *Luxilus cornutus*, and *Opsopoeodus emiliae*. The sequence of behavioral events is presented in Table 2. A male minnow would pick up rocks with his mouth and place them onto the nest, forming a mound. The male would then use his body to form a spawning cup. Before the nest contained eggs, a school of approximately 25 or more fish was observed in the vicinity of the nest. One fish in the school appeared to be the dominant male. This male remained at the upstream side of the nest and hovered over the spawning area, most likely protecting the nest. Although never observed, this is most likely the male that also spawns and fertilizes the eggs of the female. Behind this guarder, there usually was another minnow, a helper, followed by the rest of the minnows approximately 0.5 meters downstream. The guarding minnow guarded the nest and prevented other fish from approaching but paid no attention to the helper male. Both the guarding and helping males attacked approaching fish, presumably other males, either by swimming at them head on and 'head-butting' them, or by swimming along the side of the intruder and 'pushing' him away from the nest. While the dominant (guarding) male was defending the area or courting, the helper minnow would move upstream and hover over the spawning cup, warding off intruders. When the dominant male came back, however, the helper would again move into his reserve position. If a larger male minnow came along, the helper minnow would relinquish his position to the larger male. The helper minnow rarely fought any larger fish for his position. If the larger minnow left, however, the helper minnow would take over his position again. The dominant minnow ignored the minnows behind him unless they came over the guarded spawning cup. Another minnow (either of the same or of different species) was never seen to come in and take the dominant males' nest.

There were an abundance of interspecific interactions observed. The dominant and reserve (helper) males were never conspecifics: the dominant male usually was *Nocomis biguttatus*, and the reserve male was *Luxilus cornutus*. Also, all the minnows downstream of the nest appeared to be either *Luxilus cornutus* or *Opsopoeodus emiliae*. Most *Nocomis biguttatus* appeared to be bigger than the other two species, thus probably accounting for the dominant position.

Table 2: Ethogram of nest building behavior in Cyprinidae

1. Area-A male finds an area of suitable substrate.
2. First mound-The male moves rocks with his mouth from the outside to the center area, placing them in a way such that a mound is formed. The male will travel as far as 0.5 meters away from the center of the mound.
3. Spawning cup-The spawning cup is located on the upstream slope of the mound. The male nuzzles his ventral portion into the slope slightly moving the rocks away to form a depression.
4. Spawning occurs.
5. Mound-After spawning occurs, the male covers the spawning cup with rocks, thus adding to the mound that was previously formed. The final size of the mound is two to three times the size of the first mound.
6. Re-use-The male may use the same spawning cup again by covering the original eggs with a layer of substrate.

In some instances, a third minnow, the outsider minnow, would swim to the side of the guarded nest. This minnow (usually a *Luxilus cornutus*) was noticeable smaller than the other two. The outsider stayed to the side of the nest behind the dominant male and either behind or adjacent to the helper minnow. When the guarding male moved away from the nest, this minnow would move closer to the spawning area but would not displace the helper. It is likely that this male is a satellite fish trying to steal the nest, the eggs being guarded, or maybe even the female being courted from the guarding male, however, his role was never observed in full. The dominant fish never spent more than a minute away from the nest and remained in viewing distance of the nest.

If an object other than another fish came into the guarding male's territory, such as a hand, foot, or ruler, the male would attack it. The male's attacks were forceful, either bouncing off the surface of the object or feeling like a pinch, as if the male was biting. This behavior was observed in both the cyprinids and black crappie, and became more intense when the nest contained eggs.

Courting behavior of the cyprinids also was observed. The male would flip back and forth from side to side exposing his ventral surface. This behavior was observed in various times of courting and while guarding. When a potential mate entered the nesting area, however, the male would swim to her side and the pair would swim upstream with their caudal fins in synchronization. Sometimes, the female would swim in very rapid circles around the male and flip from side to side. As the dominant male left the nest, however, the school behind would move up into his territory causing him to leave the female and return to guard his nest. The actual mating process of the cyprinids was never observed.

DISCUSSION

Cyprinidae nest building techniques have been frequently studied. Lobb and Orth (1988) examined habitat preferences of *Nocomis platyrhynchus* in the New River, West Virginia. They found that *Nocomis platyrhynchus* built nests in areas of small and large gravel (3-64 mm diam), shallow depths (0.15-0.75 m), and medium current velocities (0.05-0.69 m/s) (Lobb and Orth, 1988). These data are consistent with the conditions that appear in the present study of cyprinid nest building. Lobb and Orth (1988) found that *Nocomis platyrhynchus* nested from mid-April to mid-June in areas, where current velocities were slower than in the wetted channel. The minnows avoided the shallowest depths because daily flow fluctuations can seriously disrupt spawning as well as egg and fry survival, and larger nests in shallow water are susceptible to desiccation or scouring (Lobb and Orth, 1988). They also observed that most mounds were located only in riffles, runs, and tails of pools. Yant (1982 as cited in Lobb and Orth) also reported that *Nocomis biguttatus*, like *Nocomis platyrhynchus*, maintained nest mounds close to substrate consisting of small rocks.

Results from the present study indicate that current velocity and depth are two important parameters influencing nest location. A nest built in too swift a current is likely to be swept away and one built in too shallow of water is likely to dry out due to changes in stream water levels throughout the spawning season.

The courting behavior of freshwater minnows is similar to that of other species of freshwater fish in that it is a ritual needed for the propagation of the species. The courtship and spawning behaviors involve distinct actions on the part of both male and female. Observations made on the cyprinids in Tenderfoot Creek are similar to those reported for the courtship and spawning behavior of smallmouth bass (*Micropterus dolomieui*) (Ridgeway et al., 1989).

Maurakis et al. (1991) described the courting behavior of *Nocomis biguttatus, Nocomis leptocephalus,* and *Nocomis micropogon* as a three-stage process of nest construction, circle swims, and spawning cup fanning. In the present study, however, a more appropriate division would be: nest construction, guarding, and upstream synchronized swimming. The circle swims and the spawning cup fanning were not performed by *Nocomis biguttatus* in the ten week field study. The courting behavior consisted mostly of upstream swimming in pairs with an occasional rapid circle of the female around the male. It was clear, however, that unlike most species of animals the male, not the female, played the major role in the protection of the unhatched offspring. The male builds and guards the nest until the eggs have hatched. This can be explained on the basis of parental investment (Alcock, 1989). The male benefits more by building and guarding the nest because he had the probability of fertilizing the eggs of multiple females. By investing the time and energy in guarding the nest, the male is ensuring that other fish can not eat the fry or use the nest. The female, however, would not get enough benefit out of the energy commitment because she can only produce a certain number of eggs.

If she devoted herself to guarding a nest, she would not be able to feed effectively, resulting in a loss in body size. This would be damaging to her, especially if the female's fecundity increases exponentially with increasing body size, as is thought to be the typical case for fishes (Alcock, 1989). It is more energy efficient for her to lay eggs in the nest of a male and let him guard her young until they hatch.

Vives (1990) studied the intraspecific and interspecific interactions between *Nocomis biguttatus* and *Luxilus cornutus*. Spawning pairs often were conspecifics. A study of the Atlantic Salmon (*Salmo salar*) also showed that intraspecific interactions can be important (Montgomery et al., 1987). The dominant salmon males build the nests and sequester the females. Younger, smaller, subordinate males, however, are seen using 'sneak' tactics. These subordinate fish (called parr) perform different behaviors depending on the presence or absence of the dominant male (Montgomery et al., 1987). The parr are premigratory juvenile fish whereas the dominant fish are salmon that have returned from the sea to spawn in their home stream. Intraspecific interactions associated with *Nocomis biguttatus* spawning also have been reported. Vives (1990) observed that the male common shiner (*Luxilus cornutus*) often shared a nest with the hornyhead chub.

The data of Montgomery et al. (1987) and Vives (1990) provide evidence that the outsider male described in the study was indeed trying to use 'sneak' tactics in order to steal the dominant males nest. In the study completed by Vives (1990), hornyhead chubs and common shiners were seen sharing the same nest, with the hornyhead chub serving as the dominant male and the common shiner as the male in reserve.

This ten week study supports results consistent with many other behavioral studies on stream minnows. It confirms that interspecific relationships exist between cyprinid fishes. It describes the nest building and courting behavior of common freshwater minnows and their preferences in nest distribution and location.

It can be concluded from this study that stream pollution and development will have serious consequences on stream minnows. If the number of riffle areas decrease, cyprinids will have to adapt their nest building location and techniques for a pool environment. Without the greater current velocity, fish fry will not have as plentiful a supply of oxygenated water moving through the nest. This could, possibly, harm their development. Also, pollution can cause variations in the flora of the stream which may affect fry development. Therefore, it is important ecologically to maintain the number of riffle areas, as well as, keep the stream water and its sources clean.

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