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Cover Preference of the Carolina Madtom (*Noturus furiosus*), an Imperiled, Endemic Southeastern Stream Fish

ABSTRACT

In a laboratory setting, we investigated cover preference of the Carolina madtom (*Noturus furiosus*), an imperiled, endemic southeastern USA stream fish. Fish were tested individually and given 24 hours to make a selection from four cover options, including rock, leaf pack, mussel shell, and an artificial cover unit. Among 30 trials, Carolina madtom preferred the artificial cover unit, selecting it 63% of the time. Rock was selected 23% of the time, and leaf pack 13%. Mussel shells were not selected during any trial.

Habitat destruction is considered the primary threat to threatened and endangered fish species (Wilcove et al. 1998), and this is particularly true for benthic and endemic groups, which include some of the most impacted species in degraded systems (Angermeier 1995, Piller et al. 2004). In particular, the madtoms (*Noturus* spp.) are significantly imperiled (Piller et al. 2004), likely because nearly all members of this group are both benthic and endemic. One important aspect of stream fish habitat is physical cover, and cover is especially critical for many benthic species, serving a number of purposes throughout a fish's ontogeny, such as a location for spawning and egg incubation and a shelter from predators (Vogele and Rainwater 1975, Wills et al. 2004).

The Carolina madtom (*Noturus furiosus*) is an endemic, cover-associated fish found in only two river basins entirely within the state of North Carolina, USA. In 2008, the conservation status of the species was listed by the state as threatened (LeGrand et al. 2008). Recent work has shown that cobble and leaf packs are the most suitable instream covers (Midway et al. 2010), although Burr et al. (1989) noted anecdotal observations of mussel shell and discarded aluminum can use. However, it is not clear how the availability of natural habitat might influence the cover preference of Carolina madtoms. Thus, we examined madtom cover use in a controlled setting and quantified use of artificial cover relative to natural cover.

Fish were collected during June and July 2008, but because of its threatened status, experimentation was limited to a small number of individuals. Upon collection, fish were immediately returned to the laboratory and acclimated to ambient conditions (well water, 18-19°C, and a 14:10 [light:dark] photoperiod). Fish were held in 19- or 38-L aquaria, and each fish was provided one of two types of cover, either a polyvinylchloride (PVC) pipe with one open end or two 15 x 5 cm tiles glued together at a right angle. These cover types were unlike any of the experimental cover types. The bottoms of the holding tanks and the experimental system were covered with approximately 2.5 cm of crushed rock that closely resembled the typical substrate size in Carolina madtom natural waters.

Cover preference experiments were conducted in a 530-L recirculating stream system (Frigid Units, Toledo, Ohio), which provided a 132 x 44 cm experimental area. This area was divided with a removable partition into an acclimation zone (1/3 of the space) and an experimental zone where the four cover types were placed—rock, leaf pack, mussel shell, and artificial cover unit. The rock and mussel shell were collected from a local stream. The leaf pack was composed of oak leaves held together with a thin mesh net. The artificial cover unit consisted of two clay flowerpot saucers, one 100 mm and the other 150 mm in diameter, inverted and glued together. The smaller, top saucer had a 25-mm opening on one side and three small vent holes on the opposite side. Cover configuration (i.e., the locations of rock, leaf pack, mussel shell, and artificial cover unit)

within the experimental zone were randomly generated for each trial, and individual fish never received the same configuration in repeated trials.

Each trial was conducted as follows. An individual fish was transferred to the acclimation zone for 30 min, after which the divider was lifted and the fish was moved into the experimental area, with gentle prodding if necessary. The divider was replaced, and the observer left the room, returning 24 hours later to record the cover, if any, that was selected. The observations were made through a viewing pane so that the test fish was not disturbed by noise or changes in light or temperature. A total of 30 trials was conducted using 12 fish, each completing between one and four trials.

To maximize the amount of information collected from a small number of fish, we generated bootstrap data sets by first sampling individual fish (with replacement) from the test set of experimental fish, and then mimicking the cover-choice trial by choosing a cover type based on the actual cover choices of each fish. Each bootstrap fish was used for a variable number of cover-choice trials to match the structure of the empirical data. We then calculated the proportion of times that the artificial cover type was chosen in each of 100,000 bootstrap data sets. These bootstrap proportions were used to calculate a percentile-based 95% confidence interval for madtom preference for the artificial cover, and to generate a *P*-value to test the null hypothesis that cover choice was random (i.e., artificial cover was chosen 25% of the time).

Carolina madtom overwhelmingly selected the artificial cover unit, choosing it in 19 of 30 trials. Rock was selected seven times, leaf pack was selected four times and mussel shell never used (Fig. 1). In multiple trials with individual fish, cover selection often varied, suggesting that the high rate of artificial cover use was not influenced by a few, highly selective fish. The 95% confidence interval for selection of the artificial cover was 37-87%. Thought a fairly large range, this effectively rejected (P=0.0025) the null hypothesis that use of the artificial cover type was 25%, the expected use if cover choice were random and without preference.

We also tested for an effect of holding tank cover (PVC vs. tile) and experimental cover position (i.e., configuration), individually, with standard chi-squared goodness-of-fit tests. These tests did not detect any trend, suggesting that fish did not favor any

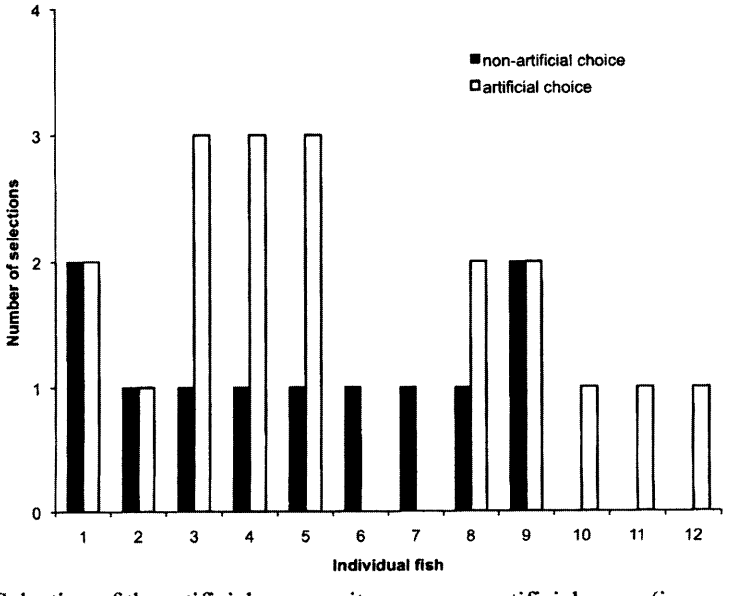

Figure 1. Selection of the artificial cover unit versus non-artificial cover (i.e., natural cover) of the 12 fish used in the experimental trials.

location within the experimental zone and that cover exposure during non-experimental periods did not influence experimental cover preference.

Our results are consistent with field observations of artificial cover use by Carolina madtom (Midway et al. 2010) and other observations of Carolina madtoms inhabiting artificial structure or human refuse (Burr et al. 1989). Our findings, combined with documented use of the same artificial cover unit in natural systems (Midway et al. 2010), provide information relevant to development of habitat conservation plans for the Carolina madtom. In streams where cover is limiting, introduction of these cover units to suitable microhabitats could provide potential benefits to this species. However, because cover is only one component of habitat, it should not be assumed for all or different systems that high levels of occupancy would result from a random or other instream distribution of artificial cover units. Examination of other habitat components and their influence on cover usage is relevant and warranted.

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