# EFFECTS OF SUBSTRATE EMBEDDEDNESS ON BEHAVIOR OF THE GILT DARTER (*Percina evides*)

Andrew B. Sutherland

*AUTHOR:* Graduate Student, Institute of Ecology, University of Georgia, Athens, GA 30602.
*REFERENCE: Proceedings of the 2001 Georgia Water Resources Conference,* held March 26-27, 2001, at the University of Georgia. Kathryn J. Hatcher, editor, Institute of Ecology, the University of Georgia, Athens, Georgia.

**Abstract.** We investigated the general behavior of the gilt darter (*Percina evides* Jordan and Copeland), a benthic fish whose distribution has been shrinking since the early part of this century. Direct observations (by snorkeling) were made in Fall 1999 in five streams that differed in sedimentation, measured as substrate embeddedness. Embeddedness varied from 40% - 70%. Ten fish were observed per stream, each for 15 minutes. Observations focused on foraging, swimming, and resting as well as number of feeding strikes. Time spent foraging, swimming, and resting was significantly different ($p < 0.001$) among sites, as was number of feeding strikes per observation period. We also found a marginally significant ($p = 0.08$) relationship between foraging time and mean substrate embeddedness. Number of feeding strikes versus embeddedness was also marginally significant ($p = 0.06$). Swimming and resting time were not correlated with embeddedness. Mean number of feeding strikes was significantly correlated with mean foraging time ($p = 0.03$). This study suggests that increasing embeddedness may affect the activity of this relatively silt-tolerant darter, implying that less tolerant benthic taxa may be more heavily influenced by increasing streambed sedimentation.

## INTRODUCTION

North America has the highest diversity of temperate freshwater fishes in the world. The southeastern US, which may harbor as many as 500 species, is the center of this rich fish fauna (Walsh et al. 1995). Within the southeast, the greatest diversity is in the Appalachian Mountains.

Excessive sedimentation of rivers and streams has been linked with the imperilment of southeastern freshwater fishes (Walsh et al. 1995). Specifically, sedimentation and siltation resulting from poor land-use practices is leading to the elimination of suitable habitat for many benthic fish species (Burkhead and Jelks, in review). According to Jenkins and Burkhead (1994) the range and abundance of these benthic spawning fishes is declining. To date, however, the majority of research involving the effects of sediment on fishes has been conducted on game species, primarily salmonids (Sigler et al. 1984, Redding et al. 1987, Magee et al. 1996). Of the few studies involving non-games species, only a couple have looked at effects on Cyprinidae (Gradall and Swenson 1982, Newcombe and Jenson 1996).

The effects of excessive stream sedimentation due to land disturbance on the *behavior* of non-game stream fishes have not been thoroughly studied. Research has shown that salmonid behavior is influenced by increased turbidity. Barrett et al. (1992) found a reduction in feeding strikes, foraging time and reactive distance when ambient turbidity was increased from 5 - 15 NTU. Redding et al.(1987) also found that increased turbidity caused sublethal physiological stress and reduced several types of performance.

Another theory yet to be tested is that turbidity reduces activity by reducing an individuals ability to see potential predators. Turbidity is positively correlated to the embedding of the substrate with fine particles (Figure 2). The objective of this study was to examine the general behavior of a benthic lithophilos fish, at streams differing in land use and substrate embeddedness.

## METHODS

Five streams draining similar watershed areas (15 - 30 $km^2$) were chosen based on preliminary habitat (embeddedness) transect data. Embeddedness was determined visually at one meter intervals along 20 randomly selected transects per site. Mean embeddedness estimates for each site are presented in Figure 1. Direct observations were made by snorkeling a 50 meter reach, at each stream.

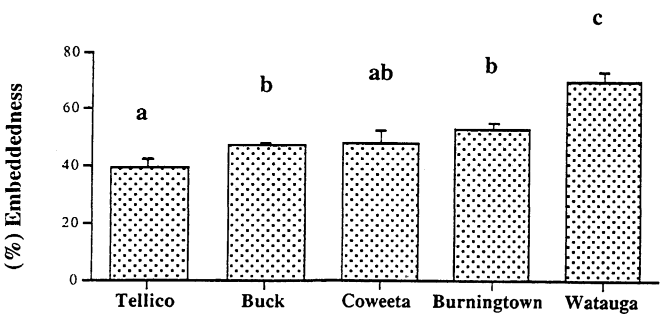


**Figure 1. Mean substrate embeddedness at Little Tennessee study sites. Different letters denote a significant difference ($p < 0.05$).**

Ten fish were observed per stream, each for 15 minutes. One of three behaviors were recorded every 15 seconds (foraging, swimming, and resting). Swimming data is not presented.

Three other behaviors were counted per 15 minute observation period: 1) feeding strikes, 2) alert behavior, and 3) mouth gaping. Data for the latter two are not presented here.

## RESULTS

Foraging time decreased at sites with increased embeddedness (Figure 2). However, the two more pristine sites (with over 99% forested watersheds and low embeddeness) were not different. Although there was a significant difference between some pairs of sites (including the most embedded and least embedded), there was only a marginally significant relationship between foraging time and substrate embeddedness ($p = 0.08$) (Figure 3).

As with foraging time there was a trend with resting time and increasing embeddedness. Once again the two pristine sites were not significantly different and resting time increased with increasing sedimentation.

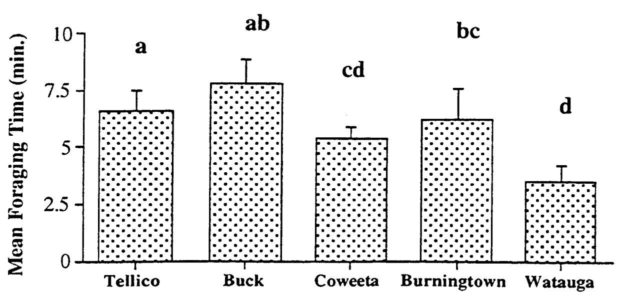


**Figure 2. Mean foraging time in minutes at Little Tennessee Study sites. Different letters denote a significant difference ($p < 0.05$).**

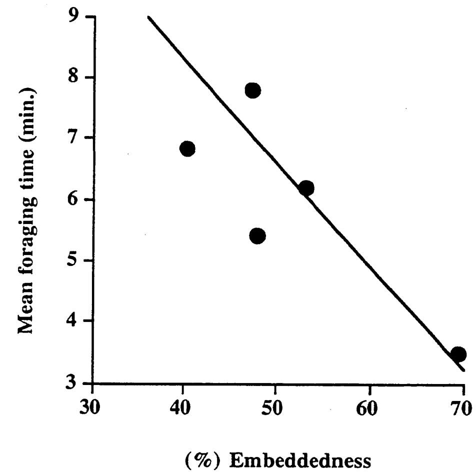


**Figure 3. Regression of mean embeddedness vs. mean foragaing time. Relationship is marginally significant ($p = 0.0835$, $r^2 = 0.68$).**

Similar to the foraging data, there was a marginally significant relationship between resting time and percent embeddedness, though not as strong as with foraging.

Feeding strike data was also significantly different among sites ($p < 0.01$). Feeding strike data was also strongly correlated with percent embeddedness data. Mean number of feeding strikes were also strongly correlated with mean time spent foraging ($p < 0.001$) (Figure 4).

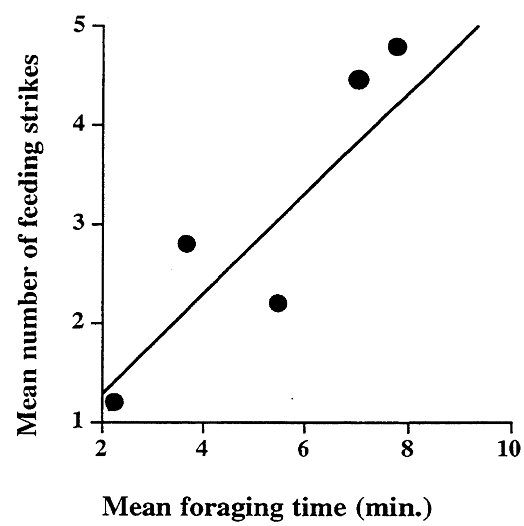


**Figure 4. Regression of mean foraging time vs. mean number of feeding strikes, ($p < 0.001$, $r^2 = 0.25$).**

## DISCUSSION AND CONCLUSIONS

This study suggests that the general behavior of the gilt darter is influenced by streambed sedimentation. Foraging, swimming and resting time were significantly different among sites ($p < 0.001$), yet there was not a significant relationship (at $\alpha = 0.05$) between percent embeddedness and these three behaviors. However, there was a marginally significant negative relationship between substrate embeddedness and both foraging time ($p = 0.08$) and number of feeding strikes ($p = 0.06$). There was also a strong correlation between time spent foraging and number of feeding strikes ($p = 0.03$, $r^2 = 0.83$).

While this research suggests a relationship between bed sedimentation and foraging behavior, the mechanism is not clear. Foraging may decline as a function of increased turbidity, or increased physiological stress. Decreased prey abundance may also be partly responcible for this trend, though this might also be expected to increase foraging because of decreased feeding efficiency.

The influence of human-induced sedimentation on the behavior of instream organisms is poorly understood. Further behavioral research may help to explain observed patterns in declining fish abundance and diversity.

## LITERATURE CITED


Barrett, J.C., G.D. Grossman, and J. Rosenfeld. 1992. Turbidity-induced changes in reactive distance of rainbow trout. Transactions of the American Fisheries Society. 121: 437 – 443.

Burkhead, N.M. and H. Jelks. In press. Effects of suspended sediment on the reproductive success of a crevice-spawning minnow, the tricolor shiner (Teleostei: Cyprinidae). Transactions of the American Fisheries Society

Gradall, K.S. and W.A. Swenson. 1982. Responses of brook trout and creek chubs to turbidity. Transactions of the American Fisheries Society 111: 392 – 395.

Jenkins, R.E. and N.M. Burkhead. 1994. Freshwater Fishes of Virginia. American Fisheries Society, Bethesda, Maryland.

Magee, J.P., T.E. MacMahon, and R.F. Thurow. 1996. Spatial variation in spawning habitat of cutthroat trout in a sediment-rich stream basin. Transactions of the American Fisheries Society. 125: 768 – 779.

Newcombe, C.P. and J.O.T. Jenson. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management 16: 693 – 727.

Redding, J.M., C.B. Schreck and F.H. Everest. 1987. Physiological effects of coho salmon and steelhead of exposure to suspended sediments. Transactions of the American Fisheries Society. 116: 737 – 744.

Sigler, J.W., T.C. Bjornn, and F.H. Everest. 1984. Effects of chronic turbidity on density and growth of steelheads and coho salmon. Transactions of the American Fisheries Society 113: 142 – 150.

Walsh,S.J., N.M.Burkhead andJ.D.Williams. 1995. Southeastern Freshwater Fishes. Pp. 144-147 in E.T. LaRoe, G.S. Farris, C.E. Puckett,P.D. Doran and M.J. Mac (eds), Our living resources: a report to thenation on the distribution, abundance, and health of U.S. plants,animals, and ecosystems. U.S. Department of the Interior, National Biological Service, Washington D.C. 530 p.