

Swimming Speeds of the Central Stoneroller

William G. Layher and April Osmer Ralston¹

U. S. Geological Survey, Biological Resources Division

University of Arkansas at Pine Bluff

1200 North University Drive, P. O. Box 4912

Pine Bluff, AR 71611

¹Present Address: Arkansas Game and Fish Commission, #2 Natural Resources Drive, Little Rock Arkansas 72205.

INTRODUCTION

Silviculture activities require access to remote areas of forests. Stream crossings are often made for logging access and other purposes. Culverts used at such crossings have the potential to impede movement of fishes upstream (Meehan 1974). Such movements are necessary for some fishes to complete life cycles (i.e. spawning).

The paleback darter, Etheostoma pallidorsum, inhabits headwaters of the Caddo River drainage in Arkansas (Distler and Metcalf 1962) and a small tributary of the Ouachita River (Robison 1974; Robison and Buchanan 1988). The species is of special concern to the U. S. Forest Service due to its restricted distribution. The paleback darter uses small springs and spring seeps as spawning habitat (Robison and Buchanan 1988). Much of the area known to be utilized by the darter is within the boundaries of the Ouachita National Forest.

Culvert structures on logging roads could be designed to afford fish passage if swimming speeds of the fish were known or could be estimated. Species of fishes selected for this study are similar in size to the paleback darter. Substitute species were used to avoid injury or causing mortalities to the less common paleback darter. The species used included the greenside darter (Etheostoma blennoides), orangebelly darter (Etheostoma radiosum), redbfin darter (Etheostoma whipplei), central stoneroller (Camptostoma anomalum), and the golden shiner (Notemigonus crysoleucas). Determining swimming speeds of these fishes would allow culvert design to accommodate their passage. The assumption is made that paleback darters would also be able to pass through such designed culverts.

MATERIALS AND METHODS

Apparatus

An apparatus was built to enable the determination of swimming speeds of small fishes. The apparatus was similar to that used by Matthews (1985) but was modified to obtain variable current velocities. The system consists of a submersible pump with an 18-inch riser 1.5 inches in diameter. This discharges through a diverter valve and a main flow valve. Bushings in pipe size ultimately divert flow through a three-inch clear PVC pipe. A petcock at one stage allows air to bleed from the tubing. An access plug located at the end of the clear pipe allows fish entry and exit to the system. A strainer at each end prevents fish from moving downstream or upstream out of view. Flows are diverted back into an aquarium equipped with temperature control; the same location as the water source.

A guide was placed in alignment with the valve handle to calibrate and allow velocity computation. The guide was marked in degrees so positions of the handle could be recorded during trials.

Flow through the clear pipe was determined by allowing the pump to run at a particular setting for a known period of time. Water volume per unit time was divided by area of the pipe cross section to obtain velocity. The process was repeated five times at five settings. With settings regressed against velocities one could enter the setting from the valve handle guide into the regression equation to obtain velocity at any desired time. Velocities produced by the apparatus ranged from 11.124 cm/sec to 72.890 cm/sec. The apparatus has been fully described by Ralston and Layher (1997).

Fish collections and experiments

Central stonerollers (Campostoma anomalum) were collected on June 1, 1992 from the upper Ouachita River at three localities using a back-pack electrofishing unit. High mortalities were experienced and fish were again collected on July 7, 1992 near Pine Ridge, Arkansas. A third collection of fishes were made on August 10, 1992.

Four 20-gallon aquaria with carbon filters were used to maintain fishes in the laboratory. Individual fishes were placed into the testing apparatus; then allowed to acclimate to a low velocity. After acclimation was achieved, velocity was increased slightly. The fish was again acclimated for approximately two minutes.

Eventually a point was reached at which the fish encountered some difficulty maintaining position. This point was referred to simply as "difficulty". Velocity was again increased until the fish was swept through the tube with no recovery upstream. This point was termed "cannot hold".

RESULTS and DISCUSSION

Means of the “difficulty” and “cannot hold” velocities for fish length groups were plotted (Fig. 1 and 2). Thirty-one stonerollers were utilized in these trials. No significant relation was found between length of fish and velocity measurements for either difficulty or cannot hold measurements using all data, $n=31$ ($R^2=0.132$, $\text{prob}>F=0.04$; $R^2=0.174$; $\text{prob}>F=0.019$). Mean velocities plotted by length groups do suggest such a relation however (Fig. 1 and 2).

Layher and Ralston (1997a) found that electrofished orangebelly darters (Etheostoma radiosum) could not swim against higher currents that their non-electrofished counterparts could. Golden shiners (Notemigonus crysoleucas) which were collected by electrofishing exhibited no relations between velocities and fish length while those collected by seining showed significant relations between swimming performance and length of fish (Layher and Ralston 1997b). Layher and Ralston (1997b) hypothesized that electrofishing may result in poorer performance due to skeletal, muscular, or neurological damage. Data in this study should be viewed as conservative assuming fish performance was effected by collection method.

Stonerollers of the length used in this study did not appear to use positioning to assist in maintaining position against currents. Stonerollers positioned themselves in this study in the water column. Layher and Ralston (1997c) found that larger stonerollers do utilize positioning at higher flows.

Central stonerollers between three and five centimeters in length showed difficulty in maintaining position at water velocities between 30 and 35 cm/sec and could not hold their positions above 40 cm/sec (Table I). However, longer specimens approached cannot hold velocities at nearly 70 cm/sec. These values were based on tests of 31 individuals.

Table I. Mean Lengths (CM) cannot hold (CH) and difficulty (DIFF) velocities (cm/sec) for length groups of central stonerollers by group.

Group	Length	DIFF	CH	N
3	3.70	36.86	40.20	2
4	4.48	34.81	39.08	6
5	5.32	43.72	47.54	5
6	6.45	37.81	42.30	7
7	7.42	40.18	44.64	8
8	8.20	45.81	54.63	1
9	-	-	-	0
10	10.00	40.20	45.81	1
11	11.00	63.58	66.92	1
Total n = 31				

LITERATURE CITED

- Distler, D. A. and A. L. Metcalf. 1962. Etheostoma pallididorsum, a new period fish from the Caddo River System of Arkansas. Copeia 1962 (3):556-561.
- Layher, W. G. and A. O. Ralston. 1997a. A comparison of swimming performance of orangebelly darters collected by kick-seining and back-pack electrofishing.
- Layher, W. G. and A. O. Ralston. 1997b. Difference between electrofished and seined golden shiners as related to swimming performance.
- Layher, W. G. and A. O. Ralston. 1997c. Notes on the swimming behavior of a large central stoneroller.
- Matthews, W. J. 1985. Critical current speeds and microhabitats of the benthic fishes Percina roanoka and Etheostoma flabellare. Envir. Biol. Fishes 12(4):303-308.
- Meehan, W. R. 1974. Part 3. Fish habitats in the forest ecosystem of Southeast Alaska. USDA For. Serv. Gen. Tech. Rpt. PWW-15. 41 pp.
- Ralston, A. O. and W. G. Layher. 1997. An inexpensive ichthyonotometer for assessing swimming performance of small fishes.
- Robison, H. W. 1974. An additional population of Etheostoma pallididorsum Distler and Metcalf in Arkansas. Am. Midland nat. 9(2):478-479.
- Robinson, H. W. and T. M. Buchanan. 1988. Fishes of Arkansas. Univ. of Arkansas Press. 536 pp.

Figure 2. Cannot hold velocities (CH) (cm/sec) for groups of central stonerollers. Variable group is in cm.

Figure 1. Difficulty velocities (Diff) (cm/sec) for groups of central stonerollers. Variable group is in cm.





