Critical Current Speeds of Several Darter Species of the Genus Etheostoma

by

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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 blenniodes), orangebelly darter (Etheostoma radiosum), and redfin darter (Etheostoma whipplei). 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 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 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 trails.

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 and its performance have been previously described (Ralston and Layher 1997).

Fish collections and experiments

Fish were collected from the upper Ouachita River at three localities using a back-pack electrofishing unit. High moralities were encountered and fish were again collected near Pine Ridge, Arkansas. A third collection of fishes was also made.

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 is 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

Swimming speeds were obtained for three darter species collected from the upper Ouachita Rier. Fishes were collected by backpack electrofishing utilizing short bursts of power and allowing fish to drift from riffle areas into a net. Previous collections using continious shocking resulted in high mortality rates and obvious injury.

None of these three fish species showed significant relations between velocity and total fish length. Most of the fish used in this experiment were of small size and only a few might be considered adult fishes. This size restriction may have hampered our success in detrmining fish length-water velocity relations.

Mean velocity values for the difficulty measure and the cannot hold measure were similar for all three species tested (Table I). Redfin darters exhibited slightly lower difficulty and cannot hold velocities than other species. Specimens of redfins darters were slightly smaller, however, than other species used (Table II).

Maximum cannot hold velocity for redfin darters was 45.81 cm/sec while one orangebelly darter maintained position up to 51.29 cm/sec. Greenside darter maximum cannot hold velocity was similar to that recorded for the redfin darter. Body form in small darters may be as important as size in tolerating given velocities (Matthews 1985).

Darters in this study were electroshocked by short bursts of power rather than continuous shocking. It is unknown wheter the lack of length vs. velocity relations for darters is real or a product of electroshocking. Layher and Ralston (1997) found significant differences between swimming performance of kick-seined and electrofished orangebelly darters. Other researchers have found that body shape in darters plays an important role in maintaining position in currents.

Since these fish have no air bladder and are not continually positioned up in the water column, there may be little difference between size groups and velocities which represent maneuverable conditions. Some researchers have conducted experiments on small fishes and disregarded body length as important, or not considered it as a variable to contend with (MacLeod 1967; Farlinger and Beamish 1977).

If water velocities in culverts are below 35 cm/sec, these data indicate potential upstream passage by darters. Larger stonerollers and golden shiners can traverse velocities in excess of 65 cm/sec and fish length increases relate to tolerance of higher velocities (Layher and Ralston 1997b; 1997c). Velocities tolerated by both darters and cyprinids tested in this study appear to be above the 3-6 body length/sec reported by Bainbridge (1958) for many juvenile and adult fishes. Those data however were for sustained swimming speeds. Endurance was not reported on in this work. Bainbridge (1960) found larger goldfish (Carossus auratus) to be able to achieve higher velocities for the same time periods than smaller goldfish and Thomas ans Donahoo (1977) reported on fish size relations to endurance for Salmo gairdneri.

These experiments do not address the sustainability of speeds of the fishes tested. It is obvious that fishes tested were subjected to increasing velocities. Small increments of velocity were used in tests with approximately two minute intervals between velocity increases. Therefore it seems logical that the position described as "difficulty" could be sustained for some time. The "cannot hold" position is probably somewhat less than what might be achieved if velocity adjustment periods were shortened. These values are certainly less than achievable burst speeds. If culverts on logging roads were designed to contain velocities at the difficulty level or below, assuredly fishes would be able to traverse the short distances involved.

Table I. Statistics by species for difficulty (DF) velocity (cm/sec) and mean cannot hold (CH) velocities (cm/sec).

	Greenside Darter	Redfin Darter	Orangebelly Darter
		Difficulty	
n	9	8	29
min.	15.62	13.72	13.48
max.	40.20	40.20	45.81
mean	31.16	28.01	29.55
s.d.	8.11	11.30	10.82
		Cannot Hold	
n	9	8	29
min.	19.09	16.82	16.82
max.	45.81	45.81	53.56
mean	34.36	13.70	33.20
s.d.	8.95	11.28	11.42

Table II. Total length (cm) statics for three darter species tested.

	Greenside Darter	Redfin Darter	Orangebelly
n	9	8	29
min.	4.00	3.00	3.30
max.	6.80	6.00	6.50
mean	5.14	4.37	5.26
s.d.	1.14	1.10	0.86

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