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Home Range Estimates for Three North American Stream Fishes

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We estimated home ranges of three fish species inhabiting a fourth order stream in the Blue Ridge Mountains of North Carolina. Individuals were uniquely marked with a subcutaneous injection of acrylic paint. *Cottus bairdi, Rhinichthys cataractae* and *Clinostomus funduloides* moved an average of 12.9, 13.4, and 19.3 m respectively, between captures. Mean time interval between captures was 128 d; 86% of recaptures were in the stream section of previous capture. Individuals may not have moved throughout the entire section length (mean length = 10.4 m); thus, these values likely overestimate actual movements.

LITTLE is known about home ranges or movements of stream fishes. Yet, this information is of interest from both basic and applied scientific perspectives. For example, it would be difficult to predict the effects of an environmental disturbance without knowledge of the home ranges of the species in the affected area. In addition, quantification of the home ranges of assemblage members is desirable in studies of assemblage organization (Grossman, 1982; Connell and Sousa, 1983; Grossman et al., 1985).

Herein, we describe home range sizes of three widely distributed stream fishes (Lee et al., 1980): mottled sculpin (*Cottus bairdi*), longnose dace (*Rhinichthys cataractae*), and rosyside dace (*Clinostomus funduloides*). The first two species are benthic, whereas *C. funduloides* is a water-column inhabitant. Additional natural history information on these species can be found in Ludwig and Norden (1969), Davis (1972), Gibbons and Gee (1972), and Rohde and Arndt (1981). These fishes numerically dominate (>80% numerical abundance) an assemblage that is currently the focus of a long-term assemblage organization study. The objective of this paper is to estimate the home range sizes of the three species.

MATERIALS AND METHODS

The study site was a 177 m length of a fourth order stream, Coweeta Creek, comprising 79 m of riffles, 46 m of runs, and 52 m of pools. This site is located in the Blue Ridge Mountains of Macon County, North Carolina. Stream width ranged from 2–11 m, with most sections 5–8 m in width. Depth averaged ca. 20 cm in riffles and between 40 and 70 cm in runs and pools; average current velocity varied spatially and temporally, but was approximately 25 cm/s. Rhododendron (*Rhododendron maxima*), dogwood (*Cornus florida*) and mountain laurel (*Kalmia latifolia*) dominated the riparian vegetation.

To quantify home range size, we divided the stream into 17 sections using natural barriers such as cobble/boulder or debris obstructions, with numbered flags marking the boundaries of each section. Secondary cross section breaks subdivided sections greater than 15 m length. Thus, section lengths ranged from 3.3–26.7 m, but averaged 10.4 m (subsections averaged 6.8 m).

Approximately twice per month for 18 mo (May 1983–Nov. 1984), divers captured adult fishes (i.e., ≧40 mm standard length) using hand-held nets; sampling in an upstream direction minimized displacement of individuals. After netting a fish, we recorded the date and location of capture, and anesthetized the fish with tricaine methanesulfonate (MS-222). To recognize individuals, we marked each fish with one of six liquid acrylic paints in one of 28 body positions. A laboratory assessment of the marking technique (Hill and Grossman, 1987) indicated that growth and survivorship were not affected by the marks and that the marks had sufficient longevity for a field study of this duration. Each sampling period, we checked captured fish for marks. Unmarked fish were given marks over a 12 mo period. All fishes were held until an entire section was sampled (20–30 min), then released as close to the exact capture area as possible.

We defined home range as the linear distance normally traveled during the lifetime of an individual (Burt, 1943) and used the method of Logan (1963) to estimate home range size. This

TABLE 1. HOME RANGE ESTIMATES FOR COWEETA CREEK FISHES, MAY 1983–NOV. 1984.

Species	Number recaptures (no. marked)	$\bar{x}$ Days between captures (maximum)	Home range size (m) $\bar{x}$ ± 95% CI (max. dist. moved)	Percentage recaptured in same section
C. bairdi	51 (180)	155 (458)	12.9 ± 2.4 (54.8)	92
R. cataractae	17 (51)	87 (322)	13.7 ± 4.4 (40.0)	82
C. funduloides	26 (134)	102 (276)	19.3 ± 8.0 (98.4)	77

method does not require multiple recaptures of individuals. Home range was calculated by summing the lengths of capture and recapture sections plus all intervening sections. If the fish was recaptured in the original capture location, the length of that section was considered to be the home range. Home range values for individuals were then averaged to obtain a home range estimate for each species.

Some investigators (Stefanich, 1952; Funk, 1955) have found that part of a fish population may exhibit extensive movements whereas the remainder is sedentary (but see Gerking, 1959). To check for extensive long-term movements of individuals outside the study site, we regularly sampled three sections adjacent to the upstream and downstream ends of the site and electrofished two 30 m sections of stream 30–60 m upstream and downstream of the study site. The distances of these sections from the study site were arbitrarily chosen. Each section was sampled between three and seven times during Feb. 1984–March 1985.

RESULTS

Most fishes were recaptured in the section or subsection of previous capture. Home range estimates are given in Table 1. The greatest distances between subsequent captures were 54.8 for *Cottus bairdi*, 40.0 for *Rhinichthys cataractae*, and 98.4 m for *Clinostomus funduloides*, respectively. During our 18 mo study, a total of 94 individuals of the three species were recaptured of 365 individuals marked (Table 1). Recapture rates averaged 26% and varied among species (*Cottus bairdi*—28%, *R. cataractae*—33%, *Clinostomus funduloides*—19%). The average number of days between subsequent captures was 128 with a maximum of 458 d.

Three storms may have influenced home range estimates. During the first week of May 1984 (after the first 12 mo of data collection), storms produced 17 cm of rainfall and caused a five-fold increase in flow rates of Coweeta Creek (J. Waide, Coweeta Hydrologic Laboratory, pers. comm.). Before the storms, home range sizes (95% CI) were 12.9 ± 4.7 m for *Cottus bairdi*, 14.8 ± 5.9 m for *R. cataractae*, and 13.2 ± 2.3 m for *Clinostomus funduloides* (compare these with Table 1). The two benthic species exhibited minimal changes in home range size after the storms. Home range size of the water column species, *C. funduloides*, increased by 50%. Of the seven *C. funduloides* recaptured after the storm, three exhibited extensive movements ($\bar{x}$ = 67.7 m) (Fig. 1). These individuals all had moved from a pool with few structural refuges to the next pool downstream that possessed structural refuges. Consequently, the large movements of these individuals may have been caused by displacement during the storm events, due to a lack of refuges in the original capture site, rather than by active movement.

Electrofishing of 30 m sites above and below the study area yielded no marked individuals, although one marked *C. funduloides* was caught by seining the downstream site. This individual had been marked prior to the storm in the same section as the other three *C. funduloides* that had moved large distances.

DISCUSSION

Home range estimates for both benthic (*Cottus bairdi* and *R. cataractae*) and water column (*Clinostomus funduloides*) species were small, between 10 and 20 m. Because most recaptured fishes remained in the section of previous capture (Table 1), our estimates of home range size probably were high. Three storm events also may have inflated our values. These storms did not cause increased movements of benthic species, but may have displaced several *C. funduloides*, the only water column species examined. Storm events of similar intensity occur with an approximate frequency of 1–2 yr at Coweeta (J. Waide, Coweeta Hydrologic Laboratory, pers. comm.). Consequently, the movements of water column species like *C. fundu-*

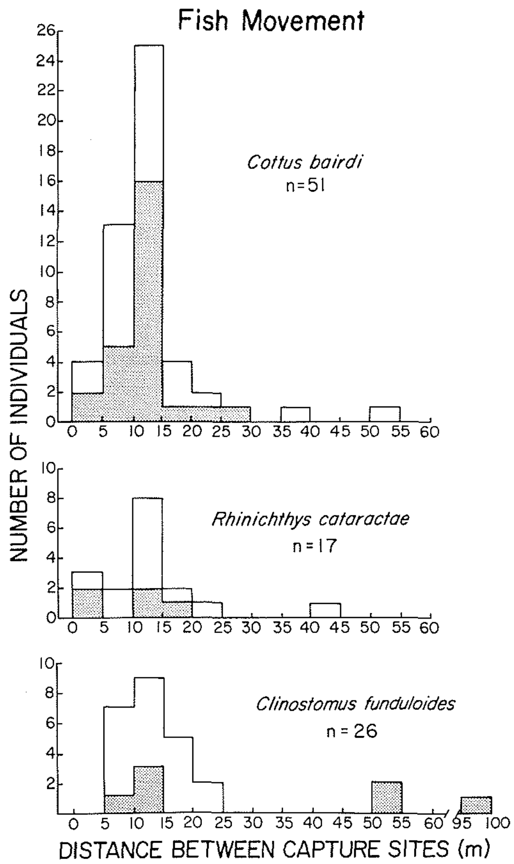

Fig. 1. Frequency distributions of recapture distances for *Cottus bairdi, Rhinichthys cataractae,* and *Clinostomus funduloides.* Open bars depict data prior to the May 1984 storm event, whereas hatched bars represent data collected after the storm.

loides may be affected by the magnitude and frequency of large scale storm events as well as by the presence or absence of structural refuges. Other studies yield conflicting results regarding the impact of floods on fish movements (large effects: Olmstead and Cloutman, 1974; small effects: Gerking, 1950; Minckley and Barber, 1971). Certainly, the degree of fish displacement detected during and after storms depends not only on the severity of the storms, but also on the habits of the fishes under study.

Few recaptured fishes exhibited large movements as revealed by intensive sampling above and below the study site. Because only one individual (*Clinostomus,* likely displaced by the storms) was found outside the study site, these species appear to be sedentary. This is in agreement with Gerking's (1950, 1953) conclusions regarding movements of other stream fishes, but opposed to the findings of Stefanich (1952) and Funk (1955). Some individuals may move or be transported outside their home ranges, a behavior which would allow for repopulation after experimental or accidental (e.g., toxic spill) defaunation (Olmstead and Cloutman, 1974).

Although studies exist on movements of stream fishes (Stefanich, 1952; Funk, 1955; Gerking, 1959; Logan, 1963; McCleave, 1964; Shetter, 1968; Brown and Downhower, 1982, among others), few investigations have been published on the home range of non-game species. Previous studies of *Cottus bairdi* movements suggest that the home range of *C. bairdi* was less than 50 m during 12 mo (Bailey, 1952) and 8 mo (McCleave, 1964) periods, respectively. Bailey (1952) and McCleave (1964) used electrofishers to capture specimens. Gerking (1950) pointed out that repeated electrofishing may result in increased movements or inaccurate capture locations of fishes. Shetter and Hazzard (1939) also found considerable movement of *Cottus* spp., but used seining as a collecting procedure. The biases of this collection technique are unknown. In contrast, Brown and Downhower (1982) estimated that mean movement between captures for *C. bairdi* was 1.2 m. In their study, tiles were added to a stream to increase the availability of nesting sites. Fish were collected using a capture box (Downhower and Brown, 1977) rather than by electrofishing or seining. Specimens also were uniquely marked which allowed for accurate estimates of movement. Unfortunately, Brown and Downhower's (1982) study lasted for only 1 mo. In addition, the experimental increase in shelter may have decreased movements artifactually.

We avoided problems associated with electrofishing and seining in our study by capturing fish underwater with hand-held nets. This procedure minimized fish displacement and also allowed the diver to identify specimens disturbed by the diver's presence. Unfortunately, our methodology did not yield high numbers of recaptures. Due to the limitations of our mode of capture and the need for individually identifiable marks, only a portion of the fish populations was marked; therefore, the probability of a marked individual being recaptured was low. This, in combination with mark loss and natural mortality, contributed to the low numbers of recaptures. The accuracy of our estimates could be improved through the use of smaller sections (i.e., <10 m) because most individuals did not move among sections (Table 1). This bias probably has caused our estimates to be higher than the true home ranges of the species examined.

Because the three species studied are the dominant components of the fish assemblage in Coweeta Creek, a test of assemblage regulation (sensu Grossman, 1982) could be performed in this system using a relatively small section of stream (e.g., 30 m, which encompasses the 95% CI of the largest home range estimate). Additionally, 30 m sections of other streams may be appropriate for assemblage regulation studies if the physical and biological characteristics are similar to those of Coweeta Creek. Home range may vary, however, in different systems. Limited food availability, for example, may cause organisms to range further in search of preferred prey. Similarly, physical characteristics, such as abundance of refuge sites, may influence home range. Thus, use of these home range estimates for fishes in widely differing systems would be inappropriate.

Our results show that home ranges of three abundant stream fishes were less than 20 m in stream length over an 18 mo period. Because these species typically do not live longer than 4 yr (Ludwig and Norden, 1969; Davis, 1972; Rohde and Arndt, 1981), this time period represents a considerable portion of their lifespan, and thus, is a reasonable assessment of home range.

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