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HOMING OF MORPHOLINE-IMPRINTED BROWN TROUT, *SALMO TRUTTA*

Homing for the purpose of spawning is well documented for lake-run brown trout, *Salmo trutta* (Stuart 1957; Niemuth 1967), but the mechanism by which they find their natal tributary is not understood. Our own recent studies on related species—coho salmon, *Oncorhynchus kisutch,* and rainbow trout, *Salmo gairdneri*—suggest that they become imprinted to the odor of their natal tributary when they begin their downstream migration and later use this information for homing (Hasler and Wisby 1951; Scholz et al. 1973, 1975, 1976; Cooper and Scholz 1976; Cooper et al. 1976). In these experiments 18-mo-old hatchery-raised fish were exposed to a synthetic chemical, morpholine, for 40 days and then stocked in Lake Michigan. During the spawning migration the fish homed to a simulated home stream which was scented with morpholine. Since the life cycle of migratory brown trout is similar to that of coho salmon and rainbow trout, we conducted the present study to determine if odor imprinting could be extended to brown trout. The methods used in this study were similar to procedures reported by Cooper and Scholz (1976) since both experiments were conducted concurrently.

Methods

In 1972, hatchery-raised, 18-mo-old brown trout fingerlings were transported to South Milwaukee, Wis. (Figure 1). The fish were marked with fin clips, divided into three groups of 300 each, and held in separate tanks at the South Milwaukee Water Filtration Plant. Lake Michigan water was supplied to all three tanks from an intake crib

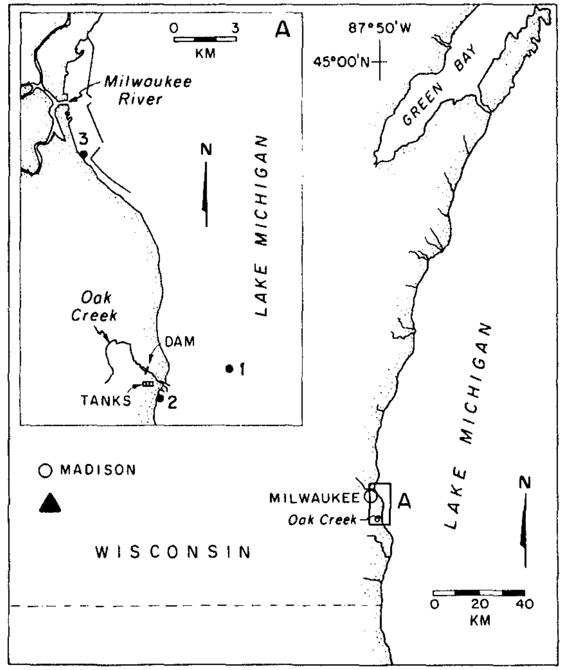

FIGURE 1.—Research area, South Milwaukee, Wis. (after Cooper et al. 1976). The solid triangle indicates the location of the hatchery where the fish were reared. Inset (A) shows detail of: 1) the water intake for the tanks at the South Milwaukee Water Filtration Plant, 2) the Oak Creek stocking site, and 3) the Milwaukee Harbor stocking site.

located 1.5 km offshore. Morpholine (C_4H_9NO) was metered into one tank for 34 days in May and June. This period was selected because it is the time when brown trout would normally begin their downstream migration (Stuart 1957; Niemuth 1967). A concentration of 5×10^{-5} mg/l morpholine was maintained in the tank throughout the exposure period.

The morpholine-exposed group and one unexposed control group were then stocked in Lake Michigan at Milwaukee Harbor, 13 km north of Oak Creek (Figure 1). The second control group was released at the mouth of Oak Creek. During the spawning migration in fall 1972 and 1973, morpholine was metered into Oak Creek at the same concentration used for imprinting. The stream was surveyed for marked fish by gillnetting, electrofishing, and creel-census methods (summarized in Table 1). Fish were unable to move past a dam situated 1.5 km from the mouth. Surveys began before the spawning migration started and continued until no fish were left in the river. The results are recorded in Table 2.

TABLE 1.—Summary of effort spent in monitoring Oak Creek during the spawning migrations of brown trout in fall 1972 and 1973. Creel-census surveys were conducted three to five times each day and electrofishing surveys were made once or twice each week. A total of 51 marked brown trout were caught by anglers; 17, by electrofishing; and 2, in gill nets.

Fall	Creel census	Electrofishing	Gill net
	Number of trips		
1972	274	11	62
1973	451	24	54

TABLE 2.—Recoveries of brown trout at Oak Creek in fall 1972 and 1973 from those released in spring 1972. Morpholine-exposed and control fish were released 13 km north of Oak Creek and a second control group was released at the mouth of Oak Creek. Fin clip: RP, right pectoral; LP, left pectoral; LM, left maxillary.

Experimental group	Fin clip	Number released	Number recovered 1972	1973	Total	Percent of fish stocked
Morpholine	RP	300	23	30	53	17.7
Control	LM	300	1	2	3	1.0
Oak Creek	LP	300	3	11	14	4.7

Results

A total of 53 morpholine fish (17.7% of the total number originally stocked) were captured as compared with 3 control trout (1.0%) released at Milwaukee Harbor and 14 control trout (4.7%) released at Oak Creek. Thus, the data show that morpholine-exposed brown trout returned to the scented stream in larger numbers than either control group. Both control and morpholine fish experienced uniform stocking procedures after the initial treatment. If the selection of the morpholine-scented stream were attributed to a cue learned after the treatment, we would have expected to capture as many control fish as morpholine-treated fish in the scented stream. The fact that this was not the case implies that the cue was morpholine. Therefore we conclude that morpholine-exposed brown trout used morpholine as a cue for homing. To locate the scented stream morpholine fish were able to search a distance of at least 13 km. This experiment should be repeated because of the low numbers of fish stocked but the results are of interest because of the high percentage of morpholine-exposed fish captured in the scented stream.

Discussion

In view of our findings it is of interest to consider two unpublished observations made by Stuart[1] on homing of brown trout at Dunalastair Reservoir in Scotland. In one case brown trout were marked in one branch of a forked stream which flowed into the reservoir. After the fish had migrated to the reservoir, all of the water from the home fork was diverted into a new channel. The original channel was also maintained with water from the second fork. During the spawning migration, adult trout homed to the new channel in preference to the channel by which they had entered the reservoir.

In the second instance Stuart reported that, when a different stream broke its banks, the stream bed below the break dried up and the entire flow of water was diverted into a marsh through which it percolated into the reservoir. During the spawning migration, brown trout congregated off the marsh where the percolating water entered the reservoir and not off the dry stream mouth.

Both of Stuart's observations clearly indicate that the fish homed to water originating from the home tributary, rather than to a specific home location and are, thus, consistent with our conclusion that it is a characteristic of the home water, specifically odor, which provides brown trout with homing cues.

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DIURNAL VARIATIONS IN CATCHES OF SELECTED SPECIES OF ICHTHYONEUSTON BY THE BOOTHBAY NEUSTON NET OFF CHARLESTON, SOUTH CAROLINA[1, 2]

The Boothbay neuston net is becoming a standard gear for collection of ichthyoneuston. Sherman and Lewis (1967) reported using this gear for collection of lobster larvae. Personnel participating in Cooperative Investigations of the Caribbean and Adjacent Regions (CICAR) activities have prepared a "Plan for Sampling the Early Development Stages of Pelagic Fish during CICAR Operations" which describes the use of the neuston net (FAO[3]). The Boothbay neuston net, initially adopted as the standard for the Marine Resources Monitoring, Assessment and Prediction Program (MARMAP), consists of a pipe frame 2 m wide by 1 m deep with an 8.5-m long net.[4] Because little was known concerning the sampling performance of this gear, an experiment was designed to test the operating characteristics of two types of frame (galvanized pipe and aluminum pipe) and two lengths of net (4.9 m and 8.5 m with ratios of mouth to open mesh aperture areas of 1:6 and 1:11, respectively). The nets were of 0.947-mm Nitex[5] mesh.

The results of the experiment defining the operating characteristics of the two types of frame and two lengths of net were described by Eldridge et al. (1977). The present report will describe mainly diurnal variations in catches of ichthyoneuston during the latter experiment, which was conducted during 9-15 July 1973 utilizing the RV *Dolphin*.

Materials and Methods

The neuston net was towed from a boom extending 3 m from the starboard side of the RV *Dolphin*, and the ship was ordered in an arc of radius 1 n.mi. or less to starboard to keep the net mouth out of the ship's wake. The net was towed so that one-half the height (0.5 m) was in the water.

Towing speeds of 1, 2, and 3 m/s were employed with a total of 48 tows being conducted. Twenty-four daylight tows were made between 1107 and 1627 EST and 24 night tows between 2206 and 0432 EST. After setting (which took an average of 29 s), nets were towed 10 min and then retrieved

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[2]Contribution No. 451 from the Southeast Fisheries Center, National Marine Fisheries Service, NOAA, Miami, Fla.

[3]FAO-UNDP Fisheries Program, Mexico City. 1970. A plan for sampling the eggs and larvae of the fishes of Mexican waters. Unpubl. manuscr.

[4]MARMAP is now using a 0.5 × 1 m neuston net.

[5]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.