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MOVEMENTS AND HABITAT SELECTION OF INTRODUCED ADULT LARGEMOUTH BASS (*MICROPTERUS SALMOIDES*) IN AN ILLINOIS LAKE

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ABSTRACT

The movements, home areas, and habitat selection of introduced adult largemouth bass (*Micropterus salmoides*) released in an Illinois lake were studied by radiotelemetry. The fish moved from their release sites along the edge of a macrophyte patch, and then remained in one location for a short time period (2-13 days). Thereafter, they swam around the lake or moved to another location where they remained for a few days. Average daily movements of individual fish, excluding those within home areas, ranged from 129 to 324 m. Maximum distances for each fish varied from 290 m to 680 m. The sizes of home areas varied from 0.01 to 3.15 hectares. Often, two or more radio-tracked fish occurred in the same home area or were swimming around the lake together. All of the introduced largemouth basss were usually located (51% to 59% of a tracking day) in an ecotone, i.e., edge of macrophyte patch. Heavy macrophyte patches were also heavily utilized. Habitat selection for ecotones was significantly greater ($p < 0.05$) than that for any other habitat. Habitat selection for heavy macrophytes was second to that of ecotones and significantly different ($p < 0.05$) from other habitats. Whether fish were located in an ecotone or macrophyte patch, they were usually found around or in a small patch of broadleafed *Potamogeton* sp.

INTRODUCTION

The purpose of our study was to examine the movements, home areas, and habitat selection of introduced largemouth bass (*Micropterus salmoides*) and to com-

pare their responses to native largemouth bass. The term, introduced largemouth bass, referred to fish that lived under natural conditions but were released and studied in a lake with which they were not familiar. Native largemouth bass were those familiar with the lake and presumably lived in the lake all of their lives. Intuitively, one would expect that an animal introduced into a new environment would spend some time exploring (Krebs, 1987). Winter (1976, 1977) documented such behavior for a single introduced largemouth bass in a Minnesota lake. This fish did not establish a home range in contrast to native largemouth bass which did. The behavioral responses of the introduced largemouth bass were compared to those reported for native largemouth bass (Fish and Savitz, 1983; Savitz *et al.*, 1983a,b; Tranquilli *et al.*, 1981; Warden and Lorio, 1975; Winter, 1976, 1977).

Warden and Lorio (1975) found that the initial response of largemouth bass released in a lake was to move around the lake; thereafter, fish would remain for varying lengths of time in one location or home area. They also found that largemouth bass remained in areas of shallow water which had physical cover and where there was deep water adjacent to the cover. Fish did travel between home areas, and the average daily travel distance appeared to be influenced by water temperature. Tranquilli *et al.* (1981) reported that the highest average travel distance occurred in a heated zone in Lake Sangchris; they also measured the maximum distance traveled by each of their fish. Fish and Savitz (1983) and Savitz *et al.* (1983a) examined habitat use and selection and found that largemouth bass selected ecotones, i.e., the edge of macrophyte beds. Savitz *et al.* (1983b) showed that forage availability influenced home range establishment and size for largemouth bass.

METHODS

Fish were captured by electro-fishing at the Max McGraw Wildlife Foundation in Dundee, Illinois, and by seine at Deep Lake in northern Illinois. They were transported to Loyola University and within a few weeks, radio transmitters were externally attached to the fish. The transmitters were manufactured by AVM Instrument Company, Dublin, California and weighed approximately 4.5 g. Most fish seemed to recover within an hour after transmitter attachment and this agreed with other observations (Gallepp and Magnuson, 1972; Ross and McCormick, 1981). None of the fish were in reproductive condition and they varied in size from 26.7 to 29.8 cm. Seven largemouth bass were released at the end of July and beginning of August, 1983, in Cedar Lake (114 hectares). Each fish was released one to three days after transmitter attachment.

Individual largemouth bass were placed in fish release boxes (Savitz *et al.*, 1983b) and lowered to the bottom of the lake ($\simeq$ 2 m depth) and released several hours later. Fish were released at two locations which were separated by a distance of approximately 200 m. At each location, there was a feeder (Savitz *et al.*, 1983b) from which minnows could escape. One feeder did not contain minnows; the other did, and minnows escaped from that feeder at a rate of ten minnows per hour (Savitz *et al.*, 1983b). Largemouth bass were released in this manner in order to compare the responses of introduced fishes to those previously reported for native fishes under similar conditions (Savitz *et al.*, 1983b). After the fish were released, triangulation was used to locate them. Fish were tracked several times per day for three to five days per week. The tracking began on July 25 and ended on August 26. All data

were collected during the day since there was little evidence of movement at night in this study as well as previous ones (Savitz *et al.*, 1983a). For determinations of movement distance each day, the distance between the first location of a fish on consecutive sampling days was determined.

Each fish's location was plotted on an enlarged map of Cedar Lake which included shore stations and dimensions of habitats measured in 1981. While the dimensions might have changed slightly, there were no obvious changes. The habitats were heavy macrophyte (H), primarily *Myriophyllum* sp.; light macrophyte (L), primarily *Potamogeton* sp.; sand (S), shallow areas without macrophytes; open water (O), and a minimum depth of approximately 6 m with no vegetation; and ecotone (E), 1.5 m on either side of a boundary between macrophyte beds and sand and/or open water. This boundary was usually distinct in Cedar Lake. The proportions of each habitat were 8.7% for heavy macrophyte, 8.9% for ecotones, 23.3% for open water, 27.2% for light macrophyte, and 31.9% for sand habitats.

In determining habitat utilization and habitat selection, procedures similar to those of Gilmer *et al.* (1975) and Fritzell (1978) were used. The following steps were used to compute habitat utilization. The proportions of tracked locations in each habitat for each fish in each tracking day were calculated. These proportions were added and divided by the total number of tracking days for each fish. This computation determined the average proportion of a tracking day spent in each habitat or habitat utilization (Fish and Savitz, 1983). For calculating habitat selection, the latter proportions were divided by the proportionate area of each habitat in the lake (Winter and Ross, 1982; Savitz *et al.*, 1983a). The habitat selections were ranked and a Friedman test which takes into account individual differences among the largemouth bass was used. If a significant difference in habitat selection was found, a multiple comparison test by rank was used (Zar, 1974).

The sizes of home areas were measured by the convex polygon method (Winter, 1977; Fish and Savitz, 1983), connecting the outermost fish locations to obtain the most convex polygon possible. Warden and Lorio (1975) and Hubert and Lackey (1980) felt that three or more consecutive days in one area was sufficient to indicate a home area. Fish and Savitz (1983) defined a home range with a minimum time period of five consecutive days, and this definition was followed in determining home areas in this study. Other aspects of the home areas were that the location of the fish was predictable from day to day (Ford, 1983), and fish moved about the home range (Fish and Savitz, 1983; Savitz *et al.*, 1983b).

RESULTS

Fish Movements

All of the fish had similar movements regardless where they were released; the supplementary forage did not influence their movements or use of home areas. They swam to a nearby macrophyte bed, swam along its edge for varying distances, and then remained in a particular area for two to thirteen days. Afterwards, they moved to a new area where they might remain for a short time period or, to use the description of Winter (1976), wandered around the lake. Often, two or more radio-tracked fish were located in the same home area or swimming together around the lake. Usually, these fish were not released on the same day or at the same location, and we did not know if other largemouth bass were swimming with the radio-tracked fish.

The average movements per day for our fish were between 129 and 324 m; these distances did not include those within a home area but included those between consecutive sampling days when fish were moving around the lake or between home areas. The maximum movement between consecutive sampling days varied from 290 m to 680 m. These distances were similar to those reported by other investigators (Warden and Loris, 1975; Tranquilli *et al.*, 1981). At water temperatures comparable to those during our study, Warden and Lorio (1975) reported an average movement distance between home areas of 303 m, and Tranquilli *et al.* (1981) found average daily movements from 91 m to 248 m. The maximum distances in Lake Shelbyville varied from 0.12 km to 14.34 km (Tranquilli *et al.*, 1981), but it would be impossible to approach the largest maximum distances in a small lake such as Cedar Lake (114 hectares).

Home Areas

Fish utilized home areas for variable periods of time (Warden and Lorio, 1975; Winter, 1977; Hubert and Lackey, 1980; Fish and Savitz, 1983). Six of the largemouth bass utilized a home area from five days (the minimum time period for a home range as defined by Fish and Savitz, 1983) to thirteen days (Table 1). Another largemouth bass utilized an area for two consecutive days. The median time period on a home area was 9.5 days. Home area size varied from 0.01 to 3.15 hectares (Table 1). Home areas for introduced largemouth bass were utilized for shorter time periods and were generally smaller than those for native largemouth bass. Fish and Savitz (1983) reported that native largemouth bass utilized home ranges between 0.24 and 2.07 hectares for 8 to 110 days. Savitz *et al.* (1983b) found home ranges varied from 0.05 to 0.10 hectares with increased levels of forage and in the absence of supplementary forage, home ranges increased in size to 0.79 and 7.17 hectares.

Introduced fish undoubtedly used these home areas for forage but these areas also afforded the fish protection. The home areas of LMB2 and LMB3 provided some evidence for this conclusion. Several days after LMB2 and LMB3 left their home area, LMB1, LMB2, LMB3, and LMB5 were found in this area on a day when there were strong winds and heavy wave action.

Habitat Selection

There was a significant difference ($x^2 = 25.94$, $p < 0.001$) in habitat selection: $\underline{E\ H\ LS\ O}$. Ecotone had the highest ranked selection which was significantly different ($p < 0.01$) from other habitats. The heavy macrophyte habitat was selected less than the ecotone but had significant ($p < 0.01$) greater selection than the remaining habitats. Ecotones were utilized 51% to 69% of an average tracking day, and heavy macrophytes were usually the second most utilized habitat (Table 2). When largemouth bass were located in heavy macrophytes or along ecotones, they were usually found among the stems of a broad-leafed *Potamogeton* sp. which occurred in small patches. Warden and Lorio (1975) found that most home areas were located where there was physical cover and the same conclusion was apparent for the introduced largemouth bass. Light macrophyte and sand habitats were not significantly different ($p > 0.05$) and LMB1 was the only fish located in open water.

DISCUSSION

In previous studies, largemouth bass movements and home areas were influenced by water temperature (Warden and Lorio, 1975; Tranquilli *et al.*, 1981), season (Ross and Winter, 1981), cover (Warden and Lorio, 1975), forage availability (Savitz *et al.*, 1983b), familiarity of fish with the lake (Winter, 1976). Undoubtedly, other factors such as fish size and lake size which might influence largemouth bass movements will be documented. In comparing movements, habitat selection, and home areas of our introduced largemouth bass to those of native largemouth bass, differences and similarities in factors which might influence the results must be discussed.

Our introduced largemouth bass were released at the same locations, in the same manner, and during the same months (July and August) as native largemouth bass in 1981 (Savitz *et al.*, 1983b). In addition, water temperatures were similar and the same investigator did the majority of the radio-tracking for the introduced largemouth bass and native largemouth bass (Savitz *et al.*, 1983b). The introduced fish did not respond in the same manner as the native fish. The difference might have been caused by some unrecognized factor or the introduced fish might not have been as aware of the differences in forage availability as those fish familiar with the lake. Higher levels of supplementary forage might have elicited a similar response as that with native largemouth bass. From a fisheries management perspective, stocking largemouth bass at the supplementary forage levels used in this study would not result in home range establishment in the vicinity of the feeder. Usually, when largemouth bass were stocked in lakes, fish size and stocking procedure were different than used in this study.

The movements of our introduced fish were similar to those reported by other investigators. Winter (1976) found that an introduced largemouth bass wandered around a lake, but was located in a small area, 0.4 hectare, for five consecutive days. Warden and Lorio (1975) and Tranquilli *et al.* (1981) found similar average movement distances as occurred in our study.

The habitat utilization and selection of introduced largemouth bass were similar to that of native largemouth, but there were also some differences. Introduced fish utilized ecotone and heavy macrophyte habitats with little difference between individual fish. Native largemouth bass were more frequently located in shallow sand bottom area and to a somewhat lesser extent in the ecotone habitat (Fish and Savitz, 1983). In the calculation of habitat selection, the area of each habitat was important, and, since the ecotone habitat had a much smaller area, the habitat selection for the ecotone was greater than that of shallow sandy bottom areas. However, there was no significant difference in selection between these habitats (Savitz, *et al.*, 1983a). Also, among native largemouth bass, there were individual differences in habitat utilization; two were more frequently located in heavy macrophytes (Fish and Savitz, 1983). The data on native fishes were collected in different months, May through December, than the introduced fish; however, no seasonal differences in habitat utilization of native fish were obvious (Fish and Savitz, 1983). It appeared that the introduced fish needed physical cover.

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Table 1. Home range sizes and residence time for stocked largemouth bass in Cedar Lake (LMB 5 never established a home range).

Fish	Home Range (hectares)	Residence Time (days)	Dates of Home Range
LMB 1	1.93	11	July 25 - August 4
LMB 2	0.01	5	August 1 - August 5
LMB 3	0.01	5	August 1 - August 5
LMB 4	0.10	10	August 2 - August 11
LMB 6	0.14	9	August 3 - August 11
LMB 7[a]	3.15	13	August 10 - August 22

[a]LMB 7 was caught by fisherman on evening of August 22.

Table 2. Habitat utilization by each fish presented as percent of an average tracking day in each habitat

Fish	Number of tracking locations	Number of tracking days	E	H	L	S	O
LMB 1	44	19	57.0	13.1	7.9	16.7	5.3
LMB 2	41	18	58.3	16.7	11.1	13.9	—
LMB 3	40	18	68.5	21.7	4.2	5.6	—
LMB 4	40	16	61.4	16.6	18.8	3.2	—
LMB 5	37	15	57.1	32.3	3.3	7.3	—
LMB 6	35	14	60.7	14.3	21.4	3.6	—
*LMB 7	26	9	50.9	6.4	13.0	30.7	—

*This fish was caught by fisherman in the evening on August 22, 1983.