Aspects of the life history of a freshwater population of the mummichog, *Fundulus heteroclitus* (Pisces: Cyprinodontidae), in the Bronx River, New York, U.S.A.

Jeanette M. Samaritan[1] & Robert E. Schmidt[2]
[1] *Fordham University, Bronx, NY 10458, U.S.A.*
[2] *Hudsonia Ltd, R. D. #4, Box 208, Newton, NJ 07860, U.S.A.*

Keywords: mummichog, landlocked populations, life history

Abstract

A freshwater population of the mummichog, *Fundulus heteroclitus,* was sampled during summer and autumn 1979, from the Bronx River, New York. Other occurrences in freshwater of this common estuarine cyprinodontid fish have been noted in Pennsylvania, New Hampshire and Canada. In the Bronx River, this species is a significant part of the fauna and is one of the few species found throughout the river system. Specimens were examined to determine the growth and diet. It appears that this freshwater population does not differ from its brackish water conspecifics with respect to age structure, growth rate and feeding behavior.

Introduction

Landlocked populations of estuarine and marine fishes generally exhibit reduced growth rates and smaller maximum sizes. These phenomena have been reported for at least Clupeidae, Salmonidae, and Osmeridae in North America (Scott & Crossman 1973).

The mummichog (*Fundulus heteroclitus*), a common Atlantic coast cyprinodontid, is generally regarded as a shallow water estuarine species which occasionally ascends into freshwater. Freshwater populations have been reported from the Susquehanna River drainage in Pennsylvania (Denoncourt & Cooper 1975; Denoncourt *et al.* 1975, 1978); several ponds in Windham, New Hampshire (Scarola 1973); Sable Island, Nova Scotia (Garside 1969; McAllister 1970); Digby Neck, Nova Scotia (Klawe 1957); and on Prince Edward Island (Hubbs *et al.* 1943). This species is landlocked and is very abundant throughout the Bronx River, New York (Schmidt & Samaritan 1980). Since little life history information is available for freshwater populations, we determined the age composition, growth and diet of the Bronx River fish to compare to brackish water populations.

Materials and methods

One hundred seventy-two specimens of *Fundulus heteroclitus* were collected by electrofishing and seining at 16 stations along the length of the Bronx River (Fig. 1), southeastern New York. All specimens were fixed in 10% formalin in the field and later transferred to 40% isopropanol. Collections were made 6–22 August 1979 and 4–26 October 1979. Concomitant with the fish collections, several water quality parameters were measured.

Total length (TL) was measured to the nearest millimeter; stomachs (length of gut from pharynx to first bend) were excised, and all food items were identified and counted. Stomach content data were expressed as frequency of occurrence, percent composition of diet and significance (Windell 1971). Scales were removed from just below the lateral line on the anterior left side, rinsed in water to rid them of mucus and pressed between glass slides. When

Hydrobiologia 94, 149–154 (1982). 0018-8158/82/0942-0149/$01.20.

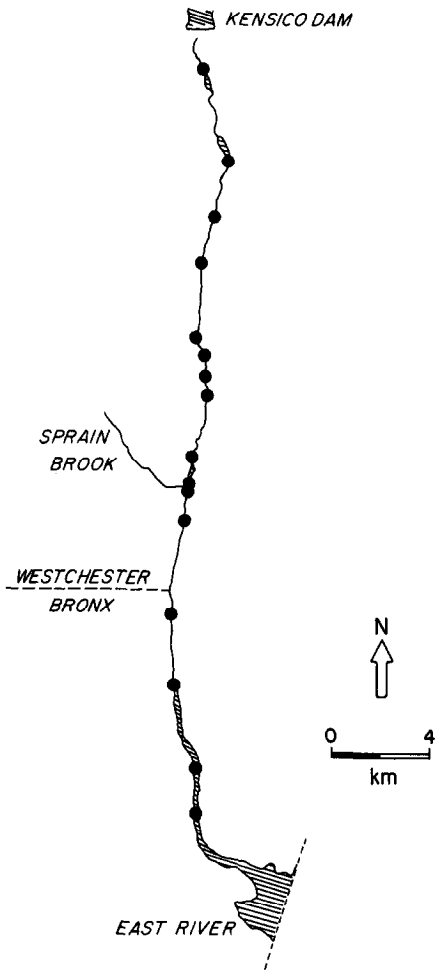

Fig. 1. Bronx River, NY, showing sampling sites for both August and October collections. *F. heteroclitus* were collected at all stations.

dry, scales were examined with a Bausch and Lomb microprojector (45X) and the scale radius and annular distances were measured. Back calculations of lengths at earlier ages were performed by an IBM 5100 computer.

Results and discussion

The Bronx River is low gradient with rocks covering much of the river bed. Its urban setting is reflected by the presence of refuse on the banks and in the water. The river and most of its tributaries are classified as 'C' or 'D' waters (not fit for drinking or swimming) according to New York State classification of surface waters (Anon. 1977a). Within the Bronx, New York City, two raw sanitary sewers, seven combined sewers and one storm sewer discharge into the river. In Westchester County illegal connections into storm sewers may be responsible for raw sewage input (Anon. 1977b).

Despite the poor water quality in the lower river and the variability of the substrate (silty to rocky), *Fundulus heteroclitus* was found at all stations. Bigelow & Schroeder (1953), Pickford *et al.* (1969) and Voyer & Hennekey (1972) considered them as a tolerant species. The only other species with such cosmopolitan distributions in the Bronx River were

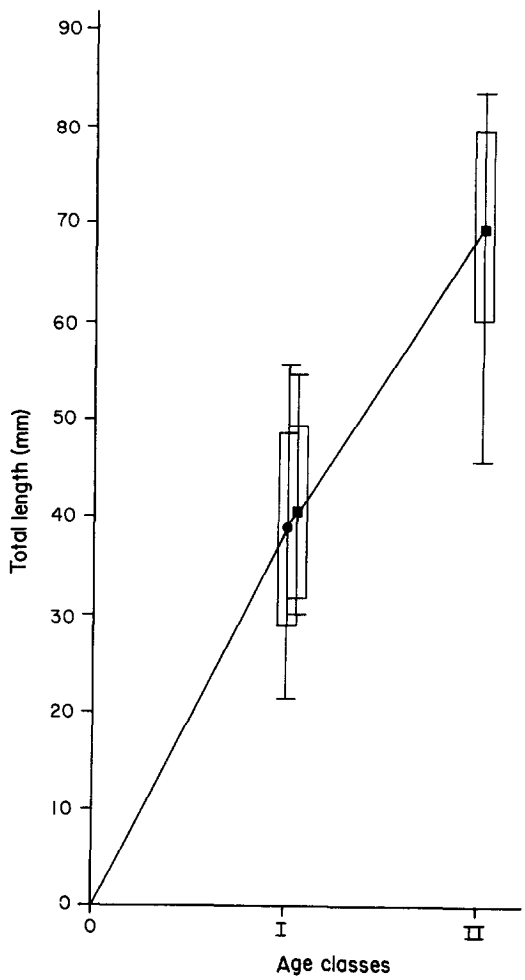

Fig. 2. Mean of I+ (•), mean of II+ (▪), range (single vertical lines), and standard deviation (vertical rectangles) of back calculated lengths of *F. heteroclitus* from the Bronx River, NY. Mean growth is 40 mm/yr for I+ Individuals and 30 mm/yr for II+ individuals.

Etheostoma olmstedi (Percidae) and *Anguilla rostrata* (Anguillidae), also considered tolerant species. Prior to this study, the mummichog was recorded in the Bronx River (W. R. Whitworth, pers. comm.) in June 1974 at the Scarsdale railroad station. Previous surveys (Greeley 1936; W. H. Kelly, pers. comm.) did not include this species.

In the course of sampling, we observed juveniles in the riffles often in very shallow, quiet areas among the rocks or in shallows right on the shoreline. Adults seemed to prefer the deeper areas for their habitat. We frequently caught adults under falls or in deep areas in the riffles. We did not collect any mummichogs in the large open pools that we sampled.

Only three age classes were sampled. The annual growth rate was 40 mm and 30 mm the first and second year, respectively (Fig. 2). Young-of-the-year accounted for 55% of the specimens collected and ranged in length from 18 to 67 mm TL. The October collection consisted entirely of juveniles (41 specimens). Mummichogs in their second growing season (I+) include 27% of the sample and were 40–77 mm TL: those in the third growing season (II+) encompassed 18% with a range of 71–101 mm TL.

The age composition and length distribution of the population we examined are similar to those of the freshwater population reported by Denoncourt *et al.* (1978) in the Susquehanna River drainage, Pennsylvania (Fig. 3). The age classes of the specimens we caught during August fit into a similar distribution; however, we feel that our October sample, which consisted of only juveniles, reflects sampling bias and does not indicate mortality of larger fish.

The population of mummichogs in the Bronx River appears to be younger than their estuarine counterparts since we took no III+ specimens. Valiela *et al.* (1977) found III+ individuals in a Massachusetts salt marsh population of *Fundulus heteroclitus*. However, the inclusion of this age class may

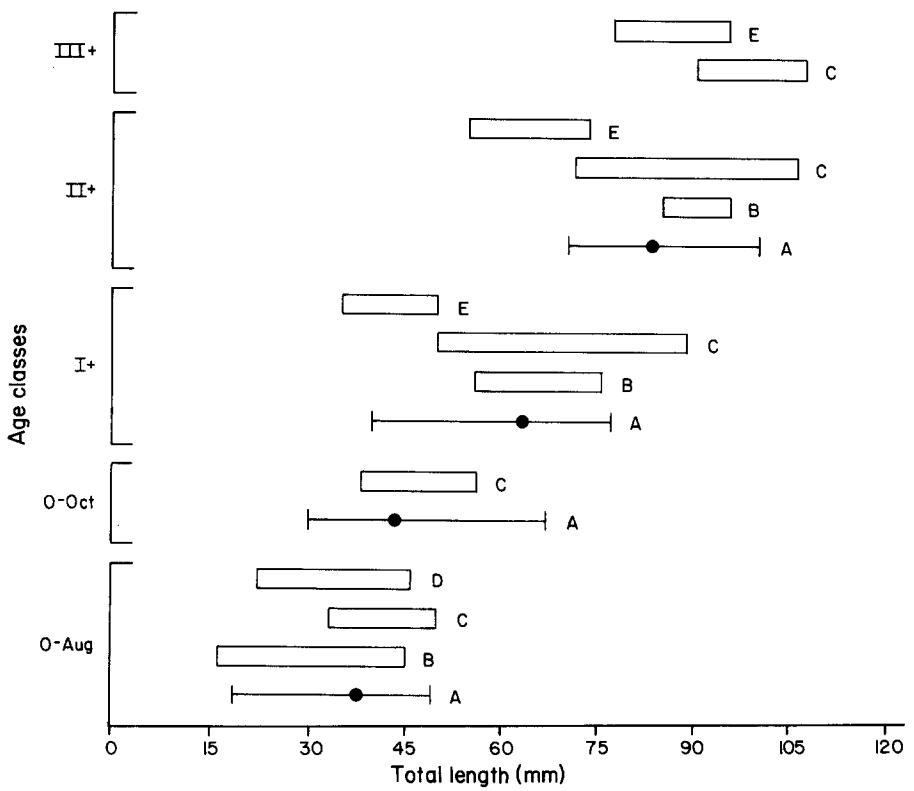

Fig. 3. Comparison of age and length of Bronx River *F. heteroclitus* (N = 172) to those in the literature. (A) This study; (B) Denoncourt *et al.* (1978); (C) Valiela *et al.* (1977); (D) Richards & McBean (1966); (E) Fritz & Garside (1975). Solid circles are the mean lengths in our collections; horizontal lines capped by vertical bars are the ranges of lengths.

be a reflection of their very large sample size. Hence, our catch of 172 specimens may have been inadequate to demonstrate the presence of III+ individuals in the Bronx River. Investigators agree that the species does not survive beyond a fourth growing season (Fritz & Garside 1975). Data given by Richards & McBean (1966) and Valiela *et al.* (1977) do not suggest that there is any difference in growth for any age class between our landlocked and their brackish water populations (Fig. 3). The consistently smaller size of Fritz & Garside's (1975) specimens is probably a reflection of the latitude (Nova Scotia) where they were collected. No difference in growth rates for freshwater or estuarine populations was revealed by their study.

The distribution of mummichogs throughout the length of the Bronx River and the age of the specimens suggest that these fish have had considerable time to establish themselves in the river. Perhaps their presence is due to bait bucket introduction since the Bronx River once was the site for community recreation and a 7.2 km stretch of the river still supports a put-and-take trout fishery. Previous surveys (Greeley 1936; W.H. Kelly, pers. comm) could have missed this species because habitats preferred by mummichogs are not usually sampled.

Table 1. Analysis of food habits of *F. heteroclitus* for specimens taken during summer and fall in the Bronx River, NY. (Computations were made on the basis of contents of the 120 stomachs containing material). The inclusive taxa (e.g. insects) do not represent the sum of preceding values in each column but are the recomputed numbers for the incidence of any item in that group in the diet.

Food item	% composition	% occurrence	significance (S)
Chironomid - larvae	50	72	60
- pupae	6	21	11
- adults	8	28	15
Dipteran - larvae	6	9	7
Tipulid - larvae	0.2	2	0.65
Trichopteran - larvae	2	9	4
Insect parts (adult)	7	10	8
Unidentified adult insects	0.6	8	2
INSECTS	78	84	81
Copepods	15	23	19
Amphipods	2	8	4
Cladocerans	0.1	2	0.5
CRUSTACEANS	17	33	24
Bivalves	0.4	3	1
Snails	3	18	7
MOLLUSCS	4	22	9
Oligochaetes	0.1	0.8	0.3
Polychaetes	0.3	3	1
ANNELIDS	0.4	3	1
Blue-green algae		0.8	
Filamentous green algae		18	
Filamentous red algae		0.8	
Diatoms		5	
ALGAE		23	
Seeds		4	2

Perhaps because of the difficulty in seining the localities in which the mummichogs are found, these areas may have been skipped during those collections (most of our specimens were taken with an electroshocker). Additionally, other species which were not recorded in those surveys were collected by us (*Semotilus atromaculatus, Notropis hudsonius*).

Examination of stomach contents shows that the mummichog's diet primarily consisted of a variety of benthic invertebrates (Table 1). Chironomid larvae were the most frequently ingested (% occurrence = 72) and most significant (S = 60) food item. Other insect larvae and adults comprised much of their diet, the pooled significance value for insects being 81. Copepods (S = 19) and snails (S = 7) often appeared in the stomachs, particularly at certain stations. Algae, detritus, sand and pebbles were present probably as a consequence of feeding off the bottom. The juveniles which made up the October sample either had empty stomachs (34%) or had only a few food items present. Taking into consideration the average water temperature during the autumn sampling period ($\bar{X}$ = 12.5 °C) as compared to that during the summer ($\bar{X}$ = 22.4 °C), the decline in temperature probably accounts for the decreased feeding activity. The omnivorous nature of these mummichogs and the tendency to be benthic feeders agrees with other reports on the food habits of saltmarsh specimens (Bigelow & Schroeder 1953; Valiela *et al.* 1977; Kneib & Stiven 1978).

Summary

It appears, in respect to the parameters we measured, that the Bronx River freshwater mummichog population differs from estuarine populations only in its salinity regime. Age, growth and feeding behavior are similar among populations of both habitats. The attractive hypothesis that freshwater environments are in some way inferior for growth of estuarine or marine species is not applicable for at least one cyprinodont.

Acknowledgements

We would like to thank Mrs. R. Anderberg, Mr. A. Horn and Ms. M. E. Harris of The Bronx River Restoration for making this study possible. Funds were made available for research through a grant from the EXXON Corporation administered by The Bronx River Restoration to JMS. The field assistance of A. Pappantoniou, K. Rivlin, and J. Potoczek is appreciated. The critical review of this manuscript by Dr. G. Dale and Dr. W. Whitworth is acknowledged.

References

Anon. 1977a. Areawide Waste Treatment Management Plan, Westchester County. 208 Exhibit II-3.

Anon. 1977b. 208 Water Quality Task Force Report #523 Part V. Local Tributary Studies. Hazen & Sawyer Environ. Engineers, New York.

Bigelow, H. B. & Schroeder, W. C., 1953. Fishes of the Gulf of Maine. Fish. Bull. #74: 1-577.

Denoncourt, R. F. & Cooper, E. L., 1975. A review of the literature and checklist of fishes of the Susquehanna River drainage above Conowingo Dam. Proc. Pa. Acad. Sci. 49: 121-125.

Denoncourt, R. F., Fisher, J. C. & Rapp, K. M., 1978. A freshwater population of the mummichog, Fundulus heteroclitus, from the Susquehanna River drainage in Pennsylvania. Estuaries 1: 269-272.

Denoncourt, R. F., Robbins, T. W. & Hesser, R., 1975. Recent introductions and reintroductions of the Pennsylvania fish fauna of the Susquehanna River drainage above Conowingo Dam. Proc. Pa. Acad. Sci. 49: 57-58.

Fritz, E. S. & Garside, E. T., 1975. Comparison of age composition, growth and fecundity between two populations each of Fundulus heteroclitus and F. diaphanus (Pisces: Cyprinodontidae). Can.J. Zool. 53: 361-369.

Garside, E. T., 1969. Distribution of insular fishes of Sable Island, Nova Scotia. J. Fish. Res. Bd Can. 36: 1390-1392.

Greeley, J. R., 1936. Fishes of the area with annotated list. In: A Biological Survey of the Lower Hudson Watershed. Suppl. 26th Ann. Rept., Part II, pp. 45-103.

Hubbs, C. L., Walker, B. W. & Johnson, R. E., 1943. Hybridization in nature between species of American cyprinodont fishes. Contr. La. Vert. Biol. Univ. Mich. (2): 1-21.

Klawe, W. L., 1957. Common mummichog and newt in a lake on Digby Neck, Nova Scotia. Canadian Field - Natur. 71: 154-155.

Kneib, R. T. & Stiven, A. E., 1978. Growth, reproduction, and feeding of Fundulus heteroclitus (L.) on a North Carolina salt marsh. J. exp. mar. Biol. Ecol. 31: 121-140.

McAllister, D. E., 1970. The fresh and brackish water fishes. In: Fauna of Sable Island and its zoogeographic affinities. Nat. Mus. Natur. Sci. Publ. Zool. 4: 38-43.

Pickford, G. E., Grant, F. B. & Umminger, B. L., 1969. Studies on the blood serum of the euryhaline cyprinodont fish, Fundulus heteroclitus, adapted to fresh or to salt water. Trans. Conn. Aca. Arts Sci. 43: 25-70.

Richards, S. W. & McBean, A. M., 1966. Comparison of post-larval and juveniles of Fundulus heteroclitus and Fundulus majalis (Pisces: Cyprinodontidae). Trans. Am. Fish. Soc. 95: 218–226.

Scarola, J. F., 1973. Freshwater Fishes of New Hampshire. N. H. Fish & Game Dept., Concord, NH. 131 pp.

Schmidt, R. E. & Samaritan, J. M., 1980. A survey of the ichthyofauna of the Bronx River. Rept. Bronx River Restoration Project. 26 pp.

Scott, W. B. & Crossman, E. J., 1973. Freshwater fishes of Canada. Fish Res. Bd Can., Bull. 184: 966 pp.

Valiela, I., Wright, J. E., Teal, J. M. & Volkmann, S. B., 1977. Growth, production, and energy transformation in the salt marsh killifish, Fundulus heteroclitus. Mar. Biol. 40: 135–144.

Voyer, R. A. & Hennekey, R. J., 1972. Effects of dissolved oxygen on two life stages of the mummichog. Prog. Fish.-Cult. 34: 222–225.

Windell, J. T., 1971. Food analysis and rate of digestion. In: Ricker, W. E. (Ed.) Methods for Assessment of Fish Production in Fresh Waters pp. 215–226. IBP Handbook No. 3. Blackwell Scientific, Oxford.

Received 10 August 1981; accepted 15 October 1981.