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Hypersaline Bays as an Environment of Young Fish

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Abstract

Investigations on the hydrological properties of the bays of Curacao have shown that the water is hypersaline during most of the year. Although the water is rather turbid, its fertility is very low compared with continental bays. Nevertheless, the bays are crowded with young fish, especially juveniles of *Mugil, Atherina, Elops,* and *Harengula.* Environmental factors that may attract these juvenile fish are discussed. It is not unlikely that, just as in elvers, it is some organic compound that attracts the fish.

CURAÇAO IS AN ISLAND of 450 square km, only 75 km from the Venezuelan coast, surrounded by clear oceanic water without any trace of continental influence. The island has many shallow lagoons and inland bays, all with exits to the Caribbean Sea. The tidal differences are minute, about one foot, so the daily exchange of water between the bays and the sea is small. The bays and lagoons are mostly hypersaline as evaporation is high (4-7 mm a day) and rainfall is low (50 cm a year). Great efforts are made to conserve rainwater and prevent its loss by run-off from the land into the bays.

As in continental brackish waters, the hypersaline Curaçao bay waters are poor in numbers of species of plants and fish, but are rich in numbers of individuals. In the saltiest waters the same species are to be found which are common in almost fresh water: the seagrass, *Ruppia maritima;* the chenille algae, *Batophora oerstedti;* the killifishes, *Cyprinodon dearborni, Mollienesia sphenops, Rivulus mamoratus;* the gobies, *Dormitator maculatus* and *Eleotris pisonis;* mullets; silversides; and halfbeaks. In less hypersaline waters, juvenile forms of ladyfish, tarpon, mojarra, grunt, grouper, snapper, parrotfish, and barracuda are especially abundant.

In Curaçao there is great demand for live baitfish. As only mullet seems to be available in quantities, we tried to find a way to increase the yield of young mullet. This can be accomplished by improved fishing techniques, by attracting larvae from the open sea, or by cultivating the mullet.

First, the habitat of the young mullet had to be studied. Research on the fertility of the inland bays was started during the first half of 1962. The investigations were carried out by Mr. W. Ch. de Kock of Amsterdam University, Holland, and Mr. W. J. J. O. de Wilde of Leiden University, Holland. Their results will be published soon. The following survey has been compiled, mainly from their report but also from other sources.

TABLE 1

COMPARISON OF INLAND BAY AND OPEN SEA HYDROGRAPHIC CONDITIONS AROUND CURAÇAO

	Inland Bays		Sea	
	Average	Range	Average	Range
Salinity in ppt	36-39	36-47	36	35.9-36.1
Temperature in °C	27-29	25-31	27	25-28
pH	7.9	7.8-8.1	7.9	7.9
Oxygen % sat.	104	92-130	103	98-112
B.O.D. (20-23 C)	0.4	0.04-0.98	0.4	0.0-1.05
Total P (μg-at/L)	0.6	0.1-0.9	0.1	0.1-0.2
PO4" (μg-at/L)	0.1	0.0-0.5	0.0	0.0-0.5
Chlorophyll mg/m^3	0.2	0.0-0.5	0.1	0.0-1.0
Secchi disc-visibility in m	2.0	0.65-4	>40.0	—
KMnO4 - value (mg/L)	0.9	0.0-1.8	0.0	0.0-0.1

From Table 1 it is clear that the inland bays of Curaçao are poor in nutrients when compared with most continental bays. Piscaderabay has been omitted, as it is nutritionally rich only because of sewage.

After the preliminary chemical studies were completed, we began research into the behavior of mullet. Probably all of our experiments have been performed with young of *Mugil liza* (syn. *M. brasiliensis*), but the identification of the species, especially in juveniles, is difficult. Single small fishes of 3-6 cm were caught and placed in aquaria where each could choose between two types of water partly divided by a glass wall. The fish could swim from one part to the other (for techniques see Baggerman 1957, p. 116). Five times, at intervals of about 2 hours, the fish were observed for 15 minutes. During these periods the time each fish spent in each compartment was noted. The length of their stay was taken as a criterium of their preference. There is no reason to believe that the fish were passively trapped. In each series 50 individuals were tested.

In the first series (Table 2, series A), the fish had a choice between normal seawater and (hypersaline) bay water. The mullet showed a marked preference for bay water. This preference cannot have been caused by differences in temperature, pH, or oxygen content since these factors were kept the same in both experiments.

TABLE 2

PREFERENCE OF 50 SINGLE YOUNG MULLET WHEN BEING PRESENTED THE CHOICE BETWEEN DIFFERENT TYPES OF WATER

Series	Type of water I	Type of water II	Preference for
A	seawater, during day	bay water, during day	II, 86%
B	" in darkness	" in darkness	II, 78%
C	" (36 ppt)	" diluted to 19 ppt	II, 82%
D	" passed filter paper	" passed filter paper	II, 80%
E	" passed charcoal	" passed charcoal	II, 52%
F	" unfiltered	" passed charcoal	I, 68%
G	bay water, unfiltered	" partly filtered	I, 72%

Salinity does not affect the preference, as the preference for bay water did not change after this water had been diluted with distilled water (series C). Food particles or other particles probably are not of importance, as the preference of the mullet did not change after the water had been filtered over filter paper (series D). However, when the water had passed a Norit charcoal filter, the mullet lost their preference for bay water almost completely (series E). If only the bay water was filtered over charcoal and the seawater was left unfiltered, the fish showed a small preference for seawater (series F).

The charcoal filter is likely to affect the water in two ways. First, the water becomes clear and this might have influenced the choice of the fish in a negative way. However, when the test was performed in complete darkness (series B), it showed that the preference for turbid water could not have been caused by a visual stimulus. The second way that charcoal filtration affects the water is that it is supposed to remove all organic compounds. Creutzberg (1961) proved that elvers are attracted by some organic compound present in inland water, and from our experiments one is inclined to think that the same mechanism holds for mullet.

If the amount of dissolved organic compounds has been halved (series G) by filtering only one-half over charcoal, the fish prefer pure bay water; so they are apparently able to distinguish between different concentrations of whatever substance is attractive to them. It would be interesting to know which organic compound might be responsible, but no work has been done in this respect.

Some additional experiments were carried out with the brown shrimp, *Penaeus aztecus*, and with *Cyprinidon dearborni*, a fish that is known from both fresh and hypersaline water. Both species were tested with unfiltered water, and with water filtered over charcoal as in series A and E. Both species showed a preference for unfiltered bay water. This preference was lost after the water had been filtered. From these experiments it seems clear that the abundance of fish and invertebrates in shallow bays does not necessarily imply that salinity, temperature, or food are the factors that attract them. On the other hand, it is clear that these factors will be very important in determining growth and survival.

From the above experiments we can only say that the animals apparently prefer bay water. We do not know how they reach that habitat. It might be that the organic compounds act only as a stimulus and that there are other factors such as currents which help in guiding or transporting animals toward the mainland bays.

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