SULFIDE SENSITIVITY IN FISHES OF THE INDIAN RIVER LAGOON, FLORIDA

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ABSTRACT. Lagoon fishes, in netted holding cages, were placed in an impounded salt marsh and submitted to a gradient of sulfide-rich artesian well water. Near the well head, all specimens of 13 species died within 5–45 min, while all individuals of 5 species survived. More distant from the well, survival time increased sufficiently to rank species in approximate order of sensitivity to sulfide.

Mosquito Control Agencies along Florida's central East Coast use impounded marshes as part of their source reduction program. During the fall through late spring months culverts are opened to allow exchange of water, nutrients and aquatic organisms between the Indian River lagoon and the impoundments. During fall drawdown of impounded water, massive fish kills have often been observed. When surface water is drawn down first, the remaining marsh water would be suddenly enriched in sulfide, produced by anaerobic decay of bottom vegetation, and presumably kill the fish. On the other hand, in the perimeter ditch of an impoundment in Indian River County, FL, several fish species were observed in an area with 2 mg sulfide per liter at the surface (Van Handel 1987). Laboratory studies have established toxicity of sulfide both in fresh water (Adelman and Smith 1970) and salt water (Bagarinao and Vetter 1989) species.

We investigated sulfur sensitivity of fish from the Indian River lagoon and mosquito control impoundments. Specimens were collected with a 30 × 2 m seine with 5 cm mesh, and a 15 × 2 m seine with 2 cm mesh. Fishes were transported in an aerated container and tested the same day in an impounded mangrove marsh at the Florida Medical Entomology Laboratory. Three 1 m^3 frames were constructed from plastic pipe and covered with 1 cm mesh netting, except at the top. An artesian well provided sulfide-rich water through a 10 cm wide pipe controlled by a valve. Fourteen catches, a total of about 700 specimens, were tested from April to July 1990. One cage was placed within 1 m of the well head, a second one (central cage) about 5 m downstream, and a control cage, about 15 m downstream. Temperatures varied between 27 and 31°C. During the experiments, salinity in the 3 cages remained the same. Each cage received, as close as possible, an equal number of specimens from each species. No species was recorded unless at least 2 specimens per cage were available. Individual specimens of several additional species, not available in sufficient numbers, died in a rising sulfur level, but were not listed. Because of the usually small number of specimens per test, especially for the larger game fish, results were recorded when all specimens of the species were dead, rather than as a 50 or 90% lethal dose as is customary in laboratory experiments. None of the specimens in the control cage died during the time that none of the sulfide-sensitive species in the 2 experimental cages survived. Sulfide in the cages was measured (Van Handel 1987) using calcium sulfide as a standard, at the well head every 5 min, and in the central cage every 10 to 15 min. The control cage remained sulfide-free throughout the experiments. The water column in the cages varied between 60 and 80 cm.

After a one hour acclimation period, the valve of the well was opened. In the cage near the well head, sulfide rose to 4.5–5.0 mg/liter in less than 5 min and then remained constant. These high sulfide levels were acutely toxic to 13 species, with mortality between 2 and 45 min and nontoxic to 5 others. The non-sensitive species *Cyprinodon variegatus* (sheepshead minnow), *Fundulus grandis* (gulf killifish), *Fundulus similis* (longnose killifish), *Lucania parva* (rainwater killifish) and *Gambusia affinis* (mosquito fish) survived over 24 h at that sulfide level. Resident mosquito fish was commonly seen at the outflow of the artesian well.

Oxygen assays, in the presence of sulfide, are considered unreliable and therefore not attempted. It is unlikely that acute mortality was due to sudden oxygen depletion. On the contrary, the outflow of the artesian well from the 10 cm pipe about 35 cm above the water surface caused severe turbulence and aeration that did not occur at the control cage. Furthermore, nonsensitive species would not have survived without oxygen. Even if sudden death was caused by oxygen depletion, the depletion itself was due to sulfide, and therefore would not affect the results. It is unlikely that artesian well water contained any other component detrimental to fish. This was tested by letting artesian well water age for several days in barrels until sulfide had disappeared. Specimens of striped mullet,

Table 1. Sulfide toxicity in fishes of the Indian River lagoon, Florida, subjected to a slowly rising sulfide level. The data summarize mortality in 217 specimens of 13 species collected over a 4 month period in 14 separate experiments. At the time that all specimens subjected to the sulfide gradient had died, no mortality occurred in controls. The total number of fishes tested for each species is *n*.

Names	Toxic sulfide concentration (mg/liter)	*n*
Spanish sardine, *Sardinops sagax*	0.4	12
Pigfish, *Orthopristis chrysoptera*	0.7	26
Silver perch, *Bairdiella chryoura*	1.5–1.8	12
Grunt, *Haemulon* spp.	1.5–1.8	12
Spot, *Leiostomus xanthurus*	1.5–1.8	22
Spotted seatrout, *Cynoscion nebulosus*	1.5–1.8	13
Silver jenny, *Eucinostomus gula*	2.0–2.5	17
Yellowfin mojarra, *Gerres cinereus*	2.0–2.5	22
Sheepshead, *Archosargus probatocephalus*	2.0–2.5	9
Atlantic croaker, *Micropogonias undulatus*	2.0–2.5	16
Striped mullet, *Mugil cephalus*	2.6–2.8	7
Pinfish, *Lagodon rhomboides*	2.6–2.8	40
Red drum, *Sciacnops ocellatus*	2.6–2.8	9

pinfish, and spot survived for many hours but died soon after being transferred to fresh artesian water.

To link mortality more quantitatively to sulfide, the central cage was used in which the sulfide level rose to a maximum of about 3 mg/liter in several hours. Spanish sardine died shortly after sulfide became detectable whereas red drum was the last of the sensitive species to die.

Table 1 lists the order of sensitivity to sulfide for 217 specimens of 13 species, collected over a 4 month period, tested in the central cage. As mentioned before, no mortality occurred in the same number of specimens in the control cage. It may be assumed that toxicity will occur at much lower sulfide levels when exposure time is increased.

These experiments demonstrate that death of fish by sulfide poisoning may occur when sulfide is enriched by drawing down sulfide-free surface water ahead of bottom water. The study may help improve design of impoundments used for control of salt marsh mosquitoes.

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