COMPARISON OF AVOIDANCE RESPONSES OF AN ESTUARINE FISH, *FUNDULUS HETEROCLITUS*, AND CRUSTACEAN, *PALAEMONETES PUGIO*, TO BIS (TRI-N-BUTYLTIN) OXIDE

ALFRED E. PINKNEY, LENWOOD W. HALL, Jr., MICHAEL J. LENKEVICH, DENNIS T. BURTON

The Johns Hopkins University, Applied Physics Laboratory, Aquatic Ecology Section, Shady Side, MD 20764 U.S.A.

and

SCOTT ZEGER

The Johns Hopkins University, School of Hygiene and Public Health, Department of Biostatistics, Baltimore, MD 21205 U.S.A.

(Received April 10, 1984; revised June 18, 1984)

Abstract. Avoidance responses of an estuarine fish, mummichog (*Fundulus heteroclitus*), and crustacean, grass shrimp (*Palaemonetes pugio*) to the antifoulant bis (tri-n-butyltin) oxide (TBTO) were evaluated. Four out of six groups of mummichogs tested at 1.0 μg total organic Sn L⁻¹ showed avoidance. Total organic Sn concentrations of ≥ 3.7 μg L⁻¹ were avoided by this fish species in all cases. Higher concentrations of total organic Sn did not result in greater avoidance responses. Grass shrimp did not avoid total organic Sn concentrations between 2.3 and 30.0 μg L⁻¹. Response data at 2.3 and 30 μg L⁻¹ were similar. Mummichogs and grass shrimp differed greatly in their abilities to avoid potentially adverse concentrations of total organic Sn. Since mummichogs are major predators of grass shrimp, these behavioral responses may have important implications for tidal marsh ecosystems.

1. Introduction

Mobile aquatic organisms often have the ability to detect and avoid chemical and physical agents in the environment (Giattina and Garton, 1983). In some cases avoidance reactions can mitigate the effects of pollutants. However, reduced long term survival of organisms that avoid toxicants can occur as a consequence of physiological or ecological stresses resulting from these movements (Olla et al., 1980). Data on the avoidance responses of fish and invertebrates are important additions to standard toxicity test results for hazard assessment (Cherry and Cairns, 1982).

A major source of organotin compounds in the aquatic environment is their use in antifouling paints. Zuckerman *et al.* (1978) estimated that annual U.S. consumption of biocidal organotins (primarily as antifoulants) was 0.9 × 10⁶ kg in 1976; projected consumption figures for 1986 are approximately 4.5 × 10⁶ kg. Bis (tri-n-butyltin) oxide (TBTO), an active ingredient in antifouling paints, is lethal to fish and invertebrates at low μg L⁻¹ levels (Seinen *et al.*, 1981; Ward *et al.*, 1981; Laughlin and French, 1980; U’reen, 1983). TBTO has been found in fresh and marine waters at concentrations as high as 2 to 3 μg L⁻¹ (≈ 0.8 to 1.2 μg L⁻¹ total organic Sn) in areas associated with the use of antifouling paints (Maguire *et al.*, 1982; Waldock and Miller, 1983).
There are few data on the avoidance responses of estuarine biota to organotin compounds. Hall et al. (1984) reported that juvenile striped bass (Morone saxatilis) and Atlantic menhaden (Brevoortia tyrannus) did not avoid TBTO at concentrations found in the environment. The present study was designed to evaluate the avoidance responses of mummichog (Fundulus heteroclitus) and grass shrimp (Palaemonetes pugio) to TBTO. These species were selected for the following reasons: (1) to provide a comparison of TBTO avoidance responses between an estuarine fish and a crustacean; (2) to document avoidance responses by key species found in tidal marsh ecosystems (Welsh, 1975; Weisberg et al., 1981); and (3) the habitats of these species may be affected by organotin compounds resulting from water craft activity.

2. Materials and Methods

2.1. General Procedures

*F. heteroclitus* (mean total length = 7.3 cm) and *P. pugio* were collected from the Parrish Creek area of Chesapeake Bay near Shady Side, MD. At the time of collection ambient water temperature was approximately 25 °C. Both species were acclimated under continuous flow conditions for ≥ two weeks (fish) and ≥ three days (shrimp). Mummichogs were fed finely ground trout chow daily. Grass shrimp were fed a flake fish food (TetraMin) several times a week. A photoperiod simulating natural conditions was used during the acclimation period for both species. A light intensity of approximately 970 lux at the water surface was used during the avoidance tests. Water quality parameters during acclimation and testing for both species were as follows: temperature, 22 to 27.5 °C; pH, 7.0 to 7.7; dissolved oxygen, >4.5 mg L⁻¹ and salinity, 9.9 to 11.2‰.

2.2. Experimental Procedures

Avoidance tests were conducted during daylight hours in a modified dual subtrough (2.44 × 0.23 × 0.31 m) avoidance unit located in an isolation room (Shelford and Allee, 1913; Meldrim and Gift, 1971; Hall et al., 1982). The unit, head tanks, and mixing chambers were treated with five coats of a Teflon TFE compounded aerosol film (Durafilm CTF; American Durafilm Co., Inc., Newton Lower Falls, MA) to minimize adsorption of TBTO to surfaces. The delivery system for the avoidance unit consisted of a toxicant delivery component (TBTO delivery) and an ambient estuarine control water component. A stock solution of TBTO was prepared in two 160 L fiberglass tanks (Tank 1 and Tank 2). A submersible pump in Tank 1 was used to maintain a constant level in Tank 2 throughout the tests. TBTO stock was delivered from Tank 2 in a 1:12 ratio with estuarine water into a 19 L mixing chamber. Diluted TBTO of the appropriate concentration then entered a 160 L head tank. Estuarine water for the control side of the subtroughs was delivered from a separate 160 L head tank. Control and TBTO-contaminated water from each respective head tank were delivered to opposite ends of each subtrough and drained at the center, thus providing test organisms.