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Effects of Trichloroacetic Acid, a New Contaminant Found from Chlorinating Water with Organic Material, on Dragonfly Nymphs

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It has been recognized since the mid-1970's that chlorination of water rich in organic matter results in the formation of chloroform and some related volatile organic contaminants (Rook 1974). However, it was only relatively recently that chlorination of water rich in organic matter was found to produce an array of non-volatile chemical products including trichloroacetic acid (TCA) and dichloroacetic acid (DCA) (Uden and Miller 1983). Interestingly, the concentrations of TCA and DCA found in community drinking water are thought to equal or exceed those for chloroform. Levels of TCA and DCA in Amherst, Massachusetts drinking water have been found in the range of 100-200 µg/L (Uden and Miller 1983). In light of the limited data base associated with the effects of TCA and DCA on animal models, especially at environmentally relevant levels, a study was undertaken to assess the effects of TCA on respiration and ammonia excretion rates of the dragonfly (Somatochlora cingulata), a widely used indicator organism for the assessment of environmentally-induced physiological stress.

MATERIALS AND METHODS

Dragonfly nymphs were collected during September 1983 from Cranberry Pond in Leverett, Massachusetts. They were acclimated at 21 ± 1°C in filtered pond water for seven days on a diet of mayfly naiads. Feeding was stopped two days prior to the initiation of the experiment. The live weight of the 56 specimens used varied betweem 0.1-0.4 grams.

The oxygen consumption rate of each nymph (seven replicates) was monitored during an 8 hour exposure to one of four concentrations (0.00, 0.01, 0.1 and 1 ppm) of TCA administered in a flow-through assembly (Correa and Coler 1983). Prior to the initiation of a run,

each test animal (seven replicates) was prepared by adding an appropriate amount of reagent grade TCA (98% pure) to 20 liter reservoir bottles of filtered pond water. Water flow was regulated with Pasteur pipettes at a rate of 10 ± 0.5 ml/min. The differential dissolved oxygen (DO) concentrations were performed on water collected from the downstream and upstream DO bottles flanking the respiratory chamber in accordance with the Alsterberg Azide modification of the Winkler Method (APHA).

Ammonia excretory rates of individual nymphs were monitored in a static system (Correa et al. 1983). One set of DO bottles was filled with filtered pond water (control) and 3 other sets containing 0.01, 0.1 and 1 ppm of TCA. The nymphs (seven per set) were each blotted, weighed and placed individually in 300 ml DO bottles for 24 hours. Ammonia concentrations were measured according to the Nesslerization Methods (APHA 1980).

RESULTS AND DISCUSSION

Oxygen consumption was markedly and progressively enhanced in Somatochlora cingulata as a result of the TCA treatment (Table 1). Highly significant differences ($P < 0.01$) were found between controls and experimental animals exposed to TCA with the respiration rate at 1 mg/L being nearly double that of the controls. Ammonia excretion levels increased significantly ($P < 0.05$) in a dose-dependent manner as a result of exposure to TCA. As with oxygen consumption, the average ammonia excretion rate at 1 mg/L was twice that of the controls.

While the mechanisms by which the TCA treatment caused significant increases in oxygen consumption and ammonia excretion remains to be elucidated, it is of interest that the physiological changes observed occurred at levels of environmental relevance (i.e. 10-100 ppb) for only a single four hour exposure. Clearly, further research is needed to assess not only the effects of TCA but also DCA, which was not addressed in this study.

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Table 1. Relationship Between Wet Weight-Respiration ($\mu g\ O_2 H^{-1} g^{-1}$) and Excretory Rates ($\mu g\ NH_4\text{-}Nh^{-1} g^{-1}$) for the Dragonfly Somatochlora cingulata Exposed to Indicated Concentrations of Trichloroacetic Acid (mg/L) at 21 ± 1°C.

Each value is the mean and ± SD of 7 observations.

	Control	0.01	0.1	1
Respiration	228.5 ± 18.7	290.3 ± 39.8	331 ± 33.0	449 ± 58.7
Excretion	11.32 ± 2.32	13.06 ± 3.19	14.28 ± 2.01	20.55 ± 3.37

*Note: Using Duncan's multiple range test (Duncan 1955), the values of the specific treatments underlined do not differ from each other at the $P < 0.05$ level, while those not connected by the underline differ significantly at $P < 0.05$.

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