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Oxygen Consumption by the Crayfish *Orconectes propinquus* (Girard) Exposed to Aquashade

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One approach to controlling growth of aquatic plants has been to reduce light penetration by the application of light attenuating dyes. Eicher (1947) reported that nigrosine was effective in controlling curley leaf pondweed. Buglewicz (1972) tested the effects of various brown and blue dyes in an eutrophic Nebraska pond. He reported that Potamogeton spp. were eliminated by application of either brown or blue dyes, whereas Chara spp. were only controlled by the blue dye. White et al. (1975) reported that the blue dye Aquashade decreased growth of 4 species of submerged plants, and Osborne (1979) observed that Aquashade prevented reinfestation of hydrilla following initial treatment with Hydrothol 191 in a small Florida pond.

Aquashade is a blue, liquid mixture of acid blue 9 and acid yellow 23. Aquashade has a peak absorbance at 630 nm (Osborne 1979) and apparently indirectly inhibits photosynthesis by reducing the light available to photosystem II light harvesting pigments (Spencer unpublished data). Aquashade does not appear to be directly toxic to algae. The dye components of Aquashade are food colors, and based on feeding studies with rats, mice, and dogs, they are believed to be nontoxic to mammals (Radomski 1974). There is little published information, however, on the toxicity of these compounds, either alone or together, on invertebrate species which would likely be exposed during the routine use of Aquashade. The purpose of this study was to examine the toxicity of Aquashade to the crayfish Orconectes propinquus (Girard) which is widely distributed throughout the eastern United States (Hobbs 1976).

MATERIALS AND METHODS

Crayfish were collected from Fall Creek (Marion County, IN) upstream from the Indianapolis Water Company Pumping Station on August 11, 1983. The crayfish were

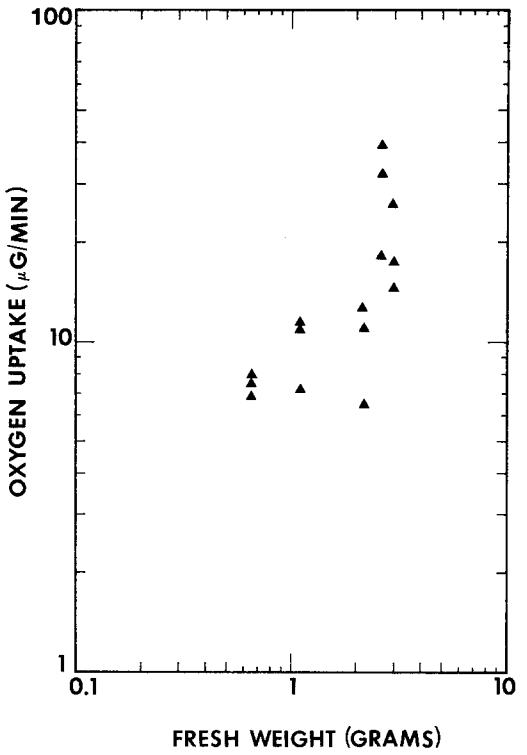

Fig. 1. Oxygen uptake uptake rate vs. fresh weight for Orconectes propinquus which served as controls.

placed in polyethylene buckets in aerated tapwater at room temperature (ca. 24 C). Tapwater was used in the following experiments. The crayfish were identified as Orconectes propinquus (Girard) using the keys in Pennak (1953) and Hobbs (1976). The organisms used in these experiments were 0.9 - 3.3 g fresh weight.

Individual Orconectes propinquus were placed into 300 ml glass BOD bottles. Tapwater or tapwater treated with the appropriate concentration of Aquashade was used to fill the bottles. Each bottle was capped with a plastic cap and aerated continuously. The bottles were placed in a growth chamber which maintained 24 C in the dark. Bottles were removed individually and oxygen consumption rate measured using an Orion model 97-08 oxygen electrode in conjunction with an Orion model 901 ionalyzer. A Commodore 64 computer was interfaced with the 901 ionalyzer. A BASIC program was executed and following a 10 minute delay, the dissolved oxygen concentration in the BOD bottle was recorded every three minutes for 27 minutes. The computer program printed the data and calculated the linear

regression coefficient according to the method outlined by Sokal and Rolf (1969). Measurements were made at 24 C. Oxygen consumption rates were calculated by dividing the regression coefficient by the fresh weight raised to 0.69 power. The calculated oxygen consumption rates were analyzed statistically using release 82.2 of the Statistical Analysis System (SAS Institute Inc 1982) running on the Decsystem 2060 computer at IUPUI.

Two experiments were performed. Each involved a two-way analysis of variance design with time of exposure and Aquashade concentration as the main effects. There were three replicates for each combination of treatments. The first experiment ran for three days and used Aquashade concentrations of 0, 5, 10, and 15 ppm. Oxygen consumption was measured following 1, 2, and 3 days exposure to the various levels of Aquashade. The water in the BOD bottles was replaced each day after the oxygen consumption rate was measured. The second experiment was similar except that oxygen consumption was measured after 1, 3, and 5 days of exposure to Aquashade. In these experiments one of the control organisms died on day 2. This resulted in an unbalanced statistical design.

RESULTS AND DISCUSSION

Oxygen consumption rates for invertebrates increase as a power function of fresh weight (Prosser 1973; p 190):

$$M = KW^b$$

Where: M = total oxygen consumed per unit time
W = body weight
K,b are constants

In order to determine the oxygen consumption rate per unit body weight, the value for b for 0. propinquus had to be determined. This was accomplished by regressing the logarithm of oxygen uptake rate vs. the logarithm of fresh weight for the 0. propinquus which served as controls (Fig. 1). The value of b was 0.69 which is similar to those reported for other crustaceans (Prosser 1973). This value was used in the calculation of oxygen consumption rate (µg O_2/min/g fr wt).

Mean oxygen consumption rates ranged from 7 to 10 µg O_2/min/g fr wt in the first experiment (Fig. 2). Oxygen consumption rates for Aquashade-treated individuals did not differ significantly from controls during the three day exposure period (Table 1). The range of oxygen consumption rates was greater in the second experiment being 9 to 21 µg O_2/min/g fr wt (Fig. 3).

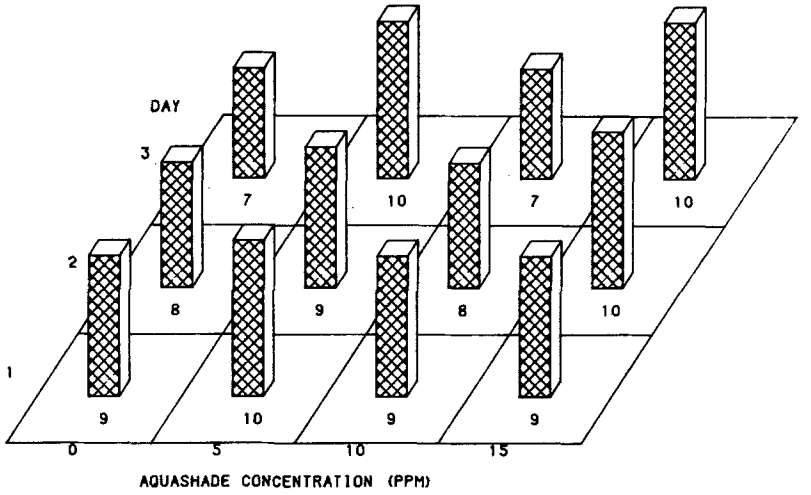

Fig. 2. Oxygen uptake rate (µg/min/g/fr wt) for Orconectes propinquus during a three day exposure to Aquashade. The value at the base of the bar is the mean uptake rate, (N=3).

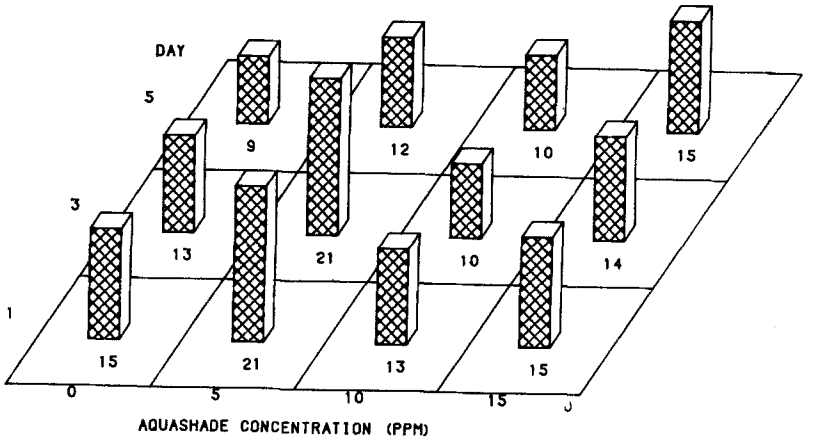

Fig. 3. Oxygen uptake rate (µg/min/g fr wt) for Orconectes propinquus during a five day exposure to Aquashade. The value at the base of each bar is the mean oxygen uptake rate. N=3 except for the control when N=2.

Oxygen consumption rates for individual Orconectes exposed to Aquashade were not significantly different from those measured for control organisms (Table 2). Based on the data presented here Aquashade applied at the recommended rate (1 ppm) should not significantly alter oxygen uptake rates of Orconectes propinquus. Although the dyes used in Aquashade have been judged to be safe based on feeding tests with rats, mice, and dogs, this is the first published report which suggests that Aquashade does not adversely affect common aquatic invertebrates.

Table 1. Analysis of Variance* for oxygen consumption rate by Orconectes propinquus during exposure to Aquashade for three days. NS signifies not significant at alpha equal to 0.05.

Source	DF	SS	F	SIGN.
Aquashade	3	22.13	0.47	NS
Day	2	4.26	0.14	NS
Aquashade x Day	6	7.36	0.18	NS
Error	24	373.72		

*Analysis performed by PROC ANOVA of SAS.

Table 2. Analysis of Variance* for oxygen consumption rate by Orconectes propinquus during exposure to Aquashade for five days. NS signifies not significant at alpha equal to 0.05.

Source	DF	SS	F	SIGN.
Aquashade	1	11.11	0.81	NS
Day	1	46.86	3.44	NS
Aquashade x Day	1	14.40	1.06	NS
Error	8	164.00		

*Analysis performed by PROC GLM of SAS

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