TOXICITY OF TEN COMMONLY USED CHEMICALS TO AMERICAN EELS[a]

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Abstract: Malachite green, potassium permanganate, salt, formalin, Dylox, Furanace, antimycin A, Noxfish, copper sulfate, and Diquat were tested to determine 96-hour LC_{50} values for the glass eel stage of the American eel, *Anguilla rostrata* (Lesueur). Static acute toxicity tests were conducted at 22 C using deionized water reconstituted to a hardness of 40-48 mg/l, an alkalinity of 30-35 mg/l and a pH of 7.2-7.6. The calculated 96-hour LC_{50} values for the chemicals are: malachite green 0.27 mg/l; potassium permanganate 3.06 mg/l; salt 17.88 g/l; formalin 83.96 mg/l; Dylox 1.31 mg/l; Furanace 0.77 mg/l; antimycin A 0.09 μg/l; Noxfish 15.25 μg/l; copper sulfate 2.54 mg/l; and Diquat 39.02 mg/l.

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With the growing interest of the eel culture industry in the United States and the export of glass eels to other countries for culture, the toxic effects of chemicals associated with aquaculture to the American eel has become an area of concern. According to Usui (1974) eels in a culture system are susceptible to a number of diseases and parasites. According to van Duijn (1973) many diseases and parasites may be controlled using chemicals, therefore more information concerning the toxic effects of these chemicals on eels is desirable. In addition to data on therapeutics, information on toxic effects of chemicals such as herbicides and toxicants associated with aquaculture is also needed.

The objective of this study was to determine the toxic effect of some commonly used chemicals on glass eels. One measure of the toxicity of a chemical is the 96-hour LC_{50} value which is the calculated concentration of a chemical that is lethal to 50% of the test organisms during a continuous 96-hour exposure (Committee on Methods for Toxicity Tests with Aquatic Organisms [CMTTAO] 1975). Concentrations of a chemical that may be used safely can be determined from calculated 96-hour LC_{50} values, 95% confidence limits, and mortality data recorded during testing.

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METHODS AND MATERIALS

Chemicals tested were malachite green, potassium permanganate, salt (NaCl), formalin (37% formaldehyde aqueous solution), Dylox[a], and Furanace[b] used in disease and parasite control; antimycin A and Noxfish[c] used as toxicants; and copper sulfate and Diquat[d] used to control aquatic weeds and algae (Table 1). All 96-hour LC_{50} values with the exception of Noxfish are based on 100% active ingredient. Noxfish was based on the commercial product which contains 5% rotenone. These represent some of the commonly used chemicals in aquaculture.

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Table 1. Recommended application rates of chemicals selected for toxicity tests on American eels.

Chemical	*Controls*	*Application*
malachite green	*Costia, Chilodonella, Ichthyophthirius*	0.15 mg l on alternate days 2 or 3 times[a]
potassium permanganate	***Agrulus, Costia, Trichodina,*** *Chilodonella*	**0.1g/l for 5-10 min[a]**
salt (NaCl)	***Gyrodactylus***	15-30 g l for 15-30 min[b]
formalin	*Costia, Trichodina, Gyrodactylus Ichthyophthirius*	250 mg l for 1 hour[a,c]
Dylox	copepods, monogenetic trematodes	0.25 mg l once every 7 days for 4 weeks[a]
Furanace	*Chondrococcus columnaris Vibrio anguillarum*	0.5 mg l for 5 hours[d]
antimycin A	'rough' fish in catfish culture	5-10 μg l[e]
Noxfish (5% rotenone)	fish toxicant	not specified
copper sulfate	algae	up to 3 mg l[f]
Diquat	algae and aquatic macrophytes	1-2 gallons per suface acre for weeds and 0.5-1.5 mg l for algae[g]

[a]Amlacher (1970)
[b]van Duijn (1973)
[c]Bills (1977)
[d]Hine and Boustead (1974)
[e]Burress and Luhning (1969)
[f]Burkhalter et al. (undated)
[g]according to label

Glass eels were collected in the spring of 1977 and 1978 from South Carolina rivers and transported to Clemson University where they were held in aerated aquaria until testing. Eels were tested within 3 weeks of capture. Eels were acclimated to test conditions for 96 hours prior to testing. During this time the eels were not fed, permitting the digestive tract to empty to avoid fouling the test water. During the final 48 hours of acclimation the eels were held in test water at 22 C (CMTTAO 1975).

Glass eels ($\bar{x}$ total length = 55 mm) were tested in glass jars containing 3 l of water. Test water was reconstituted from deionized water to a hardness of 40-48 mg/l as $CaCO_3$, an alkalinity of 30-35 mg/l as $CaCO_3$, and a pH of 7.2-7.6 (CMTTAO 1975). Eels were randomly added to jars until each contained 10 eels, then treatments were randomly assigned to jars. Eels were exposed to 1 of the selected concentrations of each chemical or a control of 96 hours. A water bath was used to maintain the temperature at 22 C. Temperature was measured every 12 hours and varied less than 1 C in any test. Dissolved oxygen was recorded initially and every 24 hours of the test and never fell below 40% saturation. Observations were made every 12 hours and dead eels were counted and removed (CMTTAO 1975). Eels were considered dead when there was no observable opercular movement or response to probing. Tests were not considered valid if more than 10% of the control eels died during the test (CMTTAO 1975). The SAS 76 probit analysis procedure was used to calculate lethal concentration probabilities and associated 95% confidence limits (Barr et al. 1976).

[a]0,0-dimethyl 2,2,2-trichloro-1-hydroxyethylphosphonate
[b]6-hydroxymethyl-2 pyridine
[c]5% rotenone
[d]6,7-dihydrodipyrido [1,2-a: 2',1'-c] pyrazinediium dibromide

RESULTS AND DISCUSSION

Calculated 96-hour LC_{50} values, 95% confidence limits and mortality data (Table 2) indicate that the therapeutics malachite green, formalin, Dylox, and Furanace as well as the herbicide Diquat could be used safely at recommended levels (Table 1) and that Noxfish could be used successfully as an eel toxicant. Salt, potassium permanganate, antimycin A, and copper sulfate used at recommended levels could cause substantial mortality. Eels transferred from freshwater to water with salt concentrations of 20-45 g/l were stressed (erratic swimming, loss of equilibrium) within a few minutes. Additional tests with different salt concentrations, exposure times and acclimation procedures are needed before any conclusions may be drawn concerning the use of salt.

Potassium permanganate is potentially toxic to glass eels at concentrations used to control external parasites in ponds. The 96-hour LC_{50} value (Table 2) falls in the range of concentrations (2-4 mg/l) that Allison (1957) found effective for controlling *Gyrodactylus* and *Trichodina* on speckled bullheads. Potassium permanganate is an oxidizing compound and reacts quickly with organic materials (Lay 1971). In waters with high organic loads, the initial reaction of potassium permanganate with organic matter may reduce the effective concentration of potassium permanganate so fish may be exposed to lower concentrations than originally added (Lay 1971). According to Lay (1971) the use of potassium permanganate has involved more art than science, and experience may be a factor in its successful use. Thus, organic load and water chemistry must be considered when using potassium permanganate. Short duration baths suggested by Amlacher (1970) (Table 1) may be safer to use with glass eels since additional tests exposing 40 glass eels to 0.1 g/l potassium permanganate for 10 minutes resulted in no mortality during the exposure or 96-hour post treatment observation period.

Table 2. Effect of selected concentrations of chemicals on glass eel mortality and 96-hour LC_{50} values and 95% confidence limits (CI).

Chemical	*Concentration*	*% Mortality after (hours)* 12	24	48	96	*96-hour LC_{50} (95% CI)*
malachite green	mg/l					mg/l
	0.00	0	0	0	0	0.27
	0.06	0	0	0	0	(0.20-0.41)
	0.10	0	0	0	0	
	0.15	0	0	0	10	
	0.25	10	10	20	30	
	0.40	20	100	100	100	
potassium permanganate	mg/l					mg/l
	0.0	0	0	0	0	3.06
	1.0	0	0	0	0	(2.48-4.38)
	1.8	0	0	10	20	
	2.5	0	0	0	0	
	3.0	10	20	50	50	
	4.5	70	100	100	100	
salt (NaCl)	g/l					g/l
	0.0	0	0	0	0	17.88
	10.0	0	0	0	10	(10.12-26.52)
	20.0	10	50	50	60	
	30.0	100	100	100	100	
	40.0	100	100	100	100	
	45.0	100	100	100	100	

(Table 2. continued)

formalin	mg/l					mg/l
	0.0	0	0	0	10	83.96
	35.0	0	40	40	40	(0.0-197.79)
	55.0	0	40	50	50	
	90.0	0	40	50	50	
	130.0	0	0	70	70	
	200.0	10	10	70	80	
Dylox	mg/l					mg/l
	0.0	0	0	0	0	1.31
	0.5	0	0	0	0	(1.22-1.43)
	0.7	0	0	0	0	
	0.8	0	0	0	0	
	0.9	0	0	0	10	
	1.0	0	0	0	20	
	1.1	0	0	0	20	
	1.3	0	0	0	10	
	1.4	0	0	0	80	
	1.5	0	0	0	70	
	1.6	0	0	0	100	
	2.2	0	0	0	100	
Furnace	mg/l					mg/l
	0.0	0	0	0	0	0.77
	0.5	0	0	0	0	(0.71-0.83)
	0.7	0	0	0	0	10
	0.8	0	0	0	70	
	0.9	0	0	0	100	
	1.0	0	0	0	100	
	1.1	0	0	0	100	
	1.4	0	0	70	100	
antimycin A	μg/l					μg/l
	0.00	0	0	0	0	0.09
	0.02	0	0	0	0	(0.08-1.10)
	0.04	0	0	0	0	
	0.06	0	0	0	0	
	0.07	0	0	0	0	
	0.08	0	0	0	40	
	0.09	0	0	0	50	
	0.11	0	0	0	90	
	0.13	0	0	0	90	
Noxfish	μg/l					μg/l
	0.0	0	0	0	10	15.25·
	15.0	0	0	0	30	(4.98-21.04)
	20.0	10	60	60	80	
	25.0	10	50	50	80	
	30.0	30	100	100	100	
	40.0	70	100	100	100	
copper sulfate	mg/l					mg/l
	0.0	0	0	0	0	2.54
	0.4	0	0	0	0	(1.90-3.95)
	0.6	0	0	0	0	

(Table 2. continued)

	1.0	0	10	10	10	
	1.8	0	0	0	0	
	3.0	0	10	60	80	
Diquat	mg/l					mg/l
	0.0	0	0	0		30.92
	25.0	0	0	0	10	(26.85-34.43)
	30.0	0	0	0	40	
	35.0	0	0	10	80	
	40.0	0	0	80	100	
	45.0	0	0	100	100	
	50.0	0	0	100	100	
	65.0	0	40	100	100	

Antimycin A has been used without harm in catfish culture to rid ponds of undesirable scale fish such as green sunfish (*Lepomis cyanellus*) and golden shiners (*Notemigonus chrysoleucas*) (Burress and Luhning 1969). From the catfish farmer's viewpoint antimycin A could be used to rid catfish ponds of eels; however, eel culturists could not use antimycin A at concentrations used in catfish culture (Table 1) since those concentrations far exceed the 96-hour LC_{50} value for glass eels (Table 2).

The calculated 96-hour LC_{50} value for copper sulfate (Table 2) is very close to the recommended levels used for controlling algae (Table 1). According to Wellborn (1969) the toxicity of copper sulfate is affected by water hardness. However, the toxicity of copper is not totally dependent on hardness but rather on alkalinity (Stiff 1971). Most recommendations for the applications of copper sulfate are based on water hardness so knowledge of water hardness, and alkalinity would be essential before making recommendations for the use of copper sulfate.

Factors such as water hardness, alkalinity, pH, temperature, dissolved oxygen, organic load and many others may affect the toxicity of a chemical to the eel. Therefore it is essential to know the water chemistry and its effects on the toxicity of the chemical being applied. It is also important to consider laws concerning the use of any chemical on fish destined for human consumption.

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