Exposure Times Necessary for Antimycin and Rotenone to Eliminate Certain Freshwater Fish

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GILDERHUS, P. A. 1972. Exposure times necessary for antimycin and rotenone to eliminate certain freshwater fish. J. Fish. Res. Bd. Canada 29: 199–202.

In laboratory flowing-water troughs exposure required to induce 100% mortality, regardless of time to death for antimycin and rotenone against selected freshwater fish species was determined. Carp and white suckers required shorter exposures to antimycin (6 hr) than to rotenone (18–24 hr) at field-use concentrations of 5 and 50 ppb respectively. Bullheads were killed by 3–10 hr exposure to 100–250 ppb rotenone at 17 C or higher. However, the long exposure time necessary in colder water (25 hr at 100 ppb in 12 C water) made elimination of bullheads with rotenone difficult in cold seasons. Exposure time was influenced more by water temperature than by the toxicant concentration. The effects of rotenone were often reversible even after fish had been on their sides in the toxicant solution for 4–5 hr but irreversible for antimycin after fish showed the first signs of distress.

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Nous avons mesuré le temps d'exposition à l'antimycine et la roténone requis pour causer la mortalité totale, sans égard à la longueur de l'agonie, de certaines espèces de poissons d'eau douce. Les expériences se sont poursuivies en laboratoire dans des bacs pourvus d'eau courante. Les grandes espèces, telles que catostomes noirs communs et carpes, requièrent une exposition plus courte à l'antimycine (6 h) qu'à la roténone (18 à 24 h) aux teneurs en usage sur le terrain de 5 et 50 ppb respectivement. Les barbottes meurent après exposition de 3 à 10 heures à 100–250 ppb de roténone à 17 C ou plus. Toutefois, la nécessité d'une exposition plus longue dans des eaux plus froides (25 h à 100 ppb à 12 C) rend plus difficile l'élimination des barbottes à la roténone pendant la saison froide. La température de l'eau, plus que la concentration de l'agent intoxicant, affecte le temps d'exposition. Souvent, les effets de la roténone sont réversibles, même si le poisson a été sur le côté durant 4 à 5 heures. Par contre, les effets de l'antimycine sont irréversibles dès qu'apparaissent les premiers signes de détresse chez le poisson.

Received June 8, 1971

ANTIMYCIN and rotenone, the two fish toxicants registered in the United States, are commonly used to reduce or eliminate populations of undesirable freshwater fish. Some stream reclamations using toxicants have failed (Barry and Larkin 1954; Binns et al. 1964; Herrig 1964; Lennon et al. 1970), probably due to the fish not being exposed long enough to the chemical. Length of exposure is as important as concentration in contributing to a lethal dose of a toxicant. In streams where a chemical moves past the fish and in standing bodies of water where rapid dilution or degradation is likely to be a problem, length of exposure is a critical factor.

Several authors have reported laboratory studies on time to death of fish exposed to rotenone (Gersdorff 1930; Leonard 1939; Burdick et al. 1955; Bassett 1956). Apparently, Lennon and Parker (1959) did the only study where time to death for individual species in the water to be treated was determined prior to treatment. However, time to death in a solution of toxicant and length of exposure necessary to induce complete mortality are different entities, the latter being much shorter.

If treatments of streams are designed on the basis of time to death, most streams will be under treatment longer than necessary. Effective and efficient reclamations must be based on the proper balance between concentration and exposure time.

This study with antimycin and rotenone was conducted to define the effective contact time (ECT), which for a toxicant, is the length of exposure necessary to induce 100% mortality of target animals with a given concentration, regardless of the time it takes them to die.

Printed in Canada (J2197)

Materials and methods — Target species were carp (*Cyprinus carpio*) and white suckers (*Catostomus commersoni*). Other species tested were black bullheads (*Ictalurus melas*), green sunfish (*Lepomis cyanellus*), largemouth bass (*Micropterus salmoides*), yellow perch (*Perca flavescens*), and rainbow trout (*Salmo gairdneri*). Size ranges are given in Table 1.

Groups of five to 10 fish were exposed for each of several periods of time at each concentration. The fish were exposed to the toxicants in a stainless steel trough 3.75 m long, 0.34 m wide, and 0.34 m deep, divided into five equal sections by perforated aluminum plates. The water was kept at 0.12 m deep by a standpipe and supplied from a constant-head box at 28.6 liters/min. Time of travel from inlet to outlet was 4.5 min.

Laboratory well water was used for all tests at 12 C. For tests at 17 and 22 C, enough heated city water was piped into the headbox to raise the 12 C well water to the desired temperature. The ranges of some water quality parameters of the water supplies were (well water with city water values in parentheses): *p*H 7.5–8.0 (7.4–8.2), total alkalinity (mg/liter) 223–262 (209–250), and total hardness (mg/liter) 238–371 (289–340). The water contained about 8.5 mg/liter of dissolved oxygen at the outlet.

Carp, white suckers, black bullheads, and green sunfish were exposed at 12, 17, and 22 C. Species killed by shorter exposures were tested only at 12 C since they would be eliminated along with those more resistant species.

Fish were acclimated and held for recovery in a concrete tank supplied with aerated well water. The fish for each exposure time were kept in a separate screen cage. Water temperature was regulated by a steel immersion heater and a circulating pump in the tank. Fish exposed at 12 C were acclimated for 24 hr. Those exposed at 17 C were acclimated for 24 hr and the water temperature was raised from 12 to 17 C during the first 6–8 hr of the 24. Those exposed at 22 C were tempered during a period of 36 hr and were usually held an additional 24 hr at that temperature.

The fish were moved to the testing trough an hour before the addition of toxicant began. After a selected number of hours in the toxicant, each group was returned to the freshwater tank and held until 96 hr after the beginning of exposure.

The chemicals[1] used were Fintrol Concentrate, a liquid formulation containing 10% antimycin and Noxfish, a liquid formulation containing 5% rotenone. The concentrations (active ingredient) used, 5–10 ppb of

[1]Reference to brand names does not imply Bureau endorsement to the exclusion of similar products.

TABLE 1. The effective contact time (ECT) to eliminate selected species of fish with antimycin and rotenone.

Species (length, *mm*)	Water temp (C)	ECT in hr for Antimycin (*ppb*) 5	Antimycin 10	Rotenone (*ppb*) 50	Rotenone 100	Rotenone 250
Rainbow trout (64–124)	12	2	1	2	–	–
Carp (127–305)	12	6	6	24	18	16
	17	3	3	10	9	5
	22	2	1	–	5	–
Carp (41–53)	12	–	6	–	–	–
White sucker (119–264)	12	6	4	18	17	9
	17	2	1	9	5	3
	22	1	0.5	–	1	–
Black bullhead (178–250)	12	–	–	–	25	>24[a]
	17	–	–	–	10	3
	22	–	–	–	8	–
Black bullhead (56–66)	12	–	–	–	21	15
Green sunfish (30–56)	12	11	10[a]	–	8	1
	17	4	1.5	–	–	–
	22	1	0.5	–	0.5	–
Largemouth bass (64–127)	12	13[a]	6	8	–	1
Yellow perch (45–74)	12	4	2	–	0.5	–

[a]Estimated from exposure where some fish survived.

antimycin and 50–250 ppb of rotenone, are those generally used in field applications. The toxicants were mixed with water so that 3–6 liters/hr of the stock solution, applied to the inlet, produced the proper concentration. The stock solutions were injected with an electric fuel pump, adjusted to an accuracy of ±4%.

Results — Rainbow trout and yellow perch were very sensitive to both chemicals, the ECT's being from 1 to 4 hr (Table 1). The short ECT's make them easy to eliminate in the presence of more resistant target species.

Among the species studied, carp and suckers are the most likely to be the target fish in flowing water. The ECT for 5 ppb of antimycin on these species was somewhat shorter than that for 250 ppb of rotenone at 17 and 22 C, and much shorter at 12 C. At 17 C both species were eliminated by 3 hr of exposure to 5 ppb of antimycin or 5 hr of exposure to 250 ppb of rotenone. The ECT's for those concentrations to eliminate both species at 12 C were 6 hr for antimycin and 16 hr for rotenone.

No tests were conducted with antimycin against black bullheads because Walker et al. (1964) documented that it is not very effective against species of the family Ictaluridae. Rotenone was fairly effective on bullheads at temperatures above 17 C, but at 12 C, they must be exposed to 100 ppb for at least 25 hr, which ECT is too long to be practical for stream treatments.

The ECT's for green sunfish were in the same range for both toxicants. Largemouth bass were substantially more resistant to antimycin (13 hr) than to rotenone (8 hr) at minimum field-use concentrations. Against the more sensitive species the ECT for 50 ppb of rotenone was comparable to or shorter than the ECT for 5 ppb of antimycin, whereas against the more resistant carp and suckers the ECT for 5 ppb of antimycin was shorter than that for 250 ppb of rotenone.

Increasing the concentration of toxicant did not have as much effect on the ECT as did raising the water temperature. Considering all the data, doubling the concentration shortened the ECT's for antimycin by an average of 38.3% and for rotenone by 36.6%. Increases of 5 C decreased the ECT's by an average of 61.7 and 60.9% for antimycin and rotenone, respectively.

Discussion — This study revealed some consistent patterns concerning the reversibility or irreversibility of toxicity in relation to the obvious symptoms of toxicity. No fish survived after losing equilibrium due to exposure to antimycin. There appears to be a point, while they are still swimming, at which they have assimilated an irreversible, lethal dose. In contrast, the ECT for rotenone was generally reached only after the fish had been incapacitated in the toxicant solution for 1–5 hr. Often, fish that had been on their sides in rotenone solution for up to 4 hr recovered later in fresh water. This is in direct conflict with some authors (Leonard 1939; Bassett 1956) who stated that no fish could survive after losing equilibrium due to exposure to rotenone.

Antimycin appears to be more suitable for stream treatments when carp or suckers are target species. It has a short ECT and due to its apparent irreversibility fish that later find their way into untreated water are likely to die anyway.

The length of time a given concentration of toxicant must be maintained at any given point in a stream is logically the effective contact time for the most resistant target species. Thus, the ECT's for the target fish and the flow and dilution patterns for a stream must be known prior to treatment. Furthermore, the ECT may be an important consideration in standing water. For example, under conditions of highly alkaline or high *p*H waters, it is possible that the toxicant will degrade before the ECT is reached. Marking (1970) lists the half-life of biological activity of antimycin as 9.7 hr at *p*H 9, 4.6 hr at *p*H 9.5, and 1.5 hr at *p*H 10. This indicates that at some combinations of high *p*H and low water temperature it could be impossible to obtain an adequate exposure at reasonable concentrations.

The proper concentration and exposure time for a reclamation with toxicants cannot be chosen arbitrarily without some knowledge of each for the target species in the target water. Therefore, it is highly advisable to use stream-side bioassays to determine the appropriate concentration and ECT. The ECT's presented here can serve as guidelines for selecting exposure times to be used in field bioassays or short stream treatments.

Barry, G., and P. A. Larkin. 1954. Field trials with "fish-tox" in streams. Can. Fish. Cult. 15: 10–15.

Bassett, H. M. 1956. The economic evaluation of several fish toxicants. Quart. Rep. Colo. Coop. Fish. Res. Unit 2(3,4): 6–16.

Binns, A., F. Eiserman, F. W. Jackson, A. F. Regenthal, and R. Stone. 1964. The planning, operation, and analysis of the Green River fish control project. A Joint Report of the Utah State Department of Fish and Game and the Wyoming Game and Fish Department. 83 p.

Burdick, G. E., H. F. Dean, and E. J. Harris. 1955. Toxicity of emulsifiable rotenone to various species of fish. N.Y. Fish Game J. 2: 36–67.

GERSDORFF, W. A. 1930. The toxicity of rotenone, isorotenone, and dihydrorotenone to goldfish. J. Amer. Chem. Soc. 52: 5051–5056.

HERRIG, R. G. 1964. Lower Crooked River and tributaries rehabilitation project. Oregon State Game Commission. Federal Aid to Fish Restoration, Project F-20-D-22, Project Completion Report. 16 p.

LENNON, R. E., J. B. HUNN, R. A. SCHNICK, AND R. M. BURRESS. 1970. Reclamation of ponds, lakes, and streams: a review. FAO (Food Agr. Organ. U.N.) Fish. Tech. Pap. 100: 99 p.

LENNON, R. E., AND P. S. PARKER. 1959. Reclamation of Indian and Abrams Creeks in Great Smoky Mountains National Park. U.S. Fish Wildl. Serv. Spec. Sci. Rep. Fish. 306: 1–22.

LEONARD, J. W. 1939. Notes on the use of derris as a fish poison. Trans. Amer. Fish. Soc. 68: 269–279.

MARKING, L. L. 1970. Antimycin: half-life of biological activity. p. 26. *In* Progress in Sport Fishery Research-1969. U.S. Bur. Sport Fish. Wildlife Resour. Publ. 88.

WALKER, C. R., R. E. LENNON, AND B. L. BERGER. 1964. Preliminary observations on the toxicity of antimycin A to fish and other aquatic animals. U.S. Bur. Sport Fish. Wildl. Investigations in Fish Control. 2(Circ. 186): 1–18.