Effects of Rotenone and Some Common Herbicides on Fish-Food Organisms[1]

Max Zischkale[2]

Introduction

While considerable experimentation has been done on aquatic plant control and reduction of fish populations by chemicals, we know little of how these agents act on those smaller animals that serve as fish food. King & Penfound (1946) published results on the effects of two formagenic herbicides on bream and large-mouth bass. Surber (1948) gave additional information; and published (1950) a joint paper with Everhart. Their paper dealt with the effects of Nigrosine on *Daphnia magna,* (an organism used in the present study.)

I have attempted here to find what happens to a few of the smaller crustaceans and immature aquatic insects (as well as two of the common genera of aquatic snails) when standardized concentrations of the more commonly used herbicides are introduced into the water. I have also employed the fish poison, rotenone. I used it because I think that the secondary or indirect effect of these compounds on living fish-food is as important to the productivity of a body of water as their primary effect on the larger plants and fish. If both the larger plants and the food organisms are killed by the herbicides, the balance is upset and the fish may starve. Similarly, if the rotenone used to kill the fish also kills the food organisms, fish that later are added may soon show the effects of limited food. Moreover, knowledge of the over-all effect of such chemicals may help us know what dosages would be more proper and effective in a sound program of fish management.

Methods

My approach to this series of experiments was by the familiar trial and error method. Most of my experimental work was done in two gallon battery jars marked at five

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[2]Graduate Student, Southern Methodist University.

liters, rather than in standard aquaria not always dependable because of leakage. I found battery jars much more satisfactory, as they withstood the necessary moving; while glass aquaria with metal frames often developed leaks. Moreover, battery jars also could be more easily cleaned, an important factor when dealing with chemicals.

Habitat conditions which I tried to set up in the jars were far from identical with those found in nature; nevertheless, I tried to furnish in these containers a similar, healthy environment for the animals.

I used for the experiments tap water that had been "aged" four days. This was an added reason for the use of small experimental aquaria; otherwise I would not have had enough storage space for aging the water required. The final pH was 7.2 and the average temperature 27°-29°C. Soil was excluded from my tanks because it absorbs the chemical and would have to be discarded after each test. I did not have access to great amounts of muck from lake bottoms. I felt that clean sand, without muck, would give an extremely typical result as far as absorption of the chemical was concerned. For this reason I decided to work without soil.

A series of preliminary tests revealed just what minimum conditions were necessary in my aquaria to raise the various experimental animals. For instance, I discovered that the crustacean *Hyalella,* being a "sprawler" on plants by nature, soon died in plant-less containers. I therefore added a 2- to 3-inch strand of *Fontinalis* to each tank and the animals did very well, since they then had a natural substrate for sprawling.

The animals used were all local pond- and lake-dwelling species. I chose lake forms because most fish-poisoning and plant-control is done in lakes or ponds, and very little in rivers or streams. The most successful work of this kind is done in lakes, since the chemical concentrations can be more accurately maintained.

I found that I could successfully culture *Daphnia, Hyalella, Palaemonetes,* ostracods, chironomid and mosquito larvae, in addition to the snails. The other animals used (dragonfly and damselfly naiads) had to be collected before each experiment, as these predatory forms required too much food to be cultured for any period of time. These animals were always experimented with immediately after collection, so

that they would not have to go for an unnecessary period without food.

In each case, the experimental period lasted 48 hours. I had two series of battery jars working alternately so that results from one series were obtained each day. There were 20 battery jars in each set; 10 were experimental and the remainder control. Preliminary experiments indicated that a 48-hour test was long enough to get good results, and not too long for the animals to go without food. They were well fed at the beginning of each test, and my cultures maintained the animals in good condition.

Jars used in preceding tests were carefully washed, and the water was added from storage tanks in the same room as my culture tanks. This insured a uniform temperature. Since temperature is a very important factor to consider when one moves any aquatic animal from one body of water to another, animals collected locally were conditioned to water at room temperature by being placed in containers and floated in my storage tanks. After filling the aquaria, the chemical compound to be tested was introduced and thoroughly stirred. The experimental animals were then added and the various strengths of the compounds used were recorded along with the animals tested.

Forty-eight hours after setting up a test, the tanks were checked with a binocular microscope to see which animals survived. A kill of 75% or better was considered a toxic dose of the compound. Those animals which appeared to have been affected but not killed by the compound were observed for several additional days, while those unaffected were observed for 24 hours and then discarded. Results were then tabulated, and a new experiment was begun.

My stock solutions of chemicals were made up at 200 parts per million by weight. I found stock solutions of this strength more easily handled for the range of tests used.

In no test did I use more than 10 parts per million for any compound, because the effectiveness of either the herbicides or the rotenone seems to reach its maximum at much lower concentrations, actually five parts per million, or less, in all cases.

The compounds I used were furnished in part by Dow Chemical Company. The Dow products were Esteron 44, a weed killer containing the isopropylester of 2,4-dichloro-

phenoxyacetic acid, and Esteron 245, a mixture of low-volatility esters of 2,4,5-trichlorophenoxyacetic acid. Both of these organic "hormones" are comparatively new, and have been used with good results on aquatic as well as terrestrial weeds. My two other compounds were sodium arsenite (a solution containing 6½ pounds of $NaAsO_2$ by weight per gallon.) and rotenone (4.9% rotenone by weight). These two compounds have been extensively used for years in fish management; but as far as I know, nothing has been published on the way in which the organisms used in this work are affected.

	Esteron 44		Esteron 245		Sodium Arsenite		Rotenone	
Organisms tested	Max. tolerance	Min. l. d.	Max. tolerance	Min. l. d.	Max. tolerance	Min. l. d.	Max. tolerance	Min. l. d.
Daphnia	0.1	0.2	1.0	1.5	2.5	3.0	?	0.1
Eucypris	0.5	0.6	0.4	0.5	5.5	6.0	?	0.1
Hyallella	0.5	0.6	0.6	0.7	2.0	2.5	0.1	0.2
Palaemonetes	0.7	0.8	1.0	1.2	10.0	?	3.5	4.0
Amphiagrion	2.8	3.0	7.0	7.5	10.0	?	2.0	2.5
Pachydiplax, Tramea	4.0	4.5	7.0	8.0	10.0	?	3.0	3.5
Culex, Aedes & Anopheles	3.0	3.5	10.0	?	5.5	6.0	1.5	2.0
Chironomus	0.9	1.0	5.0	6.0	9.0	10.0	?	0.1
Physa	5.0	5.5	10.0	?	10.0	?	4.0	4.5
Helisoma	7.0	7.5	10.0	?	10.0	?	3.0	3.5

Before setting up a final experiment, a range-test was first run to determine roughly what concentration of chemical caused death. Then a more careful check was made within this range. Such procedure simplified the preparation and conduction of the definitive test.

Results

Charts show the results of my experiments. "Maximum tolerance" is interpreted as that strength of chemical tested which did not produce a kill in excess of 25 percent. "Minimum lethal dose" is interpreted as the weakest concentration of chemical which produced a kill exceeding 25 percent. It will be noted in some cases, with the use of the same compound, there is a difference of from 0.5 to 1.0 ppm. between the maximum tolerance and the minimum lethal dose on a

particular organism. In such cases, these results persisted even after repeated tests in the immediate range. In an attempt to eliminate such discrepancies, I dropped back to the next concentration and used this strength of chemical as the maximum tolerance if the results of repeated tests were consistent.

Queries (?) in the table under "minimum lethal dose" signify that in the range of concentrations used, no lethal dose was found for the tested organisms. It seemed unnecessary to go below 0.1 ppm. on any test, since so small a concentration of any of the compounds worked with would probably never be used in actual plant or fish control. Accordingly, I failed to get a minimum lethal dose for some of the more delicate forms. The queries under maximum tolerance indicate the ability of the hardier organisms to live in the chemicals at the highest concentration of chemical (10.0 ppm.) used in the tests.

The four graphs were made from the data on the chart. There is a graph for each compound tested, and both the minimum lethal dose and the maximum tolerance are shown on the same graph. The horizontal axes of the graphs show parts-per-million of the chemical used, the vertical axes show organisms used in the experiments. Each organism used is given a number which is explained in the legend. Accompanying each number are two parallel columns, the dark one shows the maximum tolerance while the light one represents the minimum lethal dose.

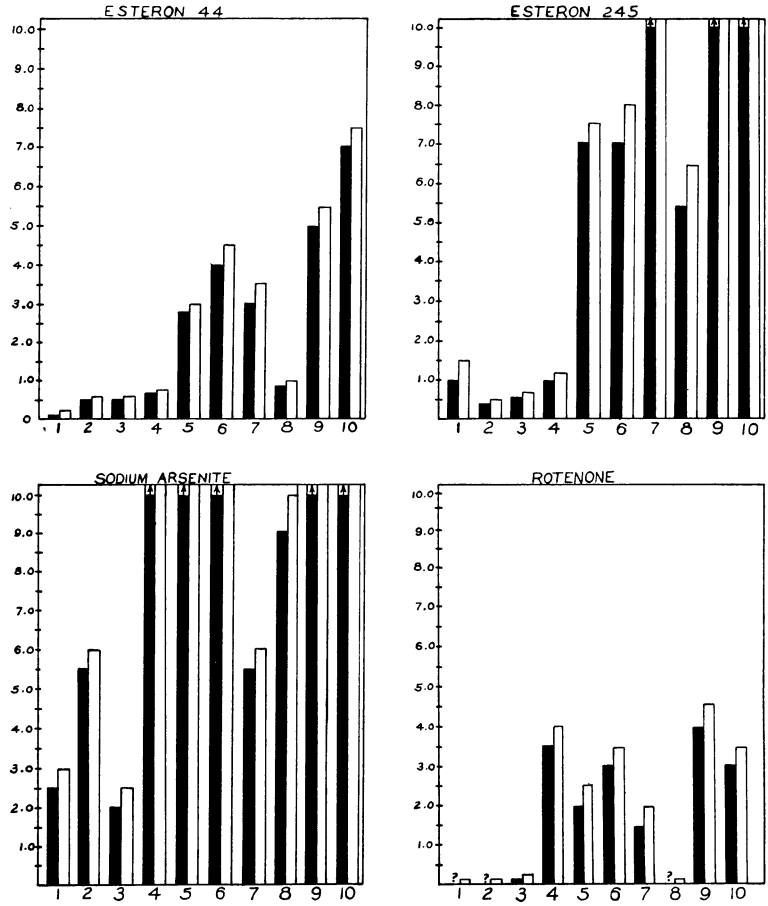
In cases where the animals withstood 10.0 ppm. (the maximum concentration used) with no observable ill effects, an arrow was placed at the top of the maximum tolerance column to show that, in all probability, the concentration of the chemical was not definitive for the species. A similar procedure was used for the minimum lethal dose in concentrations of chemical above 10.0 ppm.

Queries in the graphs indicate the inability of the organism tested to survive 0.1 ppm. of the chemical (the minimum concentration used.)

SUMMARY AND CONCLUSIONS

1. A study has been made on the effects of rotenone, esteron, and sodium arsenite on certain aquatic snails, crustaceans, and immature aquatic insects.

2. A tolerance range was established for genera tested, but no attempt was made to study the physiological effect of the chemicals tested on the organisms.



3. In most cases the animals tested fell into a rather definite sequence of resistance to the chemicals used. Starting with the most sensitive and proceeding to the most resistant genera, the series ran as follows: *Daphnia, Hyalella, Eucypris, Palaemonetes, Chironomus, Amphiagrion,* culicids, *Pachydiplax, Tramea, Physa,* and *Helisoma.* With few exceptions this sequence was approximately the same for all chemicals used.

4. From the results obtained it may readily be seen that sodium arsenite is the least toxic to the organisms tested; and following in order is Esteron 245, Esteron 44, and Rotenone.

BIBLIOGRAPHY

BAUMAN, A. C. 2,4-D and some Emergent Aquatics. Effects of Butyl Ester of 2,4-Dichlorophenoxyacetic Acid on some Emergent Aquatic Plants. *Progressive Fish-Culturist 9*(2):71-77, 1947.

———— Aquatic Vegetation Control by the Use of Butyl Ester of 2,4-Dichlorophenoxy Acetic Acid, with Special Reference to American Lotus and Water Primrose. *Missouri Conservation Commission,* 5 pp., Dec., 1946.

CORNELL, J. H. Eradication of Emergent Aquatic Vegetation with 2,4-D. *Progressive Fish-Culturist 11*(2):113-18, 1949.

GERKING, S. D. Destruction of Submerged Aquatic Plants by 2,4-D. *Jour. Wildlife Management 12*(3):221-227, 1948.

KING, JOSEPH E. & WM. T. PENFOUND. Effects of Two Formagenic Herbicides on Bream and Large-mouth Bass. *Ecology 27*(4):372-74, 1946.
KRUMHOLZ, LOUIS A. The Use of Rotenone in Fisheries Research. *Jour. Wildlife Management 12*(3):305-17, 1948.
PREVOST, G., C. LANOUETTE, and F. GRENIER. Effect of Volume on the Determination of DDT or Rotenone Toxicity on Fish. *Ibid., 12*(3):241-50, 1948.
SNOW, J. R. Control of Pondweeds with 2,4-D. *Progressive Fish-Culturist 11*(2):105-08, 1949.
SURBER, EUGENE W. Chemical Control Agents and their Effects on Fish. *Ibid., 10*(3):125-31, 1948.
———— Aquatic Plant Control with 2,4-D. U.S. Department of the Interior, Fish and Wildlife Service, *Fisheries Leaflet No. 217*, 5 pp., 1947.
———— Controlling Vegetation in Fish Ponds with Sodium Arsenite. U.S. Department of Commerce, Bureau of Fisheries, *Investigational Report No. 2, Volume 1*, 39 pp., 1932.
———— Control of Aquatic Plants in Ponds and Lakes. U.S. Department of the Interior, Fish and Wildlife Service, *Fisheries Leaflet No. 344*, 20 pp., July, 1949.
SURBER, EUGENE W., C. E. MINAREK, & W. B. ENNIS. The Control of Aquatic Plants with Phenoxyacetic Compounds. Experimental Work with Certain Plant Growth Regulators as Herbicides. *Progressive Fish-Culturist 9*(3):143-50, 1947.
SURBER, EUGENE W. & MAX H. EVERHART. Biological Effects of Nigrosine Used for Control of Weeds in Hatchery Ponds. *Ibid., 12*(3):135-40, 1950.
WALKER, C. H. Cattail Control with Scythe and 2,4-D. *Ibid., 10*(3):153-54, 1948.

Addenda on Texas Chamaesyce (Euphorbiaceae)

Lloyd H. Shinners

CHAMAESYCE **carunculata** (Waterfall) Shinners, comb. nov. *Euphorbia carunculata* Waterfall, Rhodora 50: 63-64. 1948. TYPE (not examined) from drifting sand, north of the Cimarron River, on the Waynoka sand dunes, Woods Co., northwestern Oklahoma (deposited in Bebb Herb., Univ. of Oklahoma). Five additional collections may now be cited, two in the Herbarium of Southern Methodist University, (SMU), three in that of the University of Texas (T). OKLAHOMA. WOODS CO.: unstabilized sand dunes, south of Waynoka, *U. T. Waterfall 10373,* Oct. 6, 1951 (SMU). TEXAS. HARDEMAN CO.: sand dunes of Red River north of Quanah, *B. C. Tharp,* Sept. 20, 1922 (T). WHEELER CO.: 3½ miles north of Shamrock, in deep dune sand, south side of North Fork of Red River, *V. L. Cory 50251,* Oct. 15, 1945 (SMU). WILBARGER CO.: dunes west of highway south of Red River on Round Timbers Ranch (north of Vernon), *Tharp,* Sept., 1950 (T). MEXICO. CHIHUAHUA: sand dunes, Chihuahua, *Harde Lesueur,* Oct. 10-19, 1935 (T).

This species was assigned a manuscript name in *Euphorbia* by Standley, based on the Chihuahua specimen, and honoring its collector. Acquainted only with Mr. Cory's collection from the Texas Panhandle, I was preparing to name it as a new species when Dr. Tharp kindly called to my attention the other collections and earlier names for the plant. Perhaps the most anomalous feature of *Chamaesyce carunculata* is the form of the seeds, which shown no indication whatever