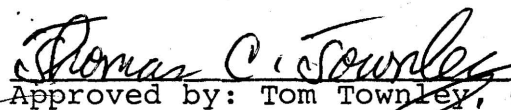


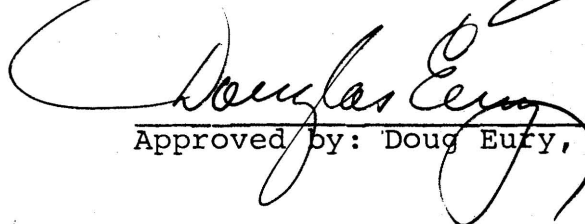
N1615

INSCRIPTION POOL HERPTIFAUNA RESTORATION PLAN

NATIONAL PARK SERVICE
EL MORRO NATIONAL MONUMENT
RAMAH, NEW MEXICO, 87321
(505) 783-4226

 8/31/86
Written by: Gary M. Stolz, Park Ranger

 8/31/86
Approved by: Tom Townley, Chief Ranger

 9/2/86
Approved by: Doug Eury, Park Superintendent

Sent to G. Holdsworth NR. P-221 - SWR 9/2/86

INTRODUCTION

El Morro, our nation's second oldest National Monument, gains its fame through a pool of water. This year-round desert oasis, 12 feet deep with 200,000 gallons, has been attracting people to quench their thirst ever since the first Zuni ancestors built pueblos here in the 13th century. While hundreds of people have used El Morro's water hole and left their marks on the famous Inscription Rock, we were not the only species to develop a dependence on this life giving desert pool.

All wildlife needs water to drink and for such reasons birds, mammals, and reptiles come to the pool. While these animals can still satisfy their thirst requirements, another group, the amphibians require use of the water to breed. Historically, there have been a number of uniquely adapted desert amphibians native to El Morro National Monument, including: Western Spadefoot Toad (Scaphiopus hammondi), Plains Spadefoot Toad (Scaphiopus bombifrons), Tiger Salamander (Ambystoma tigrinum), Woodhouse's Toad (Bufo woodhousei), and Red-spotted Toad (Bufo punctatus).

A number of years ago an exotic species of fish, the Yellow Perch (Perca flavescens), was introduced to the monument's pool. Since that time no amphibians have been known to breed in these waters. In his report of Amphibians, Reptiles, and Mammals of El Morro National Monument, Archibald McCallum states "...I think it would be desirable for salamanders once again to occupy that pool. It provides appropriate conditions for neoteny to occur, a phenomenon which could be interpreted to visitors with considerable educational profit. Accordingly, I recommend that the fish, which are not there naturally anyway, be removed. The salamanders will take care of the rest". A management objective of the National Park Service is to protect and preserve our native wildlife heritage. This proposal is to remove the fish from the monument's pool, thereby creating once again, the original amphibian breeding colony.

HISTORICAL PERSPECTIVE

Peterson reported in Southwestern Monuments Monthly Reports (SMMR), July, 1934 issue that "This is the first season I have seen frogs in the water cove, and judging from the noise they are making at present there must be a thousand of them in there". There is no known account as to what species Peterson was referring to, although Spadefoot Toads are the most abundant anuran in the monument vicinity.

Commenting on a Kingfisher (Ceryle alcyon) near the pool, E.Z. Vogt, Jr. stated in October, 1936, I'll bet he had his eye on the big juicy salamanders in the pool". At another time, Superintendent Budlong stated, "Now, when I was there, we had this low dam across the waterhole. It was filled with Axolotls... Water Dogs, I think you call them; the salamander phase of the salamander. Big things, about 10 inches long" (from 9/29/71 interview with Bob Budlong, unpublished M.S., El Morro Library).

In addition to the historic records, a few other species of anurans have been found close to the monument, and are thought (6/85 interview with Dale Belcher, Curator of Herpetology, Rio Grande Zoological Park, Albuquerque) to possibly exist within the monument. These species include: Canyon Treefrog (Hyla arenicolor), Northern Leopard Frog (*Rana pipiens*), and Midland Chorus frog (Psudacris triseriata).

PROPOSED METHODOLOGY

The most effective method for removing fish from a body of water is with the chemical Rotenone (which goes by brand names of Pro-noxfish, Syn-noxfish, Nox-fish, Chem-fish Regular, Chem-fish Special, Fix-tox, Derris, Cube, Derrin, Nicouline, Tubatoxin, Timbo Powder, etc). This chemical ($C_{23}H_{22}O_6$) is extracted from Derris or Lonchocarpus plants and is registered for use as a fish toxicant. Yellow Perch (Perca flavescens) are the only known fish species in the pool and are very sensitive to the chemical Rotenone. A dosage of less than one half part per million (PPM) would be lethal to this species (in comparison to tougher species, such as carp or

bullheads, which require two PPM for a lethal dose), according to John Trimberger, District Fisheries Supervisor with the Michigan Department of Natural Resources, in a 6/86 interview, during a recent visit to the monument.

Inscription Pool, at El Morro National Monument, is twelve feet deep and holds 200,000 gallons at full pool. For a dosage of one half PPM, this calculates out to one fourth gallon of chemical required to complete the job. Rotenone has no known harmful effects on other species and should prove fatal to the fish within minutes. The breakdown time of Rotenone in standing water is between 10-14 days, and occurs even faster if there is any water movement or aquatic vegetation present. For best results, the Rotenone should be evenly dispersed over the pool surface area and shoreline. This might be best accomplished with the use of a canoe or small raft for access to the pool's back areas (and also be helpful for gathering floating dead fish for removal and disposal).

Perhaps assistance in removing these exotic fish could be obtained from the state of New Mexico's Game and Fish Department. A potential contact here would be Mike Hatch, Fisheries Biologist, Santa Fe office. John Trimberger, of Michigan D.N.R., has also offered to assist in technical advice and in obtaining chemicals needed.

The Yellow perch were originally introduced for control of insects and/or excessive vegetation. A healthy amphibian population, if brought back, would be natural and native predators on insects. Combined with an already existing bird colony in the pool vicinity of Cliff Swallows (Petrochelidon pyrrhonota), Violet-green Swallows (Tachycineta thalassina), and White-throated Swifts (Aeronautes saxatilis), the amphibians, along with these avian species, should put a damper on insect populations. Vegetation in the pool grows primarily in the shallow section along the dam, with light-accessible holdfasts or rooting sites being a limiting factor

in deeper water. If vegetation density ever does grow to a problem level, it could easily be removed mechanically, with the aid of a rake and a standard swimming pool sein net on a periodic basis as need arises.

While the monument's native anurans and salamanders would likely return to the pool on their own, if conditions were once again made suitable, the process could be speeded up considerably if a breeding population could be transplanted in. If transplants are to be used, they should be gathered from an area as close to the monument's pool as possible, to assure the prevention of a different subspecies from entering the local gene pool. Specimens of the amphibian species named in this report have already been located in cattle tank ponds, on private lands in the vicinity of El Morro, and permission has been granted from land owners for the collection and transplanting of these animals. Another option is to gather specimens on rainy nights, through road cruising techniques.

FUTURE MONITORING

Upon completion of fish removal and re-introduction of amphibian populations, monitoring should be continued on an annual basis. The most effective season for future observations will be late spring and early summer. Audial and visual monitoring can be accomplished through flashlight lit walks in the pool vicinity on warm rainy nights. Other observations can be periodically undertaken with the use of a dip net for tadpoles and axolotls.

CONCLUSION

The implementation of this Inscription Pool Herptifauna Restoration Plan would follow the philosophy of the National Park Service, by protecting and preserving native wildlife species, while discouraging introduction of exotic species. Restoring populations of these amphibians to Inscription Pool would also enhance visitor opportunity to enjoy wildlife observations within the monument, and add to the area's interpretive potential.

APPENDIX A: ROTENONE TOXICITY DATA

MICHIGAN DEPARTMENT OF NATURAL RESOURCES

Fisheries Division

Technical Report No. 73-3

May 18, 1973

ROTENONE AS A TOXICANT FOR FISHERIES MANAGEMENT IN MICHIGAN

W. C. Latta
Fisheries Biologist

Rotenone ($C_{23}H_{22}O_6$), an alkaloid, primarily used as an insecticide, is obtained from the roots of certain plants of the family Leguminosae. Gardeners commonly use rotenone to control such things as bean beetles and cabbage worms. Since prehistoric times native inhabitants of the tropics and subtropics around the world have used extracts from rotenone-containing plants to catch fish. Depending upon the part of the world from which it comes, rotenone may be known as tuba, derris, cube or timbo. Much of the commercial supply is obtained from Derris elliptica, a plant found in southern Asia. In southeastern United States Tephrosia virginiana, devil's shoestring or goat's rue, contains rotenone and was used by the Indians as a fish poison. At the suggestion of Dr. Carl L. Hubbs, ichthyologist at the University of Michigan, rotenone was first used in fisheries management. In July 1934, Mr. Milton B. Trautman treated two small ponds on the estate of Mr. W. O. Briggs near Birmingham, Michigan. An aqueous suspension of powdered derris root (5% rotenone) was used to remove excessive numbers of goldfish (Carassius auratus) and carp (Cyprinus carpio). Since then, rotenone has been commonly used by fish managers to remove diseased, slow-growing, or undesirable fish from lakes and streams. Commercial formulations containing rotenone synergists and emulsifiers were soon developed for use in fisheries work.

Fish subjected to rotenone suffocate. Respiratory failure is caused by a constriction of the gill capillaries. Toxicity of rotenone to fish starts at 0.0025 mg/l (= ppm) but an average minimum lethal dose is about 0.05 mg/l. Fisheries workers generally use a concentration of 0.5 mg/l or greater of a 5% rotenone formulation. Professor Justin W. Leonard, now of the University of Michigan formerly director of research for the Michigan Department of Natural Resources, in 1938 worked out the first minimum lethal doses for some of the common fishes. He demonstrated that some fish; such as the goldfish (Carassius auratus) and the mudminnow (Umbra limi) are less susceptible to rotenone than others. From Leonard's study, and others that followed, it became apparent that the toxicity of rotenone decreased when exposed to light, heat, oxygen, alkalinity, and turbidity.

Although obviously extremely toxic to fish, rotenone is only slightly toxic to birds and moderately toxic to mammals and other invertebrates. In the low concentrations used in fisheries management, livestock may safely drink the treated water (although it is not recommended) and such things as dogs and snakes, frogs and ducks, are not harmed. In toxicity tests for mallards, the lethal dose for 50% of the birds was 2,000 mg/kg body weight and for pheasants 1,414 mg/kg. The acute oral lethal dose for rats has been reported as 132 mg/kg, for dogs 3,000 mg/kg, and for man 2,850 mg/kg. At this rate, a man weighing 150 pounds would have to consume almost one-half pound of rotenone to have a lethal dose.

Rotenone has been used in municipal water supplies without any adverse effects. Problems of odor and taste caused by decomposing fish or the solvent used with commercial rotenone products are easily removed with activated carbon. Rotenone

does not persist in the environment. Treated water will detoxify within a few days to a month. Waters with high alkalinity (pH), high temperatures, and abundant light and air, detoxify rapidly.

Long-term exposure of rats to low concentrations of rotenone did not result in any serious adverse results. A commercial rotenone product containing 2.5% each of rotenone and sulfoxide (a synergist) was fed to rats in drinking water at a level of 100 mg/l for 70 weeks. Average weight of the experimental animals was then less than the control group but there were no other symptoms. In addition, the commercial product in water was exposed to sunlight and air until the test for rotenone was negative and the solution was no longer toxic to fish. This formulation containing rotenone "breakdown" products was then fed to rats in drinking water at a level of 100 mg/l for one year. Again, a slight decrease in weight was observed in the experimental rats in comparison with the controls, but no gross or microscopic pathology was detected.

Humans may eat fish killed by rotenone without being harmed; however, inhalation of rotenone powder by people working with it has caused headaches, sore throat, and other cold symptoms. Contact with the powder may cause irritation of eyes and a skin rash. Liquid formulations reduce risks to safety and health. Treated waters may be detoxified by using chemical oxidants such as permanganate or chlorine. Methylene blue has been used to revive warmwater fish that have been poisoned by rotenone.

In general, the invertebrate animals are much less sensitive to rotenone than fish, with the exception of the microcrustacea which are nearly as sensitive. Phytoplankton, the microscopic plants in the water, are affected very little by the rotenone. At the concentrations of rotenone used to kill fish, in almost all cases, the microcrustacea or zooplankton populations are severely reduced and will not be completely reestablished for several months. The effect of rotenone on the benthic organisms is extremely variable. Whether these bottom-dwelling invertebrates are injured or not depends upon such things as the water temperature, alkalinity and turbidity, and the concentration of the toxicant. In some situations, after treatment the more resistant species of invertebrates become more abundant than their original populations, presumably because of decreased competition. Reinvasion and increase in the numbers of the resistant species of invertebrates insures an available food supply for the fish which are subsequently stocked.

The commercial rotenone formulation which is used in fisheries management in Michigan has been approved by the United States and the State Departments of Agriculture. In 1962 the Federal Insecticide, Fungicide and Rodenticide Act was extended to cover fish toxicants. To be registered by USDA the application and claims must be substantiated by test data. In addition, the State of Michigan Department of Public Health has acknowledged that rotenone, as used in fisheries management, is not a hazard to public health and may be used, with certain precautions, in public water supplies.

As the agriculturist needs the plow to prepare the land for new crops, so the fisheries manager needs rotenone to prepare lakes for new fish populations. Both need to manage some parts of the environment for the benefit of man. Rotenone is an essential tool for the fisheries manager.

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ENVIRONMENTAL STATEMENTS

BACKGROUND DOCUMENT

PESTICIDES

ROTENONE

MARCH, 1972
U.S.F.S.
St. Paul Office

This document paid for with State funds

I. General Information

- A. Common name - Rotenone (Nox-fish, Pro-Noxfish, Chem-fish Regular, Chem-fish Special, fix-tox, Derris, Cube, Derrin, Nicouline, Tubatoxin, Timbo Powder).
- B. Chemical name - C23 H22 O6 (Extracts from Derris or Lonchocarpus plants.)
- C. Registered uses - Insecticide, Fish Toxicant.
- D. Formulations - Liquid, synergized liquid, and powdered plant roots.
- E. Dilution of formulations for use - 2.5 to 5% rotenone.
- F. Rate and method of application - 0.5 to 2 p.p.m. either sprayed by boat of aerial application and also earlier methods using powder were applied by dragging burlap bags behind boat in the applied prop-wash.
- G. Tolerances - Rotenone is not considered a serious water pollutant. Fish killed by rotenone have been consumed by humans. It is poorly absorbed in the gastrointestinal tract, and it does not cause any tissue changes with the normal formulation and rate of application. There seems to be little danger of acute poisoning by rotenone in agricultural use. Since weathering breaks rotenone down rapidly, chronic effects are also not likely. Rotenone is one of the few pesticides that is exempt from the requirements of a residue tolerance limit (NACA, 1969).
- H. Manufacturer or producer
 - Chemical Insecticide Corporation
 - S. B. Penick and Co.
 - Chemical Formulation, Inc.
 - FMC Corp., Niagara Chemical Div.
 - Prentiss Drug and Chemical Co.

II. Toxicity Data on Formulation to be Used

A. Safety data

Rotenone is moderately toxic to animals and very toxic to fish, but produces no harmful residues on vegetable crops. Action is slow and the material deteriorates rapidly in sun and air.

1. Mammalian studies

Acutely poisoned animals show convulsive seizures followed by central nervous system depression. Death follows by respiratory failure. Studies further showed acutely poisoned animals showed loss of weight, general weakness, partial paralysis, and incoordination of extremities. Under normal rate of application for either insect control or fish control, very little, if any, effects would be expected. Rotenone will cause eye and skin irritation.

Oral Mammalian

Man	2,850 mg/kg
Dogs	3,000 Mg/kg
Rabbits	1,500 mg/kg
Guinea pigs	60 mg/kg
White rats	132 mg/kg

2. Bird studies

Acutely poisoned symptoms of birds would be: immobility, neck pulled in, and feathers fluffed or held tightly to body. The following shows that little likelihood of poisoning exists.

LD/50

Oral Mammalian

Pheasants	1,000 mg/kg
Mallard Duck	2,000 mg/kg
Chickens	1,000 - 3,000 mg/kg
Robins	1,950 mg/kg
Sparrows	1,300 mg/kg
Mourning doves	4,000 mg/kg

2. Other aquatics

One of the greatest uses of Rotenone today is as a piscicide. Depending on species, the normal rate of application is from .5 to 2 p.p.m. Its effects on some of the aquatic insects are as follows:

LD/50

Daphnia	0.23 to 0.57 p.p.m.
Cyclops	0.12 to 0.49 p.p.m.
Phantom midge larvae	0.64 to 1.32 p.p.m.
Midge larvae	0.10 to 0.31 p.p.m.

B. Physical-Chemical properties

Molecular weight	394.41
Melting point	163° C
Solubility in grams/100 ml. of:	

Water	Insoluble
Alcohol	0.2 grams at 20° C
Ether, etc.	0.4 grams (eth.)
	8.5 grams (benzene)
	0.6 grams (carbon tet.)
	7.3 grams (chloroform)

Stability - Knowledge of the stability of the fish poisons is important, since the degree of stability will determine the required duration of special water treatment. Adverse decomposition conditions such as low temperatures and exclusion of air and light, under ice cover, could result in long lasting toxic effects. Alkalinity seems to be important to the persistence of rotenone. Studies show that the toxicity of a concentration of 0.5 to 0.3 p.p.m. of a 5% rotenone emulsion was lost in 1 to 3 days at a M.O. alkalinity range between 60-284 p.p.m., while 3 to 6 days were required below this alkalinity level.

III. Efficacy Data Under Field and Laboratory Conditions

A. Effectiveness for intended purpose when used as directed.

Undesirable fish can generally be eliminated with a concentration of 0.5 ppm rotenone. Under ideal conditions much lower concentrations may be effective in selective species removal. Properly applied, 0.5 ppm rotenone should be the maximum concentration generally needed to kill most fish. A dosage of 1.0 ppm is recommended if doubt exists. Rotenone is available in powdered, emulsified, and synergized forms. The emulsified and synergized forms are recommended more than the earlier powdered compound. Emulsified rotenone is less irritating to handlers and is less bulky. The greatest value of emulsified rotenone is its ability to penetrate colder waters to a greater depth. It also results in much better dispersion of chemical. However, treatment in cold water in deeper basins continues to be unsatisfactory when powdered or emulsified rotenone is used. The emulsified form tends to form globules in cold water.

The synergistic form of rotenone shows greater toxication powers. The synergistic form consists of 2-1/2% rotenone combined with a synergist. Sulfoxide is one chemical used as a synergist when by itself it is non-toxic to fish. In addition of a synergist as sulfoxide decreases the amount of rotenone normally needed to be applied to an area.

Rotenone is not considered a serious water pollutant even though it has high toxicity to fish. Any fish killed by powdered rotenone is fit for human consumption. Rotenone can be used to obtain a complete kill of fishes in a pond, lake, reservoir or stream; to obtain a partial kill to thin populations of stunted fish; or to kill certain fish species and not others.

There are serious disadvantages of rotenone as a fish toxicant. Toxicity is affected by light, temperature, oxygen concentration, alkalinity, and turbidity. Some target species such as carp and bullheads are relatively resistant to rotenone. These species often require high concentrations and great effort for control. Fish are often repelled and tend to seek any avenue of escape, therefore, rotenone is limited for use in partial treatments.

B. Phytotoxicity - No information found.

C. Translocation with plant or animal treated.

Rotenone interferes with blood circulation and oxygen exchange in fish. Blood becomes unable to supply oxygen to various organs. Gill Capillaries shrink to a diameter through which oxygen-bearing blood is unable to flow.

Fish will recover from rotenone poisoning if they are placed in untreated water after first signs of toxicity. Rotenone anesthetizes vertebrate nerves and brain. Fat in the diet increases the tendency for rotenone to be absorbed into an organism's system. Fish killed by powdered rotenone are fit for human consumption.

D. Persistence in soil, water, or plants.

Rotenone applied as a fish toxicant detoxifies rapidly under natural conditions. Time necessary for natural detoxification is difficult to predict. In general, high alkalinity, high temperatures, abundant light and air, and lower concentrations of rotenone favor rapid detoxification. Natural detoxification results in almost no toxic residues being left. When rotenone is used in sufficient strength to kill farm pests, it is potent to fish if washed from the soil into water. About 75% toxicity of powdered rotenone may be expended in a period of 34 days. Emulsified rotenone may lose its toxicity within 20 to 41 days after treatment. A series of pond experiments in Oklahoma were reported by Clemens and Martin (1952). Dosage of emulsified rotenone varied from 1/2 to 2 parts per million and a range of alkalinities and turbidities was encountered. Surface temperatures ranged from 78 to 90 degrees F. Detoxification required 1 day to a maximum of 6 days. Equations were worked out by Post (1957) in Wyoming to predict detoxification. At water temperatures ranging from 45 to 60 degrees F., detoxification was predicted by the equation $93 - 1.33 \times \text{temperatures}$. In water temperatures of 60 degrees to 80 degrees F., detoxification was predicted by the equation $38 - 0.43 \times \text{temperature}$.

Rotenone may be detoxified immediately by using oxidants such as potassium permanganate and chlorine. The amount of detoxicant required is about the same as the amount of carrier used. Additional detoxicant is necessary in water containing high organic matter. The detoxicants used do not have significant effect on subsequent stocked fish.

E. Compatibility with other chemicals.

Studies indicate that the recently developed Antimycin A is compatible with rotenone.

IV Environmental Impact

A. Non-target organisms. (see II A, Safety data.)

Rotenone generally results in low toxicity to non-target animal species. Unicellular animals such as amoeba lose their shapes and experience cell wall disintegration when subjected to rotenone. Aquatic insects, crustacea, and other vertebrates are generally less sensitive to rotenone than are fish. Crayfish nerves and muscles appear to be unimpaired by rotenone.

Subsequent to carp removal by rotenone, aquatic plants may benefit greatly from the disappearance of turbid water conditions caused by carp. Submergent vegetation tends to spread through areas previously barren of growth due to turbid conditions.

Rotenone can be applied at specific dosage rates to selectively kill species or areas. Selective advantage can be made of different fish living, feeding, and breathing habits as well as differences in susceptibility to rotenone.

B. Residue entering food chains.

Rotenone rapidly detoxifies under natural conditions. Detoxification occurs within a few days to a month under most circumstances. Little investigation has been made on residues in fish flesh. Only a few studies have been conducted on water residues and their problems.

Rotenone is one of the few pesticides that is exempt from the requirements of a residue tolerant limit (NACA, 1969).