

TOXICITY OF DRC-1339 TO STARLINGS

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Abstract: Reduction of starling (*Sturnus vulgaris*) populations by the use of poisoned baits is frequently suggested, but an effective, nonhazardous toxicant has not been available. A recently discovered chemical, DRC-1339 (3-chloro-*p*-toluidine hydrochloride), meets many of the requirements; it is highly toxic to starlings (acute oral LD₅₀ = 3.8 mg/kg), well accepted, relatively nontoxic to rats, and generally less toxic to most other birds. Hawks are particularly resistant and there appears to be little danger that these birds, or mammalian carnivores, would be killed by eating DRC-1339-poisoned starlings. The margin of safety is less for the game birds that were tested. DRC-1339 causes a slow, nonviolent death; uremic poisoning and congestion of major organs appear to be the principal causes.

Starlings have become a serious agricultural problem in the United States since their introduction from Europe in 1890. In recent years they have caused considerable losses at livestock and poultry feedlots, particularly in the intermountain region of the West. Reductional control using poisoned bait is frequently proposed as a solution to the starling problem, but a suitable toxicant has been lacking. The Denver Wildlife Research Center has been searching for such a compound since 1961 and has tested more than 400 chemicals. These were solicited from chemical companies, selections usually based on indicated toxicities to other species of birds or structural similarity to compounds previously tested that showed promise as a starling toxicant. Chemicals with the following characteristics were sought:

1. High toxicity to starlings.
2. Low toxicity to mammals, thus minimizing the possibility of accidental poisoning to man or livestock other than poultry.
3. Little aversion by starlings to treated baits.
4. A slow, nonviolent death, which would eliminate bait avoidance caused by birds displaying symptoms or dying at the baiting site.
5. Minimum hazards to avian and mammalian predators that might eat poisoned birds.

Of the chemicals tested, only one—3-chloro-*p*-toluidine hydrochloride, coded by us as DRC-1339—met these requirements. The purpose of this paper is to describe some of the toxicological characteristics of DRC-1339 to starlings and other birds.

We acknowledge the valuable contributions by co-workers at the Denver Wildlife Research Center, principally J. F. Besser

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and Dr. R. D. Thompson. Everett Cole of Biological Research Laboratories, Denver, deserves thanks for pathological evaluations.

METHODS AND MATERIALS

DRC-1339 is a pale yellow, crystalline solid which sublimates at 220 C. It is very soluble in water and other highly polar solvents, which facilitates formulation. Preliminary technical data, which caused us to solicit the chemical, indicated that it was highly toxic to chickens ($LD_{50} < 10$ mg/kg), but relatively nontoxic to rats ($LD_{50} > 1,000$ mg/kg).

The birds used in the following experiments were captured near Denver and were held for a minimum of 2 weeks before tests were conducted.

The acute oral toxicity of DRC-1339 to starlings was determined by intubating an aqueous solution, with the exact microliter dosage calculated according to bird weight and toxicant concentration. Dosage levels were administered in quarter-log steps with four to six birds tested at each level. After being dosed, individual starlings were held in the laboratory and observed daily for 7 days, or until death.

In order to evaluate the effectiveness of DRC-1339 in baits, treated pellets were also tested. These were prepared by incorporating the proper amounts of chemical into 10-gram portions of finely ground mash (2.5 g lactose and 7.5 g commercial poultry feed pulverized in a mortar and pestle). Enough acetone then was added to form a fine slurry which was allowed to air-dry with frequent mixing. Weighed portions of the dried mixture were introduced into a pellet press equipped with a 1/8-inch diameter die. The resultant pellet was then orally inserted into the gizzard of the bird with a glass or metal probe. Pellet size and weight varied according to the weight of the bird and the concentration of toxicant.

Acute intravenous toxicity was determined by injecting 15 microliters of an isotonic solution of DRC-1339 into the jugular vein of starlings; control birds were injected with similar amounts of the nontoxic isotonic saline solution. Acute oral LD_{50} values and confidence limits were calculated using the method of Weil (1952: 251-252). Relationships between death time and dosage levels were developed by pooling data obtained from more than 50 starlings dosed with treated pellets.

Internal pathological examinations were conducted by Biological Research Laboratories, Denver, Colorado. Essentially, this involved cross-sectioning internal tissue and examining it by microscope. Birds dosed at quarter-log intervals both above and below the LD_{50} were compared to recently shot wild birds.

Acute oral toxicities to other avian species were determined by intubating appropriate aqueous solutions.

RESULTS AND DISCUSSION

Acute Toxicity

The acute oral and intravenous LD_{50} 's of DRC-1339 to starlings were remarkably close (Table 1). The acute oral LD_{50} (in an aqueous solution) is 3.8 mg/kg, and the acute intravenous LD_{50} is 3.5 mg/kg. Since toxicants commonly are many times more toxic intravenously than orally, these data indicate that most of the orally administered chemical is absorbed into the starlings' circulatory system. Even when DRC-1339

Table 1. The acute toxicity of DRC-1339 to starlings.

ROUTE	LD_{50} mg/kg	CONFIDENCE LIMITS ($\alpha = 0.05$)	CARRIER	NUMBER OF BIRDS TESTED
Oral	3.8	3.1 to 4.6	Water	30
Oral	4.2	3.2 to 5.6	Pellet	16
Intravenous	3.5	2.2 to 5.4	Isotonic saline	20

is incorporated into pelleted baits the acute oral LD_{50} of 4.2 mg/kg (Table 1) is not greatly different. The indicated absorption of DRC-1339 into the starlings' system could eliminate most DRC-1339 fecal contamination. The fate of DRC-1339, its metabolites, and the rate it is excreted by starlings are being investigated further.

Starling Death Times

The death times of starlings can be manipulated from 3 to 50 hours by varying the amount of toxicant consumed (Fig. 1), but death never occurred in less than 3 hours even when doses were increased to 100 mg/kg, approximately 27 times the LD_{50} . In field practice such variation should be of considerable importance; by selecting proper concentrations of the chemical and varying the proportions of treated and untreated baits, it may be possible to cause the starlings to die in areas where dead birds would not be objectionable.

Symptoms

External appearances and behavior of DRC-1339-poisoned starlings (dosed at levels slightly above the LD_{50}) are: birds appear normal for 20 to 30 hours, but water consumption doubles after 4 to 8 hours and decreases sharply thereafter. Food consumption remains fairly constant until approximately 4 hours before death, at which time starlings refuse food and water and become listless and inactive; they perch with feathers fluffed as in cold weather and appear to doze, but are responsive to external stimuli. As death nears, breathing increases slightly in rate and becomes more difficult; the birds no longer respond to external stimuli and finally become comatose. Death ensues shortly thereafter without convulsions or spasms. Victims usually have feathers fluffed and feet tucked inside the feathers of the lower breast.

A characteristic internal indication of

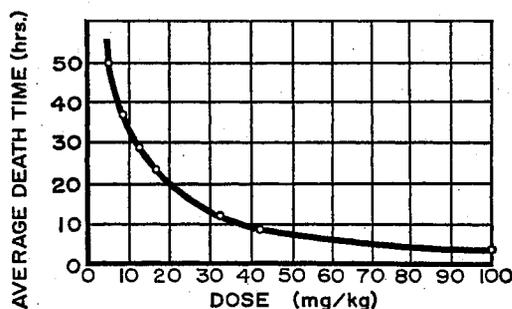


Fig. 1. Average death times of starlings dosed with pelleted DRC-1339 baits.

DRC-1339 poisoning in starlings is the large amount of white, fat-like material that collects within the body cavity, particularly in the pericardial region. Preliminary tests indicate that this is partially uric acid. Deposits are more noticeable in those birds that die 24 hours or more after dosing.

The kidneys have a mottled appearance, and cross-sections reveal hemorrhaging and extensive congestion. Damage varies from cloudy swelling to necrosis, and is confined primarily to the tubules near the corticomedullary junction. The liver also is mottled but to a lesser degree. Congestion of major blood vessels is the most obvious effect within the liver. Major blood vessels of the brain are also slightly congested. The gallbladder is often distended, occasionally to twice its normal size, and sometimes is ruptured. The lining of the gizzard is frequently loosened and occasionally is sloughed from the gizzard wall.

Pathologically, the sequence of DRC-1339 poisoning appears first to be a generalized circulatory impairment, principally in the liver, kidneys, and to some extent the brain; this is followed by necrosis of the gizzard lining and kidney tubules, the latter resulting in hemorrhage and reduced excretion of toxic compounds. Death apparently results from uremic poisoning and congestion of the major organs.

Table 2. Acute oral toxicities of DRC-1339 to various birds.

BIRD	APPROXIMATE LD ₅₀ (mg/kg)	NUMBER TESTED	REMARKS
Icteridae			
Red-winged blackbird (<i>Agelaius phoeniceus</i>)	1.8 to 3.2	10	
Columbidae			
Mourning dove (<i>Zenaidura macroura</i>)	5.6 to 10.0	5	
Pigeon (Rock dove) (<i>Columba livia</i>)	17.7	4	
Phasianidae			
Ring-necked pheasant (<i>Phasianus colchicus</i>)	10	8	
Coturnix quail (<i>Coturnix coturnix</i>)	<10	1	1 dead at 10 mg/kg
Meleagrididae			
Domestic turkey (<i>Meleagris gallopavo</i>)	5.6	6	
Anatidae			
Mallard duck (<i>Anas platyrhynchos</i>)	10 to 32	6	
Blue-winged teal (<i>Anas discors</i>)	10 to 100	4	
Pintail duck (<i>Anas acuta</i>)	>32	2	0/1 dead at 10 mg/kg and at 32 mg/kg
Corvidae			
Common crow (<i>Corvus brachyrhynchos</i>)	1.8	5	
Black-billed magpie (<i>Pica pica</i>)	5.6 to 17.7	4	
Blue jay (<i>Cyanocitta cristata</i>)	<10	2	1/1 dead at 100 mg/kg and at 10 mg/kg
Accipitridae			
Cooper's hawk (<i>Accipiter cooperii</i>)	320 to 1,000	4	
Marsh hawk (<i>Circus cyaneus</i>)	100	2	1/2 dead at 100 mg/kg
Falconidae			
Sparrow hawk (<i>Falco sparverius</i>)	>320	2	0/1 dead at 100 mg/kg and at 320 mg/kg
Floceidae			
House sparrow (<i>Passer domesticus</i>)	320 to 448	3	0/1 dead at 100 and 320 mg/kg

Toxicity to Other Birds

Information on the toxicity of DRC-1339 to other species of birds that may feed on treated baits or on poisoned birds was collected whenever practicable. Because of the limited numbers of such birds that were available, LD₅₀'s could only be approximated for most species (Table 2). Generally, symptoms and death postures were similar to those described for starlings.

The red-winged blackbird (*Agelaius phoeniceus*) and the crow (*Corvus brachyrhynchos*) were the most susceptible of the other birds tested. Ducks (*Anas platyrhynchos*, *A. discors*, and *A. acuta*) and ring-necked pheasants (*Phasianus colchicus*) were somewhat more resistant to DRC-1339 than starlings. The larger size of ducks and

pheasants, however, affords them some protection from accidental poisoning. Furthermore, an additional measure of safety is provided through use of baits preferred by starlings, but less readily acceptable by ducks and pheasants.

House sparrows (*Passer domesticus*) and three species of hawks were highly resistant to DRC-1339 poisoning. The low susceptibility of hawks is fortunate since some individuals regularly feed on poisoned starlings in the field. In the laboratory, a marsh hawk (*Circus cyaneus*), a sparrow hawk (*Falco sparverius*), and a Cooper's hawk (*Accipiter cooperii*) were fed ad libitum for 104, 141, and 135 days, respectively, a diet of starlings that had been killed with an estimated 1 to 3 lethal doses of DRC-

1339. The marsh hawk consumed 222 starlings, the sparrow hawk 60, and the Cooper's hawk 191 during the testing period. None of the hawks showed any ill effects and all gained weight.

CONCLUSION

It appears in this stage of our research that DRC-1339 can be safely used in star-

ling control, with effectiveness far exceeding previously used toxicants.

LITERATURE CITED

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POX IN MOURNING DOVES AND GAMBEL'S QUAIL IN SOUTHERN ARIZONA

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Abstract: Outbreaks of pox-virus infections were noted in mourning doves (*Zenaidura macroura*) and Gambel's quail (*Lophortyx gambelii*) in southern Arizona in 1963. Thirty-eight wild mourning doves and 11 Gambel's quail were found to be infected. Diseased birds were encountered from May through November, but the largest number was handled during October when 19 doves showed signs of the disease. Pinned doves also became infected and seven died. Mortality from pox-virus infections in wild populations appeared to be low, although mortality figures might have been higher if all dead doves could have been found and the cause of death diagnosed.

The purpose of this paper is to report on pox-virus infections found in mourning doves and Gambel's quail in southern Arizona in 1963. At that time such infection in mourning doves had been reported in only eight states (Locke 1961:211-212). We know of no published reports on the occurrence of pox in Gambel's quail, although Dr. Roger Hungerford of the University of Arizona (Personal communication) found two pox-infected quail on December 7, 1960.

MATERIALS AND METHODS

A study of mourning dove behavior has been conducted on two study areas in southern Arizona since 1962. One area is on the University of Arizona Agricultural Farm adjacent to the Rillito River on the north edge of Tucson; the other is in the Rincon Creek Valley, 20 miles southeast of Tucson. The Rincon Creek drainage flows into Pantano Wash, which joins Tanque Verde Wash to become the Rillito River, forming a geographical association between the two areas.

During these studies, mourning doves were trapped and marked so that individual birds could be recognized. All doves caught

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