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Large winter roosts of blackbirds (Icteridae) and starlings *(Sturnus vulgaris)* often cause conflicts, both real and imagined, between the birds and local human populations. These conflicts may range from objections to the noise and odor engendered by thousands or millions of birds, to fear of epidemic human and livestock diseases, and the possibility of economic losses from crop depredations. Many people believe the most direct way to combat these conflicts is to reduce local roosting populations by killing the birds. In response to this perceived need for a roost toxicant, the U.S. Fish and Wildlife Service (FWS) developed PA-14, a surfactant which can be aerially applied to problem roosts for population reduction (Lefebvre and Seubert 1970). Successful use of this material, however, requires concurrent rainfall and low temperatures, conditions which may not occur sufficiently often to permit roost treatment at desired times or places. Because of this difficulty, and continued pressures from management personnel and the agricultural community, the Service has continued its search for a safe, effective roost toxicant usable without severe weather restrictions.

One of the current candidate materials is *N*-(3-chloro-4-methylphenyl)acetamide (CAT, DRC-2698), a derivative of Starlicide^{R} (DRC-1339). This compound was initially developed by S.A. Peoples of the University of California-Davis (Peoples et al. 1976). California researchers are still investigating the avicidal potential of CAT, mainly on baits and in wick perches, while FWS interest has centered thus far on its possible utility as an aerially applied roost treatment. This report is a summary of our investigations to date.

Formulation

Technical grade CAT is a crystalline powder which must be incorporated into a liquid formulation to permit spraying. Several solvents and solvent systems were found to make concentrated solutions, but attempts to make stable aqueous dilutions by use of emulsifiers and/or co-solvents have thus far failed. In all cases CAT precipitated out of the concentrated solutions when water was added. Initial laboratory testing and a field trial have been conducted with a two-solvent system. Of the most effective solvents, *N*-methyl-2-pyrrolidone (M-PYROL^{R}) was considered the least potential hazard to users and the environment. Corn oil was chosen as an innocuous diluent to raise the flash point for safer aircraft application. In practice, CAT is dissolved in methyl pyrrolidone at the rate of 239.7 g/1 (2 lb/gal). The resulting solution is then diluted with an equal volume of corn oil for application.

Target Toxicity

The acute oral toxicity of technical grade (99+%) CAT to red-winged blackbirds *(Agelaius phoeniceus)* and starlings was determined by gavage of aqueous suspensions and propylene glycol solutions. Median lethal doses (LD_{50}) were 1.8-2.7 mg/kg for redwings and 1.0-2.6 mg/kg for starlings. Acute dermal LD_{50S} of the technical material to redwings were 4.9, 11.5, and 13.3 mg/kg, respectively, in acetone, methanol, and ethanol solutions.

Median lethal application rates (AR_{50}) of the formulated material have been determined by spraying caged birds at known rates. AR_{50}s for redwings, common grackles *(Quiscalus quiscula),* and starlings were 2.25, 2.79, and 7.96 kg/187 ℓ/ha (2.0, 2.5, and 7.1 lb/20 gal/A), respectively.

Pathological signs in affected birds included resorption of fat; visceral gout; separated or easily separable gizzard linings; mottled livers; and pale, swollen, mottled kidneys.

Nontarget Direct Toxicity

Foliar applications of formulated CAT at up to 89.7 kg/748.2 ℓ/ha (80 lb/80 gal/A) on potted bamboo *(Bambusa multiplex),* oak *(Quercus virginiana),* and redcedar *(Juniperus silicicola)* resulted in some initial necrosis which the plants outgrew. A test of phytotoxicity to potted eastern white pine *(Pinus strobus)* was inconclusive. January 1979 spray applications on 3-year-old field-grown slash pine *(Pinus elliottii)* are presently being evaluated; no effects are apparent yet.

Standard mammalian toxicity tests (National Academy of Sciences 1977) designed to evaluate acute human hazard potential (Table 1) have been completed by commercial laboratories under FWS contracts. Additional tests on other animals also were conducted to determine potential primary hazards. Domestic cats treated by gavage with aqueous carboxymethylcellulose suspensions of CAT were killed by doses of only 20 mg/kg (Palmore 1978). Miniature swine were tested dermally by leaving a CAT paste in contact with their skin for 24 h. Doses of 1 and 2 g/kg resulted in no gross evidence of dermal toxicity over a 7-day observation period. Wild-trapped opossums sprayed with the corn oil/methyl pyrrolidone formulation at 22.4 kg/187 l/ha (20 lb/20gal/A) also showed no ill effects. The AR_{50} of a similar formulation to bobwhites *(Colinus virginianus)* was 14.58 kg/187 ℓ/ha (13 lb/20 gal/A), and to robins *(Turdus migratorious),* between 13.44 and 26.90 kg/187 ℓ/ha (12 and 24 lb/20 gal/A).

Propylene glycol solutions of CAT were administered by gavage to adult bobwhites, mallards *(Anas platyrhynchos),* and coturnix *(Coturnix coturnix)* to determine oral toxicity. Acute oral LD_{50}s to these birds were 1.78, 42.2, and 1.3-2.0 mg/kg, respectively. Dietary median lethal concentrations (LC_{50}) of the compound for 10-day-old young were 25 ppm for bobwhites and 244 ppm for mallards.

Aquatic toxicity tests have been performed on a variety of species (Table 2). Techniques were those of the Committee on Methods for Toxicity Tests with Aquatic Organisms (1975). Toxicity of the compound to trout was not influenced by variations in water hardness ranging from 10 to 320 mg/ℓ total hardness as $CaCO_3$, pH values of 6.5, 8.5, and 9.5, or water temperature(7°-17°C).

Secondary Hazard Evaluation

Animals likely to be exposed by virtue of feeding on CAT-killed birds have been tested to determine whether secondary poisoning might be a danger. Predator and scavenger species were maintained for 7 days on a diet of blackbirds killed by spray application of the corn oil/methyl pyrrolidone CAT formulation at 22.4 kg/187 ℓ/ha (20 lb/20 gal/A). This feeding period was followed by a 2-week observation period during which untreated food was offered. Animals underwent necropsy at death or the end of the observation period. The results (Table 3) indicate that, of the species tested, only cats are susceptible to CAT secondary poisoning.

Field Trial

A 1.2 ha (3.0 A) blackbird/starling roost in northeastern Arkansas was aerially treated on 15 January 1979 with the corn oil/methyl pyrrolidone CAT formulation at 22.4 kg/187 ℓ/ha (20 lb/20 gal/A). Rhodamine B dye was added to the formulation to mark treated birds. The roosting population was estimated at 27,000 birds on the evening of treatment; but substantial dispersal occurred during, and probably immediately after, the application. Approximately 200 target birds believed killed by the treatment were found from 2 to 6 days after application at the treated site and at two roosts formed after treatment. Necropsies were conducted on a sample of these birds; and almost all showed signs of CAT poisoning, i.e., pale, granular-appearing kidneys; ruptured or distended gall bladders; and visceral gout. Three of four birds found dead away from roosting areas also bore signs of CAT poisoning. Thirteen of 150 target birds collected by shooting showed external evidence of having been sprayed, but only two of these exhibited internal pathological signs of CAT poisoning. We believe that few birds were killed by the treatment but do not know if this was a result of dispersal of birds during the application, inadequate application rate, or unsuitable formulation.

Analysis and Degradation

Analytical methods for technical CAT include gas-liquid, thin-layer, and paper chromatography; infrared spectroscopy; and gravimetric and colorimetric techniques. In tests at the Denver Center, the compound was only slightly degraded by exposure to 168 h of simulated sunlight at temperatures ranging from 0° to 30°C. Bioassays with rainbow trout at the LaCrosse Laboratory showed no apparent difference in toxicities of fresh aqueous preparations and those aged for 1 to 5 weeks.

Analytical techniques for the corn oil/methyl pyrrolidone formulation are being developed. Bioassays with starlings at the Florida Field Station showed no apparent loss of formulation toxicity from 1-year outdoor storage.

DISCUSSION

Many more studies will be necessary to gather the data required for registration of CAT by the Environmental Protection Agency and to satisfy FWS concerns for its safe and effective use. Among these are studies of analytical techniques, degradation, aerobic and anaerobic metabolism, microbial effects, leaching, biological accumulation, dissipation, avian reproduction, mammalian dermal sensitization, and aquatic toxicities. In addition, if a residue tolerance is sought, determinations must be made of the effects of subchronic and chronic oral exposure, oncogenicity, teratogenicity, mutagenicity, reproductive effects, and single- and multiple-dose metabolic effects. An estimated minimum of 12 field tests will be necessary to establish directions for use, efficacy, and to determine environmental effects. The cost of these studies is expected to be in the range of $2-3 million over a 5-year period.

There is some question within the FWS as to whether we are justified in continuing the search for an aerially-applied roost toxicant. Aside from the high cost involved, other difficulties are foreseen.

Use of nonspecific roost toxicants might endanger desirable birds, like robins, and nontarget blackbirds, such as the rusty *(Euphagus carolinus)* and Brewer's *(E. cyanocephalus)* in communal roosts. The relative resistance of the starling to known avicides also makes it likely that their use would result in disproportionate kills of the native blackbird species while sparing the more troublesome starling.

Unless a toxicant highly specific to blackbirds and/or starlings is discovered (an improbable situation), use of an aerially-applied avicide probably would be restricted to roosts isolated from humans. Recent experience suggests that isolated problem roosts are becoming much less common; thus available candidate toxicants. like CAT, would be of limited utility.

In foreseeable problem situations, alternative solutions are available: scare devices, roost dispersal, vegetation thinning, and chemical repellents and oral toxicants applied at damage sites. We believe that the limited resources of the FWS might be better employed in refining these existing tools than in developing roost toxicants whose utility is doubtful.

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DISCUSSION

Q: How does this relate to development of CAT as a toxicant similar to Starlicide?

A: As an oral toxicant? It doesn't relate at all to that. It is still very viable, and people at the University of California are still working on it. Their emphasis in the past has been towards oral use of material as well as in wick perches.

TABLE 1. Results of human hazard indicator tests, CAT

Test	Subject	Outcome
Technical material		
Acute oral	rat	LD_{50} 34[illegible] mg/kg
Acute dermal	rabbit	LD_{50} >20 g/kg
Eye irritation	rabbit	none at 100 mg/eye
Acute inhalation	rat	LC_{50} >2 mg/l
Formulated material		
Acute oral	rat	LD_{50} 7.1 ml/kg
Acute dermal	rabbit	LD_{50} 12 g/kg
Eye irritation	rabbit	moderate at 0.1 ml/eye
Acute inhalation	rat	LC_{50} >22 mg/l

TABLE 2. Results of CAT aquatic toxicity tests, LaCrosse National Fishery Research Laboratory and Southeastern Fish Control Laboratory.

	96-h LC_{50} (mg/l)		
Species	12ºC	16ºC	22ºC
Rainbow trout (*Salmo gairdneri*)	26.6	---	---
Channel Catfish (*Ictalurus punctatus*)	34.6	---	35.9
Bluegill (*Lepomis macrochirus*)	29.9		17.3
Asiatic Clam (*Corbicula leana*)	---	96.5	---
Glass Shrimp (*Palaemonetes kadiakensis*)	---	45.0	---
Newt (*Notophthalmus viridescens*)	---	58.5	---

TABLE 3. Results of secondary hazard potential tests, CAT.

Species	Deaths/n	Treatment-related pathological signs	
		Gross	Microscopic
Sharp-shinned Hawk (*Accipiter striatus*)	1/5[1/]	none	none
Red-tailed Hawk (*Buteo jamaicensis*)	0/5	none	none
Opossum (*Didelphis marsupialis*)	0/4	none	none
Raccoon (*Procyon lotor*)	0/8	none	none
Swine	0/6	none	none
Domestic cat (Test I)	2/5	Signs of renal dysfunction	Congestion of renal medulla in some cats
Domestic cat (Test II)	4/6	Body weight loss in some cats	Necrosis of nephric proximal convoluted tubules

[1/] Death not treatment-related; caused by ectoparasite infestation.