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ABSTRACT: From 1988 through early 1990 alpha-chloralose (A-C) was successfully used in the United States to immobilize and remove 70 Canada Geese (Branta canadensis), 315 mallard, domestic and hybrid ducks (Anas platyrhynchos), and 348 coots (Fulica Americana) from 17 commercial and residential sites including golf courses, pools, and ponds. Field trials and baiting techniques with bread and corn are described. The optimum dose of A-C for geese, ducks, and coots, using orally administered bread and corn baits, was about 20-30 mg/kg. We are currently pursuing registration of A-C as a bird control chemical with the U.S. Food and Drug Administration.

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INTRODUCTION

Waterfowl, primarily Canada geese, wild mallard ducks, domestic mallard ducks, hybrids of wild and domestic mallards, and coots, have adapted to suburban and urban environments in the United States. Ponds or impoundments in residential, commercial, and recreational areas provide an attractive environment for waterfowl. Initially a few waterfowl are admired, fed, and protected by managers, tenants, and landowners but when the numbers increase through donations, immigration, and reproduction, a threshold of tolerance is surpassed. Concentrations of waterfowl cause problems such as fouling of lawns and golf courses, contaminating water, agricultural depredation, disease, and hazards to aircraft (Hanson 1965:191-196; Nelson and Oetting 1981, 1982; Conover and Chasko 1984; Oetting 1987). In addition, situations arise whereby injured, but mobile, waterfowl occasionally create sympathetic concern to the public. Waterfowl (excluding domestic varieties) are federally protected by the Migratory Bird Treaty Act of 1918; therefore, it is unlawful to hunt, kill, trap, sell, purchase, or possess these birds except as permitted by regulations adopted by the Secretary of the Interior (Office of the Federal Register 1988). No federal permit is required to scare or harass depredating waterfowl.

Current management of urban and suburban waterfowl has consisted largely of reducing populations by trapping for translocation, nest and egg destruction, hunting within the framework of current federal regulations (Anonymous 1989), and even surgical sterilization (Nelson and Oetting 1981, 1982; Converse 1985; Oetting 1987). Other practices include posting areas against the release of waterfowl, using the media for appeals to stop releasing domestic waterfowl, and discouraging feed supplementation of existing birds (Calif. Dept. of Fish and Game 1989). Presently there are no chemical products federally registered for alleviating waterfowl problems nor are there any drugs registered for capturing nuisance birds for relocation (Pfeifer 1983).

Personnel within the U.S. Department of Agriculture (USDA) Animal Damage Control (ADC) Program and state wildlife agencies have indicated a need for the development and registration of products that will repel or capture nuisance waterfowl (Conover 1985, Fagerstone and Schafer 1988). The pilot studies being reported here were done in cooperation with ADC field personnel to determine the potential of the unregistered chemical, alpha-chloralose (A-C), for safely capturing waterfowl for relocation to alleviate nuisance problems in urban and suburban areas.

The present studies were designed to gather data on baits, baiting strategies, sedation, and recovery that would be useful in developing a safe and humane technique for capturing waterfowl. The data and experience gathered from these pilot studies were used to determine if further research was warranted to pursue a registration of A-C through the Food and Drug Administration (FDA) for use on waterfowl and perhaps other species of nuisance birds.

Description of Chemical

A-C ($C_8H_{11}Cl_3O_6$) is a chloral derivative of glucose which depresses the cortical centers of the brain but has no effect on the medulla (Borg 1955, Crider and McDaniel 1967). A-C has been used as an anesthetic in experimental animals since 1897 (Balis and Monroe 1964) but is considered a poor anaesthetic (Borg 1955). It has been used as a hypnotic in Belgium under trade names of Somio, Dorcalm, Glucochloral, and Dulcitor (Daenes et al. 1980).

A-C was used to control corvids in France during World War II when strychnine was in short supply. Later it was employed to catch crows for banding (New Zealand Pesticides Board 1977). A-C has been used to reduce populations of several species of birds that either were a nuisance, potential hazard to aircraft, or harmful to agriculture (Colquhoun 1943, 1946; Borg 1955; Anonymous 1960, 1962; Thearle 1960, 1969; Ridpath et al. 1961; Murton 1962, 1963; Murton et al. 1965; Caithness 1968; Thearle et al. 1971; Cyr 1977; Feare et al. 1981; Dolbeer 1987; Woronecki et al. 1989). It has been used to capture waterfowl (Crider 1967; Crider and McDaniel 1966, 1967, 1969; Crider et al. 1968; Cline and Greenwood 1972) and also to capture other birds for research (Murton et al. 1963, 1968; Williams 1966; Williams et al. 1966; Austin et al. 1972; Williams and Phillips 1972, 1973; Pomeroy and Woodford 1976; Hofman and Weaver 1980; Holbrook and Vaughn 1985). A-C is marketed as a rodenticide (Alphakil) in West Germany and England (Thomson 1986:148, Thomas et al. 1988) and has been registered as an avian control agent in England, France, New Zealand, and Australia.

LD_{50} (dose that produces death in 50% of population tested) and ED_{50} (dose that produces defined effect [i.e., immobility] in 50% of population tested) values for A-C have been determined for several bird and mammal species (Goldenberg 1893; Hanriot and Richet 1897; Giban 1950, 1951; Borg 1955; Ridpath 1961; Murton et al. 1965; Giban 1966; Giban et al. 1966; Cornwell 1969; Cline and Greenwood 1972; McGinnes et al. 1972; Schafer 1972; Schafer and Cunningham 1972; New Zealand Pesticides Board 1977; Hofman and Weaver 1980; Cunningham et al. 1987; Loibl et al. 1988). Mammals tested generally have higher LD_{50} values than do birds (Woronecki et al. 1989). The estimated LD_{50} and ED_{50} values for waterfowl are listed in Table 1.

STUDY AREAS AND METHODS

From 1988 through early 1990, 13 tests were conducted at 11 sites in Ohio; and in 1989 there were 11 tests at 5 sites in Nevada, 5 tests at 1 site in New Mexico, and 1 test in Oklahoma. Test sites included areas around swimming pools, ponds, and lakes at residential areas, resorts, recreation areas, golf courses, industrial sites, nursing homes, fish hatcheries, and hotel-casinos. Tests were arranged by ADC biologists who had found other methods of alleviating the problem to be unsuccessful. In Ohio tests were cooperatively conducted by ADC biologists and Denver Wildlife Research Center personnel. In other states the recommended amount of A-C and instructions were sent to the ADC biologists. They were asked to collect data (described below) and to make recommendations to reduce mortality and maximize the capture of the problem species. Cooperators were also asked to comment on the acceptance of this technique by the general public in solving the problem.

Bread baits for prebaiting were prepared by spreading 12 g of soft margarine or butter on a slice of bread and covering with another slice. The sandwich was pressed firmly with a flat board and sliced into 16 to 18 equal- sized pieces. Each piece weighed from 3.3 to 3.7 g (Woronecki et al. 1989). Bread baits treated with A-C were prepared by mixing A-C with margarine or butter to a level of 2 to 20% by weight depending on the target species. Each bait contained 13 to 150 mg of chemical.

Corn baits for prebaiting were prepared by mixing powdered sugar (0.3% by weight) with whole corn kernels and coating them with corn oil (1.4 ml per 100 g of corn). Corn baits treated with A-C were prepared by adding A-C powder (1.04 mg of A-C per kernel) to corn that had been cleaned of dust and chaff. Corn and A-C were placed in a plastic container with a lid and shaken for 60 to 90 seconds; corn oil was added (1.4 ml/100 g of whole corn) and mixed again. There were approximately 333 kernels of field corn per 100 g.

Prebaiting commenced at least 1 week before any treatment by spreading bait on the ground where the birds normally fed or by hand tossing bait to individual birds. During prebaiting, a count of the number of target and nontarget animals present and an estimate of feeding rates were obtained. Prebaiting and baiting were usually conducted in the morning. Baits were generally formulated to provide an approximate A-C dose between 20 and 30 mg/kg. Initial doses were calculated on the mean weight of targeted species as reported by Dunning (1984). Subsequent bait formulations were based on the mean weight of birds captured at the bait site or at nearby sites.

Table 1. Estimated LD_{50}, ED_{50} and related values of alpha-chloralose for waterfowl and coots.

Species	LD_{50}[a] (mg/kg)	ED_{50}[b] (mg/kg)	TI[c]	Average induction to immobility (min)	Average duration of immobility (hrs)	Optimum dose for capture (mg/kg)	Citation
Canada geese	>56	<16	>3.5	45-60	<20	20-37	d
Mallard ducks	42	13	3.2	45	2.5	--	e
	55	<20	>2.8	30	>3.0	~20-30	d
	34	15	2.3	-	-	-	f
		37		30-90	5.0	-	g
Greylag geese	>775	<50	>15.5	-	-	-	h
Domestic ducks	~50	15-20	~2.9	-	-	-	i
	>60	20-25	>2.4	-	-	-	j
Coots	>60	<20	>3.0	~15	<20	20-30	d

[a]Dose that produces death in 50% of population tested.
[b]Dose that produces a defined effect (i.e., immobility) in 50% of population tested.
[c]Therapeutic Index or Safety Factor = $\frac{LD_{50}}{ED_{50}}$
[d]U.S. Dept. Agric., Denver Wildl. Res. Cent., Ohio Field Sta., Unpubl. results 1989, gavage, bread baits.
[e]Schafer and Cunningham (1972) gavage, pellets.
[f]Cline and Greenwood (1972) gavage, propylene glycol.
[g]Hofman and Weaver (1980) barley baits.
[h]Borg (1955) gavage, gelatin capsules.
[i]Goldenberg (1893) taken from Giban et al. (1966) method unknown.
[j]Giban (1950, 1951) taken from Giban et al. (1966) gavage, gelatin capsules.

Bait selection, either bread or corn, depended upon the number of target birds on site. In situations where individual birds could be selectively fed, bread baits were preferred, because we could give each bird known amounts of A-C (e.g., 1 to 5 bread baits with 30 mg A-C/bait to achieve a dose of 30 mg A-C/kg). When large flocks or mobbing behavior prevented individual baiting, corn baits containing about 1 mg of A-C/kernel were spread over the bait site (generally an area <25 m^2). The amount of corn used varied according to the number and size of birds at the location. For example, a site with 100 wild mallards (mean weight 1 kg) would receive 3,000 kernels of corn treated with about 1 mg A-C/kernel. Theoretically, each duck would eat 30 kernels and obtain a dose of 30 mg of A-C/kg. In either situation, after birds consumed treated baits, we attempted to keep them on the bait site by feeding them token amounts of untreated bread or corn. Birds were observed to determine the time of initial bait consumption, initial reaction to A-C, reaction of unaffected birds to affected birds, and immobilization.

The following stages and symptoms produced by A-C as described by Crider and McDaniel (1967) were used to note the condition of treated birds:

Stage I. Light sedation: characterized by unnatural posture, slowly blinking eyes, sluggish reflexes, relaxed wings, and some staggering; bird is able to fly; bird cannot be captured.

Stage II. Heavy sedation or mild narcosis: signs of muscular incoordination, individuals sway forward and backward; awkward posture; bird sometimes rests on breast; preening, feeding, ruffling of feathers, and meandering may be observed; eyes may be closed if not disturbed; bird may fly short distances; difficult to capture by hand.

Stage III. Moderate narcosis: deepening hypnosis characterized by periods of dozing with eyes closed and impaired balance; usually rests on breast with bill resting upon something, most muscular coordination lost, and bird may lie on its back or side; brief periods of alert motionless, erect posture; if carefully approached can be captured by hand or dip-net.

Stage IV. Deep narcosis or anesthesia: bird rests on its breast, side, or back with head down; eyes closed; easily captured by hand.

In each trial, an estimate of the target waterfowl population was made and the number of birds treated was noted. Treated birds were kept under constant surveillance to collect data on symptoms and to prevent their accidental drowning. Birds were captured by hand or long-handled net as soon as they were narcotized and observed for 24 hours. Narcotized birds were transported in cloth bags to holding cages or an enclosed truck. Sedated birds were kept in cages lined with straw until they recovered. All birds were weighed and dead birds buried. Mallards and geese were relocated to wildlife management areas. Domestic ducks were relocated or euthanized and hybrid ducks were euthanized.

RESULTS

A total of 315 mallard, domestic and hybrid ducks, 70 Canada geese, and 348 coots were removed from 18 situations in 4 states, with 91, 57, and 77% survival, respectively (Tables 2 and 3). Nuisance waterfowl were generally accustomed to being fed various foods by various individuals; therefore, bait acceptance was not a problem. Prebaiting could have been omitted in many situations. All baits were usually consumed within 15 minutes after application. Stage I symptoms produced by A-C were usually noted from 15 to 30 minutes after waterfowl ingested treated baits. High mortality was noted during the initial trials on geese (Table 2) until an optimum lower dose could be determined and baiting techniques improved. In a later trial, we attributed the high mortality (83%) to temperatures above 32°C and high humidity (Table 2). Hyperthermia may have resulted from depressed brain activity slowing the heart and respiration rate which caused a slower dissipation of internal heat (Calder and King 1974). Narcosis may have reduced thermal regulatory mechanisms or the ability to replace evaporative water loss.

Table 2. Nuisance Canada geese: captured with alpha-chloralose from 1988 to 1990 with alpha-chloralose-treated bread baits.

Year (State)	Situation	Population target	Population removed	Percent survival	Attempted A-C dose rate: No. of baits/bird	Mg/bait	Mg/kg body wt.	Mortality comments
1988 (Ohio)	golf course	16	13	39	5	50	50	Birds given overdose of A-C
	residential	2	2	0	5	50	50	Birds given overdose of A-C
	nursing home	2	2	100	3-5	25	25	
	putt-putt-golf	5	1[a]	100	5	25	30	
1989 (Ohio)	nursing home	5[b]	5	80	1	120	30	Cause of death unknown
	residential	19	18	17	1	150	30	Temperature +32°; some birds ate more than 1 bait
	NASA	2	1	100	1	120	30	
(Nevada)	park	1[c]	0		3	45	30	
	residential	28	25	84	2	60	30	2 birds ate excessive no. of baits; 2 injured in Stage II narcosis while flying
1990 (Ohio)	residential	4	3	100	1	118	25	

[a]Adult captured with A-C and 4 young captured by net.
[b]One domestic goose was also captured.
[c]California gulls consumed baits before goose could eat them.

Table 3. Nuisance ducks and coots captured with alpha-chloralose in 1989.

State	Situation	No. of baitings	Target population	Number removed	Percent survival	Bait	Attempted A-C dose rate: No. of baits/ bird	Mg/ bait	mg/kg body wt.
OK	residential[a]	1	26	23	74	bread	1-2	20	30
NV	hatchery[b]	2	25	20	65	bread	2-3	30	20
NV	casino (pool)[a]	3	33	33	91	bread	3	23	40
NV	casino (pond-golf course)[a]	4	150	80	93	bread	2	30	60
OH	factory[c]	1	1	1	100	bread	1	100	30
OH	residential[a]	2	160	113	97	corn	30	1.04	30
OH	residential[a]	2	50	45	98	bread	1	30	30
						corn	30	1.04	30
NM	golf course[d]	5	375	348	77	bread	1-2	13.3	20

[a]Mixed flock of mallard, domestic and hybrid ducks.
[b]Wild mallards.
[c]Muscovy.
[d]Coots.

Initial bait formulations were based on 1-kg wild mallard ducks, 4-kg Canada geese, and 0.6-kg coots. However, within and between sites there was considerable variation in duck and goose weights. In Ohio, Canada geese weights ranged from 2.7 kg (juveniles) to 5.4 kg. The weight range for Canada geese in Nevada was 3.9 to 5.7 kg. Captured mallard ducks in Ohio weighed from 1.1 to 2.8 kg whereas in Nevada they ranged from 1.0 to 3.2 kg. The weights of coots captured in New Mexico ranged from 0.6 to 0.7 kg. Other fowl taken included a 3.0-kg Muscovy duck (Cairina moschata) in Ohio and a 7.2-kg domestic goose (Anser sp.) in New Mexico. Variable weights contributed to some individuals receiving either suboptimum doses or overdoses. Excessive feeding on A-C-treated baits by dominant individuals also contributed to mortality.

Affected waterfowl staggering, stumbling, or falling (Stage I and II) were typically ignored by other birds that continued to feed or rest until affected. Stage II birds often attempted to feed until they reached complete narcosis. Immobilized birds (Stage II) sometimes were still capable of erratic but sustained flight (Tomlinson 1967, Hofman and Weaver 1980) which was the cause of 2 fatal injuries (Table 2).

Birds not captured during an initial test readily accepted A-C baits in subsequent tests without any apparent bait shyness or chemical repellency. Following each baiting, the birds became less trustworthy of human activity. This nervousness was perhaps due to the activity of capturing Stage II and III birds, especially when a net was used.

In Ohio, 2 injured but flight-capable Canada geese, 1 with an arrow in its side and 1 with a missing foot, were easily captured in January 1990 with A-C baits after repeated capture attempts using other methods by state wildlife personnel failed (Table 2). Public reaction to this successful removal was very favorable.

Trials in Nevada and New Mexico involving bread baits on nuisance ducks and coots resulted in the exposure of baits to several nontarget species with resulting mortality (Table 4). During a treatment at a casino (pool) in Nevada, house sparrows (Passer domesticus) were observed feeding in the area upon crumbs of treated bread left by feeding ducks. In addition, a 2-week-old black swan (Cygnus atratus) apparently also fed upon crumbs of treated bread and was found incapacitated in a pond. The cygnet recovered within 3 hours.

During a treatment to capture a mixed flock of ducks at a Nevada casino (pond and golf course) house sparrows, boat-tailed grackles (Cassidix mexicanus), and coots fed on bread baits and were immobilized (Table 4). In addition, 20 hours after baiting ducks in the pond, 5 Koi goldfish (Carassius sp.) were observed swimming erratically on their sides and 44 hours later were found dead.

During an attempt to immobilize a Canada goose with an arrow protruding from its back at a city park in Nevada, California gulls (Larus californicus) consumed most of the bait and 4 gulls died from an overdose of A-C (Tables 2, 4). During a treatment to capture coots at a golf course in New Mexico, 14 domestic ducks, 2 American widgeons (Anas Americana), and 7 domestic geese were immobilized and captured with minimum mortality (Table 4).

Removal of waterfowl and coots with baits treated with A-C was well received by the public. When left undisturbed, Stage II birds remained calm. Even in severe overdose cases, birds did not exhibit any violent reaction to the drug. Stage IV birds receiving optimum doses and even overdoses would respond to being handled but in a nonviolent manner. Some birds in Stage III or IV even appeared dead until they were touched or handled.

Stage II and III birds normally recovered in 6 to 12 hours, Stage IV birds required up to 24 hours. Most birds recovered within 12 hours.

DISCUSSION

Although precise ED_{50} and LD_{50} values have not been determined for Canada geese and coots, the data from our studies suggest 20 to 30 mg of A-C/kg was sufficient to immobilize these birds with negligible mortality. Mortality did occur when target individuals consumed more treated baits than were intended. From these trials we determined that mortality could be reduced when untreated baits were provided as supplements to treated baits for aggressive feeders. Also, instead of trying to capture all birds of a large flock (e.g., 200 birds), at 1 baiting, it may be safer to conduct several small baitings over several days. However, in Ohio, from a single baiting we successfully captured 87 ducks from a flock of 160 with only 2% mortality when whole kernel corn baits (30 kernels providing 31 mg/kg dose to a 1 kg duck) were used (Table 3). The use of multiple baits (bread or grain) with reduced amounts of A-C per bait may help minimize mortality when 1) a large flock of waterfowl or coots are involved, 2) several species of waterfowl are present, and 3) great variability in individual weights is evident (e.g., juveniles, domestic, hybrids).

To reduce hazards to nontarget species when baiting with bread, we concluded that only fresh moist bread should be used to avoid leaving small particles or crumbs of treated material at the bait site. Other techniques for reducing nontarget hazards include providing untreated baits for nontarget individuals, continuously monitoring treated baits to frighten away nontarget animals attempting to feed, and selective bait placement to control the amount consumed by each target individual and to ensure that treated bait will only be consumed by the target species.

We determined the use of A-C-treated baits should be avoided 1) during hot and humid or extremely cold weather, especially when animals have to be transported in vehicles; 2) where thin ice or inaccessible bodies of water will hamper retrieval of affected birds; 3) where nontarget animals could consume treated baits; and 4) if it is likely that treated animals may be frightened away before Stage II narcosis.

Although Loibl et al. (1988) concluded that A-C is a less-than-marginally-safe capture drug for mallards because of a TI (Therapeutic Index or Safety Factor = LD_{50}/ED_{50}) value of 2.3 (Table 1), we believe A-C showed great potential as a technique for humanely removing waterfowl from various situations with minimum mortality. The technique was well received by the general public associated with the nuisance situation because the birds were not harassed, there were no painful or stressful symptoms, and the birds appeared to be in a deep sleep when they were removed from the area. Bait acceptance was excellent and bait shyness did not develop. Unlike the situation with A-C use on gulls (Woronecki et al. 1989), unaffected birds did not react to affected birds.

Secondary hazards did not exist because immobilized birds were removed from the area. Primary hazards to nontarget animals, although present, can be avoided or at least minimized by improving baiting techniques. When an overdose did occur, the animals could be removed from the area before death occurred. We believe that much of the mortality that occurred to target animals in these trials can be reduced with refinements in baiting techniques. These humane characteristics of A-C are especially relevant because of the increasing concern by the public and animal welfare groups regarding methods used to control nuisance and depredating wildlife (Schmidt 1989a,b). We also believe A-C has great potential as a replacement for strychnine in pigeon control. Besides presenting secondary and primary hazards, strychnine has been criticized as an inhumane method of killing animals (Rowsell et al. 1979).

We have received an Investigational New Animal Drug Agreement (INADA) from the FDA to conduct safety, efficacy, and clinical trials for the purpose of generating data for the registration of A-C for use in the capture of waterfowl and pigeons. This agreement requires that we determine more precisely ED_{50} and ED_{100} values for Canada geese, mallard and domestic ducks, coots, and pigeons. We also recommend that future pilot studies be conducted on other species of nuisance birds (e.g., gulls) to determine efficacy.

Table 4. Nontarget species immobilized during alpha-chloralose trials in 1989.

State	Situation	Target species	Nontarget species	Nontargets affected: Number immobilized	Nontargets affected: Percent survival
NV	casino (pool)	ducks[a]	house sparrows	11	0
			black swan	1	100
NV	casino (pond-golf course)	ducks[a]	house sparrows	4	50
			boat-tailed grackle	1	100
			coots	7	29
			Koi goldfish	5	0
NV	park	Canada goose	California gulls	4	0
NM	golf course	coots	ducks[b]	16	88
NM	golf course	coots	domestic geese	7	100

[a]Mixed flock of mallard, domestic and hybrid ducks.
[b]Mixed flock of domestic ducks and American widgeons (2 domestic ducks died and 2 widgeons immobilized).

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