CHEMICAL AVERSION CONDITIONING OF POLAR AND BLACK BEARS

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Abstract: Emetine hydrochloride (EHCl), alpha-naphthyl-thiourea (ANTU), and lithium chloride (LiCl) were tested as aversion-conditioning chemicals on black bears (*Ursus americanus* Pallas) and on polar bears (*U. maritimus* Phipps) from 1975 to 1977. Captive black bears were fed varying doses of EHCl and LiCl to establish effective dose levels of these chemicals. Four cow kills, treated with LiCl and ANTU, showed an apparent 50 percent increase over controls in the times taken by free-ranging black bears to consume the carcasses. ANTU, EHCl, and LiCl reduced the consumption of Gainesburger baits by free-ranging polar and black bears. Approximate effective dosages of each chemical (orally administered and based on body weight) are 25 mg/kg for ANTU, 100-350 mg/kg for LiCl, and 2.0-4.0 mg/kg for EHCl.

Polar and black bears sometimes constitute serious pest animals where they come into contact with man and his activities. Berghofer (1964) outlines several techniques for dealing with nuisance bears. Gilbert and Roy (1977) discuss damage caused by black bears to beeyards at Peace River, Alberta. Jonkel (1975) summarizes several encounters between polar bears and men in the Canadian Arctic, citing 3 previously unreported attacks. Stirling (1975) details a fatality involving an employee on an Imperial Oil offshore drilling rig located on the Beaufort Sea in the Mackenzie Delta. The employee was attacked by a subadult that appeared to be in a semi-starved condition.

The objectives of this study were to (1) define problems associated with field applications of aversion-conditioning chemical agents; (2) evaluate 2 previously untried potential aversive-conditioning chemicals; and (3) assess the abilities of EHCl, ANTU, and LiCl to reduce problem situations involving polar and black bears by inducing a conditioned response to a bait stimulus.

Ingestion of a sickness- or nausea-inducing chemical agent along with a bait food will reduce consumption of that bait type upon subsequent exposure (Rozin and Kalat 1971, Seligman and Hager 1972). This procedure is currently viewed as a viable technique for reducing predator attacks on sheep (Gustavson 1974, 1976), raptor attacks on lambs (Brett et al. 1976), bear damage to beeyards (Gilbert and Roy 1977), and various other pest situations involving visitation to a site and consumption of food or livestock (Gustavson 1976). Gustavson believes that coyotes (*Canis latrans*) can be taught to avoid sheep through an association developed with LiCl-treated mutton strip baits. Gilbert and Roy (1977) were able to reduce black bear damage to beeyards by placing LiCl baits (6-g capsules) around the yards and erecting charged electric fences near the sites.

Shumake et al. (unpublished), in experiments with 4 captive coyotes, were able to reduce consumption of specific mice (albino vs. normal) through a single peritoneal injection of LiCl. They found, however, that the transfer of an aversion from dead baits to live prey was not always successful. This finding is in agreement with Gustavson and Garcia's (1974) observations and is the basis of a criticism of the technique by Shumake et al. (unpublished).

LiCl has been the subject of aversion-conditioning experiments on various species of predatory and nonpredatory animals. Nachman (1970), Krames et al. (1973), and O'Boyle et al. (1973) have studied the effects of this chemical on rats and mice. Its mode of action has not been clarified. The substance is very hygroscopic and dosage levels determined by Gustavson (1974) were in the range of 100-500 mg/kg. It is inexpensive, safe to handle, and of low toxicity to humans.

EHCl was selected for tests because it is employed in human pharmacology as an emetic for use in cases of orally injected poisons. Its side effects in humans include nausea, extended periods of vomiting, headaches, and other discomforts relating to the gastrointestinal tract. It is normally given intravenously; however, it is active in humans when administered orally but has greater variation in effect and duration (Goodman and Gilman 1975). Human dosages are approximately 1 mg/kg intravenously and 15 ml of syrup orally. It is considerably more expensive than LiCl but the lower specific dose offsets this disadvantage.

ANTU is a species-specific Norway rat (*Rattus norvegicus*) poison that has shown strong emetic properties in dogs (Richter 1945) and some rodents (Passof et al. 1974). Richter (1945) noted that it produced vomiting and retching in dogs subjected to rat-lethal doses in the laboratory. He found the LD_{50} for dogs to be less than 100 mg/kg. He believed that the nausea and vomiting resulting from oral ingestion protected the animal from continued intake of the chemical.

DuBois et al. (1946) studied this drug further and determined an LD_{50} of 50 mg/kg for domestic dogs. He also noted the development of a degree of tolerance to the drug when sublethal doses were continued.

Shumake et al. (unpublished) state specific problems that they believe might interfere with the success of LiCl or other chemical agents in aversion-conditioning techniques. Their main criticism is that a predator eating a sublethal dose of an aversive agent will not eat that food on subsequent exposure but that only a fraction of the affected animals will transfer this aversion to live prey. The remainder, although avoiding other treated baits, are unlikely to be successfully conditioned from killing a live prey animal. Shumake et al. (unpublished) were able to demonstrate this effect with their test coyotes.

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METHODS AND MATERIALS

Captive Black Bears

Two male black bears, each weighing 100 kg and located at the Olympic Game Farm, were subjected to control and experimental baits using LiCl and EHCl. The bears were kept separate during feeding, and were maintained on the feeding regime specified on Table 1. An attractant bait was used to conceal the implanted chemical. Homogenized honey was used in LiCl experiments; raw beef was used in EHCl experiments. In each series of tests, both animals were offered untreated bait food, followed by test doses of the chemical agent under study. In the case of LiCl, a test of the effects of NaCl on bait acceptance was also carried out due to the very salty taste and high dosage levels of LiCl. After tests with aversive agents, both animals were then placed on a feeding regime that restricted their normal intake of food on specified days in order to establish the effects of hunger on the acceptance of offered baits. Untreated (no aversive chemical) baits were offered for 10 days after LiCl ingestion and for 7 days after EHCl ingestion. The acceptance or rejection of offered baits was recorded.

For the purposes of this study, rejection of an offered bait was defined as any reaction ranging from hesitation in approaching baits to complete rejection of baits upon visual or olfactory investigation.

Free-Ranging Black Bears: Open Range Country

Four bear kills of domestic cows in the interior of British Columbia were used as treated baits in order to evaluate the effects of aversive chemical agents on free-ranging black bears. Three fresh kills were observed during the experimental period; 1 kill occurred just before this experiment, and I was able to make observations on this carcass during the study. The experiments tested for differences in the time used to consume a freshly killed cow carcass (measured in days) between control and treated kills. Two of the cows were treated with chemicals, 1 with LiCl and the other with ANTU. One yearling was handled but not treated with chemicals. The fourth animal was used as an unhandled control. Each chemical was placed in shoulder incisions under the hide or was sprinkled over the exposed and partially eaten viscera of each cow. Handling of each carcass involved several procedures to minimize the effects of human odor. All experimental and control carcasses handled were approached on horseback, and disposable poly gloves and a new scalpel blade were used to make each shoulder cut. Inspection of carcasses was always carried out on horseback, except once when the carcass had been almost completely consumed.

Approximately 25 g of LiCl was placed in each of 4 incisions in 1 experimental cow. The other cow was treated with approximately 2.0 mg of ANTU in each of 4 incisions. Carcasses were evaluated twice daily, once early in the morning and once in the late evening. All carcasses were initially observed from a distance to determine whether any predator was present.

Free-Ranging Black Bears: Dumps

The responses of free-ranging black bears to control and experimental baits in British Columbia dumps was evaluated at Golden, Parsons, Bush River Camp (Columbia River valley), the Rogers Pass Park dump, and at Mission (lower mainland). Gainesburger dog food patties were placed at bait stations at each of the 4 dumps. For the first 5 days, these baits were left untreated (no aversive agents) but were soaked in sardine oil. The number of baits consumed was noted. During the next 2 days, baits treated with LiCl, EHCl, or ANTU were set out.

Treatment of baits consisted of placing the aversive chemical between 2 or more patties, as needed, to conceal the chemical. The patties were then tied together with soft string and were soaked in sardine oil. Dosages were based on a bear weight of 100 kg. After this treatment and a 1-day wait, chemically untreated dog food patties were placed at the bait stations, and the number of baits consumed were noted for 5 successive days. At the Mission dump site, bait stations were observed on alternate days for an additional 10-day interval. Observations were made in the area around each bait station in order to estimate the occurrence of other scavengers.

Free-Ranging Polar Bears: Dumps

The responses of wild polar bears to control and experimental baits were evaluated at and near the dump at Churchill, Manitoba. Baits were prepared as for black bears, and dosages of LiCl, ANTU, and EHCl were based on a bear weight of 250 kg. A dosage of 100 mg/kg of LiCl was used for polar bears, instead of the 200 mg/kg dosage used for polar bears, to reduce the total volume of LiCl which had to be concealed in the bait. Baits were covered in brown paper to reduce removal by ravens (*Corvus corax*) and arctic foxes (*Alopex lagopus*). In addition, baits were observed continuously during 2 occasions at the Churchhill area dump in order to note observable reactions by bears after ingestion of baits and to note bait removal by other scavengers. As with free-ranging black bears, the consumption of baits was noted during control and experimental periods.

RESULTS

Tables 1 to 5 summarize the responses of polar and black bears to treated and untreated baits. Effective dosages for each agent, as determined from these tests, were 25 mg/kg for ANTU, 100-300 mg/kg for LiCl, and 2-4 mg/kg for EHCl.

Table 1 summarizes the initial determinations of LiCl dose levels and the behavioral responses of 2 captive black bears. The NaCl controls were readily accepted, perhaps reflecting the pre-experiment starvation of each test bear for 3 days. Two dosage levels of LiCl administered were 300 and 500 mg/kg. Both of these dosages represented considerable amounts of salt, requiring careful mixing of agent and bait to reduce concentrated lumps of LiCl. Both bears accepted the LiCl-treated baits with hesitation, but all of the baits were consumed. Subsequent untreated honey baits, offered each day for the next 10 days, appeared to elicit a conditioned aversive response, and, in cases of acceptance, considerable hesitation was shown. The feeding regime, involving periods of starvation, may have prompted the bears to try the honey. Some indications of discomfort followed ingestion of the treated baits. Both bears moved away from the bait containers and lay down. Two hours after treatment, some diarrhea was observed in the bear subjected to 500 mg/kg LiCl. The bear that received 300 mg/kg exhibited a hunching behavior that had not previously been seen by the animal attendant, and which probably reflected some level of gastrointestinal distress.

Table 1. Effects of LiCl-treated honey baits on 2 male captive black bears, each weighing 100 kg. A = accepted and ate bait; R = rejected bait. Time to visually apparent onset of discomfort (e.g., hunched walking, diarrhea) after treatment: Bear 1, 9 min; Bear 2, 11 min (my observations only). Bears were fed on "Bear Bread" manufactured at the Olympic Game Farm.

Bait and dosage	Delay before investigating or ingesting bait (min)	Bear 1	Bear 2
Untreated honey	0	A, rapidly	A, rapidly
Honey + NaCl (300 mg/kg = 30 g)	0.2	A, rapidly	A, rapidly
Honey + LiCl (300 mg/kg = 30 g)	0.5	A, hesitantly	Not tested
Honey + LiCl (500 mg/kg = 50 g)	0.5	Not tested	A, hesitantly
Untreated honey: Day 1 feed	-	R	R
2 feed	-	R (hunching)	R
3 feed	-	R	R
4 feed	-	R	R
5 starve	-	R	R
6 starve	-	R	R
7 starve	No data[a]	R	A, hesitantly
8 feed	-	R	R
9 feed	No data[a]	A, hesitantly	A, hesitantly
10 feed		R	A, hesitantly

[a] Game Farm staff did not take these data but observed bears' reaction during acceptance.

Table 2 summarizes observations of the effects of EHCl on 2 captive black bears. Raw beef proved to be a suitable bait for these animals, as they readily accepted untreated material. The small dose levels of EHCl allowed easy concealment of the agent in each bait, which apparently prevented detection of the chemical by the bears. Treated baits were rapidly accepted. Starvation appeared to prompt bear 1 to try untreated beef again but did not prompt bear 2 to try the untreated baits. Visually apparent indications of discomfort (the bears lay down) occurred later than with LiCl. No hunching was observed.

Table 3 outlines the apparent effects of LiCl and ANTU on free-ranging black bears. Percentage increases in the time taken for a bear to consume a carcass were based on 1 unhandled control, 1 handled control, and additional data obtained from the rancher. His data had been collected according to my specifications for a period of approximately 3 months prior to the tests. Carcass areas treated with chemical agent were consumed first, as the preparation allowed easy access by predators. LiCl placed in open incisions absorbed water and blood, but the large quantity of LiCl used was sufficient in most instances to dry out the surrounding tissue, leaving quantities of the salt unaffected by water. The aversive effects of this chemical apparently remained unaffected by dilution with water or other fluids. Gelatin capsules were not used to package LiCl because their capacity was too small for the amounts used in this experiment. ANTU was considerably easier to package. It is not soluble in water and therefore should remain in place longer on baits and carcasses. Ingestion of ANTU would require ingestion of an entire capsule, as opposed to LiCl sprinkled freely on the carcass. The ANTU-treated carcass showed a greater increase in the time required for the carcass to be consumed than the LiCl-treated carcass. The handled control showed no increase over known times required for consumption. It was assumed that secondary scavengers, as well as the bear that killed each cow, were feeding on the carcasses and that these scavengers would also ingest the chemicals present in the flesh of the bait cows.

Table 4 presents observations on the responses of wild black bears to LiCl, ANTU, and EHCl in Gainesburger baits. Consumption of baits placed at bait stations is misleading, because consumption over 100 percent does not indicate what might have been consumed if more Gainesburgers were present. Increased consumption before the experimental chemicals were used would have led to a greater apparent reduction in consumption after exposure to these chemicals. LiCl showed less variation in effect (52.5 percent ± 14.85) than ANTU (37.5 percent ± 23.33). I could not establish variations with EHCl because only 1 bait station

Table 3. Effects of LiCl and ANTU on the consumption of cattle carcasses by black bears. The average for the complete consumption of a full-grown cow by a black bear and scavengers is approximately 5 days (data on range kills from the rancher and from the Predator Committee of the Cattlemen's Association).

Cow, dosage, and chemical	Days to consume	Percent increase over 5-day average
Kill 1 (prior to experiment): Cow	5	0
Kill 2: Cow		
4 25 g LiCl, shoulder incisions	9	44
10 g LiCl sprinkled on viscera		
Kill 3: Cow		
4 2.0 mg ANTU, shoulder incisions	11	55
Kill 4: Yearling		
Handled only	5 (adjusted[a])	0

[a] Assume 2 yearlings, mean weight = 140 kg; mean weight of 1 adult = 280 kg. Mean increase for kills 2 and 3 = 49.5 percent.

Table 2. Effects of EHCl-treated raw meat baits on 2 male captive black bears, each weighing 100 kg. A = accepted and ate bait (immediately after investigation); R = rejected bait. Time to visually apparent onset of nausea after treatment: Bear 1, 15-18 min; Bear 2, 12-15 min.

Bait and dosage	Delay before investigating or ingesting bait (min)	Bear 1	Bear 2
Untreated meat	0	A, rapidly	A, rapidly
ECHl + meat (2.5 mg/kg = 250 mg)	0	A, rapidly	Not tested
ECHl + meat (4.0 mg/kg = 400 mg)	0	Not tested	A, rapidly
Untreated meat: Day 1 feed	-	R	R
2 feed	-	R	R
3 starve	-	R	R
4 starve	No data[a]	A, hesitantly	R
5 feed	-	R	R
6 feed	No data[a]	A, rapidly	R
7 feed	No data[a]	A, hesitantly	A, hesitantly

[a] Game Farm staff did not take data on delay times but observed bears' reactions during acceptance.

Table 4. Effects of LiCl-, ANTU-, and EHCl-treated baits on bait consumption by black bears at British Columbia garbage dumps. Average weights of bears was assumed to be approximately 100 kg for purposes of dosage calculation. LiCl (200 mg/kg) = 0.20 g; ANTU (25 mg/kg) = 2.5 g; ECHI (3.0 mg/kg) = 300 mg.

Location and chemical	Number of bait stations	Number of baits per station	Mean percent consumption: Untreated (5 days)	Treated (2 days)	Untreated (5 days)
Golden (LiCl)	5	2	85	80	42
Parsons (ANTU)	6	2	96	92	21
Bush River Camp (LiCl)	4	2	100	88	63
Rogers Pass (ECHI)	4	2	69	56	44
Mission (ANTU)	6	2	100	100	54 (15 days)
LiCl mean percent consumption			92.5 ± 10.6		52.5 ± 14.9
LiCl mean percent reduction in consumption				43.2	
ANTU mean percent consumption			98.0 ± 2.8		37.5 ± 23.3
ANTU mean percent reduction in consumption				61.7	
EHCl percent reduction in consumption				36.2	

was set up. EHCl showed the least reduction in percentage of Gainesburger baits consumed by free-ranging black bears.

Table 5 presents data on the responses of free-ranging polar bears to Gainesburger dog food baits treated with LiCl, ANTU, and EHCl. No arctic fox sign was seen around the Churchill bait stations. The brown paper appeared to prevent the ubiquitous ravens from seeing the baits, as none of these birds was ever observed feeding on them. The baits became frozen soon after they were placed at each station, which may also have prevented consumption of baits by scaven-

Table 5. Effects of LiCl-, ANTU-, and EHCl-treated baits on the rate of bait consumption by polar bears at Churchill, Manitoba. Average polar bear weight was assumed to be approximately 250 kg for purposes of dosage calculation. LiCl (100 mg/kg) = 0.25 g; ANTU (25 mg/kg)= 6.3 g; EHCl (3.0 mg/kg) = 750 mg.

Location and chemical (per bait amount)	Number of bait stations	Number of baits per station	Mean percent consumption: Untreated (5 days)	Treated (2 days)	Untreated (5 days)
Site 1, dump[a] (LiCl - 25 g)	6	6	100	78	20
Site 2, dump (LiCl - 25 g)	5	6	90	75	30
Site 4, incinerator[b] (LiCl - 25 g)	4	6	85	65	25
Site 7, incinerator[a] (EHCl - 5 g)	6	2	75	80	60
Site 5, rocket range (EHCl - 5 g)	5	2	100	100	45
Site 6, rocket range (EHCl - 5 g)	5	2	100	98	35
Site 7, incinerator[a] (ANTU - 6 g)	6	2	85	90	40
Site 8, dump (ANTU - 6 g)	4	2	100	95	35
Site 9, dump (ANTU - 6 g)	5	2	75	60	22
LiCl mean percent consumption			91.7 ± 7.6		25.0 ± 5.0
LiCl mean percent reduction in consumption				72.7	
EHCl mean percent consumption			91.7 ± 14.4		46.7 ± 12.6
EHCl mean percent reduction in consumption				49.1	
ANTU mean percent consumption			86.7 ± 12.6		32.4 ± 9.3
ANTU mean percent reduction in consumption				62.6	

[a] Hunching observed.
[b] Vomiting observed.

gers. As with the previous experiment with wild black bears, LiCl exhibited the least posttreatment variability (25.0 percent ± 5.0), and EHCl showed greater variability and greater effect (46.7 percent ± 12.6). ANTU was less variable and less effective (32.3 percent ± 9.3) than EHCl. At the lower temperatures experienced at Churchill, no problems were experienced with the hygroscopic nature of LiCl.

DISCUSSION

Studies with 2 captive black bears indicated that effective doses of LiCl and EHCl were administered. These experiments did not indicate what the minimum effective dose might be, but field use of such agents would probably involve overdoses to insure effectiveness with bears of unknown weight. The emetic properties of LiCl, ANTU, and EHCl would tend to protect an animal from ingesting a lethal dose of any of these agents.

The large dose of LiCl required for effectiveness presents a problem in administration of a proper dose. Bears seem to require 20-50 g of this salty-tasting chemical, and if they are not sufficiently hungry, bait avoidance without achievement of an aversive response could result from initial tasting of the chemical. The captive animals subjected to LiCl were starved prior to the experiments, a condition not necessarily occurring in natural situations. Knowledge of the presence of a chemical in a bait, by taste, sight, or odor, could itself train a nuisance bear, whereas undetected chemicals would induce aversions only to the bait. Thus, LiCl may be a repelling stimulus in itself.

ANTU appeared effective as a conditioning chemical on wild black and polar bears. Experiments involving carcasses serve only as indicators of the efficacy of this chemical, as the low number of tests precludes any definitive statement on its potential. These data, however, when considered in conjunction with results of dump experiments, suggest that ANTU is a useful conditioning chemical. ANTU may present other problems, however, as it is possible for an animal to ingest a lethal dose. Care would have to be exercised in the dosage level placed in baits. Effective dosages appeared to be approximately 25 mg/kg; the established LD_{50} for dogs is about 50 mg/kg (Dubois et al. 1946).

EHCl produced results at 4 mg/kg in tests on 2 captive black bears. Tests at 2.5 mg/kg were less conclusive, and the bear subjected to this level was observed accepting untreated beef. Dump tests with EHCl suggested that this chemical could produce an aversive response to Gainesburger baits upon subsequent exposure. In these tests, EHCl did not generate the same percentage reductions as either LiCl or ANTU. EHCl may be considerably safer than ANTU because it is a strong, quick-acting emetic, thus preventing absorption of a lethal dose.

The successful transfer of an aversive response from a bait to a live prey may not occur after 1 exposure to a treated bait. This technique would probably lead initially to a strong aversion towards bait alone. The transfer of this aversion to live prey may occur in some animals (Gustavson 1974), but others may continue to kill live prey. However, I question the ability of an animal to then consume the killed prey, and it is this resulting futility that has the potential to produce the desired transfer of the aversive response from bait to live prey. The inability of the predator to consume its victim will be energetically inefficient and should lead to cessation of the preliminary killing sequences. This theory counters the arguments of Shumake et al. (unpublished) against bait-prey association.

Dump inhabitants need not form complex associations between baits and prey. A baiting program using many of the typical foods found in dumps should lead to strong aversions to each treated food. Of greater value would be the development of a *location-avoidance* response. Continued noxious or uncomfortable experiences at the bait site should lead to a reduction in visitations to that site. Gilbert and Roy (1977) apparently observed this response in black bears at beeyards, and I feel that this site avoidance was at least partially responsible for the reductions in bait consumption at Churchhill. Although I did not expect this result and therefore did not quantify it, bear numbers seemed to be reduced after treated baits were consumed. Location avoidance may well be a viable technique for reducing the numbers of bears inhabiting dump or camp areas.

The administration of LiCl under field conditions required some care. Carcass tissues treated with this substance were directly affected by the hygroscopic nature of this chemical. Alteration of the tissues surrounding the chemical may have affected their palatability or some other factor relating to their acceptability to the predator. The large dose required for polar bears made packaging difficult. ANTU and EHCl were much easier to handle under identical circumstances, and, for this reason alone, may be of greater use under field conditions.

All the chemicals tested produced a reduction in consumption of the baits or carcasses used. These chemicals will eventually be used to reduce, rather than eliminate, damage by nuisance bears. They are relatively safe compared with poisons and should prove useful in situations where animals must be controlled but need not be destroyed. It is recommended that an experimental program be developed using large numbers of bait stations or carcasses. Such a program would allow a definitive statement to be made about the viability of the technique for bear management.

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