RESPONSES OF CAPTIVE GRIZZLY AND POLAR BEARS TO POTENTIAL REPELLENTS

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Abstract: Potential bear repellents were tested on 2 male grizzly bears (*Ursus arctos horribilis*) and 2 female polar bears (*U. maritimus*) at the Churchill Bear Laboratory, Churchill, Manitoba. Fifteen to 18 stimuli were tested on each bear. The stimuli were selected randomly from a list of possible repellents that included recorded bear and people sounds, bells, horns, chemicals, and others. Extremely loud, sharp sounds and most of the chemicals were consistently repellent. Although some of the stimuli were very effective, the effects on the bears were consistently short-lived. Laboratory tests on caged animals is a valid method for screening the effectiveness of a large number of stimuli in a short time, but the results of such tests must be verified by field tests.

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Each year bears injure people and damage property. The number of injuries caused by grizzly bears has increased in recent years as the number of people visiting National and Provincial Parks in the United States and Canada has increased (Herrero 1970*a, b,* 1976, Mundy and Flook 1973), and as new areas have been developed and human populations have increased in areas used by bears (Jonkel 1975). Encounters with polar bears that have resulted in injury have increased in recent years as well (Jonkel 1970, Schweinsburg and Stirling 1976).

Because of the damage and injuries caused by bears, there is interest in methods to keep bears away from humans and the places where they live, work, and camp. Increased understanding of bear ecology and behavior can help reduce the number of encounters between bears and people. Although it is possible to adjust the patterns of use by hikers and campers in parks and to place seasonal restrictions on development, there will continue to be incidents each year.

The purpose of this study was to test the effectiveness of various repellents on captive grizzly and polar bears. Because most people either encounter or are attacked by bears while hiking or camping (Herrero 1970*a,* 1976), the tests concentrated on safe, nondestructive devices that can be carried by people as they travel in bear habitat.

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MATERIALS AND METHODS

The laboratory, in Churchill, Manitoba, is a large unheated building that has been modified for bear research. The chamber in which the experiments were performed was an enclosed room (3.7 × 6.1 × 4.6 m) with cement block walls and a well for drinking water. The doorway and window were barred and there was an elevated observation blind that allowed a full view of the chamber. The chamber's solid wall construction and its location at the corner of the building allowed complete visual isolation and moderate isolation from odors and noises from the rest of the building.

Two male grizzlies and 2 female polar bears were used in the study (Table 1). Physiological telemetry devices were implanted in the bears for another study (Miller 1980) and the bears were held in the experimental chamber for 3 days before observations began. Following the recovery period, baseline observations were begun by observing the bears without disturbing them. The bears' activity, posture, and orientation were noted every 10 minutes for 1 minute of observation according to a predetermined code (Table 2).

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Table 1. Bears used in repellents experiments.

Bear	Species	Sex	Age at testing (years)	Weight at testing (kg)	Dates of testing	Comments
Growly	Grizzly bear	M	7.5	200	Oct 1977	Problem bear from Glacier National Park, captive 1 year before testing.
Snarly	Grizzly bear	M	5.5	160	Jul 1978	(Same as Growly)
Guen	Polar bear	F	2.5	160	Aug–Sept 1978	Captured near Churchill, Manitoba, tested immediately.
Magdalene	Polar bear	F	4.5	200	Sep–Oct 1978	Captured near Churchill, Manitoba. Used in attractant study (Cushing 1980) for 2 months before testing.

Baseline observations on the first grizzly (Growly) covered all hours from dawn to dusk twice during a 3-day period. The remaining bears were observed in blocks of time not less than 4 hours nor greater than 8 hours in duration over a 5-day period to include 3 dawn-to-dusk periods.

After baseline observations, repellent tests began. Six tests per day were performed on Growly for 5 days, but no more than 4 tests per day were performed on the other 3 bears over 7 or 8 days. All tests were at least 2 hours apart. Observations were made for at least 30 minutes before and for 1 hour after each repellent test. The schedule of observations during repellent tests was the same as for baseline observations except that the behavior was summarized every minute starting 3 minutes before the stimulus and continuing until 10 minutes after the stimulus. The bears' reactions to the test stimuli were described in detail and categorized as repelled, not repelled, or no reaction. If the bear immediately retreated from the stimulus or stopped in the middle of a vigorous charge, the bear's reaction was classified as "repelled." If the charge was not stopped, the bear approached slowly, or it ignored the stimulus after it was aware of the test, the reaction was classified as "not repelled." In cases where the bear apparently never became aware of the stimulus, the classification was "no reaction."

Table 2. Behavioral parameters and codes used to compare pre- and post-testing behavior in captive bears.

Overall activity	Body position
0 urinate/defecate	
1 sleep	1 lying belly
2 quiet	2 lying side
3 eat/drink	3 lying back
4 light activity	4 sitting
5 moderate activity	5 sitting up[b]
6 heavy activity	6 standing
7 "frozen"[a]	7 standing up[c]
8 stretch or shift slightly	8 pullup at window[d]
9 no data	9 no data

[a] Bear abruptly stopped activity and became very still but alert.
[b] Sitting with front feet off the ground.
[c] Standing on hind feet only, with or without support.
[d] Climbing onto the bars of the window.

The effects of the repellent tests were analyzed from 2 perspectives. First, the behavior observed for 30 minutes prior to repellent tests (or controls) was compared with the behavior observed for 30 minutes after tests (or controls). Second, each stimulus was analyzed according to the bears' reactions as categorized above.

Most of the stimuli were sounds or chemicals (Table 3). Taped sounds of aggressive bears or of a human imitating the growls and hisses of an aggressive bear and sounds made by horns, whistles, and fireworks were all tested. The chemicals tested were readily available household chemicals or commercial dog repellents. They were sprayed into the face of the bear with a 30-ml syringe or from the aerosol cans in which they are sold. The loom stimulus was created when an assistant suddenly presented the flat face of a 1.0 × 1.5 m piece of plywood. Stimuli were delivered by an assistant standing outside the barred door of the experimental chamber. For controls, the assistant stood at the door with the appropriate apparatus and pretended to deliver a stimulus. The bears were shot in the face with water from a syringe to control for the tests of chemicals.

A random sample of stimuli and appropriate controls was tested on each animal. Twenty-nine tests and controls were performed on Growly, 28 on Snarly, 24 on Guen, and 23 on Magdalene. The Province of Manitoba did not allow me to test chemicals on the polar bears.

RESULTS AND DISCUSSION

Visual signals such as body position, head orientation, and facial expression, as well as vocalizations are important in encounters between grizzly bears (Stonorov and Stokes 1972). However, the same rules of behavior may not apply to caged bears that encounter people.

There were significant behavioral differences between the 30 minutes prior to testing and the 30 minutes after testing (Table 4). Overall activity and body position were significantly different after repellent tests in all bears. Overall activity and body position of the polar bears also changed after controls. Of the grizzlies, only Growly's body position changed after controls. The differences between pre-test or pre-control behavior and post-test or post-control behavior was that the bears were more active after tests and controls than before.

Comparisons between tests and controls are complicated by differences in the bears' behavior between pre-test and pre-control periods. However, it is apparent that the grizzlies reacted strongly only to the tests whereas the polar bears also reacted strongly to the controls. This difference reflects the fact that the grizzlies were much more active than the polar bears. Both grizzlies paced, pounded on the chamber door, and vigorously tore at objects in the chamber. In contrast, the polar bears spent most of their time sleeping or lying quietly. When the assistant came to the door to deliver a test or control, they nearly always reacted by charging the door.

Analysis of the behavioral reactions of the bears to the repellent stimuli show promising results (Table 5). Recorded sounds were generally ineffective in repelling bears; none of the recordings repelled more than 1 bear. Of the other sounds tested, only extremely loud, sharp sounds were effective. The explosive sounds of the Thunderflash and Cap-chur gun caused the bears to scramble away from the door rapidly. Although the boat horn and Sound 911 usually stopped the bears in mid-charge, they did not cause the bears to turn and run.

The chemicals were generally effective in repelling the bears. Growly was repelled by one of the control tests, suggesting that having something sprayed into its face is repelling to a bear, or that Growly had been conditioned to having repellents sprayed in his face. The repellent effects of Halt dog repellent were dramatic. Each time it was tested the bear charged until it was sprayed, then turned and ran to the farthest corner of the chamber where it rubbed its eyes with its paws and blinked vigorously. Once, Snarly went to the water well and washed his face with his paws.

Table 3. Repellent stimuli and controls tested on captive grizzly and polar bears.

Taped Sounds
Human shouting
Human barking
Human hissing
Human growling
Grizzly bear barking
Grizzly bear growling
Polar bear 1[a]
Polar bear 2[b]
Killer whale sounds
Control (hold up speaker)
Other Sounds
Thunderflash[c]
Bells[d]
Control (ring silent bell)
Boat horn[e]
Sound 911[f]
Control (hold up boat horn)
Dog whistle
Referee's whistle
Control (pretend to whistle)
Air horn[g]
Control (air horn)
Cap-chur gun[h]
Chemicals
Onion juice
Ammonia (Windex)
Mustard[i]
Halt (dog repellent)[j]
Dog Stopper (dog repellent)[j]
Git (dog repellent)[k]
Chaperone (dog repellent)[k]
Bear Trail[l]
Control (water)
Other
Strobe light[m]
Loom[n]
Control (stand at door)

[a] Adult female polar bear growling, hissing, and chuffing.
[b] Subadult female polar bear growling and hissing.
[c] Explosive firecracker; manufactured as a bear repellent.
[d] Bells sold to hikers in Glacier and Yellowstone National Parks.
[e] Freon-powered horn (98 dB at 0.3 m).
[f] Freon-powered horn (95 dB at 0.3 m) with higher pitch than boat horn.
[g] Battery-powered air horn that began and ended gradually.
[h] Fired Cap-chur dart gun without a dart.
[i] Solution prepared by boiling dry mustard in water.
[j] Dog repellent designed to stop an attacking dog.
[k] Dog repellent designed to keep dogs out of specific areas.
[l] For training dogs to track bears.
[m] Strobe light (1 flash/minute), sold to scare wildlife.
[n] Assistant suddenly presented the face of a 1.0 × 1.5 m piece of plywood.

Table 4. Comparisons of behavioral differences for each bear under different test conditions.[a]

Behavioral parameter	Growly			Snarly			Guen			Magdalene		
	X^2	df	P	X^2	df	P	X^2	df	P	X^2	df	P
Pre-test vs post-test												
Overall activity	123.4	6	<0.001*	41.6	6	<0.001*	40.6	6	<0.001*	65.8	6	<0.001*
Body position	36.9	7	<0.001*	21.5	5	<0.001*	37.4	4	<0.001*	130.7	6	<0.001*
Pre-test vs pre-control												
Overall activity	11.3	6	0.08	14.7	5	0.01*	2.0	4	0.73	15.6	6	0.02*
Body position	9.0	6	0.12	12.0	4	0.02*	7.4	4	0.12	11.8	6	0.07
Pre-control vs post-control												
Overall activity	11.3	6	0.08	6.2	5	0.29	179.0	3	<0.001*	16.5	6	0.01*
Body position	34.9	6	<0.001*	3.8	5	0.59	33.1	4	<0.001*	14.0	6	0.04*
Post-test vs post-control												
Overall activity	8.2	6	0.23	9.7	6	0.15	102.4	6	<0.001*	13.4	6	0.04*
Body position	12.8	7	0.08	4.6	5	0.47	4.9	4	0.30	6.1	6	0.41

[a] Pre- and post- periods are for 30 minutes before and after test or control. The minute in which the stimulus was given was not included.
* $P \leq 0.05$.

Table 5. Captive grizzly and polar bears were repelled (R), not repelled (N), or appeared unaware (O) of repellent stimuli and controls.

Repellent Stimulus	Behavioral reaction			
	Growly	Snarly	Guen	Magdalene
Taped Sounds				
Human shouting	R	N	N	N
Human barking	N	N	N	R
Human hissing	N	N	N	R
Human growling	N			
Grizzly bear barking	N	N		
Grizzly bear growling	R	N		
Polar bear 1			N	R
Polar bear 2			N	N
Killer whale sounds			N	N
Control (hold up speaker)	N,O,O[a]	N,N	N,N,N	N,N,O
Other Sounds				
Thunderflash	R			
Bells	N,O,O	N	N	N
Control (ring silent bell)	N			
Boat horn	R	R,R	N,N	R
Sound 911	R	R	N	N
Control (hold up boat horn)	N,N,N	O	N	N
Dog whistle		O	N,N	N,N
Referee's whistle		N	N	N
Control (pretend to whistle)		N	N	O
Air horn			N	N
Control (air horn)			N	N
Cap-chur gun			R	R
Chemicals				
Onion juice	R			
Ammonia (Windex)	R	N		
Mustard	R	N		
Halt (dog repellent)	R	R,R		
Git (dog repellent)		R		
Chaperone (dog repellent)		N		
Bear Trail		N	N	N
Control (water)	R,N	N,N,N		
Other				
Strobe light	N			
Loom	R	R	R	R
Control (stand at door)	O,O	N	N	N

[a] Symbols separated by commas indicate multiple trials of the same stimulus.

The only other stimulus that consistently repelled the bears was the loom. In each case, the bear started to charge and immediately turned and ducked when the piece of plywood was suddenly presented. The effect, however, lasted for less than 30 seconds. After that time, the bear returned to the door to investigate. The bears rapidly habituated to the loom stimulus. If the assistant repeated the stimulus 3–4 times, the bear no longer reacted strongly.

There were 3 cases out of 71 repellent tests when the bear never became aware of the stimulus. These "no reaction" cases are important. In 1 case, the second grizzly bear, Snarly, did not react to a dog whistle, and twice when small bells were tested on Growly, he slept through the test. The bells were of the type sold to hikers in Glacier and Yellowstone National Parks to warn bears of the approaching hiker and thereby prevent an encounter. In these tests the assistant, less than 6 m from the bear, failed to arouse it. Warning bears before getting too close is a good strategy for preventing encounters, but the bells currently sold to hikers for that purpose are inadequate.

Bears rarely responded to the control stimuli (Table 5). The bears were repelled once during 33 controls, and of the 10 cases of "no reaction," 7 were controls.

The effectiveness of aversive stimuli depend on the perceptual systems of the animal. For example, visual, auditory, and tactile clues are all important to quail but not to rats in developing aversions to foods that induce illness, while novel tastes are important clues for both rats and quail

(Wilcoxon et al. 1971). Illness can induce a taste aversion in rats even if there is a long delay between stimulus and illness, but electric shock cannot induce an aversion to auditory or visual clues if there is a long delay between the stimulus and the punishment (Garcia et al. 1966).

Attempts to induce an aversion for killing and consuming prey have had variable results. Although rats can be made to stop killing mice (Myer 1966), chemical irritants put on sheep to stop coyote predation are generally ineffective (Jankovsky et al. 1974, Olsen and Lehner 1978) unless supported by auditory and visual stimuli (Olsen and Lehner 1978). There has been limited success with inducing prey-specific aversions to prey killing and eating in coyotes (Gustavson et al. 1974, 1975, Bekoff 1975). It is apparent that the effectiveness of repellents depends on both the characteristics of the resource threatened and the animal doing the damage. Most human injuries caused by bears are caused by the bears protecting themselves, their young, or a food source and are not the result of predator-prey relationships (Herrero 1976, Singer and Bratton 1980).

The chemicals used in this study were effective because they caused immediate, intense pain. The chemicals were effective only if they contacted the eyes. However, in its commercially available dispenser Halt had a range of about 2 m, clearly unacceptable if one is trying to stop a charging bear in the wild. Better delivery systems for the repellents must be developed.

Biologically significant sounds may also be effective stimuli for repelling bears. The recorded sounds of barking dogs repelled Yezo brown bears (*Ursus arctos yezoensis*) but pile-hammer or jet plane sounds did not (Haga 1974). Though laboratory tests of recordings of aggressive bears and of people imitating bears were negative, field studies indicate that these sounds may be effective in the wild (Miller 1980, Wooldridge and Belton 1980).

The strong repellent effects of Halt dog repellent and loud, sharp sounds are clear. Tests on captive animals can be performed effectively. Though none of the repellent effects of the stimuli lasted more than 5 minutes, they did stop charges or repel the bears. Further studies should be done on captive animals to test more potential stimuli and to sample individuals in a broader base of sex and age classes. Finally, field tests that more closely simulate real encounters between people and bears must be performed to verify the laboratory results.

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