EVALUATION OF AN AVERSIVE CONDITIONING TECHNIQUE USED ON FEMALE GRIZZLY BEARS IN THE YELLOWSTONE ECOSYSTEM

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Abstract: Behavioral responses to aversive conditioning techniques by nuisance, radio-collared female grizzly bears (*Ursus arctos horribilis*) were studied in the Yellowstone ecosystem during 1986-89. Five females, 2 accompanied by their young, were treated 27 times with an aversive conditioning agent paired with a conditioned stimulus. Sample sizes were too small to fully evaluate responses to the conditioning stimulus, but positive trends occurred. When the aversive agent was applied, all bears responded by running from the trial site without displaying aggression. Capturing nuisance bears and removing the unnatural attractants often caused the bears to leave the problem area and precluded testing. No nuisance adult male grizzly bears engaged in nuisance behavior following initial capture and radiocollaring. Attempts to aversive condition an underweight, subadult female with poor dentition failed. This report includes recommendations for further application of aversive conditioning techniques on grizzly bears in the Yellowstone ecosystem.

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Bear problems are positively correlated with increased human activity in bear habitat and with increased use of unnatural food sources by bears (Herrero 1976, Eagle and Pelton 1979). Management agencies have implemented aggressive programs involving law enforcement, public education, and sanitation policies to prevent grizzlies from obtaining unnatural food sources and reduce human-bear conflicts.

Traditionally, managers employ 3 approaches to resolve bear-human conflicts. The first approach is to remove the attractant, a strategy that often alleviates the problem. The second approach is to relocate the nuisance bear. Finally, as a last resort, the bear is destroyed.

Generally, relocation of a bear from a site does not prevent the problem from recurring either by the same or a new bear (Meagher and Fowler 1987). Many bears become repeat offenders because of continued availability of unnatural food or other attractants and the bears are eventually removed or destroyed.

Public opinion about administering euthanasia has compelled state and federal agencies to explore alternative solutions for resolving bear-human conflicts. In response, this study was initiated to develop and evaluate the potential for resolving bear problems through modification of bear behavior.

If a negative reinforcer is presented to an organism or a positive reinforcer is withdrawn following a response, the result in either case is called punishment (Wenrich 1970). During aversive conditioning, a negative reinforcer also referred to as an aversive agent (e.g., the painful stimulus of being hit with a rubber baton), is presented while an animal is engaged in undesirable behavior, such as foraging near a campground. The repeated application of the aversive agent should teach the bear to avoid the site or campground attractants and cease the behavior in the future.

One drawback to punishment as an effective means of changing behavior is the possible necessity for repeated applications (Skinner 1953). Although conditioning can require many trials, laboratory conditioning experiments routinely show rapid learning (Rescorla 1988). Following initial conditioning, infrequent reinforcement is generally all that is required to maintain the desired response and perpetuate the newly acquired behavior (McCullough 1982).

Garcia and Koelling (1966), Garcia et al. (1974, 1985), and Palmerino et al. (1980) studied aversive conditioning and described 2 different systems, each with its own set of dynamics. The first is the "gut-defense system" in which the animal learns to associate the taste of a particular meal with illness (toxicosis). A disadvantage of this system is that the length of time between eating and onset of illness may take several hours. This delay may weaken the association and thus the animal may not learn as rapidly or may require repeated applications.

The second system, referred to as the "skin-defense system," protects an animal. Noise, pain, and fear are the primary components and create a swift rate of

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learning, often within a matter of seconds. Behavior is modified in a quick, cognitive manner to avoid a similar situation in the future.

In the gut-defense system, learning occurs through an emotional response directed at the stimulus of toxic food. Conversely, the skin defense system works according to the rules of classical conditioning whereby noise, followed by prompt peripheral pain, causes behavior modification.

According to the previous studies, not all stimuli are equally associable. Garcia and Koelling (1966) found that peripherally administered pain was more readily associated with auditory and to a lesser extent visual signals than with any of the other senses.

Previous research involving tests on bears indicated that the use of rubber batons fired from a specialized gun held promise for accomplishing behavior modification (Hunt 1985). In other studies on polar, grizzly, and black bears, results using plastic slugs fired from a 12-gauge shotgun were mixed (Stenhouse 1983, Dalle-Molle 1984, Wooldridge 1984, Derocher and Miller 1985). Other researchers conducted tests with rubber bullets and aversive conditioning on grizzly bears (Dalle-Molle 1989). Avoidance responses of bears to these tests were specific to a site or attractant type (backpack camps, trailer-truck camps, etc.).

The objectives of this study were to (1) develop methods using an aversive agent for discouraging grizzly bears that frequent developments or campsites; and (2) evaluate the effectiveness of aversive conditioning agents and conditioning stimuli in keeping grizzlies away from sites of human habitation or human food sources.

Our gratitude goes out to many individuals from various state and federal agencies that responded to the needs of the study. In particular we would like to thank D. Strickland, L. Roop, K. Inberg, M. Benker, M. Nelson, S. Benson, H. Carriles, and C. Hunt, who worked for the Wyoming Game and Fish Department during the study, D. Knight and members of the Interagency Grizzly Bear Study Team, R. Wilkes from Casper College, C. Servheen, U.S. Fish and Wildlife Service, and G. Wood, U. S. Army. We would like to thank the owners of Pahaska Lodge, B. and G. Coe, and the owners of the 7D Ranch, M. and J. Dominick, where several aversive conditioning trials were conducted.

STUDY AREA

The study area included all occupied grizzly bear range in the Yellowstone ecosystem. Study area boundaries were determined by movements of instrumented grizzly bears and verified observations of unmarked bears (Knight et al. 1982). Included in the study area are 2 national parks, portions of 5 national forests, and land in private ownership. Specific sites where grizzly bears were aversively conditioned are shown in Figure 1.

The Yellowstone ecosystem consists of a very large, high-elevation basin, primarily within Yellowstone National Park, surrounded by mountain ranges. Park visitation rates are >2 million. Fisher (1960) and Keefer (1972) give details of the geologic history of the Yellowstone area.

Approximately 75% of the study area was covered by closed canopy forests prior to the extensive forest fires of 1988 (Knight et al. 1984). Lodgepole pine (*Pinus contorta*) forests in various successional stages predominate over much of the area. Stands of Douglas-fir (*Pseudotsuga menziesii*) and spruce (*Picea* spp.)-subalpine fir (*Abies lasiocarpa*) are also common. Whitebark pine (*Pinus albicaulis*) occurs on most high elevation sites below timberline. Aspen (*Populus tremuloides*) and limber pine (*Pinus flexilis*) form significant cover in some areas, but they occur incidentally in the study area. Wildfire has been a prevalent force in the vegetation communities of the Yellowstone ecosystem (Houston 1973). Forested habitat types in the Yellowstone ecosystem are described by Pfister et al. (1977) and Steele et al. (1983).

METHODS

All grizzly bears exhibiting nuisance behavior were considered candidates for aversive conditioning. Nuisance bears were captured, radiocollared, and released on site. Candidate bears were bears frequenting or causing problems while seeking human foods in developed areas and campsites and "habituated" bears that forage near developed areas but were not seeking human foods. Cubs-of-the-year, bears causing excessive damage, and bears acting aggressively were not considered candidates.

Bears displaying undesirable behavior, including those seeking unnatural foods or habituated to humans, were presented with a conditioning stimulus and several seconds later struck with conditioning agents. Following several trials, bears were expected to respond to the conditioning stimulus alone.

One requirement for an appropriate conditioning stimulus was that it be readily associated with an unconditioned stimulus of pain. Auditory stimuli were

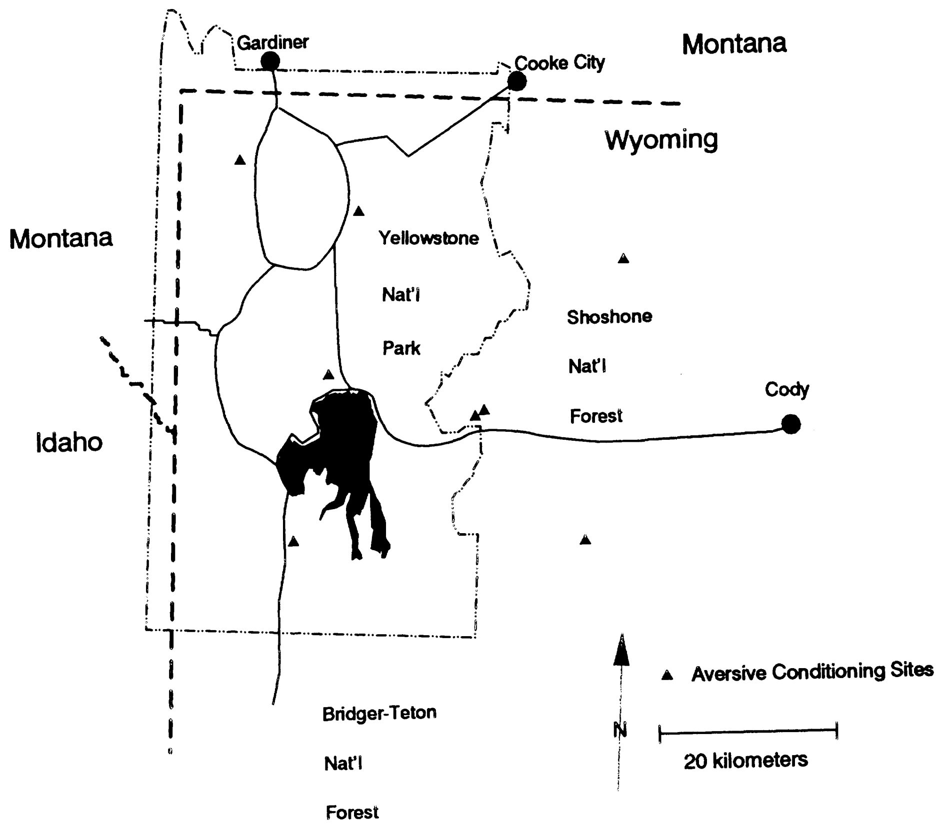

Fig. 1. Grizzly bear aversive conditioning sites in the Yellowstone ecosystem, 1986-89.

used due to the potential problems of presenting visual signals and because of greater sensitivity to auditory stimuli by bears (Craighead and Craighead 1964).

Conditioning stimuli used during the study included taped calls of California quail (*Callipepla californicus*) and ladder-backed woodpecker (*Picoides scalaris*). The ranges of these bird species do not overlap the Yellowstone ecosystem. The bird call presented during aversive agent trials was identified as the training conditioning stimulus. The bird call not used during aversive agent trials, but incorporated into the control testing phase, was identified as the neutral conditioning stimulus. The experimental design required using the same individual bear during aversive agent and conditioning stimulus tests.

Several aversive agent delivery systems were used during the study. These included Thumper gun and twelve-gauge shotgun systems. These systems were the most cost effective and available for use by state and federal agency personnel.

The Thumper gun is a Model 267 Smith and Wesson gas and flare gun converted to a 32 mm bore, with a lightly rifled (rifling about 6.35 mm wide) 55.9 cm barrel. Two different sights were used on the gun, an Aimpoint 2000 red dot sight for shooting in daylight and low-light conditions, and a military infrared scope for night conditions.

Projectiles were 602 grain rubber "bullets" made of 31.75 × 76.2 mm plastic bottles filled with 30 cc's of water (Roop and Hunt 1986). The projectile was powered with FF black powder. This load traveled at about 144 m/sec with 300 foot pounds of energy (FPE) leaving the rifle barrel. Using black powder required that the gun and shell casings be cleaned after every firing to maintain accuracy.

In addition to Thumper bullets, factory made plastic "Bear Deterrent Cartridge" projectiles and occasionally "Ferret Soft Slugs" were used (AAI Corporation, Hunt Valley, Md. 21030). The 112-grain Bear Deterrent Cartridge bullet was fired from a 12-gauge shotgun and a muzzle velocity of 194 m/sec with muzzle energy of 112 FPE. The Ferret Soft Slug, weighing 90 grains, is similar in size and shape to the Bear Deterrent bullet. Velocity of the Ferret Soft Slug was 140 meters/second with 44 FPE leaving the shotgun muzzle.

Tree stands, vehicles, or buildings were used to keep researchers in safe positions during testing. Activities and behavior were recorded when the bear was first observed and throughout testing. Procedures used during conditioning required a nuisance bear to enter an area with a radius of approximately 100 m surrounding the conditioning or attractant site. A conditioning stimulus was then played over a loud speaker.

A target zone where the bear would be struck with the aversive agent was delineated at 40 m from the conditioning site center. Reentry by a bear into the target zone initiated further application of the procedure.

Conditioning Stimulus Procedure

Conditioning stimulus test sites had specific application zones delineated. The start line for observations and data recording was 80 m from the center of the test site or under low-light conditions, whenever a sighting could be made between 40-80 m from the center of the site. The training conditioning stimulus, or neutral conditioning stimulus, was played when the bear crossed the 40-m line known as the "play zone" and continued while the bear remained there. While the bear was in the play zone the following measures were taken:

1. Speed—time required for a bear to cover the first 20 m of travel. This was identified as approach or avoidance movement.
2. Distance—meters traveled in the first 2 minutes and identified either as approach or avoidance. This measure was used if speed was difficult to determine due to erratic movements by the bear.

Bears were expected to react to the different stimuli by displaying avoidance behavior during the training stimulus and no response to the neutral stimulus. Expected behaviors were indicated by a positive reaction (+) to the tests. Unexpected reactions (-) to these stimuli were either no reaction to the training stimulus or retreat from the source of the neutral stimulus.

All statistical analyses were conducted using SPSS statistical programs. Comparisons between conditioning stimuli were made for rate of speed using Wilcoxon Signed Ranks tests at the 0.05 level of significance. This test was used due to the nonparametric nature of the data.

RESULTS

Aversive Agent Tests

Five female grizzly bears, including 2 accompanied by their cubs, were used in aversive conditioning tests from 1986 to 1989 (Table 1). A total of 41 shots were fired and 27 hits recorded.

During 1986, bears were shot at 11 times and hit 6 times with the aversive agent at 8 trial sites. All bears ran from the trial site when fired upon. Generally, bears would not reenter the site while the researchers were present and often would not return to the trial site for 2 to 4 weeks.

In 1987, natural foods were plentiful and human-bear conflicts were uncommon. Aversive conditioning experiments were conducted on 2 habituated female bears that fed near highways; both fled from their respective trial sites. However, both bears continued to forage near the highway and, due to concerns for tourist safety, were captured and relocated to remote backcountry areas.

Due to drought and extreme fire conditions, 1988 was considered a poor food year for grizzly bears. During 1988, 1 subadult female (bear 154) and 3 adult female grizzly bears (bears 134, 104, and 118 with 2 cubs-of-the-year) were tested with the aversive agent. All bears were fired upon with Thumper and Bear Deterrent rounds on 27 occasions and hit 19 times.

Table 1. Summary of shots and hits with aversive conditioning agents and number of days of conditioning and monitoring grizzly bears (1986-89).

	Bear 122	Bear 118		Bear 104				Bear 134			Bear 154	
	1986	1986	1988	1986	1987	1988	1989	1987	1988	1989	1988	Totals
No. shots[a]	5	3	6	3	1	2		2	4		15	41[b]
No. hits	3	2	5	1	1	1		1	4		9	27[b]
Days conditioning and monitoring	24	29	40	26	12	61	18	2	6	5	42	265

[a] Aversive agent device includes Thumper, Bear Deterrent, or Ferret Soft Slug.
[b] Multiple shots or hits during an individual trial counted as a single attempt. Uncorrected totals included 56 shots and 32 hits.

Bear 104 and 134 responded favorably to the aversive agent tests by moving immediately from the test site.

Bear 118 did not respond favorably during trials conducted on her and her 2 cubs-of-the-year. They began frequenting lodges and campgrounds near the east entrance of Yellowstone National Park in early August 1988. She obtained unnatural foods from a major trail head, horse corrals, campgrounds, and an open sewage lagoon. She was hit twice with the Thumper Gun and 3 times with Bear Deterrent bullets during 6 different episodes without permanently deterring her from test sites. Subtle differences were observed during the latter period of conditioning with the aversive agent as she appeared more wary and easily frightened away. One problem during tests was human foods and sewage were available to the bear throughout aversive conditioning trials.

Bear 154, an underweight subadult female lacking upper incisors from a birth defect, showed chronic habituation to people and was conditioned to human foods. The combination of drought conditions, overall natural food shortage, and displacement by nearby forest fires likely contributed to the bear's dependence on human foods. Bear 154 was struck with Thumper or Bear Deterrent bullets on multiple occasions and responded each time by leaving the test area but returning within several minutes. Application of the aversive agent was determined to be ineffective and she was relocated to a remote area.

An exceptional food year was recorded for 1989. This was partially due to a high yield of whitebark pine nuts observed throughout the ecosystem. No additional bears were conditioned with the aversive agent due to the lack of human-bear conflicts.

Throughout our testing, candidate bears displayed no aggression toward researchers. In every case, bears fled the general vicinity of the test site when fired upon, regardless of whether they were struck with the aversive agent projectile.

Five adult male grizzly bears were captured for nuisance behavior from 1986 to 1989. Four of the captured males avoided humans and unnatural food sources following their release. The fifth adult male was a 5-year-old that appeared to be in poor body condition when captured. This bear caused extensive property damage and was removed from the population before aversive conditioning was initiated.

Conditioning Stimulus Tests

During the study, 2 female bears (bear 104 and 134) with cubs-of-the-year were presented training and neutral conditioning stimuli. Responses to the stimuli were evaluated based on how the bears reacted and the speed of their response to the stimuli.

Total responses between the 2 bears included 10 positive (expected) responses and 3 negative responses. The training stimulus received 5 positive reactions in 8 tests. Neutral stimulus trials had 5 of 5 positive reactions. Speed of response data were collected during 12 of the 13 conditioning stimulus trials for the 2 test bears.

Bear 104 was presented with training and neutral stimuli as she grazed in close proximity to humans on 5 occasions during 1989 (Table 2). She reacted as expected in 4 of the trials. In 2 of the training stimulus trials, the bear ceased foraging and left the site, avoiding humans. The bear reacted in a positive manner by not moving away from the neutral stimulus tape on 2 occasions. However, she hesitated before walking or running away.

Comparisons between Bear 104's rate of reaction to training and neutral stimuli indicated no statistically significant difference between the 2 stimuli (Wilcoxon; $Z = -0.4472$, $P \leq 0.3274$) (Table 2). This comparison is somewhat misleading due to the bear hesitating upon leaving the test site.

Conditioning stimulus trials conducted on bear 134 occurred in a variety of situations during 1988-89 (Table 3). In 8 trials, the bear reacted as expected 6 times.

Speed of response comparisons for bear 134 indicated a statistically significant difference in response rates to the 2 stimuli (Wilcoxon; $Z = -1.6036$, $P \leq 0.0544$) (Table 3). The bear exited the trial site

Table 2. Comparison of grizzly bear 104 rate of speed response to training and neutral stimulus in the Yellowstone ecosystem study area, 1989.

		Stimulus[a]	
Date	Situation	Training (m/sec)[b]	Neutral (m/sec)[c]
6/01/89	Roadside	0.686 (+) [d]	
6/02/89	Roadside		0.038 (+)[e]
6/02/89	Roadside	0.398 (+)	
6/04/89	Riverside/Tourist		0.914 (+)
7/26/89	Riverside/Campground	0.000 (-) [f]	

[a] Training versus neutral stimulus not significantly different (Wilcoxon; $Z = -0.4472$, $P \leq 0.3274$).
[b] Training stimulus—California quail call.
[c] Neutral stimulus—ladder-backed woodpecker call.
[d] Avoidance behavior (+), no response (-).
[e] No response (+), avoidance behavior (-).
[f] No response, bear continued to graze.

Table 3. Comparison of grizzly bear 134 rate of response to training and neutral stimuli in the Yellowstone ecosystem study area, 1988-89.

		Stimulus[a]	
Date	Situation	Training (m/sec)[b]	Neutral (m/sec)[c]
5/20/88	Fishing	9.144 (+)[d]	
5/22/88	Lodge		0.610 (+)[e]
6/09/89	On road	1.727 (-)	
6/09/89	Campground	8.299 (+)	
6/09/89	Roadside	N/A (+)[f]	
6/10/89	Roadside		1.509 (+)
6/10/89	Fishing		0.406 (+)
6/10/89	Roadside[g]	0.000 (-)	

[a] Training versus neutral stimulus significantly different (Wilcoxon; $Z = -1.6036$, $P \leq 0.0544$).
[b] Training stimulus—California quail call.
[c] Neutral stimulus—ladder-backed woodpecker call.
[d] Avoidance behavior (+), no response (-).
[e] No response (=), avoidance behavior (-).
[f] Rate of speed data not collected.
[g] Bear nursing cubs-of-the-year during test.

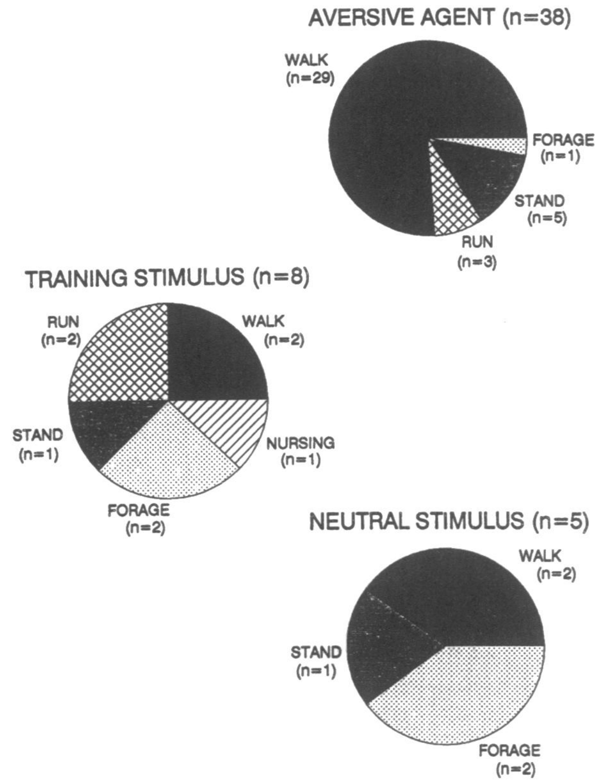

Fig. 2. Frequency of activities of grizzly bears prior to application of aversive conditioning in the Yellowstone ecosystem, 1986-89.

approximately 4 times faster when hearing the training stimuli ($\bar{x} = 4.792$, SE = 9.208) than when hearing the neutral stimuli ($\bar{x} = 0.841$, SE = 1.174).

Behavior Responses

Behavior data was collected during aversive agent trials for all bears and during conditioning stimulus trials for bears 104 and 134. Statistical comparisons were not conducted on the data due to small sample sizes. However, trends were observed between grizzly bear activity prior to aversive conditioning versus expected behaviors when aversive conditioning techniques were applied.

Prior to the aversive agent and conditioning stimulus tests, bears were involved in a variety of activities depending on circumstances occurring at test sites (Fig. 2). Following application of the aversive agent, all bears ran from the test site (Fig. 3). During 10 of 42 trials, bears showed some hesitation before leaving the trial site.

Responses to the training stimulus were variable. Three of the trials produced unexpected results as bears continued walking, foraging, or nursing young. During neutral stimulus trials, bears altered their respective activities only slightly compared to activities prior to application of the stimulus. None of the activity changes led to bears fleeing the trial site.

Rate of response to the aversive agent was usually immediate (41/42 trials) (Fig. 4). Training stimulus responses were not as conclusive as bears either delayed before leaving (4/8 trials), showed no response (3/8 trials), or reacted immediately (1 trial). There was no response, as expected, during all neutral stimulus trials.

DISCUSSION

The major goal of our study was to determine if bear behavior could be altered following a conflict with humans by giving them a strong negative experience. Application of the aversive agent to grizzly bears altered their nuisance behavior temporarily. But this technique did not appear to be a long-term solution with the sex and age classes of bears tested during the study.

Difficulty in conditioning female bears may be related to their small and sometimes restricted home ranges. Females that have selected home ranges in close proximity to humans have a greater chance of re-encountering humans following a conflict situation. These female bears may not be able to avoid humans or

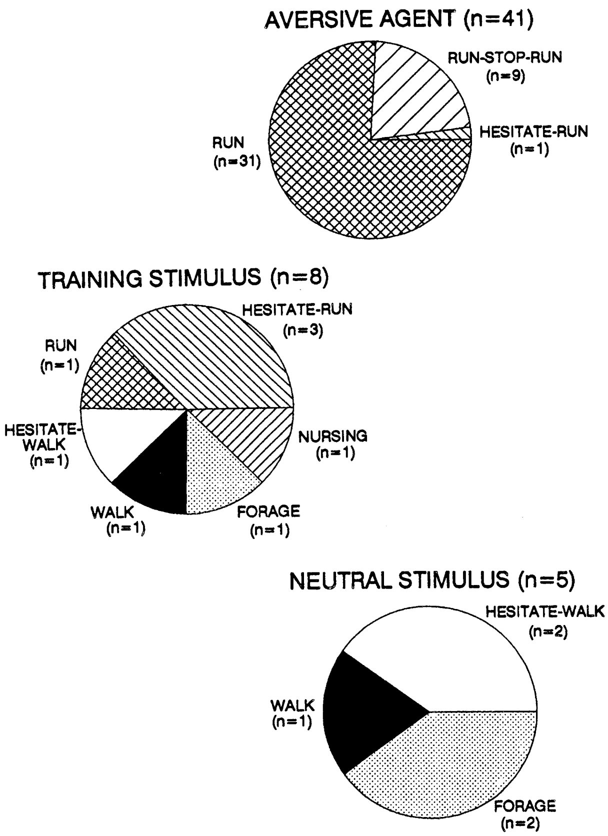

Fig. 3. Frequency of grizzly bear response immediately following application of aversive conditioning stimulus in the Yellowstone ecosystem, 1986-89.

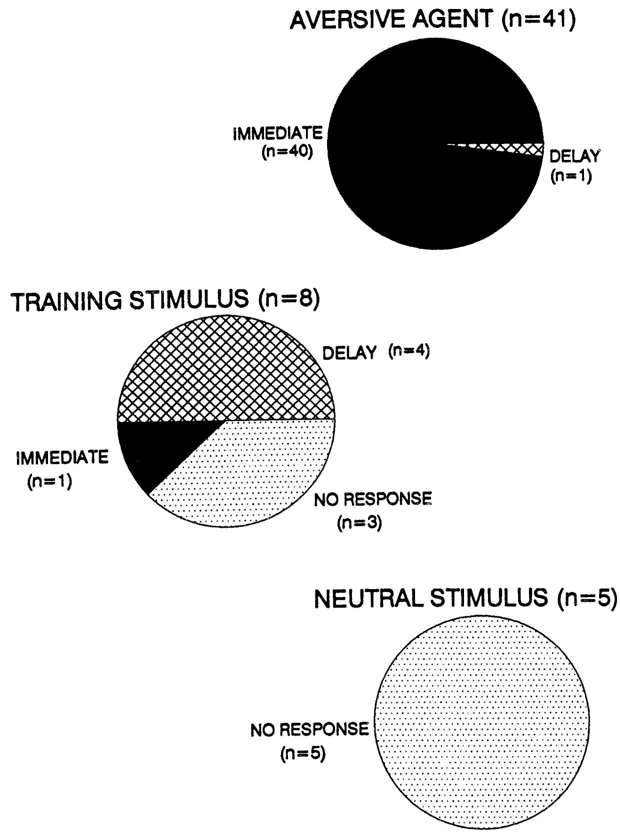

Fig. 4. Frequency of grizzly bear response time immediately following application of aversive conditioning stimulus in the Yellowstone ecosystem, 1986-89.

have the option to alter the size or shape of their home ranges if adjacent areas are fully occupied by other grizzly bears. Since female subadults often select home ranges adjacent or overlapping their mother's (Nagy et al. 1983, Wielgus 1986), their ability to move to areas where they might avoid humans is also limited.

Subadult males were not involved in nuisance behavior or aversive conditioning experiments during the study. This sex and age class would likely learn nuisance behavior from their mothers and should be involved in similar taught behaviors (Johnson and Griffel 1982, Jorgensen 1983, Knight and Judd 1983). However, subadult males generally disperse great distances in search of home ranges that are unoccupied by other bears (Martinka 1970, Russell et al. 1979, Craighead and Mitchell 1982, Wielgus 1986). By moving to unoccupied habitat, their chances of encountering humans may be less than that experienced in their mother's home range. If these bears do become involved in a conflict situation during a normal food availability year, aversive conditioning may be an effective tool since the bear has not established a permanent home range. Effectiveness may also be greater during the bear's initial encounter with humans.

In 1988, all individual bears required more than a single treatment, particularly at different conflict sites. This suggests that initially, bears had to be hit at each site because they failed to generalize a negative experience from one site to the next. Following several hits, bears appeared to recognize specific stimuli at a trial site (truck, tent, or odor) and avoided them at other sites.

One factor affecting success of conditioning experiments during 1988 was the severe shortage of natural foods caused by drought conditions. When natural foods are less available, problem bears are often more tenacious about acquiring unnatural foods. During normal to good food availability years, problem bear situations will be limited, provided unnatural food sources are made unavailable to bears and important habitat components are maintained.

The potential of instilling a fear of humans in habituated bears that might otherwise become dangerous was also evaluated in the study. During all trials, bears involved in aversive conditioning displayed no aggression toward researchers or the public. Bears ran from the trial site when fired upon with the aversive agent on every occasion, regardless of whether they were struck with the projectile. Even during training stimulus trials bears generally responded by leaving the area. Although we were not able to demonstrate a correlation between the bears' behavior and a fear of humans during aversive conditioning, the general avoidance response exhibited by bears to the aversive agent and conditioning stimulus suggests that if they were applied often enough under ideal circumstances, fear could be established in habituated bears.

Female bears involved in conditioning stimulus experiments could distinguish between the training and neutral stimuli. However, the association did not appear to be strong, probably due to the infrequent number of trials attempted. Tests of response rates were also inconclusive. Bears tested would generally leave the test site during application of the training stimulus; however, the response rate of one bear did not differ significantly between the 2 stimuli. Again, the desired learning response apparently was attained, but the magnitude of the reaction was small due to the infrequent application of the stimuli and the nonpainful training stimulus.

MANAGEMENT IMPLICATIONS

Our data indicate that under some conditions, free-ranging female grizzly bears may be conditioned to avoid specific sites within their home ranges. It appears that an individual's behavior response to aversive conditioning may depend on a variety of factors including their level of habituation to humans, level of food conditioning, sex and age of the bear, breeding status, physical condition, natural food availability, and whether they continue to receive a "food-reward" during aversive conditioning trials.

Management Situations

In some circumstances, aversive conditioning may be used as a management option to allow bears to exist in areas they are normally not tolerated. We concede that aversive conditioning may well produce "sneaky" bears. However, such a behavior change may be beneficial in resolving a particular conflict and avoiding the need for further management actions. Examples of this include changing the activity patterns of a diurnal roadside bear to a nocturnal feeder or conditioning a bear to use areas near campgrounds and trail heads only when people are absent.

We were unable to document when or how long bears in our study had been habituated to humans or how often they were food-rewarded prior to conditioning. If a female bear returns to an incident site following its first encounter with humans and is not food-rewarded but is aversively conditioned, we believe success of the technique will be greater.

Certain situations should be considered unacceptable for using aversive conditioning techniques due to uncontrollable external factors. For example, aversive conditioning techniques should not be used when human food attractants can not be removed. The first management response should be to rectify the cause of the problem, realizing that nuisance bears are only a symptom of the cause. Therefore, if unnatural food sources cannot be eliminated, it is unlikely that successful conditioning of problem bears can be achieved.

Aversive conditioning techniques will probably be used most often during poor food years when nuisance behavior increases (Knight et al. 1982). However, these techniques are potentially less effective on bears in poor condition when natural foods are limited.

Some circumstances may require the use of aversive conditioning techniques without collaring or handling bears. These situations include conditioning highly visible national park bears that forage on natural vegetation in roadside situations, or backcountry problem bears that frequent several camps but are difficult to capture due to unpredictable movements.

Candidate Bears

Sick or injured bears should not be considered candidates for aversive conditioning. During the 1988 field season, repeated attempts were made to condition an underweight subadult with poor dentition. Despite management efforts to condition the bear, little sign of learned avoidance behavior was observed. The bear appeared to accept the pain stimulus in return for a potential unnatural food reward.

Aggressiveness was not observed from female bears used in aversive conditioning tests. From a human safety standpoint, relocation or removal of bears exhibiting aggressive behavior are generally the most appropriate management actions.

We recommend aversive conditioning be conducted prior to relocating or destroying nonaggressive bears. When nuisance bears are removed from areas near human developments, managers should anticipate reoccupation of these habitats and home ranges by other bears which may be involved in similar or more serious conflicts. By training bears to avoid humans at an early period in the bear's life, coexistence may be attainable where human developments have encroached into bear habitat.

In most cases, aversive conditioning can be attempted on any age bear that has not become heavily conditioned to unnatural food sources or exhibits strong human habituation. We believe the ideal candidate for aversive conditioning is the yearling through subadult age-class bear that is conditioned during its initial exposure to humans and human food sources. Some bears become exposed to humans and their foods when they are cubs and still with their mothers. However, management actions in these cases will be directed toward the adult mother bears due to the risk of injuring the cubs. Other noncandidate bears will usually include adult age-class bears that have been repeatedly food rewarded.

Bears that have never been food conditioned are also potential candidates for aversive conditioning. These bears include those that feed on natural vegetation along roadsides but create dangerous situations for tourists. In national parks where tourist safety is of high concern, special effort should be made to apply aversive conditioning to nuisance bears when tourist numbers are low, prior to the Memorial Day holiday.

Limitations of Aversive Conditioning Techniques

Results indicated the most effective part of the conditioning process was the application of the aversive agent. The training stimulus may be effective depending on the individual bear and opportunity for repeated trials. However, an effective training stimulus was not discovered during this study and the opportunity for repeated trials on individual bears should not be anticipated during most human-bear conflict situations.

One of the major limitations of aversive conditioning is that the technique could prove time and labor intensive if it is administered to every nuisance bear. Managers should take into account the variables and circumstances that may limit the practicality of aversive conditioning techniques. These variables may include safety factors, repeatability, natural food availability, bear sex and age characteristics, and extent of previous habituation and food rewards.

Additional Techniques

Though we did not attempt to combine other management techniques with the use of aversive conditioning, the potential exists for integrating multiple management practices. One example includes following up a pain stimulus with additional harassment using specially trained bear dogs. The dogs could be used to chase the offending bear away from areas that management officials have decided are "off-limits." Properly trained dogs could solve a major problem encountered by our study where some bears learned to stay out of range of the conditioning agents but remained in the general area. Cooperative arrangements are currently being made between the Interagency Grizzly Bear Committee and the Republic of Russia to investigate the possibility of using Karelian or Laika bear dogs for aversive conditioning.

The previous recommendations are designed to assist managers in aversive conditioning techniques. The concept of aversive conditioning free-ranging wildlife is relatively new with great opportunity for improvements in methodology and equipment technology. However, the underlying reason for needing reaction-oriented management practices, such as aversive conditioning, is that humans have encroached on and altered bear habitat. Therefore, we must take responsibility for creating situations that lead bears into nuisance behavior. In areas of conflict between humans and bears, philosophies concerning the presence of people in critical bear habitat should be evaluated. Managers must determine which species, *Homo sapiens* or *Ursus arctos*, should have priority use of a critical habitat and identify the ultimate cause of the resource use conflict. A solution can then be implemented to restrict, relocate, or remove the individual species to resolve the conflict. Solutions to conflicts are difficult and people need to learn to coexist with grizzly bears.

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