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Investigating Methods to Reduce Black Bear (Ursus americanus) Visitation to Anthropogenic Food Sources: Conditioned Taste Aversion and Food Removal

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INVESTIGATING METHODS TO REDUCE BLACK BEAR (*URSUS AMERICANUS*) VISITATION TO ANTHROPOGENIC FOOD SOURCES: CONDITIONED TASTE AVERSION AND FOOD REMOVAL

by

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ABSTRACT

Investigating Methods to Reduce Black Bear (*Ursus americanus*) Visitation to Human Food Sources: Conditioned Taste Aversion and Food Removal

by

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Conflicts between humans and black bears (*Ursus americanus*) jeopardize the safety of both humans and bears, especially when bears become food-conditioned to anthropogenic food sources in areas such as campgrounds. Interest in using non-lethal techniques, such as aversive conditioning, to manage such conflicts is growing. I conducted a captive experiment at The Wildlife Science Center in Minnesota and two field experiments in the La Sal Mountains, Utah, to investigate the effects of taste aversion conditioning using thiabendazole (TBZ) with a novel flavor cue and food removal on black bear food consumption and visitation to human food sources. In 2007, I conducted food trials with 6 captive black bears (3 control, 3 treatment). Controls received 1 kg baked goods scented with a peppermint-canola oil mixture and treatments received 1 kg baked goods also scented with a peppermint-canola oil mixture but mixed with 10-20 g TBZ. In the 2007 field experiment, I baited 24 field sites with 300 g of baked goods during a baseline phase for approximately 3 weeks. Half of these sites were then treated with 10 g of TBZ and camphor during a treatment phase for 4 weeks. In 2008, I baited 22 sites with 300 g of baked goods during a baseline phase for approximately 4 weeks. I then removed food and discontinued baiting at half of the sites for 4 weeks. Infrared cameras and barbed-wire hair snags were established at field sites to document bear visitation. I did not establish taste aversion in treated bears in captivity and bears fully consumed food in the majority of trials. Treating food supplies with 10 g TBZ and camphor flavor did not significantly reduce bear visitation (P = 0.615) or food consumption at field sites (P = 0.58). However, I observed a significant reduction in bear activity at sites where food was removed (P = 0.006). Potential reasons for my failure to reduce bear visitation using thiabendazole include insufficient conditioning, reluctance of bears to desist in investigating sites that previously contained untreated food, and masking of a treatment effect due to continued encounters of sites by new individuals.

(63 pages)

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Kari D. Signor

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CHAPTER 1

INTRODUCTION

Conflicts between humans and black bears (*Ursus americanus*) have escalated in recent years with the expansion of urban development and the increased proximity of urban areas to wilderness and wildlife (Barden et al. 1995, Beckmann and Berger 2003*a,b*; Treves and Karanth 2003). The availability of anthropogenic food sources, such as garbage, is a major contributor to this increase (Barden et al. 1995). The city of Gatlinburg, Tennessee concluded that inadequate garbage control was a key factor in creating nuisance bear problems (Peine 2001). Developed areas that are surrounded by wilderness where both bear and human densities can be high are particularly vulnerable to bear-human conflicts. This is especially true in national parks where activities such as hunting no longer provide negative reinforcement from humans and bears become habituated (Graber 1989, McCullough 1982).

Historically, national parks such as Yellowstone provided human food to bears at designated feeding areas where visitors could observe (Graber and White 1978, Schullery 1991). Open-pit garbage dumps were highly accessible to bears in Yellowstone until 1970 when a new bear management plan restricted the use of these dumps (Brannon 1987). Following a rapid reduction in food availability, bears dispersed in search of alternative food sources and nuisance activities increased (Craighead and Craighead 1971). Dump closures and a shift in management policies in Yellowstone contributed to the mortality of over 100 grizzly bears (Craighead 1976).

Graber (1989) noted that the availability of human food was one of the most significant factors that influenced black bear ecology and behavior in national parks.

Beckmann and Berger (2003*a*, *b*) also observed dramatic differences in foraging and denning behaviors between bears that existed in and around urban areas and bears that existed in wildland areas, as a result of human food availability. Urban bears were reported to have begun denning one month later than wildland individuals, on average, or did not enter hibernacula at all (Beckmann and Berger 2003*a*). Black bear densities in one of the study populations grew 3-fold in a 10-year period of urban-wildland interface expansion and densities of urban bears were significantly greater than those of wildland populations. Unlike their wildland counterparts, urban bears were predominantly more active during evening and nocturnal hours when human activity was minimal (Beckmann and Berger 2003*a*). Similar differences in foraging behavior were seen in Sequoia National Park between bears that primarily fed on natural forage and those that exploited food in campground areas (Ayres et al. 1986).

Bears that wander into developed areas in search of anthropogenic food are more susceptible to dangers such as vehicle collisions and lethal removal (Ebersole 2005, Mazur and Seher 2007). Each time human food is found and consumed, it acts as a reward and the behavior is reinforced. Visits to that site are perpetuated (McCullough 1982), creating more opportunities for interactions between bears and humans and jeopardizing the safety of both (Gunther and Hoekstra 1996, Ebersole 2005, Mazur and Seher 2007). Between 1930 and 1969, bears' attraction to human food was related to the majority of bear-inflicted injuries to humans and was also the reason for most bear management activities in Yellowstone National Park (Gunther and Hoekstra 1996). Further, since bears possess diverse foraging habits and are adept at exploiting whatever food resources they encounter (Maehr 1984, Polson 1983, Sillings et al. 1989, O'Brien and Marsh 1990, Turbak 2000, Zielgltrum 2004), they have the potential to cause a tremendous amount of damage where human food is available. In 1998, black bears in Yosemite National Park broke into 1,300 vehicles in search of food, causing $600,000 in damage (Turbak 2000). Such conflicts can require aggressive management actions and the costs incurred by agencies to implement management strategies can be extensive. To maximize resources and ensure public safety, managers must respond to conflicts with the most effective management strategies available.

Numerous strategies are implemented to resolve human-bear conflicts, including lethal control (Graber and White 1978, Gore et al. 2006, Treves and Karanth 2003). In Asia, farmers still kill bears as a result of crop damage and depredation activities by these species (Huygens and Hayashi 1999, Fredriksson 2005) even though the Asiatic black bear (*Ursus thibetanus*) and the Malayan sun bear (*Helarctos melayanus*) are considered threatened with extinction under CITES Appendix 1 (Servheen 1999). Kemp (1974) reported that bear populations may increase following the removal of older individuals. As a result, non-lethal methods are critical to conservation efforts. Additionally, the use of lethal methods is becoming less tolerable to wildlife managers and the public (Barden et al. 1995, Reiter et al. 1999, Beckmann et al. 2004, Gore et al. 2006) and even systematic lethal control may not effectively reduce depredation to crops (Huygens and Hayashi 1999).

Translocation is another method that has been used to remove nuisance animals from specific areas, but it ultimately moves the existing problem to a new location and rarely provides a long-term solution (Meagher and Fowler 1989). Electrified fencing, on the other hand, has been extremely effective in keeping bears out of crops and reducing damage to other sites (Hyugens and Hayashi 1999, Madel 1996, Breck et al. 2006). It was also reported as the most effective and frequently used method of bee hive protection in a survey of North American apiarists who considered bears as the most significant threat to their beekeeping practices (O'Brien and Marsh 1990). However, using methods that involve exposed electrical devices to deliver a shock are not suitable for areas that receive high levels of human activity, such as national parks or campgrounds. Consequently, the need for the advancement of alternative, non-lethal methods of wildlife-conflict management persists (Barden et al. 1995, Reiter et al. 1999, Beckmann et al. 2004, Gore et al. 2006). One such approach involves the use of aversive conditioning.

Aversive conditioning occurs when an individual associates a specific behavior with a negative experience, such as pain or loud noise. This results in a decrease in occurrence of the target behavior in order to avoid the negative stimulus. A vast number of physical aversive conditioning techniques has been tested and used for managing nuisance bears with varying degrees of success including loud noise, rubber buckshot, rubber slugs, pepper spray, dogs, and electrified fencing (Gilbert and Roy 1977, Miller 1983, O'Brien and Marsh 1990, McCarthy and Seavoy 1994, Hunt 1999, Huygens and Hayashi 1999, Jones 2000, Beckmann et al. 2004, Breck et al. 2006). Many of these methods have been successful at immediately deterring bears from areas where human food was available, but McCarthy and Seavoy (1994) found that bears exposed to cracker shells and buckshot often returned to the same area and engaged in the same foraging behavior within several hours. Further, an undesirable side-effect of administering these types of aversive stimuli is that an animal may not associate the stimulus in the desired context. Instead, animals may establish an aversion to the individual administering the stimuli rather than to a particular area (Shivik 2003). For example, researchers attempted to deter bears from roadsides they previously frequented in Glacier National Park using aversive conditioning with Karelian bear dogs. Bears were deterred when vehicles approached, but were not deterred entirely from the roadsides themselves, and bear activity at these sites continued in the absence of vehicles (Hunt 1999). Therefore, bears likely associated vehicle presence with the negative experience provided by dogs rather than associating roadside areas with the negative experience.

Not all types of aversive conditioning are efficient at modifying target behaviors, however, and behavioral characteristics of an animal must be considered. This is due to the way in which the skin- and gut-defense system regulates how stimuli are processed (Garcia and Koelling 1966). Neurologically, external, physical stimuli are processed by the skin-defense system, whereas internal stimuli are processed by the gut-system (Garcia et al. 1985). Therefore, the behavior with which an individual associates a stimulus depends on the type of stimulus it is exposed to (external or internal) and aversive techniques must be employed appropriately to have the desired effect on behavior. For example, avian species are highly dependent upon visual stimuli and respond well to visual cues that are paired with behavior (Wilcoxon et al. 1971). Mammals, especially predators, are more specialized to use olfaction and taste to explore and gather information about their surroundings. External stimuli, such as pain, loud noise, or visual cues can only influence behaviors that are relevant to the external environment and the location of an individual. In other words, an individual can learn to avoid an external stimulus such as electric shock by moving away from the object it associates with shock.

Alternatively, internal stimuli such as gastro-intestinal malaise will influence behaviors relevant to food consumption and may be a useful technique for managing food-conditioned animals. For example, if an individual experiences severe illness following the consumption of a particular flavor, that flavor becomes what is called a conditioned stimulus (CS) and an individual becomes conditioned to reject or avoid the flavor (Quick et al. 1985). This process is called conditioned taste aversion (CTA) and is considered one of the most powerful forms of learning, as well as the most effective method of reducing food consumption (Gustavson and Gustavson 1985). Unlike other forms of conditioning, CTA can be effective after only one association with illness and a novel flavor and can still be established if the onset of punishment, or illness, from ingesting a food item is delayed; malaise does not have to be immediate (Garcia and Koelling 1966). However, the effectiveness of CTA can be strongly influenced by the novelty and intensity of the flavor consumed (Garcia et al. 1974, Revusky and Bedarf 1967) and the severity of sickness (Garcia et al. 1974). The more potent or unfamiliar the flavor and the more intense the sickness is, the stronger the taste aversion will be.

It has been suggested that vomiting may weaken the effects of taste aversion (Burns and Connolly 1980). Individual black bears that vomited following the consumption of lithium chloride-treated baits resumed consuming untreated baits more than twice as fast as one individual who did not vomit (Colvin 1975). This shows that vomiting may act as a remedy to illness and could render CTA less effective. Otherwise, gastro-intestinal malaise is inescapable and cannot be avoided by simply moving away from the stimulus (Quick et al. 1985). Therefore, sickness is not easily associated with an individual's location, but rather with gustatory cues such as food.

As an example, Cibils et al. (2004) showed that steer that were exposed to electric shock while feeding on high-quality forage surrounded by orange traffic cones associated the cones with electric shock. Individuals subsequently learned to avoid areas where orange cones were present, but still fed on high-quality forage in other areas where cones were absent. However, steer that were administered lithium chloride to induce illness after feeding on the same high-quality forage surrounded by the cones learned to associate the type of forage with illness and disregarded the presence of cones. They subsequently avoided high-quality forage but consumed other types of forage in all areas, including the areas surrounded by cones. Therefore, an individual will only learn that a general location is unattractive if stimuli are paired correctly. An animal will associate a specific visual cue with negative external stimuli such as shock, but may not associate a visual cue with negative internal stimuli such as illness (Cibils et al. 2004).

CTA has been used to reduce depredation of eggs in many bird species (Wilcoxon et al. 1971, Brett et al. 1976, Gaston 1977, Bogliani and Bellinato 1998, Nicolaus et al. 1989) and has successfully reduced consumption of target food items by many predators including raccoons (Nicolaus et al. 1982), mongoose (Nicolaus and Nellis 1987), wolves (Gustavson et al. 1976), coyotes (Gustavson et al. 1974, Ellins et al. 1977, Cornell and Cornely 1979, Ellins and Catalano 1980, Gustavson et al. 1982), wild dogs, dingoes (Gustavson et al. 1983), wolverines (Landa and Tommeras 1997), and bears (Wooldridge 1980, McCarthy and Seavoy 1994, Ternent and Garshelis 1999). Many different compounds have been tested and used to induce illness including lithium chloride, levamisole, emetine hydrochloride (EHCl), alpha-naphthyl-throurea (ANTU), carbachol, cinnamamide, ethinyl oestradiol, and thiabendazole (TBZ).

In order to establish an aversion to the target flavor or food item instead of to the compound, a relatively tasteless compound must be used or its flavor must be concealed (Gill et al. 2000). The salty flavor of lithium chloride and the amount required to induce illness in some animals makes this compound difficult to conceal and appropriate conditioning is difficult to achieve (Gilbert and Roy 1977, Burns 1980, Wooldridge 1980, McCarthy and Seavoy 1994). Ethinyl oestradiol is a synthetic hormone and can affect reproductive processes and may have detrimental effects on the environment (Gill et al. 2000). Thiabendazole has been used successfully as an emetic compound in CTA studies of several mammals, including free-ranging black bears (Gustavson et al. 1983, Polson 1983, McCarthy and Seavoy 1994, Ternent and Garshelis 1999). It also provides many desirable properties in that it induces gastro-intestinal malaise, is relatively tasteless and odorless, can be administered in large doses safely without adverse side effects, and can be easily obtained.

CTA has been studied extensively in many organisms and could potentially provide an effective management strategy for food-conditioned bears, but the issue of increasing availability of human food sources to bears should not be overlooked. Many investigators have suggested that limiting food availability is critical in reducing human-bear conflicts (McCarthy and Seavoy 1994, Garner and Vaughn 1989, Graber 1989, Smith et al. 1989). However, no studies have yet been experimentally conducted to directly address the effect of eliminating human food sources on black bear activity.

Therefore, my objectives with this study were 2-fold: First, I tested whether food consumption and black bear activity at sites where human food was available could be reduced using TBZ paired with a novel flavor. Second, I tested the effectiveness of removing human food on reducing black bear activity where food was previously available. Consistent with CTA theory, I hypothesized that bears would establish an aversion to treated food, disregard treated food as a palatable and available food source and, ultimately, reduce their activity at treated sites. My second hypothesis was that bear activity would decrease at sites where food was removed. Overall, I wanted to determine if CTA would effectively remove a target food item from a bear's foraging repertoire and if food removal, itself, was the underlying action that influenced bear behavior.

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CHAPTER 2

EFFECTS OF THIABENDAZOLE-NOVEL FLAVOR TREATMENT ON BLACK BEAR FOOD CONSUMPTION AND VISITATION TO ANTHROPOGENIC FOOD SOURCES IN THE BOOK CLIFFS

INTRODUCTION

Conflicts between humans and black bears (*Ursus americanus*) have escalated in recent years with the expansion of urban development and the increased proximity of urban areas to wilderness and wildlife (Barden et al. 1995, Beckmann and Berger 2003*a*, *b*; Treves and Karanth 2003). A major factor in this increase in conflicts is the increased availability of anthropogenic food sources, such as garbage, in urban areas (Barden et al. 1995). Bear use of human food sources is particularly problematic because of their adeptness at exploiting whatever food resources are available. As bears become food-conditioned to human food sources, they become habituated to people and can become more aggressive and dangerous, sometimes with tragic consequences for both humans and bears.

Using internal stimuli, such as gastro-intestinal malaise, can specifically influence behaviors relevant to food consumption. For example, when an individual experiences severe illness following the consumption of a particular flavor, the flavor will subsequently be rejected or avoided by the individual (Quick et al. 1985). This is called conditioned taste aversion (CTA) and is considered one of the most powerful forms of learning as well as the most effective method of reducing food consumption in organisms (Gustavson and Gustavson 1985). CTA is most effectively established when the flavor consumed is unfamiliar and strong (Garcia et al. 1974, Revusky and Bedarf 1967) and subsequent illness is severe (Garcia et al. 1974). Additionally, unlike other forms of conditioning, CTA can still be established with delayed illness (Garcia and Koelling 1966). Thus, CTA may provide an effective strategy for managing food-conditioned bears.

A variety of compounds have been used successfully to reduce consumption of target food items by many predators including raccoons (Nicolaus et al. 1982), mongoose (Nicolaus and Nellis 1987), wolves (Gustavson et al. 1976), coyotes (Gustavson et al. 1974, Ellins et al. 1977, Cornell and Cornely 1979, Ellins and Catalano 1980, Gustavson et al. 1982), wild dogs, dingoes (Gustavson et al. 1983), wolverines (Landa and Tommeras 1997), and bears (Wooldridge 1980, McCarthy and Seavoy 1994, Ternent and Garshelis 1999). However, in order to establish an aversion to the target flavor or food item, a relatively tasteless emetic compound must be used (Gill et al. 2000). Several authors have suggested that the salty flavor of lithium chloride is difficult to conceal due to the quantity required to induce illness in some animals (Gilbert and Roy 1977, Burns 1980, Wooldridge 1980, McCarthy and Seavoy 1994). However, one compound that has been used successfully and possesses desirable properties for use in taste aversion is thiabendazole (TBZ), an anthelmintic traditionally used in the treatment of gastrointestinal roundworms in both humans and ruminants. TBZ is relatively odorless and tasteless, is metabolized quickly, has a wide margin of safety, and possesses emetic properties. It has also been used successfully in field applications with black bears. Black bear damage to bee yards was reduced after baits treated with TBZ were hung within nearby game and bear trails surrounding the yards (Polson 1983). McCarthy and

Seavoy (1994) successfully averted black bears from peanut butter and honey baits using 16.5 g TBZ per bait and Ternent and Garshelis (1999) established CTA in black bears after one treatment in military meals-ready-to-eat. Therefore, we chose to use TBZ as the emetic compound for this study.

My objective with this study was to test whether food consumption and black bear activity at sites where human food was available could be reduced using TBZ paired with a novel flavor. Consistent with CTA theory, I hypothesized that bears would establish an aversion to treated food, disregard treated food as a palatable and available food source and, ultimately, reduce their activity at treated sites. In general, I wanted to determine if CTA would effectively remove a target food from a bear's foraging repertoire when food availability mimicked that found in a campground setting.

STUDY AREA

Field work was conducted in the Book Cliff Mountains, East Tavaputs Plateau, Utah between July 21, 2006 and August 27, 2006. This area is predominantly managed by the Bureau of Land Management for multiple uses, including recreation, grazing, and oil and natural gas development. I chose to conduct my study in the Book Cliffs because they are remote and uninhabited, which enabled me to bait black bears to field sites without jeopardizing public safety as might have been the case at a public recreation area with pre-existing nuisance bears. Elevations in the Book Cliffs range from approximately 1670 m to 2600 m. Lower elevations are characterized by a desert shrub ecosystem including sagebrush (*Artemisia tridentata*) and juniper (*Juniperus scopulorum* and *J. osteosperma*) while steep, mountainous terrain, valleys, and canyons characterize higher elevations. Vegetation at high elevations includes aspen (*Populus tremuloides*), Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine *(Pinus ponderosa)*, Gambel's oak (*Quercus gambelii*) and serviceberry (*Amelanchier alnifolia*). Climate conditions are generally hot and relatively dry during the summer with frequent monsoon-like thunderstorms during the day. However, this region receives heavy snowfall during the winter which persists at higher elevations into late Spring.

METHODS

I established a total of 15 sites along the Book Cliff Divide and within adjacent canyons including East Canyon, Hay Canyon, Dick Canyon, and Horse Canyon. Most sites were comprised of aspen stands, ponderosa pine, and open meadows. I affixed a 20-gallon plastic trash bin to a tree at each site using lag screws and washers and secured bin lids using bungee cords. This enabled bears to open the bin but prevented non-target animals, such as elk or livestock, from obtaining food. I strung one strand of 4-pronged barbed wire around trees surrounding each trash bin at approximately 50 cm above the ground, following the protocol of Woods et al. (1999), in order to designate the site and to collect hair from bears. Wire distance from the bin varied depending on the arrangement of trees at each site, but was strung such that bears were forced to cross the wire to reach the bin. I affixed a Cuddeback® Digital motion-sensored camera (Non Typical, Inc., Park Falls, Wisconsin) to a tree facing the trash bin to monitor bear activity at 7 sites and baited all trash bins between July 21-24, 2006 with approximately 2.5 kg of baked goods including donuts, breads, pastries, and cakes obtained from bakeries. I checked sites and replenished bait every other day except on days spent in town, once a week, to obtain bait. Sites were not checked for 3 days in these instances. During each site check, I collected hair samples, checked and downloaded images from cameras, removed and weighed any remaining bait to determine the amount of food consumed, and refreshed bait. I used photographs and hair to verify bear activity and considered a site as having been visited if food was consumed and I captured either photographs of a bear or bear hair.

Once a site was visited by a bear, it was randomly assigned to a control, treatment, or 'treatment with flavor' group. I baited control sites with 2.5 kg of baked goods. I baited treatment sites with 2.5 kg of baked goods and 10 g TBZ (Sigma Aldrich, location) distributed between food items. I baited 'treatment with flavor' sites with 2.5 kg of baked goods, 10 g TBZ, and sprayed food with a canola oil and a peppermint extract mixture (2 cc peppermint mixed in 16 oz oil).

RESULTS

Visits to baited field sites in 2006 were minimal. Bears visited a total of 6 different sites but only consumed food at 3 of these sites on a total of 7 different occasions. Untreated bait was consumed 2 times, bait treated with only TBZ was consumed 3 times, and bait treated with TBZ and peppermint was consumed 2 times. In all but one instance, all bait and TBZ was entirely consumed. However, bear visits to food sources were not eliminated.

DISCUSSION

I assumed 1) that treating human food sources with TBZ would induce gastro-intestinal illness following consumption and 2) that peppermint was a novel flavor to bears. However, the sample size was limited and any interpretations regarding treatment effects due to TBZ and/or peppermint are anecdotal, at best. Field cameras captured bears consuming a single bolus of treated bait over several days or over the course of several hours. Garcia et al. (1974) state that the strength of an aversion is related to the severity of the sickness. This is a key component in establishing conditioned taste aversion. Therefore, it is possible that if a smaller, inadequate dose of TBZ was consumed over time, its effect as an emetic agent could have been weakened. I suspected that repeated visits to one bolus of food over several hours or days suggested that TBZ could have been affecting foraging activity; however, due to the repeated visits, it may have been an inadequate TBZ dose. Cameras did not capture bears consuming bait over multiple visits prior to treating bait.. Since the bear population was free-ranging and my methods did not allow me to know or accommodate individual bear weights with TBZ doses, I used a standard amount of 10 g TBZ at treatment sites. This amount was effectively used by Ternent and Garshelis (1999) to avert bears from consuming MREs, but it has been shown that the effects of TBZ can vary widely among individuals (Polson 1983). Therefore, the treatment may have affected certain individuals, but sickness still may not have been severe enough to effectively establish a taste aversion and reduce activity. Since I was unable to determine whether 10 g TBZ/2.5 kg food was an effective dose in free-ranging bears from our field methods, I concluded that additional investigation was necessary.

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CHAPTER 3

EFFECTS OF THIABENDAZOLE-NOVEL FLAVOR TREATMENT ON BLACK BEAR FOOD CONSUMPTION IN CAPTIVITY AND EFFECTS OF TREATMENT AND FOOD REMOVAL ON VISITATION TO ANTHROPOGENIC FOOD SOURCES IN THE LA SALS

INTRODUCTION

Human-black bear (*Ursus americanus*) conflicts have been increasing in recent years as urban areas and wilderness converge (Barden et al. 1995, Beckmann and Berger 2003*a*, Treves and Karanth 2003). The increased availability of anthropogenic food sources, such as garbage, is a major contributor to these conflicts in urban areas (Barden et al. 1995). There is growing interest in alternative, non-lethal methods of wildlife-conflict management from managers and the public alike (Barden et al. 1995, Reiter et al. 1999, Beckmann et al. 2004, Gore et al. 2006). Therefore, wildlife managers are faced with the challenge of effectively managing nuisance bears without using traditional lethal control.

Conditioned taste aversion (CTA) is one alternative method that has been used successfully in reducing target food consumption in black bears (McCarthy and Seavoy 1994, Ternent and Garshelis 1999). However, while CTA shows promise as an effective strategy to manage food-conditioned bears, limiting food availability has been recognized as an important step in addressing human-bear conflicts (McCarthy and Seavoy 1994, Garner and Vaughn 1989, Graber 1989, Smith et al. 1989).

My objectives with this study were 2-fold: First, I tested whether food consumption by black bears could be reduced using TBZ paired with a novel flavor. Second, I tested the effectiveness of removing human food on reducing black bear activity where food was previously available. Consistent with CTA theory, I hypothesized that bears would establish an aversion to the novel flavor, subsequently reducing their consumption of food items treated with the flavor. My second hypothesis was that bear activity would decrease at sites where food was removed. Overall, I wanted to determine if CTA would effectively remove a food item from a bear's foraging repertoire and if food removal itself was the underlying action that influenced bear behavior.

STUDY AREA

Captive food trials. I conducted food trials at The Wildlife Science Center in Forest Lake, Minnesota. Two separate chain-link enclosures housed the bears used in my captive experiments. Four bears shared one enclosure and 2 bears shared another enclosure. Bears were provided a den box for cover and water *ad libitum* in both enclosures.

Field experiments. Field experiments were conducted in 2007 and 2008 in the La Sal Mountains, located in southeastern Utah within the Colorado Plateau. The La Sals were selected because they are remote and enabled me to bait black bears to sites without endangering public safety as might have been the case at a public recreation area with pre-existing nuisance bears. The area is surrounded by a desert of sandstone mesas, slot canyons, and sagebrush flats. Mountain peaks range from 3320 m (Grand View) to 3877 m (Mount Peale) in elevation. The mountains are comprised of the Manti-La Sal

National Forest, the La Sal Mountain State Forest, and private land dominated by ponderosa pine forests, aspen stands, open meadows, and several glacial lakes at higher elevations. During the summer, high daily temperatures typically remain below 26° C but lows can be below freezing, particularly during early summer months. Beginning in July, the region often experiences daily thunderstorms and monsoon-like rainfall. There are several established recreation sites throughout the La Sals, although public recreation predominantly occurs along the southwestern section of the mountains. Field experiments were conducted on the northeast side of the range.

METHODS

Captive food trials. I conducted a pre-treatment food trial, 3 treatment food trials, and a post-treatment food trial with captive bears (n=6) from 17 May 2007 to 25 May 2007 at The Wildlife Science Center in Minnesota. A certified veterinarian and staff weighed bears, collected blood samples, and physically examined each individual to ensure that they were in adequate physical condition to be used in trials. I first paired bears by weight, and then randomly assigned one individual in each group to a control or treatment group. One pair was not strictly randomized because laboratory results suggested a suboptimal liver condition in one individual, so I placed her in the control group and placed the individual with the next closest weight in the treatment group. Control bears weighed 75, 123, and 196 kg and the treatment bears weighed 41, 86, and 126 kg. During trials, I isolated each bear and fed them sequentially, as closely in time as possible. I removed food that was not consumed within 15 minutes and weighed what remained. I observed bears up to 1.5 hours following each trial and noted any changes in behavior, signs of malaise, or other symptoms that could indicate gastrointestinal illness or other physiological responses to TBZ. Animal care staff provided all bears their routine ration of raw fruits and vegetables including lettuce, broccoli, melons, apples, and strawberries immediately following each trial.

In the pre-treatment trial, I offered each bear 1 kg of donuts. In treatment trials, I presented Bears 1-3 (controls) with 1 kg donuts scented with a peppermint-canola oil mixture (16 oz oil and 2 cc peppermint) while Bears 4-6 (treatments) were presented with 1 kg donuts scented with a peppermint-canola oil mixture but also mixed with TBZ. In all treatment trials, Bear 4 was offered 10 g of TBZ while Bears 5 and 6, who weighed considerably more, were offered 10 g TBZ in trial 1, 15 g TBZ in trial 2, and 20 g TBZ in trial 3. I presented larger doses of TBZ to these 2 individuals to account for the possibility that the initial dose would be ineffective for their larger body size, but maintained a 10-g dose with the smallest individual (Bear 4) to avoid potential deleterious physiological effects from TBZ. Bears resumed their usual diet for one day between each trial to recover from any possible illness. In the post-treatment trial, I presented all individuals with 1 kg of donuts scented with a peppermint-canola oil mixture to test whether taste aversion was established; no TBZ was presented.

Captive food trials were conducted as a pilot study. Sample size was low and trials were observational in nature. Therefore, I limited analyses to descriptive statistics and observations.

CTA field experiment 2007. I conducted the first field study in the La Sal Mountains from 19 June 2007 to 16 August 2007. I established 24 sites along the northeast side of the mountains within state and national forests and privately owned land (JB and Redd Ranches). I chose sites based on habitat quality, locations of bear sightings from local landowners, and accessibility. My intention was to mimic the availability of food sources in areas such as campgrounds. I placed sites between 100 m and 1500 m from established roads and approximately 3 to 4 km from each other, but at least 3 km away from any building, structure, or site that appeared to be currently or previously inhabited by humans. Where sites were potentially accessible by the public, I posted signs that informed people of bear activity in the area.

At each site I used a 20-gallon trash bin to contain food. I used lag screws and washers to affix the trash bin to a tree and secured the lid to the trash bin using bungee cords. Securing the lid in this way enabled bears to open the bin but prevented non-target animals such as elk or livestock from obtaining food. I affixed a Cuddeback® Digital motion-sensored camera (Non Typical, Inc., Park Falls, Wisconsin) to a tree facing the trash bin to monitor bear activity.

I began a baseline phase on 19-20 June 2007 and baited sites with 300 g of baked goods including donuts, breads, pastries, and cakes donated from local supermarkets. I also scorched 2 strips of raw bacon using a blowtorch and hung them on a branch near the bin to attract bears to the sites. If infrared cameras recorded images, I removed the memory card and replaced it with a blank card. I removed and weighed any bait that was not consumed, refreshed bait during each site check, and investigated photographs and videos to verify bear activity. I checked sites every two days except when roads became impassable during poor weather. Sites were baited during a baseline phase until 14 July 2007.

After a 4-week baseline phase, I ranked all sites as pairs according to their frequency of bear visitation (number of days the site had been visited by a bear). One site in each pair was then randomly assigned to either a control or treatment group. Sites assigned to the treatment group were treated for 4 weeks beginning on 14-15 July 2007 during the treatment phase. I continued to bait each site with 300 g baked goods as in the baseline phase, but also treated bait at treatment sites with 10 g of powdered TBZ distributed between food items. To provide a conditioned stimulus (CS), I sprayed a camphor/canola oil mix (8 g camphor/20 ml oil) on top of the bait. Control sites received no TBZ or camphor. Sites were checked in the same manner as during the baseline phase. I also weighed any bait that remained at control and treatment sites to monitor food consumption in bears. I concluded the treatment phase and dismantled sites on 16 August 2007.

I analyzed food consumption (g) and bear activity at sites (mean number of photographs/day and mean number of minutes spent at sites/day bears were present) between the baseline phase and treatment phase using a paired, two-sample t-test. That is, difference scores between paired control and treatment sites were compared, using a t-test, between baseline and treatment periods.

Food removal experiment 2008. I conducted a second study in the La Sals from 1 June 2008 to 9 August 2008 to investigate the effect of food removal on black bear activity. I established 22 sites along the northeast side of the mountains and used the same locations as 2007 whenever possible and the same methods of data collection. At treatment sites, however, instead of applying TBZ and camphor to bait during the treatment phase, I removed all food and cleaned bins thoroughly. Treatment sites remained un-baited for the remainder of the study. Each site was checked every other day throughout the study until 8-9 August 2008, when sites were dismantled.

I analyzed bear activity at sites (mean number of photographs/day and mean number of minutes spent at sites/day bears were present) between the baseline phase and treatment phase using a paired, two-sample t-test. Videos were analyzed to investigate differences in bear behavior between phases. Behaviors were placed in one of two categories: "bin access" or "no bin access". If a video showed a bear opening the bin and investigating the contents, it was placed in the "bin access" category. Otherwise, it was placed in the "no bin access" category. This included videos that showed bears sniffing the outside of the bin but not opening it, or ignoring the bin entirely. I tested the difference in the percent of videos showing "bin access" behavior between the two phases using a paired t-test.

RESULTS

Captive food trials. All bears consumed donuts in every food trial and bears entirely consumed donuts except for two treatment bears in 3 instances (Table 3-1). Bear 6 did not attempt to approach her food dish during treatment trial 1 and left 10 g of food unconsumed during treatment trial 3. Bear 5 did not consume 50 g of food during the post-treatment trial. Therefore, I concluded that taste aversion was not established because treated bears approached and consumed all food in the majority of the trials. I observed changes in behavior in some of the treated bears following some food trials. In some cases, treated bears ignored other routine food items, remained inactive for extended periods of time, and/or appeared ataxic and uncoordinated after consuming treated food. Evidence of malaise was not observed in control individuals, which remained mobile and consumed routine produce items as usual.

CTA field experiment, 2007. Food consumption (mean amount (g) food consumed/day bears visited site) and bear activity (mean number of photographs/day and mean number of minutes spent on camera at sites) in 2007 was similar at all sites (P=0.58, P=0.615, P=0.473, respectively) between the baseline phase and the treatment phase (Table 3-2). Activity at treatment sites was higher than activity at control sites during both phases; however the data show no effect due to treatment with TBZ and camphor, as bear activity was not reduced.

Food removal experiment, 2008. Bear activity (mean number of photographs/day) declined significantly in 2008 (P= 0.006) within one week of removing food from sites. Reduced levels of activity were sustained throughout the rest of the study (Table 3-3, Fig. 3-1, Fig. 3-2), but activity was not completely eliminated. The mean number of minutes bears spent on camera at sites per day bears were present also declined substantially (P= .058). Bear activity at control sites where food was still available remained at levels comparable to those during the baseline phase. Additionally, bear behavior at sites differed between the baseline and treatment phase. The percent of videos showing bears investigating the interior of the bin during baseline visits was far greater than during visits once food was removed (P =0.001, Fig. 3-3). During the baseline phase, bears immediately opened the bin to obtain food or stuck their head into the bin to investigate once they were at the site. However, during the treatment phase, these behaviors were rarely observed. Instead, bears only sniffed the exterior of the bin or the surrounding area, or ignored the bin completely.

DISCUSSION

Captive food trials. I did not establish conditioned taste aversion in captive bears using TBZ and a peppermint flavor cue. While there were 3 instances when bears did not fully consume their food, this was likely not due to food conditioning. All bears consumed 100% of their food without hesitation during all other trials. There are several reasons why this may have occurred. First, the thiabendazole dosage may not have been sufficient, especially for larger individuals. Garcia et al. (1974) point out that the strength of an aversion is related to the severity of the sickness. TBZ dosages ranged from 51-245 mg/kg. McCarthy and Seavoy (1994) assumed a dose of approximately 165 mg/kg body weight with free ranging black bears and successfully averted bears from treated peanut butter and honey baits. However, only two of the individuals I treated received this large of a dose, as I based my doses primarily on reports of successful aversive conditioning in black bears using smaller amounts of TBZ (Ternent and Garshelis 1999). I also provided bears larger boluses of food than in other studies. It is possible that a more effective dose is best achieved when introduced in smaller boluses of food.

While I did observe behavioral changes that suggested treated individuals were experiencing gastro-intestinal malaise following consumption of TBZ (lethargy and unwillingness to consume routine food items), other behaviors (ataxia) may have been attributed to neurological effects of the drug. Second, bears were not fed their normal ration of food during trial days until trials were completed. This was to minimize the possibility of satiation and to ensure bears would be motivated to consume food during trials. However, I typically conducted trials during mid-afternoon. It is possible that hunger prevailed over potential taste aversion effects, as it has been suggested that the strength of taste aversion can be reduced if subjects are in a state of food deprivation (Grote and Brown 1973).

Third, the flavor of peppermint or donuts may not have provided a sufficiently novel taste cue for taste aversion to be established. I assumed that peppermint was a novel flavor, however the captive bears had varied and unknown backgrounds and dietary histories. Therefore, it is possible that individuals may have been previously exposed to the flavors presented. Taste aversion is most effectively established when sickness is associated with a novel flavor. The more familiar the flavor, the less likely it is for an aversion to be established. Even one exposure to a food item can inhibit the effectiveness of learned CTA (Kalat and Rozin 1973, McCullough 1982). For example, Ralphs et al. (1997) tested the effects of familiarity with locoweed on taste aversion with cattle. Naïve cattle that had not previously been exposed to locoweed only required one treatment with lithium chloride to create a complete aversion, compared with three or four doses required to establish an aversion in cattle already familiar with locoweed.

Likewise, the stronger the flavor is, the more intense the learned aversion (Garcia et al. 1974). It is possible that the peppermint stimulus was not perceived as strong enough or that the variety of flavors in the donuts prevented bears from cueing into any specific flavor. In Joshua Tree National Park, food-conditioned coyotes that frequented campgrounds discontinued visits only after consuming a variety of food types that were treated with lithium chloride (Cornell and Cornelly 1979). Additionally, Dorrance and Gilbert (1977) suggest that a variety of flavors that may exist in a garbage can could create difficulty in establishing taste aversions, as individuals must cue in to one distinctive flavor.

The three instances where food was left unconsumed can be explained. In two instances, Bear 6 did not approach her food dish in the first treatment trial and left 10 g of food unconsumed during the last treatment trial. This outcome was likely influenced by the way in which she was secluded during trials. Bear 6 shared the main enclosure with three other individuals and they were rarely separated. However, it was necessary to seclude individuals during trials to prevent control animals from consuming treatment. During the first trial, Bear 6 began pacing along the enclosure once she was secluded and ignored her food dish. She, instead, focused on the animal care staff outside of the pen and appeared distracted throughout the trial. She displayed similar behavior during other trials, but only consumed food after approaching the food dish with hesitation several times while pacing. Wildlife Science Center staff felt that Bear 6 was not displaying her typical behavior and appeared anxious, probably due to her seclusion. The third instance when food was not fully consumed occurred during the post-treatment trial with Bear 5. While he was consuming the last pieces of food, he abruptly shifted his attention away from his food bowl to a deer fawn that was being rehabilitated at the facility when it passed by his enclosure. Thus, for the bears that did not consume treated food, it is most likely that confounding factors, rather than the treatment, were responsible for any apparent aversion.

CTA field experiment, 2007. I did not observe a difference in either food consumption or bear activity between control sites and treatment sites during the field experiment in 2007. I assumed 1) that treating human food sources with TBZ would induce gastro-intestinal illness following consumption and 2) that camphor was a novel flavor to bears. I used a standard dose of 10 g TBZ/300 g food at treatment sites since the bear population was free-ranging and my methods did not allow me to accommodate individual bear weights with TBZ doses. This amount of TBZ was similar to what

Ternent and Garshelis (1999) used, however it was less than what McCarthy and Seavoy (1994) effectively used in baits and, as in the captive experiment, it is possible that this was insufficient in producing severe gastrointestinal malaise required for CTA. Individual variation in responses to aversive conditioning methods, however, cannot be discounted. Polson (1983) reported that the effects of certain dosages of thiabendazole on food consumption in rats varied widely among individuals. The largest rats treated at 200 mg/kg TBZ showed a longer-lasting CTA to food items than did smaller rats at the same dose. Therefore, it is possible that similar doses may have different physiological effects on individuals. Additionally, Beckmann et al. (2004) reported wide variation in return rates for black bears that were exposed to a variety or combination of external negative stimuli.

It is also possible that bears could have consumed smaller amounts of food and doses of TBZ if they made repeated visits to one site to fully consume a bait supply before it was refilled. Visits to one site simultaneously by multiple bears, such as a sow and cubs, could likewise prevent any one individual from consuming an effective dose. There were several instances in remote camera videos where a sow and several cubs were observed consuming bait during a visit. This could have rendered the treatment ineffective. My methods did not allow me to accurately determine during which visits food was consumed or to track consumption by individual bears

The possibility that camphor was a familiar flavor to bears is low. Neither camphor nor any flavors resembling it are found in any natural food consumed by bears in the study site. It is also unlikely that bears were previously exposed to baked goods due to the remote nature of the field site and the limited availability of human food.

However, it is possible that the variety of flavors present in bait diminished the strength or distinctiveness of the camphor flavor and the strength of taste aversion. I also observed a peak in activity immediately following application of TBZ and camphor. It is likely that bears were responding to the unfamiliar smell of camphor and curiosity led to bears investigating sites. Naïve individuals not yet exposed to the TBZ could have contributed to continued activity levels and their visits may have masked a treatment effect, even if conditioned bears visited less frequently.

Since TBZ was not successful in removing the food resource and reducing bear visits, it was not an effective management tool. On the other hand, individuals who were exposed to treatment could have encountered other untreated, 'safe' sites where they experienced no negative consequences, thus reinforcing feeding behavior at sites and reducing the possibility of establishing CTA. McCullough (1982) states that this type of reinforcement can allow an individual to recover from any previous learning, even if reinforcement is infrequent. Additionally, just as an individual can learn that consumption of a particular food item will result in illness, the opposite is also true. An individual can learn that a food item is safe (Kalat and Rozin 1973) if repeated exposures do not result in any negative consequences.

Another reason why bears may have continued to visit sites is due to environmental conditions at the time. Biologists with the Utah Division of Wildlife indicated elevated levels of nuisance bear activity within the region during the same time I was conducting my study (G. Wallace, Utah Division of Wildlife, personal communication). This was attributed to bears likely expanding their movements in search of food in response to prolonged summer drought conditions that were present. I may have observed continued food consumption and visitation at treated sites in 2007 because natural foods were scarce.

Food removal experiment, 2008. Contrary to the outcome with using CTA methods in the field, eliminating food at field sites resulted in a significant and almost immediate decline in bear activity that persisted for the duration of the experiment in 2008, while bears continued to visit and consume food that was still available at control sites. This is an indicator that even a small resource (300 g) is considered important to bears, yet its removal can result in a substantial effect on activity. Multiple authors have suggested that reducing human food availability to bears is essential to alleviating bear-human conflicts (McCarthy and Seavoy 1994, Garner and Vaughn 1989, Graber 1989, Smith et al. 1989, MacHutchon and Wellwood 2002). However, while I observed a tremendous change in activity levels at sites where I removed food, I did not completely eliminate bear presence and investigation at sites. Bears in Yellowstone National Park were observed exploring campsites even when not attempting to obtain food (Skinner 1925). In McCarthy and Seavoy's study (1994), bears avoided boluses of peanut butter and honey that were treated with TBZ and suspended in garbage containers, but still continued to visit containers to consume other untainted food items. Ternent and Garshelis (1999) reported that the majority of the MRE contents presented to bears after treatment were avoided but not after bears bit into the MREs and rendered them unfit for human consumption. Bear activity still continued to be disruptive in areas where they previously acquired MREs. Additionally, Bacon (1980) observed that bears inherently possess varying levels of curiosity towards unfamiliar objects and suggested that failure to consider this may impede conflict-management efforts, despite eliminating food availability. In my study, bears would engage in seemingly playful activities with the bin during feeding bouts at trash bins, even after consuming food.

McCarthy and Seavoy (1994) suggest that, even with food removal, allowing nuisance bears to persist in a population may augment the problem, especially if young bears of food-conditioned adults are recruited into the same population, as cubs readily learn behaviors from their mothers (McCullough 1982, Mazur and Seher 2008). Mazur and Seher (2008) found that the type of area within which sows reared cubs (wild or developed) in Sequoia National Park highly influenced where their cubs would forage once they became independent. Of cubs that were reared in areas considered wild, 86% continued to forage in wild areas later. Likewise, 81% of cubs that were reared in developed areas continued to do so as independents. Thus, failure to remove problem individuals initially may not only perpetuate nuisance activity, but in-turn could necessitate the removal of additional individuals whom could have otherwise been spared (Meagher and Fowler 1989). While non-lethal methods are preferred, removing problem animals may still be necessary to extinguish existing problematic behaviors that will likely be difficult to modify with aversive techniques (Shivik 2006). It is also important to point out that while conflicts may be reduced, they will likely not be completely eliminated and various management techniques used alone, including food removal, may not solve the issue entirely.

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Table 3-1. Amount of donuts consumed (%) during trials, observed behavior and routine food consumed following trials, and assigned groups of captive black bears at The Wildlife Science Center, Minnesota, 2007.

	Control Group				Treatment Group		
	Individual	% donuts consumed	Observed behavior after trial[d]		Individual	% donuts consumed	Observed behavior after trial[d]
Treatment 1	Bear 1	100	Mobile, consumed routine food items	Treatment 1	[b]Bear 4	100	Immobile, only consumed lettuce
	Bear 2	100	Mobile, consumed routine food items		Bear 5	100	[c]N/A
	[a]Bear 3	100	Mobile, consumed routine food items		Bear 6	0	[c]N/A
Treatment 2	Bear 1	100	Mobile, consumed routine food items	Treatment 2	[b]Bear 4	100	Immobile ignored food items
	Bear 2	100	Mobile, consumed routine food items		Bear 5	100	Ataxic, uncoordinated only consumed lettuce
	[a]Bear 3	100	Mobile, consumed routine food items		Bear 6	100	[c]N/A
Treatment 3	Bear 1	100	[c]N/A	Treatment 3	[b]Bear 4	100	Immobile, only consumed watermelon
	Bear 2	100	Mobile, consumed routine food items		Bear 5	100	[c]N/A
	[a]Bear 3	100	[c]N/A		Bear 6	90	Mobile, only consumed watermelon
Post-treatment	Bear 1	100	[c]N/A	Post-treatment	[b]Bear 4	100	Mobile, consumed routine food items
	Bear 2	100	Mobile, consumed routine food items		Bear 5	95	Mobile, consumed routine food items
	[a]Bear 3	100	[c]N/A		Bear 6	100	Mobile, consumed routine food items

[a]Housed in enclosure in Linwood Township facility
[b]Housed in holding pen adjacent to enclosure at main WSC facility
[c]Bear was in den box and was not visible
[d]Following trials, bears were offered routine produce (lettuce, apples, watermelon, strawberries, melon)

Table 3-2. Food consumption and bear activity at control and treatment sites (n=12) during baseline and treatment phases in the La Sal Mountains, UT, 2007.

	Baseline phase		Treatment phase		Comparison		
	Control sites	Treatment sites	Control sites	Treatment sites	$d_{baseline}$[a]	$d_{treatment}$[a]	P-value
x amount of food consumed (g)[b]	300	253.75	251.56	241.56	-46.25	-10.00	0.58
SE	0	21.039	36.630	16.209			
x # bear photos/day	0.739	1.017	0.510	0.924	0.279	0.415	0.615
SE	0.231	0.332	0.146	0.237			
x # minutes spent at sites/day[c]	1.772	2.504	2.670	2.184	0.732	-0.486	0.473
SE	0.612	0.709	1.194	0.458			

[a]Mean difference scores of the control and treatment site pairs
[b]Only included data from days when bears were present to consume food. Sites receiving no bear visitation are excluded (n=8)
[c]Only included sites that had videos showing unobstructed views of the trash bin (n=9)

Table 3-3. Bear activity and bear behavior at control and treatment sites (n=11) during baseline and treatment phases in the La Sal Mountains, UT, 2008.

	Baseline phase		Treatment phase		Comparison		
	Control sites	Treatment sites	Control sites	Treatment sites	$d_{baseline}$[a]	$d_{treatment}$[a]	P-value
x # bear photos/day	0.575	0.565	0.623	0.161	-0.01	-0.462	0.006
SE	0.163	0.146	0.153	0.029			
x # minutes spent at sites/day	1.757	1.938	1.398	0.399	0.181	-1.00	0.058
SE	0.428	0.491	0.222	0.059			
x % videos where bears accessed bin[b]	74.267	69.783	74.577	33.297	-4.484	-41.280	0.001
SE	10.250	9.914	5.533	5.517			

[a]Mean difference scores of the control and treatment site pairs
[b]Only included sites receiving bear visits during both the baseline and treatment phases (n=9)

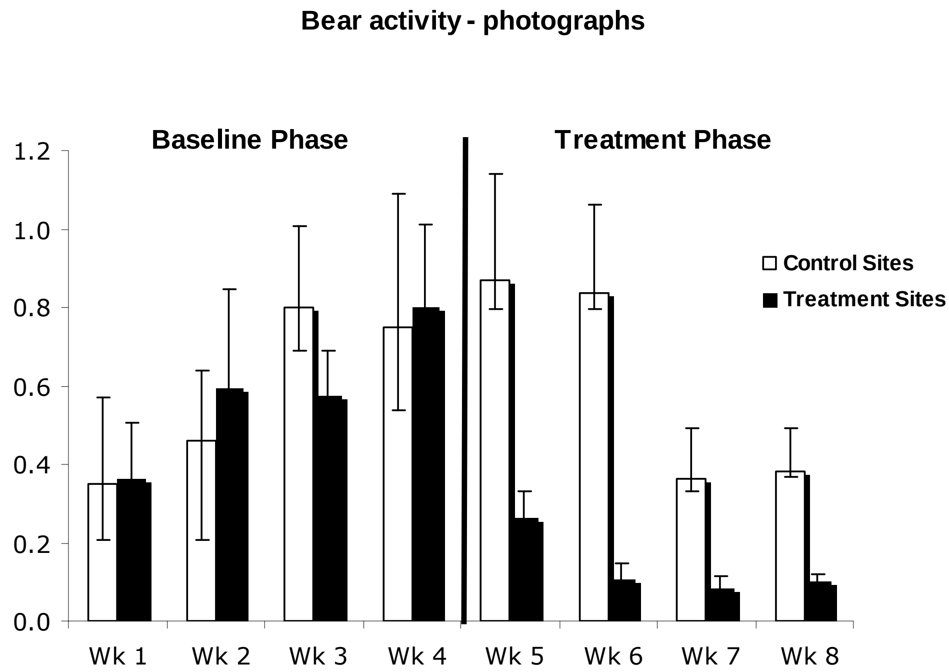

Fig. 3-1. Average number of bear photographs per day during each week of baseline and treatment phases in the La Sal Mountains, UT, 2008 (n=11).

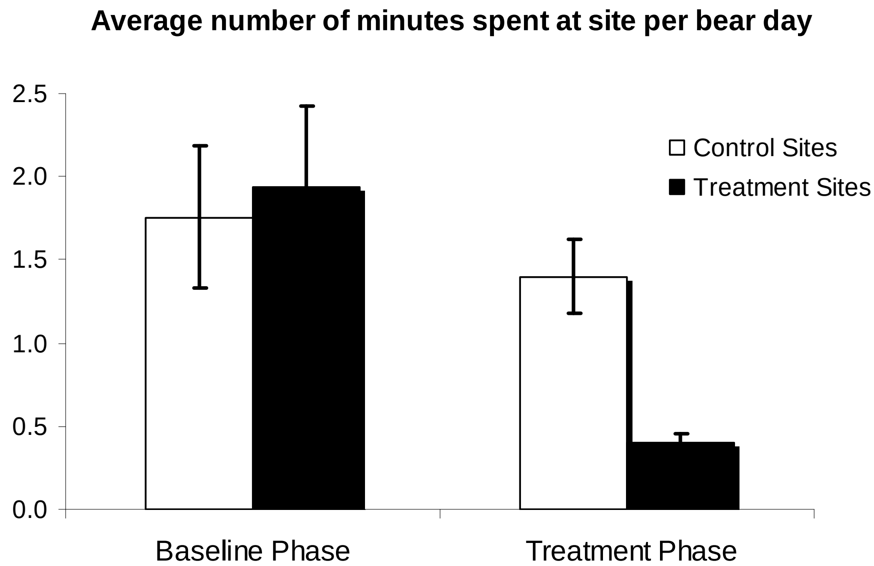

Fig. 3-2. Average number of minutes bears spent at sites (on camera) prior to and during food removal in the La Sal Mountains, UT, 2008 (n=11).

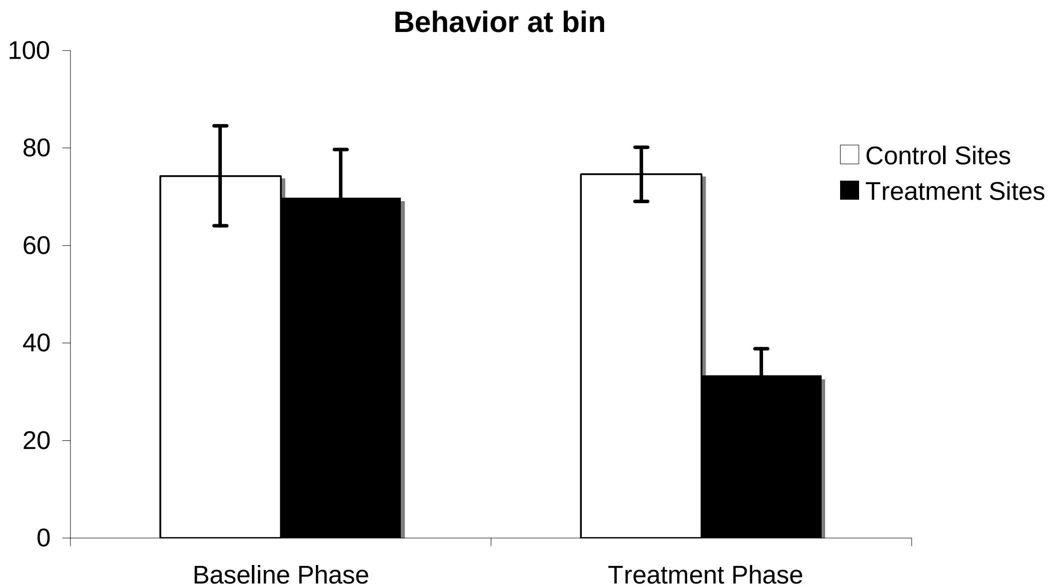

Fig. 3-3. Average percent of videos showing bears accessing bins prior to and during food removal in the La Sal Mountains, UT, 2008 (n=9).

CHAPTER 4

CONCLUSION

I was interested in testing whether taste aversion methods could successfully reduce food consumption and bear activity at sites where human food was available and whether food removal could reduce bear activity at sites. It is likely that my failure to achieve taste aversion in bears was a result of a combination of factors including insufficient conditioning due to visits by multiple bears, reinforcement at untreated sites, an insufficient TBZ dose, an ambiguous flavor cue, or heightened foraging activity in response to drought conditions. When applied under specific circumstances or to individual culprits, CTA can be a successful strategy to reduce or eliminate consumption of target food items (Ternent and Garshelis 1999, McCarthy and Seavoy 1994). However, it may be difficult to achieve success using taste aversion methods in a broad context when sites, rather than individuals, are treated. I established sites so as to simulate food availability in places such as campgrounds. In this type of field setting with free-ranging black bears, many uncontrollable factors can hinder managers from achieving successful conditioning. Additionally, any management technique, including aversive conditioning or food removal, must be rigorously implemented to maintain its effectiveness. McCullough (1982) states that learned behavior can quickly be unlearned if negative reinforcement is not encountered in the presence of the learned cue. It would be very difficult to maintain treatment with TBZ and a novel flavor at multiple campground areas, such as those found in large parks.

Implementing multiple management techniques in tandem will likely be most effective in resolving human-bear conflicts involving food-conditioned bears. Gilbert and Roy (1977) observed the most reduction in black bear damage at beeyards using a combination of electrified fencing and LiCl baits, compared with either method used alone. Therefore, managers should also consider using negative reinforcement in specific areas combined with taste aversion to increase the probability of reducing bear activity. There also is evidence that, following illness, some animals can establish aversions to places where food items were consumed. Ellins et al. (1983) reported that coyotes that were fed familiar food treated with LiCl in a novel place avoided the novel place when the same familiar food was present. However, these individuals would still consume the familiar food in places not associated with illness as well as consume other familiar foods not paired with illness in the novel place. This suggests that individuals did not form aversions to places exclusively, but rather associated illness with a food item with visual cues in the place where it was consumed. Bacon and Burghardt (1976) demonstrated that black bears have the ability to distinguish different shades of color. Therefore, while the utility of visual cues for conditioning bears to avoid an area has not been tested, it may be worthy of exploring. Using a combination of aversive stimuli to reduce bear damage to food sources may be successful in certain circumstances. However, eliminating the source of the problem - the availability of human refuse and food sources - appears to be a much more prudent and effective strategy.

Managers should also consider seasonal variation in natural food supplies and bear activity patterns to maximize the effectiveness of management strategies. Gunther et al. (2004) reported higher numbers of grizzly bear incidents with anthropogenic foods and property damage during times of poor natural food availability. A dramatic increase in human-bear conflicts also occurred after environmental conditions limited natural food availability to bears in Tennessee (Peine 2001).

In addition to implementing a variety of management techniques, extensive public education, people management, and incorporating stakeholder participation into each step of the conflict management process is crucial to successfully minimizing conflicts (Decker and Chase 1997, Peine 2001, McCarthy and Seavoy 1994, Huygens and Hayashi 1999, Beckmann et al. 2004). Management of human-bear conflicts involving anthropogenic food sources requires cooperation among state and federal wildlife agencies, law enforcement agencies, local community government, and the public (Peine 2001, Gunther and Hoekstra 1996, McCarthy and Seavoy 1994). It is essential that managers not only consider addressing behavioral modifications to nuisance animals, but to humans as well (Shivik 2004). All affected constituencies must share the responsibility for addressing human behavior modification, educating the public about conflicts, and improving human-waste containment practices in order to thoroughly address such conflicts (Barden et al. 1995, Decker and Chase 1997).

There is no single solution to resolving human-wildlife conflicts (Shivik 2004), especially conflicts that are a result of human food-conditioned bears. One management strategy or scheme that is successful in one area or in one context may not be successful elsewhere. Therefore, it is critical that a variety of techniques are used in the right context and in combination to alleviate conflicts.

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