Anthropogenic Influence on American Black Bear Diet in the Western Ozark Mountains in Eastern Oklahoma

Joseph P. Connor
School of Natural Sciences, University of Central Missouri, Warrensburg, MO 64093

Victoria L. Jackson
Department of Biology, University of Central Oklahoma, Edmond, OK 73034

Jennifer R. Mittelhauser
School of Natural Sciences, University of Central Missouri, Warrensburg, MO 64093

W. Sue Fairbanks
Department of Natural Resource Ecology and Management, Oklahoma State University, Stillwater, OK 74078

Abstract: American black bears (*Ursus americanus*) are returning to eastern Oklahoma from Arkansas, where they were re-introduced in the 1950s. This movement back into human-occupied areas can lead to conflict. Black bears are known to use anthropogenic food sources. To determine the extent of anthropogenic influence, we analyzed scat for anthropogenic food items. We collected 38 scat samples from 16 May 2014 through 17 October 2014 in the Ozark Plateau of Adair, Cherokee, and Sequoyah counties. Once collected, scat was dried for preservation. The samples were rehydrated and filtered for undigested items, which were categorized into 6 groups. We measured percent volume and percent frequency of occurrence of each item that was > 1% of the volume of the entire sample. The volumes of diet groups were significantly different (Kruskal-Wallis, $p < 0.001$) and were separated into 3 statistically distinct groups: Anthropogenic food > Reproductive plant parts > Animal matter, Herbage, Debris, and Unidentified (Tukey's Honest Significant Difference test, alpha = 0.05). There was no significant difference between the volumes of anthropogenic versus natural food (Mann Whitney U, $p = 0.368$). Though black bears will eat anthropogenic food sources if they encounter them, anthropogenic food sources do not make up a significant portion of their diet when compared against all natural forage.

Introduction

Human activity can affect wildlife populations in negative ways such as transportation of invasive species, over-harvest of species, habitat loss, and habitat fragmentation (Forester and Machlis 1996; Woodroffe 2000; McKinney 2001). Furthermore, human influence is changing specific animal behaviors, such as diet preference (Breck et al. 2009).

Food abundance and distribution can affect movements and behavior of mammals (Isbell et al. 1998), and often more so in carnivores (Jepsen et al. 2002). For some species, such as the raccoon (*Procyon lotor*), many of the effects of anthropogenic influence are positive, such as increased food supply through anthropogenic means and a decrease in natural predators (Prange et al. 2003). For other species, such as American black bears (*Ursus americanus)*, anthropogenic influence is almost always negative mainly due to the fragmentation of habitat and human-bear conflict (Mattson 1990). Conflict occurs when bears try to utilize anthropogenic food sources such as trash containers, gardens, orchards, apiaries, and corn (Merkle et al. 2013). This problem is exacerbated when humans purposely provide anthropogenic food sources to wildlife, such as deer feeders.

Understanding how wildlife populations expand to recolonize former habitats is important for management and conservation (Swenson et al. 1998). American black bears can be found in relative abundance within much of the northern U.S. but are rare in the southern states. However, bears are beginning to recolonize southern areas in the U.S., including Oklahoma. Black bears were extirpated from Oklahoma by 1915 but they were reintroduced in Arkansas in the 1950s and 1960s (Smith and Clark 1994). The population has expanded back into Oklahoma and southern Missouri (Bales et al. 2005). The southern population in Oklahoma, found in the Ouachita Mountains, is well established and growing (Pfander 2016). In 2009, the Oklahoma Department of Wildlife Conservation opened a black bear hunting season for the counties of Le Flore, McCurtain, Pushmataha, and Latimer. The east-central population in Adair, Cherokee, and Sequoyah counties is not yet self-sustaining and is not hunted (Lyda et al. 2016).

The east-central black bear population is recolonizing in an area that already has some human habitation, with 22,098 people in Adair County (14.8 people/km^2), 48,700 people in Cherokee County (24.2 people/km^2), and 41,294 people in Sequoyah County (22.3 people/km^2) (U.S. Census Bureau 2016). As these animals move in, they may begin to use anthropogenic food sources such as apiaries, deer feeders, orchards, and trash bins (Merkle et al. 2013). In Oklahoma, it is legal to bait deer and other wildlife on private land. Availability of this bait, usually corn, may have a major influence on the overall diet of the bears and other wildlife in the area. Bears have been known to break into cars if they think food is inside (Breck et al. 2009). Conflicts might also include predation on livestock, a problem that is on the rise in Colorado (Baruch-Mordo et al. 2008). Based on reports of depredation to the Colorado Department of Wildlife from 1979 to 2003, complaints of depredation by bears mostly involved sheep, but also included goats, chickens, pigs, and cows (Baruch-Mordo at al. 2008). Bears are more likely to seek out anthropogenic food sources when there is a shortage of natural forage (Clark et al. 2005). In West Virginia, from 1980-2004, black bear mortality increased in years when there was mast failure. These deaths were mainly due to road kills and landowners destroying bears that damaged property (Ryan et al. 2007).

American black bears require a variety of habitats that produce seasonal foods, as well as extensive and secluded areas for denning (Landers et al. 1979). Habitat selection by bears varies seasonally and is governed by presence of food (Clark et al. 1994; Fuller and Keith 1980). Though they are part of Order Carnivora, black bears are omnivorous. These animals prefer heavily wooded areas with mast species like oak (*Quercus* spp.), hickory (*Carya* spp.), and various species of berries (Benson and Chamberlain 2006). Black bears rarely hunt but have been known to take neonate ungulates (Schlegel 1976). When available, they will also eat carrion (Arner 1948).

In the fall, black bears prefer a greater proportion of natural foods due to the availability of hard mast such as acorns, hickory nuts, walnuts (*Juglans* spp.) and beechnuts (*Fagus* spp.) (Sara Lyda, [Oklahoma State University, Stillwater, Oklahoma], personal communication, [September 2013]). The hard mast species are still important in the spring when females emerge from their dens with cubs. Quantity and quality of acorns determines the quality and quantity of milk produced by sows (McDonald and Fuller 2005). Milk is high in fat (220 g/kg) and low in water (670 g/kg), helping altricial cubs to gain weight quickly during nursing (Oftedal et al. 1993).

Our research addressed the proportion of bear diet comprised of anthropogenic resources in the Ozark Plateau of eastern Oklahoma. We also determined the general composition of the diet based on scat analysis. Because of the availability of deer feeders, we predicted that anthropogenic foods would account for the greatest volume compared to natural foods.

Methods

As part of a larger project addressing population demography, both live capture and non-invasive genetic methods were used to identify individual bears. This project followed the American Society of Mammalogists (ASM) guidelines for the humane use of mammals (Sikes et al. 2011) and was approved by OSU's Institutional Animal Care and Use Committee (IACUC) under Protocol # AG-13-6.

The area of study was the Ozark Plateau in Adair, Cherokee, and Sequoyah counties in Oklahoma. From 1 May 2014 to 1 September 2014, average temperature for Cookson, OK, was 23.05 ˚C (73.5 ˚F) with a range of 1.1 -36.6 ˚C and the average precipitation was 0.28 cm/ per day (Oklahoma Climatological Survey 2015). Cookson, OK, is located in the eastern portion of the state and is 16 km from where these 3 counties intersect. Our study site was predominantly an oak-hickory forest with some pine associations (Duck and Fletcher 1943). In addition to the public wildlife management areas, much of the private land is used for wildlife management, though some landowners raise livestock as well (Sara Lyda [Oklahoma State University, Stillwater, Oklahoma] personal communication [August 2015]).

As part of the larger study, bears were lured into barrel traps with donuts and other baked goods. Corn was also set outside of traps. Traps were checked daily unless the forecast called for temperatures higher than 32.2 ˚C, in which case the doors were removed from the traps.

For scat analysis we followed the same methods as Greenleaf et al. (2009) and Graber (1981). From May through November 2014 we searched for scat near roads, trap sites, hair snares, natural forage areas, and potential trap sites. All samples were placed into zip-lock bags for storage. We recorded information about the scat such as: date collected, collector name, sample ID number, whether the sample was whole or partial, estimate of sample age, sample color, distance to anthropogenic food source, visible solid matter, UTM or latitude and longitude, county of collection, canopy cover, and a description of the collection site. Samples were considered partial if only a small amount of scat was collected or if the sample collected consisted of 2 or more scats and could not be separated. The partial samples were not included in the volume and frequency analysis because they do not represent a single whole sample. Samples were removed from bags later that day and dried by heat lamp to preserve for future analysis. In October 2014, we began rehydrating the samples. Samples were placed into a rubber tub with enough water and Dawn™ dish soap to submerge the samples and then were left to soak for approximately 1 hour (Graber 1981; Greenleaf et al. 2009). The Dawn™ dish soap served as a surfactant to lower the surface tension of the water. This was important to not only break up the scat, but also so particles could not stay dry by floating on the water's surface. We then washed the samples through a series of sieves (0.4 mm and 1 mm, H & C Sieving systems, Models 6998 and 7003, Columbia, Maryland, USA) to separate particles to equal size and remove any unwanted matrix. Food items were identified macroscopically as well as with a dissecting microscope. The identified items were then placed in film containers for storage. We categorized the items into 6 forage groups: anthropogenic food (corn), reproductive plant parts (fruit, seeds, and flowers), herbage (roots, stems, and leaves), animal matter (bones, hair, and insect parts), debris (rocks, wood, bark, and pine needles), and unidentifiable matter.

We identified all matter to species when possible. Insects were identified to class due to time constraints. To identify all plant material, we used *Field Guide to Oklahoma Plants* (Tyrl et al. 2002) and the United States Department of Agriculture Plant Database (USDA NRCS 2015). Many of the dietary items, such as a majority of the grass specimens, were too degraded to identify further than family. The majority of seeds were keyed to species. Bone fragments were identified to species, genus, or family. The other fragments were labeled as large animal bones or unknown bones. We then measured percent volume and percent frequency of occurrence of each food item in scat samples that were > 1% of the volume of a sample (Graber 1981; Graber and White 1983, Greenleaf et al. 2009). We measured percent volume of the 6 classes using water displacement to the nearest 1%. Volumetric analysis tends to overestimate the amount of herbage and underestimate easily digested items such as reproductive plant parts like blackberries and animal tissue (Hatler 1972; Mealey 1980; Graber 1981). To attempt to more accurately assess dietary habits, we also calculated the percent frequency of occurrence of food items as the percent of total scat samples in which an item composed at least 1% of the volume of a sample (Graber 1981; Graber and White 1983; Greenleaf et al. 2009).

All scat that resembled bear scat was collected. Bear scat is variable in shape and is based on what the bear has eaten. If the animal has eaten more berries, the scat is more globular and not as solid. If the scat is more herbage or animal matter, the sample is more tubular and solid. Size is also variable depending on the size of the animal. Coyotes are omnivorous and eat many of the same kinds of soft mast such as blackberries, black cherries, and persimmons (McVey et al. 2013), and their scat can look similar. Bear scat is more variable in shape, but tubular scats are common. Coyote scat is tubular and of a size similar to a small bear. This is a potential source of error.

The Mann-Whitney U test, a non-parametric 2-tailed test (Zar 2009), was used to compare the volume of anthropogenic food items to the volume of natural food items. We also used the Mann-Whitney U test to compare food amounts from possible coyote scat against known bear scats. Using SPSS (2009), we also compared the volumetric amounts of the 6 diet groups against each other using the Kruskal-Wallis One-way Analysis of Variance, incorporating Tukey's Honest Significant Difference (HSD) post hoc test (Zar 2009). This test was used for further analysis after running an ANOVA or Kruskal-Wallis test and it was used to determine which groups in the sample were significantly different. The alpha level for tests was set at 0.05.

Results

The majority of scat samples were found in Cherokee and Sequoyah counties with only 1 whole sample collected in Adair County. Six samples were found in or near bear traps, 5 samples were found near blackberry (*Rubus* spp.) patches, and 11 samples were collected near deer feeders. An estimated 306 hours were spent searching for scat samples.

From 16 May through 17 October 2014, a total of 38 whole samples and 2 partial samples were collected from 24 sites (8 samples in May, 8 samples in June, 16 samples in July, 5 samples in August, and 1 sample in October). The volume of each sample after being washed through the sieves ranged from 0.9 mL to 117 mL with an average volume of 35.3 mL per sample. There were 28 different dietary items collected from the scat. There were 12 samples of the 38 collected that could have been small bear or coyote based on size, shape, and contents. We used the Mann Whitney U test to compare these scat samples to the rest of the samples that resembled only bear, based on the volumetric amounts of each of the 6 food categories. These samples were found to be significantly different and they were excluded from further analyses (Mann Whitney U test, P=0.046).

Items in the anthropogenic category were the most abundant item in terms of volume (Table 1). However, anthropogenic food items ranked second in frequency of occurrence in scat samples collected. The only anthropogenic item identified was corn (*Zea mays*).

The next most abundant food category was the reproductive plant parts (Table 1). Reproductive plant parts were found most frequently in samples collected. Blackberry seeds, black cherry seeds (*Prunus serotina*), wild rye (*Elymus* spp.) inflorescence were the most abundant.

The majority of animal matter found was insect parts, primarily ant and bee exoskeletons. White-tailed deer (*Odocoileus virginianus*) hair was found and Leporid and *Microtus* bones were also present, but in small amounts.

Herbage was not very abundant in terms of volume but was abundant in terms of frequency. Blackberry leaves were the most abundant in this category. The next most abundant category was unidentified grasses. Some of the grasses identified were panic grass (*Panicum* spp.), blue stem (*Andropogon* spp.), and wheatgrass (*Agropyron* spp.).

Debris was present in most scat samples. This category consisted of small rocks, bark, wood chips, and pine needles. Unidentifiable matter made up a very small portion and consisted of anything that was too decomposed to be identified.

The volume of anthropogenic food in scats did not differ from the volume of natural food (Mann Whitney U test, $P = 0.368$, $N=26$). By comparing median ranks by ranking food categories by volume in all samples, the 6 diet groups were significantly different (Kruskal-Wallis, $P < 0.001$) and were separated into 3 statistically distinct groups: Anthropogenic food > Reproductive plant parts > Animal matter = Herbage = Debris = Unidentified (Tukey's Honest Significant Difference test, alpha = 0.05).

Discussion

The anthropogenic food identified in the scat from bears in our study was corn most likely obtained from deer feeders rather than cropland. Many of the landowners manage and/or hunt deer over bait, and they do so with deer feeders. Bear-human conflict arises when the bears destroy feeders or break into the feeders. Landowners try to deter bears from breaking into the deer feeders using several methods such as raising feeders far off the ground by cables. Many times bears are still able to breach the container and obtain the corn. Despite the frequency of deer feeders on the landscape, the abundance of corn in scat may be biased by the fact that corn was used to attract bears to trap sites, and some samples were collected near trap sites. However, bears would have to be at the trap site long enough for corn ingested at the trap site to pass through the digestive system for this to bias our results.

Reproductive plant parts were also very abundant due to the fact that blackberries and black cherries begin producing mast throughout April-May (Tyrl et al. 2002). These plants are common and attractive to wildlife. Seeds and berries are common in the diet of brown bears (*Ursus arctos*) and black bears (Graber and White 1983). In Washington, berries are a major part of the bears' diet (Lindzey and Meslow 1977).

Animal matter was somewhat common. Though the amount of animal matter by volume was not very large, animal remains were frequently found. The majority of this was insect parts. Bears frequently eat ants (Chatelain 1950; Hatler 1972; Beeman and Pelton 1980) and wasps (Hatler 1972; Boyer 1976; Beeman and Pelton 1980). The majority of insects identified were ants but there were also bee and wasp remains. Bears could have been seeking out ants or they could have ingested the ants with food items picked up from the ground. White-tailed deer hair wasn't very prevalent (volume or frequency) in the scat samples. The seasonal abundance of soft mast in the environment could attract bears more so than cervid remains, making animal tissue less prevalent in scat samples. Cervid remains in black bear scat usually represent carrion and juveniles (Schwartz and Mitchell 1945; Tisch 1961; Hatler 1972), but black bears are capable of preying on adult white-tailed deer (Svoboda et al. 2011).

Herbage was not a major component in volume and frequency in the samples. We believe this is because of the time of the year the scats were collected. Graber and White (1983) determined the amount of herbage decreases from spring to fall. Herbage is a very important dietary item in the spring, and it can make up

Table 1 Contents of American black bear scat collected in Adair, Cherokee, and Sequoyah counties, May through November 2014. N=26

Food Resource	Volume	Frequency
Anthropogenic	**54.4%**	**61.2%**
Corn	54.4%	61.2%
Reproductive Plant Parts	**32.3%**	**69.2%**
Blackberry	26.2%	34.6%
Black Cherry	1.6%	15.4%
Wild Rye	3.7%	19.2%
Animal Matter	**4.2%**	**69.2%**
Insect	2.4%	61.5%
Deer hair	1.2%	11.5%
Herbage	**2.4%**	**46.2%**
Blackberry leaves	0.9%	15.4%
Grass	0.4%	15.4%
Bluestem grass	0.4%	3.9%
Debris	**6%**	**80.8%**
Unidentifiable	**0.8%**	**15.4%**

about half of their diet (Piekielek and Burton 1975; Boyer 1976; Eagle 1979). Our first sample was not collected until May, so herbage may be underrepresented because the ripening of some berry species may have already attracted the bears away from herbage.

This study was limited in terms of scat collection and therefore was not a complete representation of the bear diet in this region. Our findings cover only a few months out of the year, and more extensive sampling would be needed to determine spring and fall diet more completely. However, our results do give a first impression of the importance of various foods in black bear diets in eastern Oklahoma.

There is a possibility that multiple samples were collected from a single bear. Elfström et al. (2013) examined gut retention time (GRT) with captive brown bears and found GRT to be 5 h 47 min with berry diets and 14 h and 30 min with meat diets. They also found that activity rate does not affect GRT. There were 3 days when multiple samples were collected from a single site. Although cameras often indicated more than one bear visiting the trap sites in a 24-h period, our samples should not be considered independent.

Similar diet studies have been conducted in Yosemite Valley in Yosemite National Park, California (Graber 1981; Greenleaf et al. 2009). In Yosemite, bears have a large variety of anthropogenic food due to a large number of campers, hikers, and other tourists bringing food to the park. Anthropogenic sources are abundant in the form of trash containers, campsites, and vehicles (Breck et al 2009.) The bears in our study area may not have access to the same concentration of anthropogenic food, but their habits are still affected.

Corn, an anthropogenic food source, accounted for a substantial portion of the black bear diet in the Ozark area of eastern Oklahoma.

This could mean bears are searching out corn over natural food sources or that deer feeders are abundant and bears use them as encountered. If bears are searching for deer feeders, this may lead to conflict, which can contribute to conflict between humans and bears.

This study showed that bear diet in the Oklahoma Ozarks area was affected by the availability of anthropogenic food resources. The bear population in this area is expanding into a human-dominated landscape, which increases the likelihood of conflict. With this knowledge, public education about living with bears and ways to reduce human-bear conflict can be directed toward the specific issues in this region.

Acknowledgments

We would like to thank Sara Lyda (senior research associate, Oklahoma State University) along with ODWC and OSU for the opportunity and equipment to conduct this research. Thanks to Emily Artz, Brittany Hoback, Colby Farquhar, Curt Allen, Jessica Mitcham, Licelle Vicenzio, Laurie Luckritz, Kyle Wilgers, Randy Kramer, Robin Bowin, Kay Bowin, Barb Lynn, Dr. Stefan Cairns, and Schuyler Greenleaf for all their assistance.

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Submitted September 10, 2018 Accepted November 6, 2018