

SEASONAL VARIATION IN THE DAILY ACTIVITIES AND TIME BUDGETS OF
THE AMERICAN BLACK BEAR, *URSUS AMERICANUS*,
IN BIG BEND NATIONAL PARK, TEXAS

A Thesis
Presented to the
School of Arts and Sciences
Sul Ross State University

In Partial Fulfillment
Of the Requirements for the Degree
Master of Science

by
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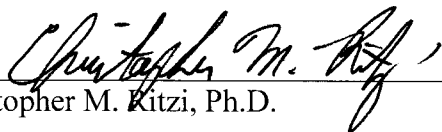
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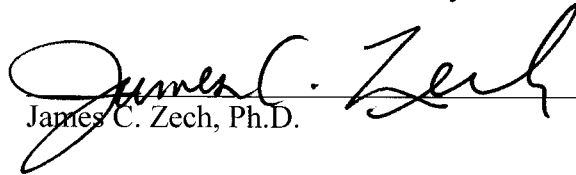
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ABSTRACT

Behavioral observations are rarely conducted in the field with large carnivores due to their normally cryptic nature, but habituation to humans provided the opportunity to study the daily activities and time budgets of American black bears (*Ursus americanus*) in Big Bend National Park, Texas. Black bears have only recently returned to Big Bend National Park after being extirpated from the region at the turn of the century, and although radio telemetry and food analysis studies have been conducted on this population, no extensive observational data have been collected and analyzed.

The objectives of this study were to determine if behavior differs based on demographic factors and/or seasons. Field observations were conducted, and visitor observations were also utilized for this study. It was predicted that feeding times would increase as the winter season arrived and that adults without offspring would travel further and more often than sows with juvenile cubs. Visitor observations found no significant variation in seasonal behaviors or demographic factors, but a significant difference was noted between behaviors in spring and summer, as well as between juvenile and adult bears and between juvenile and yearling bears in field observations.

Traveling was the most frequently observed activity in both field and visitor observations, while social and drinking activities were the least-frequent behaviors in both data sets. Observer-directed behaviors were sighted much more often in visitor observations than in field observations. This is probably the result of the attempt to reduce observer-directed behaviors in field observations, while instructions from the park employees to visitors are to scare away bears they come into contact with.

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CHAPTER I

INTRODUCTION

In the 1800s, black bears (*Ursus americanus*) occurred throughout Texas but unregulated hunting, habitat loss, and predator control caused a drastic decline in bear populations (Schmidly, 1977; Rice et al., 2007). In the 1940s, American black bears were common in the Chisos Mountains, which are now part of Big Bend National Park (BBNP). By the time the park was created in 1944, bears had been hunted to extremely low levels, and sightings were rare (McClinton, et al., 1992; Onorato et al, 2003; Mitchell et al., 2005). In 1987, the black bear was classified as an endangered species in Texas (McClinton, et al., 1992; Hellgren, 1993). As a result of emigration from Mexico, the population in BBNP began to rebound in the 1980s. According to the National Park Service, a female probably emigrated from the Sierra del Carmen in Coahuila, Mexico, and established a territory in the Chisos Mountains, with males most likely following (Skiles, 1995). Since then the population of black bears in BBNP has grown to approximately 18-22 adults, with the park being estimated to potentially support 25-30 adults (Mitchell et al., 2005).

The bears in BBNP are considered part of a metapopulation, defined as a set of local populations within some larger area where, typically, movement from one local population to at least some other patches is possible (Hellgren et al., 2005). Because the Chisos Mountains are isolated from other ranges, they are considered a “sky island,” surrounded by a sea of relatively inhospitable desert (Hanski and Simberloff, 1997; Onorato et al., 2003). The Chisos Mountains and other ranges in the Trans-Pecos provide pockets of suitable habitat for black bears to travel throughout the matrix of

islands, but range expansion is slow because the islands are geographically widespread (Hellgren et al., 2005; Mitchell et al., 2005; Onorato et al., 2007). The Sierra del Carmen range, a much larger mountain range than the Chisos and most likely the source population of black bears for BBNP, contains similar habitat of oak, juniper, and pine woodlands on which bears depend for food and shelter. Black bears have also been noted in the Dead Horse Mountains, which are geologically part of the Sierra del Carmens, but are separated by Boquillas Canyon and the Río Grande. Other bear sightings have occurred in the Del Norte, Guadalupe, Glass, and Davis Mountains (Skiles, 1995; Rice et al., 2007).

BEAR RESEARCH BACKGROUND

Worldwide, bear research is conducted using a variety of methodologies, including motion-sensitive radio collars (Knight et al., 1988; Blanchard and Knight, 1990 and 1991; McKinney and Delgadillo Villalobos, 2003; Paisley and Garshelis, 2006; Hwang and Garshelis, 2007), population modeling (Knight and Eberhardt, 1985; Eberhardt and Blanchard, 1986; Mattson and Reid, 1991), and Global Positioning System (GPS) collars equipped with activity loggers to analyze variation in habitat selection (Moe et al., 2007). Black bears in North America have been well studied using many of these methodologies, including remote photography (Bridges et al., 2004), GPS collaring (Obbard et al., 1998), and radio collaring (Garshelis and Pelton, 1980; Schwartz and Franzmann, 1992; Chaulk et al., 2005; Mitchell et al., 2005; Telesco and Van Manen, 2006). These methods are most commonly employed to study black bears because they are non-invasive techniques useful for collecting life history data. These

methods have been successful in determining population densities, travel patterns, and home ranges, but little is known about the daily activity and time budgets of black bears.

Wild animals will not typically continue their normal activities in the presence of an observer, although habituation is possible. Habituation is defined as the point at which animals cease to alter their behavior in the presence of human observers (Strier, 2007). Other species have been extensively studied using habituation techniques, including primates (Majolo and Koyama, 2006; Prates and Bicca-Marques, 2008), elephants (Shannon et al., 2008), and birds (Allison and Destefano, 2006; Carro and Fernandez, 2008). However, this is an uncommon technique for studying black bears owing to their normally cryptic behavior. Some studies reported successfully habituating black bears by associating food with the presence of researchers (Rogers and Wilker, 1990; DeBruyn, 2001). After bears became habituated to human presence, feeding ceased and the bears continued to allow the researchers to observe them. However, bears often become overly habituated to humans and develop into nuisance animals. Nuisance bears are typically found in campgrounds, towns, or garbage dumps where the animals learn to associate humans with food. These bears are often relocated or euthanized to prevent further interactions with humans (Witmer and Whittaker, 2001). Relocation or euthanasia is necessary because bears that have acquired nuisance behavior may teach it to other individuals, particularly their young, promoting deleterious bear-human interactions (Skiles, 1995; Mazur and Seher, 2008).

There are several benefits to studying habituated black bears. Observation of feeding behaviors has increased knowledge of bear diets by allowing observers to view items that are normally completely digested by bears, such as caterpillars and succulent

plants. Similarly, observation of habituated black bears allowed researchers to confirm that bears will hunt opportunistically since it was once unknown whether animal parts found in bear scat had been hunted or scavenged (Rogers, 1993).

BEARS IN BIG BEND NATIONAL PARK

In BBNP, black bears have become habituated to humans and appear to continue normal behavior. Initially, actions to prevent habituation did not occur fast enough, and bears in the early 1990s learned to obtain food from humans. These issues were quickly resolved, and problem behavior no longer accompanies habituation. Soon after bears recolonized the park, bear-proof garbage cans and food storage boxes were placed in campgrounds to avoid attracting bears to these areas (Skiles, 1995). Because bears in BBNP are now habituated to humans, direct observations are possible and provide a unique opportunity to quantify time budgets for these large mammals.

The objective of this study is to quantify time budgets of black bear in relation to demographics and seasonal variation. It was hypothesized that 1) daily movements of bears vary by gender and reproductive condition, and 2) foraging time varies by season. Based on these hypotheses, the following predictions were made: 1) solitary adults travel farther and more often than sows and juveniles, and 2) feeding time increases for all individuals in late summer, as fat reserves are increased in preparation for winter dormancy.

STUDY AREA

Big Bend National Park is located approximately 122 km south of Alpine, in southern Brewster County, Texas (Fig. 1). The park consists of 324,291 ha in the

Chihuahuan Desert, with elevations ranging from 563 m to 2,385 m. This study focused on the Chisos Mountain Basin (Fig. 2), hereafter referred to as Chisos Basin (29° 15'N, 103° 15'W). The Chisos Basin and surrounding mountains are the primary habitat of bears in BBNP because of abundant food resources such as oak (*Quercus grisea*, *Q. emoryi*, *Q. gravesii*, *Q. intricata*, *Q. pungens* var. *vaseyana*, *Q. gambelii*, *Q. muhlenbergii*, *Q. graciliformes*, and *Q. tardifolia*), juniper (*Juniperus deppeana*, *J. flaccida*, and *J. erythrocarpa*), madrone (*Arbutus xalapensis*), Texas persimmon (*Diospyros texana*), and several species of *Opuntia* (Wauer, 1996; Onorato et al., 2007). Temperatures vary with elevation, ranging from -5 to 22°C in winter and 13 to 43°C in summer. Annual precipitation is highly variable and ranges from 5.0 to 50.0 cm (Mitchell et al., 2005), with a mean annual precipitation of 30.5 cm (Onorato et al., 2003).

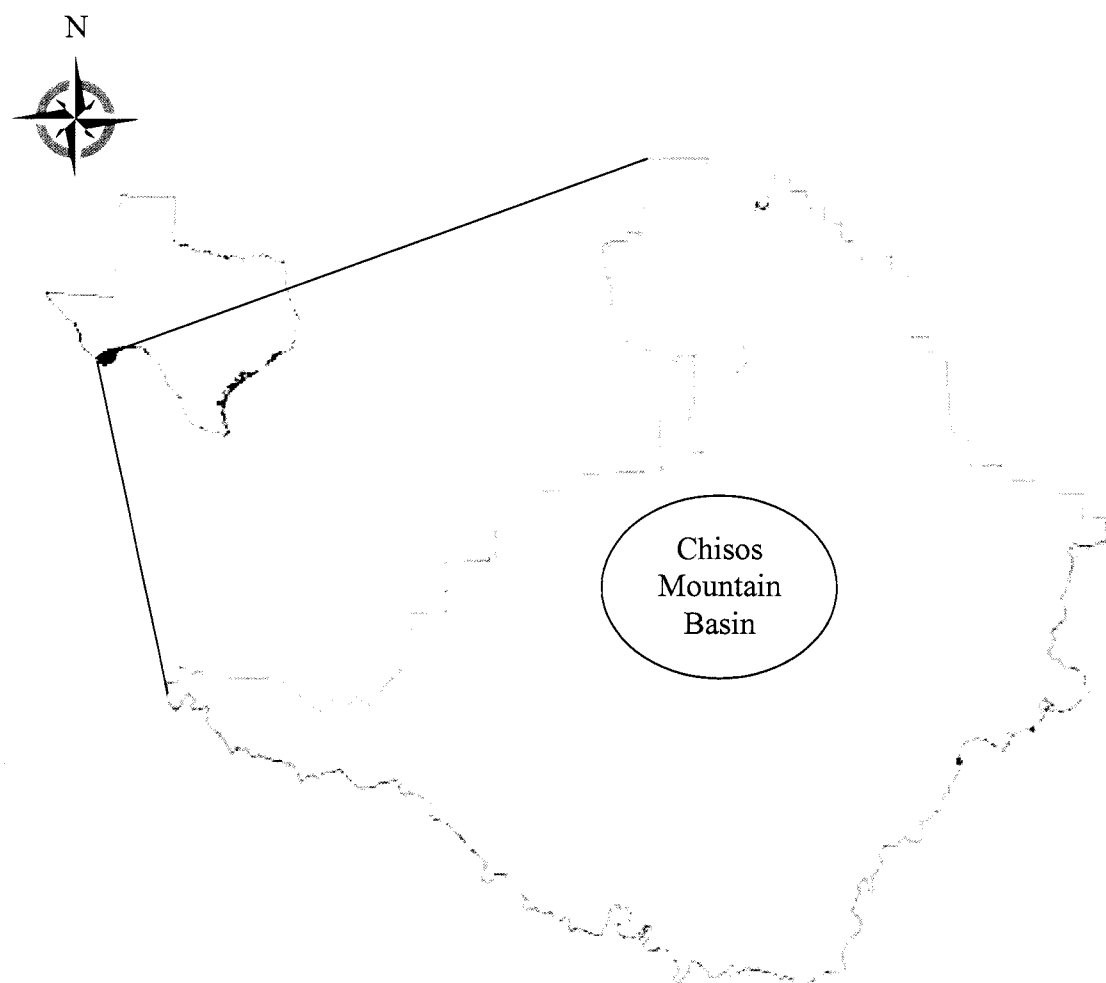


FIG. 1--State of Texas showing Big Bend National Park and location of Chisos Mountain Basin within the park (Map modified from www.nsp.gov).

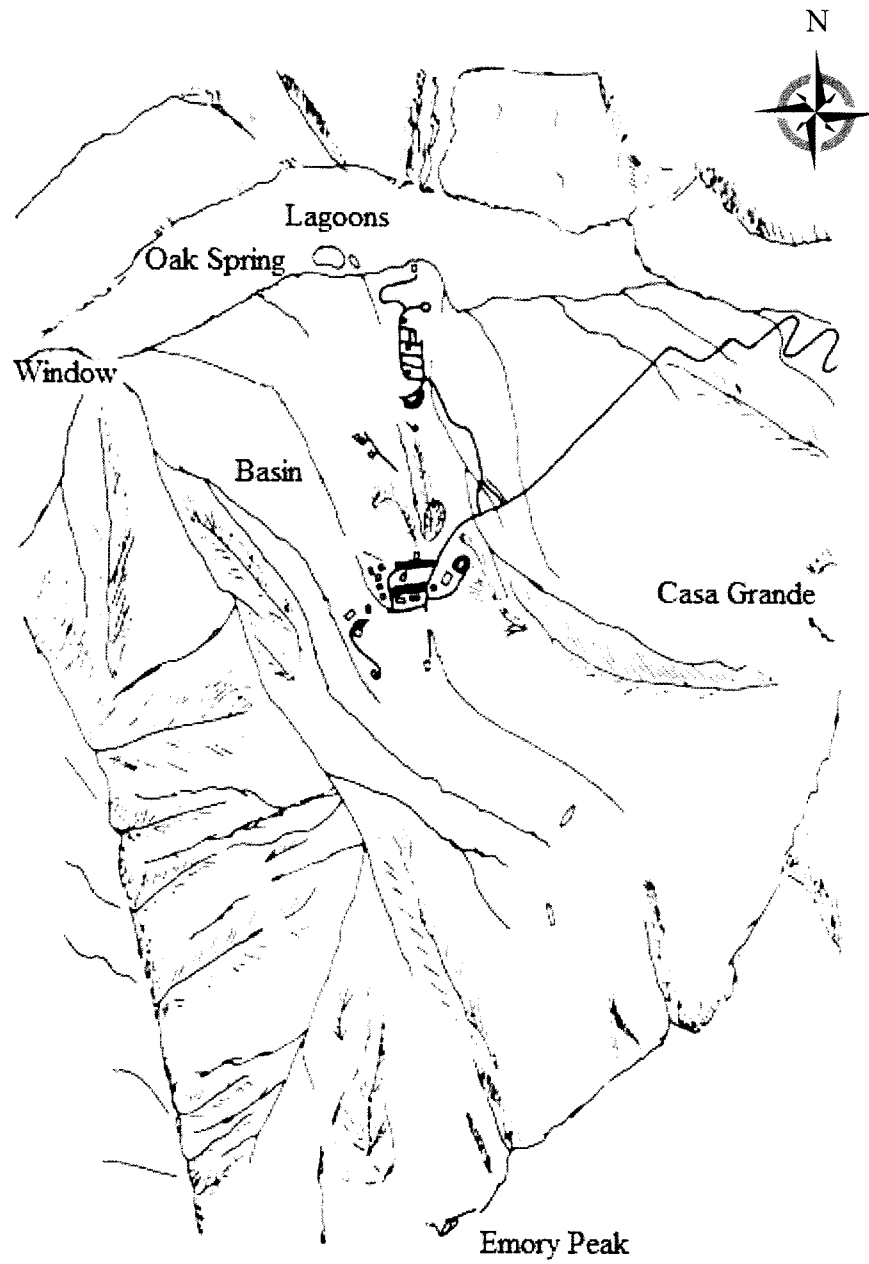


FIG. 2--The Chisos Mountain Basin in Big Bend National Park. Map not to scale (modified from www.nps.gov).

CHAPTER II

METHODS AND MATERIALS

Observational methods were used to collect data on black bears. Because no bears were collared and their day-to-day locations were unknown, searches for bears were based on reports of sightings and the map maintained in the Chisos Basin Visitor Center indicating the most recent locations of bear sightings. This technique helped delineate potential search areas where there was a high likelihood of finding bears.

DATA COLLECTION

Because this study was the first of its kind in this area, observations began in April 2009, as bears emerged from dormancy, and continued until bears entered winter dormancy in December 2009. Bears were observed with binoculars at a distance of no closer than 30 meters from the animal to decrease the amount of disturbance that could alter activity (Rogers and Wilker, 1990). Bears were classified as adults of unidentified sex, sows (females with young), juveniles (in close contact with sow), and yearlings (young that have left the sow). Sampling effort in the Chisos Basin was not uniform because previous observations had determined that bears appear to frequent only certain areas in the basin and surrounding mountains.

Following Altmann (1974), observations of bears took place in 10-minute periods, with continuous observation of the individual from the time it was located until sundown or until the individual was lost from sight and could no longer be relocated for that 10-minute study period. If the animal was recovered, the data were used only if more than two-thirds of the observation time was recorded. If the animal was out of sight for one-

third of the time or more, the study period was not recorded. When a family group was sighted, the first individual to be selected for observation was the one farthest to the observer's left side. Continuous sampling was conducted for ten minutes before switching to the next closest individual for another 10-minute session, always working towards the farthest-right subject of the group. Behaviors recorded were feeding, drinking, resting (none to slight movement), traveling (with speed and direction), observer-directed behavior (grunting or charging toward observer or discontinuation of previous task), social behavior (two or more individuals touching or communicating vocally), and others, as observed. Because there is thought to be a fairly small population of adult bears in BBNP (Skiles, 1995), repeated observation of the same individual was inevitable, making pseudoreplication unavoidable. Animals could not be individually distinguished; therefore sampling bias could exist if one individual engaged in a particular activity more frequently than others.

Visitor observations were also used to investigate bear behavior in BBNP. The park maintains an extensive collection of observation cards based on visitor sightings of bears and mountain lions. This collection contains records from 1901 to the present, first using historical journals and then continued with observation cards as they became standard practice. Visitors record sighting locations and information such as limited behavioral observations and approximate age-class or size of the bear. Because visitor observations vary, attempts were made to minimize potential bias. Because visitors are not always able to age bears reliably, assumptions must be made based on the limited descriptions often provided. For example, if an observation card described two cubs, the assumption was made that those bears were in fact yearlings that have moved away from

the sow, because a sow was not mentioned in the observation. This is considered a safe assumption because many park visitors fail to realize that black bears are somewhat smaller than other Ursids and assume that yearlings are cubs based on individual body size. Visitor observations were categorized using the same methods as field observations. If multiple observations were described in a single record, the first behavioral activity was recorded. This was done because the first observation was most likely the activity that the bear was engaged in before the visitor approached it. Although there are limitations inherent in the data set, visitor observations are invaluable because observations were made throughout the Chisos Basin, allowing for a more extensive data set due to the increased number of observers.

STATISTICAL ANALYSIS

Bears were active throughout the year, but many visitor observations did not identify the sex or approximate age of the animal. In these cases data were pooled, and animals were not assigned to a particular sex or age class in order to minimize assumptions regarding demographics. Similarly, as visitor observations were specific events rather than timed intervals, a family group was broken down so that the sow and each juvenile could be described individually, based on the description provided. Bears indicated as adults or yearlings were classified as such.

Data were first tested for normality using a Levene's Test. If the data met the assumptions of normality, an Analysis of Variance (ANOVA) was used to compare activities by age class and season (Zar, 1999). If Levene's Test indicated that the data failed to meet the assumptions of normality, a non-parametric Kruskal-Wallis test was

used to make comparisons. If significant differences were indicated, Bonferroni's Test was used in SPSS Statistics 17.0 to make pairwise comparisons (Zar, 1999). Field observations were analyzed independently from visitor records, although similar statistical procedures were followed. Results were considered significant at $p \leq 0.05$.

CHAPTER III

RESULTS

During 2009, 300.0 hours were spent in the field collecting 6.6 hours of observational data, and 827 observations were obtained from visitor records maintained by the National Park Service. Days spent in the field were limited to long-weekend trips lasting from Friday to Sunday or Monday. This limited amount of time available in the field, along with extended periods of little bear activity in BBNP, resulted in only 6.6 hours of collected field observations.

FIELD OBSERVATIONS

Of the 6.6 hours of observational data, 1.3 hours, 0.5 hours, and 4.8 hours were collected in the spring, summer, and fall, respectively. Although searches were attempted during the winter, no bears were sighted. Field observations of black bear behaviors in BBNP consisted mainly of travel and feeding; drinking and social behaviors were not observed. Observer-directed behaviors were observed more frequently than resting or other behaviors but constituted a relatively low percentage of total activity (Table 1).

Adults of undetermined sex were observed throughout the spring; no other sex or age class was encountered during this period. This precluded comparisons among demographic groups but still permitted comparisons of seasonal changes in behavior throughout the year among adult bears (Fig. 3).

TABLE 1--Field observations (minutes with percent of total activity in parentheses) of black bear behaviors in Big Bend National Park by season (January-December 2009). Bears were not observed in winter.

	Drinking	Feeding	Observer-Directed	Other	Resting	Social	Travel	Total
Spring	0.0	4.0 (5.2%)	10.0 (13.0%)	3.0 (3.9%)	16.0 (20.8%)	0.0	44.0 (57.1%)	77.0 (100%)
Summer	0.0	0.0	0.0	0.0	0.0	0.0	30.0 (100%)	30.0 (100%)
Fall	0.0	237.0 (82.6%)	20.5 (7.2%)	8.5 (3.0%)	2.0 (0.7%)	0.0	18.5 (6.5%)	286.5 (100%)
Total	0.0	241.0 (61.3%)	30.5 (7.7%)	11.5 (2.9%)	18.0 (4.6%)	0.0	92.5 (23.5%)	393.5 (100%)

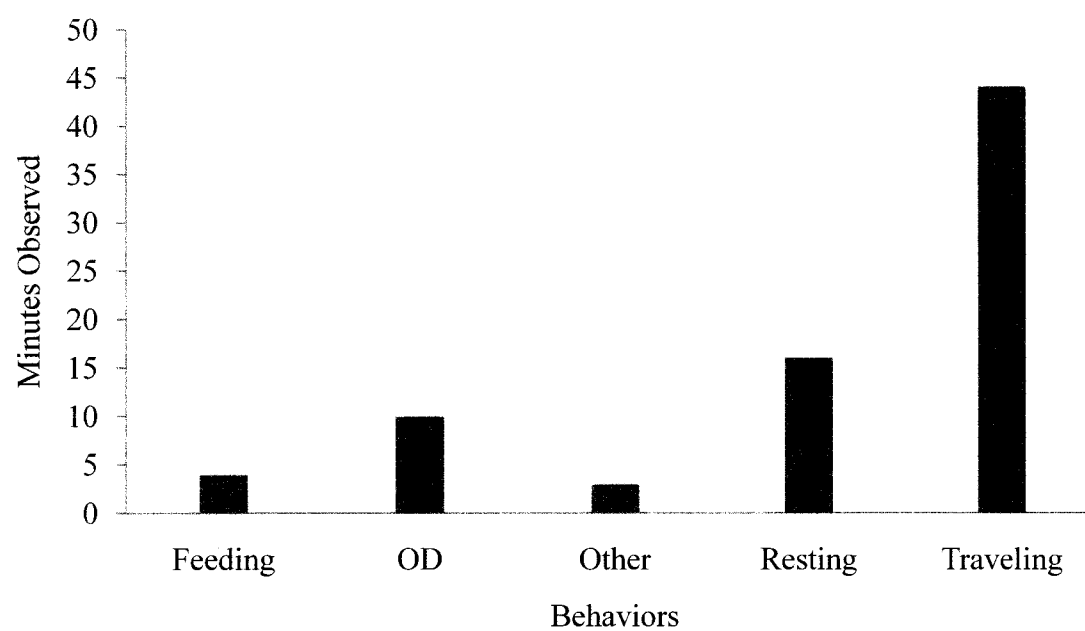


FIG. 3--Field observations (minutes) of adult black bear behaviors made during Spring 2009 in Big Bend National Park. OD = Observer-Directed behaviors.

During the summer a single adult was observed, precluding analysis of summer behaviors. All age classes were observed during fall (Fig. 4). Field observations failed to meet assumptions of normality, so non-parametric Kruskal-Wallis tests were used to compare activity by age class and to compare activity by seasons. Significantly meaningful differences were found among age classes and activity ($p = 0.028$) and between activity and season ($p = 0.001$). Post-hoc tests indicated differences in age classes between spring and fall, as well as between summer and fall (Table 2). A difference was also found between adults and yearlings (Table 3).

TABLE 2--Results of post-hoc tests comparing seasonal activity of black bears. Asterisk denotes significant difference.

Comparison	P value	Mean	Std. Error
Fall vs. Spring	0.003*	1.61111	0.46392
Fall vs. Summer	0.007*	3.44444	1.09443
Spring vs. Summer	0.322	-1.83333	1.12396

TABLE 3--Results of post-hoc tests comparing activity of different age classes of black bears. Asterisk denotes significant difference.

Comparison	P value	Mean	Std. Error
Adult vs. Sow	0.314	-2.71154	1.37327
Adult vs. Yearling	0.010*	1.94231	0.59096
Adult vs. Juvenile	1.000	-0.71154	0.89233
Sow vs. Yearling	1.000	-0.76923	1.44756
Sow vs. Juvenile	1.000	-2.00000	1.59451
Yearling vs. Juvenile	1.000	1.23077	1.00290

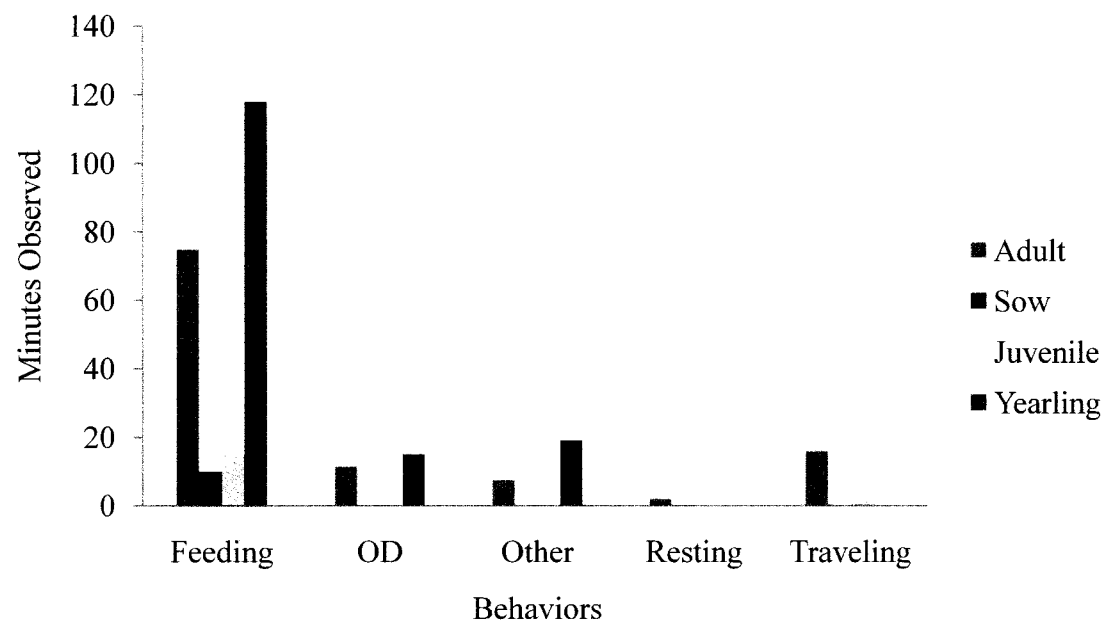


FIG. 4--Field observations (minutes) of black bear behaviors made during Fall 2009 in Big Bend National Park. OD = Observer-Directed behaviors.

VISITOR OBSERVATIONS

Visitor observations followed the same pattern as field observations, with the exception that bears remained active throughout the winter (Table 4). During 2009, numerous additional observations were made by park visitors, but many could not be incorporated into this analysis due to the lack of behavioral content. Of visitor observations that could be used, 214 observations were made of individuals of unknown age or sex (Fig. 5), 324 observations were made of sows and juveniles (Fig. 6), 169 observations were made of adults (Fig. 7), and 120 observations were made of yearlings (Fig. 8). According to these data, activity varied little between seasons because time budgets were similar throughout the year. The percentage of observations of traveling remained relatively constant throughout the year, with feeding and observer-directed behaviors observed more often than traveling.

In comparison to field observations, more visitor observations were available, allowing robust statistical analyses to be conducted. Visitor observations were normally distributed between age classes and behavioral activities, so these data were analyzed using an ANOVA. A comparison between age class and activity indicated no significant difference ($p = 0.224$). Behavioral activity and season failed to meet the assumptions of normality; thus, a Kruskal-Wallis test was used to make comparisons. Results of this analysis found no significant differences in seasonal activities ($p = 0.272$).

TABLE 4. Visitor observations (total observations with percent of total activity in parentheses) of black bear behaviors in Big Bend National Park (January-December 2009).

	Drinking	Feeding	Observer-Directed	Other	Resting	Social	Traveling	Total
Winter	5 (3.5%)	32 (22.3%)	30 (21.0%)	7 (4.9%)	3 (2.1%)	4 (2.8%)	62 (43.4%)	143 (100%)
Spring	5 (1.4%)	51 (13.9%)	125 (34.2%)	14 (3.8%)	10 (2.7%)	21 (5.7%)	140 (38.3%)	366 (100%)
Summer	0.0	24 (19.1%)	25 (19.8%)	10 (7.9%)	2 (1.6%)	0.0	65 (51.6%)	126 (100%)
Fall	3 (1.6%)	40 (20.8%)	40 (20.8%)	8 (4.2%)	6 (3.1%)	0.0	95 (49.5%)	192 (100%)
Total	13 (1.6%)	147 (17.8%)	220 (26.6%)	39 (4.7%)	21 (2.5%)	25 (3.0%)	362 (43.8%)	827 (100%)

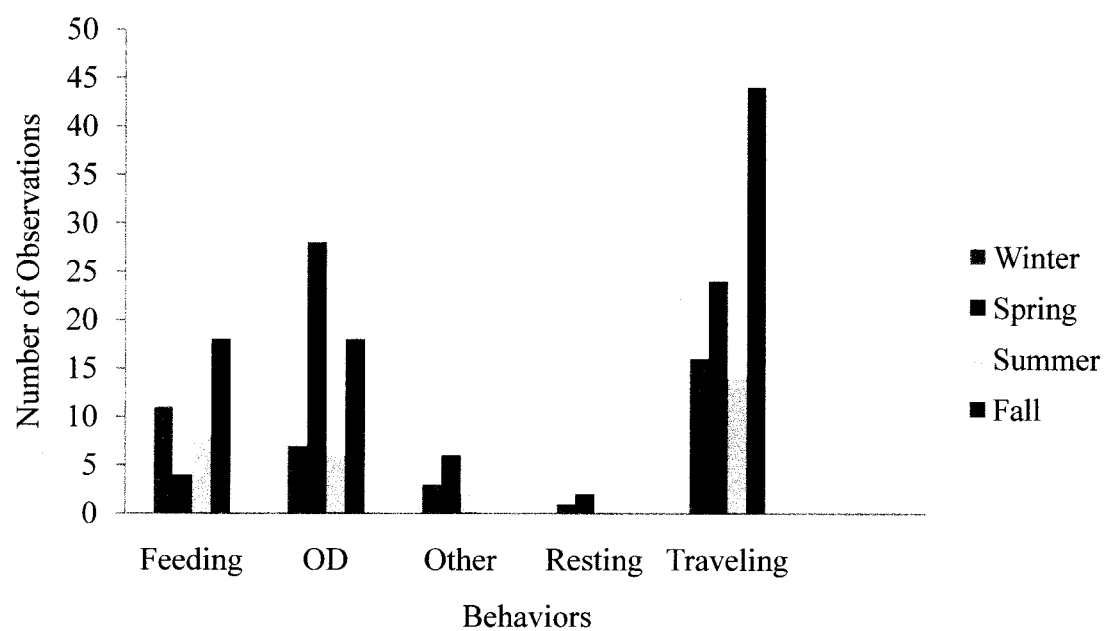


FIG. 5--Visitor observations of individual bears without age or sex identification made during 2009 in Big Bend National Park. OD = Observer-Directed behaviors.

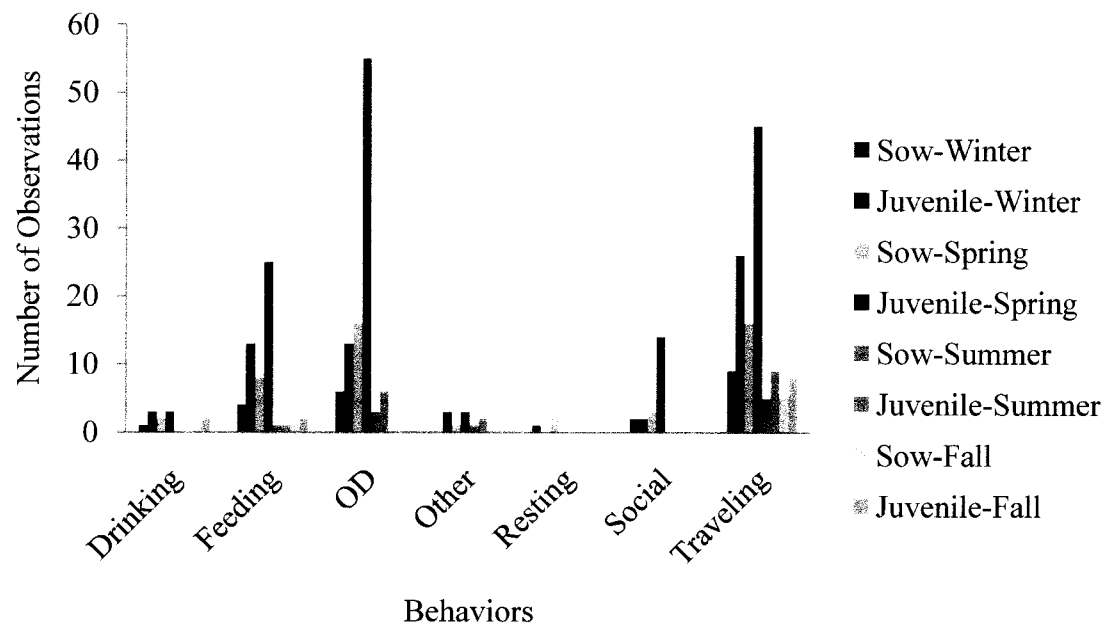


FIG. 6--Visitor observations of sow and juvenile behaviors made during 2009 in Big Bend National Park. OD = Observer-Directed behaviors.

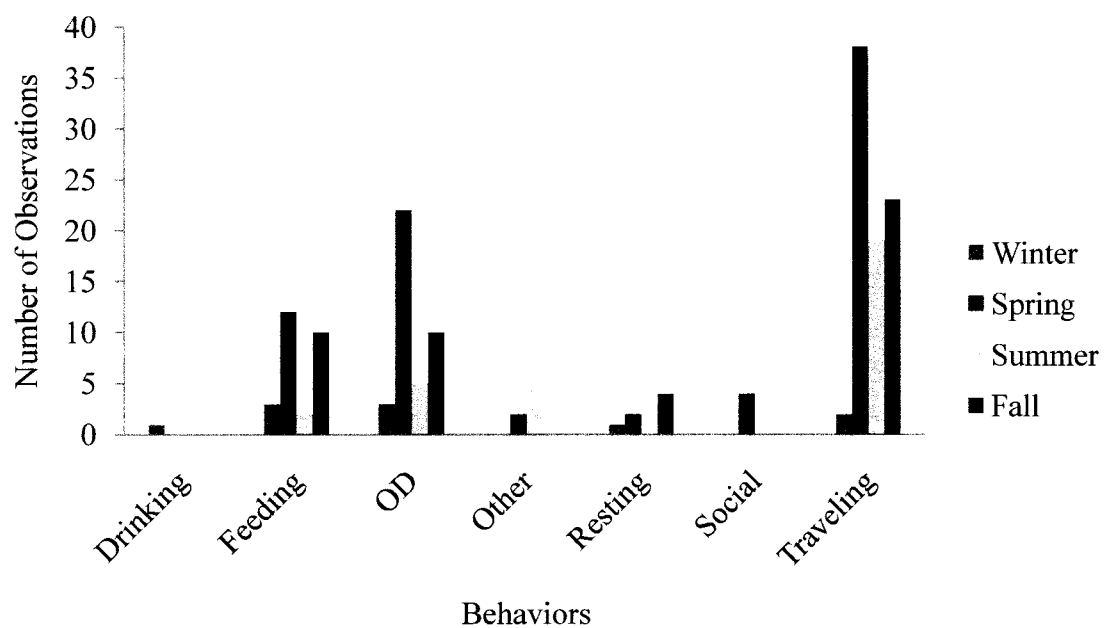


FIG. 7--Visitor observations of adult black bears of unknown gender made during 2009 in Big Bend National Park. OD = Observer-Directed behaviors.

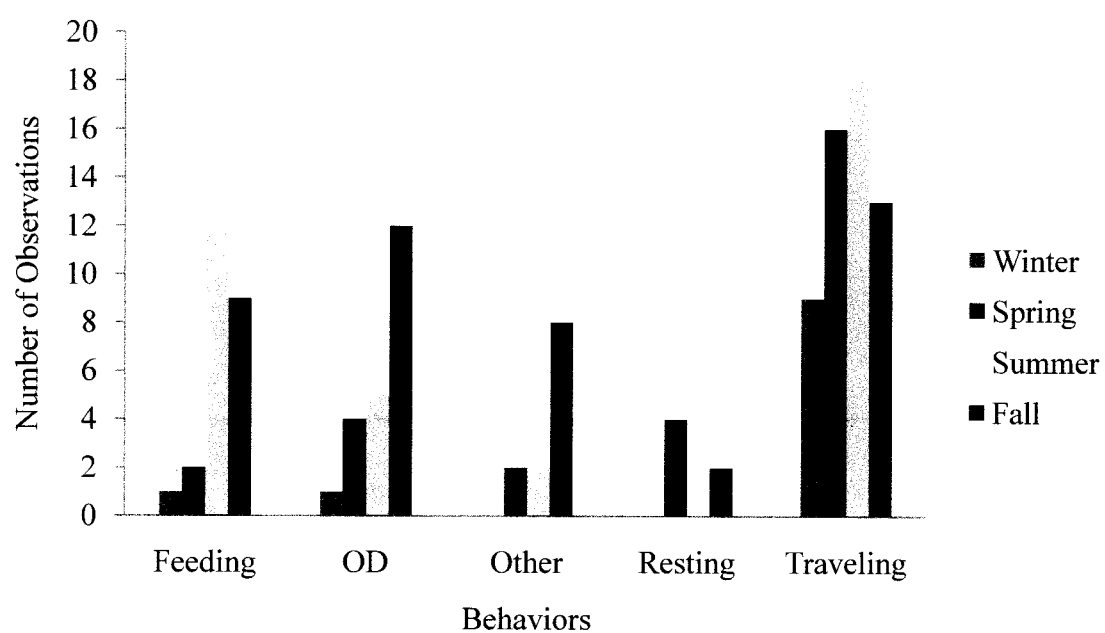


FIG. 8--Visitor observations of yearling black bear behaviors made during 2009 in Big Bend National Park. OD = Observer-Directed behaviors.

CHAPTER IV

DISCUSSION

Bears were active throughout the course of the study period, and sows and juveniles were sighted on multiple occasions in winter by park visitors. These observations support suggestions that bears in southern latitudes may be active for longer periods in the winter than bears in more northerly latitudes (Doan-Crider and Hellgren, 1996; Garrison, 2004; Mitchell et al. 2005; Garrison, et al., 2007). Pregnant females are often the only bears which enter dormancy in southerly portions of the species range (Doan-Crider and Hellgren, 1996; Rogers, 1999). These findings suggest that because activity continues through the winter, continued field observations should be possible in future studies, rather than assuming that all bears have entered dormancy.

FIELD OBSERVATIONS

Traveling was the most frequently observed activity, perhaps because bears spend a great deal of time traveling between water and food sources that are patchily distributed throughout the Chisos Basin. Daily movements are known to vary seasonally in response to food availability (Garshelis and Pelton, 1981). Black bears are also known to establish large territories and the need to patrol and defend this area could also account for the high frequency of observed traveling behavior. Females establish territories that often are shared with their adult, female offspring, while males establish extensive territories which often overlap those of other males, resulting in territorial conflicts (Schwartz and Franzmann, 1992; Rogers, 1999; Onorato et al., 2007). Lastly, the fact that traveling was the most commonly observed behavior could be due to

observer bias. A moving black bear is probably easier to locate than a sedentary individual and, thus, less likely to be over-looked. Field observations collected in this study suggest that neither gender nor reproductive condition affect traveling behavior. Similar conclusions were reached in a study using remote photography, in which no significant differences were found between demographic groups (Bridges et al., 2004).

Observer-directed behaviors were intentionally minimized by the observer in order to reduce the contact with bears and more closely observe the natural daily activities the bears participate in. Observer-directed reactions were reduced by remaining still and quiet, as well as maintaining a predetermined comfort distance from the animal. When observer-directed behaviors were observed, varying degrees of intensity were noted. Bears would act aggressively by false-charging, grunting, and shaking vegetation; bears would also turn and leave the area or look in the direction of the observer, stopping their activity out of what appeared to be curiosity. On more than one occasion a combination of these actions was observed, with a hiss or grunt from the animal, which promptly departed the area.

Feeding behaviors were frequently observed in fall among all age classes. Acorns, which provide large amounts of carbohydrates, are readily available in fall, (McClinton et al., 1992; McDonald and Fuller, 2005). Bears prepare for winter food shortages by consuming large amounts of acorns to increase their body weight. As daytime temperatures decrease, bears spend more time feeding and less time resting to further maximize their caloric intake (Garshelis and Pelton, 1980).

Less commonly observed activities were predicted to be low during the study. Resting was observed for a total of 17 minutes, and only adults participated. Behaviors

that fell into the category of “other,” such as tree climbing or defecating, were rarely observed. These activities were rare in the sense that the bears seldom deviate from the more common behaviors. Less than 10% of observed activities were categorized in this way, supporting the prediction that bears continue similar activity, albeit varied, throughout the year. Drinking and social behaviors were not observed during field observations.

VISITOR OBSERVATIONS

Observer-directed behaviors were particularly high among visitor observations in comparison to field observations. This difference may be because park visitors attempt to elicit a response during bear encounters. Park visitors are instructed by National Park Service employees, volunteers, and signs to respond to black bear confrontations with behaviors such as shouting or throwing small stones at the bears (National Park Service, www.nps.gov/bibe/naturescience/bearsbackcountry.htm). These actions are intended to reduce the chances of bears’ becoming habituated to human contact by providing strong, negative stimuli during human and bear interactions (Mazur, 2010); as such, they likely represent a major source of bias between these two data sets.

In addition, park visitation rates could partially account for seasonal differences in bear observations. There are fewer visitors to BBNP in the winter than in the spring and fall, which could result in fewer bear observations. Similarly, visitation is lowest in August and September, presumably due to the high, daytime temperatures during the summer months (National Park Service, www.nps.gov/bibe/naturescience/

bearsbackcountry.htm). The lowest number of visitor observations were in summer, coinciding with decreased periods of park visitation. Although a lack of visitor observations in summer can be partially explained, the paucity of field observations remains unclear. Bears may have traveled into higher elevations to escape high, summer temperatures or possibly modified their activities to a more nocturnal pattern as temperatures began to rise. Although there is no way to explain these activities, future studies can take these ideas into account, should the issue arise again.

Traveling was also one of the activities most frequently observed by park visitors. This could be because a traveling bear is more easily observed, but it is also possible that park visitors confuse a bear avoiding human confrontation by moving away with a traveling bear. This may represent observer bias in the number of travel observations.

As predicted in this study, bears were observed feeding more frequently in the fall in order to maximize caloric intake before experiencing winter shortages (Garshelis and Pelton, 1980). Visitors also observed an increase in feeding behaviors in spring, and this is presumably due to the sudden increase in overall bear activity. Although bears were observed by park visitors throughout winter, little activity was noted in comparison to other seasons.

Many activities are likely to be observed infrequently. For example, drinking is a comparatively uncommon event in the sense that the observation of a bear drinking is purely coincidental, and not unexpectedly it was the least frequently observed behavior in both data sets. Likewise, social behavior was infrequently observed because juveniles are the most likely to socialize in forms of play and curiosity, and juveniles were not

observed as often as adults. Resting was observed infrequently throughout the year because a resting bear is quiet and motionless, and likely escapes notice. Behaviors listed in the category of “other” were also rare.

Several studies involving black bears have been conducted in northern states such as Minnesota and Michigan (Rogers and Wilker, 1990; DeBruyn, 2001; McDonald and Fuller, 2005). Northern bear behaviors, dietary composition, and social activity are similar to observations in BBNP, but there are some differences. Adult bears are rarely documented engaging in social activities with bears other than their offspring because food sources are limited and widely scattered. Collectively, bears are rarely social and gather in groups only when food sources are abundant and clumped (Rogers, 1999; Paisley and Garshelis, 2006).

RECOMMENDATIONS FOR FUTURE RESEARCH

As this study was the first of its kind in this area, additional field observations should be conducted in order to maximize the data available. These field observations would allow comparative studies to be conducted over multiple years. Tracking radio-collared bears would decrease the likelihood of pseudo-replication. Bears are normally diurnal, engaging in nocturnal activities mainly around human developments, but radio telemetry has been used to study nocturnal activities (Bridges et al., 2004; Paisley and Garshelis, 2006). Similar studies could provide useful information about bears of BBNP in assessing habitat use and movement patterns in the park. Although bears have been studied in BBNP by telemetry in the past, radio-collared bears have never been directly observed. Instead, location signals and den locations have been recorded (Hellgren et

al., 2005; Mitchell et al., 2005). According to Rogers and Wilker (1990), tracking radio-collared bears provides information in sex-specific movement patterns and activities, as adult bears can be difficult to sex by direct observation.

The last estimation of the bear population in BBNP was conducted by Mitchell et al. (2005). Further study should also provide a more recent population assessment since reproduction appears successful in the park. On a related topic, further study should also investigate range expansions and migrations of individuals to adjacent mountain ranges, as range expansions and different mountain ranges can potentially alter bear activities. As large carnivores, bears typically maintain small populations that are vulnerable to stochastic events and habitat loss (Onorato et al., 2004). Private lands surround BBNP, possibly functioning as population sinks to dispersing bears (Rice et al., 2007). There have been many instances of assumed dispersal events (Koennecke, 2009). For example, bears have been sighted in and around the city of Alpine on multiple occasions (Appendix A), and a large male was even struck and killed by a vehicle outside of the city on 20 June 2009 (Appendix B).

Data from this study can be applied in a practical manner to management practices in BBNP. A better understanding of bear activities can allow BBNP to use employees to better interpret visitor observation cards in the future and utilize the information provided to its fullest potential. Similarly, future observational studies in BBNP will increase the knowledge of bears and their habitat use for future management plans. Because bears reside in a recreational area, it is imperative that they are better understood in order to minimize negative encounters with humans.

LITERATURE CITED

- ALLISON, N. L., AND S. DESTEFANO. 2006. Equipment and techniques for nocturnal wildlife studies. *Wildlife Society Bulletin* 34:1036-1044.
- ALTMANN, J. 1974. Observational study of behavior: sampling methods. *Behaviour* 49: 227-267.
- BLANCHARD, B. M., AND R. R. KNIGHT. 1990. Reactions of grizzly bears, *Ursus arctos horribilis*, to wildfire in Yellowstone National Park, Wyoming. *Canadian Field-Naturalist* 104:592-594.
- BLANCHARD, B. M., AND R. R. KNIGHT. 1991. Movements of Yellowstone grizzly bears. *Biological Conservation* 58:41-67.
- BRIDGES, A. S., M. R. VAUGHAN, AND S. KLENZENDORF. 2004. Seasonal variation in American black bear *Ursus americanus* activity patterns: quantification via remote photography. *Wildlife Biology* 10:277-284.
- CARRO, M. E., AND G. J. FERNANDEZ. 2008. Seasonal variation in social organization and diurnal activity budget of the Greater Rhea (*Rhea americana*) in the Argentinean pampas. *Emu* 108:167-173.
- CHAULK, K., S. BONDRUP-NIELSEN, AND F. HARRINGTON. 2005. Black bear, *Ursus americanus*, ecology on the northeast coast of Labrador. *Canadian Field-Naturalist* 119:164-174.
- DEBRUYN, T. 2001. Walking with bears: one man's relationship with three generations of wild bears. The Lyons Press, New York.

- DOAN-CRIDER, D. L., AND E. C. HELLGREN. 1996. Population characteristics and winter ecology of black bears in Coahuila, Mexico. *Journal of Wildlife Management* 60: 398-407.
- EBERHARDT, L. L., AND B. M. BLANCHARD. 1986. Monitoring grizzly bear population trends. *Journal of Wildlife Management* 50:613-618.
- GARSHELIS, D. L., AND M. R. PELTON. 1980. Activity of black bears in the Great Smoky Mountains National Park. *Journal of Mammalogy* 61:8-19.
- GARSHELIS, D. L., AND M. R. PELTON. 1981. Movements of black bears in the Great Smoky Mountains National Park. *Journal of Wildlife Management* 45:912-925.
- GARRISON, E. P. 2004. Reproductive ecology, cub survival, and denning ecology of the Florida black bear. M.S. thesis, University of Florida, Gainesville.
- GARRISON, E. P., J. W. MCCOWN, AND M. K. OLI. 2007. Reproductive ecology and cub survival of Florida black bears. *Journal of Wildlife Management* 71:720-727.
- HANSKI, I. A., AND D. SIMBERLOFF. 1997. The metapopulation approach, its history, conceptual domain, and application to conservation. Pages 5-26 in *Metapopulation biology: ecology, genetics, and evolution* (I. A. Hanski and M. E. Gilpin, editors). Academic Press, San Diego.
- HELLGREN, E. C. 1993. Status, distribution, and summer food habits of black bears in Big Bend National Park. *Southwestern Naturalist* 38:77-80.
- HELLGREN, E. C., D. P. ONORATO, AND J. R. SKILES, JR. 2005. Dynamics of a black bear population within a desert metapopulation. *Biological Conservation* 122:131-140.

- HWANG, M. H., AND D. L. GARSHELIS. 2007. Activity patterns of Asiatic black bears (*Ursus thibetanus*) in the Central Mountains of Taiwan. *Journal of Zoology* 271:203-209.
- KNIGHT, R. R., AND L. L. EBERHARDT. 1985. Population dynamics of Yellowstone grizzly bears. *Ecology* 66:323-334.
- KNIGHT, R. R., B. M. BLANCHARD, AND L. L. EBERHARDT. 1988. Mortality patterns and population sinks for Yellowstone grizzly bears, 1973 – 1985. *Wildlife Society Bulletin* 16:121-125.
- KOENNECKE, C. L. 2009. Evaluation of potential black bear habitat on the Davis Mountains Preserve, Texas. M.S. thesis, Sul Ross State University, Alpine, Texas.
- MAJOLO, B., AND N. KOYAMA. 2006. Seasonal effects on reconciliation in *Macaca fuscata yakui*. *International Journal of Primatology* 27:1383-1397.
- MATTSON, D. J., AND M. M. REID. 1991. Conservation of the Yellowstone grizzly bear. *Conservation Biology* 5:364-372.
- MAZUR, R. 2010. Does aversive conditioning reduce human-black bear conflict? *Journal of Wildlife Management* 74:48-54.
- MAZUR, R., AND V. SEHER. 2008. Socially learned foraging behavior in wild black bears, *Ursus americanus*. *Animal Behaviour* 75:1503-1508.
- MCCLINTON, S. F., P. L. MCCLINTON, AND J. V. RICHEY. 1992. Food habits of black bears in Big Bend National Park. *Southwestern Naturalist* 37:433-435.

- MCDONALD, J. E., JR., AND T. K. FULLER. 2005. Effects of spring acorn availability on black bear diet, milk composition, and cub survival. *Journal of Mammalogy* 86:1022-1028.
- MCKINNEY, B. R., AND J. A. DELGADILLO VILLALOBOS. 2003. Manual para el manejo del oso negro mexicano: guía para manejadores. CEMEX, Nuevo Leon, Mexico.
- MITCHELL, F. S., D. P. ONORATO, E. C. HELLGREN, J. R. SKILES, JR., AND L. A. HARVESON. 2005. Winter ecology of American black bears in a desert montane island. *Wildlife Society Bulletin* 33:164-171.
- MOE, T. F., J. KINDBERG, I. JANSSON, AND J. E. SWENSON. 2007. Importance of diel behaviour when studying habitat selection: examples from female Scandinavian brown bears (*Ursus arctos*). *Canadian Journal of Zoology* 85:518-525.
- OBBARD, M. E., B. A. POND, AND A. PERERA. 1998. Preliminary evaluation of GPS collars for analysis of habitat use and activity patterns of black bears. *Ursus* 10:209-217.
- ONORATO, D. P., E. C. HELLGREN, F. S. MITCHELL, J. R. SKILES, JR. 2003. Home range and habitat use of American black bears on a desert montane island in Texas. *Ursus* 14:120-129.
- ONORATO, D. P., E. C. HELLGREN, R. A. VAN DEN BUSSCHE, AND D. L. DOAN-CRIDER. 2004. Phylogeographic patterns within a metapopulation of black bears (*Ursus americanus*) in the American Southwest. *Journal of Mammalogy* 85:140-147.
- ONORATO, D. P., E. C. HELLGREN, R. A. VAN DEN BUSSCHE, AND J. R. SKILES, JR. 2004. Paternity and relatedness of American black bears recolonizing a desert montane island. *Canadian Journal of Zoology* 82:1201-1210.

- ONORATO, D. P., E. C. HELLGREN, R. A. VAN DEN BUSSCHE, D. L. DOAN-CRIDER, AND J. R. SKILES, JR. 2007. Genetic structure of American black bears in the desert southwest of North America: conservation implications for recolonization. *Conservation Genetics* 8:565-576.
- PAISLEY, S. AND D. L. GARSHELIS. 2006. Activity patterns and time budgets of Andean bears (*Tremarctos ornatus*) in the Apolobamba Range of Bolivia. *Journal of Zoology* 268:25-34.
- PRATES, H. M., AND J. C. BICCA-MARQUES. 2008. Age-sex analysis of activity budget, diet, and positional behavior in *Alouatta caraya* in an orchard forest. *International Journal of Primatology* 29:703-715.
- RICE, M. B., W. B. BALLARD, E. B. FISH, D. B. WESTER, AND D. HOLDERMANN. 2007. Predicting private landowner support toward recolonizing black bears in the Trans-Pecos region of Texas. *Human Dimensions of Wildlife* 12:405-415.
- ROGERS, L. L. 1993. Studying habituated black bears. Pages 210-211 in *Bears: majestic creatures of the wild*. (I. Stirling, editor). Rodale Press, Emmaus.
- ROGERS, L. L. 1999. Family Ursidae: bears. Pages 157-160 in *The Smithsonian book of North American mammals*. (D. E. Wilson and S. Ruff, editors). Smithsonian Institution Press, Washington D. C.
- ROGERS, L. L., AND G. W. WILKER. 1990. How to obtain behavioral and ecological data from free-ranging, researcher-habituated black bears. *Bears – Their Biology and Management*. Eighth International Conference on Bear Research and Management 8:321-327.

- SCHMIDLY, D. J. 1977. The mammals of Trans-Pecos Texas. Texas A&M University Press, College Station.
- SCHWARTZ, C. C., AND A. W. FRANZMANN. 1992. Dispersal and survival of subadult black bears from the Kenai Peninsula, Alaska. *Journal of Wildlife Management* 56: 426-431.
- SHANNON, G., B. R. PAGE, R. L. MACKEY, K. J. DUFFY, AND R. SLOTOW. 2008. Activity budgets and sexual segregation in African elephants (*Loxodonta africana*). *Journal of Mammalogy* 89:467-476.
- SKILES, J. R. 1995. Black bears in Big Bend National Park – The Tex-Mex connection. *Proceedings of the Western Black Bear Workshop* 5:67-73.
- STRIER, K. B. 2007. Primate behavioral ecology. Third edition. Allyn and Bacon, Boston.
- TELESCO, D. J., AND F. T. VAN MANEN. 2006. Do black bears respond to military weapons training? *Journal of Wildlife Management* 70:222-230.
- WAUER, R. H. 1996. Naturalist's Big Bend. Texas A & M University, College Station.
- WITMER, G. W., AND D. G. WHITTAKER. 2001. Dealing with nuisance and depredating black bears. *Western Black Bear Workshop* 7:31-81.
- ZAR, J. H. 1999. Biostatistical analysis. Fourth edition. Prentice Hall, Upper Saddle River.

APPENDIX

SUPPLEMENTAL PUBLICATIONS REGARDING BLACK BEAR SITINGS IN

BREWSTER COUNTY

APPENDIX A

From *Alpine Avalanche*, 26 June 2003

BEAR AMBLES INTO ALPINE DURING EARLY MORNING HOURS

By Gail Diane Yovanovich / Senior Staff Writer

On the morning of June 18, a five-year old, 225 lb. adult male black bear took a long stroll around Alpine before officials subdued it near the Brewster County Courthouse.

After Texas Parks & Wildlife Department personnel, Brewster County Sheriff's deputies and Alpine Police Department officers followed the bear around town for about two hours in an attempt to corner it, the animal finally climbed a tree across from the courthouse. At about 3:40 a.m., TPWD diversity biologist David Holdermann immobilized the bear with a rifle dart.

Using an anesthesia specifically tailored for bears, Holdermann said the animal was not harmed and was neither sick nor malnourished. After fitting the bear with a radio transmission collar, TPWD officials transported the animal to Black Gap Wildlife Management Area, where it was released. At about 7:40 a.m., awake but bleary-eyed, the bear wandered off into the desert. TPWD will monitor the bear's movements by radio telemetry over the next year.

According to Holdermann, the only resident breeding populations of black bears in Texas occur in the Chisos and Dead Horse mountains of the Trans Pecos region, an

area recolonized by bears from the nearby mountains of Coahuila, Mexico, during the mid-1990s. When male black bears reach sexual maturity at about four or five years of age, female family groups shun them, and the animals begin to wander in search of new territory.

"Two hundred miles is nothing for a bear to travel," said Holdermann, "and we see lone males on a regular basis in the vicinity of Alpine." He added that there is no evidence of a breeding population north of the Big Bend, due in large part to the animals [sic] strong preference for forested habitat.

Angel Torres, who heard the call for assistance on the police scanner he keeps in his home, roused his wife and daughter, packed up the cameras and headed out to see what all the fuss was about. "We wanted to see if there was really a bear," Torres told the Avalanche. His daughter, Esmeralda, photographed the animal near the Alpine Civic Center at around 1:45 a.m.

During its tour of Alpine, the bear was spotted as far west as the new post office and as far east as Food Basket.

APPENDIX B

From *Alpine Avalanche*, 25 June 2009

BLACK BEAR KILLED NEAR ROADSIDE PARK

Avalanche staff

A big black bear was struck and killed by a vehicle Saturday night near the roadside park just west of Alpine on U.S. Hwy. 90.



Black bear hit about 10 p.m. near roadside park on Hwy. 90. Photo special to the *Avalanche* / Rose Macias

Residents of Van Horn reported to friends in Alpine that they had hit the animal around 10 p.m., and a tow truck was sent to the scene.

Rose and Luis Macias of Affordable Towing said that upon arriving at the scene, they notified the Brewster County Sheriff's Office. Deputy Chris Roach and Texas DPS Trooper Rene Ybarra went to investigate the accident.

"I think at first when they got the call, they did not believe what they heard over the radio — that a car hit a bear," Rose Macias said. "Indeed, it was a bear — a big black bear. I think everyone that was on the scene had to take a picture with this beautiful animal [sic]."

“We looked like a bunch of kids taking turns getting our picture taken with him.”

Sheriff Ronny Dodson said they hoisted the bear and it turned out to be taller than Deputy Roach, who stands 6-foot-1.

“Between the game wardens, sheriff’s deputy, Texas Highway Patrol and my husband Luis, they picked up the bear and loaded it on the game warden’s truck,” Rose Macias said.

“The bear did die at the scene, I think from internal injuries because he did not have any cuts on him or it did not appear that he had any broken bones,” she added. “It looked like he was asleep.”

The bear was sent to Hippo Taxidermy shop.

Macias added that Liz Self, a Border Patrol agent who lives on South Hwy. 118 reported she had seen what appears to be this bear late last week.

“From what she says, this is the second time the bear had been spotted,” Macias said. “Who knows? There might be more in the area.”

The sheriff said yes, indeed, there have been from 8 to 10 recent bear sightings all over the county.

“One was seen around San Francisco Creek that weighed about 450 pounds,” Dodson said.

“And one bear stood up to a guy,” he added, but it didn’t hurt the man. Dodson also found a dead bear on his ranch around Black Gap that he said was quite large.