

BLACK BEAR ACTIVITY PATTERNS AND HUMAN INDUCED MODIFICATIONS IN SEQUOIA NATIONAL PARK

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In places where black bears (*Ursus americanus*) have become pests in campgrounds and other developments, their depredations most frequently occur at night (U.S. Dep. Int., Natl. Park Serv. 1980-85). Investigations of black bear activity patterns, however, have reported that black bears in areas not associated with human activities are primarily diurnal or crepuscular (Amstrup and Beecham 1976, Eubanks 1976, Lindzey and Meslow 1977, Garshelis and Pelton 1980, Quigley 1982). This discrepancy is interesting because it may point to a significant measure of behavioral plasticity in black bears. It also suggests that human activity, when imposed on black bear habitat, disrupts bear activity patterns. In national parks where hunting is not permitted, the 2 principal factors affecting the population ecology and behavior of black bears are the availability of human food, and management practices designed to remove bears from sites of human activity (Graber 1981). Nocturnal visits to developed areas and subsequent property damage by black bears can be minimized by making anthropogenic food resources unavailable (Graber 1981).

The purpose of the research was to evaluate the extent to which human activity had affected bears in Sequoia National Park, Calif., and to assess the management implications of these changes. This study of black bear activity patterns was part of a research project designed to compare ecological and behavioral parameters of bears using developed sites and those in adjacent, undisturbed habitat.

STUDY AREA

The study area, approximately 90 km², in Sequoia National Park, is on the western slope of the Sierra Nevada in California. The area is delineated on 2 sides by the deep canyons of the Middle Fork and Marble Fork of the Kaweah River. Topography at

lower and middle elevations (900-1,500 m) is rugged and steep, rising to a gently rolling plateau at higher elevations (2,100 m). Climate is characterized by warm, dry summers and cool, moist winters during which most of the yearly precipitation (\bar{x} = 276 cm) falls in the form of snow. Mean high and low temperatures range between 27 C to 12 C in August and 3 to -6 C in January.

Because of the steep topography, vegetation in the study area varies and can be divided into 5 principal plant communities. In general order of elevation they are chaparral, oak savannah, hardwood forest, mixed conifer-giant sequoia forest, and lodgepole pine forest. Chaparral is dominated by chamise (*Adenostoma fasciculatum*), whiteleaf manzanita (*Arctostaphylos viscidula*), and California lilac (*Ceanothus* spp.). The oak savannah includes blue oak (*Quercus douglasii*) with an understory of annual grasses. Canyon live oak (*Q. chrysolepis*), California buckeye (*Aesculus californica*), and bay laurel (*Umbellularia californica*) are the dominant hardwood forest species. The mixed-conifer forest on the plateau contains principally giant sequoia (*Sequoiadendron gigantea*), white fir (*Abies concolor*), sugar pine (*Pinus lambertiana*), and jeffrey pine (*P. jeffreyi*). On colder sites lodgepole pine (*P. contorta*) predominates. The plateau also contains numerous large montane hydric meadows of grasses, sedges, and forbs.

METHODS

We captured most bears with Aldrich foot snares. We used sedative darts and culvert traps occasionally, especially in developed areas. Once bears were trapped or snared, ketamine hydrochloride and xylazine hydrochloride were administered intramuscularly with a pole syringe to immobilize the bears. We took standard measurements, extracted a premolar, and then estimated age using a combination of tooth annuli counts and somatic features. We marked each bear with a numbered metal ear tag and a unique color- and symbol-coded vinyl flag for subsequent visual field identification.

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We installed 22 radiocollars on selected individuals representing specific sex and age classes. Transmitters used in this study were of 2 types: Type 2 featured 2 pulse-frequency modes. "Active mode" was triggered by movement of the sensor and continued for 5 min after motion had stopped. Type 3 possessed a 1-min time delay reset for active mode. We also used a 3rd pulse frequency to indicate the bear's head position while in active mode.

We collected the telemetry data used for this investigation June–August, 1981 and 1982. Activity readings lasting 15 sec were taken with a hand-held, 2-element Yagi antenna every 15 min, in blocks of 6, 12, or 24 hours. We recorded air temperature at each reading. Signals were recorded as "active" or "inactive" based solely on pulse mode. If 1 active reading was recorded between 2 inactive readings, we assumed this reflected merely a position change and assigned it as inactive.

We determined if bears were actually moving about in the following ways: for bears with Type 3 collars, fluctuations in pulse-frequency caused by regular head movements were interpreted as motion. We validated this criterion by comparing observations of bears wearing Type 3 collars while foraging, traveling, and resting with their concurrent signals. The movements of bears using Type 2 collars were estimated by strong fluctuations in signal strength while in active mode—indicating changes in body orientation or passage behind objects—and subsequent changes in signal direction. We again verified this method visually. Although assigning activity mode was straight forward, ambiguous information about body movements was common; this we classified as missing data.

Change in physical location, not activity mode, was the key variable for our analysis. However, active/not-moving readings recorded directly between readings of movement were treated as continuations of bear activity. For purposes of this paper, "active" henceforth means "engaged in purposeful activity."

We classified radio-collared bears as either "campground bears" using principally human foods, or those foraging for naturally occurring foods. We based bear classifications on their home ranges and observations of individuals in campgrounds.

Level of activity was determined by the proportion of active readings during each 1-hour block of 4 observations. A binomially distributed chi-square was used to test for differences among activity patterns (Cochran 1963).

RESULTS

We determined the activity profiles of 12 bears using natural forage based on 3,663 observations. These bears were diurnal and crepuscular (Fig. 1). The likelihood of finding an active bear of this class was highest at 0700 (Level of Activity = 0.70, SE = 0.04) and again at 1900 (Level of Activity = 0.83, SE = 0.03). Activity was lowest between 1100 and 1400, creating a bimodal pattern of activity during daylight hours.

The 6 bears that foraged in campground areas exhibited a dramatically different activity schedule than did bears that foraged on natural foods ($\Psi^2 = 455$, $df = 2$, $P < 0.01$). Campground bears were more active at night (sunset to sunrise) than their naturally foraging counterparts. In contrast to the diurnal, bimodal pattern found in naturally foraging bears, bears that used human foods were nocturnal, with a unimodal pattern of activity. From 1,317 observations of 6 bears, we found that activity was concentrated in 1 period. Activity levels increased at 2000 and reached a peak at 2300 (Level of Activity = 0.90, SE = 0.04), then declined and remained low during daylight hours (Fig. 2).

We observed 18 of the 22 radio-collared bears consistently following 1 of these 2 patterns. Three bears—adult female and 2 subadults, male and female—shifted between the 2 activity patterns.

We watched the adult female enter her usual campground area, investigate refuse sites, and then leave, apparently without finding any food. Her signal in-

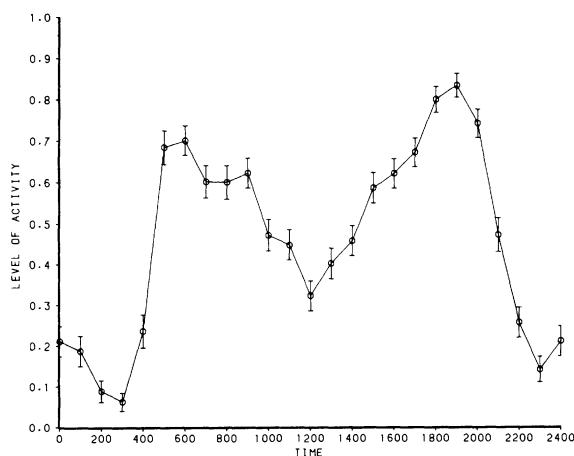


Fig. 1. Activity profile of 12 natural foraging black bears, June through August, 1981–82. Level of activity is expressed as proportion of active observations per hour. Variance is represented by 95% confidence intervals.

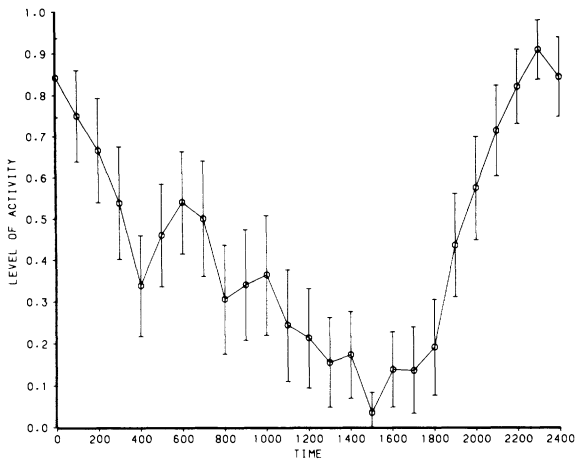


Fig. 2. Activity profile of 6 black bears using human food, June through August, 1981-82. Level of activity is expressed as proportion of active observations per hour. Variation is represented by 95% confidence intervals.

indicated she was inactive the remainder of the night. The following day, we located her, active, in the vicinity of a manzanita berry patch about 2 km from the campground. She followed the typical diurnal-bimodal activity pattern for at least 2 days before returning to the campground and her previous nocturnal pattern.

The shift in activity patterns of the 2 subadults occurred over a long time period. They were first captured on 22 June and 1 July 1982 during daylight hours in a campground. At some time during all subsequent daytime monitoring periods over the next month, when 1 of these bears was present in the campground we saw visitors or staff chasing it or otherwise interfering with its search for food until it fled the campground. By August both bears began visiting the campground at night. Occasional daytime visits continued, so a complete transformation to nocturnal activity did not take place.

When activity patterns of naturally foraging bears were broken down by age, sex, and the presence or absence of cubs, the only differences ($P < 0.50$) were between adult females with cubs and single adult females (Fig. 3). The absence of a midday decline (1300 to 1500) in activity levels for mothers was responsible for the statistical difference ($\Psi^2 = 66$, $df = 2$).

Peak afternoon temperatures during our study rarely exceeded 20 C. Because of the great topographic variation over the study area, temperatures

where bears were located may have been quite different.

DISCUSSION

Activity studies that found black bears to be crepuscular attributed this pattern to their avoiding midday heat (Garshelis 1978) while still using daylight for foraging (Eubanks 1976). Activity levels for bears in Great Smoky Mountains National Park were found to decline when temperatures exceeded 20 C (Quigley et al. 1979). If bears observed in this study were responding strictly to temperature levels, we would expect to observe increased or prolonged activity on cooler days. We detected no such relationship based on temperatures at the monitoring sites.

Foraging constraints imposed by herbaceous matter of low digestibility and energy return, requiring 2 temporally separated foraging periods, have also been proposed as an explanation for the midday decline in black bear activity and the presence of 2 active periods (Garshelis and Pelton 1980). For nursing mothers, the absence of the normal midday decline is likely a function of demands imposed by cubs. Whether these demands are translated into increased foraging, time spent tending cubs, or in comfort movements we do not know.

The commencement of ursine nocturnal activity in the campgrounds coincided with the decline in human activity and suggested that bears deviate from a diurnal schedule to minimize the chance of human harassment. A shift from diurnal to nocturnal activity

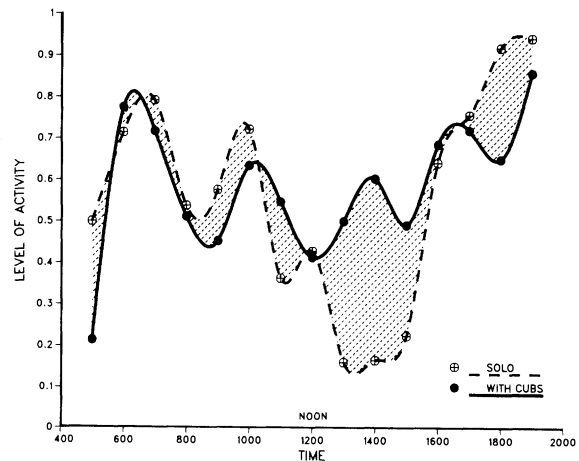


Fig. 3. Activity profiles of 3 adult female black bears with cubs (solid line) and 4 adult females without cubs (dashed line), June through August, 1981 and 1982, from 0500-900. Level of activity is expressed as proportion of active observations per hour.

schedules caused by hunting has been observed for game animals such as rabbits (Cloudsley-Thompson 1961).

The extent to which this bear population has been perturbed as a consequence of human food availability is unknown. It has often been assumed that all bears in the vicinity of campgrounds and similar sites use them as food resources. This was not true in our study area. Bears observed foraging only on natural resources and never visiting campgrounds centered their activity away from areas of high human use, even though real distance to campgrounds was small and no physical barriers prevented visits. Our occasional observation of agonistic interactions between bears in campgrounds during this study suggests that competitive exclusion may be involved in determining foraging habits and activity patterns in the vicinities of campgrounds or other centers of concentrated food resources. Particularly severe daytime competition in tropical forests has been considered as a factor responsible for the nocturnal habits of some tropical vertebrates (Cloudsley-Thompson 1980).

Except in deserts, predation and food availability are probably the most important ecological factors in mammalian diel schedules (Enright 1970). Human intervention through food resource enrichment and harassment invoked a striking functional response in bears, revealing the plasticity of this species' behavior. Although bears do not always alter their behavior in response to human presence, the great disturbance caused in many instances is enough to justify concern.

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