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Author(s): David M. Graber

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WINTER BEHAVIOR OF BLACK BEARS IN THE SIERRA NEVADA, CALIFORNIA

DAVID M. GRABER, National Park Service, Sequoia and Kings Canyon National Parks, Three Rivers, CA 93271

Abstract: Black bears (*Ursus americanus*) in the Sierra Nevada range of California do not reliably exhibit the classic pattern of compulsory winter dormancy generally reported for this species. Pregnant females and most other adults hibernate for approximately 3.5 months, but only 37% of males are winter dormant. Winter-active bears tend to use lower elevations where snow cover is sporadic, growth after autumn rains provides herbaceous foods, and acorns may remain on the ground. Warmer temperatures at these lower elevations also reduce energy costs for active bears. The absence of a single environmental or physiological factor that discriminates between winter-active and winter-dormant bears, however, suggests that a complex suite of factors affects a bear's decision to remain active or den.

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The environmental and endogenous factors that initiate and set the duration of winter dormancy in black bears have long been debated. Indeed, the very nature of dormancy remains at issue. It is generally accepted that black bear hibernation is designed to conserve energy stores during a period when the energy costs of foraging exceed the energy value of food obtained. The relative roles that food availability, weather, physical condition, functional adaptation to local climate, and evolved physiology play in this behavior remain a matter of speculation. Dormancy for pregnant females is compulsory because of the altricial state of neonates. There is an established correlation between latitude and the duration of winter dormancy. Denning periods of more than 7 months have been reported from southern Alaska (Schwartz et al. 1987); Montana, 6.5 months (Jonkel and Cowan 1971); Washington, 4 months (Lindzey and Meslow 1976); Arizona, 4 to 5 months (LeCount 1983); North Carolina, 3.5 months (Hamilton and Marchinton 1980). Johnson and Pelton (1980) working in Tennessee, and Smith (1986) working in Arkansas, assert that the characteristics of dormancy do not vary with duration nor latitude.

Physiological investigations of black bear hibernation (Nelson et al. 1973, Folk et al. 1976, Lundberg et al. 1976, Nelson et al. 1983) have found metabolic and biochemical changes in winter that suggest dormancy is structural rather than functional, and that once the transition to hibernation is effected, it is not readily reversed. In particular, this line of research proposes that food digestion during the hibernation period may not be possible.

In Arizona, however, LeCount (1983) reported that black bears spend time outside their dens on warm days well into their nominal denning period. Hamilton and Marchinton (1980) reported bears in North Carolina delaying den entry until mid-winter. Novick et al. (1981) found that some bears in the mountains of southern California remain active all winter, as did Hellgren and Vaughan (1987) in Virginia. Taylor (1971) described bears feeding and returning to dens in Louisiana.

This report of winter behavior was drawn from a research program designed to compare ecological and behavioral patterns of bears using camping or recreation sites and those in adjacent, undisturbed habitat. Although data collection in winter was sparser and less systematic than at other seasons, findings are sufficiently unusual to warrant communicating them.

I wish to acknowledge the excellent field work of L.A. Ayres, L. Chow, A. Clevenger, and J. Van Horn. L. Chow was responsible for most of the data management.

STUDY AREA

The area used by black bears described in this study lies in and adjacent to Sequoia National Park, on the western slope of the Sierra Nevada range in central California. Elevations extend from 400 m to 2,500 m, with steep topography generated by river gorges and glacial canyons. Climate is characterized by warm, dry summers and cool, moist winters during which most precipitation falls as snow above 1,500 m. Mean annual precipitation ranges from 66 cm at the lowest elevations to 125 cm at 2,000 m and varies greatly from year to year. January minimum temperatures range from 2 C to -9 C according to elevation.

Because of the steep topography, vegetation varies strikingly over short map distances. Plant communities used by black bears in Sequoia include chaparral (*Adenostoma fasciculatum*, *Ceanothus* sp., *Arctostaphylos* sp.), oak woodland (*Quercus douglasii*, *Q. chrysolepis*, *Q. kelloggii*), oak forest (*Q. kelloggii*, *Q. chrysolepis*), mixed conifer forest (*Abies concolor*, *Pinus lambertiana*, *Sequoiadendron giganteum*), and lodgepole pine (*Pinus contorta*)-red fir (*Abies magnifica*) forest.

METHODS

We captured most bears with Aldrich foot snares, occasionally supplemented by a variety of other methods. Bears were sedated with ketamine hydrochloride and xylazine hydrochloride, after which we took standard

measurements and extracted a premolar for age estimation. Unfortunately only a few of the individuals used in this analysis were weighed and measured in the autumn, so their condition at that time could not be used in this investigation. Some of those captured, particularly subadult males and adult females, were fitted with radio-transmitter collars. Two types of transmitters were used in this study: one type featured a 1-minute or 5-minute delay reset motion sensor; the other included the motion sensor and a real-time head position sensor that operated when the bear was active. I define "activity" in this paper as a change of location, established by a combination of motion sensor, signal direction, and direct observation (Ayres et al. 1986). Most telemetry data were collected on the ground with a hand-held, portable receiver, supplemented by telemetry from aircraft when bears could not be located from the ground.

From all data collected by capture, visual observation, and telemetry, I selected individual "bear-winters" as analytical units if there were sufficient location and activity records for the months of December through April to make a reliable determination of the presence, extent, and location of winter dormancy or other winter activity. Distribution and number of data points necessary varied with the activities of individual bears, but minimum sampling was once per week.

I calculated habitat selection and movements when there was a sufficient number of data points to do so. A preferred habitat was assigned to a winter-active bear if most locations during the months December through April were obtained within a single vegetation type. No food availability data were obtained. However, acorns and manzanita (*Arctostaphylos* spp.) berries are the predominant fall foods, herbaceous graminoids and dicots the predominant spring foods in the study area (Graber, unpubl. data).

RESULTS

During the winters of 1980 through 1985, we followed the activities of 31 individual bears (16 females, 15 males) for 63 bear-winters.

Denning Bears

Thirty-nine (62%) bears were winter-dormant for at least 2 weeks; the remaining 24 (38%) remained active all winter.

Females were about twice as likely (29, 81%) to den as males (10, 37%) ($X^2 = 10.6, P < 0.001$). All 7 females who had cubs denned. Individual bears did not necessar-

ily follow a pattern of dormancy from 1 year to the next. Of females for which there is information for sequential years, 80% (12) denning in 1 year did so the following year, while the remainder did not follow suit. Among males, 2 (18%) denned 2 years in a row, 3 (27%) remained active 2 winters in succession, and 6 (55%) switched behaviors.

The mean age of females in the winter study was 10.4 years, but only 4.4 years for males. (Overall, mean age of females in the study population was 2.6 years greater than males; we were less successful in locating dens of older male bears). The overall mean age of denning bears, 9.2 years, was substantially greater than that for winter-active bears, 5.7 years. However, there was little difference in either gender between the ages of denning and non-denning bears (10.7 yrs vs 9.3 yrs for females, 4.7 yrs vs 4.2 yrs for males).

The median onset of winter dormancy was 17 December, and the median emergence date was 30 March. The mean duration was 104 days (S.D. = 39). However, bears entered dens as early as 21 November and emerged as late as 31 May. One old female remained in her den for 178 days. The mean sampling interval during the winter was 3.5 days during the onset period, and 4.8 days during the emergence period, therefore there is an element of uncertainty surrounding estimates of denning periods.

We classified most bears in this study according to their association with human development. Between those that were strongly associated with human development—typically during the spring, summer, and fall—and those that rarely or never visited developments, there was little difference in denning habits. During the winter months, campgrounds are little used by park visitors or bears; the quantities of anthropogenic foods available to bears at that time are trivial. Of campground bears, 67% (12) denned, similar to 59% (23) of bears associated with natural areas ($X^2 = 0.07, P > 0.7$).

Denning rate (percent of bears denning) during the 6 years varied from 12% in 1981 to 85% in 1982. Mean winter snow depth varied (at a mid-elevation index station) from 20 cm in 1984 to 109 cm in 1983. Snow depth during December, when denning begins, varied from 0 cm in 1981 to 58 cm in 1983 and 1985. Neither variable correlates with denning rate nor median onset of denning when pregnant females are excluded and ranks are compared. O'Pezio et al. (1983) similarly failed to find a correlation between denning onset and weather in New York. However, in the winter of 1981 when 0/7 non-pregnant bears denned in Sequoia, autumn temperatures were warmest, autumn precipitation was least, and winter snow depth second-least of the 6 winters. In the winter of

1983, when 12/15 (80%) non-pregnant bears denned, precipitation and snow depth were at their greatest and autumn temperatures were the second coldest.

Data on food production for the study years were not sufficiently robust to evaluate against denning rates. We found no rank correlation, however, between autumn precipitation or minimum temperatures—the factors controlling winter greenup—and denning rate.

Winter-active Bears

Of the 24 bears that failed to den during the winter, nearly 80% changed location regularly January through March. The remainder, although active, remained confined to a few square kilometers.

Vegetation types are zoned along an elevation gradient in the Sierra Nevada (Barbour and Major 1977); in the Sequoia study area the lowest elevation type, chaparral, and the highest elevation type used by bears, lodgepole pine/red fir, are often separated by less than 10 km. Thus seasonal selection of habitat is not constrained by distance. Preferred winter habitat for active bears was quite different than that chosen for dens. The most popular habitat type for winter-active bears was chaparral (38%), followed by oak woodland (25%) and mixed conifer (25%). Bears denned preferentially in mixed conifer (38%), followed by oak woodland (23%), chaparral (15%), and lodgepole pine/red fir forest (15%). Denning bears that emerged early from dens tended to use the same habitat as winter-active bears.

Although bear scats were not systematically collected during winter, the small number examined contained either acorns or graminoids and herbaceous dicots.

Disturbance

We tried to visit most dens to confirm dormancy, to collect other information, and occasionally to remove transmitters. Unfortunately, in 8 (6 female, 2 male) of the 63 cases reviewed here, researcher visits led to den abandonment. This sometimes occurred when visitors remained at a considerable distance. If disturbance occurred before mid-February, bears re-denned within 2 weeks. But in 3 cases dormancy was abandoned entirely, and one of these led to abandoned cubs.

After bears had abandoned dens in mid-winter, we visited some of these and collected scat from the immediate vicinity. We cannot say with confidence whether these were produced during the nominal denning period, afterwards, or even by other bears in some cases. The scats, as those of winter-active bears, contained herbaceous material or acorns.

DISCUSSION

Winter activity among black bears in southern latitudes, where temperatures above freezing occur much of the time and many plants continue to grow, is more varied and complex than rigid hibernation practiced by black bears in northern climates. In Sequoia National Park and environs, oak forest and oak woodland frequently remain free of snow and provide acorns fallen from the previous autumn. The chaparral belt supports herbaceous plants growing throughout most of the winter. Yet these vegetation belts often occur less than 4 km from the conifer vegetation in which most dens are found.

If denning is elective, a functional calculation that one's energy budget is better served by hibernation than by foraging, then behavior such as that observed in Sequoia is readily understandable. Although I did not directly measure winter food availability, it is evident that a heavy autumn acorn crop provides high-energy foods into the winter. The availability of green plant material is a function of precipitation during the autumn months while temperatures are still high enough for plant growth. However, I found no pattern of denning rates reflecting these weather parameters.

Prior to the effective elimination of anthropogenic food in the 1980's, there were numerous instances of bears active and feeding in mid-winter in Yosemite Valley in Yosemite National Park, California, which is also in the Sierra Nevada (Wright 1929, Harwell 1932, Graber 1981). Although winters in Yosemite are somewhat colder than in the lower elevations of Sequoia, individual bears skilled at foraging for anthropogenic food could come out of the winter in better condition than others who hibernated if winter dormancy is a trade-off between energy conservation and foraging gain minus expenditure. The minimal difference in denning rates between well-fed campground bears and "natural" bears in this study suggests that fall fat levels may not be as important as winter food availability in determining whether denning will occur. However, the lack of direct fall weight measurements for many of the study animals makes this a weak inference.

It is tempting to propose that dormancy among black bears in the Sierra Nevada and similar climates is elective in some circumstances. Such a postulate is troubling because it conflicts with physiological evidence that hibernation is biochemically profound and it implies that individual bears consciously weigh information about present environmental conditions and perhaps their own physiological state. And if bears are capable of such calculation, may they also predict winter conditions based on environmental cues, and take this factor into account?

Research to date provides no evidence either to accept or reject this model. In locations such as Sequoia where not all bears hibernate, there is an opportunity to learn more about the forces that control this process. Accurate, quantitative information about autumn food availability, the nutritional status of individual bears, and weather, combined with high-resolution telemetric data on the winter activities of individual bears, would provide useful insights into the role of the different environmental parameters affecting the timing and extent of winter dormancy.

The Sequoia winter research effort was severely constrained by our desire not to cause den abandonment. Nonetheless this was a regular occurrence. This disturbance not only confounds analysis of winter behavior, it compromises the viability of the bears themselves. Our reticence about approaching bear dens has muddied our understanding of winter feeding. Abandonment caused by human disturbance, especially investigators, has been documented elsewhere (Poelker and Hartwell 1973, Tietje and Ruff 1980, Smith 1986, Hellgren and Vaughan 1987). This scientific and ethical problem calls for the use of remote sensing and telemetry to the greatest possible extent.

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