PANEL 2: DENNING—CONTROL MECHANISMS, SITE SELECTION AND PHYSIOLOGY

Data on Grizzly Bear Denning Activities and Behavior obtained by using Wildlife Telemetry

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INTRODUCTION

Because the Yellowstone grizzly (*Ursus arctos horribilis* Ord) is largely nocturnal, inhabits a heavily timbered area of rugged terrain and enters its den for a winter sleep that lasts 5 to 6 months, it was necessary as one phase of a comprehensive ecological study (Craighead *et al.* 1960) to develop and employ a radiotracking and locating system (Craighead *et al.* 1963, Craighead & Craighead 1965). Such a system enabled us to gather data on den site selection, den construction, prehibernating behavior and denning activities of individuals in a population of between 175 and 200 grizzly bears ranging over an area of approximately 5000 square miles. In 1961 we began developing and testing radiotracking equipment and we continued this work through the fall of 1968. During this 8-year period, we made 48 instrumentations of 23 different grizzly bears. These animals were tracked or monitored for a total of over 1, 200 tracking days; den location sometimes required monitoring for 3 months and intensive tracking for 4 consecutive days. Grizzly bear No. 40 was instrumented and monitored for portions of 8 consecutive years. Seven other bears were instrumented and monitored during 2 consecutive years each. The winter dens of six different grizzlies were located, but since more than one den was located for some bears over a period of years, we were able to obtain information on size and construction of 11 dens. Due to involvement of family groups, 22 animals were radiotracked and observed to have utilized the 11 dens.

In November, 1963, we successfully tracked a $5\frac{1}{2}$-year old female grizzly, No. 164, to her winter den (Craighead & Craighead 1965). As far as we know, this is the first instance in which a radio transmitter was used to track and locate a grizzly bear as it entered its winter den.

Prior to this study, little was known concerning the denning activities and prehibernation behavior of wild grizzlies. Dens reported to us as those utilized by grizzlies turned out to be the dens of black bears. It was generally thought that the Yellowstone grizzlies, like black bears and the European brown bears (*Ursus arctos arctos* L.), utilized natural shelters—caves, hollow trees, windfall and dense vegetation—as sites for their 'hibernation' dens (Couturier 1954).

These were supposedly enlarged by digging, or improved to varying degrees as shelters for the long winter sleep (Lyman & Dawe 1960, Kayser 1961).

A short discussion of hibernation or winter sleep seems appropriate, since differences in hibernators and in how they hibernate have caused researchers to formulate varying definitions of this phenomenon.

Authors suggesting that the bear is not a hibernator point out that though the bears go into a deep sleep and are inactive for considerable periods of time, they do not become torpid and helpless as do most hibernators (Kayser 1961: 21-50). Bears can be readily aroused after which they can react quickly and energetically to disturbance; and their body temperature does not approach the ambient air temperature.

Hibernation is generally considered to be a torpid state in which the hibernator, partially or wholly, loses its sensibility or power of motion. This is a state from which the animal can be aroused only with difficulty. Thus, bears during their winter sleep are dormant rather than torpid because they can be rather easily aroused and they can move rapidly when disturbed—features enhancing survival of a group of mammals that have been hunted by man since prehistoric times. Low ambient air temperatures, deep snow and the unavailability of food appear to make hibernation or winter sleep essential to the survival of grizzlies in the Yellowstone area.

The study area in Yellowstone Park and the surrounding National Forests lies largely between 7,000 and 8,000 feet altitude. Temperatures of —40°F. and below have been recorded, at some time, from all areas of the Park where temperature records have been kept. The lowest recorded temperature is —66°F. (Anon. 1959).

METHODS

To obtain information on denning behavior and activities of grizzlies fitted with radio transmitters, the position and movements of intrumented bears were plotted from the inter-section of bearings (fixes) which were made from a distance. Then, guided by the fixes and using portable directional receivers, we moved on foot to observe the animals at close range.

The radiotracking system was designed to provide maximum use in various types of field work. A diagram of the location system is shown in Fig. 1. The transmitter collar radiates a pulsed signal which can be received by a variety of stations, depending on the receiving antenna employed. A small, 2-lb. battery-operated receiver with a directional loop antenna was used for tracking on foot when the distance between the receiver and the instrumented animal was not greater than 2 to 3 miles.

The collar which was placed on the animal to be tracked consisted of the transmitter unit and a battery pack attached to a circular metal strap which acted both as a loop antenna and a collar (Fig. 2). The battery pack was waterproofed with paraffin and silicone rubber and the assembly was covered with fiberglass-reinforced acrylic resin to protect the electronics and batteries (Fig. 3). It also prevented flexing and bending which would otherwise have caused antenna detuning or eventual breakage.

The inside of the collar was padded with rubber hosing or foam rubber or a combination of both to make it fit the animal snugly and comfortably (Fig. 4). The collar was designed so the metal strap could be adjusted to the desired

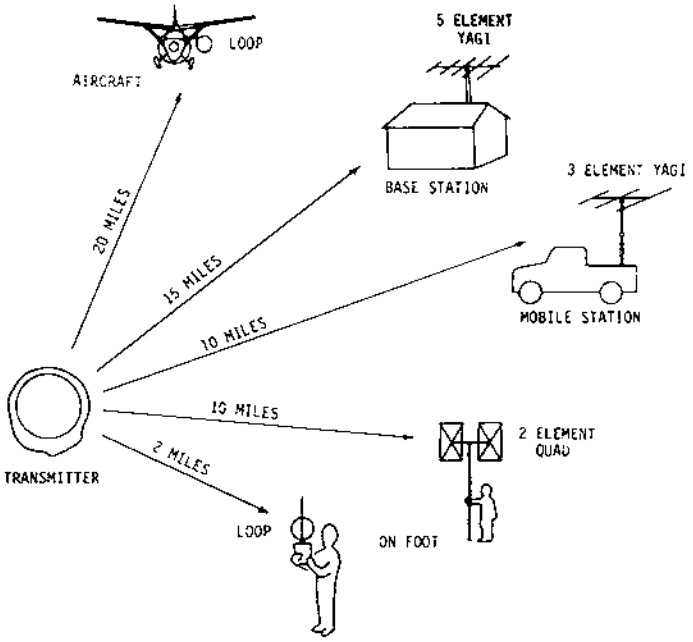

Fig. 1 Radio location system

Fig. 2 Male yearling grizzly No. 158, equipped with radio collar. He was tracked to a den shared with sow No. 39 and two littermates. Individual color-markers are visible in ears.

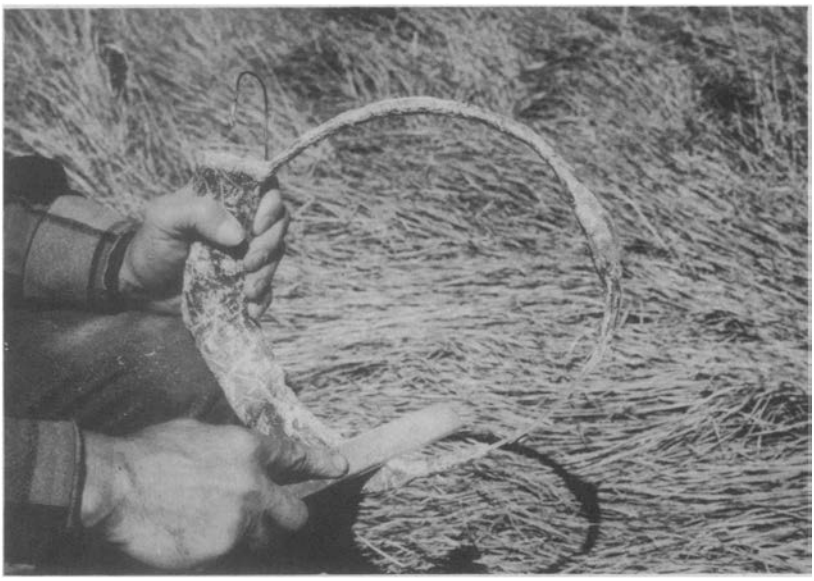

Fig. 3 Putting fiberglass on transmitter-collar assembly to make it waterproof, shockproof and bear-proof

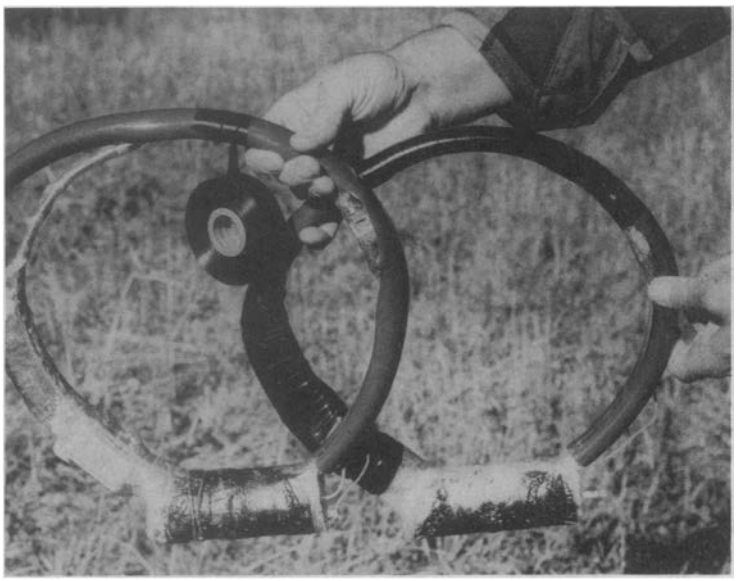

Fig. 4 Plastic hose and rubber padding, wrapped with tape of varying colors, make a comfortable and snug fit.

neck diameter by inserting two screws in a series of holes in the overlapping ends of the strap (Craighead & Craighead 1970).

We used two types of transmitters in tracking operations. One type was designed to operate continuously, emitting a 50 ms pulse at approximately 1 second intervals. The battery life with this type of transmitter (called the standard model) was 3 months. For longer life an additional timer circuit was used to turn the transmitter on and off at 30 second intervals. Battery life of this extended-life model was 9 months (Craighead & Craighead 1965). All transmitters of both types operated on the same frequency, but each had a different pulse rate which permitted identification of each grizzly.

Transistorized receivers were used for tracking on foot and obtaining bearings from base and mobile stations. Various kinds of antennas could be connected to a receiver, depending on tracking requirements. The receivers were battery-operated Citizen's band units modified to operate at 32 MHz. Early in the study some tracking at base and mobile stations was done with general-coverage communications receivers; however, these were later discarded in favor of the portable units (Craighead & Craighead 1970).

Summaries of the transmitter, receiver, and system characteristics are given in Tables 1, 2, and 3.

Normal tracking procedure was to record a signal from an instrumented grizzly at the base station using the 5-element yagi antenna. The direction of the signal source was plotted on a topographic map. A second and frequently a third bearing was made with the mobile unit. The intersection of the bearings generally fixed the animal's position to within a $\frac{1}{4}$ to $\frac{1}{3}$ mile area on the map (Fig. 5). We then hiked to within 2 to 4 miles of the fix and activated the portable receiver which was used to move in on the bear until he was sighted or jumped.

TABLE 1. TRANSMITTER CHARACTERISTICS

Frequency	32 MHz
Output power	100 mW pulse
Pulse width	50 ms
Pulse repetition rate	1 per second (nominal)
Antenna type	resonant loop, 11 inch diameter
Antenna impedance	50 ohms
DC input power	280 mW peak, 18 mW average
Battery type	mercury, low temperature 9. 3 volts, 4. 5 Ah
Weight:	
electronics	0. 1 lb
battery	0. 9 lb
complete collar	2. 0 lbs
Operating lifetime	3 months standard, 9 months with additional timer

TABLE 2. RECEIVER CHARACTERISTICS

Frequency	32 MHz
Type	dual conversion, crystal controlled
Bandwidth (3 dB)	3 kHz
Sensitivity	—123 dBm nominal for 10 dB S/N
Battery type	Nickle-cadmium, 225 mAh
Size	3 × 7 × 8 inches
Weight	2 lbs
Battery life	10 hours between charges

TABLE 3. SYSTEM RANGE WITH VARIOUS RECEIVING ANTENNAS

Antenna Type	Antenna Gain	Use	System Range*
Loop (11" dia.)	—10 dB (est.)	on foot from aircraft	2 miles 20
Dipole (reference)	0	—	
Quad	5	field station	10
3 element yagi	7	field station	10
5 element yagi	9	base station	15

*Typical value—varies widely with terrain

As the instrumented animal was approached, the signal strength increased so that, at about $\frac{1}{4}$ mile, a null became difficult to obtain. The receiver sensitivity setting was then reduced to get a null; the remaining distance to the instrumented grizzly was covered by following the null. Signal volume and receiver sensitivity provided a good indication of distance between the bear and the observer. We frequently approached grizzlies to within 100 feet before disturbing them. The average distance at which we 'jumped' them from daybeds in dense timber and windfall was 125 feet.

Grizzly bears that we planned to track to dens were generally instrumented in late summer or early fall. These animals were radiotracked almost daily either from the base station or in the field. Instrumented animals were followed on prehibernation treks to denning areas whenever possible; however, at such times the bears were not closely pursued.

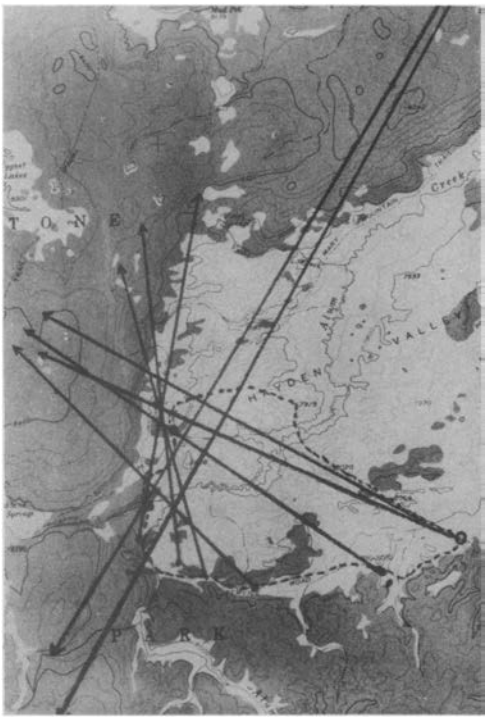

Fig. 5 Bearings of transmitter signal plotted over two consecutive days in order to locate instrumented grizzly. They were taken from a field station (circle) and the base station (upper right, just off map 8 miles to north). Dark spot is position of bear and dotted line is route of trackers using portable directional receivers.

RESULTS

Den Site Selection

The dens of six different grizzlies were located, some for consecutive seasons. Thus, 11 active ones were found and information was obtained on site preference, den size and construction. All dens used by grizzlies were located while they were being constructed, or when bears entered them for their winter sleep.

Information on den site selection (Table 4) was obtained from monitoring and observing instrumented grizzlies in the fall of the year. In 1961 and 1962 we were unable to track the radio-tagged bears to their dens. However, the dates of hibernation (29 and 21-22 October, respectively) were obtained by observing movements of grizzlies during snowstorms and the lack of tracks thereafter. Later, with improved equipment, tracking grizzlies became routine, and we obtained specific dates when they entered dens to remain for the winter.

Over a 9-year period, these dates when grizzlies entered their dens to remain varied by as much as a month. They were:

Year	*Month*	*Year*	*Month*
1960	Oct. 29	1965	November 11
1961	October 21-22	1966	November 19-21
1962	November 15 (approx.)	1967	November 19
1963	November 4-5	1968	November 3-4
1964	November 10		

Bears of both sexes and several age classes were tracked to dens. These included 1 young adult female (barren), 1 young adult female with her first cub, 2 adult pregnant females, 2 adult females with cubs, and 2 adult females with yearlings. Two young males were tracked to their dens, one as a weaned yearling and again as a 2-year-old—the other as a yearling with his mother and two littermates. Very large boars were instrumented and tracked to denning areas but none were successfully tracked to dens. Four dens of one female were located—three of these in consecutive seasons; the dens of two other bears for two successive seasons. An orphaned grizzly, cub No. 78, was observed until and soon after emerging from hibernation, evidence that cubs can survive the winter without parental care or guidance.

Grizzlies whose dens were located hibernated at altitudes ranging from 7, 800 to 9, 200 feet (Tables 4 and 5). All dens were located in timbered areas and all but one on northern slopes with the den entrance facing north. Couturier (1954) found that brown bears preferred a den that faced south. A north-facing den entrance appears to be advantageous to the hibernating grizzly in Yellowstone because prevailing southwest winds accumulate snow on northern exposures.

The deep snow that accumulates in such locations insulates the den chamber from the extreme ambient air temperatures that drop as low as —40°F. or even to —60°F. Also, there is less chance that snow on north slopes will melt during a warm period or winter 'chinook'. Water trickling into a den would appear to be disturbing and undesirable. Though early spring and later fall sightings revealed that grizzlies den throughout Yellowstone and beyond, all occupied dens were found in the central portion of the Park.

Dens were located relatively far from developed areas or human activity. Grizzlies seem to need and to seek isolation for the 6 months of their winter sleep. In the course of evolution, finding isolated den sites for hibernating would appear to be a factor favoring survival of the species. Primitive man and the American Indian undoubtedly found that grizzlies, lethargic until disturbed, were vulnerable in winter and the odds far more favorable for killing them during winter sleep than during their active period.

Den Construction

Most grizzlies prepared winter dens well in advance of the time they went into hibernation. The earliest recorded den diggings were on 3 and 8 September. The latest occurred 11 and 15 November; the bears completed these dens just in time to enter them for the winter. In one case, den construction had been delayed because the bear had abandoned her first den. The amount of disturbance needed to cause abandonment of a completed den or one under construction varied considerably with individual grizzlies.

TABLE 4. CHARACTERISTICS OF ACTIVE GRIZZLY BEAR DENS

Designation of Grizzly No.	Sex	Year Den Used	Den Location	Vegetation Type	Soil Structure	Den Elevation (Feet)
164	F	1963*	Upper Alum Creek	Lodgepole	Soft earth	8,200
158	M	1964	Upper Trout Creek	Lodgepole Pine	Packed soil Gravel layer	8,400
40	F	1964	Upper Alum Creek	Lodgepole Pine Spruce-Fir	Packed soil	8,200
40	F(3)	1965	Upper Alum Creek Beach Lake	Lodgepole Pine	Packed soil	8,200
40	F	1966	Lower Trout Creek	Lodgepole Pine Spruce-Fir	Loose soil	8,000
202	M	1965	Yellow-stone Canyon	Spruce-Fir	Rocky (talus)	7,800
202	M	1966	Yellow-stone Canyon	Spruce-Fir	Rocky (talus)	7,800
101	F	1966	Lower Trout Creek	Lodgepole Pine	Sandy soil	8,000
101	F	1967	Hedges Peak	Spruce-Fir Whitebark Pine	Packed soil Rocks	9,200
187	F	1967	Ice Lake	Lodgepole Pine	Packed soil	8,100
40	F	1968	Upper Trout Creek	Spruce-Fir	Packed soil	8,200

(1) Attempted earlier to dig den at base of tree.
(2) Den abandoned before lining.
(3) Female pregnant.
* Signs of use the previous year.

Species of Den Tree	Den Measurements (inches) Chamber L	W	Ht	Entrance L	W	Ht	Total Length	Den Lining	Fate of Den First Spring
Lodgepole	59	53	48	60	17	40	119	Conifer boughs	Remained intact
Spruce	64	60	60	32	30	42	96	Conifer boughs	Remained intact
Spruce	48	42	48	36	30	30	84	Conifer boughs	Collapsed
None	54	54	36	66	33	21	120	Grass Moss Rootlets	Remained intact
Dead stump	60	85	28	30	17	20	90	Conifer boughs	Collapsed
Log(1)	47	43	26	—	—	—	66	Conifer boughs	Remained intact
Log	43	37	28	—	—	—	63	Conifer boughs	Collapsed
Whitebark Pine	54	48	30	12	14	36	66	None (2)	Remained intact
Dead spruce	63	56	40	45	15	54	108	Fir boughs	Collapsed
Whitebark Pine	—	—	—	36	21	27	—	None (2)	Collapsed
Spruce	68	54	30	38	24	—	106	Conifer boughs	Remained intact

TABLE 5. CHARACTERISTICS OF INACTIVE GRIZZLY BEAR DENS

Den Location	Vegetation Type	Soil Structure	Den Elevation (Feet)
Upper Trout Creek	Lodgepole pine	Hard, compacted	8,200
Absaroka Range Mist Creek	Whitebark pine	Rocky	9,000
Lower Trout Creek	Lodgepole pine Spruce-fir	Loose soil	8,000
Yellowstone Canyon (North side)	Douglas-fir	Fine-rock soil	7,600
Ice Lake Area	Lodgepole pine	Packed soil	8,100
Upper Trout Creek	Spruce-fir	Packed soil	8,200

The duration of den-digging varied, but usually the major excavation was accomplished within 3-7 days; minor digging activity occurred over a period of weeks. Interrupted radio signals enabled us to determine when bears were digging dens, and we then located and observed them (Craighead 1968). For example, in 1966, No. 202 returned twice to his den and attenuated signals indicated he was digging; digging was visually confirmed on both occasions.

Natural shelters were not utilized as dens by grizzlies, though matted windfalls and rock caves were available. All the dens we located were dug by grizzlies (Table 4). The Yellowstone grizzly frequently digs a den entrance at the base of a tree, and tunnels in through the large downward and outward sloping roots (Figs. 6 and 7). The roots limit the size of the den opening and may form a ceiling. Although grizzlies do not always select the base of a tree for den sites, such sites are preferred. Exceptions were sow No. 187 and male No. 202, who dug their dens under horizontal logs (Fig. 8).

We believe it is instinctive for the grizzly to dig a den rather than appropriate or modify a natural cavity; some behavior supports this. For example, in the fall when grizzlies dig dens and gather boughs for beds, they also dig to cover carrion or kills more frequently than at other seasons of the year (Fig. 9). In addition, when they move to their dens prior to hibernation, they perform a stereotyped 'housecleaning' by digging inside and outside the den (Fig. 7). This seasonal increase in digging may reflect a biological drive.

The grizzly bear dens were usually constructed with an entrance way leading into the bed chamber. The average size of this chamber (determined from 10 dens) was: 56 × 53 × 37 inches. A den which sheltered No. 39 and her 3 yearlings was almost as wide as it was long. In 1966 when No. 40 hibernated with 2 cubs, her den was wider than it was long, and the 3 bears slept curled up side by side (Table 4). Females with cubs or yearlings dig wider dens than bears that hibernate alone. Den entrances went directly into the chamber, or had entrance tunnels as long as 66 inches. Width of den openings varied from 14

Species of Den Tree	Den Measurements (Inches) Chamber L	W	HT	Entrance L	W	HT	Total Length	Den Lining
Spruce	43	63	43	64	26	26	107	Conifer boughs
Whitebark pine	54	60	36	—	—	—	54	Conifer boughs
None	70	52	30	20	27	19	90	Conifer boughs
Matted vegetation	—	48	—	—	—	—	96	Den collapsed
Mat of *Vaccinium scoparium*	—	30	24	—	—	—	84	Den collapsed
Spruce	64	38	26	44	45	—	108	Partially collapsed

Fig. 6 Den of grizzly No. 101. This was abandoned and a new one dug.

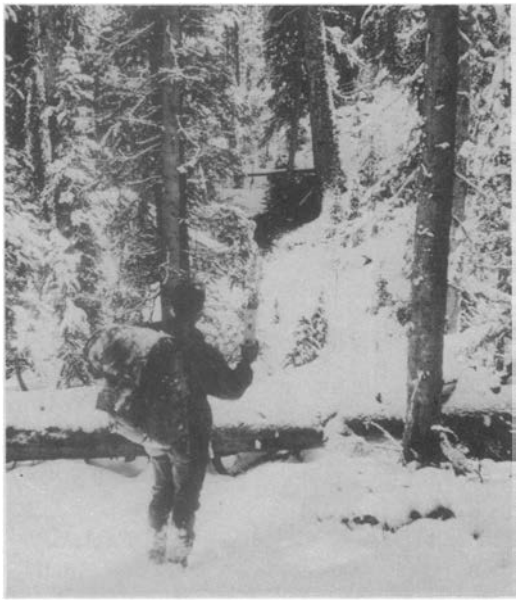

Fig. 7 Location of den of No. 40 by following transmitter signal with directional receiver. The den has been excavated at the base of a tree.

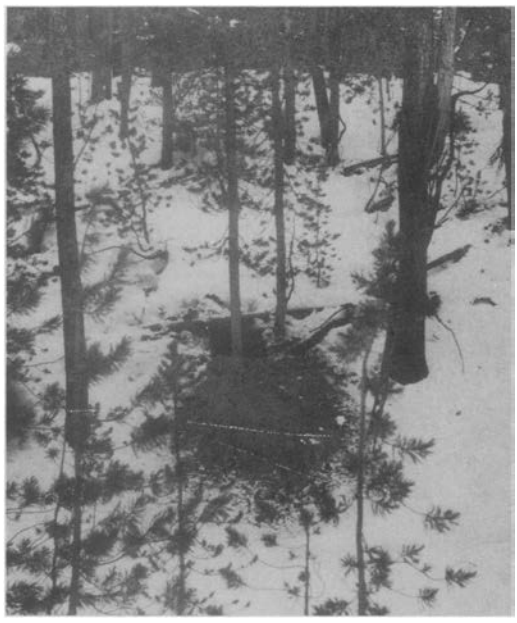

Fig. 8 Den of grizzly sow No. 187, which was abandoned prior to being lined with boughs. This was one of the few dens not dug at the base of a large tree but, instead, sited below a horizontal fallen log.

Fig. 9 Grizzly family sleeping on the remains of an elk carcass. The carcass was covered with grass and dirt when the bears were not feeding

to 33 inches and averaged 22; heights ranged from 20 to 54 inches and averaged 34.

After we located active dens by radiotracking grizzlies, a general pattern of den site preference emerged which enabled us to seek for and find dens used in previous years. The size and characteristics of six such dens are shown in Table 5.

Den Environment

Den beds were usually composed of spruce or fir boughs, 3-14 inches deep (Fig. 10). Normally boughs were chewed from spruce or fir trees growing within a radius of 50 feet of the den. During three winters when female No. 40 was not pregnant, she used conifer boughs, but when pregnant, she prepared a bed of moss and grass. Pregnant females may routinely use fine, soft material for beds. Dens are usually lined with bough beds soon after they are dug. In one case a grizzly accumulated a large pile of boughs outside the den entrance prior to starting bed construction.

The den of the grizzly bear is a very localized environment with temperatures warmer and more constant than those existing outside. In addition, when a deep insulating layer of boughs is used, many 'dead air' pockets form a microclimate next to the bear within the porous bedding material. Here the temperature is considerably warmer than the general ambient temperature of the chamber. Thus, a very narrow 'envelope' of bedding and air lies between a bear and its den.

The temperature of such a microclimate in a black bear den was recorded by placing a thermistor probe from a body temperature transmitter between the bear and his bed of dry pine needles and finely shredded twigs and rootlets

Fig. 10 Den of sow No. 40 (1966), showing the bough bed on which she and her two cubs slept side by side.

(Craighead & Craighead 1966). The maximum recorded temperature of 97°F. ± 2°F. for the microclimate closely approached the body temperature of 101°F recorded for an active bear in summer, and exceeded the average rectal temperature (96°F.) of a hibernating black bear which was monitored for 4 days (Craighead *et al.* in press). However, over a 55 minute period the temperature fluctuated between 97°F. and 83°F.

Distinctions between Daybeds and Dens

In the Yellowstone region, most grizzlies are active both day and night during the early spring months when food is relatively scarce. They are again similarly active during the fall of the year when they forage prior to entering dens for the winter. In summer, they rest during daylight hours and forage at night. They seek windfalls and dense thickets of spruce, fir and lodgepole pine in which to rest. Here they excavate daytime beds or lairs most of which vary in depth from 1 to 18 inches. Forest duff is often scraped to mineral soil. Occasionally daybeds, like winter beds, are lined with grass, pine needles or other vegetation (Fig. 11). Most beds are shallow excavations, but at times denlike burrows are dug 3 or 4 feet into slopes or under fallen logs (Fig. 12); these burrows are cooler than surface beds.

Burrow-type daybeds can be mistaken for winter dens, and occasionally a den such as that of No. 202 can resemble a daybed. However, daybeds are usually located relatively close to feeding areas, may be visited and used by different bears and are not necessarily constructed into north-facing slopes nor at the base of large trees. They may function as retreats during the breeding season. In 1964, a large boar and a female in oestrus were located in daybeds 25 feet apart. The female had dug a burrow several feet into a hillside (Fig. 12). With her body in the burrow and her head and muzzle resting on the tailings from

Fig. 11 A grizzly's daybed which has been lined. Most daybeds are unlined shallow excavations.

Fig. 12 Burrow-type daybed prepared by young female No. 6.

the cave, she could discourage unsolicited attentions from the male. Daybeds, used during the pre- and post-hibernating periods, are normally clustered around a den, but even the most elaborate of these are easily distinguished from the den itself.

Re-use of Dens

Old bedding material found in a debris pile at the den where No. 164 wintered during 1963, suggested that this den might have been used the previous year. Grizzlies No. 40 (1966) and No. 101 (1967) raked the bedding out of their dens before leaving them in spring. This suggested that they would re-use them; however, these dens and others to which we radiotracked grizzlies were never re-used. Five dens collapsed when the soil became saturated with water in late spring, and thus were not suitable for re-use; however, six remained intact (Table 4) and could have been reoccupied, but were not.

In consecutive years, grizzly No. 202 dug two dens only 300 feet apart. His first den was poorly excavated and probably inadequate for re-use the following year. The second-year den was a decided improvement; the grizzly removed an estimated ton of rock in preparing it. Although we believe that the biological drive to dig a den is instinctive, a learning process is involved and den construction improves with experience.

No feces or traces of urine have been found in recently abandoned grizzly bear dens, or even observed close to them. Harrington (1968) found that polar bears usually keep their dens clean; only traces of urine and minute fecal fragments were found in six of nine dens he examined. We have found neither feces nor urine in six active black bear dens visited while the bears were in winter sleep. Three dens were examined after immobilizing and removing the bears; all six dens were inspected in the spring after the animals left. We observed black watery excrement, passed by grizzlies prior to entering winter dens; this suggests a scouring and cleaning of the alimentary tract. The Yellowstone grizzlies normally fast from the time they enter their dens until they leave them in the spring.

Prehibernation Movement and Behavior

In the early years of the study (1960-61), we observed that grizzlies moved to their dens during a snowstorm and that tracks were not visible anywhere in the area after the storm. This suggested that certain environmental stimuli may have triggered all or most of the grizzlies to move to and enter their dens simultaneously.

Grizzlies living under the same environmental conditions entered their dens at the same time during a storm regardless of whether they were waiting close to their dens (the case of No. 40 in 1965) or were foraging at some distance. At the time of entering dens, minimum ambient air temperatures as well as maximum temperatures in shaded den sites were below the freezing level. From 1963 through 1968 we never found tracks throughout extensive areas where grizzlies had been roaming and foraging prior to the storms that put them in their dens. The nearly simultaneous entering of dens during falling snow conceals tracks that could reveal the den locations and this behavior may have survival value for the species.

Prehibernation Lethargy

In the late fall of 1965, we noticed a distinct lethargy in all grizzlies closely observed prior to hibernation.

About two weeks later on 3 November, lethargy was even more pronounced. No. 202's radio signal led us to the edge of the Yellowstone Canyon. A 3-bearing fix placed the grizzly directly below us. While we scanned the terrain with binoculars, the crash of a dislodged rock brought a roar from the grizzly lying just below. For a half hour he remained nearly motionless in a sitting-fetal posture. He appeared to be in advanced lethargy and apparently never detected us.

On 25 October 1965, we approached to within 30 feet of No. 40 in her den. She was sufficiently lethargic for our presence not to disturb her.

The lethargic condition of these bears during the fall of 1965 was comparable to the condition of lethargy that they normally attained after entering their dens in winter.

Quite possibly weather conditions in the fall of 1965 initiated lethargy early in the season and affected grizzly prehibernation behavior and movement to den sites. An early fall period of snow and unusual cold occurred from 15 through 28 September. The minimum temperature for the 18-20 September cold spell was 7°F.

The combination of early snow and low temperatures did not stimulate grizzlies to hibernate, but it did disperse some from summer to fall foraging areas, and appears to have been a factor triggering hibernation processes so that the bears became lethargic and physiologically ready to hibernate by late October, before the usual environmental stimulus of a 'final' snowstorm caused them to enter their dens for the winter on 11 November.

Defense of Dens

Information obtained with and without the use of radios indicates that the Yellowstone grizzlies are not territorial (Craighead & Craighead 1971). On a number of occasions we have observed more than 20 grizzlies at one carcass feeding together with surprisingly little friction. We have never observed the defense of a home range or compensatory movements (Craighead & Craighead 1956) or mutual avoidance (Hornocker 1970). We thought that if grizzlies defended specific areas, these areas most likely would be in the vicinity of their winter dens. Here they might also attack a man. However, we observed no overt defense of a den or den areas against either man or other grizzlies.

On 3 November 1964, after a two day trek through the snow, our radio signal of 82 pulses per minute led us to the den of grizzly No. 40. With receiver sensitivity reduced the signal indicated that we were close to the den. A growl from the cub revealed that we had found it. A patch of earth tailings darkened the snow at the den entrance which led under the base of a huge fir tree. Neither the sow nor the cub were within. We glimpsed a flash of black as the cub tardily followed his mother. Both remained hidden in the dense timber within three to four hundred yards of their den, but exhibited no agressive behavior and never attempted to come closer while we were in the vicinity.

The following day we picked up a signal at 52 pulses per minute, coming from the radio collar on the yearling grizzly No. 158. This we knew would lead us to the den of sow No. 39. We hoped to determine whether this yearling as well as his two large littermates would den with their mother (Craighead & Craighead 1969). The signal lured us deeper into the Yellowstone wilderness. Sometimes it was only a weak pulse; other times it came to us intermittently and finally strongly as we approached the den. Occasionally it halted our trek when it died out completely for long periods while the instrumented grizzly

remained in the den. In late afternoon still following the signal we entered a thicket of 'doghair' lodgepole pine. Visibility was only a few feet. A sudden increase in signal strength informed us that the instrumented grizzly and probably the entire family were moving toward us. Immediately after we climbed trees, our signal revealed that the bears were running away. Sow No. 39, a grizzly that had a record as a belligerent bear, had not attempted to defend her den.

While tracking this same sow a few weeks earlier, we had inadvertently approached to within 75 feet of her daybed. This signal from her yearling indicated that she was nearby but we were first aware of her very close proximity when her ears rose to the alert position from behind a fallen log. We retreated even more slowly and cautiously than we had approached. After climbing trees, we shouted to further alert the grizzlies and were startled by a loud roar. Within seconds our radio receiver indicated that the bears were moving away at a rapid rate. As revealed by her tracks, this ill-tempered sow had charged 20 feet through the snow in huge bounds heading directly for us. She then abruptly turned and fled in the opposite direction, an example of the bluff-like charge that is not uncommon with grizzlies.

In the fall of 1967, we approached to within 200 feet of the den of grizzly No. 101. The radio signal showed she was inside. We moved on without disturbing her. Several hours later we returned and saw fresh bear tracks leaving the den and got a faint signal on our radio receiver. We followed the tracks for a half mile through knee-deep snow. Signs showed us that after leaving the den, No. 101 crossed our trail. When she did so, she started running and urinating and the urine trail persisted for about 200 yards. We interpreted this as a physiological manifestation of fright. The female abandoned the den. Later in the season when her newly dug second den was approached, she growled threateningly, came out of the den, and retreated a short distance. We observed similar behavior at the dens of grizzlies No. 40, 164, 202 and 187.

These and other incidents, including our observation of sows Nos. 40 and 101 together at their respective den sites, suggest that grizzlies do not actively defend dens either from other bears or from humans if alternate courses of action are available to them. Grizzlies are dangerous animals but our experience over the years studying them at close range, tracking them by radio and handling them has indicated that most grizzlies respect man and although they do not fear him, they prefer to avoid him.

The most dangerous grizzlies are those that have been wounded, sows protecting cubs, and those that at one time or another have associated food directly with humans (Craighead & Craighead 1971). After such conditioning with food, they will approach so close that an overt act triggers the bear to charge, perhaps in self defense, rather than to flee.

Emergence from Hibernation

Bough and bark beds laid on the snow near the den of grizzly No. 40 and her yearlings in 1965 (Fig. 13) indicated that they had emerged from the den in late March but did not leave the den area until about 20 April. The beds were on different snow strata or levels, indicating time intervals between construction.

Other grizzlies emerged from dens 3 to 4 weeks before they left their den sites. When grizzlies first emerge, the snow is frequently too soft and deep for them to travel, and they remain at the dens until warm sunny days followed by chilly nights crust the snow so it will support their weight.

Fig. 13 Bough bed constructed in deep snow near entrance to winter den. It was made in late March.

Fig. 14 Grizzly No. 40 (instrumented) with her yearling feeding on the carcass of a drowned bison soon after they had emerged from 'hibernation'.

Our observations reveal that mature male and female grizzlies tend to leave den areas earlier than females with yearlings. Females with cubs of the year are the last to leave den sites and some may remain in the vicinity of the den until the snow has disappeared.

The carcasses of winter-killed animals (Fig. 14) form a considerable portion of the diet of grizzly bears in early spring. In addition, grizzlies kill those weakened by a severe winter. Our records include observations and authentic reports of grizzlies killing full-grown moose, bison and elk. In most cases the animals were attacked in deep snow, while crossing rivers, or when otherwise handicapped or incapacitated. Some were so close to death from malnutrition that they made no attempts to evade attack. We have a number of sight records (our own and others) of two or more grizzlies pursuing and killing elk in well-coordinated attacks. The majority of elk and bison carcasses that were utilized by grizzlies were in advanced stages of malnutrition as evidenced by bone marrow tests. The same was true of most of those that fell prey to bears (Craighead & Craighead unpub.).

A late spring with deep snow on the ground, such as occurred in 1970, can produce a higher than normal number of starving ungulates which fall prey to hungry grizzlies. Such predation is atypical except where ungulate populations exceed winter range carrying capacities. The fundamental cause of death is malnutrition, not predation.

Our observations indicate that the grizzly's role as a carnivore, prior to and immediately after hibernation, in Yellowstone is first a scavenger, second a predator on small prey species, especially when these are at high densities (Craighead & Craighead 1968) and, only last, a killer of large prey animals.

GRIZZLY BEAR MANAGEMENT

Grizzly bears constructed their winter dens in timbered areas isolated from human habitation and activities. It would appear that extensive areas of wilderness and of undeveloped Park or Forest lands are suitable for denning and in fact may be essential to the welfare of the grizzly.

The Yellowstone grizzly prefers a combination of open land habitat and dense timber (Craighead & Craighead 1963). In Yellowstone Park and surrounding National Forests, prior to winter sleep, the grizzly bears obtain the greater portion of their food in open areas dominated by sagebrush and grasses. Where such areas are isolated and denning requirements met, the grizzly is likely to 'hibernate'. To encourage a maintenance of present grizzly bear population levels, consideration should be given to managing such areas as though they were wilderness. Roading, recreation development, and heavy late fall recreation use should certainly be discouraged.

In regard to the meat portion of his diet, the grizzly is principally a scavenger and can detect and will move to 'ripe' carcasses from long distances. Some marked animals have moved airline distances of 18.5 miles to such sources of food. As many as twenty grizzlies have been observed at one time around a single carcass. Radio-instrumented grizzlies have located dead animals three miles away in three days—about the minimum time needed for a carcass to decompose to the stage where it can be readily detected by scent. In the fall of the year prior to 'hibernation' and in spring soon after emergence from 'hibernation', grizzlies can be readily attracted to carcasses. Where grizzly bear populations are low or declining the use of 'baits' to attract and shoot

grizzlies during hunting seasons should be prohibited or permitted only with reservations and with options to prevent the use of 'baits' during some seasons.

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