INTRODUCTION

In Yellowstone National Park and surrounding National Forests, an area of approximately 5,000 square miles, there are between 175 and 200 grizzly bears (Ursus arctos horribilis) (Craighead, J. and F. Craighead, 1967). This is the single largest concentration of grizzlies left in the continental United States excepting Alaska. Grizzlies have disappeared from most of the western states where they were once common. This decline has occurred from the time they were seen and collected on our western prairies in 1805 by Lewis and Clark, who recognized them as a species distinct from the black bear (Ursus Americanus, Audubon Anderson and Bachman). In just over two human life spans the grizzly has become an endangered species in the continental United States. Stover and Trevis (1955) estimate that in California alone the original grizzly bear population was around 10,000 animals. The last grizzly was seen in California in 1924.

The Yellowstone grizzly is largely nocturnal, inhabits a heavily timbered area of rugged terrain and enters his den for a winter sleep that lasts five to six months. In order to study the grizzly under these conditions it was necessary to develop and employ a radio locating and tracking system (Craighead, Craighead and Davies, 1963); (Craighead, F. and J. Craighead, 1965). This enabled us to gather data on den site selection, den construction, prehibernation behavior and denning activities as one facet of a comprehensive ecological study of the grizzly bear (Craighead, et al., 1960).

Relatively little is known of the denning activities and prehibernation behavior of wild grizzlies, nor is there much enlightenment to be found in the literature. It was generally thought that the Yellowstone grizzly, like the black bear, (Ursus americanus) Anderson and Bachman) and the European brown bear (Ursus arctos arctos) (Couturier, 1954) utilized natural shelters and caves, hollow trees, windfall and dense vegetation as a site for their "hibernation" dens. These were supposedly improved, enlarged by digging or to varying degrees prepared as a shelter for the long winter sleep. Invariably den sites and dens reported to us as those utilized by grizzlies turned out to be the dens of black bears, not grizzlies.

In November, 1963, we successfully tracked a barren female grizzly, No. 164, to her winter den (Craighead, F. and J. Craighead, 1965). As far as we know, this is the first instance where radio transmitters were used to actually track and locate a grizzly bear as it entered its winter den. Radiotracking grizzly bears to obtain information on denning and prehibernation behavior began in 1961 and continued through the fall of 1968. During this 8 year period we made 48 instrumentations of grizzly bears, 23 different grizzlies being involved. These animals were tracked or monitored for a total of over 1200 tracking days. Some were followed in deep snow for 4 consecutive days until the dens were located. Grizzly bear No. 40, (Fig. 1) was instrumented and monitored for 8 consecutive years. Seven other bears were instrumented and monitored for 2 consecutive years each. Twenty-two grizzlies, including family members, were tracked to dens. The winter dens of 6 different grizzlies were located. Information was obtained on the size, character and construction of 11 active winter or "hibernation" dens.

The term hibernation is a controversial one. Literally, it means passing the winter. The general condition is one of suspended activities, depressed metabolism, lowered body temperature and reduced heart and respiratory rates. However, differences in hibernators have produced varying definitions, these depending on the criteria set for the condition of

hibernation. For this reason a short discussion of hibernation seems appropriate. A comprehensive compilation on the subject has been presented by Lyman and Dawe (1960) and Ch. Kayser (1961). Hibernation is a condition varying in degree. Species differ in the duration of hibernation, the degree of drop in body temperature, the relation of body temperature to ambient air temperature, the accumulation of fat reserves, the depression of metabolic activities, and the variations in specialization of individual organs and tissues for functioning in the hibernating state. The bear, for example, shows less change in body functions and is generally considered less of a "true" hibernator than the ground squirrel.

If we define hibernation following Hock (1960) as "a periodic phenomenon in which body temperature falls to a low level, approximating ambient, and heart rate, metabolic rate, and other physiologic functions fall to correspondingly minimum levels", then the grizzly bear is not a hibernator. Instead of hibernation, Hock has proposed the term carnivorean lethargy. Hock has also pointed out, as have others, that due to the shortened season into which hibernators must compress their annual cycle of activities, nearly all facets of their life history and consequently their physiologic functions reflect the fact that they are constantly preparing for hibernation, hibernating, or recovering from that condition. Thus, the whole year is involved in a cyclic phenomenon that is hibernation. In northern latitudes this is true of the bear.

Those suggesting that the bear is not a hibernator point out that though 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. They can generally react quickly and energetically to disturbance and their body temperature does not approach the ambient air temperature. However, depression of the body temperature below the normal range (31° C. +) has been reported (Kalabukhov, 1956). Following anesthetizing and instrumenting of a hibernating black bear, we recorded a body temperature of 28.5° C. which gradually rose to 36.0° C. twenty-one and a half hours later (Craighead, F. and J. Craighead, 1967). Folk (1960) obtained a low heart rate of 18 ppm from a hibernating grizzly in captivity. Morrison (1960) states that it may be calculated that because of its low thermal conductance the bear cannot maintain a body temperature near the ambient air temperature. He concludes "in any event, it is clear that bears lie in the interfacial zone between animals which might last through the winter at or near their basal metabolic rates and those which cannot".

An animal's potential energy reserve is proportional to body weight in animals of all sizes, but the basal metabolic rate is weight dependent. Thus the fasting potential will vary directly with weight--the larger the animal, the lower the metabolic rate. The larger animal can thus fast longer than the smaller without a modification in metabolic level. A bear

going into winter sleep with the usual fat reserve can fast 200 days (7 months) without greatly reducing body temperature and basal metabolic rates as do "true" hibernators. Low ambient air temperatures, deep snow, and the unavailability of food appear to make hibernation or winter sleep essential to the survival of ~~bears~~ grizzlies in the Yellowstone area. Morrison (1960) suggests that the limited observed depression of body temperature and metabolism in the bear may qualify the bear as an "ecological" hibernator, and while the limited extent of these changes and the lack of adaptations for functioning at low temperatures may disqualify ~~the bear~~ him as a "physiological" hibernator. ~~Because~~ This distinction is a useful one, we will consider the bear not as a nonhibernator but as an ecological hibernator. If we recognize that the bear is superbly adapted to sleeping through long winters and in this sense is a hibernator,

Further clarification of terminology is suggested by Matson (1946) who compares hibernation to dormant state, as does Eisentraut (1933). Hibernation is considered a "torpid state"; "torpid" being defined as "having lost, partially or wholly, sensibility or the power of motion". This is a state from which the animal can be aroused only with difficulty. Bears during their winter sleep are dormant rather than torpid in the sense that they are rather easily aroused to action, and ability enhancing survival of an animal

Study Area

Yellowstone Park and the surrounding forest study area lies largely between 7,000 and 8,000 foot altitude with Electric Peak reaching an elevation of 11,155 feet, dropping to an elevation of 5,282 feet near Gardener, Montana.

Eighty to 85 percent of the area is timbered and most of this lies within the spruce-fir (Picea-abies) formation. The lodgepole pine type (Pinus contorta Dougl.), in transition to the spruce-fir climax type is the most extensive. It covers nearly 75 percent of the park (Baggley, 1936). Additional habitats have a marked influence on the grizzly bear. One of these is the sagebrush-grass type dominating dry areas of good soil for long periods before finally succumbing to the lodgepole pine and aspen (Populus tremuloides Michx.) invaders. Another is the alpine and subalpine meadow type representative of the ~~Carexpoa~~ Carex-Poa formation and characterized by grasses, sedges and numerous dwarf plants. These two open-land types in combination with timbered areas appear essential for optimum grizzly bear habitat. The open types provide the bulk of their food, the timbered areas food, daytime retreats, and denning sites. Although the timbered land consists primarily of the rather sterile lodgepole pine forests there are extensive areas where these are being invaded by young limber pine (Pinus flexilis, James) and whitebark pine (Pinus albicaulis, Engelm) both of which periodically furnish abundant pine nut crops in favorable years. A variety of berries in burned-over areas as well as huckleberries or whortleberries (Vaccinium scoparium Leidberg.) and (Vaccinium membranceum Dougl.) furnish sporadic seasonal food in the understory of timbered types.

The average maximum temperatures during the summer are in the seventies. The highest recorded temperature is 98° F. AND THE LOWEST -66°F. All areas of the Park have recorded at least -40° F. at some time. Snowfall is heavy over most of the Park which lies between 7,000 feet and 8,500 feet. Here annual snowfall averages close to 150 inches. Annual precipitation varies from an average of 13.73 to 38.26 inches. (U.S. Dept. of Commerce Climatological Summary, 1959).

Carrion forms a considerable portion of the diet of the grizzly bear and ~~so~~ its availability and abundance

grizzly bear activity and behavior prior to and following hibernation.

~~to some extent~~ influences ~~prehibernation behavior~~. Estimated populations of large mammal species include: Black bear, 500, Pronghorn (Antilocapra americana) 170, Bighorn sheep (Ovis canadensis, Shaw) 600, Bison (Bison bison) 580, mule deer (Odocoileus hemionus Rafinesaue) in winter 500, elk (Cervus canadensis Linnaeus) in winter 8,300 and moose (Alces alces, Nelson) in summer 450. (Dept. of Interior, 1970).

Carnivores sufficiently numerous to compete with the grizzly for food include the coyote (Canis latrans, Merriam) black bear and badger (Taxidea taxus Shreber).

Methods and Materials

Information on prehibernation behavior and denning activities of grizzlies was obtained by means of radiotracking. This was accomplished by plotting the position and movements of bears from

the intersection of bearings (fixes) made from a distance (Fig. 3). Then by moving in on foot, guided by portable directional receivers, the grizzlies were observed at close range. Changes in signal strength and regularity also provided information (Craighead, F. and J. Craighead, 1965). For example, an interrupted signal often indicated that a grizzly was either digging a den or moving in or out of a den.

The radiotracking system was designed so as to be as flexible and as portable as possible, thus making it of maximum use in various types of field work. Basically, the system consists of transmitter-collar assemblies that are placed around the necks of the bears (Fig. 2). A padded tuned loop-antenna acts as a collar. The transmitters are variously pulsed so that individual bears can be identified by the different pulse rates. The signal is picked up by portable, fully-transistorized receivers that are directional when used with various types of antennas. With the hand-held portable receiver, a loop antenna was employed in conjunction with a sense antenna (whip).

The equally sensitive lobes of the loop antenna resulted in a 180 degree ambiguity, making it difficult to determine signal direction unless the sense antenna was activated. This suppressed one lobe of the loop antenna pattern, thus providing a 13 db suppression of the reverse lobe and a 3 db enhancement of the forward lobe, giving a 16 db front-to-back ratio (Varney,

Observations of marked animals, made during the fall period of dispersal to den sites, revealed that some grizzlies traveled even greater distances than those measured by radio. Some definitely traveled beyond the boundaries of Yellowstone National Park. Following far ranging grizzlies at this time of year was difficult as travel was limited to hiking in snow varying from 6-18" deep. This is a fall-winter transition period where the use of snowshoes or skis is not practical. - 24 -

Grizzly Bear Daybeds

Grizzly bears tend to be more active at night than during daylight hours, but activity patterns vary with seasons, food abundance and with other factors. 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 foraging prior to entering dens for their winter sleep. In summer they rest during daylight hours and forage at night. A regular supply of food from earth-filled garbage dumps to some extent influences the grizzly's twenty-four hour activity pattern in summer. This food supply permits some grizzlies to rest more than might be customary in summer and tends to congregate grizzlies in favored daytime retreats. A twenty-four hour activity pattern obtained by radio monitoring from Grizzly #40 frequenting the dump area revealed that she spent 15.2% of her time feeding and 84.5% resting. ~~(Figure)~~. This pattern appeared typical of summer activity and was obtained in late August using an accelerometer or activity transmitter. Grizzlies usually rest in protected retreats such as windfall and dense thickets of spruce, fir and lodgepole pine. Here they rake out shallow daytime beds or lairs, usually only a few inches deep. The forest duff is often scraped to mineral soil. Occasionally the daytime bed is lined with grass or other vegetation but such beds are an exception. These beds, or others prepared close by, are sometimes used day after day by the same animals. A mother and her family will repose close together, several to twenty feet apart. Litters of cubs, yearlings and even two-year olds that have for one reason or another been temporarily or permanently separated from the mother also often spend the daylight hours resting together.

Most beds are shallow excavations, but rarely, one is dug that is a den-like burrow. These are in slopes or go back under fallen logs and are sufficiently large and deep to provide cover and shelter for the bear. Such excavations provide cooler temperatures than surface beds and may also enable the grizzlies to avoid ~~get away from~~ flies.

In Hayden Valley where grizzlies have congregated during the summer months due to artificial food supplies, the animals seek nearby timbered areas or

"timbered islands" as daytime retreats. Under these circumstances it has not been unusual to jump five or six grizzlies from beds only several hundred feet apart. Such concentrations of daytime beds seem to be associated with a local and continuous seasonal source of food. Out of literally hundreds of daybeds observed, most have been located either in very dense stands of timber or in extensive lodgepole windfall. Often a downed tree whose protruding roots with clinging soil, providing both a natural depression and a wall-like earth barrier, will be used as a daybed site. When a grizzly returns repeatedly to a resting area or retreat, the site is characterized by defecations in the general area of the daybeds.

It is possible that one of the rather rare ~~cave-like~~ BURROW TYPE daybeds might be mistaken for a winter den. However, the location is quite different. Such beds are usually located relatively close to feeding areas and they are not as isolated from the human or the bear communities as are the winter dens. Unlike winter dens, they are not necessarily constructed into north facing slopes nor at the base of large trees.

Grizzlies dislike being disturbed from their daytime beds. By following radio signals to instrumented bears, we have approached some to within a distance of 30 to 40 feet before they ran away. On one occasion during the breeding season a large uninstrumented boar was approached to within 100 feet before we spotted him and backed away without disturbing his slumbers. The average distance at which most grizzlies have been flushed from their daytime beds is about 125 feet. However, many could have been approached much closer had not the immediate presence of a ~~boar~~ BEAR been indicated by the radio-signal and sufficient noise, MADE ~~mostly~~ to warn the sleeping animals of our approach.

During the breeding season in 1964, a large boar and sow No. 7 in estrus were located in daybeds prepared twenty-five feet apart. The sow's bed was dug several feet back into a hillside and the sow rested with her body in the burrow and her head and chin on the pile of earth scooped out to make the cave. Such a daybed would discourage unsolicited attentions from the male during the breeding season, and may be an explanation for preparing this type of daybed. Another

(age)

hundred yards from these beds we jumped a young grizzly sow, #6, the daughter of #7. Mother and daughter were bedded close together and this suggest a family association that with certain individuals appears to continue for quite a few years after weaning.

In most other instances the beds of boars and sows and boars and family groups were well separated. Adult members of both sexes do not associate closely except during the breeding season (Craighead, J. et al., 1969).

Relation of Den Site to Home Range

Two types of grizzly bear seasonal and home range patterns were plotted and delineated by means of radio-tracking (Craighead, 1968). One consisted of a distinct continuous area over which the grizzlies wandered and foraged throughout the year or during spring, summer, and fall. The home range unit contained winter den sites or a den. The other range pattern consisted of summer and early fall foraging areas, often widely separated from an early-spring and late-fall area that contained the winter den. The latter pattern can be visualized as 2 distinct seasonal ranges, with the bear often traveling rapidly from one to the other. The home range of an animal provides all the essentials for life of the individual and thus by definition includes its den site. Den site selection, location and prehibernation behavior are to a certain extent influenced by the range size and pattern. They are also

Period of Winter Sleep

~~In 1966~~, On December 28, 1966 we visited the winter den of grizzly No. 40 approaching the den carefully and quietly from below on snowshoes. The den entrance was open though contracted by snow. ~~There were~~ No signs ~~to~~ indicated that the bears had ~~moved out of~~ left the den since entering in November.

To peer into the den, it was necessary to lie down with feet slightly elevated. In this position we were approximately 5' from the sleeping sow and her 2 grown cubs. The 3 grizzlies were lethargic and sleeping, but apparently the sow detected our presence for she growled and shifted her position. At the risk of eliciting a charge from the grizzly, we took flash pictures and movies of the den entrance and portions of the bough bed within. The grizzlies ~~were~~ though awakened were sufficiently lethargic ~~enough~~ that they did not ~~respond by coming~~ come out of the den.

The Yellowstone grizzly mates in June and early July but a delayed implantation occurs (Craighead, 1969) which delays embryonic development and parturition. Whelping occurs during hibernation within the winter den but no dates have been obtained through observation of ~~bears~~ litters in the ~~wild~~ den. January or February would seem to be the most likely months. No feces or traces of urine have been found in active dens recently abandoned, or even observed close to them. Apparently the grizzlies do not drink nor urinate during the winter sleep. Harrington (1968) states that polar bears usually keep their dens clean. He found only mere traces of urine and minute fecal fragments in 6 of 9 dens examined. Prior to entering winter dens we have observed black watery excrement suggesting a scouring and cleaning of the alimentary track. The Yellowstone grizzlies fast from the time they enter their dens until they leave them in the spring.

Occasionally a grizzly emerges from its den in mid-winter. One of 2 records was in response to a nearby food supply when a grizzly in the Old Faithful area came out in the latter part of February, 1967. The bear was attracted to the carcass of an elk that had either been killed or had died in the vicinity of the den.

Mid-winter emergence, however, in this area is not a common event.

Emergence from Hibernation

In general the Yellowstone grizzlies remain in their winter dens from the time they enter them in late October or November until early April. Deep, snow alone precludes travel. Tracks observed as early as April 4 indicate possible emergence from a den in late March. Signs outside the den of grizzly No. 40 in 1965 indicated emergence in late March. The grizzlies are not noticeably thin when they leave their dens and start traveling in search of food even though they live off their body food reserves for annual periods varying from 5-6 months. Some grizzlies emerge from their dens as much as 3 weeks to a month before they leave the den site for spring feeding areas. Often when they first emerge the snow is too soft and deep for the bears to travel. They remain in the vicinity of the dens until sunny days with warming temperatures, followed by chilly nights, produce a crust on the snow that will support their weight.

In the spring of 1965, No. 40 and her yearling came out of their den in late March and left the den site about April 20. Prior to leaving they built bough beds on the snow within several hundred feet of the den entrance. The beds were on different snow strata or levels indicating intervals between times of construction. The bears slept on these beds and were covered by snow from subsequent storms. As the snow piled up over the sleeping grizzlies, their breathing produced an air shaft to the surface (Fig. 13).

Apparently the bears continued in a lethargic state but were sleeping on bough beds on the snow surface rather than within the den. One suggested reason for early emergence from the den is that in the spring of the year, the outside air temperatures, at least during the day, are often warmer than those within the den. At 10:45 a.m. on April 28, 1965, the air temperature inside the den of No. 40 was 0° C. (32° F.). The air temperature in the shade, outside of the den and 3' above the snow was +4.4° C. (40° F.). The ambient air temperature in the sun was +10.0° C. (50° F.). In 1967, sow No. 40 emerged from hibernation with another family of yearlings. On this occasion they left the den area without building bough beds as was done in the spring of 1965.

Insert A

Our observations reveal that mature male grizzlies and sows tend to leave winter den areas earlier than sows with yearlings. Sows with cubs of the year are the last to leave

Insert 17

The carcasses of winter killed animals form a considerably portion of the spring diet of grizzly bears. Animals that died during winter--elk that expired with the coming of spring, buffalo that drowned crossing rivers on weak ice are readily detected and are quickly consumed by the hungry grizzly. In addition, these same ungulates, weakened by a severe winter, fall prey to the grizzlies. Our records include observations and authentic reports of grizzlies killing full-grown moose, buffalo and elk. In most cases the animals were attacked in deep snow or when otherwise incapacitated by their weakened condition. In other instances grizzlies pounced on the animal while it was lying down. A late spring such as occurred in 1970, with more than the usual snow depth can result in greater than usual spring predation by grizzly bears on large ungulates handicaped by sickness or weakened by starvation. Such predation is atypical. Later, In early summer an occasional elk calf falls prey to a marauding grizzly. However, the grizzly is not an efficient predator on large game species and the effect of their depredations on a population of ungulates does not act as a significant control. The grizzly's role as a meat eater or carnivore is first a scavenger, secondly a predator on small prey species, expecially at high population densities, and finally a killer of large prey animals.

During the summer months when other food is available, grizzlies will seldom attempt to take large prey species. The radiotracking of grizzlies indicated that they paid very little attention to elk as a source of food during the summer months. The elk in turn showed little concern over the close presence or approach of grizzlies. For example, while tracking sow No. 34 we caught sight of two cow elk standing quietly in the dense windfall and timber. Neither elk showed signs of alarm or uneasiness either before or after we jumped three grizzlies. The elk were about 75 yards from the one grizzly and less than 50 yards from the daybeds of the others. Even though the grizzlies ran quite close to the elk, they remained quiet and did not run or stampede. The dense timber with windfall was such that grizzlies could traverse it much easier than could elk. It was apparent that the grizzlies could have readily caught the elk had they attempted to do so, but they showed no interest at all. This instance is typical of numerous others where we have observed grizzlies and elk in the same habitats during the summer months.

Grizzly Bear Prehibernation and Denning Activities as Determined by Radiotracking

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John J. Craighead

Abstract

Over an 8 year period grizzly bears were studied by means of radiotracking. Eleven active dens were located and information gathered on den selection, location and construction as well as on prehibernation behavior. Den selection and digging may occur as early as September 3. Dens were dug entirely by the grizzlies and no natural shelters utilized. Dens were not large and all bed chambers were lined with boughs. No dens were re-used. It appears that den digging is instinctive behavior for the grizzly reinforced by experience. Grizzlies traveled from fall foraging areas to den sites over distances varying from a few miles to 30 or more. The dates that grizzlies entered dens for their winter sleep was influenced by environmental factors and varied by as much as a month over a 9 year period. All grizzlies living under the same environmental conditions hibernated at the same time. They entered their dens during a snow storm. This tends to eliminate tracks and appears to have survival value for the bear in protecting and isolating the grizzly during the vulnerable period of his life.

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← Prehibernation Bear-Man ~~Relationships~~ Encounters

~~During Denning and Pre-hibernation~~

Thousands of observations made of grizzlies over a ~~twelve~~ 12-year period as well as those obtained through radio-tracking indicated that there was little or no territorial defense even around carcasses on which the bears fed. We have observed more than ~~twenty~~ 20 grizzlies at one carcass feeding together with surprisingly little friction. When grizzlies feeding on carcasses were approached they tended to flee rather than to make a defensive stand. There were occasions when they ran toward us making it necessary to seek the safety of trees. These were not attacks, but situations wherein the grizzlies had detected us but had not pinpointed our position. We felt that perhaps if any real defense of an area was to be exhibited toward other bears it might be in the vicinity of a winter den. This might also be a site and a situation wherein they would more readily attack man.

Grizzly bears tend to avoid a man, but when confronted are definitely much more aggressive animals than black bears. However, ~~in twelve years of studying~~ DURING THE COURSE OF THE YELLOWSTONE and handling them in Yellowstone, we never once had to shoot a grizzly due to aggressive behavior or for any other reason. A few of the following examples are typical of our experiences with grizzlies at den sites, at carcasses, and at daybeds during late fall, just prior to entering dens.

Insert H

On November 3, 1964, after trudging through the snow for two days, our radio signal of 82 pulses per minute led us to the den of grizzly No. 40. With receiver sensitivity reduced ~~When~~ the signal indicated that we were close to the den, a growl from the cub revealed that we had found it. ~~Directly in front of us~~ a patch of earth tailings darkening the snow revealed the den entrance leading under at the base of a huge fir tree. Neither the sow nor the cub ~~was inside~~ WERE within. We glimpsed a flash of black as the cub tardily followed his mother. ~~This sow~~ Both remained hidden in the dense timber within 3-4 hundred yards of her den, but exhibited no aggressive behavior and never attempted to come closer while we were in the vicinity. ~~Near noon the next day~~ we picked up another signal ~~pulsed~~ at 52 ~~"beeps"~~ pulses per minute coming. ~~This came from the~~

V The following day

this we knew would lead us to the den of sow No. 39

radio collar on the yearling grizzly No. 158. We ~~were anxious to see if~~ hoped to determine whether this yearling as well as his other two large littermates would den with their mother, ~~sow No. 39~~. ~~For the rest of the day~~ Then 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 ~~confused~~ halted our ~~navigator~~ tracker when it died out completely for long periods while the instrumented grizzly remained in the den. ~~At 5:00 p.m. (1700 MST)~~ In late afternoon still following the signal, we entered a thicket of "doghair" lodgepole growing beneath towering pines. ~~Here~~ Visibility was ~~almost zero~~ only a few feet. ~~In this vulnerable spot,~~ a sudden increase in signal strength indicated that the instrumented grizzly and probably the entire family were moving ~~rapidly~~ toward us. Immediately after climbing trees, our signal revealed that the bears were running away. With the receiver sensitivity and volume completely down we knew that the bears had to be alarmingly close. The distance separating us could not be much over a hundred yards. From past experience, we knew that sow No. 39 was an unusually aggressive female so we immediately selected lodgepole pines and shinnied up these trees until we reached a limb. From our perch in the trees, the signal though loud, was diminshing. The bears had approached to within approximately 100 yards of us, then had turned and run off at a rapid rate. Sow No. 39, ~~and her yearlings~~, a grizzly that had a record ~~of at least~~ as a belligerent bear several charges, but without contact, and once had made an aborted charge from her daybed, had not ~~remained~~ attempted to defend her den.

While tracking this ~~belligerent~~ same sow a few weeks before she ~~went into~~ moved to her den site "~~hibernation~~", we had inadvertently approached to within 75 feet of her. The signal from her yearling indicated that she was nearby but we were first aware ~~that we were too close to her~~ of her very close proximity when we saw her ears rise to the alert position from behind a fallen log. We ~~immediately backed off~~ retreated even more slowly and ~~quietly~~ cautiously than we had approached. ~~Our research team climbed~~ and climbed trees or selected ones that could be climbed, ~~if necessary~~. After climbing trees, we then shouted ~~in order~~ to further alert ~~disturb~~ the grizzlies and ~~we~~ were ~~suddenly~~ startled by a ~~frightening~~ loud roar, ~~that started~~ us that stimulated climbing. shinnying up the nearly ~~limbless lodgepole pines to a safe heighth~~. Within seconds, our radio receiver indicated that the bears were moving away at a rapid rate. ~~When we later~~

approached the daytime bed we found that this ill-tempered sow had charged toward us through the snow in huge bounds heading directly toward us for a distance of about 20 feet. It was probably at this time that she uttered the roar. She then turned and fled in the opposite direction, This was an example of a bluff-like charge, one that is not uncommon with grizzlies.

On another occasion, not in the vicinity of a den, a mother with cubs charged and came to within about 30 feet before suddenly braking her onward rush so abruptly that her body flattened out like the head and neck of a cobra. Although she could have readily completed her attack and severely mauled one or more of our team, she turned and rapidly retreated.

Another time, a large boar approached the carcass of an elk on which he had been feeding. Three of us were beside the carcass when we saw him come out of the timber and start running toward us. We immediately began to back away from the carcass, but the nearest tree offering protection was more than a half-mile away. This animal had apparently seen movement and came toward the carcass at a fast run, stopping occasionally to rear up on his hind legs in an attempt to get an identifying scent. He then plunged forward again, his action giving the appearance of an awesome attack and was indeed terrifying. However, when this boar to all appearances charging us, reached the carcass, he detected the human scent. At this moment, he instantly turned and ran in the opposite direction.

In 1968, we tracked sow No. 101 to her den site, but approached only close enough to make sure that we had found the den. Signals monitored in subsequent days indicated that the sow was not returning to the den and we suspected that she had abandoned it. Close approach proved that this was the case, as there were no fresh tracks in the vicinity. A few days later we followed the signal to the spot where the sow had been digging a new den as determined by the interrupted signals. When we were within several hundred feet of the den situated in very dense tree growth and some windfall, the sow growled and then retreated. Hindered as we were by the deep snow and fallen timber, the sow could have readily charged us with probably disasterous results.

However, her reaction was only a threatening growl. These and other incidents including our observations 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. Bear--man encounters resulting in maulings or death can usually be attributed to some action taken by the human intruder which has threatened the animal or taken the bear by surprise. We have found this to be true with grizzlies that have habitually come in to feed at dumps on artificial or man-supplied sources of food as well as those that sparingly utilize this type of food. The most dangerous grizzlies are those that have been wounded, some with cubs and those that at one time or another have associated food directly with humans. been fed by humans so that they have learned to associate man directly with food, thus losing their fear and respect for him. After such conditioning they will approach close enough to humans that an overt act triggers the bears' instinct to charge rather than to flee.

the carcass of an animal with dirt, grass, and brush. The animal may be one having died of natural causes or more rarely an animal killed by the grizzlies. They are not consistent in burying a carcass, nor are the reasons for the variable behavior readily evident. The subject will not be elaborated here with the exception of reference to lethargic behavior.

In 1960, we observed grizzlies burying or covering the carcasses of elk as early as September 21. This phenomenon continued throughout the fall. When we approached grizzlies feeding on carcasses, we found some sleeping either on or beside their food supply. This was observed as early as October 14 and might have been interpreted as the onset of winter lethargy except when alerted they always took off on a dead run and were quite active. Apparently sleeping on the carcass was related to the heavy meals the bears had consumed rather than to any physiological changes connected with the hypothermic lethargy of winter sleep, as observed in the fall of 1965.

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Grizzly Bear Prehibernation and Denning Activities as Determined by Radiotracking

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Abstract

Over an 8 year period grizzly bears were studied by means of radiotracking. Eleven active dens were located and information gathered on den selection, location and construction as well as on prehibernation behavior. Den selection and digging may occur as early as September 3. Dens were dug entirely by the grizzlies and no natural shelters utilized. Dens were not large and all bed chambers were lined with boughs. No dens were reused. It appears that den digging is instinctive behavior for the grizzly reinforced by experience. Grizzlies traveled from fall foraging areas to den sites over distances varying from a few miles to 30 or more. The dates that grizzlies entered dens for their winter sleep was influenced by environmental factors and varied by as much as a month over a nine year period. All grizzlies living under the same environmental conditions hibernated at the same time. They entered their dens during a snow storm. This tends to eliminate tracks and appears to have survival value for the bear in protecting and isolating the grizzly during the vulnerable period of his life.

In the fall of 1965 a prehibernation lethargy was observed in grizzlies prior to entering the dens. This premature onset of lethargy appeared to be influenced by an unusual early cold spell.

Introduction

The grizzly bear (*Ursus arctos horribilis*) is largely nocturnal and the Yellowstone grizzly enters his den for a winter sleep that lasts five to six months. This remnant population of 175 to 200 grizzlies inhabit an area of about 5,000 square miles, 75 to 80 per cent timbered. In order to study the grizzly under these conditions it was necessary to develop and employ a radio locating and tracking system (Craighead, Craighead, and Davies, 1963); Craighead, F., and J. Craighead, 1965). This enabled us to gather data on den site selection, den construction, prehibernation behavior, and denning activities as one facet of a comprehensive ecological study of the grizzly bear (Craighead, *et al.*, 1960).

Relatively little is known of the denning activities and prehibernation behavior of wild grizzlies, nor is there much enlightenment to be found in the literature. It was generally thought that the Yellowstone grizzly, like the black bear (*Ursus americanus*) and the European brown bear (*Ursus arctos arctos*) (Couturier, 1954) utilized natural shelters and caves, hollow trees, windfall and dense vegetation as a site for their "hibernation" dens. These were supposedly improved, enlarged by digging or to varying degrees prepared as a shelter for the long winter sleep. Invariably den sites and dens reported to us as those utilized by grizzlies turned out to be the dens of black bears, not grizzlies.

In November, 1963, we successfully tracked a barren female grizzly, No. 164, to her winter den (Craighead, F. and J. Craighead, 1965). As far as we know, this is the first instance where radio transmitters were used to actually track and locate a grizzly bear as it entered its winter den. Radiotracking grizzly bears to obtain information on denning and prehibernation behavior began in 1961 and continued through the fall of 1968. During this eight year period we made 48 instrumentations of grizzly bears, 23 different grizzlies being involved. These animals were tracked or monitored for a total of over 1200 tracking days. Some were followed in deep snow for four consecutive days until the dens were located. Grizzly bear No. 40, (Fig. 1) was instrumented and monitored for eight consecutive years. Seven other bears were instrumented and monitored for two consecutive years each. Twenty-~~two~~ one grizzlies, including family members, were tracked to dens. The winter dens of six (6) different grizzlies were located. Information was obtained on the size, character and construction of eleven (11) active dens.

The term hibernation is a controversial one. Literally, it means passing the winter. The general condition is one of suspended activities, depressed metabolism, lowered body temperature and reduced heart and respiratory rates. However, differences in hibernators have produced varying definitions, these depending on the criteria set for the condition of

hibernation. For this reason a short discussion of hibernation seems imperative. A comprehensive compilation on the subject has been presented by Lyman and Dawe (1960) and Ch. Kayser (1961). Hibernation is a condition varying in degree. Species differ in the duration of hibernation, the degree of drop in body temperature, the relation of body temperature to ambient AIR temperature, the accumulation of fat reserves, the depression of metabolic activities, and the variations in specialization of individual organs and tissues for functioning in the hibernating state. The bear, for example, shows less change in body functions and is less of a "true" hibernator than the ground squirrel.

If we define hibernation following Hock (1960) as "a periodic phenomenon in which body temperature falls to a low level, approximating ambient AIR, and heart rate, metabolic rate, and other physiologic functions fall to correspondingly minimum levels", then the grizzly bear is not a hibernator. Instead of hibernation, Hock has proposed the term carnivorean lethargy. Hock has also pointed out, as have others, that due to the shortened season into which hibernators must compress their annual cycle of activities, nearly all facets of their life history and consequently their physiologic functions reflect the fact that they are constantly preparing for hibernation, hibernating, or recovering from that condition. Thus, the whole year is involved in a cyclic phenomenon that is hibernation. In northern latitudes this is true of the bear.

Those suggesting that the bear is not a hibernator point out that though 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. They can generally react quickly and energetically to disturbance and their body temperature does not approach the ambient temperature. However, depression of the body temperature below the normal range (31° + C.) has been reported (Kalabukhov, 1965). Following anesthetizing and instrumenting of a hibernating black bear, we recorded a body temperature of 28.5° C. which gradually rose to 36.0° C. twenty-one and a half hours later (Craighead, F. and J. Craighead, 1967). Folk (1960) obtained a low heart rate of 18 ppm from a hibernating grizzly in captivity. Morrison (1960) states that it may be calculated that because of its low thermal conductance the bear cannot maintain a body temperature near the ambient temperature. He concludes "in any event, it is clear that bears lie in the interfacial zone between animals which might last through the winter at or near their basal metabolic rates and those which cannot".

An animal's potential energy reserve is proportional to body weight in animals of all sizes, but the basal metabolic rate is weight dependent. Thus the fasting potential will vary directly with weight/--/the larger the animal, the lower the metabolic rate. The larger animal can thus fast longer than the smaller without a modification in metabolic level. A bear

going into winter sleep with the usual fat reserve can fast 200 days (7 months) without greatly reducing body temperature and basal metabolic rates as do "true" hibernators. Low ambient temperatures, deep snow, and the unavailability of food appear to make hibernation or winter sleep essential to the survival of bears in the Yellowstone area. Morrison (1960) suggests that the limited observed depression of body temperature and metabolism in the bear may qualify the bear as an "ecological" hibernator, while the limited extent of these changes and the lack of adaptations for functioning at low temperatures may disqualify the bear as a "physiological" hibernator. Because this distinction is a useful one, we will consider the bear not as a nonhibernator but as an ecological hibernator.

Further clarification of terminology is suggested by Matson (1946) who compares hibernation to dormant state, as does Eisentraut (1933). Hibernation is considered a "torpid state"; "Torpid" being defined as "having lost, partially or wholly, sensibility or the power of motion". This is a state from which the animal can be aroused only with difficulty. Bears during their winter sleep are dormant rather than torpid in the sense that they are rather easily aroused to action.

Methods and Materials

Information on prehibernation behavior and denning activities of grizzlies was obtained by means of radiotracking. This was accomplished by plotting the position and movements of bears from

the intersection of bearings (fixes) made from a distance (Fig. 3). Then by moving in on foot, guided by portable directional receivers, the grizzlies were observed at close range. Changes in signal strength and regularity also provided information (Craighead, F. and J. Craighead, 1965). For example, an interrupted signal often indicated that a grizzly was either digging a den or moving in or out of a den.

The radiotracking system was designed so as to be as flexible and as portable as possible, thus making it of maximum use in various types of field work. Basically, the system consists of transmitter-collar assemblies that are placed around the necks of the bears (Fig. 2). A padded tuned loop-antenna acts as a collar. The transmitters are variously pulsed so that individual bears can be identified by the different pulse rates. The signal is picked up by portable, fully-transistorized receivers that are directional when used with various types of antennas. With the hand-held portable receiver, a loop antenna was employed in conjunction with a sense antenna (whip).

The equally sensitive lobes of the loop antenna resulted in a 180 degree ambiguity, making it difficult to determine signal direction unless the sense antenna was activated. This suppressed one lobe of the loop antenna pattern, thus providing a 13 db suppression of the reverse lobe and a 3 db enhancement of the forward lobe, giving a 16 db front-to-back ratio (Varney,

1963). In practice, this proved very effective in accurately determining signal direction.

The base station antenna was a five-element yagi and for the mobile units, a three-element yagi antenna and a portable quad antenna were utilized. The system thus consisted of a base station, a field station, several mobile tracking units and the portable hand-held tracking receivers. The radio frequency utilized was 32.02 mc. The output of the transmitters was approximately 100 milliwatt pulses when powered by seven Mallory mercury cells, type 1450 in series. The range varied from 15-20 miles with a five-element receiving antenna to 2-3 miles with the portable receivers and loop antenna under average conditions of terrain and shielding effect. The maximum life of the continuously pulsed transmitters was over three months and the life of the extended-life transmitters, with an ON-OFF period of 10 and 20 seconds, respectively, was approximately one year. The performance of the system is difficult to express in terms of degree of accuracy or percentage of error of bearings. This is due largely to the varying conditions under which the work was carried out. However, some idea of system performance can be obtained through the citing of examples. For instance, a transmitter dropped by a grizzly was recovered using a bearing made from a distance of nine miles. When two miles away, we "homed in", with a portable receiver and sighted the radio-collar in a depression when 15 feet away.

The average distance at which we jumped instrumented grizzlies from daybeds in dense timber and windfall was 125 feet. Locating grizzly No. 150 on two consecutive days (October 10-11, 1964) was typical of our tracking operations. The grizzly was located and jumped eight miles from our base station to the north and three from the field station. The bearing from base was 2.5 degrees in error. Terrain conditions were such that the receiving station was 120 feet lower than the grizzly with an intervening timbered ridge rising several hundred feet above the instrumented animal. This shielding ridge was 300 to 400 feet above many of the locales where grizzly No. 150 was monitored from base.

In 1964, when grizzly No. 40 and grizzly No. 158 were radio-tracked to their dens, field station bearings, as verified later, went directly through the den site of No. 40 and slightly to the east of No. 158's den.

Results

Den Site Selection

The winter dens of six different grizzlies have been located, some for consecutive seasons. Thus eleven active dens have been found and information obtained on site preference, den size and construction. All dens were located either while they were being constructed, or at close to the time the bears entered them for their winter sleep.

Information on den site selection was obtained by instrumenting grizzlies in the fall of the year with radio transmitters (Fig. 1). In 1961 and 1962, we were unable to track the radio-tagged bears to their dens. Our first successful tracking occurred in 1963 with improvements in equipment performance (Varney, 1963). Tracking grizzlies to their dens became routine after this. Observations and sight-tracking of grizzlies in the fall of 1960, 1961, and 1962, provided us with information on hibernation dates. Thereafter (1963-1967) radio-tracking revealed the dens as well as the dates when the grizzlies entered them to remain for the winter. These were:

Year	Month	No. of Dens
1960	October 29	0
1961	October 21-22	0
1962	November 15 (approximately)	0
1963	November 3-4	1
1964	November 10	2
1965	November 11	2
1966	November 19-21	3
1967	November 19	3 (1)
1968	November 3-4	1

The dates through 1962 were obtained by observing movement of grizzlies during snowstorms with lack of tracks thereafter. The date at which grizzlies entered their dens to remain varied by as much as a month over a nine year period.

The grizzlies whose dens were located hibernated at altitudes ranging from 7800 to 9200 feet (Table 1). Those ranging and foraging at altitudes two to three thousand feet lower, as at Mammouth or Gardiner, Montana did not hibernate simultaneously with those distributed throughout the Yellowstone Central Plateau.

All dens were located in timbered areas and all but one on northern slopes with the den entrance facing north. Couturier (1954) found the brown bears preferred a den that faced south. A north-facing den entrance appears to be advantageous to the hibernating Yellowstone grizzly. Prevailing southwest winds accumulate snow on northern exposures where there is less chance of snow melting during a warm period or winter chinook. Water trickling into a den would certainly be disturbing and undesirable. The deep snow that accumulates in such locations insulates the den chamber from the extreme ambient temperatures that may drop as low as (-40 to -60° F.) Though grizzlies den throughout the Park and beyond, all active dens were located in the general area of Hayden Valley. All dens, except those that were abandoned prior to using them, were lined with conifer boughs or other bed material (Fig. 4). Dens were located relatively far from human habitation or human activity. For example, the winter dens of the young male grizzly No. 202 were dug in

rocks on a forty-five degree talus slope in a steep, nearly inaccessible part of the Yellowstone Canyon. Snow avalanches run down these slopes each spring. Huge rocks periodically break off from the cliffs and start small rock avalanches on the slopes below. There are few trees not deeply scarred by the careening rocks. Islands of timber, some containing quite large trees, have established themselves between the avalanche runs. However, even these do not appear to be a safe place for a bear to hibernate; yet No. 202 dug his dens in such a spot. The common denominator that these and other known den locations seem to provide is isolation. Conceivably this need for isolation is so imperative that young insecure grizzlies unknowingly risk destruction by avalanches while assuring privacy for winter sleep. These dens were difficult to approach in summer and practically impossible to reach after the first snow.

Isolation emerges as a factor that the grizzlies need and seek when spending six months of their lives under rather vulnerable conditions. Primitive man and the American Indian undoubtedly found that the odds were far more favorable for killing a lethargic grizzly during winter sleep than when active in summer. In the course of evolution seeking isolation during hibernation would be a factor favoring survival of the species.

Bears of both sexes and a variety of age classes were tracked to winter dens. These included one young adult female (barren), one young adult female with her first cub, two adult pregnant females, two adult females with cubs, and two adult females with yearlings (Table 3). One of these was a rather old bear. Two young male bears were tracked to their dens, one as a weaned yearling and again as a two year old; another as a yearling with his mother and two littermates (Fig. 2). Very large boars were instrumented and tracked to denning areas but none successfully tracked to winter dens. The dens of one female grizzly were located four times and for three consecutive seasons; the dens of two other bears, for two successive years (Table 1).

An orphaned grizzly cub No. 78 was observed up to hibernation time and soon after emerging. He apparently had no trouble surviving the winter without parental care or guidance.

Den Construction

Most grizzlies prepared winter dens well in advance of the time that they went into hibernation. The earliest recorded den diggings were September 3 and September 8 (Table 3). The latest occurred November 11, 1967 and November 15, 1966, the bears completing the dens just in time to enter them for the winter. In these latter cases den construction had been delayed by abandonment of previously prepared dens or had been influenced

by one kind of distrubance or another which affected or altered the behavior of the animal. We usually did not approach dens closer than a hundred feet, but even so some were abandoned (Den of No. 101 in both 1966 and 1967, No. 187 in 1967). Individuals varied considerably in the degree of disturbance needed to cause abandonment of a completed den. Dates of den digging activity shown in Table 3 are dates when excavating was first detected and do not show the duration of digging. Usually the dens were dug in a matter of a few days with subsequent minor digging activity. Interrupted radio signals were correlated with den digging activities. All dens (Table 1) were completely dug and prepared by grizzlies themselves. This is in contrast to the European brown bear where natural shelters are often used (Couturier, 1954). No natural shelters were utilized by the grizzlies though natural shelters ranging from matted windfall to rock caves were available. Seven of the eleven (11) dens (Table 1) were dug at the base of trees (Fig. 5). Three others were dug at the base of stumps or with the entrance excavated beneath a horizontal log. Erickson (1964) found that most black bears favored dens dug beneath objects such as logs, stumps, or holes dug into hillsides. No mention is made of dens excavated beneath trees. The Yellowstone grizzly appears to prefer to dig a den entrance at the base of a tree, tunnelling

This urge to dig may be reflected in the fact that grizzlies appear more prone to cover or bury carcasses of animals in late fall than during the summer period. To some extent burying serves to protect the food from ravens, magpies and coyotes that usually wait nearby for a chance to feed when the grizzly leaves. However, if den digging is instinctive behavior for the grizzly, a partial and reasonable explanation for this burying of food may be that in fall, environmental conditions stimulate a need or instinct to dig more than at other seasons. Thus the grizzlies not only dig their dens and gather boughs for beds, but the bears tend to excavate dirt and to uproot grass and herbaceous vegetation to cover their food supplies. It may also be significant that when the grizzlies move to their dens with falling barometers and in snowstorms, only to remain outside with subsequent clearing and warming temperatures, they busy themselves with a "housecleaning" type of digging both within and outside the den.

The grizzly dens were not extensive excavations (Table 1), but were adequate for the number of bears sheltered, whether a single individual or a family. Sows with cubs as well as sows with yearlings slept in the same den in close contact with one another. The dens were usually constructed so that there was an entranceway leading into the bed chamber (Fig. 7). The average size of this chamber determined from ~~ten~~ 10 dens was: 56 ~~inches~~ " long, by 53 ~~inches~~ " wide, and 37 ~~inches~~ " high. The den entrance varied START from

no tunnel entrance at all, where the opening went directly into the chamber, to an entrance tunnel 66 ~~inches~~ long. The width of the entrance or the den opening varied from a narrow width of 14 ~~inches~~ to a mixaimu of 33 ~~inches~~ with the average 22 ~~inches.~~ Heights ranged from a minimum of 20 ~~inches~~ to a maximum of ~~54~~ ~~inches~~ the average being about 34 ~~inches.~~ The den openings seem relatively small considering the size of the grizzlies. In some instances, it was difficult to visualize even a medium sized bear squeezing through the opening and into the chamber beyond. Total length of the den chamber plus entranceway averaged 92 ~~inches.~~ The den chambers were small enough that body heat from the bears would be sufficient to modify den ambient temperatures. No dens contained more than ~~one~~ bed chamber or room and no alcoves as reported for the polar bear (Harrington 1968).

Table 2 reveals size and characteristics of seven additional grizzly bear dens. These were constructed by unknown grizzlies and were not in current use. After a few active dens were located, a general pattern of den site location emerged which enabled us to seek for and find dens other than those found through radiotracking. The inactive dens were on north facing slopes, in timber, in secluded areas, and quite often were dug at the base of large trees. The bed chamber measurements averaged 52 ~~inches~~ in length, 50 ~~inches~~ in width, and 39 ~~inches~~ in height. Total lengh of den chamber and entranceway was 108 ~~inches~~ (Table 2). Three out of five of these dens, ~~were~~ complete measurements were obtained, revealed that the

den chamber was wider than it was long. We suspect these were used by sows with offspring as in the case of grizzly No. 39 where the den sheltered her instrumented yearling No. 158 as well as two littermates. This den was almost as wide as it was long. The 1966 den of No. 40, housing the sow and her two large cubs, was wider than it was long and the three bears slept within curled up side by side (Fig. 4). This might indicate a tendency for sows with cubs and sows with yearlings to dig wider dens than do those bears that are hibernating along or with only a single cub.

The data gathered on the denning activities of the young male grizzly No. 202 indicated that the den digging activities of both sexes was grossly similar. It appears logical that the denning habits of young males would continue relatively unchanged into maturity. On this basis we assume that adult boars as well as sows dig their winter dens. Unfortunately grizzly No. 202 was eliminated through control operations following his second year of independent den preparation.

Den Environment

Den beds were usually composed of spruce or fir boughs sometimes laid as deep as 14 inches (Fig. 4). A variance from this was a bed of moss and grass prepared by pregnant female grizzly No. 40. Pregnant grizzlies may tend to use finer and softer bed

material in nativity dens. Occasionally the bed chamber was slightly above the entranceway, similar to the bed platform in a snow house, thus creating a heat trap that prevented warm air from escaping out the den opening (Fig. 8). Digging a den so as to form a heat trap is probably accidental, but there may be an instinctive tendency for the animals to do so when feasible. Dens not so prepared but with the bed lower than the entranceway were situated so that the entrance would fill up with snow (Fig. 9). Thus, in effect a similar result was obtained, the snow forming a sealed chamber with little transfer of air. The grizzly bear winter den is a very localized environment with temperatures warmer and more constant than those existing outside. In addition, when a deep insulating bed of boughs is used, a microclimate is created between the bear and his bed that is considerably warmer than the general ambient AIR temperature of the den chamber. The bough bed prepared by grizzly No. 202 was circular and cuplike in shape. The diameter of the depression across the top was 31 inches. It was 12 inches deep[1]. The yearling bear curled himself up in this bed cavity with his head and shoulders protected by the partially dug den (Fig. 6). The rest of his body was covered and insulated by accumulating snow.

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1 The depth was measured in spring following winter use. It was probably closer to 16 or 18 inches deep when first constructed.

The temperature of the microclimate between a bear and his bed was recorded by placing a thermistor probe from a body-temperature transmitter between a black bear and his well-insulated bed. The winter bed was fashioned from a porous mixture of dried pine needles and finely shredded twigs. The temperature of the microclimate approached that of the bear's body, the maximum reading being 36° C. ± 1° C. This probably occurred when the probe was under a portion of the bear's body where his fur was thin and heat conduction was efficient. The bear had been awakened and was alert, and at this time probably had a body temperature close to the normal activity temperature of 37.8° C. The microclimate between the bear and his bed constituted an estimated area of approximately three-quarters of the bear's body surface when curled in sleep. The insulated bed was 18 inches deep by 30 inches in diameter, cuplike in shape, with nearly perpendicular walls against which the bear's body fit snugly (Fig. 10). Bed materials differed from those used by grizzlies, but in its dimensions and structure the bed was very similar to that prepared by grizzly yearling No. 202. When the black bear was curled in his sleeping position just slightly below the rim of the bed cavity, he was in a microclimate where temperature changes were minimized. Possibly the resulting microclimatic temperature achieved when the bear is sleeping determines within limits the degree of hypothermia or of lethargy needed and achieved by the

bear in its winter den, whether it be a black bear or a grizzly. In other words, the dormancy temperature may be influenced by the temperature of the microclimate enveloping the bear, and this in turn may to a considerable extent vary with or even be regulated by the bear's thermoregulatory processes. Winter sleep conditions of wild bears thus may vary with individuals and with the care and extent to which each prepares a den and bed. It probably also varies considerably from conditions observed in captivity.

Distances Traveled to Den Sites

Instrumented grizzlies traveling to their winter dens or sites from fall or summer foraging areas covered the following airline distances:

Grizzly Number	Distance Traveled
40	5.5
40	5.5
40	6.75 6.8
101	2.5
101	11
202	8
202	8
187	11
39	5
14	16
164	14
7	14

Distances Traveled to Den Sites (con't)

Grizzly Number	Distance Traveled
34	16+
150	6
96	30+
76	21+

Observations of marked animals, made during the fall period of dispersal to den sites, revealed that some grizzlies traveled even greater distances than those measured by radio. Some definitely traveled beyond the boundaries of Yellowstone Park. Following far ranging grizzlies at this time of year was difficult as travel was limited to hiking in snow varying from six to eighteen inches deep. This is a fall-winter transition period where the use of snowshoes or skis is not practical.

Relation of Den Site to Home Range

Two types of grizzly bear seasonal and home range patterns were plotted and delineated by means of radiotracking (Craighead, 1968). One consisted of a distinct continuous area over which the grizzlies wandered and foraged throughout the year or during spring, summer and fall. The home range unit contained winter den sites or a den. The other range pattern consisted of summer and early fall foraging areas, often widely separated from an early-spring and late-fall area that contained the winter den. The latter pattern can be visualized as two distinct seasonal ranges, with the bear often traveling rapidly from one to the other. The home range

of an animal provides all the essentails for life of the individual and thus by definition includes its den site. Den site selection, location and prehibernation behavior are to a certain extent influenced by the range size and pattern. They are also influenced by numerous other factors including age and sex of the bear, social status, topography, vegetation, general and seasonal availability of food and meteorological conditions.

Examples of interesting prehibernation behavior of monitored grizzlies as related to their ranges was recorded. On October 25, 1965, yearling grizzly No. 202 left his regular summer haunts (summer range), swam the Yellowstone River and headed northward directly for his hibernation site on the steep slopes of the Yellowstone Canyon. In 1965, No. 202 was carefully monitored. His first purposeful and independent move away from the summer range of his mother was when he crossed the Yellowstone River and headed for this den site. As far as we know, except during his spring trek from the den of his birth and his return travels the ensuing fall, this young bear spent all of his life in the immediate vicinity of Hayden Valley. This weaned yearling had not prepared his den in advance as mature bears had done, but dug it within a few days of selecting the site. The den constructed by the inexperienced grizzly in rocky talus was not much more than a daybed (Fig. 6), but it is interesting that he hibernated within the home range of his mother as revealed by evidence gathered on marked sow No. 65.

In comparison to No. 202, weaned grizzly No. 188 also established a summer range within the home range of his mother, No. 40, but left this to hibernate. His summer range was smaller and largely distinct from hers. In view of the fact that this yearling had spent all of his life within a rather restricted area (20 square miles), the range of his mother, it seemed logical that he might hibernate within this familiar territory. However, in late October during a snowstorm, he took off into new and strange territory to seek a distant hibernation site thus establishing a range pattern quite different from that of his mother's and one that he may continue to follow throughout his life. This fall dispersion of young bears is a common occurrence. The young independent bears, low in the bear social hierarchy and insecure, wander both in spring and fall more than do other segments of the population.

Re-Use of Dens

Old bedding material in debris piles at some dens suggested that the dens had been used in previous years (Fig. 11). Such evidence was found at the den of No. 164 and it may also be significant that No. 40 cleaned out two of her dens prior to leaving them in spring. The roof of one collapsed a few months later making the den untenable for another winter. No dens to which we radiotracked grizzlies were ever reused. Most dens collapsed when the soil became saturated with water in late spring, and thus were not suitable for reuse (Fig. 12). Grizzly

No. 202 dug two separate dens in consecutive years only three hundred feet apart. His first den was poorly excavated and probably inadequate for reuse the following year (Fig. 6). The second-year den was a decided improvement as the grizzly removed an estimated ton of rock in preparing it. This might indicate learned behavior reinforcing an instinctive urge. Near many active den sites, we found evidence of former dens (Fig. 12). Three collapsed dens were located very close to the active den of grizzly No. 164. A collapsed den within a few hundred feet of a den of No. 40 (1966) had plant growth on the debris pile indicating it was at least five to seven years old.

It is interesting to speculate on the proximity of dens temporally separated such as those at the 1966 den site of grizzly No. 40. Most likely the site characteristics are such that the area attracted different bears at different times to this same isolated north facing timbered slope. It is also conceivable that the old den was the nativity den of No. 40 and she eventually returned to the site to dig a den of her own making.

Prehibernation Movement and Behavior

In the early years of the study (1960-61) we observed that after the grizzlies moved to their winter dens during a snowstorm there were no tracks visible anywhere throughout the area where grizzlies had previously roamed. This suggested that certain environmental stimuli triggered simultaneous movement to and

entering of winter dens. Through radiotracking we learned that after early preparation of a den (Table 3) the bears would return to their established fall foraging areas and continue to feed. Most early snowstorms did not elicit movement. The grizzlies continued with their regular feeding activities. Sometimes one small storm followed another, causing no change in grizzly behavior. Eventually, however, either a late or a major snowstorm with falling barometer moved the grizzlies back to their den sites. Occasionally grizzlies were detected moving to den sites in clear, warm weather with a falling barometer. On October 15, 1965, No. 40 started moving to her den in the morning of a warm sunny day. By late afternoon, a snowstorm was in progress and she was tracked to her den. This and similar behavior of other grizzlies suggest that they are able to detect approaching storms, possibly by variations in barometric pressure, and that such changes initiate movement to dens before storm signs are visually apparent.

If warm, clement weather followed a storm, the grizzlies tended to return to fall foraging areas until still another storm sent them denward. In some cases, the grizzlies moved back to their dens during snowstorms remaining close to the den opening until a subsequent snowfall and low temperatures put them in for the winter. In 1961 and 1963, grizzlies moved directly from fall foraging areas in falling snow, immediately entered their dens and remained within.

As early as several months prior to hibernation, some grizzlies dig and prepare their winter dens, the time varying considerably for each individual. After the dens are dug, they are usually lined in advance of use with a bough bed. In some cases large piles of boughs were accumulated outside the den entrance prior to actual bed making. All of the grizzlies living under the same environmental conditions hibernated at the same time. The grizzlies entered their winter dens during a storm regardless of whether they were waiting close to their dens or were foraging at some distance. After this storm, no tracks have been evident anywhere throughout extensive areas where the grizzlies roam, except in a few cases right at den entrances. Minimum ambient air temperatures at this time are below (32° F.) 0°C (CONVERT TO C.) (Table 3) and the maximum temperatures in the shaded den sites are also probably below (32° F.) 0°C (CONVERT) Grizzlies moving to prepared dens during storms followed by above freezing temperatures did not enter dens. The near simultaneous entering of winter dens during falling snow serves to conceal signs revealing den location and is no doubt a behavior trait favoring survival during a vulnerable period. It is in contrast to the Yellowstone black bear (Ursus americanus) where individuals enter winter dens earlier and over an extended period of time.

The only grizzly whose final move to a den was not during a storm was weaned yearling grizzly No. 202. He moved directly to

his den site on October 25-26, 1965, and remained there. He began digging and preparing his den immediately upon arrival. He traveled with only patchy snow on the ground and the day clear. However, prior to this on October 15 during a snowstorm with 3-4 inches of new snow on the ground, this grizzly left his regular summer and fall haunts and moved to another area. The storm initiated his movement away from his summer and fall foraging area and precipitated the final move to a den site.

In 1961, the grizzlies hibernated on October 21, the earliest date of which we have records. This was the coldest fall period of the entire study with snow and cold weather starting early and continuing with few breaks until the bears hibernated. The first snowstorm of three to four inches occurred on September 11 and was followed by another snowfall on September 18, adding four to five inches in some areas. September was characterized by periodic snowstorms, with snow on the ground throughout much of the month. However, the lowest minimum temperature for this month was only (19° F.) -7.2°C CONVERT occurring on September 14. The average minimum temperature for September of 1961 was (29°) -1.7°C CONVERT and the average maximum 51° F. +10.6°C CONVERT The October 1961 average minimum and maximum temperatures were 22° -5.5°C CONVERT and 45° F. +7.2°C CONVERT; such averages are not too meaningful but give a general idea of ambient air temperature conditions.

Available food in combination with altitude, latitude and meteorological conditions affect at what time and even whether or

Our observations indicate that prehibernation behavior as well as the time of entering dens are quite definitely influenced by environmental factors. A combination of low temperatures and snowstorms appear to condition the bears and eventually influence the time at which they enter their winter dens. A convenient food supply with little snow and relatively high ambient temperatures tends to delay hibernation. On the other hand, adequate and and available food will not deter the bears in the wild condition from entering their dens if snow is accumulating on the ground and snowstorms and severe cold occur at the same time. A fall period with general food scarcity combined with snow and cold weather tends to put the bears into hibernation earlier than usual.

The time of hibernation over an ~~eight~~ 8 year period varied by as much as a month. It therefore appears that light or darkness is not a factor in inducing the grizzlies to hibernate. Kayser (1961) mentions that this was also the conclusion of Johnson (1930) following researches conducted on the ground squirrel (Citellus tridecimlineatus pallidus and C.t. arenicola). By measuring the length of hibernation of these ~~two~~ 2 species, Johnson comes to the conclusion that the length of hibernation is independent of light. Hock (1955) working with Citellus undulatus and studying the different climatic and ecological factors that may be influential, states that there is no relationship between the beginning of hibernation and the temperature, the snowfalls, or the amount of available food. The only close correlation observed

is between illumination and hibernation. It appears that the finding of Hock working with a "physiological" hibernator are just the opposite to those we have found with the grizzly, an "ecological" hibernator.

Although family units such as a sow with cubs or sow with yearlings hibernated together, individual grizzlies as well as families sought isolation ~~and hibernated alone~~. There was one interesting exception. During the summer of 1966 instrumented grizzly No. 40 with her two cubs established a close relationship with grizzly sow No. 101 and her cub. Throughout the summer months they traveled together, slept together, foraged together, and were apparently inseparable--one always being seen when we saw the other or moved in on a signal bearing to observe them. The close relationship of these sows and their cubs continued up to the time they entered their dens. Apparently the relationship affected the selection of den location by both bears. Instead of returning to her former hibernation site in the upper reaches of Alum Creek, No. 40 dug her den in the upper Trout Creek area and No. 101 excavated her den only one and one half miles away. A year later, in the fall of 1967, after the sows had separated, we located the den of No. 101 near Dunraven Pass, apparently the area where she normally hibernated. The usual denning areas of sows No. 40 and No. 101 were approximately sixteen airline miles apart; thus No. 101 had dug her den thirteen miles from her normal hibernating site and No. 40 three miles from hers. With snow on the ground

and conditions favorable for the bears to remain close to their dens, they traveled back and forth from one den site to the other. They appeared loathe to separate for the period of winter sleep. Our approach to No. 101's den caused her to abandon it, so we were unable to determine how long this situation would have continued. The prehibernation behavior of these bears was contrary to that exhibited by most of the grizzlies who sought solitude for themselves or families. The forceful attraction of one for another was further supported by their actions the following spring. No. 40 weaned her yearlings and bred the same spring. No. 101 did not come into estrus but kept her YEARLING and adopted the two yearlings weaned by sow No. 40, thus providing the yearlings with maternal care while No. 40 followed a two-year breeding cycle. In practice such a behavior pattern would tend to increase the productivity of the species and would benefit the survival of an age class where mortality is relatively high.

Prehibernation Lethargy

In the fall of 1965, we observed what appeared to be a marked lethargy in grizzlies prior to hibernation. This lethargy was apparent at one time or another in all the grizzlies closely observed during late fall. For example, On October 14, 1965, we jumped instrumented grizzly No. 188 from his daybed in lodgepole timber. He moved away slowly, but only after we started talking. He soon stopped and sat down on a wooded hillside. Within a few minutes his head began to sway and the bear slumped forward with his muzzle on the ground turned inward under his body. Aware of

our presence he struggled to remain awake and alert, but acted as though he were drugged. Following efforts to raise his head he slouched forward again, his muzzle tucked inward. This muzzle position is very similar to that of grizzlies when first reacting to being drugged with succinylcholine chloride (Craighead, et al., 1960). We moved to ~~wintin~~ within 100 feet in this grizzly before he again rose to his feet and lumbered off. Similar behavior was observed when we jumped instrumented grizzly No. 202 on the same day.

About two weeks later on November 3, this lethargy was even more pronounced. Number 202's radio signal led us to the edge of the perpendicular walls of the Yellowstone Canyon. A three-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 startled grizzly who had been lying at the entrance to his den. For the next half hour he ~~stood~~ sat nearly motionless except for an occasional slow raising of his nose to seek a scent and the tucking of his nose under his body as though in sleep. The grizzly seemed in an advanced lethargic condition. He should have detected our scent with the air movement favorable, but he gave no indication of doing so.

On October 25, 1965 we approached to within 30 feet of No. 40 in her den, ~~but the grizzly did not come out~~ that our presence did not disturb her. She was apparently sufficiently ~~somewhat~~ lethargic. ~~No. 40 did not remain in her den for the winter, but~~ In this condition she stayed close to her den and at times within it. This behavior continued ~~from October 15~~

to November 11, when she entered the den during a snowstorm and remained within for the winter. Grizzly No. 40 moved to her den a full month before entering it. It is reasonable to assume that the early onset of lethargy influenced this movement as well as the fact that she was pregnant. The apparent lethargic condition of these bears and their early movement to den sites, particularly the movement of No. 202 to a den site without a triggering storm, seemed to indicate that hibernation physiology, possibly including a hypothermic lethargy, had been initiated prior to actual entering of dens or movement to them.

Higher warm-blooded animals have an activity temperature above 36° C. Rectal temperatures of grizzlies and black bears taken in summer and fall have shown a temperature of 37.8 - 38.4° C. With protracted action of cold, it is possible to go below the lower threshold of activity and a hypothermic lethargy ensues (Eisentraut, 1960). This did not appear to be the case with the grizzlies under observation. During previous fall periods with more prolonged cold they did not exhibit lethargy prior to denning. However, cold did appear to be an influencing factor.

Weather conditions in the fall of 1965 differed in at least one significant way from conditions in other study years. This quite possibly initiated lethargy and affected grizzly pre-

hibernation behavior, and movement to den sites. An early fall period of snow and unusual cold occurred from September 15 through September 28. The minimum for the September 18-20 cold spell was ~~70 F~~ -13.9°C. (7° F.). This was the coldest early period of snow and low temperatures experienced in the course of the study. Ambient air temperatures were lower than at the November 1965 time of hibernation. Four to ~~six inches~~ 6" of snow covered the ground at our Canyon laboratory and more at higher elevations. This cold spell was followed by warm mild fall weather. The combination of early snow and low temperatures did not stimulate grizzlies to hibernate, but it did disperse some from summer to fall ranges, 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 environmental stimulus of a final snowstorm caused them to enter their dens on November 11 for their winter sleep.

It is characteristic of grizzlies to at times bury or cover the carcass of an animal with dirt, grass, and brush. The animal may be one dying of natural causes or more rarely an animal killed by the grizzlies. They are not consistent in burying a carcass, nor are the reasons for the variable behavior readily evident. The subject will not be elaborated here with the exception of reference to lethargic behavior.

In 1960, we observed grizzlies burying or covering the carcasses of elk as early as September 21. This phenomenon continued throughout the fall. When we approached grizzlies feeding on carcasses, we found some sleeping either on or beside their food supply. This was observed as early as October 14 and might have been interpreted as the onset of winter lethargy except when alerted they always took off on a dead run and were quite active. Apparently sleeping on the carcass was related to the heavy meals the bears had consumed rather than to any physiological changes connected with the hypothermic lethargy of winter sleep, as observed in the fall of 1965.

Period of Winter Sleep

In 1966, on December 28, we visited the winter den of grizzly No. 40 approaching the den carefully and quietly from below on snowshoes. The den entrance was open though contracted by snow. There were no signs to indicate that the bears had moved out of the den since entering in November. To peer into the den, it was necessary to lie down with feet slightly elevated. In this position we were approximately ~~five feet~~ 5' from the sleeping sow and her ~~two~~ 2 grown cubs. The ~~three~~ 3 grizzlies were lethargic and sleeping, but apparently the sow detected our presence for she growled and shifted her position. At the risk of eliciting a charge from the grizzly, we took flash pictures and movies of the

den entrance and portions of the bough bed within. The grizzlies were lethargic enough that they did not respond by coming out of the den.

The Yellowstone grizzly mates in June and early July but a delayed implantation occurs (Craighead, 1969) which delays embryonic development and parturition. Whelping occurs during hibernation within the winter den but no dates have been obtained through observation of bears in the wild. January or February would seem to be the most likely months. No feces or traces of urine have been found in active dens recently abandoned, or even observed close to them. Apparently the grizzlies do not drink nor urinate during the winter sleep. Harrington (1968) states that polar bears usually keep their dens clean. He found only mere traces of urine and minute fecal fragments in six of nine dens examined. Prior to entering winter dens we have observed black, watery excrement suggesting a scouring and cleaning of the alimentary track. The Yellowstone grizzlies fast from the time they enter their dens until they leave them in the spring.

Occasionally a grizzly emerges from its den in mid-winter. One of two records was in response to a nearby food supply when a grizzly in the Old Faithful area came out in the latter part of February, 1967. The bear was attracted to the carcass of an elk that had either been killed or had died in the vicinity of the den.

Mid-winter emergence, however, in this area is not a common event.

Emergence from Hibernation

In general the Yellowstone grizzlies remain in their winter dens from the time they enter them in late October or November until early April. Deep snow alone precludes travel. Tracks observed as early as April 4 indicate possible emergence from a den in late March. Signs outside the den of grizzly No. 40 in 1965 indicated emergence in late March. The grizzlies are not noticeably thin when they leave their dens and start traveling in search of food even though they live off their body food reserves for annual periods varying from ~~five~~ 5 to ~~six~~ 6 months. Some grizzlies emerge from their dens as much as ~~three~~ 3 weeks to a month before they leave the den site for spring feeding areas. Often when they first emerge the snow is too soft and deep for the bears to travel. They remain in the vicinity of the dens until sunny days with warming temperatures, followed by chilly nights, produce a crust on the snow that will support their weight.

In the spring of 1965, No. 40 and her yearling came out of their den in late March and left the den site about April 20. Prior to leaving they built bough beds on the snow within several hundred feet of the den entrance. The beds were on different snow strata or levels indicating intervals between times of construction. The bears slept on these beds and were covered by snow from subsequent storms. As the snow piled up over the sleeping grizzlies, their breathing produced an air shaft to the surface (Fig. 13).

Apparently the bears continued in a lethargic state but were sleeping on bough beds on the snow surface rather than within the den. One suggested reason for early emergence ~~for~~ FROM the den is that in the spring of the year, the outside air temperatures, at least during the day, are often warmer than those within the den. At 10:45 a.m. on April 28, 1965, the air temperature inside the den of No. 40 was 0°C (32° F.) CONVERT The air temperature in the shade, outside of the den and three feet above the snow was +4.4 °C (40° F.) CONVERT The ambient air temperature in the sun was +10.0 °C (50° F.) CONVERT F. In 1967, sow No. 40 emerged from hibernation with another family of yearlings. On this occasion they left the den area without building bough beds as was done in the spring of 1965.

Our observations reveal that mature male grizzlies and sows tend to leave winter den areas earlier than sows with yearlings. Sows with cubs of the year are the last to leave den sites. Some may remain in the vicinity of the den until most of the snow has disappeared.

Hibernation or winter sleep appears to be an essential part of the grizzly bear's annual cycle in the Yellowstone area. Both instinctive and learned behavior traits tend to have survival value for both young and adults during this vulnerable period. Den digging and bed making result in a localized micro-environment that protects the bear from extreme climatic conditions. Seeking of isolation during hibernation and the entering of dens during snow storms tend to provide added protection.

The apparent need for isolation during hibernation implies that in managing the endangered grizzly consideration must be given to maintaining large expanses of relatively wild country free of man and his developments.

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