ACTIVITY AND FOOD HABITS OF BARREN-GROUND GRIZZLY BEARS IN ARCTIC ALASKA

By

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B.A., University of Montana, 1974

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ABSTRACT

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From 1977 to 1982 data were collected on the activity and food habits of grizzly bears in the North Slope foothills of the western Brooks Range, Alaska. Activity budgets and patterns were calculated from 987 hours of observation of radio-collared bears during 1978, 1979, 1981, and 1982. Three females with cubs were active from 20% to 40% of 24-hour periods in the weeks just after den emergence. One of these females was active 46% to 58% of the day after she moved from the vicinity of the den. A female with 2- and 3-year-old offspring was active 50% to 74% of 24-hour periods: her activity level dropped to a range of 15% to 30% during the first 3 days of consorting with a male. Daily variation in activity levels and cycles indicated that caution is necessary when interpreting activity data. Food habits were based on analysis of 503 scats, 360 hours of feeding observations from 1978, and feeding site and habitat examination. Three seasonal feeding strategies were evident. From den emergence through greenup, Hedysarum alpinum roots were the most important food, supplemented by overwintered Arctostaphylos rubra berries, emerging vegetation, and the floral parts of plants. Spring habitats providing staple plant foods were dry tundra types, floodplain communities, and tussocks. As snowmelt and greenup progressed, bears grazed more succulent vegetation and flowers, primarily Equisetum arvense, Boykinia richardsonii, and grasses/sedges, During the summer, bears used the greatest variety of habitats, though wet sedge meadows, ecotones between wet sedge and drier tundra, and late snowmelt areas were preferred. By late summer and early fall as leafy vegetation decreased in quality, bears began to feed on roots and ripening berries. Although the bears fed primarily on plants, they frequently supplemented their diet with animals. Ground squirrels were the most important fall food. The foothills are a topographically diverse area with a complex vegetative mosaic offering a good variety of plant and animal foods. Every habitat had foods of interest to bears; although general use patterns were evident, bears used all habitats throughout the year.

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Work in the Arctic is logistically difficult and expensive. The Alaska Department of Fish and Game provided most of the funding and logistical support. Additional support was provided by the Arctic Institute of North America, the Audubon Society, the Montana Cooperative Wildlife Research Unit, the Naval Arctic Research Laboratory, the Theodore Roosevelt Fund of the American Museum of Natural History, and the Wildlife Management Institute/American Petroleum Institute.

I was fortunate to work with competent people who became good friends. I owe special thanks to Harry Reynolds; to pilots Jim Rood, Craig Lofstedt, Bill Lentsch, and Dennis Miller; and to field assistants Brian Cooper, Roger Smith, Russell Lachelt, Bob Brannon, Slader Buck, Mike Phillips, Sue Steinacher, and Susan Warner. Jim Gebhard helped collect scats in 1977.

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CHAPTER I

INTRODUCTION

This thesis contains 2 chapters about the activities and food habits of barren-ground grizzly bears (Ursus arctos) of the North Slope foothills of the Brooks Range, northwestern Alaska. Each chapter is written as a paper to be submitted for publication. The writing style of each chapter is tailored to the journal targeted for submission.

The work reported herein was part of a cooperative grizzly ecology study conducted by Harry Reynolds, Alaska Department of Fish and Game, Fairbanks, from 1977 to 1982 in the National Petroleum Reserve-Alaska. Intensive ground-tracking of radio-collared females and their young complemented aerial radio-tracking data from other bears. During 1977, Jim Gebhard, a graduate student from the University of Alaska, Fairbanks, studied the behavior of Female No. 1086 and her yearlings, while I studied their food habits. During 1978 and 1979, I again followed No. 1086 and her young, expanding my work to include behavior. During the springs of 1981 and 1982, other females and young were observed with the help of field assistants.

Chapter II contains data on the activity budgets and activity patterns collected from observation of Female No. 1086 during 1978 and 1979, of Female No. 1097 during 1981, and of Female No. 1169, and an unmarked recognizable female during 1982. The paper was presented at the International Conference on Bear Research and Management, Grand Canyon, Arizona, February 1983.

Chapter III contains information on the food habits of bears in the Meat Mountain area. These data were obtained by analyzing scats collected during 1977, 1978, 1979, and 1981. Direct observations of the family group of Female No. 1086 during 1978 and habitat and feeding site examinations during 1977, 1978, 1979, and 1981 were also used to determine feeding activity.

The Appendices contain graphs of activity data collected for 4 female grizzly bears during 24-hour observation sessions.

CHAPTER II

ACTIVITY BUDGETS AND ACTIVITY PATTERNS OF FEMALE GRIZZLY BEARS IN ARCTIC ALASKA

ABSTRACT

Data were collected on the activity budgets and daily activity patterns of 5 female grizzly bears (Ursus arctos) on the North Slope of the Brooks Range, northwestern Alaska. More than 987 hours of direct observation were recorded during 4 field seasons. Three females with cubs were active for 20-40% of 24-hour periods in the weeks just after den emergence when they remained in the vicinity of the den. One of the females, observed after she began to move away from the vicinity of the den, was active 46-58% of the day. A female with 2- and 3-year-old offspring was active 50-74% of the 24-hour periods, but her activity level was only 15-30% during the first 3 days of consorting with a male. The large amount of daily variation in the percentage of activity observed for these bears indicated that caution must be used when interpreting activity data.

Key words: Alaska, activity budgets, activity patterns, behavior, grizzly bear, Ursus arctos.

INTRODUCTION

Studies of behavior have indicated that some of the circadian rhythms exhibited by species may have an endogenous physiological basis (Aschoff 1966). Information on how bears allocate their time, and on the distribution of activity during 24-hour periods, could be useful to researchers and managers (Stelmock 1981, Roth 1983). If this behavior is characteristic of species or populations, then changes in these patterns could be used to detect environmental stresses such as disturbance or food shortages (Roth 1983). First, however, we must have baseline information from different areas and animals to determine how and why bears schedule their activity.

Activity data for bears have been collected indirectly with the aid of radio-telemetry (Amstrup and Beecham 1976, Garshelis and Pelton 1980, Sizemore 1980, Schleyer 1983) and directly by observing bears (S. Linderman, unpubl. rep., Alaska Dep. Fish and Game (ADF&G), Fed. Aid Proj. W-17-6, Job 4.12R, 1974; Knudsen 1978; Stelmock 1981; Gebhard 1982). Garshelis and Pelton (1980) discussed the limitations of the various indirect methods. Direct observation of animals is the most accurate method for collecting activity data. However, observing an animal without influencing its behavior is an arduous, time-consuming task. In most areas, it is impossible because of concealing vegetation, darkness, and wariness of the animals. Even in areas such as the Alaskan tundra where 24-hour observation is feasible, sample sizes that can be obtained are usually small.

The literature on activity patterns for bears indicates that bears are nocturnal, diurnal, and crepuscular (Craighead and Craighead 1965;

A. Erickson, unpubl. rep., ADF&G, P-R Job Prog. Rep., Proj. W-6-R-5, 1965; Pearson 1975; Amstrup and Beecham 1976; Garshelis and Pelton 1980; Sizemore 1980; Stelmock 1981). Intelligent, opportunistic omnivores such as black (Ursus americanus) and grizzly bears are capable of much behavioral plasticity; therefore, generalizations based on relatively small sample sizes must be viewed carefully.

From 1977 to 1982, the ADF&G studied an unhunted population of grizzly bears in the National Petroleum Reserve-Alaska (NPR-A), the largest undeveloped area on the North Slope (H. V. Reynolds, unpubl. rep., ADF&G, Fed. Aid Proj. W-17-11 and W-21-1, 1980, 1981). Although the area is still relatively undisturbed, the vulnerability of grizzly populations to disturbance at the northern range limits is high (Brooks et al. 1971). Once protected by its remoteness, even this area has been made readily accessible by fixed-wing aircraft and helicopters. In addition to the information generated by aerially radio-tracking large numbers of animals, more detailed information of what individual bears were doing was needed to provide a better understanding of grizzly ecology and to help anticipate and minimize the effects of human encroachment and development. A number of studies have demonstrated the value of intensively observing a few individual bears (Craighead and Craighead 1965, Murie 1981, Stelmock 1981). This paper presents data on the activity budgets and patterns of 5 grizzly bears that were monitored for 987 hours during 4 field seasons.

Work in the Arctic is logistically difficult and expensive. The ADF&G provided most of the funding and logistical support. Additional support was provided by the Arctic Institute of North America, the

Audubon Society, the Montana Cooperative Wildlife Research Unit, the Naval Arctic Research Laboratory, the Theodore Roosevelt Fund of the American Museum of Natural History, and the Wildlife Management Institute/American Petroleum Institute. I was fortunate to work with competent people who became good friends. I especially thank Harry Reynolds; pilots Jim Rood, Craig Lofstedt, Bill Lentsch, and Dennis Miller; and field assistants Brian Cooper, Roger Smith, Russell Lachelt, Bob Brannon, Slader Buck, Mike Phillips, Sue Steinacher, and Susan Warner.

STUDY AREA

The study area is located on the North Slope of the Brooks Range in the vicinity of Meat Mountain (68°56' N, 160°45' W), approximately 320 km southwest of Barrow, Alaska. The area is in the Southern Foothills Physiographic Province (National Petroleum Reserve in Alaska Task Force, 1978), an area characterized by a series of ridges, mesas, and buttes generally oriented on an east/west axis, and separated by river drainages and broad valleys. The Southern Foothills have the greatest diversity of topography and habitat types in the region. Elevations range from 360 to 1100 m.

The climate of the area is "arctic," characterized by long, cold winters and short, cool summers. Freezing temperatures may occur during any month. Detailed climatic information for the area is lacking, but precipitation (light to moderate summer rain and light winter snowfall) is estimated as 15 to 50 cm. Strong winds are frequent throughout the year. From early May through mid-August, 24-hour daylight occurs (National Petroleum Reserve in Alaska Task Force, 1978).

Permafrost is found throughout the area, and patterned ground resulting from periglacial processes is conspicuous. The treeless vegetation of the arctic tundra is characterized by prostrate growth forms, except for the riparian shrubland tundra which contains willows up to 3 m tall.

METHODS

Radio-collared bears were observed by crews of 2 people working out of a backpacking tent. Camping on high, barren ridges provided good visibility of surrounding valleys and helped to minimize conflicts with the bears, because they rarely used those habitats. Bears were located with radio-tracking gear, binoculars, or unaided vision, then followed on foot and observed from ridgetop vantage points using variable power telescopes.

Observations were limited to 1 or 2 bears or family groups at a time. Continuous observations of the focal animals were conducted when possible. The time (Alaska Daylight Time) to the nearest minute each new activity began was recorded with shorthand notation. With the exception of important behaviors of short duration, such as aggression or defecation, activity that lasted less than 1 minute was not recorded.

The amount of detail that could be observed depended on a number of factors, including distance from the bears (which ranged from 50 m to 5 km), light, wind, rain, haze, and heat waves. Movements of the bears were plotted on mylar overlays of airphotos, or on topographic maps when possible.

Whenever possible, we observed the bears continuously for at least 24 hours. Such observations were facilitated by terrain, tundra vegetation, and 24-hour daylight during spring and summer. However, most attempts to complete 24-hour activity sessions were foiled by low clouds and fog, rain, snow, terrain, extensive movements by the bears, or tall riparian vegetation.

During 1978, we attempted periodic 24-hour observation sessions and then examined areas the bears had used to gather information on habitat types and the phenology of important plant species, to examine feeding sites, and to collect scats. Therefore, most observation periods during the 1978 season were less than 24 hours. In 1979, 1981, and 1982, more emphasis was placed on continuous observation, limited only by weather, observer fatigue, or extensive movements by the bears.

The numbers of minutes each bear spent in each of the active categories, resting, or in unknown activities were tallied. For the purpose of this publication, activity data were grouped into 3 categories: active (feeding/foraging, traveling, playing, courtship, intra- and interspecific interactions, and nursing), rest (periods of inactivity longer than 1 minute, or time in a den), and unknown. The proportion of time the bear was active was calculated by dividing the number of minutes observed active by the total number of minutes of actual observation excluding the unknown category. The percentage of observation time that bears were active was calculated for 24-hour periods, for seasons, and for the entire year. Three seasons, based on the food habits of the bears and plant phenology, were recognized: spring,1 May-15 June; summer, 16 June-31 July, and fall, 1 August-1 October (Hechtel, in prep.). The G-test was used in the data analysis.

To describe the variability of 24-hour activity budget data, I calculated all the possible 24-hour activity samples (n = number of hours of observation + 1 - 24) that occurred within the longer observation sessions. For example, 7 different 24-hour periods (each beginning and ending 1 hour later than the previous) could have been obtained from a 30-hour session. Because the samples were not independent, statistically meaningful variances could not be calculated. The calculations did provide a median and a range of values that illustrated the amount of daily variation in a bear's activity.

In addition to activity budgets, the data were used to plot activity cycles of the bears by graphing the proportion of activity per hour for a bear during a given time period. The Wilcoxon Signed Rank Test was used to test for significant differences in activity patterns.

RESULTS

Female No. 1086

I observed bear No. 1086, a 17.5-year-old female, for 228.7 hours between 31 May and 13 September 1978, when she was accompanied by 2, 2-year-old offspring. The percentages of observation time that No. 1086 was active were 60% (30.5/50.9 hours) during spring, 54% (56.6/104.1 hours) during summer, and 52% (38.1/73.7 hours) during fall 1978. The seasonal differences were not significant (G-test, $\underline{P} > 0.90$). For the entire 1978 season, No. 1086 was active during 55% of the observation time (125.2/228.7 hours). Four bouts of 24 hours or longer (Table 1) provided data on the proportion of activity on a daily basis. For the 28-hour observation period during late June, each of the 5 possible calculations of the percentage of activity during a 24-hour bout was 66%. The daily activity pattern for No. 1086 during the 1978 field season showed a tendency for an extended afternoon/early evening rest period (Fig. 1).

During spring 1979, exceptional conditions prevailed and I was able to observe No. 1086 for a 170-hour span with only minor breaks in the observations. During the first part of this period, from 1000 h on 31 May through 1700 h on 3 June, No. 1086 still traveled with her 3-year-old young. No. 1086 was active 65% (48.8/74.6 hours) of the time she was being observed during this period. Two independent 24-hour samples were obtained (Table 1). In addition, 54 continuous hours of observation provided 31 24-hour activity values that ranged from 56% to 74% (median = 63%). During spring 1979, the activity cycle of female No. 1086 accompanied by her young was similar to that observed in 1978--a high overall activity level with most rest around midday (Fig. 2).

An abrupt change in No. 1086's behavior occurred during the 78 hours from 1800 h on 3 June, when she chased her cubs away and consorted with a large male, through 0000 h on 7 June 1979. She was active only 21% of the time (15.9/75.3 hours) during this breeding period. This was a significant change from her activity level with her young (G-test, $\underline{P} < 0.001$). The percentages of time active during 3 independent 24-hour bouts on 4, 5, and 6 June 1979, appear in Table 1. If I calculated activity levels from the 55 possible 24-hour samples that occurred

Table 1. Summary of observation periods and percent activity for 5 female grizzly bears, 1978-82.

Bear no./young	Observation period	Number of hours observed	% of total hours active
1086/2 2-yr-olds	0000 31 May-0000 1 Jun 78	24.0	58
	1315 2 Jun-1315 3 Jun 78	24.0	68
	1400 29 Jun-1800 30 Jun 78	28.5	68
	1630 14 Jul-1630 15 Jul 78	22.8	50
1086/2 3-yr-olds	1200 1 Jun-1200 2 Jun 79	24.0	68
	1200 2 Jun-1200 3 Jun 79	23.6	57
1086 breeding	0000 4 Jun-0000 5 Jun 79	24.0	18
	0000 5 Jun-0000 6 Jun 79	22.6	26
	0000 6 Jun-0000 7 Jun 79	23.6	20
1087	1400 11 Jul-1800 12 Jul 79	26.8	55
1097/3 cubs	0500 19 May-1900 20 May 81	37.9	34
	1300 22 May-0000 24 May 81	35.0	27
	2100 7 Jun-1300 9 Jun 81	38.3	48
	1700 10 Jun-2100 12 Jun 81	49.8	49
1169/2 cubs	0900 24 May-0500 27 May 82	66.7	27
	0000 30 May-0000 31 May 82	22.4	17
UM/1 cub	1500 23 May-2300 25 May 82	55.0	33
	0130 26 May-0130 27 May 82	23.8	27

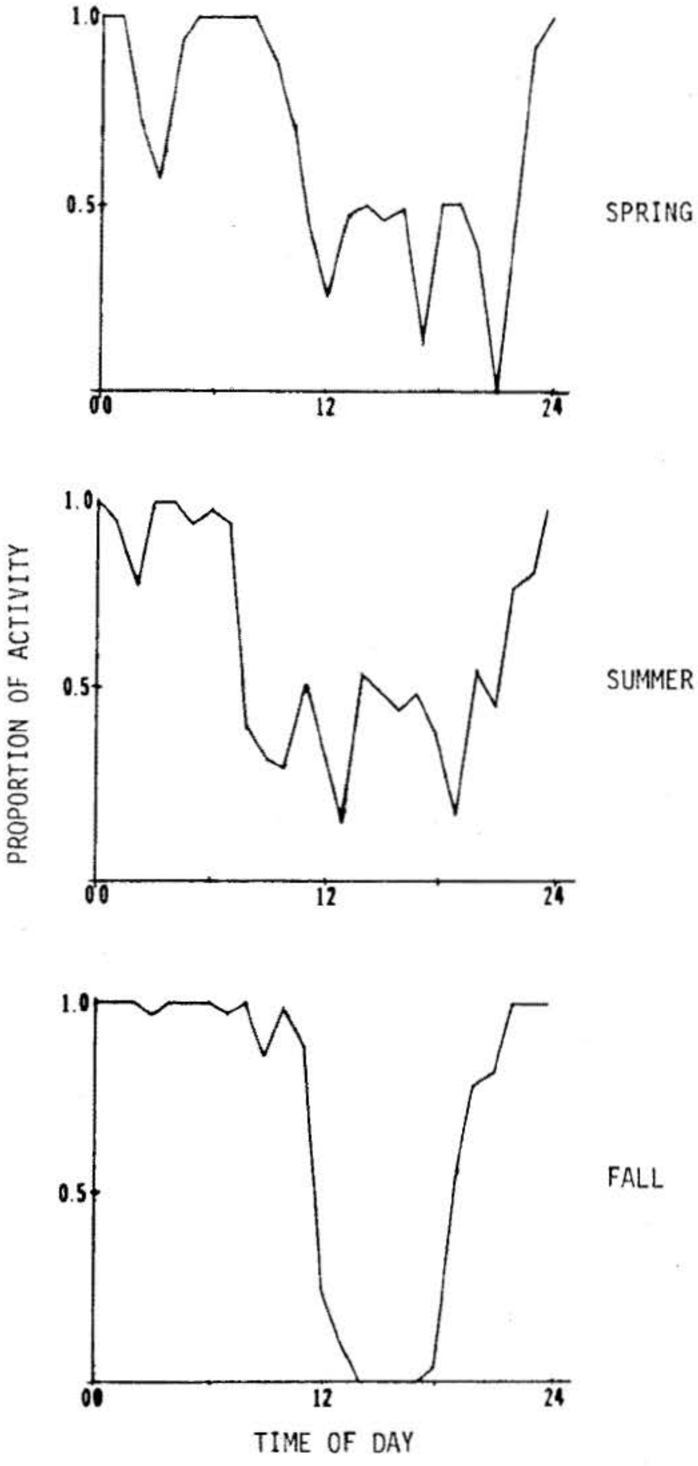

Fig. 1. Seasonal proportion of activity by hour for female grizzly bear No. 1086, 1978.

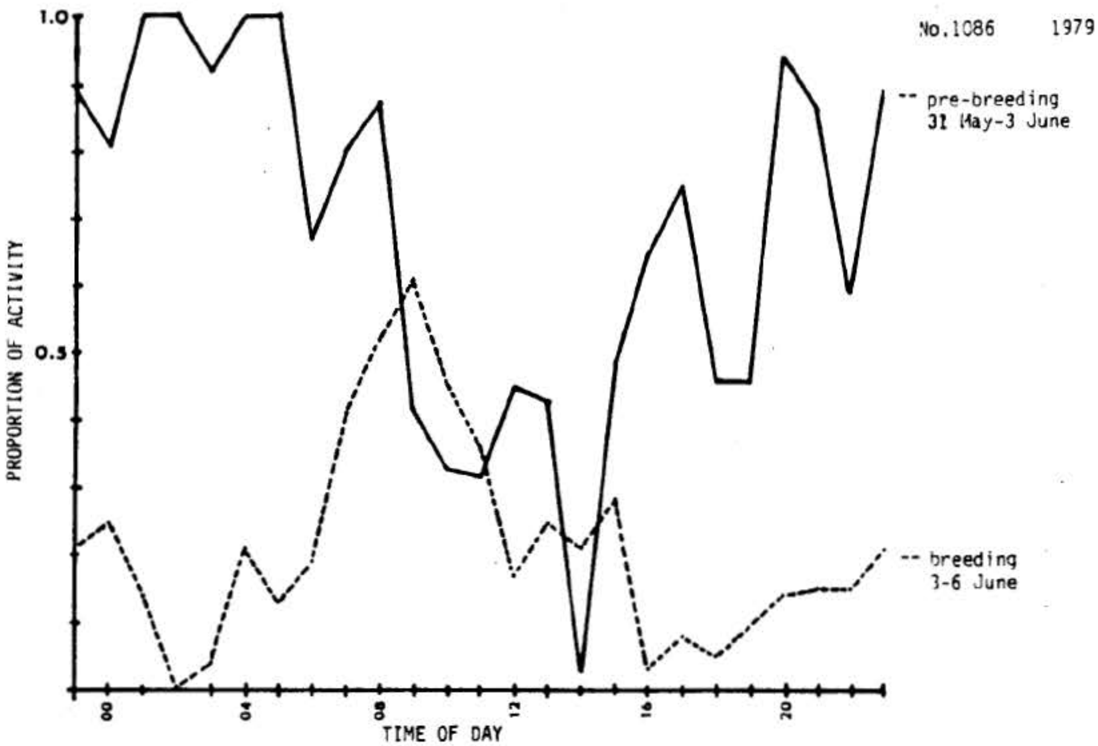

Fig. 2. Proportion of activity by hour for female grizzly bear No. 1086 prior to and during breeding, 31 May-6 June 1979.

during the 78 hours watch, a range of values from 15% to 30% with a median of 22% was obtained. The percentage of time spent feeding also dropped dramatically from approximately 60%, to less than 10%. A change in activity pattern was also evident (Fig. 2).

Female No. 1097

No. 1097, an 11-year-old female, and her 3 cubs were observed for 321.3 hours between 17 May and 12 June 1981. She was active during 37% of the time. I divided this time into 2 different periods: 17 May through 3 June, when her activity centered around the den, and 4 June through 12 June, when she left the den vicinity.

No. 1097 foraged near her winter den during the first period, using the den for resting through 19 May and afterward using day beds near the den through 3 June. No. 1097 was active 29% of the 186 hours of observation in the first period. Two continuous observation periods of 38 and 35 hours were obtained (Table 1). From the first session, 15 24-hour activity samples ranged from 31% to 40% (median = 36%). The 12 24-hour percentages from the second bout ranged from 20% to 28% (median = 24%). The daily activity pattern for this early period showed a peak in activity around midday (Fig. 3).

On 4 June 1981, No. 1097 moved away from the den and appeared to be more active. During 135 hours of observation from 4 through 12 June, No. 1097 was active 48% of the time. Table 1 summarizes the activity level from 2 continuous bouts of 39 and 53 hours. The 16 activity levels calculated from the first bout ranged from 51% to 57% (median = 53%), and the 30 from the second ranged from 46% to 58% (median = 52%).

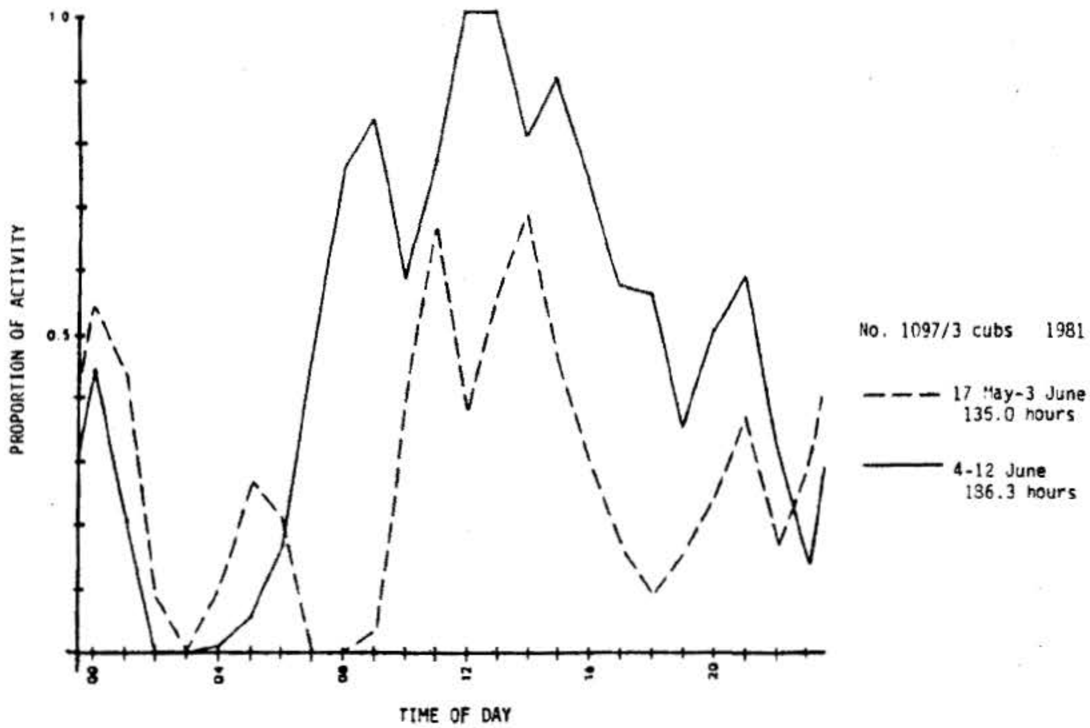

Fig. 3. Proportion of activity by hour for female grizzly bear No. 1097, 17 May-12 June 1981.

The daily activity pattern from this second period was very similar to the earlier one, and also reflected the overall increased level of activity during the period (Fig. 3).

Female No. 1169

Thirteen-year-old female No. 1169, accompanied by 2 cubs, was active during 23% of the 151 hours of observation between 23 May and 1 June 1982. During this period, she remained in the vicinity of her den. Activity levels from 2 extended observation periods were calculated (Table 1). The 45 24-hour activity samples calculated from the 68-hour session ranged from 20% to 36% active (median = 30%). Her daily activity pattern is plotted in Fig. 4.

Unmarked female

An unmarked female with a single cub shared the mountainside with No. 1169. She was observed for 83 hours between 1400 h on 23 May and 0130 h on 27 May 1982. During 83 hours of observation the bear was active 31% of the time. Two activity periods are summarized in Table 1. The 33 24-hour activity levels calculated from the 56-hour observation session ranged from 28% to 35% (median = 32%). The unmarked female's daily activity cycle is plotted with that of No. 1169 (Fig. 4).

Female No. 1087

Female No. 1087, the weaned offspring of No. 1086, was observed for 28 hours between 1400 h on 11 July and 1800 h on 12 July 1979. She was active during 55% of the 27 hours of observation during this period.

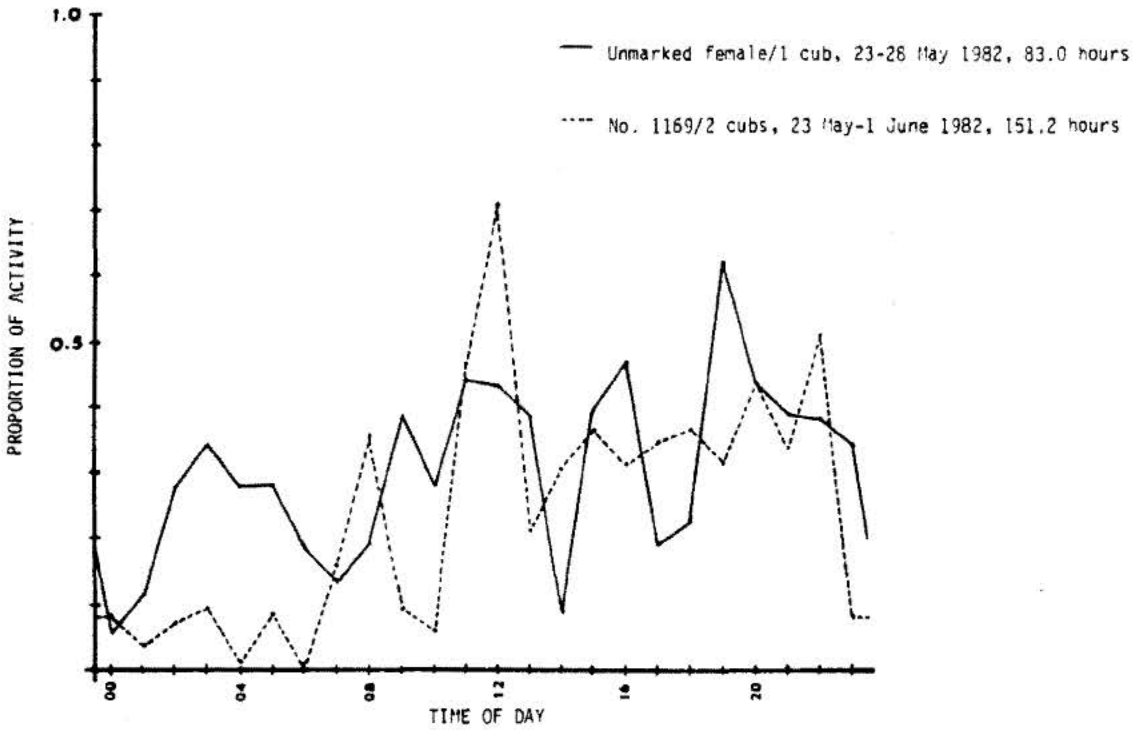

Fig. 4. Proportion of activity by hour for 2 female grizzly bears with cubs, 23 May-1 June 1982.

Her activity levels from the 5 possible 24-hour samples ranged from 51 to 65% (median = 58%), a figure comparable to the 57% activity during 23 hours she was observed while with her mother the previous year on 14 through 15 July 1978.

DISCUSSION

Nelson et al. (1983) proposed 4 annual physiological stages for bears--hibernation, walking hibernation, normal activity, and hyperphagia--that were reflected in their activity and behavior.

Observations from the post-denning "walking hibernation" phase were obtained for 3 females with cubs. They were inactive the majority of the time during late May and the first few days in June. During this period, the females remained in the general vicinity of their winter dens and were active for short intervals, using either the den or nearby day beds for frequent rest bouts. The 20-40% range of percent activity for these females was fairly consistent during this early period. Female No. 1097 was the only female that was also observed after she left the den area and began to move more extensively. Her level of activity after she moved away from the den (4-12 June) was in the 46-58% range, although the increase was not statistically significant. Initial low activity that increased during the spring was also noted for black bears in Tennessee (Garshelis and Pelton 1980). These results were consistent with the hypothesis that bears were anorectic for 10-14 days after emergence from the den, during the transition from body fat catabolism to normal diet (Nelson et al. 1983).

The range of percent activity during the "normal activity" stage (Nelson et al. 1983) observed for No. 1086 while she was accompanied by her 2- and 3-year-old offspring, and for No. 1087, a weaned subadult, was 50-74%. This range was similar to Gebhard's (1982) average monthly figures for No. 1086 during 1977, and to the 45-60% summer/fall activity range for European brown bears (Roth 1983). The lowest value (50%), from midsummer 1978, occurred during the warmest weather and worst insect conditions. I detected no seasonal trend in No. 1086's activity during 1978. Gebhard (1982) stated that, based on his figures (which were computed as total active minutes/total minutes observed), there was a seasonal increase in activity through fall. All of his values except 1, however, fell within the range of values that were found in a 3-day period during early 1979. Sampling, rather than trend, could have accounted for the variation observed.

I detected no fall hyperphagia, but observations were hampered by increasing darkness and the sample size was small. Nelson (1980) reported that bears were active 20-hour per day during hyperphagia. Gebhard (1982) stated that No. 1086 was active 20-hour per day during late fall 1977. But that figure was based on an 85% activity level from only 13.3 hours of observation between 9 September and 10 October 1977. During the 13.5 hours I observed No. 1086 in late fall 1978, she was active only 21.4% of the time. With such small sample sizes, one should not try to draw conclusions.

The proportion of activity in 1979 for No. 1086 in the 3 days prior to breeding ranged from 56 to 74%. This dropped dramatically to 15 to 31% during the first 3 days of breeding (Fig. 2). Stelmock (1981) observed mated pairs were active 67% of the time. Other researchers have reported that activity levels during the breeding season are unchanged (Pearson 1975) or even higher than at other times (Garshelis and Pelton 1980).

Considerable variation among the bears was seen in their activity patterns. No. 1086 showed a strong tendency for long afternoon to evening periods of inactivity during 1978 (Fig. 1). Gebhard (1982) reported this was also true for No. 1086 in 1977. No. 1097 seemed to maintain a pattern of greatest activity during midday even as her overall level of activity increased (Fig. 3). No. 1169 and the unmarked female showed different activity patterns even though both were observed on the same mountain at the same time, also indicating the amount of individual variation among bears (Fig. 4). Roth (1983) reviewed diel activity data for brown bears, found much variation reported, and concluded that "the scarcity of systematic and quantitative data precludes a detailed discussion." Many factors including weather, humidity, temperature, light, lunar phase, season, human disturbance, and the sex, age, and reproductive status of the bear have been reported as factors contributing to the variation observed. Studies of individual bears' activities have demonstrated that much individual variation also occurred (Stelmock 1981, Roth 1983, Schleyer 1983).

The capacity of individual bears or bear populations to respond to a wide variety of resources and environmental conditions with a strategy of flexible social structure, food habits, and activity patterns contributed to the species' success at exploiting a wide range of habitats.

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CHAPTER III

FOOD HABITS OF BARREN-GROUND GRIZZLY BEARS IN NORTHWESTERN ALASKA, 1977-1981

ABSTRACT

Food habits of grizzly bears (Ursus arctos) in the North Slope foothills of the western Brooks Range, Alaska, were studied from 1977 to 1981 using scat analysis, direct observation of feeding behavior, and feeding site and habitat examination. Three seasonal feeding strategies were evident: spring use of Hedysarum alpinum roots, overwintered Arctostaphylos rubra berries, and emerging vegetation and floral parts of plants primarily in dry tundra types, floodplain communities, and tussocks; summer grazing of succulent vegetation and flowers, primarily Equisetum arvense, Boykinia richardsonii, and grasses/sedges in wet sedge meadows, ecotones between wet sedge and dry tundra, and lush areas below snowbanks; late summer and early fall use of roots, ripening berries, and ground squirrels in dry tundra types, riparian areas, or wet sites such as string bogs that contained dry microsites that produced berries. Bears' diets consisted primarily of plants but were supplemented, whenever possible, with animal protein. In fact, ground squirrels were the most important food during fall 1978. The foothills are a topographically diverse area with a complex vegetative mosaic offering a good variety of plant and animal foods in relatively small areas compared to the Arctic Coastal Plain or the mountains. Every habitat has foods of interest to bears, and, though general use patterns were evident, bears could be encountered in any habitat at any time.

INTRODUCTION

Historically, grizzly bears exploited a wide range of habitats across most of western North America from northern Mexico to the Arctic Ocean (Craighead and Mitchell 1982). Their curiosity, intelligence, and omnivorous diet were responsible for widespread distribution, but also led to their near demise. Conflicts with modern man and habitat destruction caused the elimination of grizzlies from most of their former range before anything could be learned about their ecology (Rausch 1951).

Early studies of arctic grizzly populations indicated that, at the northern limits of the bear's range, home ranges were large, the density of bears was low, productivity was low, bears matured slowly, and bears spent the majority of the year in dens (Quimby 1974; Pearson 1975; Reynolds 1976, 1980). Because they inhabited remote regions, arctic grizzlies have, until recently, avoided most conflicts with Man. However, energy resource exploration and development has spread, and aircraft have provided easy access to the formerly inaccessible areas. Impacts of development on grizzlies in the Arctic were described by Harding and Nagy (1980) and Follmann and Hechtel (in press). Their low productivity and the lack of escape cover in the Arctic make bears particularly vulnerable (Brooks et al. 1971, Reynolds 1980).

The purpose of this study was to investigate the food habits of grizzly bears in a part of the National Petroleum Reserve-Alaska that was scheduled for oil and gas exploration. This was accomplished through scat analysis, feeding site examination, and by ground-tracking and observing radio-collared animals. Females with young were studied because of their restricted movements, small home ranges, and importance to the productivity of the population. An understanding of the relationships between bears and their foods and habitats should help land managers assess the impacts of development and avoid some of the potential conflicts.

Work in the Arctic is logistically difficult and expensive. The Alaska Department of Fish and Game (ADF&G) generously provided most of the funding and logistical support. Additional money was provided by the Arctic Institute of North America, the Audubon Society, the Montana Cooperative Wildlife Research Unit, the Naval Arctic Research Laboratory, the Theodore Roosevelt Fund of the American Museum of Natural History, and the Wildlife Management Institute/American Petroleum Institute. I owe special thanks to Harry Reynolds, Erich Follmann, Bart O'Gara, Charles Jonkel, and Joe Ball; to pilots Jim Rood, Craig Lofstedt, and Bill Lentsch; and to my field assistants Brian Cooper, Roger Smith, and Russell Lachelt. Jim Gebhard helped collect data in 1977.

STUDY AREA

The study area is centered around Meat Mountain (68°56'N, 160°45'W), an 870 m high mesa on the North Slope of the Brooks Range. This mountain is approximately 320 km southwest of Barrow, Alaska, in the Southern Foothills Physiographic Province (National Petroleum Reserve in Alaska Task Force 1978). The Southern Foothills are characterized by a series of ridges, mesas, and buttes from 365 to 1110 m in elevation, and generally oriented on an east/west axis. The foothills are separated by river drainages or broad valleys. Permafrost is found throughout the area, and patterned ground from periglacial processes is conspicuous. Seasonal thaw depths are greater in the coarse, well-drained soils of raised areas and steep slopes than in the poorly drained, fine soils of the gentle slopes.

The climate of the area is "arctic," characterized by long, cold winters and short, cool summers. Freezing temperatures may occur during any month. Detailed climatic information for the area is lacking, but precipitation (light to moderate summer rain and light winter snowfall) is estimated at 15-50 cm (National Petroleum Reserve in Alaska Task Force 1978). Average snow depths are shallow, but strong prevailing northeasterly winds create snow banks up to 15 m deep and 2 km long on the lee sides of ridges and in depressions. These snow banks often persist into midsummer. Ground fog and low clouds with bases below 460 m frequently occur during summer months (National Petroleum Reserve in Alaska Task Force 1978). Stream volumes fluctuate rapidly after rainfall. Strong winds are frequent throughout the year. From early May through mid-August, 24 hours of daylight occurs daily.

The treeless vegetation of the area is characterized by prostrate growth forms except for the shrub tundra which may reach heights of 3 m along major rivers. Arctic vegetation is characterized by few species of plants (many with wide environmental tolerances), and vegetation types that are often distinguished by changes in dominance. The steepness of environmental gradients determines the distinctness of boundaries between vegetation types (Johnson et al. 1966). Microsites containing species characteristic of different habitats were prevalent.

Detailed habitat mapping of the study area was not conducted. However, I described the major habitat types based on observations of the vegetation, collections of reference plants, and examination of feeding sites as well as on the studies of Spetzman (1959), Bliss and Cantlon (1957), Johnson et al. (1966), and Kuropat and Bryant (1980).

The *Dryas* fell-field vegetative type occurs on the wind-swept ridge tops and rock outcrops. These areas have only sparse vegetative cover characterized by low-growing scattered mat and cushion plants that cover less than 20% of the surface. Slight surface depressions offer more protection from the wind, tend to accumulate snow, and contain thicker patches of vegetation; but bare rock and soil predominate. Species characteristic of this type include *Dryas octopetala*, *Saxifraga oppositifolia*, *Oxytropis nigrescens*, *Minuartia arctica*, *Phlox sibirica*, and *Potentilla uniflora*.

Talus and scree slopes occur along some of the ridges and usually have sparse vegetative cover, but they also include small stabilized areas with more complete plant cover. Some plants found on talus slopes include *Saxifraga oppositifolia*, *S. tricuspidata*, *S. eschscholtzii*, *Draba caesia*, *Smelowskia calcyna*, *Bupleurum triradiatum*, *Festuca vivipara*, *Trisetum spicatum*, *Hierochloe alpina*, *Oxytropis borealis*, *Oxyria digyna*, and *Salix* spp.

The frost-scarred *Dryas* vegetative type is found on the loose, well-drained soils of raised areas and ridge slopes. A large percentage of the ground consists of bare soil in the form of "frost boils," as series of flat "steps" of exposed ground parallel to the slope with steeper vegetated margins, or as "stripes" of dirt perpendicular to the slope alternating with vegetated stripes. The bare ground of the frost-scarred Dryas is the result of disturbance by frost action (versus fell-field where isolated patches of vegetation are pioneering the barrens). The Dryas steps have a rich diversity of plants. Most fell-field species are also found in frost-scarred Dryas. In addition, Salix reticulata, Polygonum bistorta, Astragalus umbellatus, Oxytropis borealis, Hedysarum alpinum, Arctostaphylos rubra, and many other species are found there.

The Dryas-dwarf shrub meadow vegetation type is also found on well-drained sites and slopes (often adjacent to fell-field or frost-scarred types) and is characterized by similar species to the other Dryas types, but has more complete plant cover in the form of a turf. In addition to Dryas, dwarf willow and some of the other common Dryas-associated plants, Rhododendron lapponicum, Carex bigelowii, and Lupinus arcticus, occur.

The Dryas-Carex bigelowii meadow type often occurs downslope of the Dryas-dwarf shrub (on slightly wetter and gentler slopes) and above tussocks. The ground often has a hummocky appearance and most of the ground is covered by vegetation. Carex bigelowii increases in importance as the type grades into tussocks.

Tussock tundra varies from a mixture of Carex bigelowii/Eriophorum vaginatum tussocks through Eriophorum vaginatum- dominated stands. Tussocks are found on gentle slopes with little relief and with cold, wet, poorly drained soils. It is one of the most extensive vegetation types of the broad, foothill valleys. Other species characteristic of this type include Ledum decumbens, Betula nana, Salix pulchra, Empetrum nigrum, and Vaccinium vitis-idaea.

Wet sedge meadows occur on sites with the poorest drainage and often contain standing water. Drainageways in large tussock fields also contain this type of vegetation. Sedges are most common, but willows are also found on many sites. Important species include Carex aquatilus, Eriophorum angustifolium, E. russeolum, E. scheuchzeri, and Salix pulchra.

String bogs are similar to wet sedge meadows except they contain series of sinuous ridges 15-25 cm high that provide microsites for species such as Salix reticulata, Ledum decumbens, Vaccinium uliginosum, and V. vitis-idaea.

Floodplain communities are more dynamic because of the shifting stream and river channels, and the tendency for melt-off and precipitation to cause rapid fluctuations in stream volume. Successional stages from pioneer perennial herb through young feltleaf willow (Salix alaxensis) and decadent feltleaf willow have been identified (Bliss and Cantlon 1957). Species that invade the floodplain gravels include Crepis nana, Epilobium latifolium, Artemesia tilesii, Oxytropis borealis, Lupinus arcticus, and Hedysarum spp. The young feltleaf willow community is characterized by tall stands of S. alaxensis and an herb layer that includes L. arcticus, O. borealis, Hedysarum spp., and A. tilesii. The decadent stage is characterized by dying out of feltleaf willow, and increases in Salix arbusculoides, S. glauca, Arctostaphylos rubra, Ledum decumbens, Pyrola grandiflora, and Equisetum arvense.

Betula thickets, thick stands of dwarf birch (Betula nana), occur on certain slopes and high center polygons. These thickets also contain willow, Lupinus arcticus, Pyrola grandiflora, and mosses.

Snowbed communities result from the prevailing northeasterly winds forming large snowbanks on the lee sides of ridges. Ericaceous heath communities characterized by Cassiope tetragona, Ledum decumbens, Vaccinium uliginosum, and V. vitis-idaea are found in some of the earlier melting areas. Some of the larger snowbanks nurture lush herbaceous communities of grasses, sedges, Boykinia richardsonii, and Equisetum arvense. The phenology of these plants is retarded by the snow so that young succulent stages are present when, in most other areas, similar species have completed the season's growth.

Ground squirrel (Spermophilus parryii) mounds are primarily found in the drier, well-drained soils of Dryas communities and along stream and river banks where large burrow systems can be constructed. Ground squirrel digging, feeding, and defecating modifies the environment around the burrows and influences the vegetation. Lush growths of Arctagrostis latifolia, Trisetum spicatum, Poa arctica, Salix pulchra, and S. glauca often characterize these sites.

Mammalian species inhabiting the area include: caribou (Rangifer tarandus), moose (Alces alces), wolf (Canis lupus), red fox (Vulpes vulpes), arctic fox (Alopex lagopus), wolverine (Gulo gulo), ermine (Mustela erminea), least weasel (M. nivalis), marmot (Marmota browerii), arctic ground squirrel, collared lemming (Dicrostonyx groenlandicus), brown lemming (Lemmus sibiricus), red-backed vole (Clethrionomys rutilus), tundra vole (Microtus oeconomus), singing vole (M. miurus), and 3 shrews (Sorex arcticus, S. cinereus, and S. obscurus). Raptors, ptarmigan (Lagopus spp.), shorebirds, and passerines migrate to the area and nest.

METHODS

As part of an ADF&G study of grizzly bear ecology, bears were immobilized from a Bell 206B helicopter, measured, and marked (Reynolds 1980). During spring 1977, female No. 1086 and her yearlings (male No. 1164 and female No. 1087) were selected for intensive ground-tracking and observation. The ridge tops and slopes of Meat Mountain, near the center of the female's home range, served as excellent observation sites. During 1977, I studied food habits and habitat use of these bears, while Gebhard (1982) studied their behavior. During 1978 and 1979, I expanded my work to include behavioral observations.

Field crews of 2 people working out of a backpacking tent observed the bears. Camping on high ridges provided good visibility of surrounding valleys and helped to minimize conflicts with the bears which rarely used the barren ridgetops. Bears were located with radio-tracking gear and binoculars, or sometimes were just sighted. The bears were followed on foot and observed from ridgetop vantage points using variable power telescopes.

From 1977 through 1979, intensive study centered on No. 1086 and her young, but additional observations of other bears provided supplemental data on food habits. During observation sessions, the time each new behavior began was recorded to the nearest minute with shorthand notation. With the exception of important incidents of short duration, such as aggression or defecation, behavior that lasted less than 1 minute was not recorded. The amount of detail that could be observed depended on distance between observers and the bears (50 m to 5 km), light, and weather. Data were collected on specific food items consumed (when viewing conditions were ideal) and on the amount of time involved in different types of feeding activity. Feeding behavior was classified as either feeding or foraging (depending on whether more or less than 50% of the time was spent obtaining or eating foods), and was also broken down, when possible, into the following subcategories: digging roots, digging squirrels, chasing/digging microtines, chasing/feeding on caribou, grazing, eating berries, nursing, or a mixture of the above. Other behavior recorded included resting, traveling, playing, mating, and other intra- and interspecific interactions.

When possible, we observed bears for 24 hours at a time. Such continuous observations were facilitated by terrain, tundra vegetation, and 24-hour daylight during spring and summer. However, most sessions were interrupted by factors such as low clouds and fog, rain, snow, terrain, tall riparian vegetation, or movements of the bears.

Areas the bears used were later examined to gather information on habitat and the phenology of important plant species, and to examine feeding sites. We attempted to retrace their paths using terrain features, tracks, scats, and other sign. Interspersing the feeding site visits with bear observations helped us interpret the feeding behavior we observed during subsequent sessions. Scats, reference plants, and samples of food plants for qualitative analyses were also collected.

Scats were collected from 1977 through 1981. In 1977, all scats encountered were collected. No black bears (Ursus americanus) occurred in the area and tundra vegetation simplified the task of locating scats. Scats of unknown age were examined for the presence of new food items, but were not used in food habits calculations. As of 1978, only scats whose ages could be accurately estimated were collected. Criteria for aging scats are listed by Hamer and Herrero (1983). In addition, we often observed defecations and were able to collect those scats. Scats obtained by ADF&G personnel during captures provided additional data.

After debris was removed from their surfaces, the scats were bagged, labeled, and either frozen or air-dried. In the laboratory, scats were rehydrated and washed through screens. Five to 10 subsamples were examined in shallow enamel pans with magnifying lenses, and, when necessary, with a dissecting microscope. Intact remains, such as flowers or grass seed heads, were removed and stored for later identification.

I estimated the percent composition of each item in the scat as 1 of 6 categories: trace-5%, 6-25%, 26-50%, 51-75%, 76-95%, or 96-100%. For calculating composition and volume, the midpoint of each category (2.5, 15.5, 38, 63, 85.5, 98) was used. The year was divided into 3 seasons corresponding to the phenology of the vegetation: spring or pre-greenup (1 May-15 June), summer or the growing season (15 June-1 August), and fall (1 August-1 October). For each item and season, I calculated the following:

Frequency = the number of scats containing the item

$$\text{Percent frequency} = \frac{\text{frequency}}{\text{total number of scats for the season}}$$

$$\text{Mean percent composition (MPC)} = \frac{\text{sum of midpoint composition values for the item}}{\text{frequency}}$$

$$\text{Percent total volume (PTV)} = \frac{\text{sum of midpoint volume values for the item}}{\text{sum of midpoint volume values for all items for the season}}$$

Percent total volume (PTV) was considered the best figure for comparing the various food items because it combined the values for frequency and composition of each item in the scats into 1 number.

RESULTS

Scat Analysis

From 1977 through 1981, 503 scats were collected (87% in 1977 and 1978) and analyzed (Fig. 1). Scats were actively collected whenever encountered in 1977 and 1978. During subsequent years, fresh scats were collected opportunistically to increase the sample sizes.

During spring seasons, 143 scats were collected (Table 1). Five of 13 items (roots, overwinter *Arctostaphylos rubra* berries, *Eriophorum vaginatum* floral parts, caribou, and ground squirrels) made up 95% of the total volume of spring scat material (95.0 PTV). Combined animal matter accounted for 9.3 PTV. In Table 2, the PTV and rank of the 8 most important spring foods were compared with the values for 1977 and 1978. Roots occurred most frequently and had the highest PTV of all spring foods (more than 5 times as high as the next most important item). Compared to scats analyzed in 1977, the 1978 PTVs of roots, caribou, and grasses/sedges declined and those of berries, ground squirrels, microtines, and flowers increased. *E. vaginatum* floral parts were only found in 1981 scats, but were fed upon extensively early that spring by 1 female with 3 cubs.

During summers, 227 scats were obtained (Table 1). The greatest diversity of foods occurred in summer scats. No single item dominated the summer diet as roots did the spring diet. Seven of 19 items (*Boykinia richardsonii*, *Equisetum arvense*, grasses/sedges, ground squirrels, roots, caribou, and *Oxytropis borealis* flowers) totaled 96.1 PTV. Vegetative and flowering parts of plants formed the basis of the summer diet (76.9 PTV). Animal food made up 14.1% of the total summer

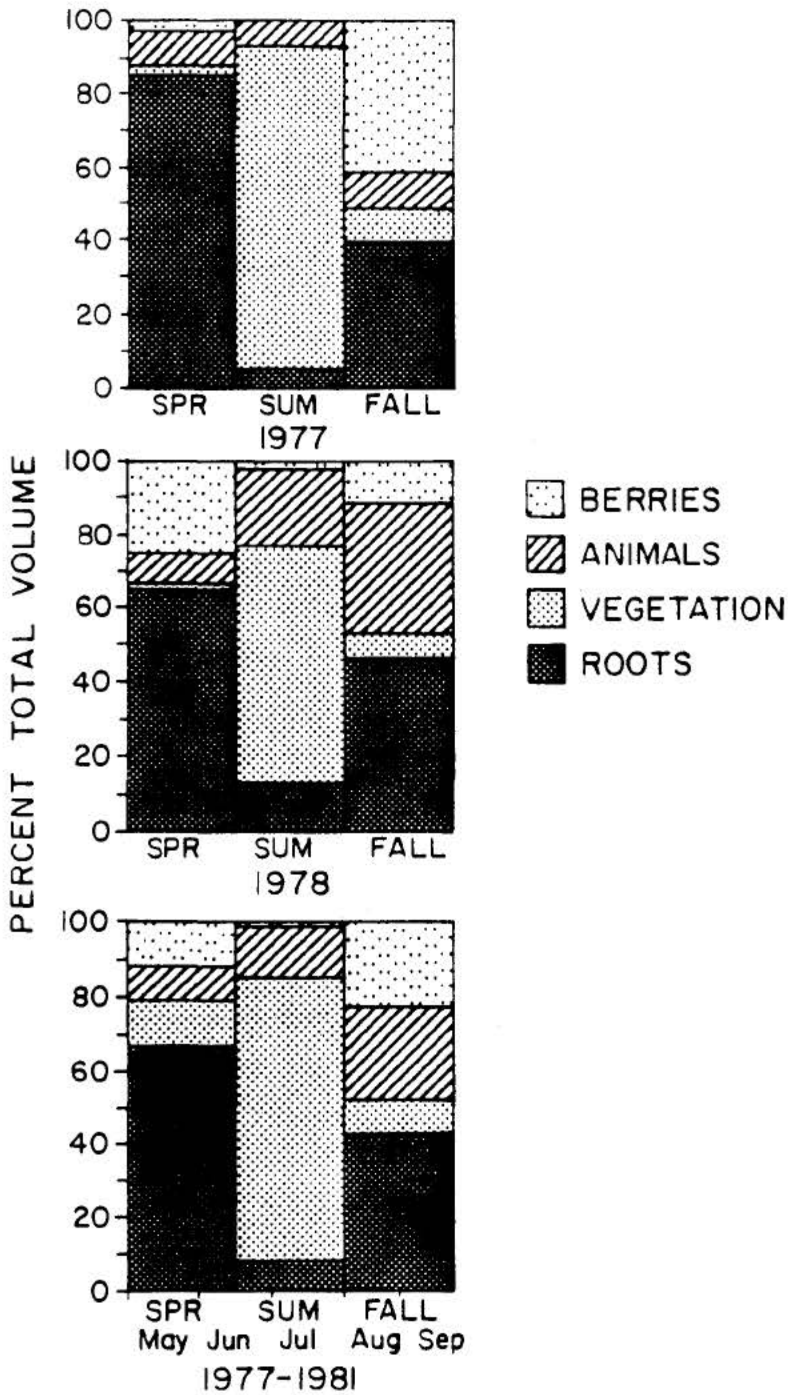

Fig. 1. Seasonal and yearly percent total volume (PTV) of food from grizzly bear scats, North Slope Foothills, Alaska, 1977-1981.

Table 1. Seasonal composition of 503 grizzly bear scats from the North Slope Foothills, Alaska, 1977-81.

Food item	Frequency	% frequency	Mean % composition	% total volume
SPRING n = 143				
Roots	118	83	79	66.6
Berries	54	38	32	12.2
Eriophorum vaginatum floral parts	14	10	87	8.7
Caribou	10	7	56	4.0
Ground squirrels	22	15	23	3.5
Microtines	24	17	11	1.8
Grasses/sedges	25	17	7	1.3
Flowers/seed heads	11	8	16	1.2
Equisetum arvense	3	2	23	0.5
Miscellaneous	-	-	-	0.2
SUMMER n = 227				
Boykinia richardsonii	139	61	52	32.0
Equisetum arvense	126	56	46	25.8
Grasses/sedges	195	86	18	15.6
Ground squirrels	55	24	33	8.0
Roots	42	19	42	7.8
Caribou	16	7	59	4.2
Oxytropis borealis flowers	27	12	23	2.7
Microtines	20	9	13	1.2
Berries	11	5	22	1.1

Table 1. Continued.

Food item	Frequency	% frequency	Mean % composition	% total volume
Unknown forbs	13	6	9	0.5
Miscellaneous	-	-	-	1.0
FALL n = 133				
Roots	104	78	54	42.4
Berries	88	66	34	23.0
Ground squirrels	72	54	42	22.9
Grasses/sedges	44	33	21	7.0
Microtines	11	8	20	1.7
Boykinia richardsonii	7	5	20	1.1
Eriophorum rhizomes	2	2	63	1.0
Equisetum arvense	4	3	21	0.6
Miscellaneous	-	-	-	0.4

Table 2. Seasonal rank and percent total volume (PTV) of important grizzly bear foods of the North Slope Foothills, Alaska.

Season	Food item	1977-1981		1977		1978	
		Rank	PTV	Rank	PTV	Rank	PTV
Spring	Roots	1	66.6	1	84.8	1	64.6
	Berries	2	12.2	5	1.7	2	30.0
	Eriophorum vaginatum floral parts	3	8.7	-	-	-	-
	Caribou	4	4.0	2	6.6	5	1.4
	Ground squirrels	5	3.5	4	2.0	3	5.7
	Microtines	6	1.8	8	0.4	4	1.8
	Grasses/sedges	7	1.3	3	2.7	7	0.4
	Flowers	8	1.2	7	0.4	6	1.0
Summer	_Boykinia richardsonii_	1	32.0	1	36.9	1	26.4
	Equisetum arvense	2	25.8	2	30.0	2	21.6
	Grasses/sedges	3	15.6	3	16.7	3	15.0
	Ground squirrels	4	8.0	7	2.2	4	13.0
	Roots	5	7.8	4	4.9	5	12.9
	Caribou	6	4.2	6	2.4	6	6.3
	Oxytropis borealis flowers	7	2.7	5	3.6	9	0.4
	Microtines	8	1.2	8	0.9	8	1.0
	Berries	9	1.1	13	0.2	7	2.2

Table 2. Continued.

Season	Food item	1977-1981		1977		1978	
		Rank	PTV	Rank	PTV	Rank	PTV
Fall	Roots	1	42.4	2	39.3	1	46.4
	Berries	2	23.0	1	40.4	3	11.1
	Ground squirrels	3	22.9	3	9.3	2	35.0
	Grasses/sedges	4	7.0	4	8.8	4	5.1
	Microtines	5	1.7	6	0.4	6	0.6

scat volume. Feathers and eggshell (0.4 PTV), bees (0.3 PTV), and marmots (0.1 PTV) were of minor importance. The 1977 and 1978 rank and PTV summer scat values are compared with the combined total in Table 2. Even though grasses/sedges constituted the most frequently occurring item, mean percent composition was relatively low, giving it a consistent third ranking. B. richardsonii and E. arvense occurred less frequently but in higher volumes, giving them the 2 highest PTVs. Compared to scats analyzed in 1977, the 1978 PTVs of B. richardsonii, E. arvense, grasses/sedges, and O. borealis flowers decreased, while those of ground squirrels, roots, caribou, and berries increased.

One hundred and thirty-three fall scats were analyzed (Table 1). Four of 12 items (roots, Arctostaphylos rubra berries, ground squirrels, and grasses/sedges) made up 95.3% of the scat volume. The 24.9 PTV of combined animal remains, the highest for the year, was 92% ground squirrels. The miscellaneous food items found in fall scats included bees (0.3 PTV) and traces (less than 0.1 PTV) of feathers, caribou, and unknown bone. The fall rank and PTV values for 1977 and 1978 are listed in Table 2. The PTVs of roots and of ground squirrels increased while those of berries and grasses/sedges decreased.

Direct Observation of Feeding Behavior

Data on food habits from direct observations of feeding behavior were collected during 1978. On 29 May 1978, we arrived at Meat Mountain, and we completed the field work on 19 September. We watched bears for 277 hours 41 minutes (10% of the 2736 hours of this 114-day field season). Seasonally, this represented 16% of the 18 spring days, 11% of the 46 summer days, and 7% of the 50 fall days. Increasing darkness was partly responsible for the low fall sample. Even though the bears spent only part of the observation time feeding or foraging, we often watched more than 1 bear at a time, and we were able to record more than 360 bear-hours of feeding behavior during 1978.

Seasonal observations

During spring 1978, more than 101 bear-hours of feeding activity were recorded (Table 3). Bears spent the greatest amount of time digging and eating roots of *Hedysarum alpinum*. During 15% of feeding observations, bears were pursuing or eating mammalian foods, primarily ground squirrels. Bears were eating overwintered *Arctostaphylos rubra* berries during 1% of feeding time, but these observations were probably biased because some feeding on berries was recorded as grazing. The bears grazed on emerging grasses and sedges, and the fruiting and vegetative shoots of *Equisetum arvense* as soon as the succulent vegetation appeared. The time spent feeding on *Eriophorum* rhizomes involved an observation of female No. 1093 and her yearling digging and gnawing at a microtine rhizome cache that had been flooded and frozen.

Most plant growth occurred during the summer, and bears grazed during more than half of the 157 bear-hours of summer feeding (Table 3). We observed them eating *Boykinia richardsonii*, *Equisetum arvense*, grasses and sedges, *Oxytropis borealis* flowers, and *Oxyria digyna*. Bears grazed the succulent, early phenological stages of these plants. The bears pursued or ate mammals during 17% of the feeding time. More than 25% of the feeding activity could not be classified.

Table 3. Percent of total seasonal feeding/foraging time that grizzly bears spent in particular activities, North Slope Foothills, Alaska, 1978.

	Percent of total feeding/foraging time		
Feeding/foraging activity	Spring (n = 101)[a]	Summer (n = 157)[a]	Fall (n = 102)[a]
Digging roots	72.1	5.9	15.2
Digging ground squirrels	10.7	12.3	40.3
Grazing[b]	3.7	51.0	9.8
Hunting microtines	3.1	0	0
Digging up microtine caches	1.2	0	0.6
Eating berries	1.0	0.04	13.5
Feeding on caribou	0.8	4.6	0
Unknown	7.4	26.1	20.7

[a] Bear-hours of feeding/foraging behavior.

[b] Grazing includes some feeding on berries.

During fall 1978, more than 102 bear-hours of feeding were recorded (Table 3). The pursuit of ground squirrels occupied more than 40% of my sample of the bears' feeding time. Grazing and feeding on berries were next in importance at 23%. Another instance of bears digging up microtine caches of Eriophorum rhizomes was observed. About 20% of the feeding behavior was unclassified.

Ground squirrel use

In addition to recording the percentage of feeding time bears spent in pursuit of ground squirrels, an attempt was made to gather data on the success rate for obtaining squirrels. A seasonal summary of ground squirrel digging activity by bear No. 1086 and her 2, 2-year-old offspring in 1978 is presented in Table 4. Depending on conditions, determining if a bear was successful during a given dig was not always possible. However, an estimate of the bears' efficiency was obtained (Table 5). Two methods were used to estimate the bears' success at capturing ground squirrels. The most conservative approach, which counted all digs of unknown outcome as unsuccessful, was simply to divide the number of squirrels caught by the total number of digs. This method resulted in annual capture rates of 11.4%, 11.3%, and 8.4% for Nos. 1086, 1164, and 1086, respectively. If the assumption was made that the success rate of digs of unknown outcome was similar to that of digs of known outcome, the success rate could be calculated by dividing the successful digs by total digs for which the outcome was known. I defined this as the probable capture rate. This method gave annual

Table 4. Seasonal numbers and duration of grizzly bear digs for ground squirrels on the North Slope Foothills, Alaska, 1978.

		Successful digs			Unsuccessful digs			Digs of unknown outcome			Total digs		
Season	Bear	Number	$\bar{x}$ length (min)	SD	Number	$\bar{x}$ length (min)	SD	Number	$\bar{x}$ length (min)	SD	Number	$\bar{x}$ length (min)	SD
Spring	1086	1	5.0	-	21	6.5	6.4	1	3.0	-	23	6.3	6.2
	1164	2	2.0	0	17	6.7	5.8	-	-	-	19	6.2	5.7
	1087	1	4.0	-	24	6.3	4.5	1	3.0	-	26	6.1	4.4
Summer	1086	2	6.0	2.8	19	12.3	12.4	4	21.3	24.6	25	13.2	14.4
	1164	1	2.0	-	17	13.8	15.1	3	25.7	30.6	21	14.9	17.5
	1087	5	12.4	11.1	17	12.4	11.6	3	25.0	29.5	25	13.9	14.1
Fall	1086	9	5.8	4.5	30	5.2	4.8	18	9.9	7.5	57	6.8	6.0
	1164	6[a]	15.3	14.1	21	5.8	4.1	13	10.6	7.0	40	8.8	7.9
	1087	2[a]	6.5	2.1	31	5.9	5.7	11	10.5	6.6	44	7.1	6.1

[a] During one dig, No. 1087 caught a ground squirrel but No. 1164 stole and ate it.

Table 5. Data collected during observation of grizzly bears pursuing and capturing ground squirrels, and estimated seasonal number of digs and squirrels caught, North Slope Foothills, Alaska, 1978.

Season	Bear number	% of total observation time spent pursuing ground squirrels	% of total feeding activity spent pursuing ground squirrels	Number of digs observed	Number of squirrels observed caught	Capture rate (squirrels/dig)		Number of digs per hour of observation	Estimated total number of digs during season[c]	Estimated number squirrels caught	
						A[a]	B[b]			A[d]	B[e]
Spring	1086	5.3	9.5	23	1	.043	.045	.44	190	8	9
	1164	4.0	7.3	19	2	.105	.105	.36	157	16	16
	1087	6.1	11.0	26	1	.038	.040	.50	215	8	9
Summer	1086	5.9	12.6	25	2	.080	.095	.23	251	20	24
	1164	5.3	11.3	21	1	.048	.056	.19	211	10	12
	1087	6.2	12.5	25	5	.200	.227	.23	251	50	57
Fall	1086	19.9	46.7	57	9	.158	.231	.75	899	142	208
	1164	15.2	37.7	40	6[f]	.150	.222	.53	631	95	140
	1087	16.1	40.0	44	2[f]	.045	.061	.58	694	31	42

Table 5 continued.

[a] Capture rate A = $\dfrac{\text{number of successful digs}}{\text{total number of digs observed (including digs of unknown outcome)}}$

[b] Capture rate B = $\dfrac{\text{number of successful digs}}{\text{number of successful digs + number of unsuccessful digs}}$

[c] Estimated total number of digs during season = number of digs per hour of observation X total number of hours in season.

[d] Number of squirrels caught estimated by using minimum success rate A times Estimated number of digs during season.

[e] Number of squirrels caught estimated using success rate B.

[f] During one dig, No. 1087 caught a squirrel but No. 1164 seized and ate it; No. 1164 consumed 7 squirrels, No. 1087 ate 1.

capture rates of 14.6%, 14.1%, and 10.0% for the female and her male and female offspring.

An estimate of the total number of digs was obtained by extrapolating the number of digs witnessed per hour of observation into the total hours during the field season. I estimated that Nos. 1086, 1164, and 1087 dug into 1040, 792, and 941 squirrel holes between 29 May and 19 September 1978. By multiplying the estimated number of digs by the probable capture rate, I calculated that No. 1086 caught between 119 and 152 squirrels and that her male and female young caught from 89 to 112, and 79 to 94. When the success rates, digs, and captures were calculated for each season and then combined to give an annual total, estimates of squirrels caught ranged from 170 to 241, 121 to 168, and 81 to 108 for the 3 bears (Table 5).

Nursing

No. 1086 nursed her 2-year-old offspring throughout the 1978 field season. We observed 28 nursing bouts between 30 May and 11 September; the mean lengths were 4.8 minutes (SD = 1.5), 4.5 minutes (SD = 1.3), and 4.5 minutes (SD = 1.5) for Nos. 1086, 1164, and 1087, respectively. One bout involved only the female cub, while her sibling was digging out a ground squirrel. Seventeen minutes later, No. 1164 attempted to nurse but the female refused to let him. No significant differences were noted between the lengths of each cub's bouts, or between bouts that the mother interrupted versus those the young completed. Because viewing conditions were usually less than ideal, undoubtedly some nursing was not observed, and the nursing interval (time between initiation of successive bouts) could not always be calculated. During an 8.7 hour observation session on 2 July when conditions were ideal, we observed 4 nursing bouts and 3 intervals (2.5 hours, 1.9 hours, and 2.3 hours; mean = 2.2 hours, SD = 0.3). The mean of 4 intervals between 5 bouts on 30 May was 3.7 hours (SD = 1.5). Although 15 intervals were recorded (mean = 6.1 hours, SD = 4.7), 4 probably included unobserved nursing activity. The mean length of the other 11 intervals was 3.7 hours (SD = 1.6), a more realistic approximation.

Data on the activity of the bears preceding and following nursing bouts and on which animals initiated and terminated the bouts were collected. Ten bouts occurred in the middle of a resting period, 4 just prior to resting, 4 at the end of a resting period, 3 in the middle of feeding bouts, and 7 during a mixture of feeding/resting activity by different family members. The mother initiated 3 nursing bouts, the male cub 7, the female cub 3, and both young together initiated 5. The initiator of 10 bouts was unknown. Fourteen of the nursing bouts ended when the young quit suckling; the female ended 5 bouts while both young were still suckling; she ended 4 bouts after only 1 cub had finished on its own (3 for No. 1087); and the end was unknown for 5. The percentages of seasonal feeding time that nursing activity composed during spring, summer, and fall, respectively, were 2.5%, 2.4%, and 0.7% for No. 1164 and 2.6%, 2.2%, and 0.9% for No. 1087. During 2 24-hour watches on 30 May and 2-3 June 1978, the percentage of observation time that No. 1086 spent nursing was 1.7% and 1.1%, respectively.

Aggression

During the 1978 field season, 11 instances of aggression were recorded. All but 1 (between young during a play bout) were food-related, and 8 occurred while digging for ground squirrels. Of 9 incidents within the family, No. 1164 was the aggressor 4 times (3 toward his sibling and 1 toward the sow), No. 1087 was the aggressor 3 times (all toward her sibling), and No. 1086 was aggressive once toward each of her young. Surprisingly little aggression was observed, and many times when the young attempted to nurse, or really crowded the female as she dug, she would whirl and run away or ignore her young, and no aggression was observed. Once, No. 1087 was observed to grab a squirrel from her mother, and no aggression occurred.

Feeding Site Examination

Identifying the species of roots being dug at feeding sites was easier than determining them from scat analyses. Direct evidence of feeding was most evident where bears had dug. During the first 2 weeks of observation in 1977, the bears dug roots in the mat and cushion vegetation on the steep, north-facing slope of Meat Mountain. They pried up cushion plants, either uprooting the plant or breaking off the top and scraping down further until they could grasp the tap root with their teeth and pull it out. The dried tops of the dug-up mats were found and the plant was later identified as *Oxytropis borealis*; all digs that were examined during spring 1977 on the steep talus involved this species.

As spring progressed, the bears moved lower on the slopes to Dryas meadows and out onto raised Dryas areas on the flats north of the mountain where they used a slightly different digging technique. They scraped and peeled back chunks of turf where the vegetation cover was thick, or they scraped through loose soil until they could grasp and pull out long roots. Identification of the species being eaten was not as straightforward as it was with O. borealis, because the overturned chunks of turf contained the broken-off tops of many species, and Hedysarum alpinum, the legume sought at these digs, did not have a surface vegetative mat. Dig sites were routinely checked to determine the type of roots dug.

Rhizome use was observed during spring 1978. A female and her yearling dug and ate small, sweet-smelling rhizomes for more than 30 min in 1 spot. Apparently the bears had slowly thawed, gnawed, and scraped out these rhizomes from the frozen ground. I was unable to identify the rhizome, and did not understand why I had not previously observed its use if it was so prized. That fall I observed No. 1086 and her young in a string bog apparently digging for roots, an unusual incident. Obvious microtine sign along the raised ridges of the meadow accompanied evidence that the bears had dug into some of the tunnels and chambers. However, the bears had not displayed behavior typical of hunting for microtines, and little microtine sign was evident. We imitated the type of digging the bear sign indicated by peeling back sections of the vole runways. After 10 minutes, we discovered a large cache of Eriophorum rhizomes. This also explained the unknown spring dig into a similar flooded, frozen cache.

Feeding sign was not always obvious where bears grazed. However, observation and feeding site visits revealed use of overwinter Arctostaphylos rubra berries, fruiting and vegetative stalks of Equisetum arvense, flowers of Oxytropis borealis, Boykinia richardsonii, Trisetum spicatum, Oxyria digyna, and legume pods. I also observed a yearling bear bite off a Pedicularis kanei flower, walk 2 m and drop it.

DISCUSSION

A combination of scat analysis, direct observation of feeding/foraging behavior, and feeding site and habitat examination provided a more complete picture of grizzly bear food habits than could have been obtained by a single method. Analyses of scats indicated what the bears ate and when it was eaten. The relative quantity of food remains in the scats did not, however, reflect the amounts of food actually eaten because all foods were not digested equally. Meat, for example, was much more digestible than plant food, and the importance of animal protein was under-represented. Small prey probably occurred in greater proportion relative to weight, and in lesser proportion relative to numbers than did larger prey (Floyd et al. 1978). Direct observation revealed the types of feeding behavior that different bears engaged in, and when and where they fed. Under ideal conditions, identifying specific foods consumed was possible. An index to the importance of food classes was obtained from the percentage of time spent in various types of feeding activity. Because the amount of food ingested relative to the amount of time spent seeking and eating a food item varied for different kinds of feeding (e.g., grazing versus digging roots or digging ground squirrels), percentages of feeding time were indications of effort and preference, rather than of yield. In addition, the direct observation method was tedious, getting a large sample was difficult (only a couple of individuals could be watched at a time), and in some areas vegetation and darkness limited observations. Examination of feeding sites complemented observations and scat analysis with information on what was eaten, and when and where it was eaten. However, evidence of feeding was more obvious for some foods.

All 3 methods gave a fairly consistent picture of the bears' food habits in the area. Staple foods included Hedysarum alpinum roots, Arctostaphylos rubra berries, Boykinia richardsonii, Equisetum arvense, grasses/sedges, ground squirrels, and caribou. Minor, but significant, foods included Oxytropis borealis roots, Eriophorum vaginatum floral parts, sedge rhizomes, microtines, flowers, other berries, and birds. Foods that were only occasionally used or that were probably insignificant included willow, bees, marmots, and Oxyria digyna.

Roots

Roots, primarily Hedysarum alpinum and to a lesser degree Oxytropis borealis, were the most important staple spring food for bears in the study area. O. borealis was found in dry tundra, on talus and rubble slopes, and in floodplain communities. During spring 1977, bear No. 1086 and her yearlings fed extensively on O. borealis roots on the north-facing talus slope of Meat Mountain. Apart from this 1 extended period of use, O. borealis was only dug occasionally. It appeared that H. alpinum was the preferred species of root, and it was not known why

O. borealis was used heavily during that spring. Possibly, ease of digging when the ground was frozen may have promoted use of O. borealis over H. alpinum, because the oxytrope had an above-ground mat that the bears could grasp. H. alpinum occupied similar habitats to O. borealis, primarily Dryas tundra and riparian areas with coarse, well-drained soils. Other than during spring 1977, H. alpinum was the root used almost exclusively. The percentage of the total volume of roots in scats and the percentage of total feeding/foraging time spent digging roots each indicated that roots were by far the most important spring staple, were slightly less important in the fall, and were of minor importance in the summer (Fig. 2). The 1977 scats, and Gebhard's (1982) direct observations of the bears, further substantiated this pattern. Studies of grizzly bears from other areas of interior and northern Alaska, northwest Canada, and the Canadian Rockies found similar patterns of Hedysarum spp. use (Pearson 1975, Valkenburg 1976, Hamer et al. 1978, Stelmock 1981, Nagy et al. 1983). Hamer et al. (1977) suggested that: the ease of digging was important; bears preferred digging roots on slopes; the nutritional value of Hedysarum compared favorably with that of green vegetation; and crude protein levels of Hedysarum spp. increased during late summer and fall.

Berries

Berries were an important staple food in the fall, but were also used during spring. Arctostaphylos rubra was common on well-drained sites in Dryas habitats and floodplain areas. Vaccinium uliginosum was recorded from heaths and string bogs, and V. vitis-idaea was common in

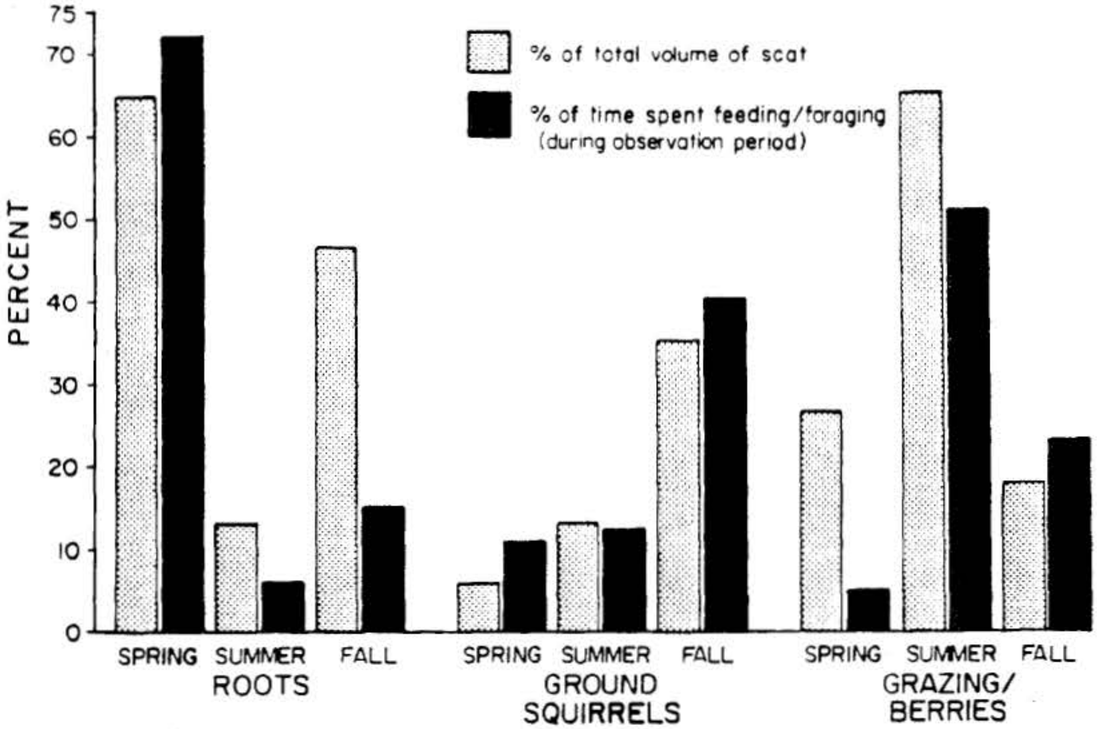

Fig. 2. Comparison of the percent total volume (PTV) of food from grizzly bear scats with percent of observation time feeding/foraging for the same item, 1978.

tussock habitats. Empetrum nigrum was found in moist areas from tussocks and string bogs through Carex bigelowii-Dryas dwarf shrub types. During spring and fall 1977 and 1978, Arctostaphylos rubra was eaten most frequently even though Vaccinium uliginosum, V. vitis-idaea, and Empetrum nigrum were also found in the study area. Overwintered A. rubra berries were used each spring, but during spring 1978 they were the second most important spring food, probably reflecting a good berry crop in fall 1977. This was supported by a greater use of berries in fall 1977 than in fall 1978. Hamer et al. (1977) found that overwintered berries have higher sugar content than they did the previous fall. Based on PTV for fall scats, A. rubra berries were the second most important food. Until they began to ripen in late summer/early fall, berries were only used minimally during the summer. I occasionally observed bears eating a few unripe berries. Many berries appeared unbroken in the scats, which often looked as if someone had sprinkled them with fresh berries. Other studies recorded use of berries in spring and fall, but the species consumed and the degree of use varied (Pearson 1975, Hamer et al. 1978, Murie 1981, Stelmock 1981, Nagy et al. 1983). Most other northern study areas were located within the range of Shepherdia canadensis, whose berries were a fall staple (Pearson 1975, Murie 1981, Stelmock 1981). S. canadensis was absent from my study area and A. rubra was used instead.

Ground Squirrels

Although the majority of the bears' diets consisted of vegetation, ground squirrels were also a staple food, especially during fall.

Squirrels were probably the most important fall food during 1978. Bear No. 1086, for example, spent more than 46% of her fall feeding/foraging time pursuing ground squirrels, and I estimated she caught between 170 and 241 squirrels during the 1978 field season (Table 5). Gebhard (1982) also reported ground squirrels as an important fall food source in 1977. The increasing use of ground squirrels from spring through fall was evident both from scats and observations (Fig. 2). The reported significance of ground squirrels as grizzly bear food varied greatly. In many areas, bears were reported to expend more energy digging out the squirrels than could have been gained from their capture (Dean 1957, Murie 1981). Squirrels may also have acted as a dietary supplement (Hamer at al. 1978, Stelmock 1981). In other areas, ground squirrels were a significant source of protein for fall weight gain (Nagy et al. 1983). Two factors, abundance of squirrels and ease of digging them out, appeared to dictate how important squirrels were in the bears' diets. The Southern Foothills portion of the western North Slope had high densities of squirrels with burrow systems in well-drained, loose soils that could be dug with relative ease when thaw depths increased during late summer. During fall, young squirrels dispersed to marginal burrows, probably increasing the bears' success rate. The squirrels' behavior also influenced the seriousness of the bears' digging. On several occasions, I observed a bear stop digging and walk away from a burrow, only to run back and continue digging after the squirrel emerged and emitted its alarm call.

The substrate in which squirrels dug their burrows also apparently affected the importance of squirrels to the bears' diets. If, for example, most squirrels occupied rock and talus types, they would probably be less vulnerable to predation by bears (unless caught away from their burrows), and therefore be less important to the diet of the bears in the area. This hypothesis is supported by the findings of Nagy et al. (1983). In my study area most squirrels occupied Dryas communities, talus, creek bluffs, and floodplain communities where they could construct burrows. The bears spent most of their time searching for and digging ground squirrels in the large Dryas step area south and west of Meat Mountain and along Seismo Creek bluffs, where they were able to move large amounts of dirt with relative ease.

Relationships between grizzly bears and ground squirrels in the Arctic are complex. Banfield (1958) commented on the similarity of distribution of the bears and squirrels. This is probably a reflection of similar ecological requirements for food and substrate for dens/burrows, rather than the grizzlies dependence on the squirrels for food. Squirrels competed with bears for such foods as Hedysarum alpinum roots and grasses/sedges, but were themselves an important part of the bears' diets. Squirrels also indirectly supplied bears with food; lush vegetation of ground squirrel mounds was often grazed by bears.

Caribou

The study area was located near the calving grounds of the Western Arctic Caribou Herd. The herd, estimated at more than 100,000 animals, arrived in the area from 1 to 25 May (Davis et al. 1980). Calving began as early as 27 May and peaked between 2 and 10 June (Valkenburg, pers. comm.). Reynolds (1980) attributed the high bear density in the Utukok area to the availability of caribou as a food source. The importance of caribou in scats and from observation was highly variable. Bears were quick to take advantage of carrion, and occasionally attempted capturing live caribou. The family groups I watched rarely chased caribou, even on occasions when they were encountered at close distances. Some bears are probably more predatory than others (Murie 1948). Stelmock (1981) found that female bears with young "most often responded to close proximity of ungulates by avoidance." The large post-calving migration herd did not pass by Meat Mountain during the years of my study. Reynolds (1980) found that bears did not appear to move far to hunt caribou, but readily took advantage of the food source when the herds moved through their home ranges. A minimum of 4 caribou carcasses were located in my study area; 1 was not fed upon by bears. Wolf densities were low, precluding opportunities to scavenge wolf kills. The caribou migrated out of the area during winter, and the spring supply of winter kills important to other grizzly populations (Craighead and Mitchell 1982) was not available.

Grazing

Grazing was the most important feeding activity during summer. Bears began to graze as soon as succulent vegetation appeared in the spring. They continued to use green vegetation into the early fall when they could find patches of young succulent stages of foods such as those found below late-melting snowbanks. The most heavily used forage was the young leaves, stems, and flowers of *Boykinia richardsonii*. This was followed in importance by *Equisetum arvense* and various grasses and sedges, including *Arctagrostis latifolia* and *Trisetum spicatum*. Favored grazing sites included moist herbaceous meadows, ground squirrel mounds, lush meadows below snowbanks, and the ecotone between wet sedge and drier habitats. Heavy grazing of *Eriophorum vaginatum* floral parts, a nutritious spring caribou food (Kuropat and Bryant 1980), was recorded in 1981 for a family group that had denned in the middle of a large tussock field. Other items of minor importance grazed were *Oxytropis borealis* flowers, *Oxyria digyna*, and willow buds and catkins. Grazing was an important feeding activity throughout the grizzly bear's range. Though the plant species grazed may vary, a tendency for bears to select early phenological stages of succulent vegetation was apparent (Pearson 1975, Hamer et al. 1978, Murie 1981, Stelmock 1981, Craighead and Sumner 1982). Some foods, such as *E. arvense*, were used over much of the bears range (Pearson 1975, Hamer et al. 1978, Sizemore 1980, Stelmock 1981). On the other hand, in some areas with vegetation similar to my area, bears did not use *B. richardsonii* very much, and instead relied more on grasses (Murie 1981, Stelmock 1981).

Miscellaneous Animal Food

Five species of microtine rodents occurred in the study area. Their numbers fluctuated, but when they were abundant, they were included in the bears' diets. Bears also took advantage of the caches of *Eriophorum* rhizomes stored by *Microtus oeconomus*. Numerous birds migrated to and nested in the study area. While hiking, we frequently discovered nests of passerines, shorebirds, or ptarmigan. The occurrence of feathers and eggshells in scats indicated that bears took advantage of this resource. Dead birds may also be eaten. I found a ptarmigan and a jaeger chick dead on the tundra, and presumably a bear would have consumed them. I found a 15-cm long dead whitefish washed up along Seismo Creek, but never found any fish remains in scats or observed any bears in the study area fishing. Cannibalism also occurred. I observed a large, male bear feeding on a dead cub, and predation on cubs by males may have resulted in the disappearance of a number of litters (Reynolds and Hechtel 1983).

Garbage

The study area was remote, with little human activity or opportunity for bears to use garbage. The propensity of bears to take advantage of artificial food sources, if they are available, has been well documented (Craighead and Craighead 1972, Follmann and Hechtel in press). The only artificial item found in the scats was a piece of plastic day-glo streamer. Female No. 1086 and young raided one of our food caches in 1978, but that was the only such incident during 4 summers.

Nursing

Grizzly bear milk is a concentrated energy source for young bears (Jenness et al. 1972) and is the sole source of nutrition for cubs from birth through den emergence, a period of rapid weight gain. Milk probably remains the most important energy source for cubs even for some time after they begin to eat other foods. Young bears continue to nurse each season they remain with their mother. Good evidence exists, however, that the yearly lactation cycles of females with older young were interrupted by dry spells during hibernation (Stelmock in press). No. 1086 nursed her offspring during their fourth spring together until the breakup of the family group when she consorted with a breeding male. Stelmock (in press) reviewed important aspects of nursing behavior as related to grizzly ecology. Average lengths of nursing bouts from various studies were consistently between 4 and 5 minutes (Haftorn 1960, Murie 1981, Stelmock 1981, Gebhard 1982). Murie's (1981) data indicated a trend of increasing length of nursing intervals with age of young (means of 2.0, 2.6, and 3.6 hours for cubs, yearling, and 2-year-olds), but this study and others showed no such trend (Stelmock 1981, Gebhard 1982). The mean length of 12 intervals reported by Gebhard (1982) for No. 1086 and her yearlings in 1977 was the same as I observed for 11 intervals from the same family group in 1978.

SUMMARY

Grizzly bears in the Southern Foothills of the North Slope of the western Brooks Range were opportunistic omnivores that hibernated about 7 months a year during the period of inclement weather and food shortage. Except for breeding, from emergence in the spring to denning in the fall, the active year of the bears consisted of searching for and eating large quantities of food to meet basic maintenance requirements and to store enough fat to survive the dormant period. Most of the bears' diets consisted of plants, supplemented whenever possible by animal protein. Three seasonal feeding strategies were evident.

From the time the bears emerged from dens through greenup, Hedysarum alpinum roots, high in starches, were the most important food, supplemented by overwintered Arctostaphylos rubra berries as well as emerging vegetation and floral parts of plants. Spring habitats providing staple plant food were dry tundra types, floodplain communities, and tussocks.

As snowmelt and greenup progressed, bears shifted to a summer grazing mode. Bears began grazing succulent vegetation and flowers, primarily Equisetum arvense, Boykinia richardsonii, and grasses/sedges. This shift also corresponded with a decrease in the quality of roots. The number of potential bear foods was greatest in early summer, and the diversity of habitats offering feeding opportunities was also greatest at this time. On many dry sites, however, the quality of food plants had already dropped due to the advanced phenology of plants on these sites. The phenology of plants over large areas (e.g., tussocks and wet meadows of broad valleys) was synchronized, and for a short time a superabundance of lush early growth occurred. In areas with more topographic diversity, more variation in phenology occurred because of different rates of snowmelt, and succulent vegetation was available for a longer period. Equisetum arvense and grasses/sedges were widely distributed and bears used food plants based on localized phenology rather than habitat. During early summer, bears were able to use the greatest variety of habitats, though wet sedge meadows, ecotones between wet sedge and dry tundra, and lush areas below snowbanks were preferred.

By late summer and early fall, most vegetation had decreased in quality, and only a few grazing sites where the phenology had been retarded by snow were used. Bears now began to use roots (whose quality was again increasing) and ripening berries. Habitat use shifted back to dry tundra types, riparian areas, or to wet sites, such as string bogs, which contained dry microsites that produced berries. Fall food habits were similar to those in spring, except for differences in the relative importance of the foods.

In addition to the seasonal plant foods, bears frequently used animal foods. Animals were taken opportunistically in all habitats throughout the year. Generally, however, caribou moved through the area in spring and early summer. Most opportunities to use caribou and their calves occurred during this time. Ground squirrels became more important as the year progressed, young were born and dispersed, and digging was facilitated as thaw depths increased. In fact, ground squirrels were the most important fall food. Other animals were used to a lesser degree. Bears, other than females with young cubs, moved more than necessary when eating vegetation. Thus, bears increased the chances of encountering animal food, monitored the phenology of plants in different parts of their home range, and, in the case of females with young, helped their cubs become acquainted with the area.

The foothills are a topographically diverse area with a complex vegetative mosaic offering a good variety of plant and animal foods in relatively small areas compared to the Arctic Coastal Plain or the mountains. Every habitat has foods of interest to bears and, though general patterns were evident, bears could be encountered in any habitat at any time.

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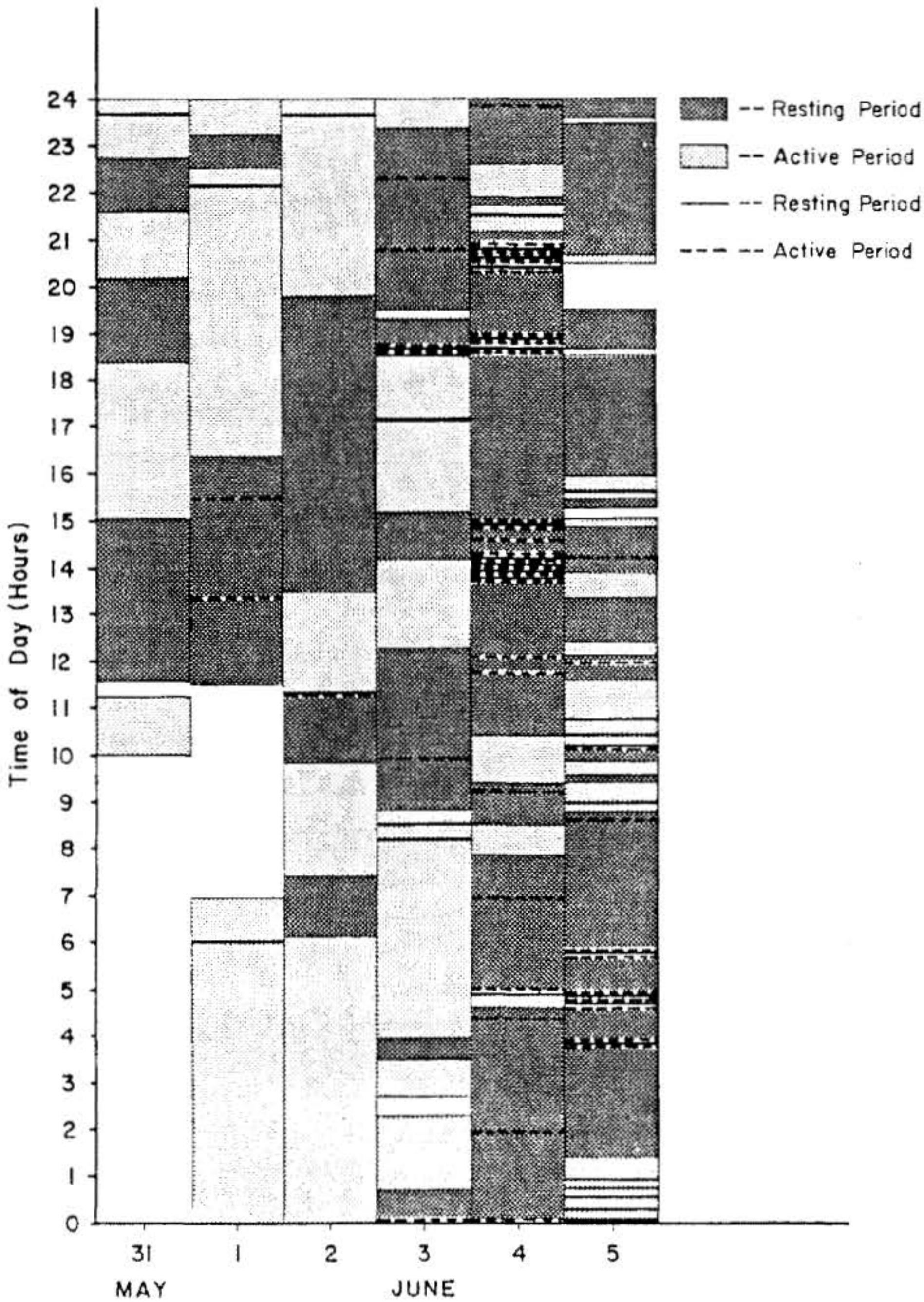
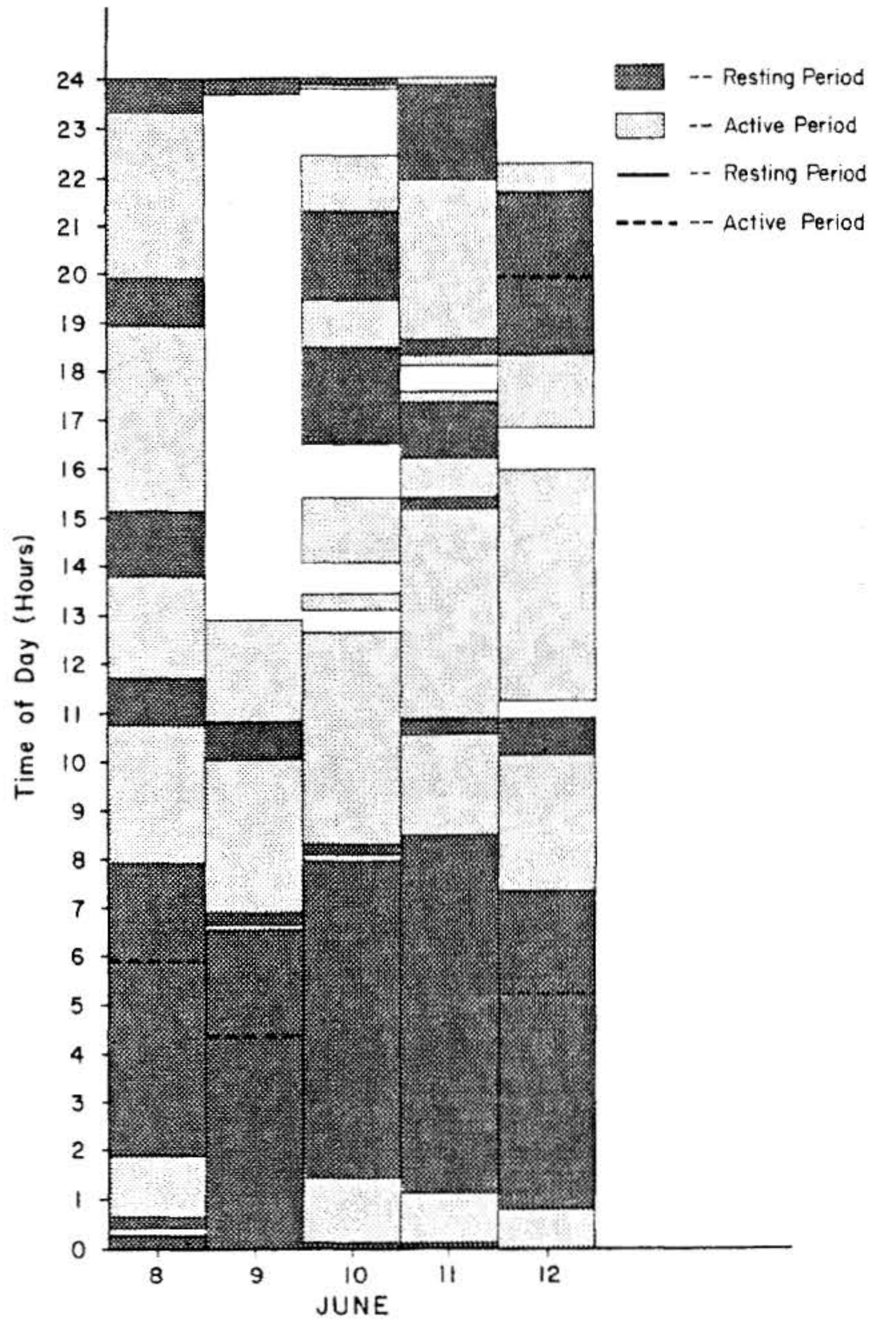
APPENDIX A

ACTIVE AND REST PERIODS OF FEMALE GRIZZLY BEAR NO. 1086 BY HOUR AND DAY, 31 MAY-5 JUNE 1979



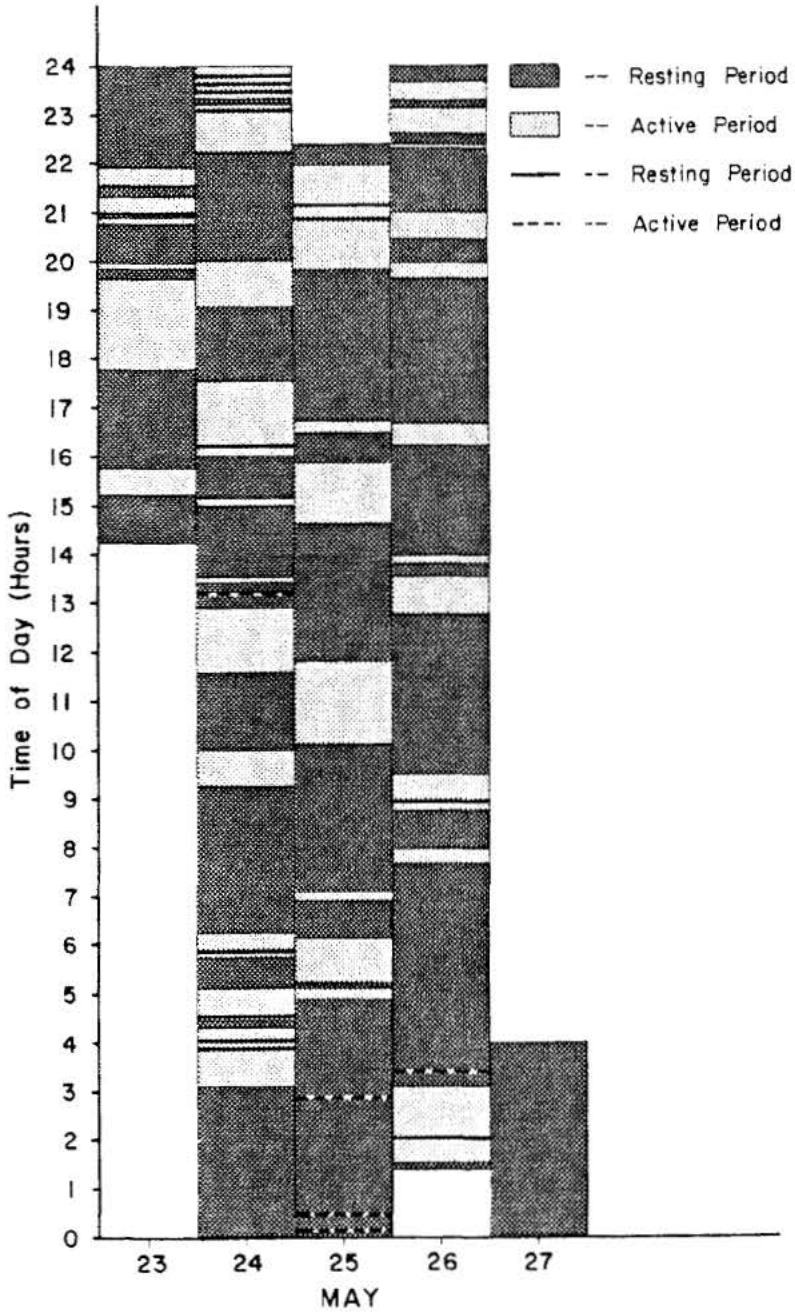
APPENDIX B

ACTIVE AND REST PERIODS OF FEMALE GRIZZLY BEAR NO. 1097 BY HOUR AND DAY, 8-12 JUNE 1979



APPENDIX C

ACTIVE AND REST PERIODS OF AN UNMARKED FEMALE GRIZZLY BEAR WITH ONE CUB BY HOUR AND DAY, 23-27 MAY 1982



APPENDIX D

ACTIVE AND REST PERIODS OF FEMALE GRIZZLY BEAR NO. 1169 BY HOUR AND DAY, 23 MAY-1 JUNE 1982