Some Quantitative Aspects of the Behavior of Marmots

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Abstract

Sunning and watching was the predominant behavioral activity in two colonies of yellow-bellied marmots. Following emergence from the burrow in the morning, the sequence of major activities was sunning, feeding and other active behaviors, and sunning and watching. Marmots spent more time feeding on cloudy days than on sunny days. There was no evidence that one marmot acts as a sentinel while another marmot feeds. Habitat utilization was characterized by activity in vegetation below 80 cm high and by the presence of large rocks used for sunning behaviors. Much of the marmot behavior is interpretable as adaptation to the high altitude environment and to predation. Trans. Kans. Acad. Sci., 75 (4), 1972.

Introduction

The general organization and behavioral patterns of yellow-bellied marmots (*Marmota flaviventris*) were described by Armitage (1962). These descriptions were essentially qualitative and were not related to each other sequentially. Thus, this paper presents a quantitative analysis of behavioral patterns with emphasis on their frequency of occurrence, time of day of occurrence, and their sequential relationships.

Armitage (1962, 1965) observed marmots in a rather uniform environment; that is, the marmots occupied a meadow of grasses and clover in which old bridge foundations formed the focal point of activity. Although Armitage (1962) emphasized that the most successful burrow systems were located under large rocks or log piles, the rather uniform habitat provided little information about how marmots utilize a diverse habitat. Therefore, this paper describes the pattern of use by marmots of two diverse habitats.

Methods

Description of Study Localities. The marmot localities under observation are located on the east-facing slop of Gothic Mountain in Gunnison National Forest, Colorado, at about 2900 meters elevation. Locations of localities 1 through 7 were shown in Shirer and Downhower (1969).

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Locality 8 lies between localities 3 and 4 on the west side of the East River. Locality 3 and locality 8 were each divided into three principal activity areas with the locus of observable behavior in each area centered around a cluster of rocks which was used by the animals for sunning and observation.

The boundaries of locality 3 were formed by spruce (*Picea*) and willow (*Salix*), but the locality itself is more complex vegetationally than locality 8. Area a, a large grassy meadow containing several observation rocks, also has small distinct clusters of willow and spruce. Areas b and c are talus and are separated by an extensive expanse of aspen (*Populus*). Between areas a and b lies an area of aspen intermixed with scattered underbrush.

At locality 8, the slope is bounded at the base by dense willows, and on both sides by spruce forest. Rocky cliffs form the upper natural limits of the area. Each cluster of rocks is situated near a grassy meadow and in two of the areas the expanse of low vegetation was divided by patches of *Veratrum*. Two of the areas are sharply bounded by willows in combination with spruce or *Veratrum*. Areas a and b are separated by a stream and dense willows approximately 10 meters wide that extend down the middle of the hill. Areas a and c are separated by a willow thicket approximately 50 meters wide and by considerable vertical distance. Scattered spruce and considerable vertical distance separate areas b and c.

Locality 3 was studied from June 17 to August 6, 1972 and locality 8, from June 28 to August 6, 1971 and included a total of 130 hours of direct field observations. Observations were concentrated between 0630–0900 MST which is the period of major daily activity (Armitage, 1962). Three adult females, an adult male, and 12 young were resident at locality 3. The observations focused on the animals resident in areas a and b as the varied topography made it impossible to view all the activity areas from any one observation point. Two adults were resident at locality 8 at area b and observations focused on these animals.

Both localities were mapped by measuring ground distance between rocks, willow clumps, burrows, etc. and arranging the features in the map by triangulation. The principal vegetation types, rocky areas, and burrows were recorded on the finished diagrams, which were then mimeographed and used for recording data. The height and species composition of the vegetation were determined at specified intervals across the locality. The marmots were observed with a spotting scope from a field approximately 300 m. distant. From this vantage point two types of data were collected. A census was taken every 10 minutes and the position of each animal was recorded on a map. Between each census, a randomly picked animal was

observed more closely, and its behavior, location and the amount of time spent in each activity were recorded continuously for 5 minutes. Near the end of the season, increasing vegetation height somewhat obscured visibility, which may have biased the recorded survey positions, because it was easier to see the animals when they were on rocks or in bare areas.

Description of Behavioral Patterns. Feeding, locomotion, grooming, and greetings were described previously by Armitage (1962). Although Armitage (1962) described "sitting up," the same behavior here is called "alert watching." The behavior is characterized by the animal standing on its hind legs, keeping the body somewhat stiff and with the head cocked into an alert position.

Sunning is characterized by the animal lying almost perfectly flat on a rock, with its legs spread and head down. In the early morning the animals often lie broadside to the sun, whereas in the afternoon or late morning they usually lie lengthwise to the sun's rays.

Sunning and watching consists of a body posture in which the legs are tucked under the body, with the front paws slightly extended so that the front portion of the body is elevated. The head is held erect and the tail is usually flat and extended directly behind the animal.

Results and Discussion

General Activities. Adult marmots spend three-fourths of their observed above ground behavior sunning and watching (Table 1). By contrast, only about one-eighth of their above ground time was sunning (Table 1). Alert watching accounted for less than 2% of the observed activity. This pattern of above ground activity apparently maximizes time spent sunning and in being alert. Presumably, sunning alone exposes the animals to a higher probability of predation. A young, freshly killed marmot laid on a rock in an approximate sunning position was seized by a red-tailed hawk (*Buteo jamaicensis*) (Svendsen, pers. com.). In 15 years of observing marmot behavior, no other successful predation by hawks has been observed by Armitage or his co-workers. Obviously, a marmot cannot continuously maintain the alert watching position. Thus, the essential problem is to explain why marmots spend so much time sunning and why they do so in an alert manner.

The experiment with the dead young marmot suggests marmots are subject to predation and one would expect natural selection to quickly favor those behavioral patterns tending to minimize predation. In addition to birds, coyotes (*Canis latrans*) and mustelids are predators on marmots in our study area (Armitage and Svendsen, manuscript). Armitage

several times observed adult marmots vigorously chase weasels (*Mustela frenata*) and Travis observed two chases of a marten (*Martes americana*) by a marmot. Other workers have also observed marmots chase marten (Downhower, pers. com.; Waring, 1965). Armitage has observed many times a colony of marmots giving alert cries when a coyote was in the vicinity. Thus, there is ample evidence that marmots are alert to the possible intrusion of predators into their colonies and this awareness seems sufficient to account for the watching component of sunning and watching behavior.

The most plausible hypothesis to explain the extensive sunning behavior is that marmots gain an energetic advantage. Kilgore (1972), in a bioenergetic study, showed that marmots store more energy in net production than do populations of non-hibernating mammals. This ability to store more energy resulted from the relatively low weight-specific metabolic rate of marmots. Perhaps marmots use solar energy as a major component of the maintenance of body temperature, thus conserving metabolic energy. Such energy conservation was shown for the roadrunner (Ohmart and Lasiewski, 1971) and radiant energy reduced the metabolism of cowbirds and lowered the low end of the zone of thermal neutrality (Lustick, 1969). Thus, it is not unreasonable that this mammal may similarly utilize radiant energy.

Feeding accounted for 5 to 10% of the above ground activity; locomotion not associated with feeding occupied about 3% of the animal's time. Thus, behaviors characterized as active accounted for an average of 10% of marmot activity (Table 1). These results show much more time spent in sunning behavior and much less time spent in active behaviors than reported previously. Our reexamination of the daily activity

Table 1. The amount of time spent in above ground activities during the morning activity cycle.

	T	S	SW	AW[1]	F	L	Active (F&L)	Amicable[2]	Maintenance
Locality 3									
Number of minutes	724	99	545	14	41	18	59	3.5	2.7
% of total		13.6	75.3	1.9	5.5	2.3	7.8	0.5	0.4
Locality 8									
Number of minutes	726	91	541	.....	73	19	92	0.7	1.1
% of total		12.5	74.5	.....	10.1	2.7	12.8	0.1	0.15

S = Sunning, SW = Sunning and Watching, AW = Alert Watching, F = Feeding, L = Locomotion, T = Total Number of Minutes of Activity.

[1] Accurate data available only for locality 3; these data included in SW for locality 8.
[2] Amicable behavior includes mutual grooming and greeting.

cycle published by Armitage (1962) suggests that about 50–60% of the time was spent in sunning behaviors and 40–50% of the time was spent in active behaviors. Kilgore (1972), who observed marmots at localities 1 and 4 (Shirer and Downhower, 1969), reported that adult marmots generally spent less than 50% of their above ground time in any form of activity, including feeding. Armitage and Kilgore used census methods to derive activity patterns whereas our data are based on five-minute observation periods of a single animal. Although we picked animals at random, it may have been easier to pick out a conspicuous animal; i.e., one that was sunning. However, the fact remains that marmots spend half or more of their time above ground sunning.

Amicable behavior (Ewer, 1968:186) accounted for less than 1% of the observed activities. Mutual grooming or epimeletic behavior (Scott, 1956) was not observed between the adults of locality 8, but occurred frequently between adults and young at locality 3. Agonistic behavior was so rare in these two colonies that it was not included in the analysis.

There is little difference between the two colonies in the amount of time spent at various activities (Table 1). The major difference is in the time spent feeding and this difference will be discussed below.

Time Distribution of General Activities. Sunning peaked in the early morning (0630–0700) and declined to a relatively steady level at both localities (Table 2). Sunning and watching peaked in the latter half of the morning activity cycle. Active behaviors peaked in the second time block (0700–0730). This peak was more sharply defined at locality 3, but extended into the next time block as a broad peak at locality 8. The more defined peak of active behavior at locality 3 may reflect the presence of young. Adult females with active young spend a considerable time sunning and watching and this activity peaked earlier in the morning at locality 3 than at locality 8. Amicable behavior and maintenance activities also seem to peak during the 0700–0730 time period, and then slowly decrease.

There are several interpretations of these patterns. Marmot body temperature decreases at night (Downhower and Pauley, 1970) and the animals quickly warm-up when they first emerge from the burrows. The sun shines fully on the localities at about 0630, and this first period of sunning corresponds to the time when air temperature is low (Fig. 1), and the sun is substantially illuminating the locality. After the activity peak the gradual decrease in overall activity with time could be attributed to a corresponding increase in air temperature (Fig. 1) (also see Armitage, 1962).

Table 2. The distribution in time-blocks of time spent in above ground activities.

Time blocks[1]	Behavior: / Locality:	S 3	S 8	SW 3	SW 8	F 3	F 8	L 3	L 8	Active F&L 3	Active F&L 8	Amicable 3	Amicable 8	Maintenance 3	Maintenance 8	T 3	T 8
0630–0700																	
	Number of minutes[2]	8	15	21	16	0	0	.1	3	.1	3	0	0	.3	0	30	34
	%of total[2]	27	44	71	47	0	0	.3	9	.3	9	0	0	1	0		
0700–0730																	
	Number of minutes	6	16	86	98	34	24	9	6	43	30	3	.5	1.3	.2	140	145
	% of total	4	11	61	67	24	17	7	4	31	21	2	.3	.9	.1		
0730–0800																	
	Number of minutes	30	30	176	158	6	33	2	8	8	41	.5	.2	.3	.5	215	228
	% of total	14	13	82	69	3	14	1	3	4	17	.2	.1	.1	.2		
0800–0830																	
	Number of minutes	37	30	177	207	.5	11	5	1	6	12	.2	0	.7	.4	220	249
	% of total	17	12	80	83	.2	5	2	.5	2	6	.2	0	.3	.2		
0830–0900																	
	Number of minutes	18	.5	85	63	0	5	1	1	1	6	.1	0	.1	0	105	70
	% of total	17	.7	81	91	0	7	1	1	1	8	1	0	1	0		

S = Sunning, SW = Sunning and Watching, F = Feeding, L = Locomotion, T = Total Number of Minutes of activity.

[1] All times are mountain standard time (MST).
[2] Vaues above 1 are rounded to the nearest whole number.

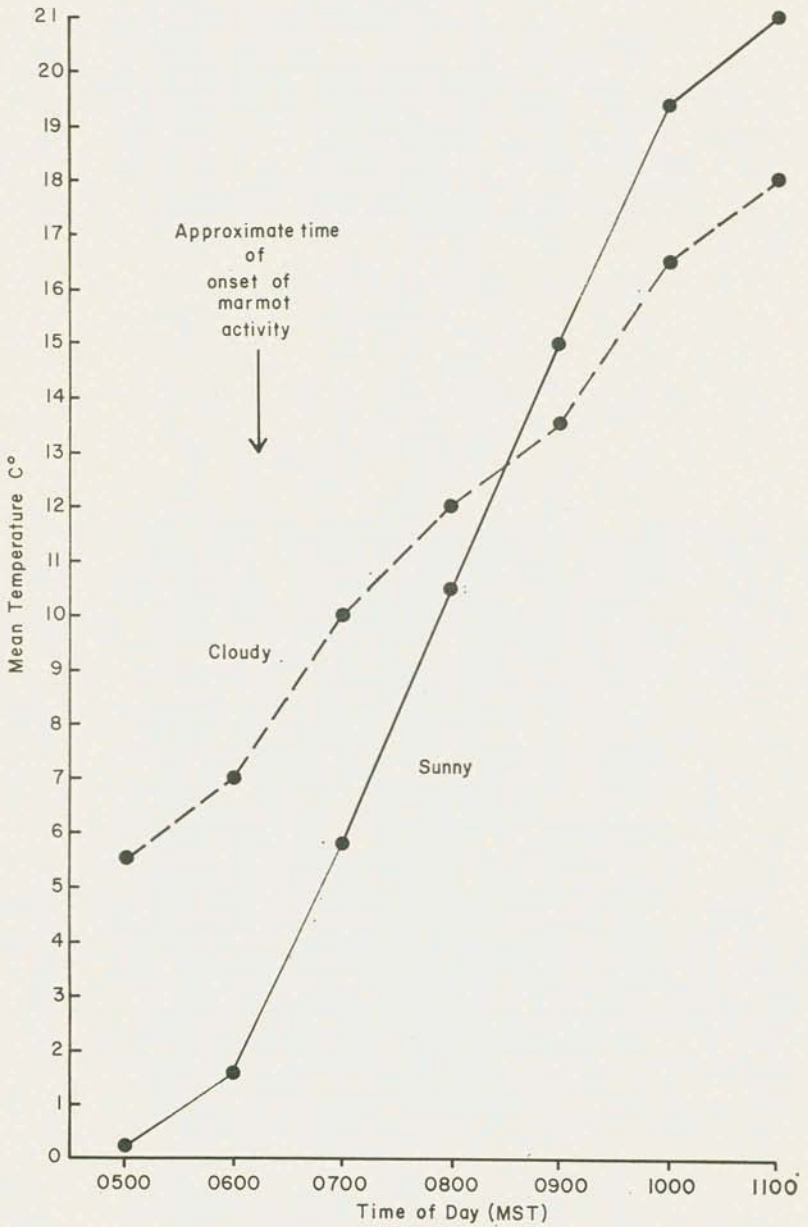

Figure 1. Temperature curves for Gothic, Colorado, 1972. The means for each time of day are derived from the recorded temperature data at the Rocky Mountain Biological Laboratory weather station for those days marmots were observed.

Considering the increased difficulty of dissipating body heat with increased temperatures, there should be a reduction in active behaviors that generate heat as the morning heat becomes greater. This trend daily progresses to the point where many animals remain in their burrows from about 0930 to 1500; i.e., for the hottest part of the day. A simple statement of these patterns is that the marmots emerge, warm up, feed, and then gradually become inactive.

Another possible explanation for the retreat of marmots into their burrows is the presence of biting flies. In most summers, snipe flies (*Symphoromyia* sp.) are abundant. The flies generally become active between 0745 and 0815. Movement reduces the flies swarming and decreases the probability of being bitten. However, marmots spent a greater percentage of their time in inactive behaviors after 0800 which indicates that biting flies are not an important determinant of the time of burrow seeking behavior by marmots.

On cloudy days feeding activity occurred five times as frequently as on clear days (Table 3). On the other hand, considerably more time was spent in watching and sunning, and sunning on clear days than on cloudy days. This last observation is understandable; sunning related behaviors and postures are more adaptive when there is sun. The weather related difference is evidence that solar radiation is an important environmental factor and that the activities recorded are not just a function of habitual patterns developed by the animals. This difference in the amount of feeding in cloudy and sunny days probably accounts for the differences between colonies in the amount of time spent feeding (Table 1). In 1972, there were virtually no cloudy days during the study period; thus all feeding time is for sunny days. A comparison of time spent feeding on sunny days at locality 8 (Table 3: 10%) with the time spent feeding at locality 3 (Table 1: 5.5%) reveals essentially no difference.

Table 3. A comparison of selected activities as a function of sunny or cloudy days at locality 8.

	S	SW	F	L	T
Sunny					
Number of minutes	77	170	30	9	286
% of total	27	60	10	3	
Cloudy					
Number of minutes	5	38	52	9	104
% of total	5	36	50	9	

Abbreviations as in Tables 1 and 2.

The difference in time spent in locomotion on cloudy vs. sunny days is related to the time spent in feeding. Because more time is spent feeding on cloudy days, more time is spent in locomotion as the animals move through the feeding areas and from one feeding area to another.

There is no ready explanation to account for the much greater time spent feeding on cloudy days. Possibly animals must decrease activity on sunny days because of the environmental heat load; however, because the marmots sun extensively after 0730, one would expect that they could use some of that time for feeding as moderate activity probably would not increase the heat load significantly. Also, marmots could feed in shady areas. Possibly the palatability of the food differs on cloudy and sunny days. Marmots have never been observed to drink in the field and do not drink in the laboratory when fed fresh food. Perhaps on cloudy days the vegetation maintains a higher water content which enables the animals to increase their feeding. Another hypothesis is that animals increase their activity and feeding on cloudy days to compensate for the lack of radiant energy. On cloudy days the air temperature is well below marmot core body temperature of about 36–38°C (Downhower and Pauley, 1970). Thus metabolic expenditures to maintain body temperature should be higher and increased feeding could compensate for this increased metabolism.

There is no correlation between the amount of time spent in alert behavior and the kind of vegetation that the animals are in, or have just been in (Table 4). Perhaps watching behavior is more a function of distance from the home burrow rather than the type of vegetation (Armitage, 1962).

A common belief is that one member of a group of marmots may act as a sentinel (e.g. see Palmer 1954:169). The data indicate otherwise. Only 20.0% of the time when one animal was eating was another watching (Table 5). In 6 of 8 cases where one animal was watching and the second was feeding, the animal eating continued to periodically watch. However, a female marmot does spend considerable time sunning and

Table 4. Alert behavior as a function of vegetation at locality 8.

	Meadow[1]	Veratrum
Number of times alert behavior observed	10	13
Number of 5 min. observation periods in which alert behavior occurred	8	8
Total number of minutes spent in alert behavior	15	14.3

[1] Animals were never observed in, entering, or leaving willows.

watching when her young emerge from their burrow. This behavior may account for the slightly greater time spent sunning and sunning and watching by animals at locality 3 as compared to animals at locality 8. The "sentinel" behavior of the female is more apparent when marmots are observed for a greater period of time as the female with young maintains above ground activity later in the morning to a much greater degree than other adults (Armitage, unpublished data).

Some behavioral activities were closely associated (Table 6). At locality 8, alert watching and feeding were the most closely interrelated, probably because animals were more susceptible to predation when they have moved away from their burrows to feed. At locality 3, sunning and watching was highly associated with sunning, grooming, and watching. The difference between the two colonies probably resulted from the presence of young at locality 3, and the subsequent social interactions and "sentinel" effect shown by the mother. Feeding and locomotion occurred together, probably because of the mode of feeding (see above, and

Table 5. A test of "sentinel" behavior.

	Watching	Feeding
Number of occurrences	98	40
The number of times 1 animal is watching while another is feeding as a fraction of the total number of occurrences	8/98	8/40
The above fraction as a percentage	8.2%	20%

Table 6. Pairs of behavioral sequences. Each number is the number of times each behavioral sequence occurred in 340 five-minute observation periods.

	Locality 3	Locality 8
Sunning–Sunning and Watching	101	....
Sunning–Feeding	1	1
Sunning–Locomotion	7	2
Sunning–Alert	....	5
Sunning–Greeting	2	....
Sunning–Grooming	2	....
Sunning and Watching–Feeding	3	2
Sunning and Watching–Locomotion	30	10
Sunning and Watching–Alert Watching	12	....
Sunning and Watching–Greeting	6	....
Sunning and Watching–Grooming	65	....
Feeding–Locomotion	14	12
Feeding–Alert Watching	10	31
Locomotion–Alert Watching	....	13
Alert Watching–Grooming	....	2

Armitage, 1962). Locomotion and alert watching also are frequently associated; probably because marmots appear to carefully survey their surroundings before moving into another area.

Habitat Utilization. All three areas of locality 8 where animals were observed share certain similar properties. Each is bordered at one edge by a tall row of spruce, has a willow thicket either at the boundary or within the colony, and all three have a grass meadow (50–60 cm. in average height) within easy visibility of the rock used by the animals for sunning and sunning and watching. The presence and placement of this high rock is perhaps the most striking feature of each area. In each case it is at the lower edge of the habitat, and is high enough in elevation above the rest of the vegetation that it affords an almost unobstructed view of the entire hillside and habitat. In each activity area at least one-third of the total sightings occurred at the colony's "lookout" rock, and in two of the areas the figures were higher, 83.3% and 53.3% respectively. Most of the other repeated sightings occurred at smaller rock outcroppings, or in low grass. With the exception of six sightings, no animals were observed in vegetation over 90–100 cm (Fig. 2). Estimates based on body length and hind foot length indicate that a marmot standing on its hind legs is between 60–80 cm. in height. This will vary depending on the size of the animal and the amount of stretch. Thus, one possible explanation for this observation is that in vegetation exceeding this height it would be difficult to get a clear view of an approaching predator. Also in only one case was an animal sighted more than 20 meters from a burrow.

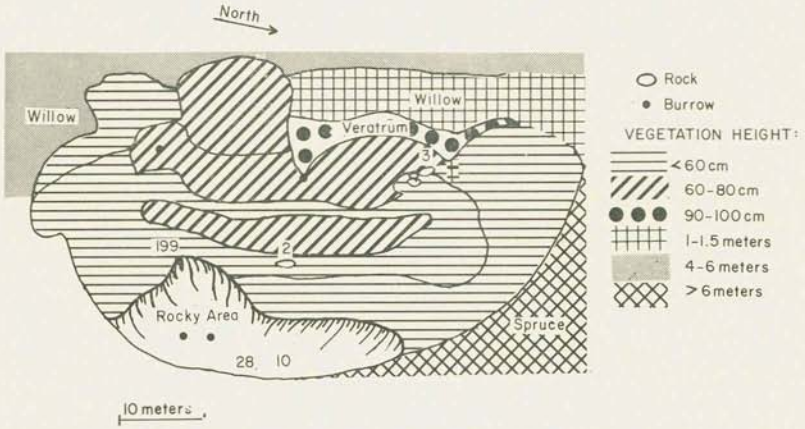

Figure 2. Map of area b of locality 8 showing vegetation patterns and marmot activity. The number of sightings is indicated on the map where the sightings occurred. The number of sightings which occurred on rocks is placed near the rock on which the marmots were seen.

Because of predation pressure the factors of vegetation height, density, and distance from the home burrow combine to limit the normal movements of the animals, and determine the utilization of specific areas of the colonies.

The majority of the sightings of marmots at locality 3 occurred at a series of large rocks scattered throughout a large meadow and in the meadow itself (Fig. 3). A secondary concentration of activity was at 2 rocks in the lower talus of area b just above and to the northwest of the meadow (Fig. 3). Movement between the talus and the meadow was observed. This movement usually followed a clearly defined trail.

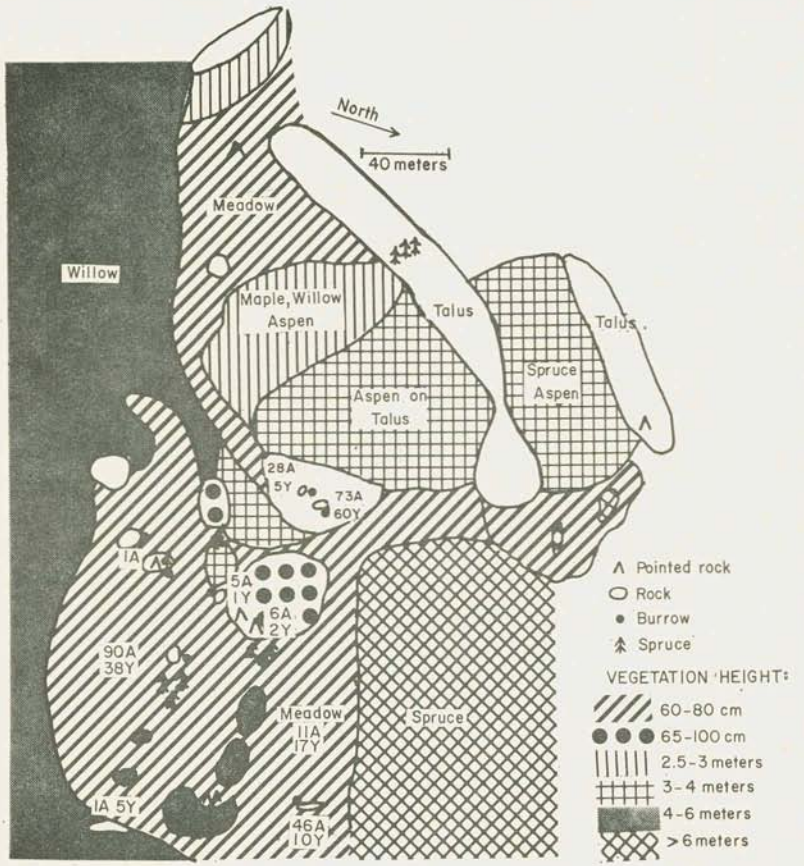

Figure 3. Map of locality 3 showing the vegetation patterns and marmot activity. The number of sightings is indicated on the map at the place where the sightings occurred except "meadow" sums all sightings in the meadow of area a regardless of location. The number of sightings which occurred on rocks is placed near the rock on which the marmots were seen. A = adult, Y = young.

Although the trail passes through vegetation of an average height of 80–90 cm., the vegetation is not dense nor uniformly high. There was no movement observed between areas a and/or b and c, probably because of the long stretch of aspen separating area c from the other areas (Fig. 3).

Because vegetation factors limit movement, vegetation factors may be the major factor which isolates individual marmots or small social groups. The upper reaches of area a and area c of locality 8 are divided by at least 50 m. of high dense willows that inhibit almost any kind of movement. Area c and area b are separated by a large open vertical and horizontal distance, of a type in which a marmot could easily be seized by a predator if it frequently traveled the area. Area b and area a are divided by a stream and a dense willow thicket about 10 m. wide. However, there is an animal trail connecting the two areas. At least once an animal was observed disappearing along the trail connecting the two regions, indicating that this trail is used at least occasionally. However, after that period no animals were observed to use the trail. Vegetation also apparently isolated a female and four young at area c of locality 3 from the other animals in the colony.

Habitat utilization was similar in the two localities in that marmots focused their activity on an area where vegetation was relatively low and where large rocks were available for sunning behaviors.

Summary

Behavioral activities of two colonies of yellow-bellied marmots occupying two localities on Gothic Mountain, Colorado, were described quantitatively. A combination behavior designated sunning and watching predominated. This behavior maximizes the time spent sunning while the marmot remains alert to the possible approach of predators.

Sunning behaviors characterized the first activity period following emergence from the burrow in the morning. Active behaviors peaked in the second or third half-hour activity period following emergence. Sunning and watching characterized the behavioral activity following the decline in the active behaviors. This pattern may be related to radiant energy exchange between the marmot and its environment.

Marmots spent more time feeding on cloudy days than on sunny days. There was no relationship between the amount of time spent in alert behavior and the kind of vegetation with which the animals were associated. There was no evidence that one marmot acts as a sentinel while another marmot feeds. However, female marmots apparently spent more time sunning and watching when their young were active above ground.

Habitat utilization was characterized by activity in vegetation below 80 cm high and by the presence of large rocks used for sunning behaviors. Dense, high vegetation may separate individual marmots or small social groups from one another. Much of the above ground behavior of marmots is explicable as adaptation to the high altitude environment and to predation.

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