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STRUCTURE AND LOCATION OF BURROWS OF YELLOW-BELLIED MARMOT

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ABSTRACT. The yellow-bellied marmot spends approximately 80% of its life in a burrow. Burrows provide protection from the rigors of the environment, predators and other marmots. They provide a hibernaculum in winter and may function as a nursery in summer. Selection of a burrow site is therefore an important aspect in the biology of marmots. Measurements were made on direction of exposure, angle of slope, drainage, soil type, topographic features, and vegetation. Home burrows occur on open grassy or herb-covered slopes of an angle of 15°–40°, facing in a northeasterly or southwesterly direction, and containing rocks and boulders. The latter support the burrow and serve as sunning and observation sites. Five dissected home-burrows showed no marked differences in general configuration.

The yellow-bellied marmot (*Marmota flaviventris*) is a semi-fossorial rodent which spends up to 80% of its life in a burrow. Marmots are seasonally active above ground from early spring to fall (Armitage 1965). During this time they exhibit a bimodal pattern of daily activity which peaks during the morning and again in late afternoon. Marmots retire to the confines of the burrows during mid-day and at night. Subalpine populations of yellow-bellied marmots are characterized by seasonal activity limited to about five months out of the year. The remainder of the year is spent in hibernation. Hibernation accounts for about 60% of the total underground existence of a marmot. In summer, if conditions of the present burrow are not suitable, a marmot can move or construct a new burrow. During winter, the marmot is hibernating and there is no way for it to control the environment in which it must survive. Hibernation burrows must be elected prior to onset of adverse environmental conditions and must provide the necessary requirements for survival. In summer the burrow also serves as a nursery, a haven from predators, and seclusion from interactions with other marmots. The quality of the burrow site is therefore a critical aspect to be considered in the biology of the marmot. Marmot burrow sites are usually located in open, herb-covered, talus slopes or grassy meadows in which rock outcrops and boulders are common

(Svendsen in press). Rocks are used to burrow beneath, for lookouts, and in sunning.

METHODS and STUDY AREA. Burrow sites of yellow-bellied marmots were studied in the vicinity of the Rocky Mountain Biological Laboratory (RMBL), 2900 m, Gothic, Gunnison County, Colorado. Data on the angle of slope, direction of exposure, environmental features associated with the burrow, soil characteristics, and drainage were gathered on known, well-used homesites. Five burrows were excavated to determine burrow structure.

Physical Characteristics of Burrow Sites. Burrows of yellow-bellied marmots are located on slopes facing in all directions (Fig. 1), but they do not occur on all slopes in equiprobability ($X^2 = 9.05$; df $= 3$; $p < .05$). More burrows occur on northeasterly and southwesterly exposures than is expected in a random distribution.

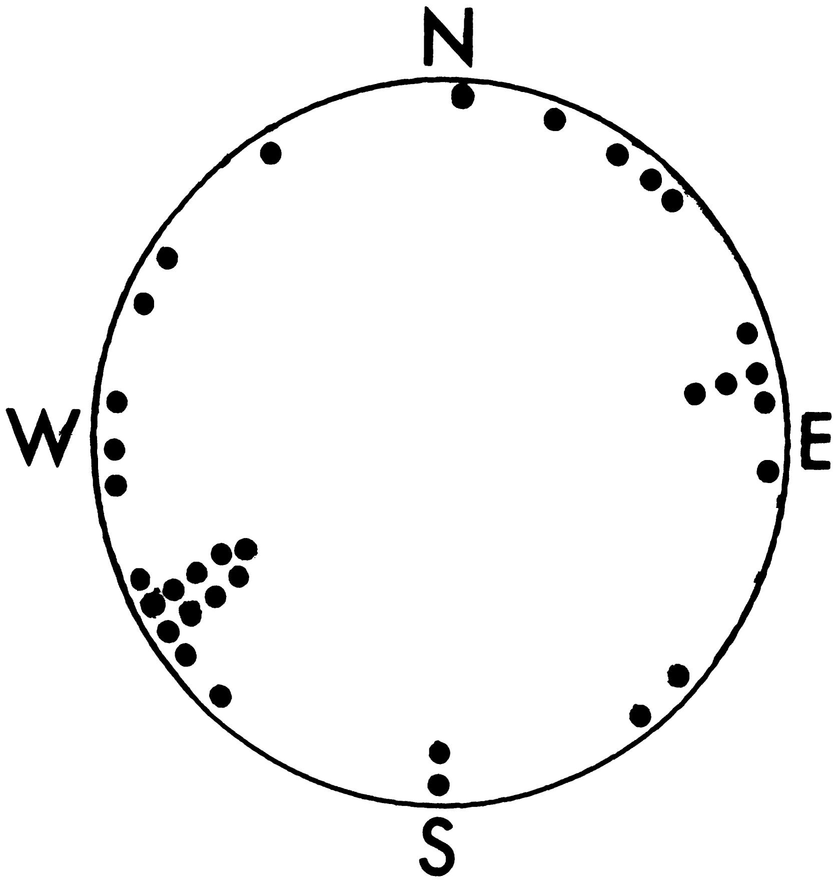

Fig. 1. Location of 34 burrows of yellow-bellied marmots with respect to the direction of exposure of the slope on which they are situated.

Bopp (1955 and 1956) found burrows of *Marmota marmota* situated primarily on slopes facing between northeast to southwest. About 65% of yellow-bellied marmot burrows lie within this arc. Anderson (1949) evaluated angle of exposure in woodchuck (*Marmota monax*) dens and could not derive any conclusions about angle of exposure from the data, but did conclude that slope was important. Yellow-bellied marmot burrows are also usually located on hillsides or on the sides of cliffs or mounds where burrow entrances enter at an angle into the terrain. Burrows were found on slopes from 2° to 54° (Fig. 2). About 75% occurred on slopes between 15° to 40° ($\bar{X} = 27.26$ degrees). This compares with a mean angle of 36 degrees for *M. marmota* (Bopp 1955). I have recorded marmot burrows located on cliff faces estimated to be between 70° to 90°, where the animals scampered about on narrow rock ledges. The precipitious cliffs prevented detailed investigation of the burrows, however. The angle of slope of the terrain is important because it allows for clear vision of the surroundings, provides for drainage, and exposes the animal to the sun. Yellow-bellied marmots spend a considerable amount of their above ground activity sunning. These heliotherms emerge as the first rays of the morning sun strike the colony and spend the first 15 to 30 minutes grooming and sunning (Armitage 1962). The significance of this behavior is not known. It may play a role in thermoregulation or the strong UV radiation of the alpine sky may be used as an insecticidal or therapeutic agent to kill insect, fungal or bacterial infestations of the skin and pelage. Regardless of the function of sunning, marmots use the large boulders, rock ledges, tree roots and stumps, foundations and porches near the burrow entrance for sunning. In addition to exposing the marmot to the sun's rays, these structures also provide a vantage point for the marmot. The marmot gets a com-

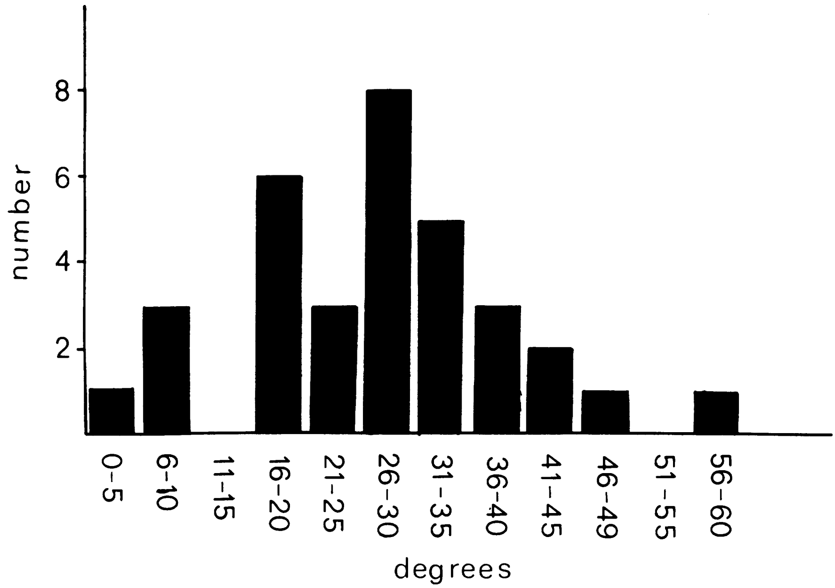

Fig. 2. Frequency of occurrence of burrows of yellow-bellied marmots on terrain of different slope. Slope is measured in degrees.

manding view of the surroundings for protection against predators and for interactions and displays with conspecifics. The rocks, tree roots and fallen trees also serve to support the burrow entrance.

The soil is similar at burrow sites located throughout the area. The mountains are in an early mature stage of the erosion cycle and the soil formed from the erosion processes is a sandy loam containing rocks varying in size from pebbles to boulders (Langenheim 1955). Drainage on the slopes selected by marmots for home burrows is excellent with the porous soil and slope providing rapid removal of the surface water.

Burrow Dissection. Marmots are ground squirrels and require soil in which to dig their burrows. Many marmot burrows are constructed in soil containing boulders so large and numerous, or in rock fissures or ledges with soil accumulations, that dissection of such systems is physically impossible. Five burrows were dissected completely to determine their configuration (Fig. 3). These sites were used as the home burrow by four females and one male. The main entrance entered the hillside at an angle between 30° and 80° and extended to a depth of about 0.6 meter, before

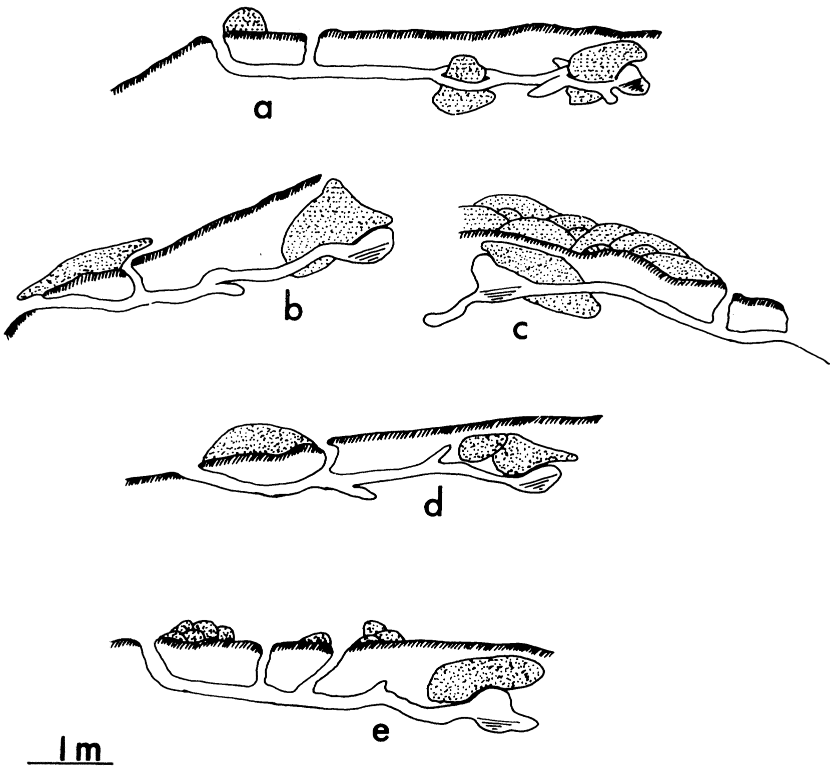

Fig. 3. Schematic diagams of five dissected yellow-bellied marmot burrows. Burrow a, b, c and d were used as homesites by adult females, burrow e by an adult male. The stippled objects are rocks.

angling parallel with the surface of the ground. In many cases the nest site is actually higher than the entrance due to the slope of the terrain that the burrow is constructed in. Up to three entrances join the main burrow passage within 0.5 m of the entrance. The main passageway extends into the hillside between 3.8 to 4.4 m, at a depth of between 0.4 to 0.6 m. The burrows are slightly deeper at the rear and end in blind passages. Rocks located at the entrance serve to support and protect the opening and those along the burrow passageway give support in the coarse soil. The mat of plant roots overhead provides support so that the loose soil does not collapse into the burrow. On two occasions, when the root mat was lifted the burrow beneath collapsed. Several short, lateral tunnels from 0.3 to 0.8 m in length branch from the main passageway. Nest material is located in chambers hollowed out beneath a large rock at the termination of the burrow. Short, blind tunnels may extend from this chamber. The general configuration of these burrows is similar in design, extent and depth to others dissected in the area (R. K. Enders, RMBL, personal communication) but differ in that no caches of green plant material and feces were found in any of the lateral tunnels.

DISCUSSION. There appears to be no difference in the basic "design" among the burrows excavated. Two burrows were occupied by adult females with young (a and c, Fig. 3), two by females without young (b and d), and one by an adult territorial male (e). Burrows a and b were known not to be used for hibernation, whereas burrows c and e were thought to be. Seasonal preferences of burrows were noted in the study area. On several occasions, females with newborn litters would move the young, as well as the center of activity, to a specific burrow site. These same females used different burrow sites at other times of the year, and in years when they had no litter. Over the years, different females would choose the same burrow as a nursery. In one year, two females with litters lived in the area of a burrow site typically used for raising young. The female with the earliest litter immediately moved to that burrow. After a few weeks the other female with a litter moved into the burrow, displacing the first female and litter which then occupied another site.

Some burrows which are actively used during one part of the season when the vegetation is low, are abandoned when vegetation grows higher. Burows used for hibernation are not necesarily used in summer but many burrows are used continuously during the year as well as repeatedly by different animals over several years. Evidently different burrows are characterized by subtle features which make them attractive under different situations, and few are used extensively. At one locality, there are estimated to be 78 burrows in various stages of use on an area of 0.85 ha. Only four to six of these burrows are used regularily for home sites and hibernacula however.

Bibikow (1968) reported differences in construction and extent of summer and winter burrows of the gray marmot, although some burrows are used throughout the year. In general, burrow systems of the gray marmot are much more extensive than those found for yellow-bellied marmots. They have many interconnecting underground passageways that lead to nest chambers, are deeper (1 m), longer (6 m), and have multiple entrances. Boulders and rocks are not associated with all the gray marmot burrow entrances and mounds of earth similar to prairie dog burrow seem to be present. Burrows of *M. marmota* were associated with the root network of trees in mountain valleys, under stones in high alpine pastures and in natural rock fissures at elevations over 1800 m (Müller-Using 1957). The latter had no evidence of dirt at the entrance and the author believed the dens were in natural gaps of the rocks. All cliff burrows I investigated have had soil in the crevices where the burrows were dug. On two occasions burrows were associated with tree roots, and foundations of cabins attract marmots very soon. Even in the space beneath the cabin floor, the marmot digs a burrow in the soil however.

In the winter the burrow provides protection against the rigors of the environment and from predation while the marmot is in hibernation. In summer the burrrow provides similar protection. Svendsen (1974) suggested that the marmot spends its life at a narrow range of temperatures around 10 C; one which has been shown to be physiologically optimal to this species. In the vicinity of RMBL the ground does not freeze during the winter if the snow cover remains undisturbed (George Sibley, RMBL Caretaker, Personal Communication), thus marmot hibernacula are not in danger of freezing temperatures unless snow cover is lost. Burrows used for hibernation are located where snow accumulation is greatest (Svendsen 1974) and thereby exposure is minimal. The accumulation of snow over the hibernation burrows remains long after emergence and marmots are not hindered by burrowing up through 3 meters of hardpack snow. Williams and Rausch (1973) reported nest box temperatures of *M. caligata* as low as —25 C and an annual ambient temperature in the next box of 36 C. Kilgore (1972) on the other hand reported that burrow temperatures of yellow-bellied marmots deviate little from 10 C from June to October. The artificial nest boxes of the former do not have any of the physical characteristics of a marmot burrow however. They are composed of wood and lined with .25 inch cement asbestos board. This is in sharp contrast to the natural, porous walls of a burrow which allows free exchange of gases, moisture and heat. Carbon dioxide levels up to 13.5% and oxygen levels as low as 4% were recorded from the nest box in winter and it would be interesting to contrast these levels in the natural situation.

Evidence that marmots do use plugs to seal their hibernacula is known from the gray marmot (Bibikow 1968), and hoary marmot (Rausch and Rausch 1971). A mixture of feces and dry grass is usually used. Quantities of old fecal material and dry grass are found around the emergence holes of yellow-bellied marmots and this probably represents the remains of a burrow plug in this species as well. A plug would reduce circulation within the burrow, but probably more importantly, it would seal the hibernaculum off from small predators (i.e. weasel, marten) which would find the torpid marmot a succulent feast early in the winter.

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