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Observations on plant choice by foraging Yellow-Bellied Marmots

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Abstract. Yellow-bellied Marmots (*Marmota flaviventris*) are generalist herbivores that feed on a wide variety of grasses and forbs. Food items are not used in proportion to their abundance in the environment and some parts of plants are preferred over other parts. Plant species composition differs among marmot habitats and seasonally. Thus, marmots must adjust plant choice based on availability. For example, at one site marmots in late summer forage extensively on fruits of gooseberries (*Ribes*) and elderberry (*Sambucus*), which are not present at other sites. Marmots selectively forage on flowers of tall plants (*Lupinus*, *Aquilegia*, *Delphinium*) and seed heads of grasses by standing, grasping the plant with the forefeet, and bending the flower or seed head to the mouth. Other plant species are treated similarly, but rejected after they are placed into the mouth or touched to the lips (*Linum*, *Aster*, *Helianthella*, *Castillea*). Plants not utilized by marmots may grow abundantly around marmot burrows (*Happlopappus*, *Epilobium*). Some widespread species growing in meadows where marmots forage are not eaten (*Veratrum*, *Frasera*). Early in the spring when food resources are low, marmots feed on the spring beauty (*Claytonia*) but not glacier lilies (*Erythronium*). Similarly, in late summer when many plant species are senescent and food resources are declining, marmots do not use many abundant species, such as various composites and gentians. Selection of particular species such as elderberry may increase foraging time but with low feeding time. Food choice may in part be determined by experiences as well as palatability and availability.

Key words: food choice, plant rejection, burrows, seasonal changes

Introduction

Marmots are generalist herbivores that eat a wide variety of grasses and forbs (see reviews by Bibikow 1996, Armitage 2003). Marmots feed selectively; old leaves and plant species with alkaloids or other secondary compounds may be rejected (Armitage 1979) and forbs may be preferred over grasses (Bassano *et al.* 1996, Armitage 2003). Flowers are often preferred and plant species may be selected for their protein, mineral, or essential fatty acid content (Armitage 2003). Marmot diet is affected by plant phenology (Frase and Armitage 1989), the geographic distribution of plant species (Badmaev 2003), and by local ecological distribution (Bibikow 1996, Armitage 2003).

Plant species composition varies among habitats occupied by Yellow-bellied Marmots, *Marmota flaviventris* (Svendsen 1973, Frase and Armitage 1989) in the Upper East River Valley, Colorado. The differences occur over an elevational range of 2867m to 3008 m and a linear distance of about 12km. The differences in plant composition probably occur because of differences in local ecology that favors some plant species over others. Although the relative abundance of some plant species may be affected by marmot feeding behavior (see Semenov *et al.* 2003), we have no evidence that presence or absence of a plant species is a consequence of Yellow-bellied Marmot foraging. Because some Yellow-bellied Marmots on a site are immigrants, they likely encounter unfamiliar plant species. Therefore, we can ask the question if Yellow-bellied Marmots test plants for their palatability. In addition, we can examine food choice early in the active season when food resources are scarce and late in the summer when many plants species become senescent but when late-season plant species are abundant.

In this paper I report marmot behavior with more than 30 plant species available, sometimes in high abundance, in marmot habitats. Most of the low growing plant species that are widely utilized by yellow-bellied marmots are not included (see Frase and Armitage 1989, for a listing of these species). The report focuses on those plant species of potential seasonal importance when food resources may be scarce and on those on which marmots feed on selective parts.

Methods

Each year from 1962 through 1999 all marmots present at five sites were live-trapped, sexed, and marked with a unique pattern of stripes and/or blotches with a non-toxic fur dye. Each marmot was provided with numbered ear tags when first captured. The tags gave each individual a unique identification number that allowed most marmots to be aged and their reproductive success, measured at the number of young weaned, determined until the marmot disappeared. The fur mark permitted the identification of each marmot during observations. The dye mark was lost when the marmots molted, necessitating re-trapping and re-marking of newly molted individuals.

During approximately 5000 hr of observation various activities were recorded such as location in the habitat, social interactions, responses to interspecific intruders, and type of activity; e.g., sitting, foraging, vigilance (for a complete list of activities, see Armitage *et al.* 1996). Observations were concentrated in the morning (sunrise to 10:00hr) and afternoon (16:00hr to sunset) when marmots were most active. When marmots were foraging, I attempted to record which plants were ingested. As the vegetation grew taller by mid summer, it became almost impossible to determine plant choice in areas of dense vegetation. We earlier reported that yellow-bellied marmots fed in patches dominated by *Potentilla gracilis*, *Taraxacum offinale*, *Lathyrus leucanthus*, *Vicia americana*, *Thalictrum fendleri*, and grasses. The species composition in these patches varied among sites (Frase and Armitage 1989). I concentrated my efforts on how yellow-bellied marmots reacted with encounters with other species conspicuous and often abundant in marmot foraging areas. The plant species and marmot behavior were recorded; e.g., plant ingested or rejected. I also focused a number of observations on marmot behavior with plant species known to contain plant secondary compounds but the flowers of which were eaten in feeding trials (Armitage 1979).

Results and Discussion

1. Plants rarely or never eaten

Frasera speciosa forms a basal cluster of large, strap-like leaves that may number 20 or more before flowering. The plant dies upon flowering but substantial recruitment may occur in the year following widespread flowering (Taylor and Inouye 1985). A flower stalk up to two meters tall bears numerous greenish-white flowers, but yellow-bellied marmots have never been observed to eat the flowers. Although the basal clusters of leaves persist for up to 45 or more years (average 37yrs) before flowering occurs and the plant may be highly abundant, leaves are never eaten.

Veratrum californicum often grows in dense patches in marmot habitats (Travis and Armitage 1972, Svendsen 1973). The leafy-stemmed plant may attain a height of two meters. Yellow-bellied Marmots frequently enter the dense patches, but do not eat *Veratrum* and apparently forage on lower-growing *Potentilla*, *Vicia*, or *Lathyrus*.

The Big Sagebrush, *Artemesia tridentata*, is abundant at one site (River Colony) where marmots forage among the shrubs. Most Yellow-bellied Marmots apparently ignore sagebrush, but several have been seen eating or nibbling at the tops of upright branches. Nettles, *Urtica dioica*, are abundant around the burrow areas at one site (Picnic Colony). Yellow-bellied Marmots generally avoid eating nettles, but a few individuals feed on flowers or seeds hanging down from the nodes.

2. Flowers only

Delphinium or Tall Larkspur, *Delphinium barbeyi*, and Blue Columbine, *Aquilegia coerula*, are locally abundant within marmot sites. Yellow-bellied Marmots typically sit upright, grasp a delphinium or columbine with their forepaws, bend the plant toward their head, and eat the flowers. Yellow-bellied Marmots have not been observed feeding on stems or leaves and rejected leaves and stems in laboratory feeding trials (Armitage 1979).

Yellow-bellied marmots ate Little Lupine (*Lupinus floribundus*) in laboratory feeding trials, but consumed flowers. Therefore, I expected the marmots to eat only flowers in the field. In 22 observations of marmots eating lupines, ten were restricted to flowers or flower buds. Marmots frequently grasped a plant stalk and pulled the plant over to the mouth. In the remaining 12 observations, leaves were eaten and flowers or seed heads were also consumed. The leaves that were eaten were nearly always the young leaves growing at the top of the plant.

Rose bushes (*Rosa woodsii*) are abundant at one site, but are rarely eaten. I have observed a young yellow-bellied marmot climb up into a bush and eat flowers and buds.

3. Plant species tested and rejected

Both the Yellow Paintbrush, *Castilleja surphurea*, and blue flax, *Linum lewisii*, may be locally abundant in meadows frequented by Yellow-bellied Marmots. The Little Sunflower, *Helianthella quinquenervis*, may be abundant on mountain slopes, but is uncommon in marmot habitats. The mustard, *Draba sp.*, is uncommon and also rare in meadows where yellow-bellied marmots forage. I observed marmots grasp and sniff mustard flowers before releasing them, but typically the flower is taken into the mouth and then rejected. One adult male and an adult female ate a few flowers of the paintbrush, but four adult females and a yearling male rejected paintbrush after placing the flower in the mouth. Two adult females rejected sunflowers but one adult female ate the outer ray flowers and rejected the inner disk flowers. Blue flax and mustard were always rejected by adults, yearlings and young.

Cinquefoil (*Potentilla gracilis*) grows in all yellow-bellied marmot habitats and is an important food. It appears early in the spring and may be especially important at that time (Svendsen 1974). The leaves are mostly basal and yellow flowers are produced on stems that may be up to 60 cm tall. I have observed marmots foraging in patches of cinquefoil when the plants were blooming and rarely eating the flowers. The marmots foraged among the flowers and clearly did not seek flowers as they do with columbine, lupine, and tall larkspur. The failure to ingest cinquefoil flowers is in marked contrast to dandelion (*Taraxacum officinale*) flowers. Yellow-bellied Marmots move from one dandelion plant to another and selectively eat the flowers. Because of this foraging behavior, the foraging range of the marmots can be discerned by the absence of dandelion flowers within the foraging area and their abundance outside the area. Clearly cinquefoil flowers are not sought, but it is unclear whether they are avoided or simply passed by because they extend above the marmot foraging on low-growing plants.

4. Burrow associates

Some Yellow-bellied Marmot burrow areas have considerable soil mixed with rocks or rocks are mostly absent. These burrow areas are often colonized by plants that are not palatable to marmots. Fireweed,

Epilobium angustifolium, may form dense growths around a burrow area. Yellow-bellied marmots ate a few flowers in laboratory trials, but I have never seen them feed on fireweed in the field (Armitage 1979).

Blue penstemon (*Penstemon stricta*) grows in disturbed areas and thus may colonize marmot burrow areas. I observed one adult male eat a few flower buds, but essentially this species is avoided. The large, showy composite, *Happlopappus sp.*, also colonizes disturbed areas such as marmot burrow sites. I have observed yellow-bellied marmots eating a few flower heads, but mainly this species also is avoided.

5. *Seasonal choice*

A few plant species begin to grow as snow melts, but the growing season does not really begin until the winter snow-pack disappears (Inouye *et al.* 2000). Yellow-bellied marmots emerge when, on average, over 100cm snow remain on the ground; thus, food should be a critical need during the early post-emergence season.

The larkspur, *D. nelsoni*, and the little bluebells, *Mertensia fusiformis*, are among the first plants to grow and flower after the snow melts (Inouye *et al.* 2000). Only once have I observed a yellow-bellied marmot nibble at the flowers of larkspur; the plants are poisonous as they contain alkaloids (Craighead *et al.* 1963). Bluebells were readily consumed in laboratory feeding trials; but selection did not differ from random encounter (Woods 2001). In field observations, bluebells were eaten when encountered, but marmots did not modify the direction of their foraging pattern to follow the distribution of bluebells. Some animals by-passed bluebells while foraging on other plants that were close to the ground.

Spring beauty, *Claytonia lanceolata*, and the glacier lily, *Erythronium grandiflorum*, are among the earliest plants to appear as the snow melts. Yellow-bellied marmots forage on the spring beauty; clumps of flowers disappeared as marmots foraged through patches where spring beauty grew. This species was readily detected in fecal samples in mid July, long after they were apparent in the landscape (Frase and Armitage 1989). The consumption of spring beauty when other plants are abundant suggests that it may be a selected food. By contrast, the glacier lily is mostly avoided at a time when food is scarce. Some marmots obviously avoided glacier lilies and I observed one adult female that "crushed against flower stalks and sometimes knocked them over, but did not ingest". A glacier lily might be sniffed and then rejected and rarely were flowers ingested. This obvious rejection of glacier lilies is surprising given that the leaves are readily eaten as salad greens by humans (including the author).

Plant biomass declines rapidly in mid to late summer (Kilgore and Armitage 1978, Frase and Armitage 1989). Many plant species become senescent, turn brown, and become much drier at this time. The senescence of leafy vegetation is compensated, in part, by the availability of seeds. Yellow-bellied marmots at this time feed extensively on grass heads; the stems are grasped and the seed-laden grass head is pulled to the mouth and eaten. Shrubs present at some sites are ignored as a source of food until fruits are produced. Yellow-bellied marmots eat the fruits of the gooseberry (*Ribes inerme*) and stand, reach up, and pull down branches of elderberries (*Sambucus pubens*) to their mouths. The time spent foraging increases as marmots spend considerable time moving among the branches and manipulating them to reach the berries, but the time spent feeding decreases as a clump of berries is quickly consumed once it is reached.

Some fall-blooming plants may be widespread and represent a potential source of palatable food. The goldeneye (*Viguiera multiflora*) and aster (*Aster foliaceus*) form extensive populations. I have never seen a yellow-bellied marmot eat either of these species. One adult female grasped a stalk with many flowers of aster, sniffed and then released them. Clumps of a gentian (*Gentiana calycosa*) are common in the meadows; I've watched marmots forage around these clumps, but I've never seen marmots ingest either flowers or leaves. Examination of these clumps revealed no evidence of herbivory. Fireweed is abundant in late summer and, as described above, is not eaten.

Summary and Conclusions

Although yellow-bellied marmots are considered to be generalist herbivores, they are to some degree selective foragers, at least to the extent that some plant species are not eaten. By contrast, some plant species that are readily accepted in feeding trials, such as cow-parsnip (*H. lanatum*) and mountain bluebells (*M. ciliata*) (Armitage 1979), may be little utilized by free-ranging yellow-bellied marmots. Yellow-bellied marmots have been observed to select cow-parsnip in a thick growth of gooseberry bushes and to travel across a meadow slope directly to a patch of cow-parsnip and feed on the leaves; this behavior indicates a preference for this species, which is a source of essential fatty acids (Hill and Florant 1999). However, this species occurs primarily in rich, damp soil, especially in open woods and along streams (Craighead *et al.* 1963) and is absent or rare in yellow-bellied marmot habitats. However, it may be locally abundant distant from marmot burrows where ecological conditions favor its growth. Thus, yellow-bellied marmots may travel beyond their normal foraging range to feed on this plant species and I have observed them to do so, especially during a dry summer when cow-parsnip, growing in low moist areas, was one of the few plant species that were palatable. Similarly, mountain bluebell grows along stream banks in dense clumps, but is little utilized by yellow-bellied marmots because the plants are located far from marmot burrows.

The apparent testing and rejection of some plant species suggests that yellow-bellied marmots do assess food items before deciding whether to eat them. However, in laboratory tests, there was no evidence that the marmots examined the plant species before eating one of them; e.g., dandelions were chosen first among 7 species in 7 of 11 trials (Woods 2001). However, all 7 species used in this experiment were known food items and all existed in the environment from which the marmots were trapped. Possibly the marmots had cues unknown to the human observer that directed the marmot to its choice.

It is unclear to what degree seasonal choice affects survival and reproduction in yellow-bellied marmots. In the spring plant species may appear and grow quickly enough so that the few species that are not eaten are not essential to marmot biology. The situation may be more critical in late summer. Most age-sex classes achieve hibernation mass by late July or early August except for reproductive females and young that accumulate mass through late August or early September (Armitage 1996). Thus, older, non-reproductive animals may escape the late summer food problem whereas these two groups need to accumulate mass when many plant species become senescent and other species are not used as food. The situation could be critical in years of late summer drought; these two groups are more likely to suffer high mortality (Armitage 1994). In fact, juvenile survival is a major demographic mechanism in yellow-bellied marmot population dynamics (Oli and Armitage 2004).

Plant choice by yellow-bellied marmots is affected by plant phenology, palatability, rejection of some plant species, especially those known to contain secondary compounds, availability in marmot habitat, and selection to meet nutritional needs. Selection may change seasonally; *M. marmota* selected plants based on high digestibility and energy content throughout the active season and additionally during the period of fattening preferred plants with high concentrations of 18:2n-6 and avoided plants with high concentrations of 18:3n-3 fatty acids (Arnold *et al.* 2003). The relative importance of these factors needs further analysis with emphasis on selection to meet specific nutritional needs and the role of plant secondary compounds in plant choice or rejection.

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