What Makes an Animal Choose a Forage?

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INTRODUCTION

Have you ever considered why animals behave as they do and what it means for management? Why livestock moved from pastures or rangelands to confinement or vice versa often get sick, perform poorly and refuse to eat even when fed nutritious foods? Why animals moved to new, unfamiliar environments frequently suffer more from predation, malnutrition, and overeating poisonous plants? Why some animals know exactly which poisonous plants to avoid while others don't have a clue? Why livestock on pastures and rangelands perform better when they have a wide variety of plants than when they only have a few plant species to eat?

Simple strategies that use knowledge of behavior can improve the efficiency and profitability of agriculture, the quality of life for managers and their animals, and the integrity of the land. Which foods animals eat and where they forage influences weight gains, reproduction, and carrying capacity of pastures and rangelands. What factors drive food and habitat selection? Animals are thought to prefer foods that are palatable, but what is palatability. Is it merely a matter of taste?

WHAT IS PALATABILITY?

Palatability is considered to be a matter of taste. Yet, if palatability is merely a matter of taste, why do herbivores supplemented with polyethylene glycol increase their intake of unpalatable plants high in tannins? Why would goats eat woodrat houses? Why would cows prefer to eat moldy hay and endophyte-infected grass high in alkaloids rather than nutritious pasture legumes?

Flavor-Feedback Interactions. Palatability is much more than a matter of taste. Palatability is the relationship between a food's flavor and its nutrient and toxin content. When an animal eats a food, it is digested releasing nutrients and in many cases toxins, because all plants contain some level of toxins. These nutrients and toxins are absorbed in the gut and travel to the cells and organs of the body. Signals are then sent back to the brain to tell it how well a food meets the animal's nutritional needs. The brain then pairs the food's flavor with its nutritional benefits and/or toxicity. The brain stores this information for future use. Scientists refer to this process as postingestive feedback (Provenza 1995).

Feedback is positive (increases palatability) if a food meets nutritional needs. Feedback is nega-tive (decreases palatability) if a food is low in nutrients, has too many rapidly digestible nutrients (like grain), or contains high levels of toxins. Palatability is influenced by the nutrient and toxin content of the food, the nutritional needs of the animal, and the animal's past experience with the food. The senses (smell, taste, sight) enable animals to discriminate among foods and provide pleasant or unpleasant feelings associated with eating. Whether or not an animal eats a food is not determined by flavor alone, rather is determined by the experiences associated with eating the food.

Changes in palatability through flavor-feedback interactions occur automatically. Animals don't need to think about or remember the feedback event. Even when animals are anesthetized, postingestive feedback still changes

palatability. When sheep eat a new food and then receive a toxin during deep anesthesia, they become averse to the food because the negative feedback of the toxin happens even when the animals are deeply asleep. Thus, feedback occurs automatically. At times, changes in palatability may not be rational. For example, people acquire food aversions even when they know their illness was not caused by the food. People often acquire strong aversions to foods eaten just before becoming nauseated even if they know the flu, carsickness, or seasickness - not the food - was responsible for the nausea.

Polyethylene Glycol. Many woody plants contain tannins. Tannins reduce the digestibility of protein and energy in foods, and some are toxic. Polyethylene glycol binds (PEG) with tannins, preventing their adverse effects. Animals fed small amounts of PEG eat much more of foods high in tannins because the tannins no longer produce negative effects. Thus, it is the aversive post-ingestive effects of tannins, not their flavor that renders plants high in tannins unpalatable. Once PEG binds tannins, the positive post-ingestive effects of nutrients in the food make high-tannin foods palatable. That's why PEG can enable animals to eat unpalatable plants, such as serecia or oak brush, that are high in tannins.

Goats and Woodrat Houses. The shrub blackbrush is deficient in energy and protein. Several years ago during a winter-grazing study, we placed small groups of goats on six blackbrush pastures. As the study progressed, goats became increasingly averse to blackbrush. In one pasture they began to eat woodrat houses. Goats acquired a preference for woodrat houses because the houses contained urine-soaked (nitrogen-rich) vegetation that helped goats rectify their deficiency in protein. By the end of the study, goats that ate woodrat houses lost 12% of body weight, whereas goats that didn't eat woodrat houses lost 20%. Animals deficient in nutrients seek out new foods, and they are likely to form a preference for a food, no matter how odd, if the food corrects a nutritional deficit or imbalance.

Cows and Legumes. Animals form preferences for foods high in nutrients but diets too high in nutrients or diets that are not nutritionally balanced can cause ruminants to limit intake and search for other foods. When it comes to nutrients, herbivores can get too much of a good thing. High quality pasture may provide cattle with a diet too high in protein relative to energy, which results in ammonia toxicity. The dietary imbalance probably caused cows grazing a pasture high in legumes to seek moldly hay and mature endophyte-infected grass. When strips of grass were planted in the pasture, cattle performance increased and their strange feeding behaviors stopped.

IF THAT'S ALL THERE IS TO PALATABILITY....

So, palatability is the interrelationship between flavor, feedback, and nutritional state. But if that's all there is to palatability, then why do dairy cows reared in confinement perform poorly on pasture and livestock reared on rangelands may perform poorly in drylot or feedlot? In both cases, animals have nutritious food available free choice, but food intake is low, performance is poor, and animals are more likely to suffer diseases. Likewise, why do cows of the same age and breeding differ in performance when eating ammoniated straw?

Livestock Culture. Pasture and rangeland researchers and managers typically consider foraging only in terms of how the physical and chemical characteristics of plants influence an animal's intake rate. The social environment is rarely considered important when studying diet and habitat selection. This is unfortunate because a young animal's interactions with their mother and peers have a lifelong influence on where it goes and what it eats. When it comes to managing pastures and rangelands that contain a variety of foods and terrain, it is critically important to understand how social factors influence the foods eaten by livestock and foraging locations, both of which affect animal performance and carrying capacity.

The impact of social learning on adaptation helps account for why herbivores of the same species can live in very different environments and survive on radically different foods. A calf reared in shrub-dominated deserts of southern Utah is different from a calf reared on grass in the marshes of Louisiana. A bison reared on shrub-dominated ranges in Alaska is different from a bison reared on grasslands in Montana. We typically consider cattle, elk, and bison to be grazers and goats, deer, antelope, and sheep to be forb eaters and browsers. However, "grazers" can live nicely on diets of shrubs, and "browsers" can survive primarily on grass if they learn to do so.

Mom teaches her young about her environment from the location of water and cover, to dangers such as predators, to the kinds and locations of nutritious and toxic foods. Learning about foods from mom begins early in life as flavors of foods mom eats are transferred to her offspring in utero and in her milk.

As offspring begin to forage, they learn what to eat and where to go by following mother. Young animals learn quickly to eat foods mother eats, and they remember those foods for years. Lambs fed nutritious foods like wheat with their mothers for 1 hour per day for 5 days eat more wheat than lambs exposed to wheat without their mothers. Even 3 years later, with no additional exposure to wheat, intake of wheat is nearly 10 times higher if lambs are exposed to wheat with their mothers than if lambs are exposed alone. Lambs exposed with their mothers to various foods - grains like barley, forbs like alfalfa, shrubs like serviceberry - eat considerably more of these foods than lambs exposed to these foods without their mothers.

Mother also reduces her offspring's risk of eating toxic foods. If a mother avoids toxic foods and selects nutritious ones, offspring acquire preferences for foods mom eats and avoids foods mom avoids. Lambs given a choice of palatable shrubs such as mountain mahogany or serviceberry - one of which their mother was trained to avoid - show a preference for the shrub they ate with mother. Through her actions, mother models appropriate foraging behaviors for her offspring.

Dairy and Beef Cows. To reduce the high cost of feeding lactating dairy cows in confinement, many producers use intensively managed pastures as a source of high-quality forage. Unfortunately, for a dairy cow raised in confinement, the barn is habitat, a total-mixed ration is food, and water comes in a trough. Thus, mature dairy cattle reared in confinement are at a disadvantage when put on pastures and expected to harvest forages they have never seen. Although they may be quite hungry, they lack the knowledge and the skills to eat pasture. Little wonder they stand at the gate and bellow to be fed - grass isn't food and the pasture isn't home. Conversely, for a beef cow reared on rangelands, riparian areas and uplands are habitat, grasses, forbs, and shrubs are food, and water comes in streams and ponds. When these animals are moved to feedlots, total-mixed rations aren't food and feedlot pens aren't habitat.

The fear and stress of new foods and environments can cause huge decreases in intake and milk production. To ease these losses, dairy cows should be exposed to green chop in the barn before grazing the first time. The time cows spend on pasture should be increased gradually to reduce stress and losses in production. Exposing calves to pastures where they will be expected to forage later in life will help them be more productive as adults by increasing their preferences for pasture species and enabling them to acquire needed foraging skills. Likewise, before leaving home, cattle on their way to the feedlot should be exposed to the foods they will be expected to eat in the feedlot.

Ammoniated Straw. During a 3-year study, 32 cows - 5 to 8 years of age - were fed ammoniated straw from December to May to reduce winter feed costs. Some cows performed poorly, while others maintained themselves. Researchers were baffled until they examined the dietary histories of the animals. Half of the cows were exposed to ammoniated straw with their mothers during their first 3 months of life, while the other half had never seen straw. Throughout the study, the experienced cows had higher body weight and condition, produced more milk, and bred back sooner than cows with no exposure to straw, even though they had not seen straw for 5 years prior to the study.

Producers should incorporate unfamiliar low-quality foods such as ammoniated straw into their winter-feeding program cautiously. Low-quality forages should make up only a small portion of the winter forage and be increased gradually. Replacement heifers should be exposed to low-quality forages with their mothers early in life to increase intake of these foods later in life.

IF THAT'S ALL THERE IS TO PALATABILITY....

So, palatability is the interrelationship between flavor, feedback, and nutritional state and is influenced by an animal's past experiences with food. But if that's all there is to palatability, then why do animals perform better when offered choices of different foods and why is the grass always greener on the other side of the fence? For example, why do sheep prefer to eat clover in the morning and grass in the afternoon, even though clover is more digestible and higher in protein than grass? Why do cattle perform better when offered individual ingredients from a total mixed ration than when fed a total mixed ration formulated to meet their needs? Why do cattle on a ranch in Montana eat plants like snowberry and sagebrush that cattle don't normally eat?

Each Critter is Different. With the advent of statistics in the 20th century, great emphasis has been placed on assessing the response of the "average" animal to a treatment. While statistics has advanced our ability to conduct experiments, it also has made variation among individuals an enemy to counter. Nutritionists determine needs and formulate diets for the "average" member of the herd, not for individuals. Yet, variation is common in the need for nutrients and ability to cope with toxins, even among closely related animals.

Differences among individuals in food intake and preference depend on how animals are built physically, their body's chemistry, and past experiences with different foods. When we force livestock to eat a ration to meet the needs of the "average" animal, or pastures that planted with a single plant, we may only meet the nutritional needs of some of the individuals in a herd. Individuals can better meet their needs for nutrients and regulate their intake of toxins when offered a variety of foods that differ in nutrients and toxins than when constrained to a single food, even if the food is nutritionally balanced. Variety allows individuals to uniquely balance their own diet.

Variety is the Spice of Life. Variety is the spice of life for herbivores. Like us, they may get tired of eating the same food(s) and prefer to eat a variety of foods. Preference for particular foods declines as foods are eaten. When sheep and cattle eat a food in one flavor, such as maple- or coconut-flavored grain or straw, they prefer food with the alternate flavor on the following day. Preference also drops if animals eats too much of a food on a particular day, just as our preference for turkey declines right after eating a Thanksgiving Day meal. That's why we cook foods in different ways using a variety of herbs, spices and ingedients: How many ways can you cook ground beef?

Interactions between the senses and the body help to explain why palatability changes within meals and from meal to meal. Satiety refers to the decrease in preference for the flavor of a food during eating because of interactions between a food's flavor and postingestive feedback from nutrients and toxins. Flavor receptors respond to taste (sweet, salt, sour, bitter), smell (a diversity of odors), and touch. Flavor receptors interact with receptors in the body that respond to nutrients and toxins, concentration of salts, and gut distension. Preference for the flavor of a food declines automatically as that food is eaten because of interactions between the senses and the body. These interactions cause temporary decreases in the preference for foods just eaten.

This decrease in preference is more persistent when a food has either too many or too few nutrients. Aversions may be pronounced when foods contain excess toxins or rapidly digestible nutrients, such as some forms of protein and energy. Aversions also occur when foods are deficient in nutrients. They even occur when animals eat nutritionally

adequate foods, particularly if those foods are eaten too often or in too great an amount. Thus, eating any food to satiety causes a temporary aversion to the flavor of that food. When forced to eat the same food too frequently or excessively, people typically remark, "I'm sick of it." Through their actions, livestock echo the similar sentiments.

Sheep and Clover. Sheep on a grass-clover pasture eat clover in the morning and switch to grass in the afternoon. Why? In the morning, hungry sheep initially prefer clover because it is highly digestible compared with grass. As they continue to eat clover, however, sheep satiate - acquire a mild aversion - from the effects of nutrients like soluble carbohydrates and proteins, from the effects of toxic cyanide compounds, and from eating the same flavor. The mild aversion causes them to switch to grass in the afternoon. During the afternoon and evening, the sheep recuperate from eating clover, and the aversion subsides. By morning, they are ready for more clover. The combination of clover and grass likely enables sheep to eat more each day than if only one species were available.

Sowing clover and grass in separated strips can further enhance intake and performance compared to clover-grass mixtures. When grass and clover are planted in strips, as opposed to conventional mixtures, dry matter intake of sheep increases by 25% and milk production of dairy cows increases by 11%. The choice allows each animal to balance the mix of grass and clover, and the strip evidently minimizes time spent searching for the desired amounts of the different forages.

Choice at the Bunks. Cattle fed barley, corn, alfalfa, and corn silage were compared with animals fed a nutritionally balance ration of those ingredients. Cost per pound of gain were 20% less for animals offered a choice than for those fed the mixed-ration because animals offered a choice ate less, and they ate less grain. Apparently, animals met their needs for energy and protein more efficiently when offered a choice among foods than when fed a mixed-ration, even when the ration was nutritionally balanced. Allowing individuals to choose their own diet may be less stressful for animals thereby reducing illness and improving performance.

Montana Cows. Ray Banister manages 7,200 acres of rangeland in eastern Montana. His management style has evolved over 40 years from rotational grazing that involved relatively short periods of grazing and rest to boom-bust management that consists of intensive periods of grazing followed by two growing seasons of rest. Ray's boom-bust grazing management stresses systems with intensive grazing pressure, then allows them to recover. Ray believes that stress, and recovery from stress, strengthens systems.

The change to boom-bust grazing challenged the Hereford cattle on Ray's ranch. Cattle could no longer eat only the most palatable plants as they had under rotational grazing. Instead, they were forced to eat all of the plants. Under the new management procedures, Ray monitors the least palatable plant species - shrubs like sagebrush and snowberry and various weeds - as indicators of when to move cattle to a new pasture. Cattle are allowed to move only after adequate use of unpalatable species. Thus, Ray reduces the competitive advantage unpalatable plants have over palatable species because grazed plants are at a disadvantage for water and nutrients when competing with ungrazed plants.

Under boom-bust management, cattle now eat snowberry and sagebrush as soon as they enter a new pasture. The cows evidently have learned how to mix their diets in ways that better enable them to eat all plant species. Cattle likely lessen the aversive effects of toxins by eating palatable plants high in nutrients along with unpalatable species high in toxins. The better the nutrient status of the animal, the better it is able to detoxify toxic compounds found in all plants.

It took Ray's cows 3 years to adapt to the boom-bust style of management. During that time, the weaning weights of calves plunged from well over 500 pounds to 350 pounds then rebounded back to over 500 pounds. Once the older

cows made the transition, their calves learned from their mothers how to thrive under boom-bust management. The calves that Ray keeps as replacements never have to make the harsh transition because they were trained by their mothers that all plants are food at Ray's place.

Ray has increased the carrying capacity of his ranch, and made his operation less subject to the adverse effects of drought. Occasional disturbance, followed by rest, creates a diversity of micro and macro habitats for all plants, and that reduces the number of invasive plants. It is hard to find any part of the ranch - riparian areas or uplands - that lacks abundant plant cover, and that creates a forage bank during drought. The abundance and diversity of plants also lessens soil erosion, which leads to clean water and great habitat for fish, waterfowl, and upland wildlife.

CONCLUSION

Scientists and managers often ignore the power of behavior to transform systems, despite compelling evidence. We know that the environment acting on biological steps is as important in shaping creatures as their genetic code. For those willing to understand how environment interacts with genes to influence behavior, the potential is virtually unlimited. Once mastered, behavioral principles and processes become a part of the "infrastructure" of the person, so they are readily transferred from one situation and locale to another. People who understand and use behavioral principles in management can enhance the welfare of animals and the integrity of land.

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