WHAT MAKES AN ANIMAL CHOOSE A FORAGE?

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ABSTRACT

Consider the following scenarios: To cut the costs of ranching a researcher explores feeding cattle ammoniated straw in winter. Some of the cows maintain themselves on the diet while others lose weight, produce less milk and fail to conceive. A producer in Missouri plants a pasture rich in legumes and high in crude protein, yet his cattle prefer moldy hay and endophyte infected tall fescue to the legumes. Why do animals behave this way? Animals are thought to prefer foods that are palatable but what is palatability? We define palatability as the interrelationship between a food's flavor and postingestive feedback from nutrients and toxins in the food. Palatability is further influenced by an animal's current nutritional state and its experiences with the food. Animals form preferences for foods that are high in nutrients and low in toxins. Furthermore, they prefer foods that are familiar especially those eaten early in life. Lastly, each animal's nutritional needs are unique thus they perform best when they are provided with a variety of foods that allow them to balance their own diets.

Key Words: palatability, preference, diet selection, behavior, foraging, management

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 refuse to eat, get sick, and perform poorly even when fed nutritious foods? Why wild and domestic animals moved to unfamiliar environments frequently suffer from predation, malnutrition, and over-ingestion of toxic plants? Why some individuals know exactly which toxic plants to avoid while others don't have a clue? Why livestock on pastures and rangelands perform better with a wide variety of plants than when they only have a few plant species to eat? Why changes in grazing management can reduce livestock performance for up to 3 years?

Unfortunately, efforts to help people make a living often ignore how animals make their living. Yet 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, reproductive performance, and the carrying capacity of pastures and rangelands. What factors drive food and habitat selection, and what are the implications for management? Animals are thought to prefer foods that are palatable, but what is palatability and is it merely a matter of taste?

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WHAT IS PALATABILITY?

Palatability is considered to be a matter of taste, and all popular definitions focus on either a food's flavor or its physical and chemical characteristics. 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 do cows eat moldy hay and endophyte-infected grass high in toxic alkaloids rather than highly nutritious pasture legumes?

Flavor-Feedback Interactions. Palatability is more than a matter of taste. It is the interrelationship between a food's flavor and its postingestive effects. Flavor is the combination of odor, taste, and texture. Postingestive effects are feedback from the cells and organs. Feedback is positive (increases palatability) if the food meets nutritional needs. Feedback is negative (decreases palatability) if the food is inadequate or excessive relative to nutritional needs or if the food is toxic. Thus, flavor-feedback interactions are influenced by the nutrient and toxin content of the food and the nutritional needs of the animal. The senses - smell, taste, sight - enable animals to select among foods and provide pleasant or unpleasant feelings associated with eating. Thus, postingestive feedback influences an animal's liking or disliking for a food - its palatability, and that depends on how well a food meets the needs of the body.

Feedback within the body is critical for health and well-being. Bodies are made up of cells, organs, and organ systems all with nutritional needs. They interact with one another through feedback from nerves, neurotransmitters, and hormones. In the case of flavor-feedback interactions, nerves for taste meet with nerves from the body at the base of the brain. These nerves interact as they send information throughout the central nervous system. Feedback from the body to the palate is how groups of cells and organs influence which foods and how much of those foods are eaten.

Changes in palatability through flavor-feedback interactions occur automatically. Animals don't need to think about or remember the feedback event, just as none of us need to consider which enzymes to release to digest the foods we eat. Even when animals are anesthetized, postingestive feedback still changes palatability. When sheep eat a nutritious food and then receive a toxin dose during deep anesthesia, they become averse to the food because the negative feedback of the toxin occurs even when the animals are deeply asleep. Thus, feedback operates automatically, and often in the absence of rationality, to change palatability. For example, people acquire food aversions even when they know their illness was not caused by the food. A person often acquires strong aversions to foods eaten just before becoming nauseated even if the person knows that the flu or seasickness - not the food - was responsible for the nausea.

Polyethylene Glycol. Tannins reduce the digestibility of protein and energy in foods, and some tannins are toxic. Polyethylene glycol binds with tannins, preventing their adverse effects. Animals fed small amounts of polyethylene glycol 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, and it is the positive post-ingestive effects of nutrients in the food that make high-tannin foods palatable. That's why polyethylene glycol can be used to train animals to eat unpalatable weeds, such as

serecia, that are high in tannins.

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 alternative foods. When it comes to nutrients, herbivores can get too much of a good thing. The pasture likely provided 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 pastures and rangelands perform poorly in drylots or feedlots? 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 uniform age and breeding differ markedly in performance when ingesting 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 ability to achieve high rates of intake. The social environment is rarely considered important when studying diet and habitat selection. This is an unfortunate oversight because a young animal's interactions with 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 creatures and the locations where they forage, 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 occur in very different environments and survive on radically different foods. A young herbivore learns what kind of creature it will be through social interactions. A calf reared in shrub-dominated deserts of southern Utah is different from a calf reared on grass in the bayous 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.

Socializing with mother helps young animals learn about every facet of the environment from the location of water and cover to the wide array of hazards such as predators to the kinds and locations of nutritious and toxic foods. Learning from mother about foods begins early in life as flavors of foods mother eats are transferred to her offspring in utero and in her milk. For instance, in livestock the flavor of plants like onions and garlic is transferred this way, which increases the likelihood that young animals will eat onion and garlic when they begin to forage.

As offspring begin to forage, they further 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. Research shows that 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 without their mothers.

Mother also reduces her offspring's risk of eating toxic foods. If a mother avoids harmful foods and selects nutritious alternatives, the lamb acquires preferences for foods its mother eats and avoids foods its mother 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, who learn what to eat and where to forage.

Dairy and Beef Cows. To reduce the high cost of feeding lactating dairy cows in confinement, many producers are using intensively managed pastures as a source of lower-cost, high-quality forage. Unfortunately, for a dairy cow raised in confinement, the barn is habitat, ingredients from a total-mixed ration are food, and water comes in a trough. Thus, mature dairy cattle reared in confinement on processed foods 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 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. To reduce the cost of ranch operation, researchers are exploring ways to feed low-cost foods such as straw to livestock during winter. During a 3-year study, 32 cows - 5 to 8 years of age - were fed ammoniated straw from December to May. 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

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 as they are 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?

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 the discipline of statistics has advanced our ability to conduct experiments, it also has made variation among individuals an enemy to counter rather than a friend to embrace. We emphasize means and populations rather than individuals and variation, while nature and evolutionary processes do the opposite. Research and management strategies in nutrition determine needs and formulate diets for the "average" member of the herd, not for individuals. Yet, marked variation is common even among closely related animals in needs for nutrients and abilities to cope with toxins.

Differences among individuals in food intake and preference depend in part on differences in how animals are built morphologically, and how they function physiologically, and in part on their past experiences with different foods. When we unduly constrain individuals by mixing food to meet the needs of the "average" animal, by planting monocultures of forages on pastures, or by restricting the ability of animals to fully use pastures and rangelands, we may only meet the nutritional needs of a subset of individuals in a herd - and abuse landscapes in the process. 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 the uniqueness of the individual to be manifest.

Variety is the Spice of Life. Whether confined or foraging on pastures or rangelands, variety is the spice of life for herbivores. Like us, they periodically satiate on familiarity and thrive on variety. That combination causes animals to continually investigate different foods and foraging locations. Sheep and cattle prefer foods in different flavors, just as eating maple-flavored oatmeal for breakfast every day causes people to prefer oatmeal in a different flavor. Preference for particular foods declines as the 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 a person's preference for turkey drops markedly following a Thanksgiving Day meal. That’s why we cook foods in different ways using a variety of flavors: 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. Flavor-, nutrient-, and toxin-specific satiety refer to the decrease in preference for the flavor of a food during and after eating because of interactions involving 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 (astringency, pain, temperature). Flavor receptors interact with receptors in the body (liver, gut, central nervous system, and elsewhere) that respond to nutrients and toxins (chemo-receptors), concentration of salts (osmo-receptors), and gut distension (mechano-receptors). 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.

Animals fed a nutritious food in one of two flavors for a day prefer the other flavor in a meal on subsequent days. The decrease in preference, which is influenced by an animal's nutritional needs relative to a food's chemical makeup, 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 transient 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 same sentiments.

Sheep and Clover. Sheep in the United Kingdom satiate on clover in the morning and switch to grass in the afternoon. 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 spatially separated strips can further enhance intake and performance compared to clover-grass mixtures. When grass and clover are planted in distinct strips, as opposed to conventional intermixtures, dry matter intake of sheep increases by 25% (265 g/sheep/day) and milk production of dairy cows increases by 11% (2.4 kg/cow/day). 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. Planting forages in strips overcomes many difficulties inherent in establishing and maintaining mixed pastures. It also mimics what happens naturally as different plant species aggregate in response to environment.

Choice at the Bunks. In a recent study, cattle fed barley, corn, alfalfa, and corn silage were compared with animals fed a chopped and mixed ration of those ingredients**.** Averaged throughout the trial, animals offered the mixed-ration ate slightly more food than animals given a choice but they did not gain at a faster rate. Gain per unit food consumed was similar for both groups. However, daily food costs were less for animals offered a choice than for those fed the mixed-ration ($1.36 per day vs. $1.58 per day) because animals offered a choice ate less, and they ate less grain. Cost/lb gain was less for the choice group than for the mixed-ration group ($0.68/lb vs. $0.84/lb). Animals meet their needs for energy and protein more efficiently when offered a choice among foods than when fed a mixed-ration, even if the ration is nutritionally balanced. Allowing individuals to choose their own diet may be less stressful for animals thereby reducing illness and improving performance.

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 the genome 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.

FOR ADDITIONAL INFORMATION

A book and companion video titled ***Foraging Behavior: Managing to Survive in a World of Change*** have just been published. The scientific discoveries and real-life situations in the book and video provide insights into why animals behave as they do, and they show how understanding behavior can enhance management in any part of the country. The book and video are filled with new discoveries about the age-old topic of grazing animals and forage resource management. Anyone challenged with managing natural resources - soils, water, plants, herbivores, people - can use these principles. The book and video are available for the cost of shipping and handling. Send requests in writing to: Fred Provenza or Beth Burritt; Forest, Range and Wildlife Sciences; Utah State Univ.; Logan, UT 84322-5230 or send requests by e-mail to bethb@cc.usu.edu. Visit our website at www.behave.net.