

The Spice of Life

Variety is the spice of life, not only for people, but also for herbivores, whether they are confined or foraging on pastures or rangelands. Like us, they periodically satiate on familiarity and thrive on variety. That combination causes animals to continually investigate different foods and foraging locations. When we unduly constrain animals by mixing food to meet the needs of the “average” animal, by feeding total-mixed rations in confinement, by planting monocultures of forages on pastures, or by restricting the ability of animals to fully use rangelands, we will only meet the nutritional needs of a subset of individuals in a herd—and abuse lands in the process.

Variety of theories

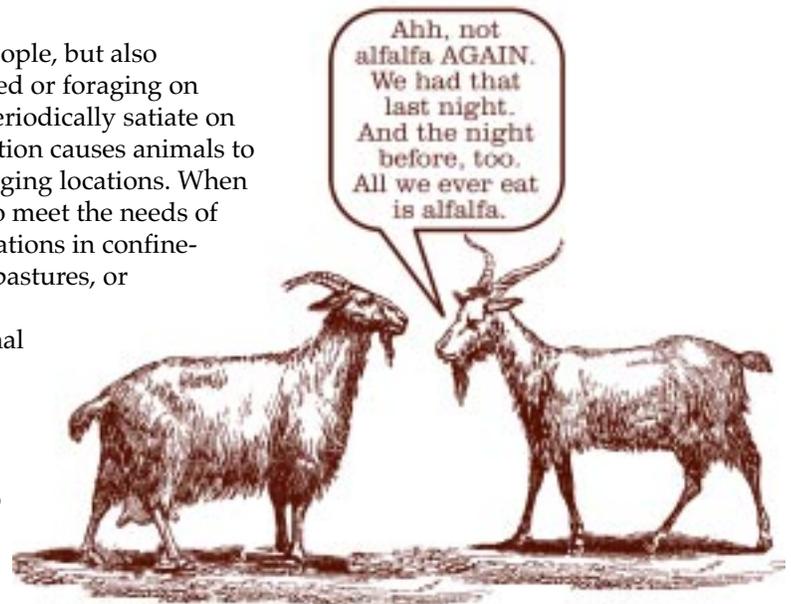
Herbivores and omnivores are often referred to as generalists because they eat a wide variety of foods. Some experts believe that eating a variety of foods reduces the likelihood an animal will over-ingest toxins. They hypothesize that toxins limit the amount of any single food an animal can tolerate, and to meet needs for macronutrients, animals must consume small amounts of a variety of foods with different toxins, each of which presumably is detoxified by somewhat different means. Others believe animals eat a variety of foods to meet nutritional needs—no single food contains the required mix of macronutrients, minerals, and vitamins. Both theories are valid, but neither accounts for the fact that animals eat an assortment of foods even when toxins are not a concern and nutritional needs are met.

Looking over clover

Sheep in the United Kingdom 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?

Animals prefer highly digestible foods because the delay between beginning to eat and nutrient reinforcement is short and the amount of reinforcement is high. However, if animals eat too much of a highly digestible food, and rates of fermentation are too high, they become ill and begin eating less digestible foods. When the immediate positive postingestive effects of nutrients are then followed by mild illness, the pattern of intake becomes cyclic: gradual increases followed by sharp declines. The more familiar an animal is with a food, and the greater the positive feedback from nutrients, the less likely the animal is to acquire a lasting aversion. This response is characteristic of nutritious foods like larkspur, which contains toxic alkaloids, or rapidly fermentable foods like grain (high in carbohydrates) and some pasture forages (high in protein).

This helps explain why sheep in the United Kingdom eat clover in the morning and switch to grass in the afternoon. 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 soluble carbohydrates and proteins and from the effects of toxic cyanogenic compounds. The mild aversion causes them to seek the less nutritious grass, which is lower in nutrients and toxins, in the afternoon. During the afternoon and evening, the sheep recuperate from eating clover, and the aversion subsides. By morning, they’re ready for more clover.



Mary Donahue

File Photo

Why animals search for variety

Sheep and cattle prefer foods in different flavors, just as people who eat maple-flavored oatmeal for breakfast everyday eventually prefer 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 overingest a food on a particular day, just as a person's preference for turkey drops markedly following a Thanksgiving Day meal. When forced to eat the same food too frequently or excessively, people typically remark, "I'm sick of it." If livestock could speak, they would echo the sentiments, as their actions show.

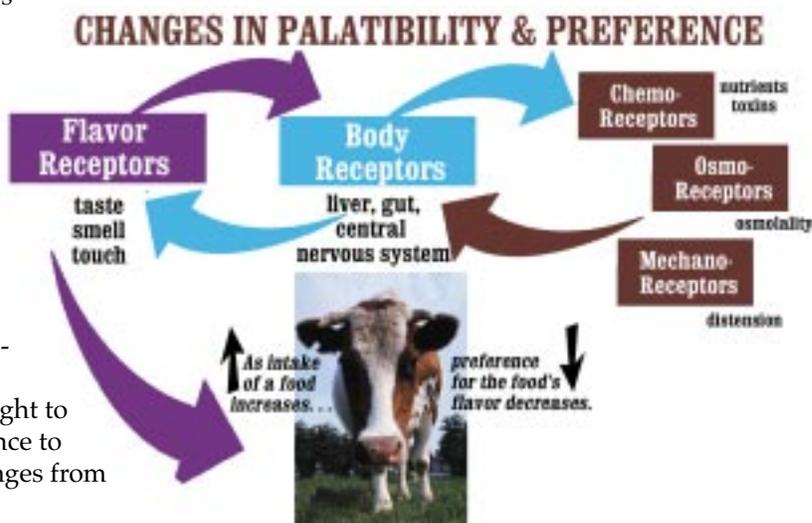
Interactions between the senses and the body help to explain why palatability changes within meals and from meal to meal. Flavor-, nutrient-, and toxin-specific satiety refer to the decrease in preference for the flavor of a food during and after eating due to interactions involving a food's flavor and 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), osmolality (osmo-receptors), and 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 transient decreases in the preference for foods just eaten; interactions that can be understood as operating along a continuum of stimulation from slight to extreme—that is from aversion to preference to aversion as a food's utility to the body ranges from inadequate to adequate to excessive.

The decrease in preference is influenced by an animal's nutritional needs relative to a food's chemical characteristics. Animals fed nutritionally balanced food in one of two flavors for a day prefer the other flavor in a meal on subsequent days. The decrease in preference is more persistent when a food is either deficient or excessive in needed 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 specific 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. That's why people cook familiar foods in different ways using a variety of different flavors. How many ways can you cook ground beef?



Bob Nichols, USDA Natural Resource Conservation Service

Landowner Dorlene Rides at the Door Waln, and NRCS conservationist discuss the operation of the ranch. This Montana ranch supports approximately 2,000 head of Hereford and Black Angus cattle and 12,500 acres of wheat, barley, and oats.



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Herding sheep

Many of the principles related to flavor-, nutrient-, and toxin-specific satiety have been used in human nutrition and in pastoral grazing systems, and they are important in understanding feeding behavior. The reasons might not have been clear but the effects were evident.

Herders in France use these principles to stimulate food intake and more fully use the range of plants available by herding in grazing circuits. The grazing circuit includes a moderation phase, which provides sheep access to plants that are abundant but not highly preferred to calm a hungry flock; the next phase is a main course for the bulk of the meal with plants of moderate abundance and preference; then comes a booster phase of highly preferred plants for added diversity; and finally a dessert phase of abundant and palatable plants that complement previously eaten forages. Daily grazing circuits are designed to stimulate intake and satisfy an animal's appetite for different nutrients and to ensure use of many different plant species, thereby enhancing plant biodiversity.

Moving animals to fresh pastures or moving them to new areas on rangelands is likely to have the same effect. The new areas offer nutritious forages and a change of scenery. Livestock producers have learned how easy it is to move animals to new pastures. Once the animals have learned the routine and experienced the benefits, they move themselves.

Humans, too, have developed culinary practices that combine foods grown locally to meet nutritional needs. Corn and beans, for example, are staples in the diets of many traditional American cultures and a major source of caloric intake. Both corn and beans are inadequate in certain essential amino acids, but the amino acids in short supply are complementary. Eaten in combination, corn and beans are an adequate source of amino acids and a great source of energy.



Tim McCabe, USDA Natural Resource Conservation Service

This South Dakota rancher rotates sheep from one cell to another in a cell-grazing system designed to manage range grasses.

Variation among individuals

With the advent of statistics during the 20th century, researchers and managers have placed great emphasis on devising experiments to determine the response of the "average" animal to a particular treatment. While these experiments have enabled us to better understand biological processes, they have obscured the vital importance of variation among individuals. We make decisions based on "averages" obtained from "populations" rather than on individual responses.

From studies of behavior and nutrition, we typically determine nutritional needs and formulate rations (for animals in confinement) or make predictions of food preferences (for animals on rangelands) for the herd, not for individual members of the herd. The same is true for habitat use. We typically assess the carrying capacity of pastures and rangelands based on factors such as slope, site productivity, and



Gary Neuenwander

In the real world, we all know there is no such thing as "average"—only a multitude of individuals.

food preference of the “average” member of the herd. We calculate “means” but no such thing exists. There is no “mean” weather, soil, plant, herbivore, or person. Variations among individuals and the ongoing interactions among individual components of each sub-system virtually guarantee that systems will continually vary across time and space.

Anyone studying nutrition or toxicology soon realizes the great degree of variation among individuals. Variations in dental structure and arrangement affect the foraging abilities of individual sheep and goats, as do differences in organ mass and how animals metabolize macronutrients. Lambs of uniform age, sex, and breed vary widely in their preferences for foods. Some lambs prefer foods high in energy, while others prefer foods with medium or even low energy. Doses of sodium propionate (sodium and energy) that condition preferences in some lambs condition aversions in others. Sheep, goats, and cattle show similar variation in susceptibility to toxins. Some sheep fed a high level of the plant goatsrue failed to show any symptoms of toxicosis; others were killed by a low dose. The point is that individual differences in morphology and physiology influence food and habitat preferences of individuals, and they provide a basis for “natural” and “artificial” selection. Diets and habitats that enable animals to select among alternative foods and locations enable *each individual* to best meet its needs.

Noted biochemist Roger Williams was convinced that each individual is “built in a distinctive way in every particular, and that this was the basis of individuality.” Williams was aware of the functional significance of differences in people, and he articulated those notions:

Stomachs vary in size, shape and contour . . . They also vary in operation . . . A Mayo Foundation study of about 5000 people who had no known stomach ailment showed that the gastric juices varied at least a thousand fold in pepsin content . . . Such differences are partly responsible for the fact that we tend not to eat with equal frequency or in equal amounts, nor to choose the same foods . . . In fact, marked variations in normal anatomy are found wherever we look for them . . . Some of the most far-reaching internal differences involve the endocrine glands—thyroids, parathyroids, adrenals, sex glands, pituitaries—which release different hormones into the blood. These, in turn, affect our metabolic health, our appetites for food, drink, amusement and sex, our emotions, instincts and psychological well-being . . . Our nervous systems also show distinctiveness . . . Since our nerve endings are our only source of information from the outside world, this means that the world is different for each of us.



Gary Neuwander

Individual differences in morphology and physiology among herbivores means varied food and habitat preferences.

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Confined and constrained

Animals in feedlots, dairies, or dairy/pasture operations are fed total-mixed rations of concentrates and roughages formulated to meet the needs of the “average” animal. We often feed total-mixed rations to animals in confinement because we’re afraid they’ll eat too much grain and we believe that they are unable to balance their own rations. What would happen to food intake, weight change, and the cost of food per day if animals could choose their own diets from a variety of concentrates and roughages? Conventional wisdom says animals will eat too much grain and perform poorly or die because they cannot balance their own rations.

But when goats, sheep, and cattle are offered a variety of foods, including grain concentrates, they seldom eat too much grain if they have time to adjust. Rather, they limit intake of grains and roughages and adjust intake according to nutritional needs. Indeed, they eat less grain than animals force-fed a total-mixed ration designed to maximize weight gain. Excess grain causes acidosis, which induces food aversions.

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. Food selection varied widely among individuals offered a choice of the four ingredients throughout the 63-day trial. Intake of dry matter, energy, and protein all changed from day to day, as did ratios of protein to energy for animals fed free-choice. On 21 of the 63 days, animals offered a choice had protein-to-energy ratios higher than animals fed the total-mixed ration. On 2 days the ratios were equal. On 40 of the 63 days they had protein-to-energy ratios lower than the animals fed the total-mixed ration. No 2 animals selected a diet similar to the total-mixed ration, and none consistently chose the same foods. Yet each animal apparently selected a diet that met its needs.

Averaged throughout the 63-day trial, animals offered the mixed-ration tended to eat more than animals offered a choice (109 vs 102 g/kg MBW/day), but they did not gain at a faster rate (0.89 vs 0.92 kg/day). Gain/unit food consumed also was similar for both groups (0.09 vs 0.10 kg/kg). However, food cost/day was less for animals offered a choice than for those fed the mixed-ration (\$1.36 vs \$1.58). Because animals offered a choice ate less, and they ate less of the more expensive grains, cost/kg gain was less for the choice than for the mixed-ration group (\$1.49 vs \$1.84). These findings suggest that: (1) individual animals can more efficiently meet their needs for macronutrients when offered a choice among dietary ingredients than when constrained to a single diet, even if it is nutritionally balanced; (2) transient food aversions compound the inefficiency of a single mixed diet by depressing intake even among “uniform” groups of animals suited to that nutritional profile; and (3) alternative feeding practices may allow producers to efficiently capitalize on the agency of animals, thus reducing illness and improving performance.



Even though cattle fed individual ingredients by free-choice ate slightly less food per day, the end result of reaching finished body condition was the same for both groups of cattle. However, the cost per day to feed the free-choice animals was much less because they ate less grain. In the end, the weight gained per amount eaten did not differ between the groups, nor did the cattle differ in grade at slaughter.