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The Use of Animal Behavior As a Tool for Biological Control

Melissa Biscornet
Utah State University

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Range Honors' Thesis

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I tried, and

I failed,

I believed, and

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INTRODUCTION

Animal behavior, the way that an animal acts, is a combination of instinctive traits and learned responses to particular situations (Robinson and Bolen 1984). Behavior in young animals involves several different learning mechanisms, including the following: generalization, social facilitation, neophobia, cue-consequence specificity, and harvesting skills. Preferences instilled in young animals through learning can influence diet selection, grazing patterns, and habitat selection later in life (Squibb et al. 1990)

Animals learn about foods through two interrelated systems, the cognitive and the affective systems (Provenza et al. 1991). Through the cognitive system, the animal relates taste to postingestive consequences. Learning is enhanced by combining both taste and smell with postingestive consequences (Provenza et al. 1991). Through both of these mechanisms, animals learn food aversions and preferences, or diet selection.

Preferences can be manipulated to promote biological control of undesirable plants (Walker et al. 1990). Through the use of both cognitive and affective learning techniques, animals can be taught to select for or against undesirable or desirable plants. Biological control is enhanced when the animal selects for the undesirable vegetation.

Biological control is achieved by using both selective grazers and natural enemies. While selective grazers suppress

plant growth primarily through defoliation, natural enemies (i.e., insects, and disease organisms) defoliate, or remove leaves, inhibit seed production, and remove vital fluids from the plant.

The use of biological control as a vegetation manipulation tool causes less damage to the environment, is more predictable, and in a more conservation-oriented society, requires less labor and inputs than either chemical or mechanical manipulations. Biological control agents also help to improve range condition by selectively removing undesirable vegetation.

Selectivity, or forage selection, is based upon animal body size, type of digestive system, size of digestive system relative to body weight, and mouth size and shape (Holechek et al. 1989).

This paper will focus on how preferences are instilled in young animals as they develop, and on food neophobia, or the cautious sampling of new foods.

LEARNING BEHAVIOR

Genetic influences and learning are interrelated in the development of animal behavior. Learning can be classified according to the following: respondent conditioning, operant conditioning, or observational learning. Respondent conditioning occurs as a neurological or physiological response to a stimuli, and evolved through natural selection (Provenza et al. 1991). Harvesting skills may be respondent.

Cue-consequence specificity, novel/familiar dichotomy, generalization, and neophobia are all examples of a voluntary response resulting from a positive or negative consequence called operant conditioning (Provenza 1991). Observational learning occurs when an animal observes the behavior of others (Provenza et al. 1991). Social facilitation is an example of one type of observational learning.

The following section attempts to define and give examples of types of learning behavior.

Novel/Familiar Dichotomy

The novel/familiar dichotomy involves the introduction of animals to a novel, or a new food, and to a familiar food at the same time. If the exposure results in illness, the animal will associate the illness with the novel food. It will not associate the illness with a familiar food that did not previously cause sickness. Thus, the animal will either avoid or eat smaller quantities of the new food, depending on its level of experience (Burritt and Provenza 1990). Experienced animals eat smaller quantities of novel foods than naive lambs (Burritt and Provenza 1990).

In a recent study combining both generalization and social facilitation, early exposure to novel foods significantly affected food preferences in lambs (Nolte et al. 1990). However, the degree of preference depended upon the second exposure. Lambs continually exposed to the same food developed a strong preference for it. If the second food the

lamb was exposed to was different, the animal showed a strong preference for the first novel food. Lambs will develop a preference with or without their dams present during exposure. However, maternal presence enhances persistence of preference (Nolte et al. 1990).

Generalization

Through generalization, an animal can be taught to eat a novel food if it tastes or looks like a familiar food. However, the familiar food cannot have caused an illness resulting from previous consumption, or the animal will avoid both foods (Launchbaugh and Provenza 1992).

Social Facilitation

A young animal observes a social model such as its mother, another unrelated female, or a companion in social facilitation learning. The young animal will develop a preference for the food that its model consumes through observation of that model (Mirza and Provenza 1992).

Biological control of undesirable plants can be facilitated by exposing lambs with their dams, other adult models, or peer groups to undesirable plants early in life (Squibb et al. 1990, Mirza and Provenza 1992). However, the food also had to be first accepted by the social facilitator. By combining social facilitation and neophobia with the novel/familiar dichotomy concept, lambs previously exposed to shrubs of mountain mahogany (*Cercocarpus montanus*) consumed

more than lambs not previously exposed. As the age and experience of the lambs increased, consumption of, and familiarity with, the shrub increased. However, there is an optimal time of exposure, which occurs during the transition period from gastro-intestinal digestor to ruminant in lambs. During this time lambs learn what to consume from their dams. This is shown by the close proximity of lambs to their grazing dams during this time.

Social learning is also more efficient than trial and error learning (Thorhallsdottir et al. 1990). Social models help lambs to effectively develop food preferences. Lambs will eat more of a novel food in the presence of a social model than when alone. The presence of the dam is more influential than that of a dry ewe. Social models decrease food neophobia and increase the rate of acceptance of novel foods. However, the lamb must be exposed to the same foods as the social model either while the model is grazing or immediately after the lamb has observed the model. Otherwise, observation is ineffective.

Harmful foods can be most effectively selected against by trial and error learning, or can be consumed in smaller amounts by watching the dam. Trial and error learning enhances the animals ability to learn due to the relationship which exists between postingestive consequences and taste and odor.

Food Neophobia

Food neophobia is the cautious sampling or complete rejection of new foods. Neophobia, not unpalatability, is the major factor affecting consumption by naive, or inexperienced sheep (Squibb et al. 1990). Sheep generally consume small portions of novel foods; if no negative consequences ensue, then they will gradually increase intake of those foods.

Neophobia has been described as an herbivore survival mechanism in relation to poisonous plants. Rather than ingesting a poisonous plant in lethal quantities, an animal cautiously samples and ingests the plant in small quantities. The animal quickly learns to avoid a new food that causes gastro-intestinal distress.

In contemporary livestock production systems, animals are often exposed to novel foraging environments. Bulls, rams, or replacement females may be transported thousands of miles as part of breeding programs. Lambs and calves also encounter novel feeds at weaning time, when they are placed in feedlots for fattening. The acceptance of safe novel foods in these situations can influence weight gain, and even survival (Ortega-Reyes et al. 1992).

Cue-Consequence Specificity

In cue-consequence specificity, an animal is given either a positive or a negative consequence (i.e. an induced illness, or increased rate of metabolism) after it has consumed a food. The consequence may be associated with either the skin or the

gut defense systems. The animal learns to avoid or to seek out the new food, depending upon the type of consequence associated with the food.

Conditioned food aversion has been effectively used to train cattle to avoid eating larkspur (Delphinium spp.) (Ralphs et al. 1989). Since larkspur can be toxic to cattle, and adult animals prefer it, social models like mothers may teach their offspring to ingest larkspur. Instead, young animals have to be trained, or conditioned, through either novel/familiar dichotomy or cue-consequence specificity, to avoid larkspur.

Acquisition of Harvesting Skills

With harvesting skills, an animal can be taught to eat more of a type of vegetation. As experience in harvesting plants increases, harvesting skills improve, and the efficiency of harvest also increases. Factors influencing foraging efficiency include the following: foraging experience, prehension patterns, and plant phenology and morphology (Flores et al. 1989b). Generally, inexperienced lambs are less efficient foragers because they lack the necessary skills to prehend and ingest vegetation (Flores et al. 1989b). Harvesting skills must be developed. As the animal gains experience consuming a plant form, it will be able to ingest more of that forage per unit of time (Flores et al. 1989c), and thus, be more efficient. Sheep spend less

time and energy foraging in familiar environments than in unfamiliar environments (Flores et al. 1989b).

High bite rates or large bite sizes do not necessarily indicate increased success (Flores et al. 1989c). Inexperienced lambs which increase their bite size on a particular life form may actually have similar efficiency harvesting to that of more experienced lambs with smaller bite sizes (Flores et al. 1989b). Smaller bites generally mean more nutritious bites. The intake rate of experienced lambs is much higher than that of inexperienced lambs because the familiar lambs have better prehension skills (Flores et al. 1989b). Prehension patterns include jerking and breaking grasses, chewing shrubs, and plucking leaves. Twig breaking and leaf stripping are considered more difficult prehension patterns (Flores et al. 1989b). Thus, prehension skills are specific to mouth shape, size, and movement potential, and harvesting skills are specific to plant form (Flores et al. 1989b).

Lambs are able to increase bite size and biting rate to compensate for changes in the availability and structure of forages. Prehension experience is influenced by forage morphology and phenology. As a plant matures from vegetative to reproductive morphology, bite size and intake rate increase, while bite rate decreases (Flores et al. 1989a). As the plants mature, animals must use different prehension skills to harvest them. Prehension skill experience

determines the amount of forage ingested per unit of time. Thus, lambs with more experience in foraging will be able to increase their intake rate. However, reduced bite rate increases the time involved in finding acceptable herbage. Bite rate is reduced under sward conditions which support larger bite sizes. Due to the increasing plant height and number of tillers as plants mature, animals are able to take bigger bite sizes and to have higher intake rates.

The next section will examine several selected grazing studies. In these studies, one or several mechanisms of learning behavior have been combined to enhance diet selection, and, thus, biological control.

SELECTIVE GRAZING STUDIES

Experience

Experience is effective in increasing intake of leafy spurge (Euphorbia esula) (Walker et al. 1990). Experienced orphan lambs consumed more leafy spurge than naive lambs not previously exposed to spurge plants. Experienced lambs showed no preference for the age or developmental stage of the plant. Experienced lambs only had high consumptions on dense concentrations of leafy spurge, not on areas with moderate densities. Thus, palatability of spurge for experienced lambs was greater than for inexperienced lambs, provided unpalatability is caused by lack of experience and not toxicosis. Introducing lambs early in life to an undesirable plant may increase the efficiency of biological control of

that species. For biological control to be effective, selective grazing should be enhanced by implementing the right combination of the following factors: type of animal, species composition, season of use, phenological stage, density of stand, stocking rate, and grazing system (Walker et al. 1990).

Sheep and Douglas Fir

A specific type of species of animal may be used to suppress a specific plant species. Sheep can be used to control composition of undergrowth in Douglas Fir (Pseudotsuga menziesii) plantations (Sharrow et al. 1989), while being trained to selectively avoid the firs. Sheep control ground vegetation while allowing commercial trees to increase in diameter.

Phenological stage and density of stand, as well as seasonal use greatly influence selectivity of Douglas Fir by sheep. Grazing can decrease annual net growth in forbs and grasses during early phenological stages of development, when brush is least preferred by sheep. Generally, forbs respond with slow regrowth. While some shrubs have the ability to resprout, many shrubs do not have regrowth mechanisms. Their control mechanisms focus on inhibiting herbivory rather than responding to herbivory through regrowth. One must first know the regrowth mechanism before control can be effective. Regrowth mechanisms must be first learned to determine the proper kind/class, season and distribution of biological controllers.

Seasonal use depends upon the fluctuation of the nutritional content of plants. During certain seasons, plants may be deficient in essential nutrients that are abundant in other plants. Forbs and shrubs have a generally higher content of protein and phosphorus than grasses during the winter dormant season. Many grasses have relatively high energy contents when dormant during the winter, while many shrubs are low in energy during the active growing season.

Cattle, Sheep, Horses, and Sagebrush-Grasslands

Cattle and sheep will consume a lot of palatable browse, such as bitterbrush (*Purshia tridentata*), if left on sagebrush-grassland foothill range (Urness and Austin 1989). Horses are better than cattle and sheep in suppressing understory plants via defoliation (Urness and Austin 1989), but season of use influences selectivity. Cattle and sheep were most effective on herbaceous vegetation suppression on spring ranges. Shrubs gain a competitive advantage if herbaceous vegetation is grazed during the spring. This competitive advantage stems from an increase in available soil moisture and nutrients to shrubs. Thus, grazing can be used to benefit mule deer habitat by producing more vigorous, dense growth forms of species such as mountain mahogany (*Cercocarpus montanus*), bitterbrush, and cliffrose (*Cowania mexicana*).

Goats and Blackbrush

Goats can be used to stimulate regrowth, rather than to suppress old growth in woody vegetation such as blackbrush (Coleogyne ramosissima) (Provenza 1978). Through browsing and suppressing blackbrush, goats make other shrubs more palatable available for cattle, deer, and bighorn sheep (Urness and Austin 1989). This occurs when the proper stocking rates and season of use of goats are used. Browsing during the winter removes the old growth, stimulating the twigs to produce younger, more palatable vegetation. Otherwise, blackbrush is poorly utilized by cattle and wildlife.

Goats and Gambel Oak

Goats have also been used effectively to control Gambel oak (Quercus gambelii) (Davis et al. 1974, Urness and Austin 1989), and serviceberry (Amelanchier alnifolia), while increasing understory herbaceous species (Riggs and Urness 1989). Reduced competition from suppressed oak plants helps to increase soil moisture, forage and nutritional value of other species, and cattle production. Goats also help to increase associated shrubs otherwise suppressed by Gambel oak (Urness and Austin 1989). These shrub species include big sagebrush (Artemisia tridentata), green rabbitbrush (Chrysothamnus viscidiflorus), and snowberry (Symphoricarpos spp.). Other species in the mountain brush zone, such as chokecherry (Prunus virginiana), boxelder maple (Acer negundo), and blackbrush may also be controlled by goats.

However, season of use, grazing system, and stocking rate are important (Davis et al. 1974). Goats should be used twice a year, during critical growing seasons (Davis et al. 1974) to be effective. In late June, goats browsed plants in full bloom. In late August, goats browsed regrowth. During both periods, goats were used to modify growth form to increase forage production of associated species, and accessibility for bighorn sheep and deer.

The above literature review was designed to provide an understanding of how and why animal behavior may be manipulated to manage vegetation. A series of experiments was conducted to determine how to influence diet selection behavior in young animals. In the first experiment, the role of social facilitation in ewes and lambs was examined to determine grazing skill acquisition in both naive and ewe-reared animals. In the second experiment, the role of flavor generalization was examined to determine if lambs could recognize familiar flavors in novel foods. In the third and final experiment, the role of repeated exposure to novel food acceptance was examined. By influencing social facilitation, flavor generalization, and novel/familiar dichotomy, more effective methods of biological control may be developed for vegetation manipulation.

EXPERIMENT 1--PREFERENCES INSTILLED IN YOUNG ANIMALS

Objective

The main objective of the first study was to compare the grazing behavior of orphan lambs and ewe-raised lambs to determine the following: 1) if naive lambs can learn to forage as efficiently as experienced lambs; and 2) if grazing skill acquisition is influenced by the presence of social models. The first study focuseds on the combined learning behavior of novel/familiar dichotomy, social facilitation, neophobia, generalization, and most of all, acquisition of harvesting skills. A comparison was made between the ewe-raised experienced, ewe-raised naive, naive orphan, and experienced orphan lambs based upon the following: fecal outputs, forage consumption by life form, weight trends, and time spent grazing.

Study Site

The first study was conducted at the U.S. Sheep Experiment Station, six miles north of Dubois, Idaho on I-15, with trials on July 10-13 and August 27-31. Dubois is located on T.11N R.36E in Clark County. The 11,024 hectare station headquarters is administered by the Agricultural Research Service, the Idaho Agricultural Experiment Station, and several Universities of the Western Region. The Station consists of ten separate areas, including summer subalpine range allotments and a winter feedlot, for a total area of 34,965 hectares.

Climate is semiarid, with 295 milimeters of annual precipitation. High rainfall occurs in May and June. There is abundant snowfall from November through March. Temperatures range from -33°C to 48°C, with a mean annual temperature of 19.4°C. The aspect of the study area is southwest, with a slope of approximately 3 to 10%. Soils consisted of calcixerolls and argiustolls. The frost-free period ranges from 75 to 95 days. Elevation of the study area, pasture numbers 16a, 16b, 17a, and 17b, each 40 ac, was approximately 1,615 meters. All pastures were fenced, and a young Ackbash guard dog was present and free to move between pastures.

Current vegetation of the four pastures consists of the following shrub species: Artemisia tridentata (big sagebrush), Purshia tridentata (antelope bitterbrush), Tetradymia canescens, (horsebrush), and Chrysothamnus viscidiflorus (rabbitbrush). The main perennial forb species were the following: Balsamorhiza sagittata (arrowleaf balsamroot), Eriogonum umbellatum (Sulfur eriogonum), Achillea millefolium (western yarrow), and Phlox hoodii (Hood's phlox). Perennial grass species include the following: Oryzopsis hymenoides (Indian ricegrass), Stipa comata (needle-and-thread grass), Stipa occidentalis (western needlegrass), Pseudoroegnaria spicata (bluebunch wheatgrass), and Agropyron smithii (western wheatgrass). No trees were present.

Methods

Four groups of Targhee X Polypay crossbred lambs were used in the study: 21 experienced ewe-raised lambs, marked black; 16 naive ewe-raised lambs, marked green; 11 experienced orphan lambs, marked purple; and 11 naive orphan lambs, marked red. Naive animals (16 ewe-raised and 11 orphan) were penned and fed hay or lamb starter for their first 60 days before being weaned, and were placed on pasture on July 1. Experienced lambs (21 ewe-raised and 11 orphan) were placed on pasture on May 14. For the first 14 days, orphan lambs were fed milk replacer. All animals were observed to determine the age at which they began grazing. The animals were placed on separate, adjacent pasture forming four separate groups. All treatments foraged separately during testing.

The first trial was conducted from July 10-13. The second trial was conducted 45 days later on August 27-31. During the trials, bite counts were taken on Tandy 100 computers. An observation of an individual animal lasted for five minutes. Individual plant species were not recorded. Bites were entered as either bites or as plant manipulations. Plants were entered by life form (i.e. grass, forb, or shrub). A step taken by an animal was recorded as a walk.

Vibracorders were fitted to five animals in each of the four groups to determine the total amount of time spent grazing. According to O'Shea (1969), a vibracorder is a continuous, non-subjective recording of animal movement and

activities under field conditions. A vibracorder is fitted to an animal's neck and only records movements when the animal's head is in the grazing position. Before the time trials and sampling began, animals were allowed an adjustment period of five days for the vibracorder, and two days for the fecal bags. Both were used for the five-day trials.

Fecal bags were used to measure forage consumption. The animals were always penned the night before the studies. Morning grazing time usually began in August about ten minutes after dawn, approximately 6:50 a.m., when the sheep were released, and lasted until about 9:30 a.m. Fecal samples were collected both in the morning after grazing, and in the evening. The fecal samples were weighed each morning and composited over the five day period for the individual animals.

Before the trials began, esophageally fistulated wethers were placed on the pastures, and were sampled to establish diet quality. The lambs were rotated from pasture to pasture two to three times per week. During the August trial, sheep were rotated daily. The rotations were done to eliminate bias from the trials by making sure that it was not just the pasture that accounted for differences in behavior. The animals were all weighed three times during the study on July 19, August 22, and October 9.

Results

During the second trial, experienced animals both ewe-raised and orphans, spent a significantly lower amount of time, in minutes per day, foraging than naive animals (Tables 1 and 2). However, in the first trial experienced animals, both ewe-raised and orphans spent a significantly higher amount of time, in minutes per day, foraging than naive animals. This appears to contradict the evidence that, as experience increased, bite rate increases while bite size and intake rate decreased.

Table 1. Grazing time in minutes of lambs on ontogeny of grazing behavior study, U.S. Sheep Experiment Station; Dubois, Idaho, July 10-13, Trial 1.

	TRIAL 1	
	EWE	ORPHAN
EXPERIENCED	518	457
NAIVE	500	424

Table 2. Grazing in minutes on ontogeny of grazing behavior study at the U.S. Sheep Experiment Station; Dubois, Idaho, August 27-31, Trial 2.

	TRIAL 2	
	EWE	ORPHAN
EXPERIENCED	490	466
NAIVE	528	547

At five months of experience, the experienced animals appear to have reached their highest foraging efficiency. The

rate of weight gain declined for experienced animals. The naive animals had weight gains similar to those of the experienced animals after three months (Table 3). The influence of social models appeared to have been a significant advantage in weight gain to experienced lambs, which had the highest overall gains.

Table 3. Changes in weight gain during Trials one and two, between experienced and orphan ewe-reared and naive lambs.

	WT 1 EWE	ORPHAN		WT 3 EWEORPHAN
EXP	62.5	59.5	EXP	77.870.4
NAIVE	55.6	53.2	NAIVE	65.463.1

	WT 2 EWE	ORPHAN		CHANGE 2 EWEORPHAN
EXP	68.9	65.7	EXP	8.64.7
NAIVE	59.4	55.2	NAIVE	6.07.9

	GAIN 1 EWE	ORPHAN
EXP	6.4	6.3
NAIVE	3.8	2.0

Fecal output was similar for all animals except the naive orphans (Tables 4 and 5). Naive orphans had the highest fecal output of all four treatments. From the first to the second trial, fecal outputs from the other three treatment groups did not appear to have significantly changed. However, for the

naive orphans, as they gained experience in foraging, their fecal outputs doubled. All groups showed an upward trend in fecal output from Trial 1 to Trial 2.

Table 4. Changes in fecal output by body weight during Trials one and two, between experienced and orphan ewe-raised and naive lambs.

	FO/BW	
	EWE	ORPHAN
EXPERIENCED	0.012	0.015
NAIVE	0.016	0.014

Table 5. A comparison of fecal output for experienced and naive ewe-raised and orphans lambs for July 10-16, 1990; U.S. Sheep Experiment Station; Dubois, Idaho.

	FO/BW	
	EWE	ORPHAN
EXPERIENCED	0.018	0.019
NAIVE	0.019	0.026

Naive, ewe-raised lambs had the highest mean grass consumption rates (Table 6), and consumed similar amounts of shrubs (25.5 g) and forbs (28.8 g). Naive orphans, with the lowest mean grass consumption, had the highest mean shrub consumption. Experienced orphans and ewe-raised lambs consumed high percentages of grass, and almost equal percentages of forbs (Table 7). Ewe-reared, experienced lambs consumed almost twice as many bites of shrubs as experienced orphans. Both ewe-raised and experienced orphans exhibited a similar number of mean bites per minute for all forages. Experienced orphans consumed more bites per minute of all

forages than the other animals (Table 8). Experienced orphans also took the most steps between foraging bouts (Table 9). Experienced, ewe-raised lambs took the least amount of steps between foraging.

Table 6. Summary of bites per minute data for grasses, forbs, and shrubs for ewe-raised and orphan naive and experienced lambs, Trial 1; July 10-13, 1990. U.S. Sheep Experiment Station; Dubois, Idaho.

	GRASS MEAN	GRASS STDERR	FORB MEAN	FORB STDERR	SHRUB MEAN	SHRUB STDERR	TOTAL
TRT							
EXPER. EWE REARED	36.8	4.6	23.5	3.9	24.2	4.7	84.5
EXPER. ORPHAN	46.7	3.9	30.5	6.0	13.6	3.1	90.8
NAIVE EWE REARED	52.3	5.4	22.8	3.3	25.5	5.4	100.6
NAIVE ORPHAN	14.0	4.1	30.5	6.7	55.3	12.0	99.8

Table 7. Percent of bites that were shrub, forb, and grass, ontogeny of behavior grazing study, U.S. Sheep Experiment Station; Dubois, Idaho.

	% OF BITES THAT WERE SHRUB		% OF BITES THAT WERE FORB		% OF BITES THAT WERE GRASS	
	MEAN	STDERR	MEAN	STDERR	MEAN	STDERR
TRT						
EXPER. EWE REARED	25.5	4.2	33.0	5.5	41.5	4.8
EXPER. ORPHAN	14.7	3.1	30.4	5.1	54.9	4.8
NAIVE EWE REARED	22.6	4.0	25.3	3.6	52.1	4.5
NAIVE ORPHAN	49.5	7.9	34.3	6.3	16.2	4.9

Table 8. Average bites per minute of grass, forb, shrub, and total forages for ewe-raised and orphan experienced and naive lamb for Trial 1; July 10-13, 1990; U.S. Sheep Experiment Station; Dubois, Idaho.

	AVERAGE BITES PER MINUTE FOR ALL FORAGES		GRASS BITES PER MINUTE		FORB BITES PER MINUTE		SHRUB BITES PER MINUTE	
	MEAN	STDERR	MEAN	STDERR	MEAN	STDERR	MEAN	STDERR
TREATMENT								
EXPER. EWE REARED	38.1	2.8	38.8	2.9	41.6	3.0	34.0	2.5
EXPER. ORPHAN	44	4.4	42.0	4.2	48.1	4.1	41.9	4.9
NAIVE EWE REARED	38.2	1.8	36.9	1.2	42.6	2.5	35.0	1.6
NAIVE ORPHAN	35.3	3.2	41.8	4.2	34.9	3.0	29.3	2.3

Table 9. Average number of steps taken by ewe-reared naive and experienced and orphan experienced and naive lambs for Trial 1; July 10-13, 1990; U.S. Sheep Experiment Station; Dubois, Idaho.

	WALK BITES	
	MEAN	STDERR
TREATMENT		
EXPER. EWE REARED	15.9	1.1
EXPER. ORPHAN	23.3	1.3
NAIVE EWE REARED	20.6	1.2
NAIVE ORPHAN	14.2	1.4

During the first hour of morning grazing, most animals appeared to primarily feed on grasses, mostly bluebunch and western wheatgrasses, and some needle-and-thread, with only a

trace of Indian ricegrass, as it was less abundant. Later, sheep fed on shrubs and forbs. Bitterbrush was highly palatable at all periods of grazing. Hood's phlox, horsebrush, and rabbitbrush were consumed in small quantities. Big sagebrush was avoided by all animals.

Discussion

Experienced, ewe-raised lambs appear to be the most efficient foragers. Thus, grazing skill acquisition is influenced by the presenece of a social model. However, after harvesting skill acquisition has developed, the abiltiy of lambs to continue increasing their skills declines with time. Social models also played a role in helping lambs decide which form of plant to eat. Experienced, ewe-raised lambs preferred grasses. However, they were also able to eat a high volume of shrubs, unlike the naive animals.

Increasing animal selection for undesirable species through the manipulation of animal behavior can thus help in biological control. The acquisition of harvesting skills through novel/familiar dichotomy, neophobia, social modeling, cue-consequence specificity, generalization, and instinctive learning is important for developing preferences. By combining learned behavior with animal type, species composition, season of use, phenology and density of stands, stocking rate, and grazing system, animal selection can thus be manipulated. Animal selection can be learned through the

manipulation of animal behavior to facilitate biological control to improve deteriorating range conditions.

These next two experiments were designed to increase the acceptance of novel foods. The second experiment decreases the novelty of a food by adding a familiar flavor to it. The third experiment increases consumption of a novel food through repeated exposure to novel foods.

EXPERIMENT 2--FLAVOR GENERALIZATION

Objective

Generalization occurs when animals respond in a uniform way to a group of stimuli (Mazur 1990). In diet selection, animals may generalize selection responses among foods with similar flavors. For example, a group of poisonous plants may contain the same toxin and, therefore, have a common salient flavor. Herbivores may avoid a group of plants based on a common flavor. Generalization may also be important in the selection of novel foods. A new food may look, smell, or taste like a familiar food that is preferred or avoided. Launchbaugh and Provenza (1992) demonstrated that the acceptance of a new food can be decreased if it tastes similar to an averted food. In this first experiment Dr. Karen Launchbaugh and I examined if adding the flavor of a preferred food to a novel food increases its acceptance.

Methods

In this experiment we used 30 orphan lambs from the U.S. Sheep Experiment Station, at Dubois, Idaho, raised to 4 months of age. Prior to the trial the lambs were penned individually and offered alfalfa pellets, water, and salt ad libitum. The lambs were divided into three groups of ten lambs. The first group was offered 300 g of ground barley for ten minutes on the first day of the trial. The second group was offered 300 g of ground rice with 5% onion powder. The third group was offered ground barley with 5% onion powder. On the third day of the trial, all lambs were offered 300 g of rice with onion powder for ten minutes.

An analysis of variance was used to compare the three treatments with regards to intake of rice with onion powder on the test day. A Newman-Kuels test was used to separate treatment means.

Results

The food eaten by lambs prior to the test strongly influenced the intake of onion-flavored rice on the test day ($P<0.05$; Figure 1). The intake of a novel food, onion-flavored rice, was greater by lambs that had been previously exposed to onion-flavored barley than by lambs that had only been exposed to barley ($P<0.05$). Lambs that were familiar with onion-flavored rice ate an amount of onion-flavored rice on the test day that was intermediate to, and not different from, the other two treatments.

Discussion

These results suggest that adding a familiar flavor to a novel food can increase its initial acceptance. In other words, neophobia can be overcome by giving a novel food a familiar flavor component.

EXPERIMENT 3--REPEATED EXPOSURE TO NOVEL FOODS

Objective

We know that animals show heightened neophobia after they have eaten a novel food that caused illness (duToit et al. 1991). An interesting question is, is neophobia decreased if animals have several "good" experiences with novel foods. Capretta (1977) showed partial evidence for this idea when he observed that experience with a variety of flavors by rat pups increased the acceptance of novel flavors compared to rat pups with limited flavor experience. The purpose of this experiment was to determine if animals are more likely to accept a novel food if they have had experience with several safe, novel foods.

Methods

In this third experiment, 72 orphan lambs also obtained from the U.S. Sheep Experiment Station were raised to five-months-of-age. Prior to the experiment lambs were penned individually and offered alfalfa pellets ad libitum for two hours per day. Lambs had access to water and salt at all times. On days one, two, and three of the trial lambs were

offered 500 g of one of four novel foods: cracked corn, rice, wheat bran, or calf mana[1]. (Each of the novel foods were eaten by 18 lambs). On days four, five, and six of the trial each group of lambs was offered a different novel food. Lambs were again offered a different novel food on days seven, eight and nine; and days, ten, eleven and twelve. This resulted in each lamb receiving four novel foods for three consecutive days and each feed being consumed by 18 lambs on each day. The order of presentation of novel foods was controlled through blocking in a cross-over design.

An analysis of variance was employed to determine the effect repeated experience with novel foods has on the initial intake of a novel food. A Newman-Kuels mean comparison procedure was used to compare intake on the first day of offering the first, second, third, or fourth novel food.

Results

Lambs ate more of the fourth novel food than the first novel food on the first day each food was offered to lambs ($P<0.05$; Figure 2). There was no difference in the initial consumption of the other novel foods.

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[1]Calf mana is a concentrate-based, pelleted feed produced by the Mana Pro company.

Discussion

Exposing lambs to a number of novel foods appears to decrease food neophobia. This will probably occur as long as exposure results in positive post-ingestive feedback.

Management Implications

It is important that animals readily accept new foods when they are placed on new feeds. Overcoming neophobia by adding a familiar flavor to their feed or ameliorating neophobia through repeated exposure to new foods may be important for increasing the acceptance of novel foods.

In addition to generalization and repeated exposure, both social facilitation and the age of the animal when first introduced to the novel food affect learning in diet selection, and may be important in overcoming neophobia. Social facilitation occurs when a young animal learns from its mother, another adult female animal, or from its peer groups. The animal learns what is safe to eat by watching and feeding alongside its model (Chapple and Lynch 1986).

Age of first exposure also affects neophobia. Young animals are more willing to accept novel feeds in their diet than older animals (Chapple and Lynch 1986). Young animals generally have less experience with feed aversions, and thus neophobia may not be strongly reinforced in young animals.

Figure 1. Experiment 2. Consumption in grams by familiar, general, and novel groups of lambs of ground rice with 5% onion powder.

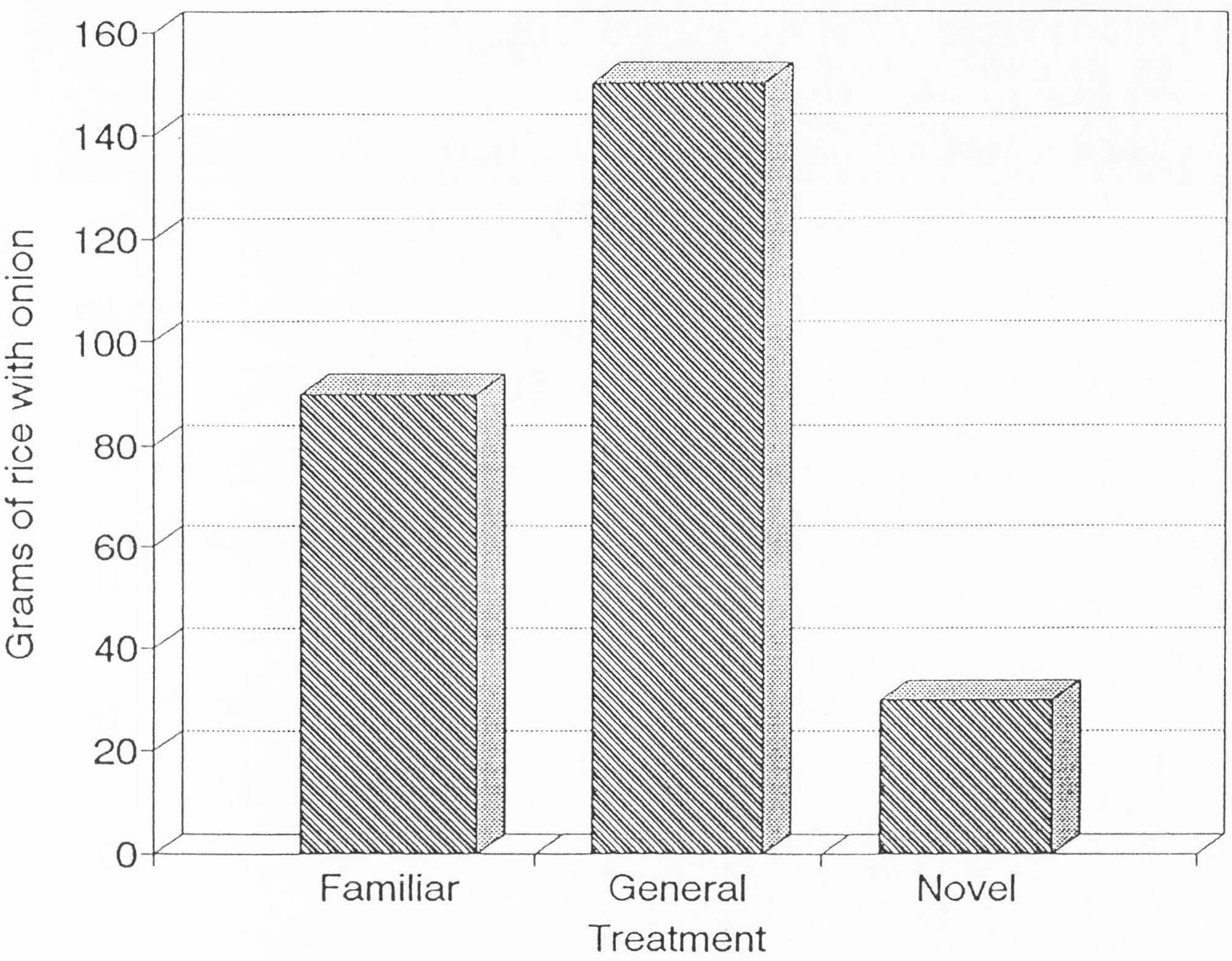
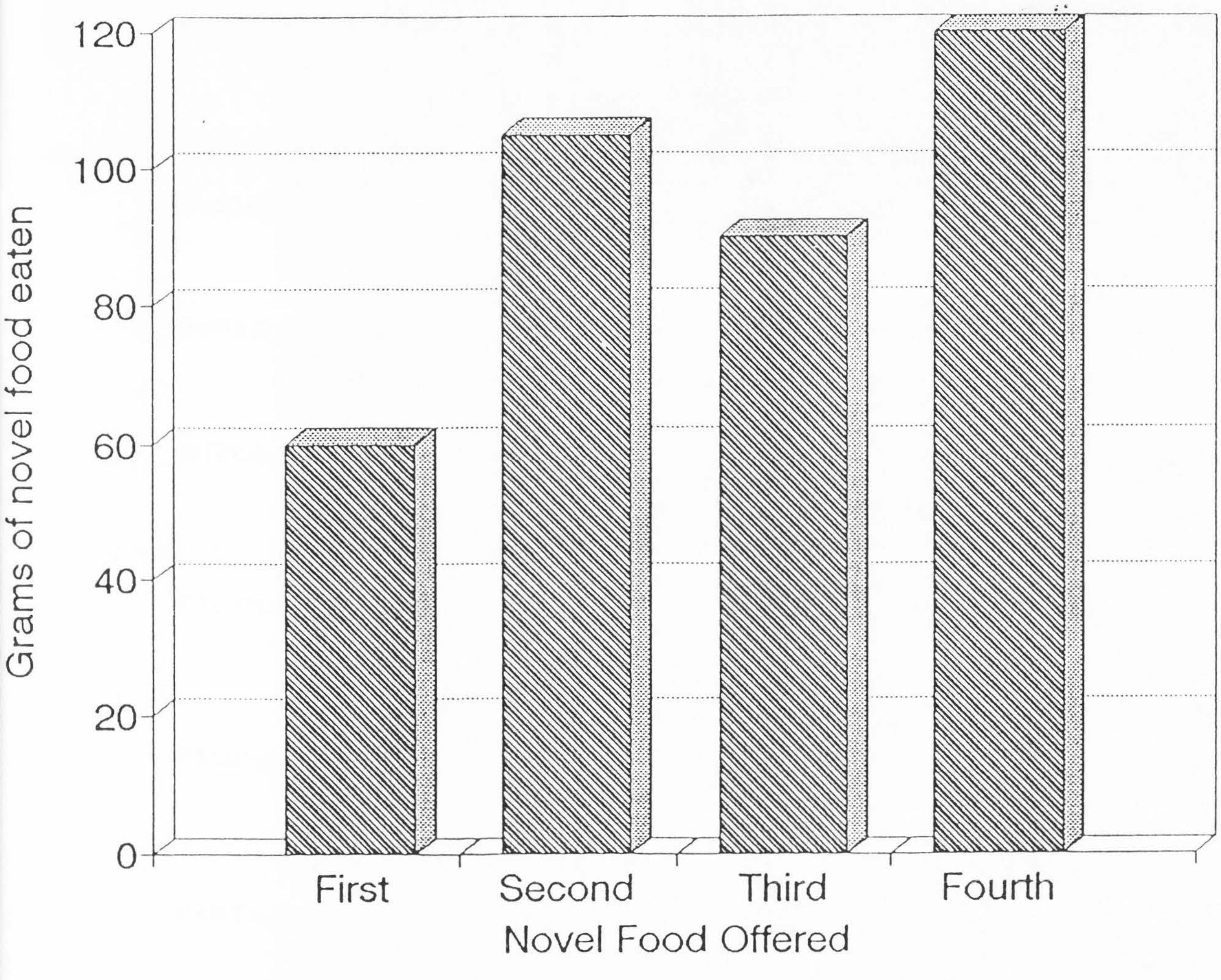


Figure 2. Experiment 3. Consumption by lambs of four novel feeds in grams.



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