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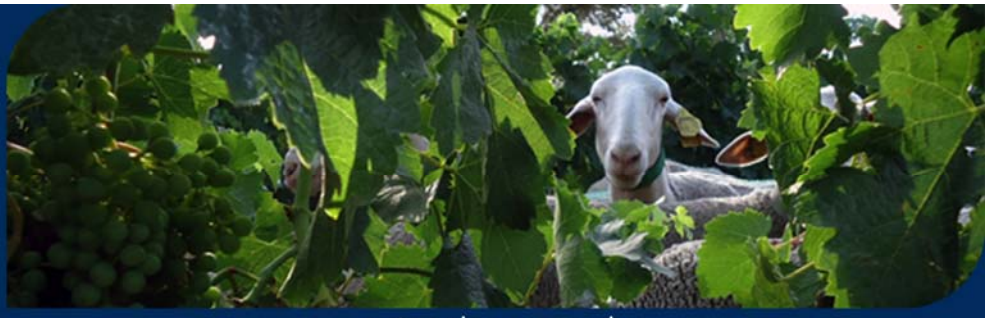

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Training Livestock to Avoid Specific Forage

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Sometimes a single plant prevents managers from grazing livestock in an area with good forage production. Often the plant has high agronomic value, like fruit trees, Douglas fir trees or grapevines. Livestock could easily graze fruit orchards, forest plantations or vineyards, improving fruit harvest and tree growth, if only they could be persuaded not to eat the trees or vines. In such cases, the key is to train livestock to avoid the food.

How Do Animals Learn About Foods?

Animals have two defense systems to keep them safe – the gut defense system, which keeps them safe from poisoning, and the skin defense system, which keeps them safe from physical harm. Humans are built the same way. We associate nausea with foods and physical pain with actions or locations. If after a long hike, I wake up in the night with aching muscles, I don't think, "What did I eat? Rather, I think, "Why did I hike so far today?" Likewise, if I wake up feeling nauseous, I don't think, "Why did I hike so far today? I think, "What did I eat that is making me nauseous?" especially, if the food I ate had been in the refrigerator a bit too long. Negative associations with food can cause strong aversions, especially if we get violently ill. We can form aversions to foods, even if we know that the flu or motion sickness, not the food, caused nausea (Garcia et al. 1985).

Training livestock to avoid particular foods entails giving the animal lithium chloride (LiCl) using a stomach tube, oral drench, or a balling gun. LiCl causes temporary nausea, which can be associated with a recently consumed food. Why does the animal avoid the food rather than blaming it on the person with the stomach tube or the balling gun? The animal will associate the person with the attack on its skin-defense system and will avoid the person in the future, but it will associate the food with nausea and avoid the food in the future. Foods are automatically paired with illness, no thought is required. Even if a person could explain to the animal that the toxin – not the food – caused the illness, the animal would still avoid the food. The gut-defense system is designed to automatically pair eating a food with gastrointestinal illness regardless of what the animal "thinks" caused the illness (Garcia et al. 1985). In fact, animals under deep anesthesia can also form aversions. The animal doesn't even have to be awake during the nausea to form an aversion to a food (Provenza et al. 1994).

The Basics of Aversion Training

The best way to teach an animal not to eat a particular plant is to pair eating the plant with nausea. Many toxins in plants cause food aversions by stimulating the emetic system of the midbrain and brain stem, the same feedback system responsible for nausea in humans and other mammals. LiCl is ideal for causing aversions because it can be given in doses high enough to condition strong aversions without causing death or obvious signs of illness (duToit et al. 1991).

* Photo in header by Maristela Rovai

When training livestock to avoid a food, it's very important that the target plant is novel, meaning the animal has never eaten the plant before (Ralphs 1997). When animals are properly conditioned, aversions can persist for years. However, it is important to understand that aversions can diminish over time and various environmental and social conditions can rapidly accelerate the loss of a trained aversion. Tips on minimizing conditions that can degrade trained aversions are covered in subsequent sections.

Animals quickly learn to avoid a novel food when they experience nausea soon after eating a food. Thus, LiCl should be given to the animal immediately after it eats the food. Unfortunately if animals eat some of the target plant later when foraging on pasture, and don't experience illness, the positive feedback from nutrients may cause the animal to eat more of the target plant.

How can one create aversions that are so strong that most animals will no longer sample the target food? Here, we outline the procedure to condition a persistent food aversion.

Creating a Food Aversion

During conditioning, animals are allowed to eat the target plant (the plant you want them to avoid), then given a dose of LiCl. The LiCl is usually delivered in a gelatin capsule with a balling gun, or in a solution with a stomach tube or drenching gun, immediately after the animal eats the food. Animals are usually trained in pens where access to foods can be controlled and where they can be watched to ensure that each animal eats the target plant (Burritt and Provenza 1989).

Below are the steps for training sheep to avoid grape leaves in vineyards because much of the practical application of creating and using food aversions has been with sheep in vineyards. However, cattle and goats have also been trained to avoid eating a variety of plants using LiCl. Read these directions carefully and thoroughly before beginning the aversion training process.

Plan your training well ahead of time. If you are training animals to avoid plants only available at certain times of the year, such as grape leaves, then you need to train animals when that plant is fresh. Remember that plants change in flavor, nutrition, and chemistry throughout the year. If you want sheep to avoid spring growth, then it's best to use spring growth for aversion training. Animals should also be familiar with most of the plants growing in the understory. If they aren't, make sure they are given about a month to graze understory plants in the absence of the target plant before training. As previously stated, it is important that the target plant is a novel food while the plants you want animals to eat need to be familiar. Aversions are unlikely to last over time if the target plant is a familiar food and animals have already had positive experiences from eating it (Ralphs et al. 1997).

Materials Needed for the Aversion Training Process

1. Healthy sheep with known weights. Mark each animal with a unique number with a paint brand or other marker. Numbers help identify animals when grazing.

2. Feed tubs or forage clamps to hold the target plant. Figure 1 shows a picture of a forage clamp used to feed grape leaves.

3. An ample supply of the novel target plant.

4. A small scale to weigh LiCl.

Figure 1. Forage clamp used to feed grape leaves. (Photo by Morgan Doran)

5. LiCl solution (see section on Determining the Correct Dosage of LiCl). You can buy LiCl from chemical companies such as Sigma Aldrich (http://www.sigmaaldrich.com), Fisher Scientific (http://www.fishersci.com) or from a laboratory

supply company such as The Science Company (http://secure.sciencecompany.com).

6. Drench gun/syringe (Figure 2) OR gelatin capsules and a balling gun, depending on preferred method of administration.

Figure 2. Drench gun use to dose animals with the LiCl solution. (Photo courtesy of Haleakala Ranch)

Prior to training, test how willing animals are to eat the target plant. It's important on the day you dose animals with LiCl that animals eat the target plant fairly well. Most animals only eat a bite or two the first time new foods are offered. If animals initially only eat a few bites of the plant, take a day or two to expose animals to the target plant prior to training. Or if you have a large number of animals (more than 10), expose the group to a small amount of the target plant the night before training. Make sure all animals eat some of the plant. It's important not to let animals get too familiar with the target plant. Once sheep begin eating the target plant, you're ready to begin aversion training.

Caution: If animals readily eat the target plant the first day they're offered it, chances are the target plant is not a novel food. You'll need to use different animals for aversion training to your target plant.

Steps for Training

The evening before aversion training, place all the sheep in a corral and withhold food, but make sure they have fresh, clean water. Aversion training can begin the next morning and preferably in the early morning hours in order to coincide with the sheep's normal hours of food consumption. If aversion training is delayed until late-morning or mid-day, the sheep may not be interested in eating the target plant, especially those sheep already reluctant to eat the target plant. Conduct the training on small groups of animals, 5 to 10 individuals, depending on the number of people you have to help. Place the first group of sheep in a pen with the target plant, for 5 to 15 minutes. The more they eat the better, but any amount over 20 bites is adequate (Figure 3).

Figure 3. Sheep eating a novel food, grape leaves. (Photo by Roger Ingram)

Immediately after the sheep have eaten the target plant, dose them with LiCl. When using the drench gun or syringe, be sure the head is upright, the neck slightly extended and the drench tube or syringe is placed in the back of the mouth. Don't give the solution so quickly that it squirts into their trachea causing them to aspirate some of the solution. Hold the head upright for a few seconds after administering the solution to be sure it's swallowed. Or you can use gelatin capsules filled with a known weight of LiCl and a balling gun (Figure 4).

After sheep receive LiCl, move them to another corral with water, but no food. Be sure that the corral floor and any feed bunks have no straw, feed or other plant material. Repeat this procedure with the rest of the sheep. Once all the sheep have been dosed with LiCl, wait at least 2 hours before feeding them their normal ration or turning them out on pasture.

Testing the Aversion

The aversion can be tested the day after training. Withhold feed the evening before the test. Expose groups of 5 to 10 sheep to the target food for about

Figure 4. Dosing an animal with a capsule of LiCl using a balling gun. (Photo by Gary Neuenswander)

5 minutes (Figure 5). Some sheep may take a few bites, but they shouldn't eat any more than 5 to 10 bites. Any animal that eats more than 10 bites should be re-dosed with LiCl. If you're uncertain whether some sheep should receive another dose of LiCl, you can encourage them to eat more of the target food by placing them in a pen with sheep that readily eat the target plant. The partially averted sheep will likely be encouraged to eat more of the target plant when it sees other sheep eating the same food. If they eat more of the plant they can be re-dosed with LiCl.

Figure 5. Testing the aversion. After these sheep ate grape leaves, they were dosed with LiCl. They are no longer interested in eating grape leaves. (Photo by Roger Ingram)

Carefully watch your trained sheep the first few days after conditioning and remove any animal that begins eating the target plant. Remove them from the grazing project or condition them again to the target plant.

Trainees Need Adequate Salt

Make sure your animals have free access salt. LiCl is not normally lethal at doses used to create an aversion (150 mg/kg body weight) unless animals are deficient in sodium. Lithium and sodium are similar chemically. Lithium takes the place of sodium in the body if animals are deficient in sodium.

Basal Ration Must be Familiar

Remember the basal ration (daily ration, pasture, hay, etc.) must be familiar. Animals need to consume their basal ration at least 2 weeks (a month would be better) prior to giving them LiCl. Otherwise, animals may form an aversion to their basal ration. Make sure you remove the basal ration the night before animals are dosed with LiCl. Animals can form temporary aversions to familiar foods. If your animals have a rumen full of their basal ration and a few bites of the target plant when dosed them LiCl, they're likely to have a weak aversion to both foods. Also, make sure animals are familiar with the plants that are growing in the understory of the vineyard, orchard, etc. (Burritt and Provenza 1996).

Persistence of Aversion Depends on Novelty, Amount, and Frequency

The flavor and novelty of the target plant and the dose of LiCl affect the strength and persistence of a food aversion. Make sure you use novel plants. Aversions to foods are most persistent if animals get very sick the first time they eat the food.

Many so-called "unpalatable" plants deter livestock through the interaction of flavor and toxins. The least palatable plants have strong, novel flavors and maintain high levels of toxins. Animals feel sick every time they eat the plant and this illness is associated with the plant's flavor. It is much harder to condition a lasting aversion to a familiar food because animals are more likely to try the food again (Burritt and Provenza 1991; 1996). Aversions quickly fade if animals sample the food and don't get sick. This is especially true if the food is highly nutritious.

Animals often sample some of the target plant the day after dosing with LiCl. Aversions can be strengthened provided animals consistently get sick each time they eat the target plant. Allow animal to

eat (resample) the target plant for several days after receiving the initial dose of LiCl. Each time the animal eats the target plant give it a dose of LiCl to reinforce the aversion. Generally, within a few days they show no interest in the target plant. However, don't overdo it with the LiCl (Burritt and Provenza 1989).

Age of the Animal

Younger animals can be more difficult to train than mature animals. Older animals are more set in their dietary ways. Thus, they are less apt to eat a new food, provided they have an ample supply of familiar foods, and they are less likely to resample a novel food if ingestion of the new food is followed by illness. On the other hand, young animals are learning about new foods. Thus, they are more likely than adults to eat novel foods and to resample new foods previously paired with illness. When a young animal eats the target food without experiencing illness, the aversion quickly diminishes (Ralphs and Cheney 1993).

Social Influences

Young animals are prone to eat foods their mothers eat and avoid foods their mothers avoid. Nevertheless, they also learn on their own by cautiously sampling new foods. If young animals experience positive nutritional feedback from a food, even from a food their mother avoids, the youngsters will increase the amount of the food in their diet, whether or not their mother eats the food. Likewise if they experience illness from a food their mother eats, the youngsters will decrease the amount of that food in their diet (Provenza et al. 1993).

Finally, and very importantly, animals trained to avoid a plant should not be allowed to forage with untrained animals that eat the plant. When trained and untrained animals forage together around a target plant, the trained animals observe the untrained animals eating the plant and are more likely to sample the plant despite the aversion (Provenza and Burritt 1991; Ralphs and Provenza 1999). The nutritional benefits of eating the plant will quickly counter-condition the aversion. A group of cattle trained to avoid larkspur did not eat larkspur for 2 years after the aversion was established. However, when they were allowed to forage with cattle that ate larkspur, the aversion was extinguished after 2 weeks (Ralphs 1997).

Provide Nutritious Alternatives

Once an aversion is established, it is critical that animals have access to a variety of familiar nutritious alternatives (Kimball et al. 2002). It is not enough simply to cause an aversion to the target plant. When the option is to eat the target plant and suffer more nausea or starve, animals eat, even if the plant is toxic. Lack of alternatives can also be a problem in bedding areas and in areas where salt, water, and supplemental feed are placed because these areas tend to be overused. Animals are usually hungry after resting or drinking but often wait for the herd before moving to forage. If the target plant is the predominant food in the area, hungry animals may sample the plant, and in the process extinguish the aversion. Thus, salt, water, supplemental feed, and bedding areas should be in areas devoid of the target plant.

Environmental Influences

The persistence of an aversion can be positively or negatively affected. The surrounding environment can positively or negatively influence the persistence of an aversion. Animals seem to enjoy a variety of comfortable surroundings and may become quite bored when confined to a single environment, such as an orchard or vineyard. Boredom may provoke inquisitiveness and occasional sampling of the target plant. Providing access to alternative and comfortable environments, such as a rangeland, adjacent to a vineyard or orchard adds variety, comfort and more natural grazing behavior for the sheep that may minimize the risk of degrading the trained aversion (Doran, personal observation). Such alternative areas are ideal for locating water and salt, as described in the previous section.

Animals should be trained in the same location as they will forage. This will not be a problem in most cases. Aversions are less likely to persist if animals are trained in a familiar location and then moved to an unfamiliar location (Burritt and Provenza 1997). Also, the environment where a plant grows can affect the flavor of the plant and possibly the persistence of the aversion.

Determining the correct dosage of LiCl

The amount of LiCl given to each animal depends on its weight and the strength of the dose. The weight of each sheep is easy to determine by weighing the sheep on a scale. A more difficult determination is deciding how much LiCl should be administered given the sheep's dietary experience. Sheep with very little dietary experience, feeding on only a few types of forage, will most likely be averted to specific feeds with a very small dose while sheep with broad dietary experience may need a moderate to high dose of LiCl.

Sheep that have grazed rangeland forages with a high diversity of plant species may need the higher dose of LiCl than sheep that have spent most of their time on irrigated pasture or in corrals eating hay. The strengths of the LiCl doses are indicated below. Dosage is the same for cows, sheep and goats (duToit et al. 1991).

Small LiCl dose = 125 mg LiCl per kg BW
Medium LiCl dose = 150 mg LiCl per kg BW
High LiCl dose = 175 mg LiCl per kg BW

Once you have weighed the sheep and determined which dose of LiCl you plan to give, use the following formula to calculate how much LiCl each sheep should receive.

$$BW\ kg\ \frac{mg\ LiCl/kg\ BW}{1000\ mg/g} = grams\ LiCl$$

For example, if you have a ewe that weighs 72.6 kg (160 lb) and you want to administer a moderate dose of 150 mg LiCl per kg of body weight, you will calculate the dosage as follows.

$$72.6\ kg * \frac{150\ mg\ LiCl/kg\ BW}{1000\ mg/g} = 10.9\ g\ LiCl$$

Since we are more familiar with pounds than kilograms, we can calculate the amount of LiCl by using a pounds-to-kilograms conversion factor in the formula.

$$\frac{160\ lb\ BW}{2.2\ lb/kg} * \frac{150\ mg\ LiCl/kg\ BW}{1000\ mg/g} = 10.9\ g\ LiCl$$

Although it is time consuming to calculate the exact dose for each sheep, it is a good exercise to understand. In situations in which many sheep will be averted, it is often more efficient to use a standardized solution of LiCl and administer the solution orally using a drench gun or drench syringe. An easy standardized solution can be made with 750 milliliters of water and 500 grams of LiCl to make a total of 1000 milliliters or 1 liter of solution with a concentration of 0.5 grams of LiCl per ml. Using this solution concentration, the dosage amounts can be quickly identified in Table 1 for the various weights of the sheep that you will dose with LiCl.

First you will need to make a standard solution by following these directions.

Mixing Instructions:

1. Start with a mixing vessel that is larger than 1 liter (about 1 quart).

2. Measure all the water (750 ml) and pour into the mixing vessel.

3. *Slowly* add the LiCl (500 grams) to the water and stir the mixture. DO NOT ADD THE WATER TO THE LiCl.

4. As you add the LiCl to the water and stir the solution, the mixture will generate heat. You can place the mixing vessel in a water bath to cool the solution as you stir.

5. Stir until all the LiCl is dissolved.

This recipe makes a little more than a liter of solution with a concentration of 0.5 gram LiCl/ml of solution.

Remember that 1 ml = 1 cc and 1 ml of water weighs 1 g.

A smaller amount of solution can be made, but the proportion of LiCl and water needs to be the same. For example, 250 grams LiCl can be mixed with 375 ml water to create 500 ml of solution with the same concentration of 0.5 grams LiCl per ml of solution. The ratio of LiCl to water is 1 gram LiCl to 1.5 ml water. Table 1 contains information on how much LiCl solution to dose an animal based on its body weight.

Table 1. Amount of LiCl solution (0.5 g/ml) given orally based on body weight and strength of dose

Body Weight		Low Dose	Med Dose	High Dose
Lbs	kg			
40	22.7	6	7	7
50	27.3	7	8	8
60	31.8	8	10	10
70	36.4	9	11	11
80	40.9	10	12	13
90	45.5	11	14	14
100	50	13	15	16
110	54.5	14	16	18
120	59.1	15	18	19
130	63.6	16	19	21
140	68.2	17	20	22
150	72.7	18	22	24
160	77.3	19	23	25
170	81.8	20	25	27
180	86.4	22	26	29
190	90.9	23	27	30
200	95.5	24	29	32
210	100	25	30	33
220	104.5	26	31	35
230	109.1	27	33	37
240	113.6	28	34	38

Examples of Application

Training animals to avoid a particular plant species has been applied predominately with sheep weeding vineyards. University of California Cooperative Extension has conducted most of these demonstrations and added greatly to our knowledge about using this method in a commercial setting. Below are examples of training animals using LiCl to avoid a particular plant, both successes and failures.

Vineyards

Using Sheep to Reduce Vegetation on Vineyard Floors[1] – Sheep grazing is a cultural practice to manage vineyard floor vegetation. Sheep can eliminate the need for herbicides, and be used rain or shine. The biggest drawback to sheep is they like to browse the spring growth of grapevines.

Trials conducted at Hopland, California, determined if sheep could be trained to avoid eating grape leaves, but eat the plants growing underneath and in between the grapevines (Figure 6).

Figure 6. Sheep are working hard weeding a vineyard. (Photo by Morgan Doran)

Field observations of sheep showed that after training, they don't eat immature grapes or grape leaves, while untrained sheep did. Trained sheep ate few grapevines while untrained sheep removed about of 50 percent of all vine shoots and leaf material. The aversion persisted for at least 9 months.

Sheep with an aversion to grape leaves can extend the time sheep graze vineyards through the spring months when floor vegetation is abundant. This trial also showed that the amount of vineyard floor vegetation at the end of May in the grazed treatments was comparable to normal floor management that uses machinery or herbicides.

Benefits of Trained Sheep[2] - Navarro Winery doesn't use herbicides or pesticides so weed-removal is done either by hand or by tractor. Sheep keep down weeds without gasoline or herbicides (Figure 7).

The sheep training research has many potential benefits for grape producers and sheep herd managers. Sheep weed control fits guidelines for organic production, in which no artificial pesticides

[1]Rewritten from a 2007 Associated Press article entitled *Grape News! Sheep trained to weed vineyards* http://www.nbcnews.com/id/19714199/#.Umqd1CiK_fg. Last accessed October24, 2013

[2] Rewritten from a 2009 Farm Press article entitled *Trained sheep offer vineyard benefits* http://southwestfarmpress.com/orchard-crops/trained-sheep-offer-vineyard-benefits Last accessed October 2013.

Figure 7. Grazing vineyards gives sheep producers another source of forage. (Photo by Colby Elerman)

or fertilizers are used, and biodynamic production, a system that builds on the organic philosophy with additional natural and holistic management practices. Conventional farmers may want to look at using trained sheep for vegetation management.

In very wet years, farmers may not be able to get tractors into the vineyard to mow or apply herbicides. Sheep can easily get in and clear the vegetation regardless of mud and rain.

In dry years, vineyards provide an additional food source for sheep (Figure 8). A tremendous amount of feed grows on the floor of a vineyard, so it gives a sheep producer an alternative feed source when traditional feed sources on the range may be low.

Figure 8. A vineyard after sheep grazing (Photo by Morgan Doran)

***Lack of Alternative Foods Can Ruin Aversion*[3] –** Winery owner Jim Taylor spends a lot of time and money each year spraying herbicides control the weeds around his grapevines. But soon sheep may provide weed control for Jim.

Working with Roger Ingram, UC Cooperative Extension Farm Advisor, the two are trying to train sheep to eat weeds but leave the grapevines alone.

Sheep were fed grape leaves, followed by a harmless dose of lithium chloride that causes nausea. Sheep associate nausea with eating grape leaves and avoid eating them in the future.

According to Taylor, the experiment worked for 3 days, and then one of the sheep started eating the grapevines. Sheep are social animals when they saw one animal eating grapevines; they all started eating the vines. Soon 12 vines were grazed down to a nub.

Problem may have been lack of understory vegetation. They ate and ate and when they ran out of ground vegetation, they saw the sweet succulent tasty grapevines and began eating them.

Aversion Training for Very Large Groups of Sheep – Averting small groups of sheep allows a higher degree of scrutiny to ensure that each individual is properly averted. One drawback is the time required if there is a large number of sheep to be averted. Since aversion training is best accomplished in the early morning hours, averting a large group of sheep in small batches of 5 to 10 sheep can stretch well beyond the optimal time, thus compromising the training process.

Strategies to avert groups up to 100 sheep per batch have been successfully used (personal observations by M. Doran, 2011) immediately prior to vineyard grazing. In this process, sheep were allowed to graze an orchard floor for 2 days so that the floor was clean of vegetation. Newly pruned grape shoots were offered on the orchard floor to one group of 100 sheep. To another group of 100 sheep shoots were elevated about 2 feet off the floor (Figure 9).

[3] Rewritten from a 2009 KCRA article entitled *UC Davis, Auburn Winery Team Up To Test 'Super Sheep'* Article no longer available online.

Figure 9. Exposing a large group of sheep to grape leaves. (Photo by Morgan Doran)

Consumption of grape leaves in both groups appeared adequate, although consumption by a few individuals in each group was low. LiCl solution was administered to the sheep with a drench gun immediately after consuming the grape leaves. Using this method, four people were able to process 200 sheep in about 1 hour. All the sheep, verified by a test later the same day, achieved a surprisingly strong aversion to grape leaves and vineyard grazing began the following day.

The strong aversion persisted several weeks until the aversion was challenged in a particular vineyard block with low forage quantity and quality and a lack of access to an alternative site adjacent to the vineyard. In hindsight, this particular vineyard block should not have been grazed with averted sheep.

Goat Aversion Training on Maui

On the Haleakala Ranch, on the island on Maui, Greg Friel and Bobby Brooks planted Tarramba as forage for livestock. Tarramba is an improved cultivar of the forage legume *Leucaena leucocephala* and it provides high quality protein and energy to ruminants even during dry periods. Unfortunately, weeds were growing in the Tarramba planting making herbicides or other traditional weed management methods impossible. Friel and Brooks wanted to use goats to graze the weeds but avoid the Tarramba.

In November 2011, they trained 30 goats to avoid Tarramba using aversive conditioning. Prior to training, goats were penned overnight without feed.

Figure 10. Goats eating the forage Tarramba. (Photo courtesy of Haleakala Ranch)

The next morning, goats were offered freshly cut Tarramba branches. Even after an overnight fast, some goats were reluctant to taste the brush because it was a novel food (Figure 10). Once goats ate Tarramba, they were drenched with LiCl solution to cause mild nausea. After dosing, goats were moved to another pen for about an hour to strengthen the neural link between nausea and the flavor of Tarramba (Figure 11). They were then let out to pasture. This process was repeated over the next 3 days. Even goats that readily ate the Tarramba the first day hardly sniffed it on subsequent days. Several months later the goats were still eating weeds and avoiding Tarramba.

Friel and Brooks were so impressed with the persistence of the aversion; they

Figure 11. Goats avoid Tarramba after receiving LiCl. (Photo courtesy of Haleakala Ranch)

averted another 25 goats several months later. This group was only treated with LiCl once. They all tasted Tarramba on the first day of exposure, but wouldnt try it again over the next 3 days. Greg even put eight ewe-lambs that readily ate Tarramba in with the goats to entice them to eat, but the goats just ignored the Tarramba.

Seed Production in Utah

Niels Hansen, who raises Russian wildrye for seed, asked researchers in rangelands at USU if they could avert animals to grass. The answer was yes in theory. Hansen proposed to avert goats to grass because goats tend to prefer browse and broadleaf plants.

When grown for seed, Russian wildrye is planted in rows 3 feet apart leaving plenty of room for weeds such as bindweed, cheatgrass, bulbous bluegrass, lambsquarter, pigweed, fillaree, Russian thistle, and knotweed to grow. Hansen averted goats to the grass and reported that the goats ate the weeds and avoided the grass. They even ate the weeds in between the grass and wrapped around the grass (Figure 12).

Figure 12. Russian wildrye grown for seed. Goats averted to the grass were used as weeders. (Photo by Niels Hansen)

Olive Trees and Vineyards in Spain

Woody plants (olive trees, grapevines, fruit trees, etc.) grow on 27 percent of the cultivated land in Spain. Weeds grow around trees and vines and are usually controlled with herbicides and/or farm equipment. Unfortunately, herbicides cause environmental concerns and farm equipment causes soil compaction. Using sheep or goats to graze unwanted weeds would reduce the use of herbicides and fertilizers because manure from sheep and goats will return nutrients to the soil.

Researchers at the Autonomous University of Barcelona School of Veterinary Medicine showed that sheep and goats can be trained not to eat olive leaves, a food these small ruminants particularly like (Figure 13). To condition the aversion, researchers fed olive leaves and soft shoots to animals, both were novel foods. Then they dosed animals with LiCl. After a single dose of LiCl, sheep and goats rejected the olive leaves (Figure 14). Animals not given LiCl readily ate olive leaves and shoots. The aversion lasted over 4 months (Manuelian et al. 2010).

The project was conducted under commercial conditions. Sheep and goats acquired an aversion for olive leaves and sheep also learned to dislike grapevines.

Figure 13. Goats readily eat olive tree leaves. (Photo by Maristela Rovai)

Figure 14. After training, goats avoid olive tree leaves and graze forage under trees. (Photo courtesy Maristela Rovia)

Researchers in Spain used a different set up to test the strength of an aversion to grape leaves of conditioned sheep (Figure 15). Sheep readily grazed the grape leaves (Figure 16) at first, but after receiving LiCl sheep were successfully used as weeders in the vineyards (Figure 17).

Training Sheep to Avoid Shrubs in a Research Plot

In the late 1980s, the first study at Utah State University to train sheep to avoid browsing a specific plant species was more than academic; it was practical.

Figure 15. Frames used by researchers in Spain to test an aversion to grape leaves. (Photo by Elena Albanell)

For several years prior to the first study, technicians routinely covered shrubs in a 20acre research plot with plastic bags, then hand-sprayed the plots with herbicide to control the weedy understory and promote shrub growth.

During the study, sheep were trained to avoid two shrubs, mountain mahogany and serviceberry.

Figure 16. Sheep not averted to grape leaves readily eat them. (Photo by Maristela Rovai)

Figure 17. After grazing vineyards using sheep conditioned to avoid grape leaves. (Photo by Gerardo Caja)

Researchers demonstrated that sheep could be taught to avoid the shrubs, but continue to eat the grasses and forbs in the understory to promote shrub growth (Burritt and Provenza, 1989) (Figure 18). Further study showed the aversion lasted for at least a year (Burritt and Provenza, 1990). Sheep were successfully used as weeders for several years at the site.

Summary

Sheep, goats, and cattle can be trained to avoid particular plant species. Provided animals have adequate salt, are handled with care during dosing and the correct amount of LiCl is used for each animal, training is quick and harmless. Once animals are trained, aversion can persist for years by maintaining the following conditions: 1) the

Figure 18. Sheep trained to avoid the shrub mountain mahogany weed research plots. (Photo by Gary Neuenswander)

plant is novel; 2) use mature animals; 3) provide an ample supply of nutritious familiar foods; 4) don't allow trained animals to forage with animals that eat the target plant; 5) train animals where they will be used; and 6) provide animals alternative areas away from the target plant.

References

Burritt, E.A., and F.D. Provenza. 1989. Food aversion learning: conditioning lambs to avoid a palatable shrub (*Cercocarpus montanus*). Journal of Animal Science 67:650-653.

Burritt, E.A., and F.D. Provenza. 1990. Food aversion learning in sheep: Persistence of conditioned taste aversions to palatable shrubs *(Cercocarpus montanus* and *Amelanchier alnifolia).* Journal of Animal Science 68:1003-1007.

Burritt, E.A., and F. D. Provenza. 1991. Ability of lambs to learn with a delay between food ingestion and consequences given meals containing novel and familiar foods. Applied Animal Behavior Science 32:179-189.

Burritt, E.A., and F.D. Provenza. 1996. Amount of experience and prior illness affect the acquisition and persistence of conditioned foods aversion in lambs. Applied Animal Behavior Science 48:73-80.

Burritt, E.A., and F.D. Provenza. 1997. Effect of a novel environment on the formation and persistence of a conditioned food aversion and ingestion of novel foods by sheep. Applied Animal Behavior Science 54:317-325.

Doran, M., J. Harper, R. Ingram, S. Larson, M. George, and E. Laca. 2009. Targeted Grazing - Using Aversion Trained Sheep for Vineyard Floor Vegetation Control. 62nd Society for Range Management Meetings, Albuquerque, NM. Abstract

duToit, J. T., F.D. Provenza, and A. Nastis. 1991. Conditioned taste aversions: How sick must a ruminant get before it learns about toxicity in foods? Applied Animal Behavior Science 30:35–46.

Garcia, J., P.A. Lasiter, F. Bermdez-Rattoni, and D.A. Deems. 1985. A general theory of aversion learning. p. 8-21, in N.S. Braveman and P. Bronstein (eds.). Experimental Assessments and Clinical Applications of Conditioned Food Aversions. New York Academy of Science, New York.

Kimball, B.A., F.D. Provenza, and E.A. Burritt. 2002. Importance of alternative foods on the persistence of flavor aversions: implications for applied flavor avoidance learning. Applied Animal Behaviour Science 76:249–258.

Manuelian C.L., E. Albanell, A.A.K. Salama, and G. Caja. 2010. Conditioned aversion to olive tree leaves (*Olea europaea L.*) in goats and sheep. Applied Animal Behaviour Science 128:45-49.

Provenza, F.D., and E.A. Burritt. 1991. Socially induced diet preference ameliorates conditioned food aversion in lambs. Applied Animal Behaviour Science 31:229–236.

Provenza, F.D., J.J. Lynch, and J.V. Nolan. 1993. The relative importance of mother and toxicosis in the selection of foods by lambs. Journal of Chemical Ecology 19:313-323.

Provenza, F.D., J.J. Lynch and J.V. Nolan. 1994. Food aversion conditioned in anesthetized sheep. Physiology and Behavior 55:429-432.

Ralphs, M.H. and C.D. Cheney. 1993. Influence of cattle age, lithium chloride dose level, and food type in the retention of food aversions. Journal of Animal Science 71:373-379.

Ralphs, M.H., and F.D. Provenza. 1999. Conditioned food aversions: Principles and

practices, with special references to social facilitation. Proceedings of the Nutrition Society 58:831-820.

Ralphs, M.H. 1997. Persistence of aversions to larkspur in naive and native cattle. Journal of Range Management 50:367–370.

Ralphs, M.H., D. Graham, M. L. Galyean, and L.F. James. 1997. Creating Aversions to Locoweed in Naive and Familiar Cattle. Journal of Range Management 50:361-366.

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