# TECHNIQUES USED IN RODENT CONTROL TO SAFEGUARD NONTARGET WILDLIFE

Rex E. Marsh
Specialist in Vertebrate Ecology
Wildlife and Fisheries Biology
University of California
Davis, CA 95616

ABSTRACT.

In addition to wildlife-pesticide education and the criteria which must be met before a rodenticide can be registered and used, there are many other techniques that can be used to safeguard nontarget wildlife. They include the appropriate selection of rodenticide, bait type and formulation, the rate and distribution of the bait, restricting accessibility of nontarget species to the bait, and timing of control. The importance of the type of grain used for bait, the concentration of toxicant in the bait, artificially colored baits, and emetics is detailed. Delivery systems and bait application methods are discussed as they relate to protecting wildlife from exposure. Several examples are given of future directions for continuing efforts to provide new safeguards to nontarget wildlife.

## INTRODUCTION

Whether field rodent control is conducted for public health or economic reasons, the concern over possible adverse effects on nontarget wildlife is long-standing (Gabrielson 1932). Following the turn of the century, the concern was primarily for game species, which was not surprising, since those species were utilized extensively for subsistence. Concerns for the welfare of our wildlife have increased over the years, and significantly so over the last two decades, with a much greater emphasis now being placed on the habitat and other needs of nongame wildlife. The intent of this paper is to discuss some technical aspects that play an important role in safeguarding nontarget wildlife when toxic baits are used to control rodents and rabbits when they become pests, particularly in agriculture and forestry. Although rodent control is conducted on millions of acres annually in California, the instances of significant wildlife losses are rare. In those instances, there were frequently some rather atypical implicating factors. One such incident in the Tule Lake basin of Northern California and Southern Oregon involved populations of meadow mice (*Microtus montanus*) of plague proportions reaching populations as high as 3,000 per acre (Spencer 1958). Such a catastrophic occurrence resulted in extensive use of mouse baits over a larger area within the Pacific flyway and at a time and in a location which jeopardized migratory waterfowl. Past history in California has shown that in certain situations migratory waterfowl are at risk more than any other wildlife group with field rodent baiting. Changes in rodent baits and control practices, however, have done much to minimize these potential hazards to waterfowl as well as other nontarget wildlife.

Many methods and techniques are used to make rodent control as selective as possible to safeguard wildlife as well as domestic livestock. But before we delve into these, three other aspects deserve mention because they are fundamental to this subject. The first relates to administrative concerns by key state agencies, the second to agricultural and wildlife education, and the third is in reference to the Federal and State pesticide regulatory agencies.

## WILDLIFE POLICIES, EDUCATION, AND REGISTRATION

In California, the Departments of Fish and Game and of Food and Agriculture and the County Departments of Agriculture play major roles in preventing wildlife losses when controlling rodents. They have joint policies concerning rodent control programs and practices administered by the counties. California is the only state I am aware of which has such a formal and effective working arrangement. The educational efforts of all departments do much to maintain a high level of public and pesticide user awareness concerning wildlife-pesticide hazards.

Vertebrate pest management education plays a key role in training personnel in proper rodent control practices. In addition to the educational efforts of the Cooperative Extension Service, formal courses are taught as part of the curriculum at several state universities as well as at the University of California, Davis. Special training programs are also conducted throughout the state by knowledgeable specialists for various agricultural, forestry, or special interest groups who have a need for knowledge of rodent control in their profession or occupation. A vertebrate pest conference, the largest of its kind anywhere in the world, is held every other year as an educational effort. These efforts are unmatched by any other state.

The role of the pesticide regulatory agencies is critical because they determine whether a rodenticide will be registered. Rodenticides and other pesticides are scrutinized carefully to assess potential hazards to wildlife prior to registration by the U. S. Environmental Protection Agency (EPA). The same rodenticides are further evaluated at the state level in many states, including California. Potential rodenticides will not be granted registration if they present a significant potential hazard to wildlife. An example of a rodenticide which was not registered in California is endrin as a foliar ground spray for the control of meadow mice (*Microtus californicus*), although it has been registered by EPA and a number of other states. It is used in other states in apple orchards and in such situations so as not to pose a significant hazard to nontarget wildlife. In California, very early experiments with endrin, at effective mouse control rates, was found to be unacceptably hazardous to migratory waterfowl that use treated alfalfa fields. Gophacide, O,O bis (p-chlorophenyl) acetimidoylphosporamidothioate, is known to be an excellent toxicant for jack rabbit (*Lepus californicus*) control but because of its secondary hazards to eagles, registration for this use was never pursued.

Regulatory agencies commonly mitigate potential pesticide wildlife hazards by restrictions or, when possible, through modifications of use patterns, methods of applications, application rates, or time of application. This is most often accomplished through pesticide-use label directions, but may be further controlled through restrictions or conditions specified in use permits. There are also several processes by which registered pesticides can be removed from use if found to cause unacceptable wildlife losses.

Acute rodenticides, such as strychnine or zinc phosphide used in field rodent control, for the most part are classified as restricted pesticides and can be used only by certified applicators. Sodium fluoroacetate (1080) is even more highly regulated and in California can only be used for field rodent control under the direct supervision of some governmental agency.

## METHODS AND TECHNIQUES FOR SAFEGUARDING WILDLIFE

Methods and techniques for safeguarding wildlife relate to the selection of the most appropriate rodenticide for the situation, bait type and formulation, the rate and distribution of the bait, restricting accessibility of nontarget species to the bait and timing of control operations.

### Rodenticide Choice

The choice or selection of a toxicant (i.e., rodenticide) to use for a specific rodent control situation is of foremost importance because other factors such as concentration in the bait, rate of application, and the method and timing of application are often dictated by the rodenticide used and rodent species to be controlled. If there is a choice, select the rodenticide for which the pest rodent is highly susceptible and the wildlife species at potential risk have low susceptibility.

The selection of the most appropriate rodenticide for field rodent control that has minimal potential hazards to specific wildlife is made easier if there is a number of available rodenticides to choose from. The more rodenticide options there are, the more carefully rodent control can be tailored to safeguard wildlife.

For example, zinc phosphide rodent baits have very little potential for secondary poisoning of predator or scavenger species that may consume dead rodents. Zinc phosphide has the further advantage of relatively rapidly detoxification if it becomes wet, especially under slightly acid conditions. First-generation anticoagulant rodenticides of the coumarin group are low in bird toxicity and present minimal hazards to birds either primarily or secondarily. The multiple-dose anticoagulant rodenticides that require repeated feedings to be lethal are advantageous in safeguarding those species that may incidentally ingest some bait on a one-time or a highly intermittent basis. Most species of birds are much less susceptable to 1080 than are rodents, hence 1080 rodent baits for ground squirrel (*Spermophilus spp.*) control presents little hazards to raptors, game bird species and most other birds. Red squill often produces an emetic action in most carnivores as well as domestic cats and dogs and thus minimizes associated hazards to some species that might otherwise be affected by Norway rat (*Rattus norvegicus*) control in and around buildings. Norbormide, the most selective of all rodenticides, is toxic only to the genus *Rattus* and presents no hazard when used for Norway or roof rat (*R. rattus*) control. Unfortunately, it is no longer marketed in the United States. A currently registered toxicant/chemosterilant, alphachlorohydrin, is also relatively species-specific as it relates to the chemosterilant aspect for it causes sterility in only male Norway rates.

Bait Composition

Effective rodent control relies on the selection of baits that are highly preferred by the target species and baits that will successfully compete with available natural foods. Grain baits usually are the choice because of their acceptability by the target rodent species, availability, cost, ease of bait preparation, and storage life.

Safeguards to wildlife are greatly enhanced if several different grains have been tested and found to be highly acceptable to the target species and poorly consumed by nontarget species. Whole kernels of oats, barley, and wheat may be nearly equally accepted by certain ground squirrel populations; however, since wheat is much more apt to be consumed by certain large seed-eating birds than either barley or oats, it is not a good choice of bait for above-ground baiting. For this reason, wheat is not recommended for ground squirrel or meadow mouse (*Microtus spp.*) control in California. Wheat, oat groats, and milo are all quite well accepted by pocket gophers (*Thomomys spp.*). Pocket gopher baits are placed below ground in artificial or natural tunnels, but should any spillage occur above ground, milo would present more potential hazard to ground-feeding seed-eating birds because it normally is more acceptable to birds than oats or wheat (Geis and Hyde 1983).

Whole oats and barley are often selected as baits for ground squirrels and for meadow mice, with oats generally preferred. The rolled or crimped oats are frequently more highly acceptable to ground squirrels and meadow mice and are easier to formulate into baits. Rolled grain also deteriorates more rapidly under moist or wet conditions, which can be an added advantage in eliminating residual bait following application. Rolling or crimping creates flattened kernels, which alters their natural appearance, and when dyed are thought to appear larger and less attractive to birds than nonrolled kernels of the same grain. Cracked, broken, or coarse-ground grains are generally avoided for spot-baiting or broad-cast-baiting for field rodents because the small particle size makes them more acceptable to smaller seed-eating birds.

The pelletization of field rodent baits for broadcast purposes offers opportunities to safe-guard nontarget species since size, shape, and hardness can be controlled with precision. Pellets can also be designed in particle size with various binders or hydroscopic ingredients added so they will degrade more rapidly in the field.

Dilution baiting is the blending of toxic grain bait with that of clean (i.e., untreated kernels). When applied in the field for rodent control such a dilution makes it more difficult for some nontarget species to be able to ingest a fatal dose even though they consume some bait. This approach has been used for meadow mouse control in Northeastern California as an added safeguard to waterfowl. It has also been used in Australia for the control of the European rabbit (*Oryctolagus cuniculus*) (Gooding and Harrison 1964).

Perishable baits such as fresh chopped alfalfa, carrots, apples or cabbage are used in some situations for certain pest species because they are more effective and may be more selective depending on the wildlife species at risk. Chopped alfalfa has been occasionally used with strychnine for jack rabbit control and placed within protective barriers such as described by Wetherbee (1967). Carrots cut into small pieces and treated with a suitable rodenticide are sometimes placed in underground burrows for pocket gopher (*Thomomys spp.*) control. Chopped cabbage is used in some areas as a bait for the control of the Belding (*S. beldingi*) ground squirrel in California and for the Richardson ground squirrel (*S. richardsonii*) in Nevada. Perishable baits are more expensive to prepare, but as they are more efficacious, less frequent baitings are needed which reduces the amount of rodenticide placed in the field. Fresh fruit or vegetable baits are avoided by most seed-eating bird species and tend to deteriorate more rapidly than grain baits. Both increase selectivity, and bait degradation can be advantageous in safeguarding certain wildlife species.

Paraffin rodent bait blocks (i.e., cereal baits embedded in melted paraffin and solidified into a block), although initially developed for use in high-humidity or high-moisture situations, have proven very effective in increasing bait selectivity to gnawing rodents (Marsh and Plesse 1960). Paraffin bait blocks are used effectively for controlling both muskrats and Norway rats in rice-growing areas and along agricultural irrigation and drainage water systems in California (Clark 1975, Marsh 1968). They offer good selectivity against birds of all sizes. Except for gnawing rodents, herbivores do not apparently recognize them as a food item.

## Toxicant Concentration in Baits

Baits are designed so as to contain the optimum amount of the toxicant that will provide a fatal dose to the target rodent. These optimum concentrations are arrived at and based on the susceptibility of the pest species, the weight of the animal, the amount of food consumed in a single-feeding bout (with acute rodenticides) or the amount consumed daily (with the slow-acting anticoagulants). Baits prepared with too little toxicant will be ineffective because fatal doses will not be acquired, and baits prepared with too much toxicant will often be rejected because of the taste, may be unnecessarily hazardous to nontarget wildlife, and be more costly to make.

Baiting rates and distribution patterns are closely tied to the bait concentrations. An adjustment in one factor frequently requires a counterbalance in at least one of the others. Highly efficacious rodenticides and rodent baits lead to less toxicant being placed in the environment and thus better safeguarding wildlife. This is primarily because the more efficacious the bait, the less often bait will need to be applied. There are innumerable examples of how optimum bait concentrations coupled with effective application rates for specific rodent species provide protection for other species at potential risk. As an example, aircraft-broadcast 1080 bait for ground squirrels has almost no impact on jack rabbits because of the bait concentration and scattered pattern of the bait. Likewise, it would be virtually impossible for deer or cattle to pick up a lethal dose even if they sought out the bait.

The concentration of the rodenticide in baits may be such that few individual birds or nonrodent mammals will receive a lethal dose even if they consume some bait. Sublethal symptoms from acute rodenticides often occur, causing nontarget animals to stop feeding. This aversion reaction to a bait can be more than a response of the moment and may lead to lasting aversive conditioning cued by vision, taste, texture, or odor (Avery 1984, Fuller and Hay 1983, Mason and Reidinger 1982, Wilcoxon et al. 1971). Aversive conditioning is a phenonmenon which is synonymous with bait or toxicant-shyness in the target species. Bait aversion results from an atypical feeling or from becoming ill as a result of consuming a sublethal dose of a toxic bait. Food (bait) associated aversion resulting from initial sublethal ingestions must be considered an important factor in safeguarding nontarget wildlife. The rodenticides strychnine, 1080, zinc phosphide, phosphorous, red squill, arsenic and ANTU are known to produce significant aversions.

Bait Additives

(a) Artificially colored baits

The value of artificially colored (i.e., dyed) field rodent baits to assist in protecting seed-eating birds was introduced by Kalmbach (1943). Kalmbach and Welch (1946) experimented with green and yellow-colored grains containing the rodenticide strychnine and discovered that the dyed baits were rejected by birds to a much greater degree than undyed baits. Considerably fewer bird fatalities resulted when dyed baits were used. Current evidence suggests that the dye may not have been alone in producing the desired repelling response from birds, and that a taste-conditioned aversion to strychnine or other acute rodenticides may also be implicated, with the color serving as a visual cue (Marsh 1983).

The effectiveness of dyed or colored bait relies on the fact that the birds perceive color and use color in selecting or rejecting food items. The evidence suggests that many birds will avoid dyed foods apparently because they appear unnatural. A variety of dyes and pigments, especially those in the bright green and yellow color spectrum, have been used to color rodent baits. Gray and black coloring agents have also been found to repel birds. Rodents, on the other hand, apparently lack true color vision and perceive colors as shades of black and white, and, if the dye is tasteless and odorless, the colors do not seem to influence bait consumption.

More recent studies of the value of artificial coloring of rabbit bait to repel birds were conducted by Caithness and Williams (1971) and Brunner and Coman (1983). With a different objective, Pank (1976) found that certain dyes and coloring agents were of value in reforestation efforts, protecting conifer seeds from unwanted bird consumption.

The dyeing of field rodent baits has been a common practice for safeguarding seed-eating birds in California and elsewhere since the late 1940s (Dana 1962, Hayne 1950). The dyeing of baits is not, however, claimed to be foolproof. There are incidents where birds consumed fatal quantities of dyed bait but significant losses are rare. As an aid in protecting seed-eating birds, the practice of dyeing bait is a must. Coloring rodent baits also helps people distinguish toxic baits from food or feed, thus preventing accidents caused by human error.

(b) Emetics in baits

The idea of the use of emetics in toxic bait formulation was advanced by F. E. Garlough of the U. S. Biological Survey (Spencer 1938). Tartar (antimony potassium tartrate) emetic was subsequently used in a number of bait formulations, particularly in commensal rodent baits, primarily for the protection of pets and humans (Bai and Majumder 1982). Rodents cannot vomit and hence emetics have little effect on them from the standpoint of eliminating poisonous bait from their stomachs. Tartar emetic by itself is somewhat toxic and reduces bait acceptance for the target species and for these reasons has fallen into disuse in the last two decades.

Several rodenticides cause regurgitation in some species and thus also act as emetics. Red squill, which is used for Norway rat control, is one such rodenticide, and that is one reason it is considered so safe. It triggers vomiting in cats, dogs, and humans when ingested, and thus the stomach is emptied or partly emptied of the toxicant.

Bait Delivery Systems and Application Methods

(a) Mouse tubes

Mouse tubes were an innovative bait formulation and delivery development that not only were effective in the control of meadow mice, but also protected the bait from most nonrodent species (Libby and Abrams 1966). The treated grain bait was adhered to the inner surface of a hollow cardboard tube (1.75 inches in diameter and 5 inches long) with an edible glue. In essence, the mouse bait was a bait-loaded miniature bait station that was formulated as a single unit designed for field use (Marsh et al. 1967). Because of its cost, the mouse-tube delivery approach never progressed much further than the experimental stage.

(b) Place packs

Place packs are commonly used as a means of delivering bait in commensal rodent control, but have not gained much use in field rodent control. Place packs are small cellophane or plastic packets of bait. The rodents must gnaw into them to obtain the bait. In and around buildings, outdoor infestations of Norway rats are often controlled with these packets placed well back into the burrow opening. Such a technique reduces the chances of child and nontarget animal exposure. The approach definitely has a greater place in certain kinds of field rodent control and needs to be perfected for such pests as pocket gophers, wood rats, and possibly meadow mice.

(c) Bait stations

The use of bait stations in rodent control principally evolved following the development of the anticoagulant warfarin. Bait stations or boxes were needed to contain sufficient bait to provide the multiple feedings necessary to give a high percentage of rodent control. Bait boxes protect the bait from rain and other adverse weather conditions, but, more importantly, they also protect the bait from nontarget wildlife of a size larger than the openings provided for the rodents. The use of bait boxes substantially increases the cost of rodent control, thus are most often used over relatively small acreages or to control rodents to protect high-value crops.

The placement of baits in semi-concealed areas available to the target rodent, but not to wildlife or domestic stock, has long been practiced. Bait placement in the entrance of a wood rat (*Neotoma spp.*) nest or in the mouth of a mountain beaver (*Aplodontia rufa*) burrow is common in rodent control. Small fenced enclosures are sometimes used to exclude livestock and deer from jack rabbit baits ((Wetherbee 1967) which are placed in open bait stations or small handful-sized piles. Scattered baits are ineffective for jack rabbits.

(d) Bait application

Bait application methods are generally closely linked to application rates (i.e., the amount of bait per placement or per acre). The method of bait application hinges on the biology and behavior of the pest species; however, when alternative choices are available, the determining factor can be the method least apt to put select species at risk. For example, ground squirrels can be controlled with either small piles of bait or well-scattered bait; however, well-scattered bait is less hazardous to deer and cattle than are piled baits, and hence the scattering of bait is always recommended and used. Pocket gopher baits are placed below ground within their burrow systems with a probe dispenser or deposited in an artificial tunnel produced by mechanical burrow builders. Neither of these methods presents significant hazards. To avoid under- or overbaiting, mechanical or mechanized bait applicators are accurately calibrated to comply with the established label rates. For accuracy in spot-baiting, special spoons or measuring devices are often used.

Timing of Control

Proper timing of control relative to bait acceptance and rodent activity will assure the maximum intake of bait by the target species so there will be a minimum of residual bait. Control of rodents may be deliberately avoided when migratory waterfowl are about to arrive or are frequenting an area. Some farmers and ranchers also avoid conducting rodent control just prior to or during dove, quail, or pheasant hunting seasons so that the birds will have no chance of picking up even incidental bait particles. Others avoid rodent control prior to the hunting seasons where hunting dogs may be prone to consuming carcasses of poisoned rodents.

Good control practices include the control of rodents before they reach high populations, for this increases control success and minimizes the amount of rodent bait needed. In rodent control the amount of rodenticide used with most application methods is in direct proportion to the population density and distribution of the pest species. Because of this, the threshold for triggering control is usually relatively low when protecting agricultural crops and reforestation efforts.

## FUTURE POSSIBILITIES FOR INCREASED SELECTIVITY

The use of avian-sepcific repellents theoretically may play an important role in the future to safeguard birds from rodent baits. One such potential compound is dimethyl anthranilate (DMA), which has recently been studied by Mason et al. (1983). DMA is a common food flavoring which is repellent to birds but not mammals.

Research on rodent pheromones has not reached the stage of practical use in rodent control (Marsh and Howard 1979), yet some potential exists. The right effective pheromone may someday make rodent control more selective and efficient, greatly reducing the amount of bait and toxicant required for control.

The discovery or development of more species-specific toxicants is always a possibility for the future; however, because of the limited market potential, this will probably have to come from government-supported efforts.

## SUMMARY

Safeguarding wildlife can be enhanced through the proper selection of rodenticides and through bait composition and formulation techniques. Bait composition includes the selection of grain(s) or other kinds of food items used as bait and how these grains or materials are processed and formulated into a finished product. Color, size, shape, texture, and hardness are bait characteristics that can make them both effective and selective for the target species. Bait delivery systems such as place packs and bait boxes can be useful in some situations. When options exist, the least potentially hazardous bait application method can be used.

Concern over the protection of nontarget species is long-standing in field rodent control. While considerable progress has been made, there remains substantial room for new bait application approaches and innovations in formulating baits to further safeguard wildlife and yet continue to be effective in controlling pest field rodents.

## LITERATURE CITED

Avery, M. L. 1984. Relative importance of taste and vision in reducing bird damage to crops with methiocarb, a chemical repellent. Agriculture, Ecosystems and Environment 11: 299-308.

Bai, K. M. and S. K. Majumder. 1982. Enhancement of mammalian safety by incorporation of antimony potassium tartrate in zinc phosphide baits. Bull. Environm. Contam. Toxicol. 29: 107-114.

Brunner, H. and B. J. Coman. 1983. The ingestion of artificially coloured grain by birds, and its relevance to vertebrate pest control. Australian Wildlife Research 10: 303-310.

Caithness, T. A. and G. R. Williams. 1971. Protecting birds from poisoned baits. New Zealand Department of Internal Affairs, Wildlife Publication No. 129. 4 pp.

Clark, D. O. 1975. Vertebrate Pest Control Handbook. State of California, Department of Food and Agriculture. 180 pp.

Dana, R. H. 1962. Ground squirrel control in California, pp. 126-143. In Proceedings Vertebrate Pest Control Conference, February 6-7, 1962, Sacramento, California. 389 pp.

Fuller, P. J. and M. E. Hay. 1983. Is glue production by seeds of *Salvia columbariae* a deterrent to desert granivores? Ecology 64(4): 960-963.

Gabrielson, I. N. 1932. Rodent-control studies--develop specific methods for different species. U. S. Dept. Agri. Yearbook of Agriculture. pp. 325-328.

Geis, A. D. and D. B. Hyde, Jr. 1983. Wild bird feeding preferences. National Wildlife Federation Leaflet, 6 pp.

Gooding, C. D. and L. A. Harrison. 1964. "One-shot" baiting. J. Agr. West. Aust. 5: 12-15.

Hayne, D. W. 1950. Mouse populations in orchards and a new method of control. Michigan Agricultural Experiment State Quarterly Bulletin 33(2): 160-168.

Kalmbach, E. R. 1943. Birds, rodents and colored lethal baits. Transactions North American Wildlife Conference 8: 408-416.

Kalmbach, E. R. and J. F. Welch. 1946. Colored rodent baits and their value in safeguarding birds. Journal of Wildlife Management 10(4): 353-360.

Libby, J. L. and J. Abrams. 1966. Anticoagulant rodenticides in paper tubes for control of meadow mice. Journal of Wildlife Management 30(3): 512-518.

Marsh, R. E. 1968. Rat control in California agriculture. Pp. 58-66, Proc. Asia-Pacific Interchange--Rodents as Factors in Disease and Economic Loss, June 17-27, 1968. Center for Cultural and Technical Interchange Between East and West, Honolulu, Hawaii. 285 pp.

__________. 1983. Rodenticide selection and bait composition to minimize potential primary hazards to nontarget species when baiting rodents, pp. 155-159. In D. J. Decker, (ed.) Proc. First Eastern Wildlife Damage Control Conf., September 27-31, 1983. Cornell University, Ithaca, New York. 378 pp.

Marsh, R. E., R. E. Cole and W. E. Howard. 1967. Laboratory tests on the effectiveness of Prolin mouse tubes. Journal of Wildlife Management 31(2): 342-344.

Marsh, R. E. and W. E. Howard. 1979. Pheromones (odors) for rodent control. Pest Control Technology 7(6): 22-23.

Marsh, R. E. and L. F. Plesse. 1960. Semipermanent anticoagulant baits. State of California, Department of Agriculture Bulletin 49(3): 195-197.

Mason, J. R., A. H. Arzt and R. F. Reidinger, Jr. 1983. Evaluation of dimethyl anthranilate as a nontoxic starling repellent for feedlot settings, pp. 259-263. In D. J. Decker (ed.) Proc. First Eastern Wildlife Damage Control Conf., September 27-30, 1983. Cornell University, Ithaca, New York. 378 pp.

Mason, J. R. and R. F. Reidinger. 1982. Observational learning of food aversions in red-winged blackbirds (*Agelaius phoeniceus*). Auk 99: 548-554.

Pank, L. F. 1976. Effects of seed and background colors on seed acceptance by birds. Journal of Wildlife Management 40(4): 769-774.

Spencer, D. A. 1938. Cultural and other methods for the control of injurious wildlife. USDA Bureau of Biological Survey. Wildlife Research and Management Leaflet BS-115. 6 pp.

__________. 1958. Biological aspects of the 1957-58 meadow mouse irruption in the Pacific Northwest. U. S. Dept. Interior, Fish and Wildlife Service, Denver Wildlife Res. Lab. Spec. Rept. 9 pp.

Wetherbee, F. A. 1967. A method of controlling jack rabbits on a range rehabilitation project in California. Proc. Third Vertebrate Conf. San Francisco, March 7-9, 1967. Univ. of California, Davis. pp. 111-117.

Wilcoxon, H. C., W. B. Dragoin and P. A. Kral. 1971. Illness-induced aversions in rat and quail: Relative salience of visual and gustatory cues. Science 171(3937): 826-828.