Humane Considerations in Rodent Control

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**Introduction**

For centuries, man has tried to eliminate rodents from his environment for public health, crop protection, and aesthetic reasons. The ability of rodents to suffer and feel pain makes the methodology of rodent control an ethical issue. While the need to kill rats and mice is understandable, it is man's moral obligation to eradicate them as humanely as possible. It is estimated that four billion rats and untold billions of mice are killed by man in America each year (Humane Information Services, 1968), so the choice of methods has profound implications- for animal welfare.

**Background**

There are over 2000 rodent species, which is almost half of all mammal species (Meehan, 1985). Rodent control programs generally focus on three commensal species, which tend to eat and damage food. They are Mus musculus (house mouse), Rattus norvegicus (brown rat, Norway rat), and Rattus rattus (black rat, roof rat). Other rodents, such as squirrels and field mice, are considered pests in certain localities.

Rats and mice are resourceful animals, and they will thrive wherever they can find food. Thus, the first and most important aspect of rodent control is elimination of access to food (U.S. Dept. of the Interior, 1974). Successful killing of entire rodent colonies results in only short term victory as long as access to food remains.

**The Most Widely-Used Rodenticides**

Ideal rat poisons should be palatable to rodents, slow in onset (to avoid bait shyness), specific to target species, unlikely to induce development .of tolerance or resistance, inexpensive, easy to formulate, biodegradable, and lethal in quantities that a rodent may consume easily. The most-popular rodenticides today are the anticoagulants, followed by zinc phosphide, but several other chemicals are employed. The anticoagulants block the vitamin K-dependent coagulation factors, resulting in spontaneous hemorrhages (Mallis, 1982). Rodents usually die from rapid, massive gastrointestinal (stomach and intestines) bleeding, leading to loss of blood volume and subsequent circulatory collapse. Since rats cannot vomit, the blood can accumulate and-cause distention and discomfort. Occasionally, rodents have paralyzed limbs, which suggests bleeding into the brain. This can cause severe headaches in people. Another concern is painful hemorrhage into joints and muscles.

Coumadin (Warfarin, D-Con) had been the most widely-used rodenticide in the 1950's to the 1970's, but rats and mice have become resistant in many localities. Newer anticoagulants are much longer-acting and, manufacturers claim, require only a single dose to kill a rodent, unlike coumadin. However, many exterminators find multiple applications necessary. They are probably the most popular rodenticides in-America today due to their enhanced efficacy. Examples of these newer compounds are brodifacoom (Talon-G), chlorophacinone (Rozol), and bromadiolone (Maki). It appears that some resistance to these compounds has occurred.

All animals are susceptible to the effects of anticoagulants, but non- target animals rarely consume lethal doses. Consequently, they are generally safer than most poisons. An additional advantage of the anticoagulants is that "bait shyness" is rarely a problem. Rats avoid most acute toxins if they survive the initial exposure, because they associate unpleasant symptoms with the compound. Anticoagulants take several days to exert an effect, so the rats are without symptoms until near lethal doses are reached.

Zinc phosphide (ZP) has an offensive odor and unattractive color that repels most animals. Rats and house mice, however, seem to like the taste and smell of zinc phosphide (Mallis, 1982). Most of its toxic effects result from phosphine gas, which is produced when the compound reacts with stomach acids. The gut absorbs the gas, and the phosphine then enters the bloodstream. Death usually occurs in from seventeen minutes to several hours, apparently by heart paralysis. Several organs are injured, however, and the cause of death may be multi-factorial. Animals that linger may develop fatal liver or kidney damage after several days. One way to attempt to assess whether zinc phosphide causes suffering is to consider cases of human poisoning. Zinc phosphide is a strong acid that causes intense gastric and substernal pain and violent vomiting and diarrhea. Fluid loss can lead to circulatory collapse and death. As with rodents, residual liver and kidney damage may occur. Survivors may develop esophageal or gastric strictures (Murphy, 1970; Anon., 1985).

**Some Less Popular Rodenticides**

Yellow phosphorus and phosphorus paste (white phosphorus) are contact poisons that are placed along walls where rodents run. The animals ingest the substance when they groom themselves. In man, phosphorus causes severe burns to the gastrointestinal tract, resulting in extreme abdominal pain. Initially, headache, weakness, fever, and seizures may be seen. Rats die after several hours from gastrointestinal bleeding or later from liver and kidney damage (Mallis, 1982; Anon., 1985).

Lindane (gamma benzene hexachloride) is another contact rodenticide that is also used widely as an insecticide and for certain medical therapies. It is a chlorinated hydrocarbon which is chemically similar to DDT (Gilman et al., 1980). Its mode of toxicity to rats is unclear, but a major effect is alteration of the permeability of neuronal membranes. Rats suffer convulsions and then die from respiratory paralysis (Meehan, 1985). Lindane is effective in the clinical treatment of scabies (Kwell), but side effects from its topical administration have occurred. Patients can experience nervousness, irritability, insomnia, vertigo, stupor, and coma7 as well as irritation to skin, eyes, and mucous membranes.

Arsenic is relatively odorless and tasteless, making it dangerous to animals other than rodents. In man, arsenic poisoning causes dehydration, intense thirst, severe abdominal pain, cardiac rhythm disturbances (arrythmias), muscle cramps, lethargy, and delirium (Schoolmaster and White, 1980; Hutton, 1982; Anon., 1985). Rodents experience onset of symptoms 30-60 minutes after ingestion. They usually succumb from fluid and electrolyte abnormalities caused by leakage of fluid into extra-vascular spaces.

Strychnine kills rats and mice in 15-60 minutes by causing convulsions which impair respiratory function. The involuntary muscular spasms are intensely painful (Brewer and Haggerty, 1958; Boyd et al., 1983; Anon., 1985). If the rodents survive the initial insult, they experience muscle breakdown, which can lead to kidney failure.

**Some Inhumane Fumigants**

Methyl bromide (CH3Br), an effective insecticide, is the conventional fumigant for rodent control indoors, such as in silos or ships. It is also used outdoors in the United States and Canada. Liquid methyl bromide evaporates into a colorless, odorless, highly toxic gas. There is little information on its effects on rodents. People exposed to methyl bromide may experience nausea, vomiting, dizziness, blurred vision, fatigue, headache, abdominal pain, confusion, and convulsions. Skin contact produces severe blisters similar to burns (Meehan, 1984). In cases of fatal human poisoning, the victims die; from fluid in the lungs, convulsions, and kidney damage (Hine, 1969).

Phosphine (PH3) was developed as an insecticide in the 1950's, but its use as a rodenticide has been more recent. As mentioned earlier, phosphine is the most toxic product of zinc phosphide. The interaction of aluminum or magnesium phosphide with moist air releases phosphine gas. Its toxicity remains unclear, but depression of the central nervous system is a major effect. Poisoned people initially experience fatigue, buzzing in the ears, nausea, abdominal pain, and pressure in the chest. Severe exposure leads to choking attacks, intense thirst, unsteady gain, severe pains in the limbs, and rapid onset of stupor (Meehan, 1984).

**Nervous System Poisons**

Sodium monofluoroacetate (1080) and fluoroacetamide (1081) are organofluorine compounds that are very toxic in small amounts to all animals. Only licensed professionals may use these chemicals, which are effective for rodent control in sewers and ships. The organofluorines block the Krebs cycle, resulting in toxic accumulation of citric acid. Their main effects are upon neurologic systems, and severe convulsions occur prior to death (Scott, 1969). Rats die in 1-8 hours, either from respiratory failure secondary to convulsions or from arrythmias. People poisoned with these compounds can experience nausea, vomiting, diarrhea, respiratory depression, arrythmias, agitation, irritation, and convulsions. Toxic symptoms occur at much less than lethal doses (Harrisson et al., 1952; Brockman et al., 1955; Reigart et a I . , 1975).

Gophacide is an organophosphorus compound which, like many insecticides, is a cholinesterase inhibitor (Meehan, 1984). It acts more slowly than most poisons, with onset of highly variable symptoms after 8-12 hours. Rodents often have convulsions, diarrhea, incoordination, and labored breathing. Apparently, rodents succumb from respiratory and/or cardiac paralysis (Meehan, 1984)

Crimidine (Castrix) is another central nervous system toxin which is used widely in continental Europe. Apparently, a metabolite of crimidine antagonizes vitamin B6. Rodents experience convulsions 15-45 minutes after ingestion, characterized by restlessness, biting, and jumping. Seizures follow, which are often fatal, presumably from respiratory failure (Knudsen, 1963) .

**Outdated Approaches**

Some rodenticides have been popular in the past but are used less today. Scilliroside, the active component of red squill, is a cardiac glycoside derived from a Mediterranean lily plant. It has an unpleasant taste, and it induces vomiting. Consequently, when most animals eat red squill, they tend to become sick but recover upon vomiting. Rats, unable to vomit, are not protected. Rats succumb in 2-48 hours from arrythmias, but other symptoms occur, including convulsions, paralysis of the hind legs, diarrhea, and excessive urination (Meehan, 1985). It is not very effective for roof rats or mice.

Alpha-naphtylthiourea (ANTU) is highly toxic to Norway rats, dogs, and pigs, but less toxic to roof rats, mice, and cats (Mallis, 1982). It kills within 48 hours by causing accumulation of fluid in the lungs, leading, essentially, to drowning. This is similar in symptomatology to death from congestive heart failure. Rats tend to nibble small quantities of a new' food. Thus, ANTU often fails, because rats avoid the poison if the initial dose is sublethal. Great Britain has banned ANTU, because it appears to cause bladder cancer (Meehan, 1984).

**Poisons Which Appear less Inhumane**

Cholecalciferol (vitamin D3, Quintox) and calciferol (vitamin D2, ergocalciferol) are newer rodenticides that elevate calcium levels in the blood, leading to life-threatening arrythmias and to renal failure from kidney stones (Meehan, 1985). Death from arrythmias can be sudden and virtually painless, but people with kidney stones often suffer severely. Human vitamin D overdose can cause increased urination, dehydration, lethargy, loss of appetite, itching, headache, nausea, vomiting, constipation, and, later, damaging calcium deposits in the kidneys, soft tissues, and vessels. Small doses of vitamin D prevent rickets in children and osteomalacia in adults.

Another recently-developed rodenticide that, like vitamin D, may be more humane than most chemical poisons, is bromethalin. As of 1984, it was not commercially available, but Meehan (1984) predicted that it may be popular in the future. Bromethalin interferes with oxidative phosphorylation and increases cerebrospinal fluid (CSF) pressure. Initial symptoms include loss of pain sensation and paralysis of the hind quarters. People with elevated CSF pressure suffer headaches and may die quickly from herniation of brain tissue.

Norbormide (Raticate) kills rats in from 15 minutes to 4 hours. Scott (1969) suggested that central nervous system effects on blood pressure and heart rate lead to fatal circulatory compromise. Roszkowski et al. (1965) noted that animals initially assume a huddled position and have difficulty walking due to weakness of the hind extremities. In the terminal stages, rats struggle, have labored breathing, and occasionally exhibit mild convulsions. Roszkowsk et al. (1965) also observed circulatory shock, but they attributed this to irreversible constriction of small vessels throughout the body. This process, documented on histopathological examination, results in fatal damage to several vital organs. Grossly, there is pronounced blanching of the extremities. It is unclear whether lack of oxygen to the heart, lungs, gastrointestinal tract and extremities, which can be painful in man, causes suffering to rats poisoned with norbormide. Scott (1969) concluded that, based on laboratory observations, rats generally die rapidly and without great suffering. Norbormide is not toxic to other animals, including mice, and it is not very effective against roof rats (Mallis, 1982).

**Humane Alternatives**

Alpha-chloralose is probably the most humane rodenticide available (Meehan, 1985). It is a sedative, initially used as an anaesthetic, which is related to chloral hydrate. It slows all physical and mental processes, leading to obtundation and death by hypothermia. Alpha-chloralose is most effective against animals that do not have large stores of metabolites and against small animals, which have a larger surface to volume ratio and dissipate heat quickly. Consequently, it is useful against mice, but it is must less toxic to rats. It requires a cool environment, and recovery is common at temperatures above 61 F. Mice may become tolerant after repeated exposures, and it is often unpalatable to target animals. Generally, it is only used indoors, because it is very toxic to birds.

Reserpine is a relatively humane poison that depletes catecholamine stores in the brain. Among its effects are prolonged sedation, which induces hypothermia (Meehan, 1985). Symptoms of sedation occur within a few hours, complete sedation takes about two days, and death usually results within the next two to three days. It is more effective for mice than rats. and it works better at lower temperatures, similar to alpha-chloralose. Clinically, physicians sometimes prescribe reserpine as an anti-hypertensive, but side effects have restricted its use. Patients may complain of abdominal cramps, diarrhea, nightmares, and, occasionally, psychic depression (Gilman et al., 1980). Poisoned animals usually have diarrhea.

Hydrogen cyanide (HCN), a fumigant, has limited use, because it is very toxic to all animals. To produce hydrogen cyanide, calcium cyanide (Cyanogas) or calcium and magnesium cyanide (Cymag) powder reacts with damp soil or air (Meehan, 1985). Cyanide blocks an intracellular enzyme needed for cellular respiration, resulting in cell death (Gilman et al., 1980). Animals die virtually painlessly in minutes. Poisoned people have complained of head- aches, and seizures are common immediately prior to death. It is likely that the animal is unconscious during these pre-morbid convulsions.

High concentrations of carbon dioxide gas produced from crushed dry ice can displace oxygen and asphyxiate animals. It may cause a sensation of shortness of breath, but death should be quick and relatively humane. Fatal carbon monoxide poisoning is nearly painless, but carbon monoxide is very toxic and may only be used outdoors. To apply, one connects a hose from the exhaust pipe of a vehicle to a rodent burrow.

**Control of Rodenticide Use**

Humanitarian concerns in England led to the Animals (Cruel Poisons) Act, 1963. This legislation outlawed most uses of several rodenticides, including strychnine, phosphorus, crimidine, and red squill. Apparently, this act was based on the overt physical symptoms of poisoned animals (Meehan, 1985). No careful studies verified that all inclusions or exemptions were appropriate. As an example of this deficiency, anticoagulant poisoning may be quite painful, but without obvious symptoms. Detailed post-mortem examinations might reveal bleeding into joints or into other areas likely to cause pain. Naturally, such research should be done only if it were needed to implement a policy of humane rodent control, not to satisfy curiosity.

**Mechanical Methods**

There are several indications for non-poisonous alternatives to the chemical rodenticides. They include biological resistance to normally effective rodenticides, "behavioral resistance" when animals inexplicably avoid the baits, abundance of other foods, difficulty placing poisons in certain structures, and dangers from chemicals to non-target animals and to people (Meehan, 1985). Sometimes, cost and convenience favor mechanical devices.

Recent refinement of glue board technology has expanded the use of glue boards. Rodents usually die of asphyxiation when they cover their faces with glue, trying to escape. They may be found alive, if the boards are checked frequently. If this happens, they could be killed relatively humanely, by being struck with a stick or, less preferentially, drowned. Usually, however, they are discarded alive into the trash. In addition, rats step onto g1ue boards tentatively, sometimes trapping one leg. They may bite off the leg or drag the board away and die later of starvation. Although effective against mice, glue boards are often inadequate for rat control. Rats are intelligent animals, which tend to avoid or throw dirt on glue boards (Mallis, 1982).

The traditional snap-traps generally kill instantly. However, non-lethal injury may occur, particularly to rats. Failure to inspect traps frequently can lead to a slow death for those animals not killed by the initial blow.

The cage traps are potentially the most humane among the mechanical de vices. As long as the cages are checked frequently, animals may be killed quickly or released unharmed to acceptable dwelling places. Mice occasionally die of stress under the best of circumstances, however (Meehan, 1985).

The "Ketch-all" trap has a spring-loaded arm than can sweep up to 15 mice into a single box. Mice often die within several hours, evidently from arrythmias induced by severe stress. Usually, however, they are alive, if the boxes are checked daily. Host exterminators apply an attachment that drowns the mice. Sometimes, mice are killed with chloroform or ether, which is painless.

Another type of trap is the leg snare. This can damage an animal's limb and cause slow death if the trap is not inspected frequently. Meehan (1984) notes that leg snares are considered inefficient and inhumane.

**Other Techniques**

There is no scientific evidence that ultrasonic devices are effective, despite claims by manufacturers. Ultrasound does disrupt rodent behavior, but several studies failed to demonstrate significant changes in rodent infiltration (Meehan, 1984). The ultrasound energy dissipates quickly from its source, and it penetrates solid materials and rat burrows poorly. Furthermore, rodents may become accustomed to the sound. Studies of electromagnetic fields designed to repel rodents have been no more successful in demonstrating gross changes in rat behavior (Mallis, 1982). Thus, these two approaches, while attractive from a humane perspective, do not appear to be practical.

Chemical attracts, which attempt to draw rodents away from certain areas, have not been shown to be effective. Repellants have also had disappointing results, because odors are not significant determinants of rat feeding behavior (Meehan, 1984). Chemosterilants can reduce rodent populations, but they are unacceptable in households, restaurants, or other areas where the presence of a single rodent is not tolerated. They may prove useful in controlling rodent populations in sewers and on farms. Some are expensive and require multiple treatments, and their effectiveness varies (Meehan, 1984). This approach may someday provide a humane solution to certain rodent infestation problems.

**Current Practices**

Many municipal and independent exterminators in Cleveland and New York, with whom this author has talked, state that, among the poisons, they use the anticoagulants nearly exclusively. For resistant rodents, they usually employ zinc phosphide, but some prefer calciferol. Exterminators often find mechanical methods more expensive, but there are situations when traps are necessary. The traps require daily checking to avoid the stench of decaying animals. Glue boards are the most popular because of their low cost and ease of application, followed by snap traps and the "Ketch-all" trap. Cage traps are large, cumbersome, and inefficient, so they are used infrequently. This discussion reflects urban rodent control and does not necessarily illustrate preferred approaches elsewhere, such as on farms or ships.

**Conclusions**

Careful investigations designed to determine pain and suffering are not available for many-rodenticides. Consequently, it is difficult to state with confidence which ones are preferable on humanitarian grounds. Clearly, there are effective and humane methods among the armamentarium against rodents. The list below takes into account both duration and severity of suffering. This author believes that those methods in groups 3 and 4 appear to cause too much suffering to be acceptable from a humane standpoint.

**Group 1: Little or no discomfort**

Alpha-chloralose

Cage traps

Carbon monoxide

Hydrogen cyanide

Reserpine

**Group 2: Possibility of moderate discomfort**

Bromethalin (Group 3?)

Carbon dioxide

Cholecalciferol, calciferol

Coumadin

Long-acting anticoagulants

Norbormide (Group 3?)

Snap traps

**Group 3: High risk of severe discomfort**

Glue boards

Gophacide

"Ketch-all" trap

**Group 4: Certain severe discomfort**

Alpha-naphtylthiouria

Arsenic

Crimidine

Leg snares

Lindane

Methyl bromide

Phosphine gas

Phosphorus

Red squill

Sodium monofluoroacetate. fluoracetamide

Strychnine

Zinc phosphide

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