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RODENTICIDES IN BUBONIC-PLAGUE CONTROL

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SYNOPSIS

The relatively recent development of more-effective pulicides has been paralleled by the discovery of more-efficient rodenticides. Eight of the latter—namely, warfarin, pival, red squill, α-naphthyl-thiourea (ANTU), zinc phosphide, arsenic trioxide, thallium sulfate, and sodium fluoroacetate (1080)—are discussed with particular reference to the criteria of effectiveness against rodents and relative safety to humans and pets. Although the perfect rodenticide has not yet been found, the authors consider that, at present, warfarin appears the most successful in domestic-rat control campaigns. However, the true value of warfarin has still to be determined, and in the meantime it is necessary to select the rodenticide and bait which appear to be most appropriate in each case. In addition, the authors point out that, if the initial poisoning has been ineffective, follow-up with a second rodenticide and bait can produce good results.

Bubonic plague is primarily a disease of rodents. Other animals, including man, become affected incidentally during the time that the infection is enzootic or epizootic among domestic or wild rodents. Transmission of the etiological agent, *Pasteurella pestis*, is ordinarily accomplished through the bite of an infective flea.[3]

Bubonic plague in rodents causes the greatest hazard to man when it is seeded into domestic-rat [a] populations. Epidemics result not only because of man's more intimate contact with rats, but also because the common rat flea, *Xenopsylla cheopis*, and related species are the most efficient known vectors of the disease. The presence of plague in wild (sylvatic or campestral) rodents is not as dangerous to man because of his less intimate contact with such rodents, together with the fact that wild-rodent fleas are generally

[a] *Rattus rattus* and *R. norvegicus*

far less efficient vectors. As a result, such contacts usually do not lead to epidemics but cause only sporadic cases.

The infection chain of rodent—flea—man has been an accepted fact for less than 50 years. The research carried out by the Plague Research Commission in India (1905-16) proved without doubt that rats were the important reservoir hosts, and that fleas were the insect vectors, of plague. Before that time, although occasional association between rodent disease and human plague had been noted, control measures were based on the quarantine and isolation of human cases, with fumigation and disinfection of the living-quarters occupied by the patients.[4] Since the definite implication of the rat and its flea, control measures have been directed logically against the rat reservoir and its flea vector. Because (*a*) wild-rodent plague is usually a rural problem causing only sporadic cases instead of epidemics, (*b*) the areas affected are usually quite extensive, and (*c*) economical methods have not yet been devised to control wild-rodent plague, the following remarks are directed especially to the control of urban, rat-borne, epidemic plague.

The successful control of epidemics of bubonic plague in man requires a reduction in the numbers of both the insect vectors (fleas) and the animal hosts (rats) to a point where transmission of the disease from rat to rat and consequently from rat to man is no longer possible. Since plague-infective fleas represent the immediate hazard to man, it is imperative that insecticides be used *early in the epidemic* in order to destroy those vectors. Because fleas acquire their infections by feeding on plague-infected rats, it is equally important that these reservoir hosts be effectively controlled in order to eliminate the source of the disease organisms.

All the rodenticides discussed here fail to affect fleas directly and therefore are not immediately effective in reducing flea populations. Accordingly, infected fleas may remain active for weeks and, in relatively cool climates, possibly for months. Therefore, in order to bring murine-based plague epidemics to a quick end, the use of effective pulicides is necessary. DDT is one of these. Follow-up with rodenticides will suppress the rat population —and, indirectly, the flea population—over a considerable period. The relatively recent development of more-effective pulicides has been paralleled by the discovery of more-efficient rodenticides. It is with the latter that we are here concerned.

At the turn of the century, it was common practice to attempt to kill rodents with concoctions containing ingredients such as ground glass or plaster of paris. Then followed a period where reasonably effective but dangerous poisons like arsenic, strychnine, and phosphorus were employed. The search for less hazardous poisons led to the introduction of red squill in the middle 1920's. Subsequent developments included new and more-potent forms of arsenic, phosphorus, squill extracts, fortified squill, and thallium. Wartime research then evolved ANTU (α-naphthylthiourea) and compound 1080 (sodium fluoroacetate), the latter having an unprecedented oral toxicity for rats. The concept that rodents could best be controlled by widespread application of chemicals with higher acute toxicity ended in the late 1940's and the stage was set for a change.[1] Warfarin was one result.

All the poisons, both new and old, available for the control of commensal rats and mice have two characteristics in common : (*a*) they kill when given in single doses of appropriate strength; (*b*) they cause, to a greater or lesser extent, an acquired bait-refusal (bait-shyness) in animals which happen to take a small dose so that they are only sublethally poisoned. Many of the poisons also share a third characteristic: they are about as dangerous to man and domestic animals that happen to take a single dose, as they are to rats.

Because of these characteristics, many efforts in the past have been directed towards :

(*a*) discovering more-toxic substances of such bland taste that rats would seldom fail to take a lethal dose the first time they encountered the poison;

(*b*) discovering materials to disguise the taste of the poison, or attractants to induce rats to take more bait or to take it more surely;

(*c*) discovering more-effective techniques of pre-baiting; or

(*d*) combining emetics with the poison in order to make it less hazardous, especially to man.

None of the efforts has been strikingly successful.

Some of these considerations led O'Connor to state the requirements for an ideal rat poison. These characteristics, somewhat modified, are as follows :

(*a*) the poison must be surely effective when incorporated into baits in such small quantity that its presence is not detected to an interfering degree;

(*b*) the finished baits containing the poison must not excite bait-shyness in any way and the necessity of pre-baiting must, thereby, be avoided;

(*c*) the manner of death must be such that surviving individuals will not become suspicious of its cause, but will remain on the premises and eat freely of the bait until they themselves die; and

(*d*) the poison, in the concentration used for control, must be specific for the species to be destroyed unless its use can be made safe for man and domestic animals by some other means.[2]

Descriptions of eight of the common rodenticides follow.

1. *Warfarin*

WARF-42; compound 42; warfarin

Chemical name : 3-(α-acetonylbenzyl)-4-hydroxycoumarin

Warfarin belongs to a class of anticoagulant compounds of which dicoumarol is the most widely known. Warfarin prevents or reduces clotting of the blood when consumed over a period of several days. In most cases, the chemical produces painless death to animals by causing internal bleeding. Warfarin will not give effective control when applied in a single dose. It must be ingested several times (usually five or more) on successive days. These feedings need not be on consecutive days, but should occur within a 10-day interval with no period longer than 48 hours between feedings.

Warfarin would probably kill any warm-blooded animal if consumed in sufficient quantity over a prolonged period. However, the poison concentration in baits recommended for rat and mouse control (0.025%) is so low that there appears to be a minimum of danger to other animals.[6] The following total doses are required to kill :

Rodent	*Total dose of warfarin*
Norway rat	4 mg
Roof rat	20 mg
House mouse	10 mg

Warfarin is packaged either in the final bait form or as a 0.5% powder with corn-starch as the diluent. This concentrate is suitable for mixing with additional bait such as corn-meal, bread-crumbs, or rolled oats.

The following bait mixtures by weight are suggested as all-purpose baits for rats and mice : [5]

(*a*)	Corn-meal	65%
	Rolled oats	20%
	Powdered sugar	5%
	Vegetable oil	5%
	Warfarin (0.5% concentrate)	5%
		100%
(*b*)	Corn-meal	45%
	Rolled oats	45%
	Vegetable oil	5%
	Warfarin (0.5% concentrate)	5%
		100%

In general, any available cereal bait acceptable to rats and mice is recommended for use with warfarin. These may be used separately or mixed. Good grade, freshly ground or rolled, grains are more effective than poor grade grain. Warfarin has been used successfully in the field against Norway rats with the stock (0.5%) mixture used at the rate of 1 part by weight to 90 parts of corn-meal. One part to 45 parts of corn-meal is very effective. It has been used successfully against roof rats at 1 part to 30 parts of corn-meal. Where cost or availability of material is a problem, these dilutions may be resorted to. The greater dilutions do, however, demand very thorough mixing to ensure a proper distribution of the poison in the grain.

Powdered sugar may be undesirable in areas where it attracts ants.

The danger to other animals may be reduced by the use of protective cover for baits that will permit free access by rats and mice, but which will exclude larger animals.

Baits are placed at or near places where rats are accustomed to feed. Since baits must be available continuously, each station should be checked fairly frequently in order to replenish bait as needed. Bait should be left out for at least a week for best results.

A water-soluble form called warfarcide has recently become available and appears to have promise in mills and other premises where there is either little other water available to rats, or where grain and grain products are as attractive as, or more than, any dry bait available. It appears to be more effective against Norway rats than against roof rats.

2. *Pival*

Chemical name : 3 pivalyl-1,3-indandione.

Pival is a fluffy, yellow powder with a slightly acrid odour suggestive of tobacco. It is available in two forms : the sodium salt which is soluble in water, and the keto form which is essentially insoluble in water.

The keto form is obtainable for general use as a technical powder and, like warfarin, as a 0.5% mixture with corn-starch. The water-soluble form has, as of 1 June 1953, not been released except for experimental purposes. It is undergoing field tests.

Its lethal action is somewhat similar to that of warfarin ; when death takes place after several doses over as many days, haemorrhagic signs and symptoms occur. Large single dosages, which cause death in rats, are attended by pulmonary and visceral congestion, usually without haemorrhagic lesions.

Relatively little experience is available concerning desirable concentrations. Recommended bait-poison mixtures, dosages, and exposure are similar to those for warfarin. Two hundredths and 0.01% of pure pival in dry bait are suggested as suitable mixtures.

3. *Red-squill powder and extract*

Baits with fortified red squill or liquid squill extract are still widely used in the USA. With the exception of warfarin, they are the safest of all the rodenticides and the only ones to be used by the public or without expert supervision. Red-squill products are derived from the bulb of *Urginea maritima (Scilla maritima)* which grows principally along the Mediterranean coast. It has been employed as a rat poison for many years ;

first, the powder from dried bulbs was used, and later, the powder was fortified to yield a product of higher and more reliable toxicity.

The more desirable property of red squill is its emetic action. It is an almost specific poison for rats, since they are unable to vomit. This is also the case with sheep and goats. Most animals, other than rats, refuse to eat squill baits; even starved hogs had to be force-fed. Sick or weak pets or other animals may be killed by spasms of vomiting after eating squill baits. It is recommended, therefore, that squill baits should be placed where other animals will not have access to them.

Red squill has a sharp, unpleasant taste, and causes irritation of the skin. Apparently this feature is not objectionable to rats, but those receiving a sublethal dose of squill apparently remember its taste, and usually are wary of taking additional squill baits. Acceptance will be poor if the baits contain more than 10% by weight of squill.

The present standard toxicity of powdered squill is 500-600 mg/kg, although squill fortified to 200 or 250 mg/kg is now becoming available. Manufacturers have considerable difficulty in obtaining a uniform final product that will conform to the standard bio-assay printed on the label. Usually the material will be effective against rats in smaller amounts than the 10% by weight recommended for 500-600 mg/kg squill, but some batches will not kill even at double dosage. For large-scale effective operations, each batch of squill should therefore be tested on live rats before the stated toxicity is accepted. Only fortified red squill which has been bio-assayed by the manufacturer and found to have a toxicity of 600 mg/kg, or more, should be purchased.

Squill can be used successfully with all food baits which can be ground finely and mixed thoroughly with the rodenticide. It is not satisfactory on cubed fruit or vegetables because these materials will not take up enough squill to kill rats.[7]

4. *Alpha-naphthylthiourea*

This compound, commonly known by the abbreviation ANTU, was developed in 1942 but did not become available to the public until 1945. With the exception of warfarin and red squill, it is perhaps the safest rodenticide and, excluding 1080, is the most toxic to Norway rats. It kills by an overproduction of fluid in the lungs, death usually occurring within 48 hours. The lungs of rats develop an acute dropsy and an accumulation of fluid, causing death by drowning or pulmonary oedema. Animals surviving for 72 hours or longer give no evidence of excessive lung fluids but may develop fatty degeneration of the liver. Young Norway rats have a greater natural resistance to ANTU than adults. ANTU is unique in three respects :

(1) It is effective against the Norway rat, but not against the roof rat or the common house mouse.

(2) Rats taking a sublethal dose of ANTU quickly develop a strong tolerance for subsequent doses up to as much as 50 times the normal lethal dose. This tolerance diminishes in time, but may last to some degree for as long as six months.

(3) ANTU can be utilized either in baits or in tracking dusts.

Repeated field and laboratory tests with this compound have given good kills of Norway rats, but have rarely killed roof rats; hence ANTU is not recommended for the latter species. Whereas some rodenticides produce a cumulative poisoning of rats and others leave no after-effects, rats recovering from ANTU poisoning have a definite tolerance for greater doses of ANTU. This is important to those planning to use ANTU because it indicates that the poison should not be repeated for a considerable time, preferably at least six months.

The toxicity of ANTU to man is unknown, but is believed to be low on the basis of the value for rhesus monkeys (3,500-5,000 mg/kg). Other thioureas, equally toxic to Norway rats, have been used to test the taste senses of humans without ill effects. ANTU is very toxic, however, to cats, dogs, hogs, and baby chicks. This poison may have a slight emetic property, causing some dogs or cats to vomit before being seriously affected, but this cannot be relied upon.

The safest but the most expensive way to use ANTU is as a tracking poison in dust containing 20% ANTU and 80% pyrophyllite or some other inert powder. If rat-flea control is also desired, a dust of 20% ANTU, 8% DDT, and 72% pyrophyllite may be used against both Norway rats and their fleas. Recent experiments, however, indicate that only about 41% of the Norway rats in buildings were killed with this mixture. The tracking poison is applied as dust patches in rat runs, burrows, harbourages, and holes. This results in the death of a rat after it has walked through the patches. Patches should extend for about three feet (approximately one metre) along a runway. Death is believed to result from ingestion of enough poison by the rat when cleaning its hair and feet. The use of ANTU in patches is expensive, and this method may be reserved for places otherwise difficult to clear of Norway rats. ANTU is generally ineffective against house mice, but DDT-ANTU dust mixtures have killed nearly 70% of them in field experiments.

In poisoned baits, 2% or 3% of ANTU by weight is inexpensive and effective. In business establishments where any toxic poison would be safe, ANTU with any acceptable bait may be expected to kill Norway rats. Since ANTU is almost insoluble in water, poisoned bait may be floated on the water surface. The safest bait for city-wide programmes is probably finely ground corn or other grain which is not usually eaten by either cats or dogs. ANTU may be dangerous to livestock or young poultry on the farm, and its use there should be limited to burrow treatment or judiciously placed tracking patches. The toxicity seems to depend a great deal on particle size, better kills being obtained with ANTU having a particle size of 100 μ (0.004 inch).[7]

5. *Zinc phosphide* (Zn_3P_2)

This rodenticide has been used for many years and is a toxic and effective rat-poison. It is safer than phosphorus paste because it creates no fire hazard. Zinc phosphide is a black powder, slightly soluble in water, and with a distinctly disagreeable odour which does not repel but may attract rats. It is safer than the other highly toxic rodenticides because both its odour and colour are objectionable to man and pets. Zinc phosphide has a toxicity of about 40 mg/kg for rats. It is used 1% by weight in baits which must be thoroughly mixed because of the small amount required. It may be mixed with cereals or meat, as are other poisons. It is also exceptionally well suited for coating cubes of fresh fruit, vegetables, or coconut meat. An even, grey-coloured coating will be observed over all surfaces when mixing has been adequate. Baits may be prepared by placing cubed materials and zinc phosphide, after each has been carefully weighed, in an ordinary bucket. The bucket is then given a rotary motion until all cubes are evenly coated, and no loose poison remains in the pail.

Zinc-phosphide baits should be used only in those establishments where a toxic poison will be safe. It can be employed relatively safely outdoors if tartar emetic is mixed with it. A proportion of 3 parts of emetic to 8 of zinc phosphide should be used. If 1,000 g of bait are desired, the amounts would be 10 g of zinc phosphide, 3.75 g of tartar emetic, and 986 g of bait. Zinc-phosphide—tartar-emetic baits should be alternated with red-squill baits in poisoning programmes, because successive poisonings with red squill will yield progressively poorer kills.[7]

6. *Arsenic trioxide* (As_2O_3)

This poison, known as white arsenic or arsenious oxide, is a white, crystalline powder rather insoluble in water (2.4%). The best type for a rodenticide is finely ground or micronized powder. Arsenic trioxide has a gritty taste, which may be detected by rats, thus reducing its acceptance. The toxicity to rats is 50-150 mg/kg depending on the fineness of the powder, and the usual concentration in bait is 3% by weight. Water may be poisoned with arsenic trioxide, but it is necessary to heat the water to boiling-point and to stir it for a considerable time. The maximum strength in solution after the water cools will be 2.4% arsenic trioxide. Sodium arsenite (Na_2HAsO_3) is more soluble in water than is the trioxide but should not be used in stronger concentration than 3%. White arsenic is inexpensive and slow-acting, but dangerous. It should be used with tartar emetic in a ratio of 3:1.[7]

7. *Thallium sulfate* (Tl_2SO_4)

This poison has also been used for many years as a rodenticide. It is highly effective in poisoned water or food baits against both species of rats. It is a very heavy, white crystalline powder, which is fairly soluble in water. Thallium sulfate is a slow-acting, cumulative poison. It is also the only rodenticide discussed here that can be readily absorbed through the unbroken skin. ALL WORKERS HANDLING OR MIXING THALLIUM SULFATE SHOULD WEAR RUBBER GLOVES. Thallium sulfate has no distinctive odour or taste to humans and thus it is dangerous to use. Another disadvantage is its cost. Although 1.5% of thallium sulfate by weight is generally advocated for use in baits, recent tests by the Public Health Service have indicated that a concentration of 0.5% is equally satisfactory. Where safe to use, thallium sulfate may be mixed with any bait or dissolved in water. In routine poisoning it should never be used unless tartar emetic in a proportion of 2:1 is added. Its toxicity and effectiveness are about twice that of zinc phosphide, but it is more dangerous.[7]

8. *Sodium fluoroacetate*

This compound, commonly known as 1080, was developed as a rodenticide in 1944. It is without exception the most poisonous rodenticide now available, but it is also among the most dangerous to all warm-blooded animals. The LD_{50} toxicity of 1080 to rats is 3-7 mg/kg for *R. norvegicus*, and 1-4 mg/kg for *R. rattus*. Only 2.5 mg of 1080 are required to kill 50% of Norway rats each weighing about 1 pound (approximately 0.5 kg). The same dose would kill a 25-pound (11.5-kg) dog or a 10-pound (4.5-kg) cat. The lethal dose to humans can only be estimated, but based upon data for the LD_{50} of rhesus monkeys, a 15-pound (7-kg) child might be killed by ingesting 35 mg of 1080. A half-ounce (14-ml) cupful of 1080 water, as used to poison rats, contains 50 mg of 1080, or more than enough to kill a 15-pound child. Children have died from chewing paper-cups from which the water has evaporated.

Compound 1080 is a light, white (in the natural state), crystalline compound, odourless and tasteless, very soluble in water, but practically insoluble in oils. Compared with other rodenticides, it is fast-acting, usually producing symptoms in rats in 20 minutes or less and killing in 1-8 hours. Rats surviving sublethal doses of 1080 usually recover fairly completely within 24 hours, but recent tests indicate that some show symptoms for longer than three days. The poison is apparently not cumulative, and rats show neither aversion to, nor serious tolerance of, 1080. This poison acts chiefly on the heart, with a secondary effect on the central nervous system. Death usually results from heart failure following ventricular fibrillation. Convulsions may result from the action on the nervous system. Because 1080 has been used so successfully and the dosage can be more easily controlled in water than in food baits, it is recommended that it be used *only* in poisoning water, and not in food baits for domestic rats. Since solid baits are frequently carried by rats and may not be found for recovery, they are a menace to children, pets, and livestock. The concentration should not be more than 12 g of 1080 per US gallon [b] (3.2 g per litre) of water. Recent tests showed 12 g and 14 g per US gallon (3.2 g and 3.7 g per litre) to be essentially equal in effectiveness, and for safety the smaller concentration is recommended. Where only roof rats or mice are present, the concentration may be only 7 g per US gallon (1.8 g per litre). Individual cups to contain poisoned water should not be larger than three-quarters of an ounce (21 ml) in capacity, and no more than half-filled. The paper-cups should be waterproofed, clearly marked with a red skull and cross-bones, stamped " 1080 ", and dyed an unattractive brownish colour. This poison is effective against Norway rats, roof rats, and house mice. Many more rats (50%-100%) are recovered after the use of 1080 than with any other rodenticide (less than 50%). This apparently is because rats are not aware of any danger and the poison practically immobilizes them as soon as symptoms of poisoning develop. The morning after a 1080-poisoning, dead rats are frequently seen within 4-10 feet (1.2-3 m) of the water containers. More than with any other poison, however, it is important to search for all the dead rats, since it has been determined that 1080 remains in their carcasses and even after these have decayed and dried the poison is still toxic to other animals.

Cats, puppies, and hogs are in danger of poisoning by 1080 as they frequently eat dead rats. Several cats were killed in one instance, one of them obtaining the poison third-hand. In another case, a puppy was killed after chewing on a dried rat carcass. If the dead rodents are not collected, they may be eaten by foraging hogs or fed to them in garbage.

Compound 1080 is not available to the general public, its sale and use being limited to research workers, government agencies (city, county, State, and Federal departments), and pest-control operators. This poison should never be sold or given to persons other than those mentioned above. With certain other rodenticides, the work of several crews can be directed by one trained supervisor, but each crew using 1080 must be under the direct supervision of a trained person at all times.

This rodenticide should be coloured to distinguish it from white, powdered food products. Nigrosine, a black, water-soluble dye, is now being incorporated in the powder by the manufacturer. Experiments, incomplete at present, indicate that acceptance to rats is not materially reduced by the dye. The safety factor of the warning colour more than offsets any loss in acceptance by rats.

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[b] 1 US gallon = 0.832 Imperial gallon

A complete check on all steps from the preparation of poisoned water to the final incineration of used cups and dead rodents is essential if accidents are to be avoided. THERE IS NO KNOWN ANTIDOTE FOR 1080 POISONING.[7]

Discussion

The following tabulation gives a comparison between effectiveness against rats and relative safety to pets and humans :

Rodenticide	*Recommended concentration in food baits (by weight) (%)*	*Relative safety to pets and humans*	*Relative effectiveness against rats*
Warfarin	0.025	2	2
Red squill (400-500 mg/kg)	5-10	1	7
ANTU	2-3	3	6
Zinc phosphide	1	4	5
Arsenic trioxide	3	5	4
Thallium sulfate	0.5	6	3
Sodium fluoroacetate . .	0.32	7	1

In regard to safety, warfarin and red squill are the only poisons which can be handled without hazard by untrained personnel.

It still remains true that the perfect rodenticide has not been found. Warfarin fits O'Connor's criteria more closely than any other. Time and extensive field application will determine its true value. In the meantime, it is still necessary for those interested in achieving rat control to select the rodenticide and the bait which appear to be most applicable under the conditions prevailing in the area to be controlled. Follow-up poisoning with a second kind of rodenticide and bait material may be indicated in many instances; this has brought about good results in cases where initial efforts with one rodenticide have been ineffective. Rodenticides have an important part to play in the control of bubonic plague, following appropriate action against fleas by means of the application of insecticides.

RÉSUMÉ

Ce sont les puces infectées de peste qui représentent pour l'homme le danger immédiat; aussi faut-il recourir aux insecticides dès le début d'une épidémie afin de détruire les vecteurs. Il s'agit ensuite de s'attaquer aux rats qui hébergent les puces et d'en supprimer un nombre suffisant pour empêcher que l'infection se perpétue. Les recherches se sont poursuivies dans ces deux directions et, au cours des dernières années, on a mis au point des pulicides plus efficaces et des rodenticides plus actifs.

Au début du siècle, on ajoutait aux appâts destinés aux rats du verre pilé ou du plâtre de Paris. Plus tard, on utilisa l'arsenic, la strychnine et le phosphore. Des composés arsenicaux et phosphorés toujours plus actifs, la scille rouge, les sels de thallium furent essayés; ensuite furent introduits l'ANTU (α-naphtylthio-urée) et le 1080 (fluoracétate

de sodium). Vers 1940, l'orientation des recherches se modifia. Après avoir eu recours à des composés hautement toxiques pour tous les êtres vivants — et de ce fait dangereux pour l'homme et les animaux domestiques — on a mis à l'étude un autre groupe de substances, les anticoagulants, qui, ingérés à doses répétées durant quelques jours, empêchent la coagulation du sang et causent la mort des rats par hémorragie interne.

L'auteur décrit en détail huit des rodenticides les plus efficaces : deux anticoagulants — warfarine et pival —, la scille rouge, l'ANTU, le phosphure de zinc, le trioxyde d'arsenic, le sulfate de thallium et le 1080. Il examine la toxicité de chacun de ces produits pour les rats et pour les êtres humains chargés des manipulations, et expose les méthodes d'application les plus efficaces. Il indique, dans un tableau, par des coefficients, la toxicité relative de sept rodenticides, pour les rats d'une part et pour l'homme d'autre part, ainsi que les concentrations à ajouter aux appâts. La warfarine et la scille rouge sont les seuls de ces rodenticides qui puissent être manipulés sans risque par du personnel non qualifié. Le 1080 est le composé le plus toxique pour les rats et le plus dangereux pour l'homme (35 mg suffisent à tuer un enfant). Le rodenticide parfait est encore à trouver. Pour le moment, ce sont les anticoagulants qui possèdent le plus de qualités. Des essais pratiques en grand et l'expérience permettront, avec le temps, de juger de leur réelle valeur. Pour l'instant, il faut choisir, dans chaque cas, le rodenticide le mieux approprié aux conditions locales. Il peut être indiqué d'employer successivement deux rodenticides lorsque le premier n'a pas donné satisfaction, ainsi que différents appâts.

REFERENCES

1. Dykstra, W. W. (1951) *Anticoagulant-type rodenticides* (unpublished paper presented at the National Pest-Control Convention, Boston, Mass.)
2. Hayes, W. J., jr. & Gaines, T. B. (1950) *Publ. Hlth Rep. (Wash.)* **65**, 1537
3. Link, V. B. (1951) *Amer. J. trop. Med.* **31**, 452
4. Link, V. B. (1951) *Publ. Hlth Rep. (Wash.)* **66**, 1466
5. *Rodent and Predator Control News*, 1950, No. 1 (USDI Fish & Wildlife Service)
6. *Tropical Medicine and Hygiene News*, 1952, **1**, 14
7. US Public Health Service, Communicable Disease Center (1949) *Rat-borne disease prevention and control*, Atlanta, Ga.