

WHAT HEALTH OFFICERS CAN DO TO PROMOTE RAT EXTERMINATION

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Rats are a civic reproach and a sanitary menace of the first magnitude, not merely an unavoidable economic burden. Health officers everywhere must be active because civilization demands the coöperation of all forces in the removal of the rat menace to health and well-being. This paper outlines well-digested plans for efficient warfare on the rat.

WHILE the rôle of rats as carriers of disease is only partly determined, sufficient is known to mark these animals everywhere as perhaps the greatest single menace to the health of the human race. From their original Old World habitats they have accompanied man in his migrations, and have infested his habitations or their vicinity in spite of measures taken against them from time to time, until they now are firmly entrenched as human parasites, and they maintain this repugnant relation with a tenacity truly remarkable.

ENDEMIC PLAGUE AN AMERICAN MENACE

The best-known rat-transmitted disease, bubonic plague, has caused the deaths of millions of people since the beginning of the Christian era. This disease carried from endemic centers in the Old World manifests itself by periodic and alarming outbreaks, and evidences a tendency to form endemic centers of contagion even in America. Bubonic plague is ordinarily transmitted by fleas which have become infected from rats.

Aside from bubonic plague, rats are known to be involved in the transmission of trichinosis, infectious jaundice, and rat-bite fever, and owing to their filthy habits they are potential agents in the

distribution of many other diseases, their exact relation to which remains an important field for laboratory investigation. Infectious jaundice is probably due mainly to rat contamination of food, except possibly in certain Asiatic countries where some recent evidence suggests that poorly-shod natives, especially in coal mines, also receive the spirochætal infection directly through the skin. This disease has been generally associated with armies holding rat-infested trenches along stabilized war-fronts, hence the name "trench jaundice," also commonly applied to it.

Bubonic plague, or a plague-like disease, has been communicated probably through use of the same burrows to ground squirrels (*Citellus beecheyi*) and wood rats (*Neotoma fuscipes*) in California, and the infection is reported* to have been detected in a rice rat (*Oryzomys palustris*) at New Orleans. The ground squirrels and wood rats are widely distributed, especially in the western United States, and the rice rats occupy parts of the Mississippi Valley and much of the Atlantic seaboard from Texas to New Jersey. It should be borne in mind that the house rat, along

*Williams, C. L., Amer. Jour. Public Health, vol. 10, No. 11, p. 868, November, 1920.

with the wood rat, the rice rat, and various other indigenous American forms, belongs to the murine family, and if plague among these animals is allowed to progress unchecked it may also reach our woodchucks (*Marmota*), which with our numerous ground squirrels are closely allied to Asiatic rodents believed to be natural enzoötic hosts.

Under ordinary conditions rats tend to keep pace in numbers with the increase and congestion of the human population, an aggravating modern factor. Unless house rats are controlled the probability of the establishment in America of plague centers very difficult to eradicate and from which epizootic outbreaks would lead to wide-spread human mortality seems reasonably certain.

LIFE HABITS OF RATS

Some knowledge of the life habits and practical methods to be employed in the control of rats is essential and should be acquired by every health officer. In fact instruction in this branch might well form a part of the curriculum of every public school, until rats are no longer commonly regarded as an unavoidable evil.

Two species of rat, somewhat different in habits and both potential carriers of bubonic plague and other diseases, are to be dealt with. These are the brown rat (*Rattus norvegicus*) and the black rat (*Rattus rattus rattus*), of which the so-called "roof rat" (*Rattus rattus alexandrinus*) is merely a variety. The brown rat, usually the more important of the two in America, is, excepting in certain individuals in a peculiar black color phase, readily distinguished from its congeners by general brownish color of back, in combination with larger size, more robust form, smaller ears, and relatively or actually shorter tail. In adult brown rats the hind foot usually measures over 40 mm., and the tail is shorter than the head and body together, while in the black species the reverse is true. The brown rat is largely a burrowing animal

and lives mainly near the ground, especially in the vicinity of water, where its holes and well-beaten paths are often much in evidence; the black species, a more expert climber, is more apt to inhabit the roofs or upper floors of buildings, and is usually the more abundant of the two aboard ships. Where food supplies cannot be isolated the importance of killing the early arriving individuals by any possible means will become more evident when it is remembered that the period of gestation is only three weeks, and that a female brown rat three months old is likely to bear and may be expected to produce 6 to 10 young at a birth under ordinary climatic conditions. Litters, however, commonly contain more than ten. Rats probably produce ordinarily from three to five litters in a year, but where food and shelter are abundant the number of litters is increased.

Computations based on the assumption that rats breed only three times in a

FIGURE 1



One of thousands of well-defined rat paths leading from garbage dump into grain fields. By the number of such paths and holes with which they connect, the health officer may estimate the degree of infestation.

year, with average litters of 8, divided equally by sexes, with no deaths, reach the astounding total increase for a single pair and their progeny in three years to over 3,900,000 individuals. The mortality rate is obviously high or rats would soon literally overrun the earth.

RAT PREVENTION

All efforts to control or exterminate rats should be aimed at one or both of the two vital elements, food and shelter. Eliminate either of these completely and the problem is solved. Reduce either of these elements materially and a corresponding diminution of the rat population normally results. Rats are omnivorous and are soon attracted to any accessible food supplies, and if shelter is also available they very quickly build up large colonies.

Much has been written on modern rat-proofing methods, and these cannot be too strongly stressed, but only the general principles involved need be stated here. Traps, poisons, and other effective agents in rat destruction will be of little permanent value in most localities unless food warehouses are so constructed as to bar the entrance of these animals, and food supplies made inaccessible everywhere. Rats kill young chickens, and for this reason and to eliminate shelter for them, poultry houses, barns, and all out-buildings should be carefully closed to them. No garbage or trash piles should be allowed to accumulate in the vicinity of stores, markets, or human habitations, and loose material should be kept cleared away as far as possible. The rat-proofing of structures should precede or at least accompany all rat-killing campaigns.

In one of our great army depots in France millions of dollars' worth of supplies attractive to rats were stored in temporary structures, where under stress of war conditions rat-proofing was out of the question; but from the beginning the policy was adopted of keeping the ground as clear as possible in and about

the buildings and of turning over at intervals the great stacks of food supplies. This depot was located in the interior of the country with no heavily infested area near, but the district was well settled and rats in usual numbers were living about neighboring farms. A few, as might be expected, entered the depot of their own accord, and others were carried in with freight shipments from the base ports and in cars returned from the front. Although food supplies were easily accessible, the number of rats gaining a foothold in the depot was almost negligible. The importance of eliminating rat-harborage was strikingly demonstrated.

EFFICIENCY ESSENTIAL IN RAT CONTROL

The vital importance of eradicating rats being obvious from the sanitary as well as from the economic viewpoint, the practical problem is how to deal with the pest most effectively. All health officers, Federal, state, or municipal, should devote especial attention to rats, and be prepared to deal in the most efficient manner with the varying conditions encountered.

As a preliminary measure rats should be prevented from landing at the ports. All vessels should be fended off at least 6 feet from docks; all shore lines should carry metal discs 4 feet in diameter, to block the passage of rats; gangways should be raised; and other shore connections severed as far as possible at night. In addition all ships and cargo should be thoroughly treated as often as practicable with hydrocyanic acid gas or some other effective fumigant. In spite of all precautions, however, some rat stowaways are sure to find their way ashore, but by eliminating food and shelter, conditions should be made as uncongenial for them as possible.

The methods to be adopted in each locality or rat-infested center should be based on local examinations, as a physician diagnoses cases, and the remedy prescribed in accordance with conditions prevailing. Rat warfare is costly and

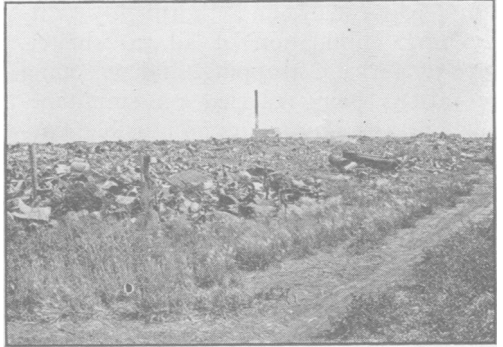
much time and money have been wasted in misdirected or inefficient methods of attack. Success will most readily be achieved where there is proper organization and where concerted efforts are based on definite plans persistently carried out. Little of permanent value will result from even a wholesale destruction of rats in a given locality if the rat-proofing of premises is neglected and neighboring areas remain heavily infested.

Rat campaigns should be organized and directed by sanitary officers familiar with the best methods and thoroughly trained in such work, all governmental agencies coöperating as fully as possible. These officers should be assisted by a corps of the most competent men obtainable, and provided with the necessary supplies in ample quantities.

The first step should be the division of the area to be treated, whether a city, county, or state, into districts the size of which will vary with local conditions and available personnel and equipment, the total area to be the largest that can be effectively handled as a unit. District

leaders should be then assigned and a district organization perfected, the men employed in destruction work being chosen with due regard to fitness. In general they should be men with a natural aptitude or liking for such work.

FIGURE 2



City garbage dump maintaining thousands of rats surrounding incinerator that proved to be a failure owing to poor construction.

At the same time a publicity service or educational campaign should be carried on by means of posters, through local newspapers, and with the aid of well-informed public speakers if possible, the

FIGURE 3



Another view showing one day's accumulation of refuse and garbage in same place. From this dump thousands of rats invaded adjoining grain fields and many passed on into the city seen in distance, until controlled by use of barium carbonate under the direction of the Bureau of Biological Survey.

aim being to focus the attention of the public on the objects of the work, and enlist local interest and coöperation, especially in the formulation and enforcement of the necessary ordinances covering garbage disposal and the construction and rat-proofing of buildings.

The work once begun should be prosecuted vigorously and thoroughly, rat-proofing, elimination of all rat shelter, care of garbage, trapping, and poisoning operations being carried on simultaneously at as many points as possible, covering in a general way the entire area. There is a popular prejudice against the use of poisons, but where rats are present in large numbers recent experience has indicated the advisability of their employment under properly controlled conditions. The use of gases also may safely and advantageously be resorted to in places, the object being to neglect no destructive agent that will facilitate or hasten the extermination of the enemy. The bacteriology of plague and other rat-borne diseases should be thoroughly understood and a standardized technique covering the determination of these developed by a competent staff. Laboratory studies should be systematically carried on, especially in every large seaport in the country, in order to anticipate epidemics and furnish a record of progress in dealing with this phase of the work.

SYSTEMATIC TRAPPING EFFECTIVE

One of the best-known methods of destroying rats is systematic trapping, in the direction of which every health officer should be an adept. This means usually the placing of traps in considerable numbers and in accordance with definite plans. If the area to be covered is large and the rats numerous thousands of traps may be required. Much time and effort is frequently wasted in desultory trapping at poorly-chosen points, or with traps of an ineffective type. In a properly organized campaign, traps will be set at fairly regular intervals in places most likely to be visited by rats, depending of course upon the degree of infestation. In general these will be at or near

entrances to buildings, or to rat burrows, along walls, or wherever there is evidence that rats are in the habit of passing.

Where traps are being placed in large numbers, some system of marking their location, depending upon local conditions, should be adopted in order to save time and the loss of traps. In or about warehouses numbers marked in chalk may often be used, and traps should be visited in the same order in which they were set.

The use of cage traps may be desirable in places in order to secure material for laboratory examinations, but for general destruction work snap traps of several designs are much more effective. The particular type of snap trap chosen should be one in which the trap will be sprung by a rat in passing and the animal caught regardless of whether it was attracted by bait. This is best accomplished by selecting a trap combining some means of fastening bait with a low, fairly broad treadle or an elevated wire released by the animal in passing underneath. Barrel or pit traps and similar devices may be used to advantage for catching rats under special conditions, but they are usually clumsy in operation and unless the animals are very numerous the results are apt to be disappointing and out of proportion to the efforts expended.

A striking example of results that may be attained by systematic trapping was furnished at the Bush Terminal Warehouses in Brooklyn, New York. These warehouses, extending for a length of 11 city blocks, with a depth of from one to three blocks, were taken over by the Government for war purposes and were found to be infested with thousands of rats. At it was planned to use them for carrying a 30 days' supply of subsistence and clothing for the overseas forces, the need of protection against rats was obvious. At the request of the quartermaster officer in charge, a representative of the Bureau of Biological Survey, U. S. Department of Agriculture, was detailed in January, 1918, to inspect the buildings and to recommend methods of

controlling or eradicating the rats. Six or eight gross of snap traps recommended were purchased and four men set to work placing them, with the result that each day's catch was at first more than a barrelful. At the end of the year the officer reported that the rat-catching campaign, persistently carried on, had reduced the rats to a negligible number and an inventory of supplies on hand when the warehouses were 90% filled showed no damage by rats except an occasional gummed label gnawed from the outside of a box. He estimated that between 35,000 and 50,000 rats had been killed and that the military stores destroyed had not exceeded \$50 in value.

VALUE OF POISONS

A popular prejudice against the use of poisons in killing rats is well founded, as the danger of accidents cannot be over-emphasized. With supervision by health officers familiar with their effects, however, the use of certain poisons under favorable conditions is strongly recommended, owing to the large number of animals that may be easily and quickly destroyed. And poisons may often be very advantageously employed at the beginning of a rat-killing campaign which is to be continued by the use of traps.

It often has been the experience of health officers that many poisons, when mixed in killing proportions with food, are readily detected by rats and that the baits are apt to be avoided. The epicurean tastes of rats are well known, and the problem is, therefore, to find baits sufficiently attractive to insure the ingestion of a fatal quantity of poison.

Barium carbonate is apparently less repugnant to rats than most poisons, and when properly administered is exceedingly effective. It possesses also the advantage of cheapness, and if reasonable care is exercised there is little danger from it to human life. Owing to these marked advantages over most other poisons, its general use, wherever warranted by local conditions, is advocated in bulletins containing directions,

issued by the Bureau of Biological Survey, U. S. Department of Agriculture; it is also being exploited commercially on a considerable scale.

The effectiveness of barium carbonate as a rat poison may be judged by some recent commercial demonstration work carried on with the consent and under the supervision of the local health officer in Center Market, Washington, D. C., which covers an area of about one city block. The bait employed was composed of a finely-chopped and very wet mixture of oatmeal, chicken entrails, fish heads, and cooked sweet potatoes, to which was added powdered barium carbonate amounting to 15 to 20% of the whole. At closing time on the evening of October 10, 1920, a tablespoonful of this prepared bait was placed on each of about 500 small wooden butter trays, which were distributed on the floor, where rats are likely to pass, throughout the market. Next morning* 48 dead rats were picked up and photographed, and while 37 others are known to have been killed, the record of the total number destroyed is doubtless incomplete. A significant feature of this work was the fact that the baits were sufficiently attractive to rats, although placed in the open market near easily accessible general food supplies of many kinds.

In connection with the use of barium carbonate, the desirability of placing very wet baits is emphasized, as they seem to be more acceptable in this condition, and some of the poison adhering to the feet of rats is apt to be licked off and swallowed.

Phosphorus is another poison which has been employed successfully in the hands of health officers in rat-killing campaigns, but unless skillfully prepared it may be highly inflammable and therefore dangerous, especially to wooden construction.

*A picture of this killing of rats has been presented in the *News Letter* for February, 1921. The poison was, however, inadvertently stated to be barium chloride instead of barium carbonate.

USES OF GASES

The importance of checking rat immigration at the ports is now generally recognized by health officers, and cannot be too strongly stressed. Stringent quarantine regulations rigidly enforced, and systematic and complete destruction of rats on board ships, are the best insurance against the entrance of plague. For this purpose hydrocyanic acid gas, also used extensively as a highly effective insecticide, is gradually replacing sulphur dioxide, over which it has so many advantages that the two should no longer require comparison. Exposure to this gas is, however, so quickly fatal to all animal life that competent direction of the work is essential as a safeguard against accidents.

Because of its volatility, hydrocyanic acid gas is adapted to use in places capable of being tightly closed, such as the hold or spaces between the bulkheads of a ship. In contrast, heavy gases, such as that generated by carbon bisulphid, may be employed to excellent advantage in treating burrows of brown rats. It is suggested that some of the heavy gases developed for war purposes might be utilized in the destruction of brown rats on a large scale in the sewers of certain cities where they are otherwise difficult to deal with.

SUMMARY

Owing to a strange human indifference to vital interests, which must be overcome through education, rats are still allowed to thrive and multiply exceedingly in many places. This is due chiefly to faulty construction of many kinds, to improper disposal of garbage, and to the prevalence of general insanitary conditions which afford an abundance of food and shelter to the enemy. In the correction of these conditions health officers, federal, state, and municipal, should take a prominent part, and, in coöperation with as many private agencies as possible, organize and carry on such systematic, far-reaching, and persistent

rat warfare that these obnoxious rodents surely will be eliminated.

The control of rats, like that of other undesirable immigrants, should begin with the prevention of their landing at the ports; but this public duty falls to the health officer instead of the regular immigration official. Much may be accomplished by the thorough treatment, whenever practicable, of ship and cargo with hydrocyanic acid gas, or some other fumigant, and the isolation of the ship by means of metal discs on shore lines and by gangways raised at night. Efforts to exclude and to destroy rats should be centered in the seaports, as these are the rat strongholds, and the places where centers of plague infestation tend to develop. This can readily be done only by adopting standardized methods of proved efficiency, to be prescribed in accordance with varying local conditions.

Rats are cunning stowaways and the extension of rapid transit to include the most isolated places will make unremitting vigilance necessary everywhere in order to detect and destroy such introductions, and prevent the establishment of new colonies.

A simultaneous and widespread educational campaign should accompany all rat-proofing and rat-killing operations. Sporadic or incomplete attempts to control rats in particular districts, leaving neighboring areas infested, result in rapid reinfestation of cleared areas and accomplish little or nothing of permanent value. Success will depend upon coördination of efforts, including the enforcement of carefully considered ordinances requiring the rat-proofing of structures in general, until not only whole cities, counties, and states, but eventually the entire country is practically free of the pest.

An effective nation-wide rat warfare will require very large appropriations of public funds, the expenditure of which is justified by the facts that the value of food eaten or destroyed, together with other damage to property by these animals in the United States, is estimated to

be \$200,000,000 per annum, and that the loss to the nation in lowered health and efficiency is incalculable.

With the advance of our knowledge of the life habits of animals, and the complex relationships existing in nature, the general field of parasitology is ever widening before us. The determination of the complete rôle of the rat, the great human parasite, in the transmission of disease is a very important field for further laboratory investigation by health officers, and this should promote the ex-

termination of the animals by emphasizing the danger to which we are exposed.

Rats are no longer regarded chiefly as merely an unavoidable economic burden, in which health officers have little or no concern; instead, their presence is recognized as a civic reproach and a sanitary menace of the first magnitude, engaging the active interest of health officers everywhere. Civilization demands the consolidation of all available forces in the removal of the rat menace to the health and well-being of the human race.



AN ACCURATE METHOD FOR DETERMINING THE ALKALINITY IN HYPOCHLORITE SOLUTIONS

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ANYONE who may have been called upon to make a determination of the alkalinity of a solution of sodium hypochlorite or chlorinated soda has been confronted with the practical difficulty of such a determination. All known indicators of acids and alkalies are almost immediately destroyed by the action of the chlorine upon them. The Columbus Laboratories were called upon a few years ago to make a series of determinations of this kind and the writers devised a method which was found to be rapid, convenient and accurate. This method consists of the removal of the active chlorine and the iodine which it releases by the use of dilute solution of

sodium sulphite in the presence of a known quantity of a decinormal solution of hydrochloric acid and subsequent titrate of the excess of decinormal acid used by a volumetric solution of sodium hydroxide. The difference between the volumes of the hydrochloric acid used and the volume of alkali required to neutralize the excess of acid shows the volume of decinormal hydrochloric required to neutralize the alkalinity of the amount of the hypochlorite solution taken. From this the percent of alkalinity can be readily expressed. The active chlorine is removed by the sodium sulphite according to the following well known reactions:

