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RODENTS IN RELATION TO DISEASE AND THEIR CONTROL

BY

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Rats!
They fought the dogs and killed the cats,
And bit the babies in the cradles,
And ate the cheeses out of the vats,
And licked the soup from the cook's own ladles,
Split open the kegs of salted sprats,
And even spoiled the women's chats,
By drowning their speaking,
With shrieking and squeaking,
In fifty different sharps and flats.

("The Pied Piper of Hamelin," by R. BROWNING.)

(1) THE RAT MENACE

Rats affect the well-being of man in many ways: they foul and destroy food and crops; they harass poultry; they burrow and tunnel in buildings and have even been known to be the cause of fires by gnawing through electric cables and gas pipes.

Not only do rats destroy the material wealth of man—the damage is estimated at £15,000,000 yearly in Great Britain alone—but they also suffer from certain diseases to which man is susceptible.

The importance of the recognition of rats as vectors of disease and as an agency in the destruction of food supplies has long been realized by those connected with their eradication, but the general attitude is one of indifference. War stresses the importance of conserving foodstuffs and the protection of the individual against disease, and this article is intended to assist in the identification of the rat, its habits, diseases spread, and methods of control.
(2) **Rat-borne Diseases**

(a) **Plague.**—The most dreaded disease associated with rats is plague. Plague has been known as “The Black Death” and two great epidemics have swept Europe; one in the 1350s when one-quarter of the European population were victims, and again in 1665 when 70,000 died out of the total inhabitants of 460,000 in the Plague of London. Nowadays it is localized in certain areas, mainly in the tropics and sub-tropics.

There are two types of Plague:

(1) **Bubonic Plague**: When a rat is suffering from plague, the fleas which feed upon it become infected and since plague is as fatal to rats as it is to man, the infected rat usually dies.

Normally, the flea will leave the dead rat immediately its body is cold, and will then find a new rat host. This will continue until about 20 per cent of the rat population have become victims to the disease, and then the fleas will vacate the rats and seek new hosts—usually man.

When the fleas have been successful in their search, they start to feed on the human host.

The man is thus bitten by the infected flea and develops plague.

(2) **Pneumonic Plague**: In the pneumonic form of plague, the septicemia with *B. pestis* has resulted in a massive involvement of lung tissue.

This form of the disease is invariably fatal and the sufferer is a constant source of droplet infection to the community.

(b) **Murine Typhus.**—An infection which occurs in rats and man. It is a mild form of typhus which is passed from rat to rat and from rat to man by the rat flea or rat louse.

In man it causes scattered cases of typhus, but no large-scale epidemic such as occurs with louse-borne typhus has ever broken out.

Even so, in some countries it is important—for example, in the U.S.A. in 1937 there were 3,000 cases with some 200 deaths.

(c) **Weil’s Disease.**—Sometimes known as spirochetal jaundice is caused by a spirochete, which lives harmlessly in the kidneys of rats and is passed out in their urine.

Man becomes infected through contaminated cuts and abrasions by water which has been fouled by rats’ urine, or by consumption of similarly contaminated water or food. The disease is associated mostly with coal miners, sewer workers and fish girls.

(d) **Rat-bite Fever.**—The germ is inoculated by the bite of an infected rat. It is particularly common in Japan; but can occur wherever rats exist.

(e) **Trichinosis.**—This is a worm disease, particularly common in certain parts of Europe. The worm encysts in the muscles of rats and pigs; man develops the disease after consuming raw or imperfectly cooked infected pork.

(f) **Amoebic Dysentery and Food Poisoning.**—It has been proved that both of these diseases have been spread by contamination of food supplies by rats.

Such then, is the indictment of the rat—and it is obvious from the above diseases that the rat should and must be eliminated. To do this, the habits,
ways of life, and species of rats must be studied so we shall next consider the two common species which are to be found all the world over.

(3) The Black Rat and the Brown Rat

<table>
<thead>
<tr>
<th>Character</th>
<th>Black Rat</th>
<th>Brown Rat</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Name</td>
<td>Rattus rattus</td>
<td>Rattus norvegicus</td>
</tr>
<tr>
<td>(2) (a) Size</td>
<td>Small and slim</td>
<td>Large and fat</td>
</tr>
<tr>
<td>(b) Weight (full size)</td>
<td>Approx. ½ lb.</td>
<td>Approx. 1 lb.</td>
</tr>
<tr>
<td>(3) Head</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Muzzle</td>
<td>Sharp, pointed</td>
<td>Blunt</td>
</tr>
<tr>
<td>(b) Ears</td>
<td>Large and thin. Hairless. Semi-transparent. When pressed forward, cover the eyes</td>
<td>Small, thick and hairy. When pressed forward, do not cover the eyes</td>
</tr>
<tr>
<td>(4) Body (female)</td>
<td>10 teats</td>
<td>12 teats</td>
</tr>
<tr>
<td>(5) Tail</td>
<td>Thin, long; as long as, or longer than, length of head and body</td>
<td>Thick, short; shorter than length of head and body</td>
</tr>
<tr>
<td>(6) Habits</td>
<td>Climber. Domestic rat in houses and ships</td>
<td>Swimmer found in houses, sewers and fields</td>
</tr>
<tr>
<td>(7) Droppings</td>
<td>Sausage shaped and scattered</td>
<td>Spindle shaped, clustered</td>
</tr>
</tbody>
</table>

The colour of a rat is no guide to the species, since over 1 per cent of brown rats are black, and the black rat exists in two other forms which are brown. Although widely distributed the black rat is more common in the warmer parts of the world whilst the brown rat inhabits the temperate zones. The black rat is thought to have been brought to Great Britain during the thirteenth century in the ships of the returning Crusaders. Quickly spreading, the rats infested everywhere, until the eighteenth century, when the brown rat was accidentally introduced, the latter, however, soon gaining ascendency over its rival. In this country at present, the black rat is restricted to the environs of the great ports, whereas the brown rat is almost everywhere.

In foreign countries, other species of rats with different habits are sometimes found, i.e. Rattus concolor in Burma. Full details of these can be obtained from the reference books mentioned at the end of this article.

(4) The Habits of Rats

(1) General.—Brown rats burrow and make nests for themselves in or near the ground in dry or well-drained situations such as rubbish dumps, hayricks, and in the earth beneath buildings. Being strong swimmers, they also inhabit the banks of canals and rivers. They readily come inside to live providing they are able to find suitable places to burrow, i.e. among sacked goods in ware-
houses or granaries, and under floorboards. Although capable climbers, they are usually more common on ground floors than on the upper floors of buildings.

Black rats do not burrow but nest in sheltered situations provided by man, i.e., spaces behind bulkheads in ships, wall cavities, ceilings and roofs of houses. They are excellent climbers and consequently common in upper stories of buildings. Being such good climbers they are capable of going to and fro from ships to shore by the cables tying them up; thus the use of rat shields on ships’ cables, preventing rats leaving a ship and getting ashore. The black rat lives in close association with man, only rarely being found out of doors in this country.

(2) Food.—Rats sleep in their nests during the daytime and at night come out in search of food and water. Being very conservative in their habits, they follow definite “runs” to their feeding places where they fill their mouths with food and return to masticate it. During the night there are three to four feeding periods, each lasting one to one and a half hours. For the remainder of the evening they wander round in search of new feeding places.

One habit that often betrays their presence is the gnawing of a hard substance; this being essential in order to limit the length of their persistently growing front teeth.

A rat always avoids objects sited in unfamiliar positions—irrespective of their nature. For example, a rat finding a new feeding place will avoid it for the first night, but on the second and third nights may eat a little. Eventually, when the rat has become fully used to the food supply, it will eat its fill.

This behaviour is of the utmost importance, especially when using poisons or traps. It must be realized that should the position of a bait or trap be altered, then the rat will regard it as a new object and in consequence will avoid it.

(3) Breeding.—The breeding season of rats extends throughout the year but there are two intense periods—one in spring and the other in autumn. Thus every effort should be made to exterminate rats in February to March, and August to September, since every rat killed then is equivalent to four or five killed in May to October.

The Female Rat: The female rat may be sexually mature when three and a half or four months old, and they can breed all the year round. The sexual season for a particular female extends for about nine months, and “heat” occurs at intervals of about ten days. The male is always ready to pair; the female cannot be impregnated except at the period of “heat” which lasts for only a few hours. The period of gestation is about three weeks, and the female is ready to be impregnated within a few hours of the birth of a litter. The average number in a litter is eight, but there are often a dozen; and there may be five or six litters in a year. The female ceases to be fertile as she grows older—a fact sometimes overlooked in estimating the rate of multiplication. She is a careful mother, but in conditions of overcrowding, inadequate food supplies, or captivity, she may devour her offspring. The young are born blind and naked, with their ear-trumpets sealed down; their eyes open in about a fortnight and they are weaned in the course of their fourth week. It will be understood that
many of the figures, such as the number of offspring in a litter, vary greatly according to the conditions of life.

The increase of rats is therefore prodigious, but this can be offset by their enemies and by shortage of their food supplies. In consequence I will now give, briefly, some of the methods used to: (a) Preserve their enemies; (b) protect food supplies; (c) destroy their breeding places.

(5) PREVENTION OF INFESTATION

(1) General.—Rats are attracted to camps and buildings but will only remain there if there are suitable food and breeding places. General preventive measures are therefore: (a) making food sources inaccessible; (b) making buildings rat proof.

(2) Food Stores.—(a) Food stores should have concrete floors: if this is impracticable and floors are wooden then care should be taken to ensure that they make a tight joint with the wall. This joint can be reinforced by fixing sheet metal to cover the lower 18 inches of the wall and extending a similar distance on the floor.

(b) Metal bins with tight-fitting lids should be used for storing grain food and similar sacked commodities. Wooden bins, if used, should be covered with 1⁄4 inch galvanized wire netting.

(c) No food should be left exposed—particularly at night.

(3) Refuse and Swill.—(a) Refuse will normally be disposed of in covered metal bins, which are placed suitably on hard impervious ground to prevent fouling of the surrounding area.

(b) If no contractor is available to remove the dry refuse, then it should be burnt.

(c) Swill should be disposed of to authorized contractors. If this is not possible, swill can be dried and incinerated.

(d) Both wet and dry swill can be disposed of by "controlled tipping." All materials placed in a tip must be compressed to minimum size in order to exclude air. The tip should be covered above and at the sides with a 6 inch layer of tightly packed earth—the working face should never be left uncovered for a period exceeding seventy-two hours. This tight packing causes production of freak heat (160°-170° F.), which, apart from rotting the refuse, also destroys any rats which may have decided to nest in the tip.

(4) Buildings—Outside.—Successful rat proofing depends upon recognizing exactly how and where the rats enter and live in the building. This can be discovered by looking for traces (vide Section 6, paras. (i), (ii), and (iii).

The following are points which should be examined:

(a) Ground floors and basement windows should be kept shut or protected by 3⁄8 inch galvanized wire netting.

(b) Can the rats enter the building by climbing up the inside or outside water pipes? If so: (i) Fit galvanized wire balloons at the top of rainwater pipes. (ii) Place a close-fitting metal cowl into the wall and projecting 9 inches from the pipe. (iii) Seal off open cavities of walls under eaves. (iv) Build up the wall between the rafters to meet slate or tiled roof.
Rodents in Relation to Disease and their Control

(c) Rats may enter alongside gas or drain pipes. Fill any gaps around pipes with concrete in which broken glass is embedded.

(d) Broken gulleys and drains should be repaired.

(e) Traps, basement doors, etc., should be protected by sheet metal.

(5) Buildings—Inside.—(a) Inside buildings it is best to start from the source of infestation and work outwards, rat proofing floors.

(b) Rats live in cavity walls, behind skirting boards and in spaces between ceilings and floors.

(c) Vertical and horizontal pipes give rats access from floor to floor and room to room. Seal these channels with wire mesh at ceiling level.

(d) Follow the “runs” from the centre of infestation, seal them off section by section and then rat proof them.

(6) Natural Enemies of Rats.—Animals which feed on or attack rats should be protected: Dogs, weasels, stoats, buzzards, hawks, kestrels, owls, ravens and seagulls.

(6) TRACES OF INFESTATION

(i) Rat “Runs” (vide Section 4, para. ii).—Take the shortest covered way between breeding places and food supplies. Rats never cross an open space.

(ii) Smears.—Rats run close to the wall and their greasy coats leave dark smears. These are particularly evident at any obstruction. Smears are bright and shiny when new. They are, therefore, useful in deciding whether or not a run is still in use.

(iii) Scrapes.—When a rat burrows or makes a hole, it heaps up the displaced material behind it. It is thus easy to decide which way the rat is tunnelling.

(iv) Gnawing Marks (vide Section 1, para. i, Section 4, para. 2).

(v) Droppings.—The droppings of the black rat are usually scattered, whilst those of the brown rat are restricted to certain special places. The amount of fresh excreta is a useful guide to the size of infestation. Fresh droppings are soft, moist, and shiny.

(vi) Footmarks.—These are a help in the recognition of “runs.” They may be seen in dust or foodstuffs such as flour. If there is any doubt as to the “run” being used, whitening may be put down and the footmarks of the rats will be clearly visible if the run is frequented.

(vii) Damage to Food.—This may be the first indication of an infestation, i.e. spillage from grain, sugar or flour sacks.

(viii) Estimates of Infestation.—From examination it is possible to estimate roughly how many rats are infesting a building. Infestations are graded as under:

<table>
<thead>
<tr>
<th>Infestation</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reservoir</td>
<td>Over 200</td>
</tr>
<tr>
<td>Major</td>
<td>Approx. 20-200</td>
</tr>
<tr>
<td>Minor</td>
<td>Under 20</td>
</tr>
</tbody>
</table>

(7) THE CONTROL OF RATS

(1) General.—The general principles of rat control have one aim, namely, to kill all rats in an infestation as quickly as possible and thereby eliminate the
natural increases due to breeding. The various methods used in rodent control are described below.

(2) Poisoning.—(a) There are four poisons in common use—they are in order of their effectiveness against rats: A. zinc phosphide; B. arsenious oxide; C. red squill powder; D. barium carbonate.

In using any of these poisons it is essential that the following information is available:

(1) The quantity of poison needed to kill a rat.
(2) The amount of poisoned food a rat must consume to be affected.

Bearing in mind these two points, the table given below shows the percentages of poison given in baits.

(3) Pre-baiting and Baiting.—Rats seldom feed at new food sources until they are fully accustomed to their presence. It is thus essential that the confidence of the rat is won. This is done by "token pre-baiting." A small amount—about 2 ounces—of unpoisoned food is put down at selected points, this being replaced by fresh baits on the second, third and fourth nights. The pre-bait is usually consumed in entirety on the last two nights: If the pre-bait is not eaten or touched by the rat a new baiting point should be selected, the former being judged as unsuitable. On the fifth night a larger quantity of bait—about 3 ounces—to which has been added poison, is laid at each baiting point. If it is found that all the poison bait is taken, post-baiting should be carried out to ensure that all the rats have consumed a lethal dose.

(4) Post-baiting.—Rats which have taken a sub-lethal dose of any poisoned bait may become prejudiced against this particular bait, but not against the place where they consumed it. This post-baiting treatment is carried out after the period of ten days has elapsed since poisoning. Hence the necessity for complete records of treatment (Section 7, para. b). To test for surviving rodents, a small amount—about 1 ounce of a different bait is put down and left for two or three days. If this is eaten, then a fresh treatment is necessary and this should be commenced after six days using a different poison from that used in the first instance.

(5) Methods of Baiting.—Baiting points should be chosen along the runs in between the holes from the breeding place to feeding place. The nearer the bait is to the hole, the more successful is it likely to be. Baits can be placed in the holes, or in definite bait containers. The latter is the better method as it diminishes the possibility of poisoning other animals or children.

For indoor baiting P.3 containers are issued (see figs. 1 and 2). They should be placed in position with a little dry bait scattered in the tunnel, on the baffles and inside. It takes up to ten days before the rats enter these containers. Before pre-baiting and baiting, ensure that they are being freely used by the rats.

For outdoor infestations D.1 containers can be constructed by cutting 3-inch piping into short 12-inch lengths and filling up one end with cement. They are used normally in batteries of four and can be left permanently in position (see figs. 3 and 4).
(6) Composition of Bait.-Baits are composed of a harmless base and a poison.

   Damp sausage rusk: Sausage rusk mixed with an equal weight of water.
   Sugar meal: 9 parts national flour. 1 part caster sugar.
   Bread mash: Dry bread mixed with water to give consistency of porridge.
   Soaked wheat: Wheat soaked in water, excess water being poured off.

2. Poisons.
   Zinc phosphide: Is used at 5 per cent by weight in any base. Liberates phosphine when wetted, this gas being injurious to man and animals. This should, when possible, be mixed with dry bases. The obnoxious smell of zinc phosphide does not repel rats.

Fig. 1.—Assembly sketch of a P.3 bait container.
Fig. 2.—The bait container P.3, near rats holes in a roof.

Fig. 3.—The D.1 containers. Four drainage pipes, with bait near traces and holes of rats.

Fig. 4.—D.1 containers. Brown rat entering drainage pipes.
Arsenious oxide: A white powder, used 15 per cent by weight in dry baits and 10 per cent in wet baits. To comply with rules for colouring poisons, a blue dye is usually added.

Red squill: Is supplied in both liquid and powder forms. Powder used at 10 per cent concentration. Liquid used as under:

- Red squill: 1 pint
- Water: 4 pints
- Sausage rusk: 9 pints

Barium carbonate: Can only be used with bread mash. It is used at 20 per cent by weight.

It is essential to mix the bait base and poison very thoroughly to ensure that the latter is distributed evenly through the bait.

<table>
<thead>
<tr>
<th>Base</th>
<th>Zinc phosphide</th>
<th>Arsen oxide</th>
<th>Red squill</th>
<th>Barium carbonate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Damp sausage rusk</td>
<td>—</td>
<td>10 per cent</td>
<td>10 per cent</td>
<td>—</td>
</tr>
<tr>
<td>Sugar meal</td>
<td>5 per cent</td>
<td>15 per cent</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Bread meal</td>
<td>—</td>
<td>10 per cent</td>
<td>10 per cent</td>
<td>20 per cent</td>
</tr>
<tr>
<td>Soaked wheat</td>
<td>—</td>
<td>10 per cent</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

Percentage expressed by weight of poisons.

**Table II.—Suitable Baits**

<table>
<thead>
<tr>
<th>Zinc phosphide</th>
<th>Barium Carbonate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sausage rusk</td>
<td>Water 10</td>
</tr>
<tr>
<td>Water</td>
<td>10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Arsenous oxide</th>
<th>Zinc phosphide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sausage rusk</td>
<td>Sugar meal 19</td>
</tr>
<tr>
<td>Water</td>
<td>9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Red squill</th>
<th>Arsenous oxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bread mash</td>
<td>Sugar meal 17</td>
</tr>
<tr>
<td></td>
<td>9</td>
</tr>
</tbody>
</table>

(7) **Poison Precautions.**—Zinc phosphide and arsenious oxide are both very poisonous to man and should be stored in a dry atmosphere. When any poison bait is laid, the following precautions will be observed: (a) Notify all concerned where the poisons have been laid. (b) Keep a clear record of all baits used. (c) All poisoned rats found should be burnt.

(8) **Gassing (a) General.**—Gassing is used to serve a rapid initial clearance when the source of infestation is in the open such as in hedgerows and in banks. On no account should this method be used for loose piles of rubbish or where there is any possibility that the rat burrows lead to human dwellings. IT MUST NEVER BE USED IN FOOD STORES OR HOUSES. The main advantage with gassing is that rat fleas are killed in addition to the rats themselves.

(b) **Hydrogen cyanide.**—Hydrogen cyanide gas is a valuable aid in clearing out infestations. It is highly dangerous and must be used with great care. The forms in which it is normally used are "Cymag" or "Cyanogas."
Cymag: All rat holes are blocked and on the second day a heaped teaspoonful of the powder is placed by means of a "spoon" in burrows that have been reopened. The holes should then be re-blocked. The powder gives off the lethal gas, destroying the rats that attempt to dig themselves out. The process is repeated on any holes that the rats succeed in un-blocking.

Cyanogas (U.S.A. Product): The powder is pumped into the rat burrows.

Precautions taken when using Hydrogen Cyanide: (a) Face down-wind when placing the powder in the burrows to avoid breathing in the dust or contaminating clothing. (b) Ensure that no moisture enters the container tins during operations. (c) Close the tins after use and store in a dry place. (d) Wash the hands thoroughly.

(9) Trapping.—Trapping is a very useful "follow-up" measure to deal with the remnant of an infestation after poisoning. Treadle breakback traps are the best types. As the rat reacts to unfamiliar objects, traps must first be set down unset with a small amount of bait on them for three or four days. The traps should be placed in regular runs near the holes. Rats are in no ways repelled by the operator handling the traps.

(10) Hunting.—The use of dogs and ferrets against rats is not regarded as an effective method of control.

(8) THE CONTROL OF MICE

(1) General.—Mice differ from rats in two important respects. First, they are very localized, rarely moving more than 10 feet from their nests; secondly, they are very inquisitive and do not avoid new objects, therefore traps need not be left unset.

(2) Trapping.—Blitz trapping is the most successful method of killing mice. Large numbers of traps should be used. They should be placed 2 to 3 feet apart, at right-angles to the run with the treadle against the wall. Good baits for attracting mice to the traps are flour, oatmeal, or breadcrumbs. Trapping fails when mice are living near plentiful food supplies.

(3) Poisoning.—Where there is little alternative food, pre-baiting for one night is adequate, but where there is an alternative food source, four nights pre-baiting is desirable. Put out the bait in ½ ounce heaps. The following baits are useful: (a) Dry rolled oats. (b) Damp sausage rusk (see Section 6, para. (2)). (c) Rolled oats, 4 parts to 1 part of water by weight, arsenic at 10 per cent or zinc phosphide at 5 per cent by weight.

Mice develop poison prejudice but not bait-base prejudice. Therefore it is only necessary to change the poison and not the base for the second treatment.

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