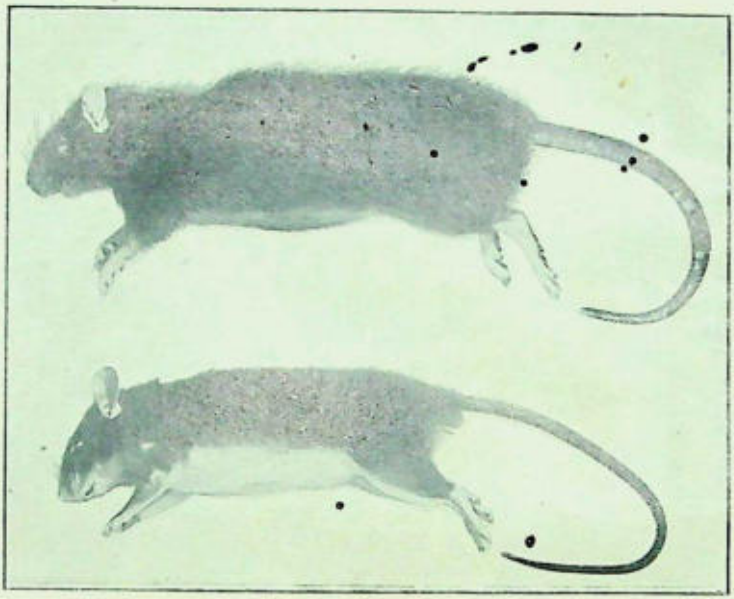
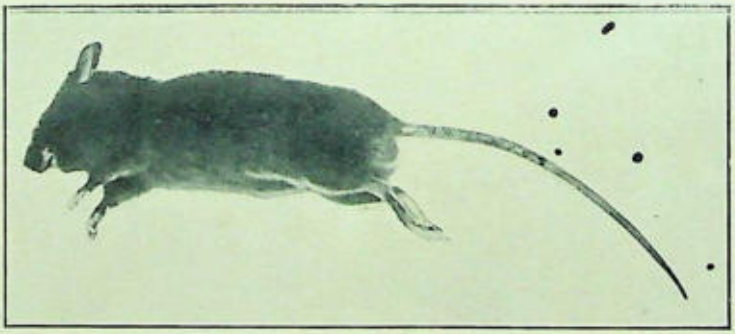


Rattus norvegicus *(above).*
Rattus rattus frugivorus *(below).*



Mus musculus.

These specimens are arranged so as to exhibit the chief characteristics mentioned in the table on page 15.

(From photographs specially taken by permission of the Director, British Museum, Natural History.)

A Practical Handbook

on

Rat Destruction

By

C. LEOPOLD CLAREMONT, B.Sc., F.I.C.

Recently Research Chemist in Charge,
Rat Research Department,
Ministry of Agriculture

Published by

JOHN HART

12/15 Henrietta Street, Covent Garden
London, W.C.2

Made and Printed in Great Britain by
Botolph Printing Works, Gate Street Kingsway, W.C.2

FOREWORD

EVERY living organism has its allotted place in the economy of Nature, whether for the weal or woe of mankind. The Rat and its diminutive relation the house mouse have always attended Man in his advances in civilisation, adversely influencing his health and material comfort. Sporadic attempts to control these pests have been undertaken for thousands of years, but until food supplies and shelter are made less accessible, and concerted action is taken to destroy rats and mice, incalculable losses will continue to occur through their depredations.

Officers under the Rats and Mice (Destruction) Act, 1919, as well as many occupiers of rat ridden premises, will no doubt welcome a hand-book from an author who has not only investigated the speculative aspect of an important problem, but has also the qualifications to speak on ways and means which have been found both simple and efficient in destroying rats and mice.

E. C. READ,

Technical Adviser on Rat Destruction to the Ministry of Agriculture.

(Natural History) I tender my thanks for permission to have photographs specially taken for this work. I also have to thank Mr. M. A. C. Hinton of the Small Mammals Department of the Museum for kindly selecting the specimens and for reading the manuscript of Chapter II and giving me the benefit of his special knowledge of this subject.

In the preparation of Chapter V, I am much indebted to the assistance of Mr. A. E. Morgan, Sanitary Inspector and Executive Officer under the Rats and Mice (Destruction) Act, 1919, to the Borough of Greenwich.

For permission to reproduce four of the subjects of the Ministry's slides I have to thank Dr. A. A. Mussen, Medical Officer of Health for the City of Liverpool. The photograph of gassing by Cyanogas is reproduced by permission of the Proprietors of the *Bristol Times and Mirror*.

Finally, I must thank the publisher and his staff for their ready help at all times and Miss Stormont for assistance in reading the proofs and preparing the index.

C. L. CLAREMONT.

262, KENNINGTON PARK ROAD,
LONDON, S.E.11.

January, 1926.

CHAPTER I

INTRODUCTION

Specialisation in Science

THE present age, so far as scientific work is concerned, is notable for specialisation and members of the various scientific professions find it increasingly desirable to qualify their work with words descriptive of the particular branch in which they specialise, thus we have analytical, organic, metallurgical, research chemists, hydraulic, electrical, mechanical, civil engineers, and so forth. Biology is no exception and as the result of the special work involved in dealing with pests, biologists working on this subject are called " economic " biologists.

In the realm of Rat Destruction, the one-time specialist was the gentleman who styled himself a " professional " rat-catcher, but modern conditions require something more than this, and the whole subject properly comes within the purview of the economic biologist and chemist.

To the Sanitary Inspector, for whose use this book has been specially written, this tendency towards specialisation is no new matter, for he is already of necessity a many-sided specialist,

if not of immediate importance in England, is the more serious aspect of the problem in tropical countries, particularly India.

Of all the mammalian pests, the rat and allied rodents easily take first place, not only in point of numbers, but also for their ubiquity and destructiveness. Indeed, so well adapted are they for existence under a variety of conditions that they have succeeded in establishing themselves firmly in many countries, notably England and America, in which they are not indigenous, but were introduced from abroad. It is not an exaggeration to say that they are perhaps of all mammals the most successful in the struggle for existence, not even excluding man, for despite disease, natural enemies and persistent persecution by the human race, they have gradually spread over almost the whole of the inhabited world.

Under ordinary conditions of nature, any creature, it may be an animal, insect, or plant, can only exist in such numbers as can succeed in evading natural enemies, in finding adequate food and in securing shelter and suitable conditions for breeding. These various factors combining to limit numbers form what is generally called "the balance of nature." If these conditions be disturbed either in a favourable or unfavourable direction, there is immediate response in the survival rate up or down, as the case may be,

and in general it is only when the favourable factors, sometimes quite obscure and therefore difficult to counteract, become excessive that the creature develops into a pest. Sometimes these conditions are merely local or temporary, as for instance, plagues of locusts, in other cases, they may be more or less general and permanent. Of course, sometimes the reverse takes place and unfavourable conditions arise, and a species may become greatly reduced or even exterminated. For these reasons it is occasionally difficult to say whether a species is a pest or not in the general sense, though there is not much difficulty in deciding when and where it has in fact become a pest. For instance, rabbits in general are not regarded as pests, though there is an increasing tendency to do so, but they unquestionably are pests in many parts of Australia, and other instances of a like nature could be quoted.

In a general way these considerations lead to the fairly obvious deduction that if the favourable factor can be traced and either removed or counterbalanced with unfavourable conditions introduced by human agency, a fair measure of control over the pest would soon be obtained, and this is exactly what is aimed at in scientific pest destruction. It is because the working out of these favourable and unfavourable factors is definitely a scientific job, that the profession of

economic biologist is of increasing importance, so much so, that Government and other Authorities both in England and elsewhere have found it necessary to maintain special scientific staffs to deal with such problems, many of which have long since got to a stage where rule of thumb methods have ceased to be effective, and the more obscure the life history and conditions of existence of a pest may be, the more need for accurate scientific work.

So far as the rat and allied species of rodents are concerned, there can be no question as to them being pests in the general sense. Everyone is aware of the fact and the reasons why rat destruction is so necessary are pretty well known. Even at the risk of repetition, it may be as well to again emphasise the enormous loss which rats occasion and their evil deeds as carriers of infectious disease; this latter question, however, will be dealt with more fully in Chapter VI, which deals with Rats and Public Health.

In dealing with the figures for the damage and loss occasioned by rats, it must be admitted that they are to an extent, unsatisfactory, in that it is extremely difficult to get any really definite figures on which to base them. They are in fact calculated from what are regarded by experts as reasonable estimates of the basic facts. It is generally assumed that there are at least as many

rats in this country as human beings, but it is more difficult to arrive at some basic figures for the cost per rat per annum. Rats in captivity cost at least ½*d.* per diem to feed, or rather less than £1 per annum; if some allowance for damage done in fouling food not eaten and in gnawing woodwork, etc., be made, each rat may be regarded as costing the community £1 per annum. These figures give a rat population of over 42,000,000, costing about £42,000,000 per annum. The latest available figures issued to the public estimate the rat population at 50,000,000, and the cost is given as £70,000,000 per annum. (*Vide* Press, Nov., 1925.)

In other countries, similar estimates have been made; in France, for instance (1904), the annual damage was stated to be 20,000,000 francs; in Germany, 200,000,000 marks; and in United States of America, 200,000,000 dollars.

Hinton* gives some figures based on very conservative estimates, showing that the cost of feeding the rat population for 1918 amounted to over £9,000,000. In India Dr. Kunhardt† estimates that the total cost of the rat, including losses due to plague, was £828,000,000 over a period of twenty years. Another authority,

* M. A. C. Hinton. "Rats and Mice as Enemies of Mankind." London, 1918. British Museum (Natural History.)

† Kunhardt. *Indian Journal of Medical Research.* 1919.

Mark Hovell* estimates that 100 rats might eat and waste in six months grain equivalent to over 2,000 quartern (4 lb.) loaves. On a basis of a rat population of 50,000,000 this works out to over 2,000,000,000 loaves per annum, the value of which with the loaf at 9½*d.* is nearly £80,000,000!! No such loss does in fact really take place in this form, but the figures are intended to bring home to the farming community in particular the enormous potential loss involved in neglecting to take adequate precautions to protect corn stacks and granaries from rats. It is almost as difficult to get specific valuation of the loss and damage in individual cases of rat infestation.

Quite apart from the actual damage, rats cause considerable discomfort and suffering and many cases are known where they have attacked children or killed live stock.

Boelter† quotes many replies received from farmers and others to a questionnaire on the cost of rat damage and these show that the damage alone in most cases was considerable and certainly in excess of the ¼*d.* a day per rat at that time considered a fair estimate of the cost, all agreed that though in most cases definite

* Mark Hovell. "Rats and How to Destroy Them." London, 1924.

† Boelter. "The Rat Problem." London, 1909.

loss was traceable to rats, it was impossible to arrive at anything like an accurate account.

The point need not be emphasised further, there is general agreement that rats do an enormous amount of damage, much of which is preventable, it is admitted that the numbers are far greater than need be the case and further it is known that they help to spread many diseases which cause death or illness, not only among man, but among domestic animals, all of which is potential loss to the community.

Such is the general position, what then is the actual problem confronting the individual, the community, the Empire, and the world? It is sufficiently serious and has gradually arisen, partly no doubt, through deliberate neglect, partly through failure to realise the potentiality of the rat menace and partly from ignorance of the means necessary to combat it. In its essence it is a "waste" problem complicated by the biological factor and it is everyday experience that the prevention of "waste" is one of the hardest problems of all to tackle. The constituent items making up a "waste" problem are so small that the people concerned, be they housewives, employees of a firm, or local or Government officials, often fail to realise the necessity of care and prevention and are the first to be surprised when the sum

total of the "waste" bill is brought to their notice.

To the community as a whole, particularly as represented by those authorities who have to deal with rat destruction, the problem is that of prevention and cure, but in order to get these efficiently carried out to the best advantage, the question of suitability of methods becomes more important and organisation for giving information and assistance is of the greatest importance, in addition to which it is necessary to arrange for proper co-operation and co-ordination of rat destruction by those responsible for it and this becomes one of the chief responsibilities of these authorities.

In many parts of the East, particularly in our own Indian Empire and Colonies, apart from any question of material loss, the rat looms large as the harbinger of death and disease. Health authorities are constantly engaged in studying the problem of plague prevention, which is intimately bound up with rat control, and the League of Nations Health Committee is the medium for international co-operation on this particular aspect of the rat menace.

Just as we have the rat problem here, so do most other countries, for the depredations of rats are not peculiar to England and the distribution of the rat over the world, is such that few countries can afford to neglect this problem.

dentition and all rat and mouse-like animals with a certain characteristic dentition are comprised in the zoological family Muridæ, of which there are three main Sub-families—Micro- e (voles and lemmings) Cricetinæ (hamsters) rinæ (true rats and mice).

his latter family only three species are of ral importance, for they are the ones which heir wonderful adaptability have spread in all over the world. There are of course other species of Murinæ but they are as of local interest only and in the majority in their aboriginal wild habits, some of them often become local or temporary pests.

These three species are :—

(1) *Rattus norvegicus* (or *decumanus*), known indiscriminately as the brown, Norwegian, Hanoverian or common rat.

(2) *Rattus rattus*, known also as the black, ship, Indian or old English rat.

(3) *Mus musculus*, the common house mouse.

All three species are met with in this country, though the brown rat is by far the commoner of the two rats. All are aliens and highly undesirable at that, being of Eastern origin, and reached this country at quite different periods. The only indigenous Muridæ are some three or four species of voles (Microtinæ), of which

the water voles (often incorrectly termed "water rats") are fairly common and two species of mice (Murinæ)—field mice and harvest mice.

Although these two species of rats differ considerably, [illegible] pearance and habit[illegible] nevertheless they are frequently confused often incorrectly identified. Though called brown and black rat respectively, it is unfo[illegible] nately the case that colour does not f[illegible] a reliable guide for identification sin[illegible] both species this characteristic is son[illegible] variable; in fact, "brown" rats are f[illegible] often grey or even black, while [illegible] are generally brownish in hue, so that an identification based on colour alone is quite fallacious. Under certain conditions both species tend to acquire a darker coat, so much so that where this has become general, a definite sub-species can sometimes be founded on it. Strictly speaking, zoologists base the identification of the species on certain anatomical differences, such as the shape of the skulls, that of the brown rat being relatively narrower in comparison with its length than is the case with the black rat. There are, however, several points in anatomical structure which are reflected in external features and these salient characteristics taken together should enable an identification to be made fairly readily.

in temperate climates, the latter breeds more quickly under warmer conditions.

Assuming an adequate food supply and facilities for undisturbed nesting—a most important factor, often overlooked—these reproductive powers if unchecked would soon result in an enormous rat population, for young female rats begin breeding when between three and four months old, the normal period of gestation is but twenty-one days and impregnation can and often does take place very soon after the birth of a litter.

Using data based on the above facts, many calculations have been made of the possible increase which a pair of rats may give rise to, and even the more conservative estimates result in very large numbers.

F. von Fischer (1872) gave an estimate of nearly 50,000,000,000,000,000,000 as the theoretical progeny of a single pair in ten years, Rucker calculated it to be over 900,000,000,000 in five years, while Lantz thought that in a generation there would be about 20,000,000. Zuschlag, assuming six litters of eight per annum with equal sexes and breeding starting at fourteen weeks old, calculated the progeny of one pair would be 880 at the end of twelve months.

Hinton* making very ample allowance for

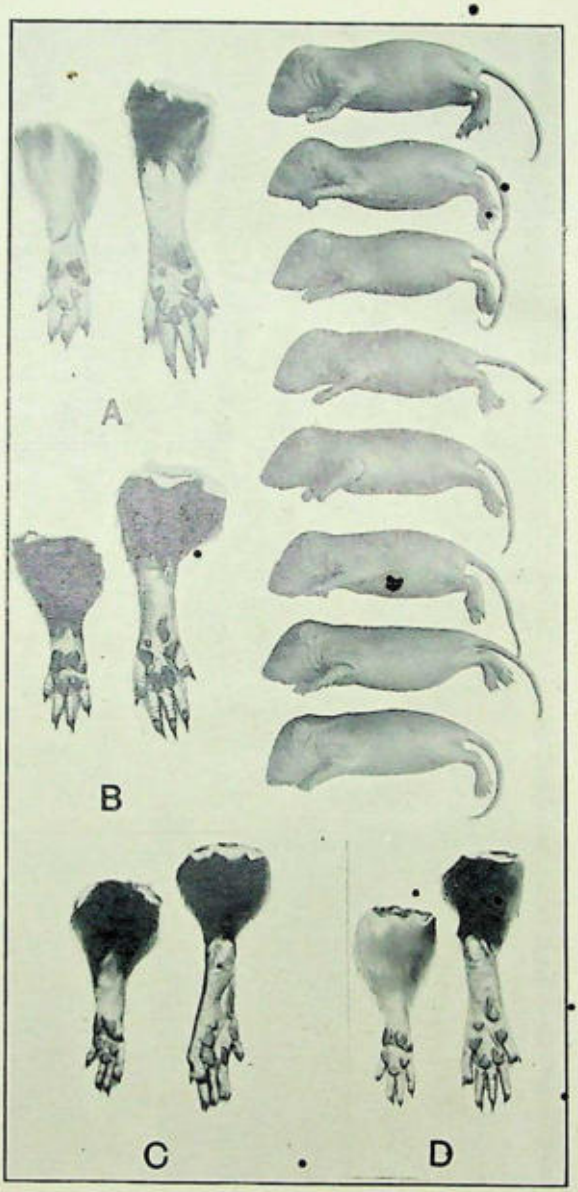
* M. A. C. Hinton *ibid.*

casualties and starting with 40,000,000, the supposed rat population in 1918, and assuming there were only 10,000,000 "*pairs*" of potential breeding rats, reckoned that in twelve months there would be 41,000,000 "*pairs*" or double the original rat population, while an additional 12,000,000 "*pairs*" might be expected to be produced before the end of the thirteenth month.

These estimates vary greatly and are open to the same objections as are calculations of the damage done by rats, for it is impossible to arrive at any exact knowledge of actual birth and survival rates, but they do serve the purpose of emphasising the real immensity of the problem of keeping the rat in check.

Rats are nocturnal in habit, sleeping by day in nests which they construct from paper, grass, felt or any other suitable material, whence they emerge at dusk to procure food and water and for breeding purposes. Much of the food they take back with them and store near their nests so that in hard times, or if danger threatens, they need not forage in the open. In eating, rats often sit up on their haunches, holding the food which they nibble in the front paws, very much in the same way that squirrels do.

Their nests are as a rule as near their food supplies as possible, but often they will travel long distances to and fro between their home



A. Hand and Foot R. norvegicus (adult.)

B. Hand and Foot R. norvegicus (younger.)

C. Hand and Foot R. rattus

D. Hand and Foot R. frugivorus

Top right—
A typical litter of R. norvegicus.

(From photographs specially taken by permission of the Director, British Museum, Natural History.)

They are most conveniently set out in the form of a table adapted from Hinton.*

Feature.†	Rattus norvegicus.	Rattus rattus.
Colour . . .	Usually grey or greyish black.	Usually brown, often quite dark.
Size	Large and clumsy.	Small and elegant.
Muzzle . . .	Blunt.	Sharp.
Ears . . .	Small and furry.	Large, translucent and almost hairless.
Tail	Short and thick.	Long and thin (at least as long as head and body together).
Pads of feet .	Relatively small.	Relatively large.
Fur	Soft, few bristles.	Soft but of distinctly bristling appearance.
Teats (in female)	Normally 12 mammæ. 3 pair on chest. 3 pair on groin.	Normally 10, sometimes 12 mammæ. 2 pair on chest. 3 pair on groin.
Weight of average adult . .	½ to 1½ lbs., sometimes more.	Rarely exceeds 8 oz.
Dejecta . . .	Large and spindle shaped, pointed ends.	Smaller but with blunter ends.

Rattus norvegicus is far more constant to type than is *Rattus rattus*, for throughout its distribution over the world it exhibits but little pelagic change, save that in Western Europe there seems to have developed a definitely darker variety which is becoming commoner in this country. As this variety was first observed in Ireland it is often described as *R. norvegicus* var. *hibernicus*.

As will be seen, this shows a parallel to the pelagic changes in *Rattus rattus*. This species also develops a thicker and longer coat when

* M. A. C. Hinton *ibid.* † *See* frontispiece and plate 2.

living under abnormally cold conditions, such as in refrigerator ships or stores. Incidentally the albino tame rats of the pet shops are apparently this species, but if bred without careful selection piebald and even typical greyish brown colours soon arise.

Rattus rattus, on the other hand, exhibits a marked variation in colour even among those found in Europe and as these varieties breed more or less true to colour and have a fairly consistent geographical distribution, they are classed definitely as sub-species. They are: (1) the black rat proper (*Rattus rattus* var. *rattus*) with black back and greyish belly; this is the typical black rat of the more temperate parts of Europe; (2) Alexandrine rat (*Rattus rattus* var. *alexandrinus*) with blackish brown back and dingy belly, mostly found in Asia Minor and Northern Africa, hence the name; (3) roof or tree rat (*Rattus rattus* var. *frugivorus*), back tawny or reddish brown, belly white, in fact not unlike a ferret in colour; this is generally found as a wild species in Southern Europe.

The variety *rattus* is the usual type found in England, but *alexandrinus* is by no means uncommon, especially in ports, while frugivorus is occasionally met with. It may be remarked in this connection that the colour tends to become darker in cooler climates, for in India,

where *Rattus rattus* is common, there are many wild sub-species mostly similar in type to frugivorus and there is but little doubt that this rat originated in this area.

Although *Rattus rattus* is now relatively uncommon in England and Europe generally, as compared to *Rattus norvegicus*, it arrived first and for many centuries held undisputed sway, becoming a fearful scourge throughout Europe, for it multiplied exceedingly and did an enormous amount of damage and worse still, carried with it the continual menace of bubonic plague, for though our knowledge of the causation of this disease is comparatively recent, it cannot be doubted that the frequent outbreaks during the Middle Ages right down to the latter half of the seventeenth century were due to the all-pervading presence of this rat.

It is generally supposed that this rat was unknown in Europe in early historical times and its arrival in England is attributed to the Crusaders who brought it back with them in their ships. Be this as it may, there is some presumptive evidence that it was well established in Eastern and Southern Europe long before that, for there was a definite outbreak of plague (historically known as the plague of Justinian) in the sixth century A.D. which spread as far

west and inland as the Frankish cities of Lyons, Chalons and Dijon,* and it is fairly safe to associate this with the presence of *Rattus rattus*.

The first invaders of Europe were doubtless of the frugivorus type and in the warmer parts, where conditions approximated to those of their natural home, they retained the open life of nature. In the other cooler and more populated areas they lived more indoors, acquiring the dusky coat of *alexandrinus*, while those penetrating still farther to North and North-Western Europe became even darker as they were forced to exist almost entirely as parasites in human dwellings and developed into the variety *rattus* such as is now usually found in England.

The brown rat *Rattus norvegicus* came on the scene at a much later date and first reached Eastern Europe in the early part of the eighteenth century, being reported in Denmark in 1716, and is said to have invaded Russia and Eastern Europe in large numbers about 1727. Its natural home is in the more temperate regions of Asia, where it is found in the wild state in two areas only, namely around the Caspian Sea, and in the neighbourhood of Lake Baikal. No other wild species are known in Asia and it must therefore have long been established there. Although

* Glen Liston, Milroy Lectures. *B.M.J.*, May, 1924.

this species was not greatly in evidence before the dates mentioned, it had been described and figured by the naturalist Gesner in a book published in 1553, though from hearsay only, as he himself had not seen a specimen. There has been a tendency to treat the arrival of this rat as if it was a sudden and overwhelming invasion and to explain it by some cause which drove the species out from its usual haunts. While this is not impossible, it is far more probable that its arrival was much more gradual than is generally supposed, and that it was due to the opening up of trade with Russia which began in the latter part of the sixteenth century and, with the growth of shipping, was continually expanding.

Whatever the cause may have been, it was certainly a case of "they came and they conquered," for in an extraordinarily short period they spread over the whole of Europe, almost entirely displacing the black rat in less than two hundred years. From Europe they spread over the entire world, being carried here and there by shipping and commerce. Meanwhile a somewhat similar expansion carried the species down into the Ports of India and Burmah. Their progress can be illustrated by the following dates—they reached England in 1728, Scotland in 1764, France and Germany 1750, Norway

1762, Spain 1800, and Switzerland as late as 1809. From England it soon reached the East coast of America in 1775, but did not penetrate to the Western coast until much later, being reported in San Francisco in 1880, while its penetration into the interior of the North American Continent is a matter of the past twenty years.

It is frequently stated that the disappearance of the black rat was due to the later invader being fiercer and stronger and therefore that it killed off the weaker species. This may be true in part, but certainly is not the complete explanation, for both species are often found in close association even in the same building. There can be but little doubt that the main reason was the gradual alteration in environment caused by the substitution of brick and stone buildings for the wood and mud walls of mediæval Europe and the general improvement in sanitation which has taken place in the past two hundred years; in other words, the brown rat arrived on the scene at a time when conditions were rapidly becoming less and less favourable to the continued existence of *Rattus rattus*, while at the same time they were such that *Rattus norvegicus* could readily adapt itself to them. Once having arrived, its larger size and greater fecundity and adaptability enabled it to become

firmly established at the expense of its black cousin, which only survived in a few isolated colonies, mainly in the vicinity of ports. It may be noted that a somewhat similar change is taking place in Bombay at the present day, where, owing to the introduction of buildings of European type and modern sewerage systems, *Rattus norvegicus* is displacing *Rattus rattus*.

In London and other large seaport towns recent observations seem to indicate a distinct tendency for *Rattus rattus* to re-establish itself. For this, again, conditions of environment are responsible. Many of the large warehouses and buildings of modern cities are in the main rat-proof in the lower portions, hence *Rattus norvegicus* does not so readily gain a footing, or survive even if he does (there being nowhere to burrow). *Rattus rattus* on the other hand often finds it possible to effect an entry by a telephone cable or stackpipe, which would be impracticable for the other species, and when inside soon finds a comfortable home in the roof spaces or even in recesses behind the butt ends of girders.

As a general guide to the distribution of these species it may be noted that *Rattus norvegicus* prefers and is most successful in temperate and cold climates, while *Rattus rattus* prefers and succeeds best in warmer climates,

in which so far it has not been displaced to any great extent by *Rattus norvegicus;* but it may be expected that the latter will continue to extend their boundaries somewhat, with the better housing of native populations in the East.

As might be expected from the foregoing, these two species differ somewhat in their habits though they have many points in common and a study of these habits is of the greatest value when we come to consider methods of destruction and control.

Both species of rats exhibit remarkable fecundity and under the artificial and sheltered conditions which they usually enjoy, breed more or less all the year round, though some observations which have been made in this country indicate that on the whole the highest birth-rate takes place from January to June.

The number of young per litter varies, as does the number of litters per year, doubtless with the age, health and food supply of the parents and the average is from five to ten, but much larger litters have been recorded, some even exceeding twenty. As a rule *Rattus norvegicus* has larger litters than does *Rattus rattus* and both have the largest families under the more favourable conditions applicable to each, so that while the former is more prolific

PRACTICAL DESTRUCTION OF RATS

Attention has already been drawn to the very rapid rate at which rats breed and therefore to be of real value rat destruction must proceed at a higher rate than this, otherwise normal breeding will replace the rat population as fast or faster than destruction removes them, and consequently the methods used must be such that this end is achieved.

Practical methods of rat destruction can be conveniently described under five headings, these are (1) Hunting methods, (2) Trapping, (3) Gassing, (4) Poisoning and (5) Artificial infection with disease, generally called the Virus method; this is really a special case of poisoning since the method of applying it is similar, and the discussion of both will be reserved for a later chapter. There is a broad distinction between the first three methods and poisoning which warrants this division, for the former are more or less mechanical, success being less dependent on the rats themselves, while in the case of poisoning, success is entirely dependent on enticing the rats to consume the poisoned food.

HUNTING

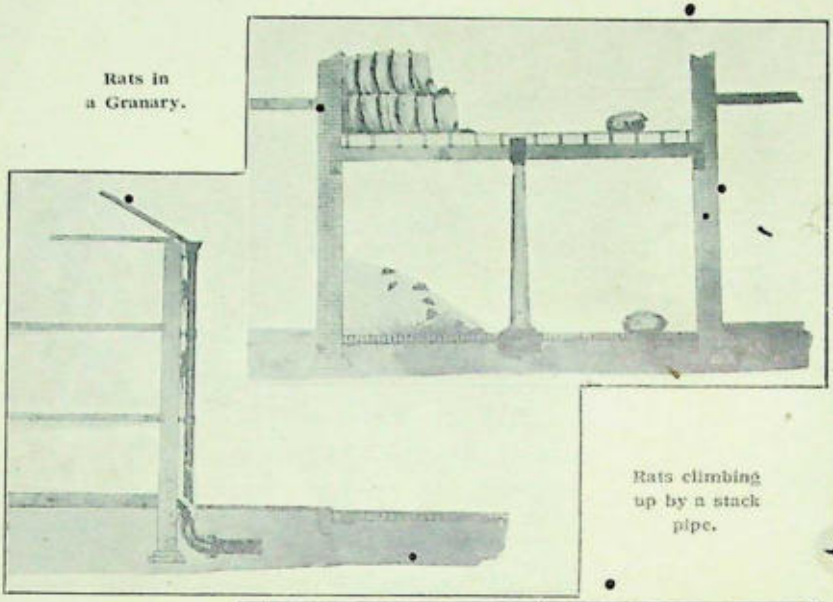
This method is without doubt the oldest of all methods and is that practised by the so-called "professional" rat-catchers. Essentially

it consists of the capture of rats by means of the combination of experienced men with well trained dogs and ferrets. The practitioners of this ancient art are a somewhat secretive race, and do not divulge their precise methods. The secrets, such as they are, are handed down from father to son and jealously guarded, for most rat-catchers claim an ancestry in the craft for several generations.

Quite apart from the use of dogs, ferrets and guns, where conditions are favourable, these men will frequently catch large numbers of rats by hand and as they work at night and are not keen on allowing outsiders to watch them, they have succeeded in surrounding their operations with a considerable air of mystery, all the more easily since most people are afraid of rats and would certainly hesitate to seize a live one in any circumstances.

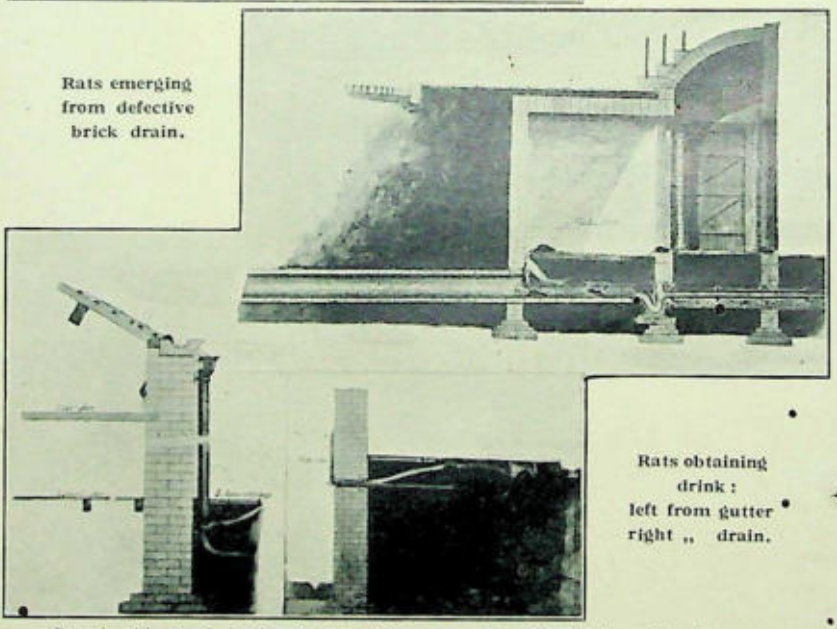
As a matter of fact rat-catching by hand is based on the well known behaviour of rats. Though cautious and suspicious they are nevertheless very inquisitive and can be enticed from their haunts by suitable lures such as certain strong smells, oil of aniseed or rhodium and sometimes cummin being used for this purpose, while gentle whistling or tapping sometimes has the same effect. Like many other wild animals they are attracted and partly dazzled

Rats in a Granary.



Rats climbing up by a stack pipe.

Rats emerging from defective brick drain.



Rats obtaining drink:
left from gutter
right „ drain.

(Reproduced by permission from Lantern Slides in possession of the Ministry of Agriculture, with acknowledgment to Medical Officer of Health, City of Liverpool.

for they will easily gnaw through a floor board or partition in a night, and even heavy doors of two-inch hard wood will soon yield to their attacks.

Rats are commonly credited with considerable intelligence and cunning and certainly they are extremely suspicious of anything strange in their normal surroundings. They frequently exhibit great ingenuity in obtaining their food supplies and considerable skill and perseverance in entering and leaving buildings and many stories are told of their escapades. It may be that many of the stories told are not free from exaggeration, but it is certain that much of the cunning so often attributed to rats is more apparent than real, for it is far more often due to man's stupidity in underrating the enemy and failing to exercise care and common sense himself in his efforts to combat them.

As already mentioned, the habits of the two species differ in several respects. Rattus norvegicus tunnels out burrows wherever possible, is more voracious and bold and though a good climber is not so agile as Rattus rattus. One condition is indispensable for its existence, and that is a convenient water supply, for it drinks frequently and is an expert swimmer. On the other hand, Rattus rattus drinks less often and never willingly enters water. Rattus

norvegicus is the more omnivorous and dirty feeder of the two and though it frequents human habitations is actually the more shy and retiring in the presence of human beings. Rattus rattus, however, will live in quite close proximity to its human host and though cautious, displays less shyness, for it will often emerge in daylight on to girders or pipes, even in offices full of girl typists, to their no small dismay.

These habits govern their modes of life, and though both are fairly adaptable to change, Rattus norvegicus in particular, as a rule they inhabit an environment which conforms to their respective needs.

Rattus norvegicus can and does establish itself in the following situations in the open: in fields and hedgerows and banks (especially along water-courses, for the water furnishes them with a ready means of migration) in which they burrow out long tunnels and there establish their nests, providing themselves with numerous bolt holes in case of need. They also live in sewers, on sewage farms and manure and refuse-heaps, where they are quite ready to consume ordure and filth, and such situations are often overrun with swarms of rats which are a serious menace to the surrounding property. It should be made clear that the description "sewer rat" so often used by the public can only refer to the environ-

ment. There is no such thing as a special species inhabiting sewers. In buildings it prefers the lower floors, burrowing into brickwork and foundations wherever it can find a weak spot. This rat will often live outside a house and work a way in to reach its food supply, or if established inside will work a path outward to obtain water.

The adaptability of this species is remarkable, and in the colder parts of Northern Europe it has become entirely a house dweller, displacing the common mouse, and will even invade the beds of the inhabitants, while in South Georgia it manages to exist out of doors in the summer by preying on sea-birds, despite the snow and icy wind.

Rattus rattus, on the other hand, though in warm climates it will live out of doors quite comfortably, generally prefers the shelter and warmth of human habitations and buildings and in Europe is almost invariably found indoors. It never inhabits sewers and will not exist on ordure. Its preference for upper floors and roofs has been mentioned and through not requiring much water it is not under the necessity of regularly leaving its haunts in search of drink; for similar reasons it is still the principal ship rat.

Finally it remains to describe the house mouse. The presence of this little animal is

often regarded with but little seriousness but it is quite capable of becoming a serious pest and of doing a tremendous amount of damage and in some respects it is more difficult to deal with owing to its ubiquity and small size.

Its appearance is familiar and it is very similar to a black rat in miniature. In colouring it is generally greyish with a tinge of brown. Its ears are large and clothed with fine hair. The tail is rarely shorter than the length of head and body together. The fur is soft and the bristles present are too fine to be apparent, while in weight it is generally about half an ounce (*see* plate 1).

Like rats, mice are extremely prolific, attaining maturity at about three months. Many litters are produced in the year, generally during the warmer months. The period of gestation is similar to that of rats, and the average number of young per litter is five or six.

In general habits it resembles the black rat. It climbs well and can swim, but does not often take to water of its own free will. It follows similar tracks and makes nests in much the same way. It, too, is omnivorous, with a preference for grain when it can get it.

Mice, unlike rats, though no doubt originally of Eastern origin, have been established in Europe from remote ages. Like rats, they are

very adaptable and in many places have developed into local sub-species with distinct characteristics and habits; for instance, in many parts of America, where there are no native Murinæ, they have taken to an out-door life and even in many parts of Southern Europe one variety lives a wild life out of doors and many naturalists regard it as a distinct and indigenous species.

Sometimes mice increase to an amazing extent, constituting "mouse plagues." These abnormal increases usually follow the sequence of a mild winter following a good harvest and at such periods the damage done by these small rodents reaches surprising amounts, crops and herbage of all sorts being utterly destroyed.

It is often supposed that rats and mice never exist together in the same building, but such is not the case; in fact it has even been stated that rats have been observed to deliberately "preserve" mice so that they can when required obtain a supply of fresh meat. Rats certainly do prey on mice and buildings to which rats cannot gain access often become overrun by mice, for it is extremely difficult to exclude mice from large buildings.

Such, then, is the natural custom of these three rodents which, by their adaptability, have spread over the whole globe and it will be sufficiently apparent that the task of repressing

them is no easy one, for they are well "dug in" and only attacks on an elaborate and world-wide scale, backed up by all the resources of science and civilisation, can succeed in dislodging them and forcing them to retire to those natural conditions of life from which they have emerged.

CHAPTER III

PRACTICAL DESTRUCTION OF RATS

The Nature of the Problem

FROM what has been said in the previous chapters it will be realised that the practical destruction of rats is by no means a simple task. The nature of pest problems in general has been discussed and it was shown that the particular problem of dealing with rats was complicated by many factors peculiar to itself and by the fact that we are dealing with an exceedingly prolific animal capable of successful existence under the greatest variety of conditions.

It was pointed out how the introduction of unfavourable conditions is one means of dealing with such a problem, and how the actual change of conditions which took place in Europe in the eighteenth and nineteenth centuries did in fact materially affect the relative distribution of the two species without, unfortunately, making much permanent difference to the practical aspect of the problem as it now presents itself to us, if anything perhaps it has even intensified it.

In the past the problem has really received

but little serious scientific attention, nor have there been many attempts to systematise or control rat destruction on the part of Governments or Local Authorities, though occasionally spasmodic and ill-directed regulations can be recorded.

A certain amount of work has been done in Europe, mainly directed to the production of cultures of germs suitable for use in preparations designed to infect the rats with fatal disease and more recently the use of poisons has been investigated in Great Britain, India and the United States under the direction of Government Departments.

There are of course many methods of destroying rats and each method may have several variations in the way it is used. No method which actually does kill rats can be called a bad method, nevertheless while none may be ideal, some are of more general application and more nearly approach the ideal than others.

Before describing these methods in detail, it may be said at once that there is no royal road to success, nor is there any wonderful specific which can be regarded as the sole and only means of success, still less, one capable of fulfilling the somewhat extravagant claims which the public often demand or have been led to expect. Indeed, success can only be achieved

(and that sometimes but a partial one) by constant attention and thoroughness in applying whatever methods may be chosen.

Rat suppression and rat destruction are not precisely synonymous terms—actual destruction of rats is after all only a palliative, a necessary one it is true, but looking at the problem as a whole it is seldom a complete success unless steps can be taken to deal with the cause which lies at the root of the trouble.

Every rat infestation, however large, or however small, is a definite problem, and as such it must be considered. At the outset it is necessary to inquire how it arose, what factors are contributing to its persistence, to what extent these factors can be removed or counteracted and finally, what steps can or ought to be taken for direct action against the rats themselves.

In some cases it may be quite easy to decide what is the direct source of a rat infestation, in others it may require a considerable amount of investigation before the rats can be traced to any special source, while in many more it can only be traced to the generally infested conditions of the surroundings and this is especially the case with estates and farms in the country.

In towns, it must be admitted that a large proportion of infestations (of course only those

where Rattus norvegicus is present) is undoubtedly due to drain defects of one sort or another; such defects may be in direct connection with the infested property and so can be fairly easily located and dealt with, or it may be a more general and deep-seated defect, difficult to locate and troublesome to remedy—at any rate the remedy is outside the competence of the unfortunate property owner. Many cases are due to rats spreading from some obvious centre of rat infestation, such as refuse tips, or open yards full of materials which attract rats because they either afford food or shelter, or both; other cases are due to the actual attraction which the place itself affords to rats, such as farms, poultry and pig farms in particular, as well as factories and warehouses where foodstuffs are made or stored.

Such reasons as these, some obvious, some less obvious, will generally be found to account for rat infestations, but this is not the whole of the story; rats may be present in any of the situations described but they need not be able to get from them into the infested premises and further investigation must be made to ascertain if possible, exactly how the rats have gained their footing inside the premises. It is in this direction that the proper means of dealing with them must be sought, in short the solution is

summed up in the comprehensive phrase "rat-proofing."

Rat-proofing is by no means always a simple matter and it is impossible to deal with it except in a very general way. It may involve anything from the bricking or cementing up of a few holes in a cellar, to the virtual reconstruction of large buildings.

In the case of town buildings, basement lights and skylights should always be protected with stout wire netting of small mesh, doors should be carefully adjusted and if necessary, protected at the foot with metal sheeting, while all windows accessible to rats should of course be kept closed at night. In large buildings with central heating, the boiler house is often the source whence rats enter, they then follow the channels in which the steam pipes are laid and emerge through holes left where pipes connect to radiators or pass through walls and floors. With more care in fitting much of this can be obviated or the holes can be protected by metal or wire netting and in many cases it is possible to devise protection for the ducts where they first enter the building. It must not be forgotten that where Rattus rattus is a likely visitor attention must be paid to skylights and defects in roofs such as open louvres.

Many cases occur where rats gain an entrance by burrowing through the ground under the floors and then effect an entrance by gnawing holes in the floor-boards or skirtings. It is true that most of these cases are due to drain defects, but it is not always practical or possible to deal with the defect and rat-proofing, to be effective, will involve the construction of a sound concrete bed.

In the country, farm buildings are notoriously ill constructed and rat-proofing, short of re-building, is often extremely difficult if not impossible. Poultry farms in particular offer great attraction to rats and little care is taken to make the poultry houses, incubator rooms and brooders rat-proof. The first at any rate are usually constructed of wood and one of the common defects is putting them much too low on the ground, this enables rats to get underneath and easily work their way into the houses. It is far better if they are raised three or four feet on posts, and then the whole carefully wired round, the wire being let into the ground about eighteen inches and turned outwards, a suitable wire gate being arranged so that in case of accidents it is possible to get in under the house without having to undo the wire. An additional precaution is to stretch wire over the under-side of the floor. Careful rat-proofing of poultry

houses may be expensive, but is certainly cheapest in the long run.

To sum up then, rat-proofing wherever practicable is the first step but even where this is impossible in its entirety much can be done to deprive rats of opportunities of obtaining food, water and shelter and so introduce unfavourable conditions in place of the existing favourable factors which contribute to their existence. In particular the greatest care should be taken to keep food out of reach of rats by placing it in rat-proof rooms or receptacles. Water tanks also should have rat-proof covers and taps and sinks should be kept free from drips. All waste food and scraps should be got rid of by burning if possible, or storage in properly covered dust bins. *Restaurateurs* are great offenders in this respect, for it is no uncommon thing to see large bins full of waste food, without a cover, carelessly exposed where rats can easily get at them. Accumulations of stores and rubbish which, though not actually edible, yet form ideal nesting places, should be turned over and restacked at frequent intervals, so that they do not form hiding places, for undisturbed nesting is a far more important factor in maintaining an infestation than is commonly supposed and those who have not tried would be surprised how m

improvement can be made by attention to this point.

It is worth pointing out in this connection that the racks usually found in warehouses are almost invariably badly designed. As a rule, the lowest shelf is about two inches from the floor, the front being frequently filled in with a fillet of wood, the idea being economy of space and neatness. The proper way is to keep the lowest shelf at such a distance from the floor that the space beneath can be easily swept out and kept empty and clear of rubbish and on no account should goods be stored in these spaces. With mice especially such ill-constructed racks are a prolific source of trouble. Another source of trouble is the existence of matchwood casings over pipes and it would certainly seem that these might be often dispensed with, at any rate in buildings of factory type, where appearances are not vital. Precautions such as those suggested are of general application, and in special cases additional measures could be devised to meet the particular conditions.

If then rat-proofing has been carried out and harbourage reduced as much as possible, the actual destruction of rats can be put in hand with much better prospects of decisive results than is the case when these precautions are neglected.

by bright lights and will approach quite close to an electric torch providing it is held perfectly still.

In catching them the operator must keep perfectly still and preferably in shadow, for the slightest movement will soon scatter the rats, though they do not seem to mind the mere presence of anyone who keeps perfectly quiet. The actual seizing of the rats is a matter of dexterity and if done properly they cannot bite, though thick gloves are generally worn as a precaution.

The successful working of ferrets and dogs is a matter of training and experience, both on the part of the animals and their owner, therefore it is not a very suitable method for use by the public themselves and anyone wishing to put this method into operation is well advised to employ a skilful and reliable man.

Apart from any question of catching by hand, the use of ferrets is of somewhat limited application. It depends for its success on the presence of rats in runs or situations from which they can readily be ejected by the ferrets and when ejected either caught in nets or despatched with sticks and dogs. The *modus operandi* is to net up carefully all the rat holes and likely exits with ordinary garden netting fixed loosely over the holes, the ferret is then introduced into one

of the holes so that it can travel along the runs, driving the rats before it while the escaping rats are caught in the netting and despatched by any convenient means. When working with a good "ratter" dog, holes within his reach need not be netted, as he should be able to do all that is necessary.

In the country this method is fairly successful in dealing with banks and has the advantage of giving a bit of sport. In town buildings where the rat holes may and often do lead to runs in direct communication with either defective sewers or neighbouring premises, the method is of less use as the rats will be merely driven away and there is considerable risk of losing the ferrets. There are too, many runs, particularly those between the joists of a floor, with dead ends, with the result the rat turns on the ferret and a fight ensues. The latter is almost always the victor and while it may not get off scathless, it frequently lies up and gorges and difficulty may be experienced in retrieving it. The method is most successful where the rats are mainly nesting and living among stacked goods rather than in holes in the fabric of the building. Runs which have been worked with ferrets would seem to be avoided by rats for some time afterwards, presumably because they retain the taint of the ferret.

Although as a rule only ferrets and dogs are trained for systematic work as ratters, cats and mongooses are sometimes used; the former however cannot be relied on to face rats though sometimes when allowed to run almost wild, they do good work, while the latter may become as great a nuisance as the rats they exterminated, as was the case in Jamaica where they were imported to deal with rats on the sugar plantations.*

Trapping

The use of traps and snares for catching rats is not particularly modern in principle, nevertheless there has been a large number of trapping devices produced during the past few years, which vary considerably in design and complexity. It is quite impossible to describe all these in detail, nor is this necessary for the principles of the method in general are more important than the mere description of mechanical details. In any case the success of trapping depends more on the skill of the trapper than on the particular form of the trap used, for a careful and cunning worker will get better results than a casual worker, even with an inferior article.

Traps may be divided into two classes, those

* Boelter, *ibid.*

designed to kill or take single rats and those capable of killing or capturing many rats. Of the former class breakback traps or those similar to rabbit traps with toothed jaws meeting in the centre, are the most popular as they are easy to set and do not take up much room and as a general rule both kill outright. Experienced workers on the whole prefer the rabbit type as they are easier to conceal.

There are many forms of traps for catching more than one rat which vary considerably in design, particularly in the arrangements for self setting, but as a general rule the simpler the trap the better the results. A common form is the barrel shaped wire trap but unless carefully made and of suitable dimensions, especially at the entrance and in the springing of the platform, it is comparatively useless. The principle of this trap as of many others consists of an inner and outer compartment, exit from the former, in which the bait is placed, being impossible once the rat is inside.

Both the Zoo experiments conducted by Mr. Boulenger* and similar observations by officials of the Plague Commission in India† confirm the importance of these points.

* "Methods of Rat Destruction." The Zoological Society, London.

† Private communication to the author

Other ingenious traps work on the principle of enticing the rat on to a balanced platform which tilts it into a tank of water below as soon as it passes the point of balance.

A form of trap which has been widely recommended is that known as the Varnish or Ratlime trap, and as its name suggests, it depends on enticing the rat on to an adhesive surface from which it cannot escape. It is prepared as follows: sheets of stout cardboard or thin pieces of wood are cut about fifteen inches by twelve inches, on them is spread with a trowel a layer of the special preparation sold for the purpose —either lithographic varnish (rat-catching) or ratlime, which is a specially tenacious variety of birdlime—making it about one-eighth to one-quarter of an inch thick and leaving the edges clear for about one inch all round. Any suitable bait is then placed in the centre of the material, and gently pressed down so as to adhere. One of these traps will frequently take many rats; dead ones can be pulled off, the surface respread if necessary and the trap relaid, for a good varnish or ratlime will retain an effective surface for several days and if the surface is stirred up occasionally will last two or three weeks. These traps are particularly useful for catching mice, for which purpose the cardboard is cut smaller, four inches by three inches being sufficient.

In using movable traps of the less elaborate types, great care should be taken to place them if possible in the direct line of the rats' run with the working parts or entrance parallel to it, the object being to catch the rat as he pursues his normal path and it is then often quite unnecessary to bait the trap. Rats are very suspicious of strange objects and will rarely enter a trap of any kind however attractively baited if it be just placed out in the open. Another way to set traps is in an artificial run made by constructing a box open at both ends, in the middle of which is placed the trap, the whole thing so arranged that the rat in his run must pass over the trap. Similarly a tunnel can often be made on the spot with bricks, slates or anything else handy, if no box is available.

When using breakbacks or rabbit type traps, it is often helpful to conceal them; this can be done by lightly covering them with sawdust or putting thin tissue paper over them when used indoors or by covering with earth or setting them just under the surface of water when used out of doors.

It is commonly stated that traps should be handled with gloves on so as to avoid tainting them with the human scent and that it is advisable to rub them in earth and so on, especially after a rat has been caught. There

may be sound reason for this when trapping in the open country or where human beings seldom enter but in the average town building there seems but little reason for it; after all, almost everything the rats run over or eat has been more or less manhandled and experience in towns hardly supports the statement. There is no infallible bait for traps, and one must use whatever circumstances and experience suggest. In some places rats seem but little tempted by special delicacies and prefer what they are used to in the premises in question but it does not seem generally known that a piece of tomato often serves as well as anything else.

There is one other form of trap which can sometimes be employed with considerable success; shortly it consists of a large box or enclosure from which rats cannot escape, provided with an entrance and exit, the former being fitted with a door which can be closed from a distance by means of a string over a pulley. It is quite feasible in some cases to make use of one of the infested rooms in a building and adapt it for this purpose. The trap is worked as follows, for some nights the trap is baited with some attractive meal which the rats cannot carry away, best placed near the exit. The rats get used to coming and when it is judged they are regular visitors, the exit is closed and as soon as sufficient

of the rats are inside the entrance is closed by a concealed observer. The trapped rats can then be despatched by dogs.

However, even with the most skilful working, it is difficult to trap rats in sufficient numbers to clear really badly infested places and rats soon learn to avoid traps, even varnish, which on the whole, seems the most successful for routine use. Trapping really is of most service after a place has been cleared, for then traps can be used with considerable success as guards along known lines of approach.

Gassing

This method is of quite recent development and is really a variant of fumigation under a shorter and perhaps more convenient name. It consists essentially of introducing a suitable toxic or asphyxiating gas into the rats' runs and warrens and so either killing them there or driving them out, in the latter case of course to be dealt with by sticks or dogs. It is an excellent method providing the terrain is really suitable and if the rats are actually in the holes a good kill should be obtained and one which is to an extent selective on does and young since they get killed in the nests. The most suitable places for treatment with gas are infested banks, hedgerows, refuse dumps or other out door

situations where burrows abound and the rat population is concentrated and where the gas is not likely to cause inconvenience to neighbouring houses or injure domestic animals. Thus it is not always possible to use it around poultry farms nor in general is it suitable for dealing with rats in houses since there would be difficulty in confining the gas to the rat runs and as numbers of the rats would die in the holes there would probably be some trouble with smells. Ships however are regularly fumigated as an anti-rat and anti-vermin measure.

Several gases have been suggested and used for this purpose such as Chlorine, Phosgene, Hydrocyanic Acid Gas, Carbon Disulphide, Sulphur Dioxide, Acetylene and even the exhaust gases from a motor-car which contain a considerable amount of Carbon Monoxide. Of these only two are of practical importance, viz. Sulphur Dioxide and Hydrocyanic Acid, since both can be easily applied on a large scale but until a quite recent development of Cyanide fumigation, Sulphur Dioxide had the field almost to itself so far as rats are concerned.

The principle is much the same whichever gas is used: the holes are carefully noted and in each group all except one, lightly stopped with earth, into this the gas is introduced by means of a flexible rubber tube. This hole

should be chosen at the top of the group if using heavy gas or at the bottom with a light one. If gas is noticed to emerge from other holes during the treatment, they too should be stopped and finally the treated one. Each group of holes is systematically dealt with, the area being divided up between several operators if necessary. The treatment is not necessarily spectacular as most of the rats will be killed before they get a chance to bolt, but it is advisable to have a good dog to seize any which do, besides which he is useful to "nose" holes and so indicate whether rats are present. It is hardly necessary to add that due care must be taken to prevent him nosing gassed holes. If counts are wanted it will be necessary to dig out the runs to find the dead rats. There is, of course, a certain amount of risk attached to the use of any poison gas and in the following notes dealing with the practical application of these gases any special precautions necessary will be mentioned.

Sulphur Dioxide which as stated has been generally used for rat gassing is the product of burning sulphur in air, strictly speaking it is an asphyxiating gas rather than poisonous and fairly high concentrations are necessary to kill rats. Its use is fairly free from danger to the operators for the same reason and its irritant

Rick undermined by rats.

Rats in a Grocer's Store.

Gassing with Sulphur Dioxide (Clayton Generator).

(Reproduced by permission from Lantern Slides in possession of the Ministry of Agriculture).

effect acts as a warning. For practical use in the field a constant supply of gas is of course necessary and this can be obtained either from cylinders of liquefied Sulphur Dioxide or by preparing the gas on the spot in special sulphur burning apparatus.

The former method is simple and convenient and easily portable cylinders of Sulphur Dioxide can be obtained which are fitted with control valves and nozzles to which the rubber tubing is attached.*

The alternative method is more trouble and requires more staff to operate, for whereas one man can handle a cylinder of gas easily, it requires at least two to operate a sulphur burning machine. For large scale operations the machine generally used is the well known Clayton Generator. It consists essentially of a chamber in which roll sulphur is burnt in a stream of air, and a pump which forces air over the burning sulphur thus causing a good draught to carry the gas along, the gas being conveyed to the holes by means of thick rubber hose. These machines are made in several sizes, large ones driven by motors being used for ships and portable ones for land work, these latter require one man to work the air pump and one to operate the hose. Apart

* "Sulphume," obtainable from Messrs. A. Boake, Roberts & Co., Ltd., Stratford, London, is suitable for this purpose.

from the capital cost of the machine this method is cheaper than using liquefied gas in cylinders.

For gassing with sulphur on a small scale a simple apparatus is described in the Ministry of Agriculture leaflet No. 244, from which the description below is taken :—

"In order to make the apparatus the procedure is as follows : Take an old paint drum (A) of about 12 in. in length and 8½ in. in diameter, fasten the lid to the side with a link hinge and punch a hole in the lid to admit the point of a small pair of bellows (D). In the base of the drum punch a hole 2 in. in diameter and in this hole fix a piece of metal piping (B), 9 in. in length. An L-shaped strip of metal 2½ in. high should be riveted on the inside of the drum at (C) to prevent the cotton waste (E) and small sulphur (F) choking the orifice of the spout (B). To facilitate carrying, a small handle can be fixed to the side of the drum as shown.

"When the apparatus is to be used the lid should be opened and some old oily cotton waste placed within and ignited. If necessary, the lid should be closed and the cotton waste fanned with the bellows to a good glow (if the lid is left wholly or partly open, free contact with the air will often be sufficient to cause the cotton waste to glow). With a view to finding out connecting runs in a burrow, in banks and

hedgerows, as soon as smoke issues from the spout (B) of the apparatus, the spout should be placed in a hole, if possible to the windward of other holes. All holes from which smoke issues except one of the lower ones and the highest, should then be plugged lightly. The drum should then be opened and a layer of sulphur (F) be sprinkled on the glowing cotton waste. The spout (B) should then be inserted into the lower hole and the bellows (D) be used. In a few minutes colourless sulphur dioxide will be generated and in about a quarter of an hour, or longer, according to the size of the burrow, the rats will either succumb to the gas or try to bolt—in the latter case to be despatched easily by sticks and dogs." The well known Burns "Eclipse Smoke Testing Machine" can also be adapted to this purpose.

Although fumigation with Sulphur Dioxide

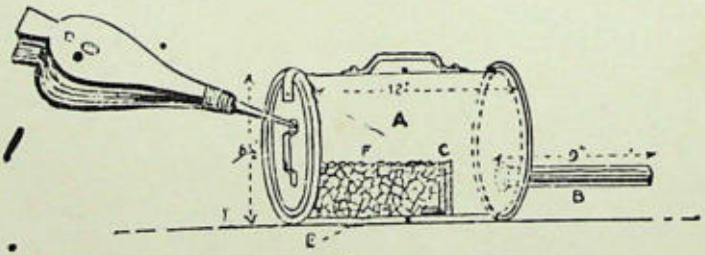


Fig. 1

Diagram of Simple Gassing Apparatus.
(Reproduced by permission of the Ministry of Agriculture.)

has the great advantage of being almost entirely free from danger and therefore suitable for use by amateurs, it is probable that for large scale operations where a technical or partly trained staff is available it will be superseded in the future by the new application of Cyanide fumigation which has been introduced during the past year.

This method depends on the use of crude Calcium Cyanide in powder form which has been introduced from America under the name "Cyanogas."* This chemical when exposed to the air is gradually decomposed by the moisture present, giving off Hydrocyanic Acid Gas much as Calcium Carbide gives off Acetylene when acted on by water but, unlike Carbide, if excess of water is added, it merely dissolves, forming a solution of Calcium Cyanide, and then gives off no gas. Calcium Cyanide itself is not a novelty but it can now be produced very easily and cheaply from Calcium Cyanamide which is the main product in the fixation of Nitrogen from the air by the process depending on passing Nitrogen separated off from liquid air over white hot Calcium Carbide.

This "Cyanogas" is made in several grades and that known as "A" dust is used for rat fumigation as well as in horticulture.

* Messrs. George Munro, Ltd., Covent Garden, London, are the distributors for this preparation.

The method of using it is exceedingly simple and its efficiency is at least equal to and probably exceeds that of Sulphur Dioxide, while since the actual gas evolved is far more deadly much lower concentrations will suffice, thus effecting a great saving in time as a burrow can be filled with a deadly amount of gas more quickly than with the other method.

The preparation is supplied in sealed tins and if desired it can be applied by merely placing an ounce or two by means of a long handled spoon in each rat hole, and then sealing up at once with earth. A far better way is by using a powder blower or duster (and the makers supply a very efficient form) with a length of rubber hose attached which is introduced into one hole and the powder forced in with a few strokes of the pump.

The powder travels along and soon emerges as a fine cloud at the other exits of the run, these are then stopped up with earth and the original hole dealt with in the same way. The makers state that one man using the special duster can easily treat 150 rat holes per hour by this method.

Although this method is so simple to apply it must not be forgotten that Calcium Cyanide itself is a deadly poison—one moreover which only chemists can legally retail—and that the

gas given off by it in air—Hydrocyanic Acid Gas (Prussic Acid)—is just as deadly when made this way as by any other.

It is therefore very necessary to take great care in using it; in filling the dusting machine the operator must be very careful not to breathe the dust and during the working it is advisable for spectators and others to keep to windward, for the same reason it is best to arrange to work down wind. It is also most important to empty the dusting machines before putting them away.

If a dog is used in conjunction with this method special care must be taken to prevent him nosing round treated holes and immediately to take away from him any rats he may kill. The treated area should be kept clear of domestic animals during and for some hours after the treatment but the residue left after all the gas is given off is quite harmless, being mainly ordinary lime.

Hydrocyanic Acid Gas being relatively light diffuses fairly quickly into the air and is not so likely to form pockets of high concentration in ditches and dips as is the case with a heavy gas like Sulphur Dioxide and therefore when using this method there is less risk of a lethal concentration arising in the immediate vicinity of the work and as a rule the operators do not wear any special protective device against gas

Gassing with Calcium Cyanide (Cyanogas), showing dusters used for "A" dust and method of pumping.

(Reproduced by permission of the Proprietors of the Bristol Times and Mirror.

Plate 5 *To face page 59*

poisoning. It would certainly be much safer if such were the general practice, and in any case the method should only be used under technical supervision and a bottle of dilute ammonia should always be kept handy in case of accidents, the vapour of which serves as a restorative in the event of a worker being slightly gassed.

Finally it should be realised that the method must never be used for treating dwellings; it can however be used for treating holes in more or less open barns or farm buildings, of course after removing all livestock, if due care is taken and the holes are promptly sealed. In such cases the building should be ventilated for at least 24 hours before allowing anyone to enter or returning the livestock.

A somewhat analogous method has also been introduced depending on the use of Hydrocyanic Acid absorbed on Kieselguhr. This is a dry powder which gives off the gas again on exposure to air.

Although this application has made Cyanide fumigation a practical proposition for rat warrens, the gas prepared in other ways has been used for fumigating ships and buildings for some considerable time. This gas is particularly useful for treating ships for it not only kills rats but also all insect vermin including the rat fleas, which is not always the case with Sulphur Dioxide,

further it has no action on metal fittings or fabrics whereas Sulphur tarnishes and bleaches. The original method of preparing the gas was by the action of Sulphuric Acid on Sodium Cyanide, this is an exceedingly cumbersome and inconvenient method (besides being very dangerous), and the use of the strong acid is liable to cause burns if by chance it is spilt.

The more usual method now is by means of Liquid Hydrocyanic acid stored in cylinders from which it is ejected as a spray by means of compressed air. This latter method can also be applied to dwelling houses, flour mills, etc., providing they are evacuated and are sufficiently far from other habitations. It is however solely a method for the technical expert and the most stringent precautions are necessary, the operators being fully equipped with gas protection devices.

The other gases mentioned are of no practical importance and are seldom used—Chlorine and Phosgene are much too dangerous besides being inconvenient to transport. Carbon Disulphide is sometimes recommended, and is used by soaking tow or cotton wool in the liquid and stuffing the soaked wad well down the hole which is then closed with earth. It is however inflammable and the vapour is very poisonous to breathe so that care must be taken. As Carbon Disulphide is not very cheap the method is only

suitable for small infestations. Probably just as good results would be got by placing in the hole a handful of Calcium Carbide, pouring in some water, not too much, and quickly plugging the hole—here again as the Acetylene gas produced is inflammable care must be taken to avoid explosion.

To sum up the three methods which have been described in this chapter have been shown to be somewhat limited in their application and to require a certain amount of practice and special knowledge if the best use is to be made of them. Each is useful in its proper place but it is important to remember that unless a choice of method is made to suit the conditions found really good results cannot be expected.*

* *Note.*—While this book was in the press, a method based on the production of Sulphuretted Hydrogen Gas has been introduced on the Continent, and is stated to be very simple and to give good results.

CHAPTER IV

RAT POISONS AND HOW TO USE THEM

General Principles of Poisoning

POISONING is of the greatest importance as a practical means of dealing with rats, yet although the principle is extremely simple, so many considerations arise and it is so often improperly used and misunderstood that no apology is needed for dealing with it in detail especially as it is the method on which the general public rely, more than any other.

The basis of the method is well enough known, it consists merely of placing in and around the rats' holes suitable food material with which is mixed a poison capable of killing rats and leaving the consummation to the rats' appetite or greed.

While this seems very simple it at once involves two questions, firstly what is the best food to use so as to be sure the rats will eat it and secondly what poison to use, and apart from the technique of the proper use of poison baits, these two points alone offer a considerable field for investigation. It may be stated at once that the use of poison baits is one of the best of all methods for destroying rats since it can

be applied with due precautions in practically every situation in which rats are found and is subject to fewer limitations than any of the methods previously described. Properly applied, it is remarkably successful and gives decisive results within a short time of its application and though it may not always at once clear a place completely it is so flexible that treatment can be maintained over long periods without ceasing to be effective.

Practical experience fully justifies these statements and there is no doubt that the public find this method of service, for there is a steady and increasing demand for rat poisons. It must not be supposed, however, that of necessity the use of poison baits will prove a panacea for every case of rat infestation; most if not all will be undoubtedly greatly reduced by this method but it does not follow that other methods should not be combined with it, providing of course they are not incompatible; for instance it would not be wise to run ferrets over an area recently treated with poison bait.

The use of poison is sometimes objected to on the grounds that it is dangerous to domestic animals and that in the case of buildings it gives rise to smells due to rats dying under floors or in inaccessible places. As will be shown however, both these disadvantages can

be almost entirely overcome provided a suitable choice of poison is made.

It will be convenient first to deal with the theoretical and practical aspects of the use of poisons for rat destruction and then to point out how they can be incorporated with suitable ingredients to form satisfactory baits and finally to explain the technique of carrying out a campaign of poisoning. There is no great difficulty involved in killing rats with poisons for on the whole they are rather susceptible to poisons than otherwise, but many poisons are unsuitable for this purpose from a practical point of view.

Poisons may be defined as substances which when introduced into the living organism cause death or injury. Strictly speaking this definition includes disease germs and those germs applicable to rat destruction will be dealt with in a separate section; for the present they need not be considered as coming within the definition of poison. This definition is somewhat comprehensive and in general parlance the word poison is restricted to those substances well known to be dangerous, while in addition there is a still more limited class of poisons, namely those included in the two schedules to the Pharmacy Acts, the retail sale of which is restricted by law to registered chemists and druggists. Many substances, of

which strychnine, arsenic, and morphine are examples, are dangerous poisons but if given in small quantities are valuable drugs. Other substances such as preparations of bismuth, borax or tin salts are not ordinarily regarded as poisons but if taken in excessive amounts may come within the above definition. There is therefore a very large field from which to select a rat poison, for by definition any substance which taken in sufficient quantities, would kill rats, comes within the term rat poison.

In practice there are a great many points to be considered before it can be said that a particular substance is suitable for this purpose and as a matter of fact there is still much need for scientific investigation on the theoretical problems connected with rat poisons, particularly as to the minimum lethal dosage for rats and their effects on larger animals. Such experiments, which involve the use of live animals can only be carried out by properly qualified scientists under license from the Home Office, for though there are no restrictions to the use of "any poison for the destruction of rats, mice or small vermin in any land or building providing reasonable precautions are taken to prevent access thereto of dogs, cats, fowls or other domestic animals,"* it is illegal to carry out anything in

* Protection of Animals Act, 1911, Section 8 and Sub-section (*b*).

the nature of deliberate administration of poison for experimental purposes.*

It is of course a *sine qua non* that any poison to be used should not only really kill rats but kill in such reasonable quantity that a rat could be expected to absorb a lethal amount in an average consumption of food material since any question of using a poison alone can be dismissed as impracticable. Further, since rats and mice are ubiquitous and live in our houses, stores, factories, warehouses, offices, barns, stables and farm-buildings of all kinds as well as in sewers, refuse tips, hedgerows, banks and sides of streams and canals, it is desirable that the poison chosen should be suitable for these various situations and in particular since so many of these involve the presence of human beings, domestic animals and food substances, that it should be if possible, at least relatively harmless both to ourselves and our domestic animals and birds.

Despite the considerable number of poisons which would comply with the first condition—that is kill rats in fairly small doses—actually in the past only three poisons—namely, arsenic, strychnine and phosphorus—have ever been in general use in this country. Occasionally, however, other poisons such as cantharides, tartar

*Cruelty to Animals Act, 1876 (Section 2).

emetic and atropine are stated to have been used. These three poisons are of course well known to be dangerous and no doubt anyone "*knowingly*" using them would take such precautions as were possible against accidents—it does not follow however, that when prepared rat poisons are purchased at shops that the nature of the active ingredient is stated or adequate warning given in the directions for its use.

Of recent years since rat destruction has become a matter of official concern and the public in general has begun to realise the importance of active measures against rats, it has been realised that these dangerous substances have many disadvantages and search has been made for more satisfactory poisons which while toxic to rats will give a reasonable margin of safety to human beings and domestic animals.

The solution of this particular problem lies in the relative danger of any given poison to rats and other animals for it is extremely unlikely that any poisonous substance will be found which will kill rats and yet be entirely innocuous to other animals "*irrespective of the quantity taken.*" Dr. Raebiger who investigated this problem in 1907* said "As the result of my experiments during the last six years I have come to the conclusion that preparations which are really

* Quoted by Boelter, *ibid.*

non-poisonous are unable to kill rats and poisons, call them what you like, if they kill rats will also kill domestic animals."

In general for any given poison the minimum lethal dose depends on the size of the animal and as a rule is less in proportion to its body weight for larger animals than for small ones, that is, though the absolute dose is greater for the larger animals the relative dose is less. Fortunately the rat is a small animal and appears to be particularly susceptible to some poisons, possibly due to the fact that it is unable to vomit or at any rate does not readily do so, and therefore the absolute dose of most poisons required to kill it is small. If then some substance with a low absolute dose for rats and a high absolute dose for larger animals can be found it could be used with much greater freedom than one in which the margin of difference was less.

In order to be considered ideal for use as a rat poison the substance chosen should satisfy the following conditions—and it must be emphasised that only the active ingredient is being considered, not prepared baits as usually sold in shops.

(1) It must be relatively harmless to domestic animals.

(2) It must be effective on rats and mice, that

is, reasonably small doses must kill for certain.

(3) It must be cheap and readily procurable.

(4) It should be tasteless or at any rate have no repellent taste or smell.

(5) It must be reasonably easy to handle and readily compounded with suitable ingredients to form attractive baits.

(6) It should keep well and retain its toxicity.

There are not many poisons with properties which approximate to this ideal, particularly in respect of their harmlessness to other animals, though there are a fair number which would comply with the other conditions.

It cannot be denied that there is a real necessity for the use of poisons which will comply with this first condition, for without it farmers and others who have special reasons for care are deprived of one of the most valuable weapons in the anti-rat armoury and one which is particularly adapted to their needs.

The three poisons hitherto in general use hardly comply with it, for though the lethal doses for rats are low it is unfortunately the case that the same is true for larger animals and many accidents have arisen from their use.

Even if the greatest care is taken to ensure that the baits are inaccessible to domestic animals there is always the risk of them finding and eating the corpses of the dead rats, and pigs in particular are liable to be poisoned in this way.

If also the action of the poison is rapid, and it is more or less the case that dangerous poisons kill with greater speed than less dangerous ones, there is more risk that the rats will die under floors or behind skirtings and thus give rise to unpleasant smells. Few poisons even in large doses are absolutely instantaneous and certainly in the form used none of the rat poisons, so that if as is usual the bait is laid in or near the holes, the rats after consuming them have at any rate some little time, perhaps but a few seconds, in which they may possibly retreat a little way back along the hole, and all will not necessarily die just near by.

The public often demand of a rat poison that it shall dry up the corpses of the rats killed by it and evidently suppose that such a poison would obviate this unpleasantness of smell from decaying corpses. Unfortunately the poison used has little or no effect on this particular point, the main factor which causes the smell being the decomposition of the contents of the rats' digestive tract. As is well known, rats are dirty and voracious feeders and therefore a dead

rat is rather likely to be offensive, especially if the corpse happens to be in a warm and damp atmosphere and as their runs so often follow hot water pipes or lead to warm nests under grates or radiators this condition is not unlikely to occur in buildings and if the rat dies quite shortly after taking the bait the risk is considerably increased.

If however the poison has any action in causing evacuation of the rat's digestive tract and in delaying death the risk of smells is much reduced, for not only is the rat less likely to die in an inconvenient place but when it does die its digestive tract is more or less freed from decomposing material. In general it may be taken that none of the poisons used for rat destruction have any direct and certain action in either preserving or drying up the corpses with the possible exception of arsenic, and even with this the amount usually ingested by a rat in a poisoned feed would probably be insufficient to ensure it.

In the search for rat poisons which would be free from these objections a good many other substances have been tried, both experimentally and practically, and as a result of these investigations two other substances, Barium Carbonate and Red Squill, have come into fairly general use as rat poisons. In particular much of the

experimental work carried out at the Rat Research Laboratory of the Ministry of Agriculture during 1920-1922 (in which latter year it was closed) was directed to investigating these two poisons, and their usefulness for this purpose was confirmed.

Both these poisons are slower in action than the others mentioned and their margin of safety is much greater, Red Squill in particular being specially useful in this latter respect. Preparations containing one or other of these substances are becoming increasingly popular in this country and their use is strongly recommended by the Ministry of Agriculture, not only because of their relative safety but also for their general convenience.

Among the other less dangerous chemicals suggested for use as rat poisons are Calcium Sulphate (anhydrous) or Plaster of Paris and Sodium Fluoride. The former certainly requires so large a dose to be effective that it would be difficult to administer it in practice, while the latter gives very variable results.

For all practical purposes the chemical poisons used for rat destruction are limited to these five substances—Arsenic, Strychnine, Phosphorus, Barium Carbonate and Red Squill—and the various proprietary rat poisons on the market almost always contain one or other of them.

Occasionally a preparation is met with which is alleged to contain a new and secret poison but chemical analysis invariably proves it is one of the well recognised poisons—more often than not arsenic. It is almost needless to add that these claims are associated with individuals of little standing who presumably are acting more in ignorance than from unscrupulousness.

These five poisons differ very considerably in their chemical properties and physiological action and some description of these is necessary in order to understand their uses and limitations as rat poisons.

No definite and systematic classification of poisons is possible either on a chemical or physiological basis and it is usual to adopt one based mainly on symptoms as being most convenient for medical men. With the exception of strychnine which is a convulsive poison specially affecting the nervous system and the only one likely to cause immediate or almost immediate death, all the others are classed as irritant poisons though other secondary symptoms may also arise.

It will be therefore desirable to consider each of them separately. It must be noted however that much of the information available on poisons has been derived from cases of human poisoning and only to a limited extent have they been

investigated from the special point of view under discussion and therefore it is not always possible to give precise figures for the doses required to kill rats and other animals.

Arsenic

The description arsenic or white arsenic as generally used, is applied to the substance chemically known as arsenious oxide—which is one of the oxides of the metal-like element arsenic. It is manufactured on a large scale by heating arsenical pyrites. In appearance it is a heavy white powder, which actually consists of several different physical forms. It has many uses in industry and the arts and is also used medicinally both in human and veterinary practice. Because of its poisonous properties it is used as a constituent of weed killers, sheep dips, horticultural sprays,* rat and vermin killers and fly papers. It is too, not uncommon as an impurity in many mineral substances and therefore the toxicologist has to exercise much care when investigating cases of suspected arsenical poisoning.

The white powder—which is the form generally used for rat destruction—is practically insoluble in water but is absorbed in the digestive tract, the extent and rate depending partly on its physical state, for it is most quickly absorbed

* Hence the contamination of apples with arsenic, recently reported in the Press.

when finely divided; it can however be absorbed in dangerous or even fatal amounts by external application through wounds or abrasions of the skin.

For all ordinary purposes arsenic can be sold only by registered chemists and druggists, but there are special regulations permitting licensed horticultural dealers to supply arsenic and arsenical preparations "to be used exclusively in agriculture and horticulture for the destruction of insects, fungi or bacteria or as sheep dips or weed killers."* In either case the purchaser must be personally known to the vendor and proper entries of the sale must be recorded and in order to comply with a special Act governing the Sale of Arsenic, all colourless preparations must be coloured with specified amounts of soot or indigo.† It seems evident that a horticultural license does not cover the sale of arsenical rat poisons since rats are neither insects, fungi nor bacteria.

When arsenic is taken in considerable amounts it generally causes acute symptoms of poisoning which arise within an hour, sometimes much less. Vomiting, diarrhœa, cold in the extremities and feebleness are the salient features and death takes place from collapse in from 5 to 20 hours.

* Poisons and Pharmacy Act, 1908, Section 2, Sub-section (1).

† Act to Regulate the Sale of Arsenic, 1851.

These symptoms are not constant and in some cases subacute or nervous symptoms are observed. When small doses are taken, spread over long periods chronic symptoms arise which may prove fatal.

It is difficult to say what is a fatal dose of arsenic, for its effect varies somewhat according to how it is given and the health and habits of the person. For instance, the arsenic eaters of Styria are capable of taking large quantities and horses also can take considerable amounts as it is by no means uncommon for it to be administered to them to improve their coats. The following however may be taken as dangerous doses. Man (adults) 2 grains; horses 30 grains; cows 10 grains; dogs ½ to 1 grain.*

Its action on rats (as indeed on most animals) is very variable, probably because it is seldom of uniform fineness, and there would appear to be no definite information of the average lethal dose for rats. In some experiments carried out by the author ¼ and ⅜ of a grain proved fatal but death was by no means rapid, occurring in about 24 hours and 48 hours respectively, while in another case the rat survived a dose of just under ½ grain and in all cases the fæces contained marked quantities of arsenic. It is

* Winter Blyth. "Poisons—Their Effects and Detection." London, 1920.

probably reasonable to assume that from ½ to 1 grain would be ample.

Lantz* also points out that arsenic is very variable in its effects on rats and adds that though it is generally considered to be a cheap poison yet measured by results it is dearer than strychnine.

It is often stated by gamekeepers who frequently use arsenic for this purpose that rats are suspicious of baits containing it and therefore the common practice is to put down preliminary baitings of unpoisoned feed for several nights before actually laying the arsenical feed, of course using identical meal throughout. There seems no special reason why this should be the case, for presumably arsenic is as tasteless to rats as to human beings. A possible explanation is that country rats are more suspicious than town rats of strange food unless particularly attractive, and it is probable that if a specially attractive arsenical bait were used initially, better results would be obtained. There is more ground for the statement that it is difficult to induce rats which have survived a bait containing arsenic to take another dose.

As a rule arsenic is given mixed with a cereal meal with or without sugar and in preparing

* "House Rats and Mice," *Farmers' Bulletin*, 896. United States Department of Agriculture, 1921.

such mixtures the proportion of arsenic need not exceed 5 per cent. or one part of arsenic with 19 parts in all of other ingredients, and 10 to 20 grains of such a mixture should be ample to kill, though some workers prefer to use 10%.

In using arsenical baits great care must of course be taken to ensure that only rats can get at the bait and any corpses found should be collected and burnt, for arsenic inside a corpse is just as deadly as outside it.

On the whole arsenic cannot be considered to offer any special advantages as a rat poison, its safety margin is low and its efficiency is not marked. It should never be used in any places where foodstuffs are prepared or handled, as traces may get in the food by accident—even sweeping up the baits might cause enough dust to contaminate foods and serious consequences would arise if such food was consumed.

Strychnine

This poison belongs to the class of vegetable alkaloids and is exceedingly poisonous. It is a complicated but definite organic substance and is obtained from the seeds of the plant *Strychnos Nux Vomica* and a few other similar species.

It is obtainable either as the alkaloid itself, which is insoluble in water but is acted on and

dissolved in the stomach, or as salts such as strychnine sulphate or chloride which are fairly soluble in water—these act more quickly when taken but the intensely bitter taste is more noticeable than when the alkaloid itself is used.

Strychnine is of course, a scheduled poison, and as such can only be sold by chemists to purchasers personally known to them, and all preparations must be labelled as strychnine and the percentage present, stated.* It has no commercial uses except in medicine and as a vermin killer.

Medicinally, strychnine is given either by hypodermic injection or by the mouth and the symptoms arise more rapidly in the former case. The fatal dose is variable and though as little as $\frac{1}{2}$ grain has caused death, recovery has taken place under favourable circumstances after as much as 20 grains. However one grain must certainly be regarded as a dangerous if not fatal dose.

The symptoms arise with great rapidity and suddenness and when injected, within a few seconds. The first sign is shuddering and convulsive seizures which take the form of general and violent tetanus, the limbs are stretched out and hands clenched and owing to the constriction of the chest muscles, suffocation arises, and this is the actual cause of death, which takes place

* Dangerous Drugs and Poisons (Amendment) Act, 1923.

rapidly, generally within two hours. It will be noted therefore that this poison has none of the symptoms of an irritant but solely affects the nervous system direct.

Strychnine vermin killers at one time were more common than they are at the present day—Allen* gives analyses of ten different ones in which the content of strychnine varied from 41.8 per cent. to 5.8 per cent. while the actual weight of the contents of the packages varied from 49.2 to 5.6 grains; even in the smallest (5.6 grains) the actual weight of strychnine was over ½ grain—while one contained as much as 4.18 grains—all were therefore highly dangerous.

The action of Strychnine on rats has been specially investigated in America† and it was shown that rats are not so susceptible to this poison when given by the mouth as was generally supposed, for it required from 6 to 8 times as much as is necessary by injection; mice however were more easily killed, only requiring about 3 to 5 times the subcutaneous dose and this is in accordance with practical experience.

The lethal dose for an average rat would appear to be in the neighbourhood of $\frac{1}{10}$ to $\frac{1}{8}$ of a grain.

* *Pharm. Journal*, XII, 1889. Quoted by Winter Blyth, *ibid.*

† Schwartze, *Bulletin*, 1023. United States Dept. of Agriculture, 1922.

Apparently rats excrete strychnine fairly readily so that somewhat large doses must be taken if a definitely lethal dose is to be retained. This necessitates using a stronger preparation than otherwise would seem necessary. If however too much is added to the bait it is refused after a few nibbles, probably because of its bitter taste.

The strychnine vermin killers as sold consist of strychnine diluted with starch and are intended to be used by mixing it on to the surface of bread and butter or with lard, oatmeal, chopped meat or fish, etc. In using strychnine it is worth while taking some trouble to prepare a palatable mixture so as to cover the bitter taste as much as possible, sugar, syrup or saccharin being generally used, and while the alkaloid itself may be preferable to the salts from this point of view, it is perhaps slightly slower in action, but if used it must be powdered, not crystalline.

It is sometimes recommended that poisoned grain treated with strychnine should be used. The use of such grain is illegal* except for *bona fide* use in agriculture, and it is doubtful whether destruction of rats or mice by such means would necessarily come within this exemption : presumably in intention the Act refers to birds taking sown seed.

* Protection of Animals Act, 1911, Section 8 (*a*).

Strychnine does not comply with either No. 1, 3 or 4 of the conditions laid down for an ideal rat poison, and in view of its great danger should be only used for rats under exceptionable circumstances. It is however, very useful in cases of severe mouse infestations, but the very greatest care should be taken to avoid accidents and as it is a very quick killer it involves some risk of smells from dead mice. The dead mice are also dangerous to cats since strychnine persists in the corpse for a considerable time.

Phosphorus

Phosphorus is a chemical element and occurs in two well known forms—yellow phosphorus and red phosphorus. These differ strikingly in properties.

Yellow phosphorus is a waxy substance which is dangerous to handle, as in air it easily takes fire, even with the heat of the hand, owing to rapid oxidation. It is therefore, always kept under water and is then fairly safe to handle. This oxidation is accompanied by the well known phenomenon of phosphorescence and a characteristic smell often described as garlic-like. It is insoluble in water but dissolves readily in Carbon Disulphide, and is an excedingly poisonous substance. Red phosphorus, into which the yellow can be converted under suitable

conditions is a powder and is neither spontaneously inflammable nor poisonous.

Yellow phosphorus is used in the manufacture of matches, and as a constituent of vermin destroyers. It is not however, a poison within the meaning of the Pharmacy Acts and therefore preparations containing it can be sold by anyone without restriction.

The symptoms of phosphorus poisoning unlike those of many poisons are very similar, both for human beings and for animals. In order to be active as a poison it must be taken in a state of fine division since in large lumps it is possible for it to pass completely through the digestive tract without causing any symptoms. As however, the former is always the case in properly made vermin killers and phosphorus (non-safety) matches, these means of poisoning are exceedingly dangerous. The symptoms sometimes arise at the time of taking the poison but often do not set in for some time. Usually there is pain on swallowing the substance, followed by nausea and vomiting, but diarrhœa is generally absent. The breath may be phosphorescent. These symptoms then subside but after an interval varying from one to five days jaundice sets in with its attendant symptoms, finally the patient dies with fever and delirium, followed by coma. In some cases the initial symptoms are as de-

scribed but in addition there is severe bleeding from nose, mouth, bladder and bowels. This may persist for months before the patient dies from anæmia and general weakness. In other cases nervous symptoms are observed but they are followed by the usual jaundice and finally, delirium, lockjaw and convulsions terminate with death.

The lowest fatal dose recorded for a human being is a little over $\frac{1}{10}$ of a grain but probably rather more should be regarded as an average lethal dose. But little information is available as to the average lethal doses for either domestic animals or rats. In the author's experiments two to three milligrams (about $\frac{1}{30}$ to $\frac{1}{20}$ of a grain) were generally fatal to rats.

Phosphorus rat poisons are very popular with the public possibly because there are no restrictions on their sale. It must be noted however that they are seldom actually described as containing phosphorus. As sold they are generally thin pastes or creams which are then spread on bread, though a few are firmer pastes which can be used direct.

Essentially these consist of finely divided phosphorus mixed into pastes made with starch and syrups. The incorporation of the phosphorus necessitates either melting the phosphorus under water and adding it with special precautions

to the paste, or else dissolving the phosphorus first in Carbon Disulphide which is itself an exceedingly inflammable, poisonous liquid. The proportion of phosphorus present varies from ½ per cent. to 4 per cent.

From this description it will be realised that the preparation of these phosphorus poisons entails considerable risk of fire and is certainly best left to the manufacturer, as it is inadvisable for amateurs to try to prepare their own.

Undoubtedly these preparations are frequently very successful rat poisons despite their apparently unpleasant smell and appearance. They kill rapidly, providing a fair dose is taken and for this reason immunity from smells must not be expected when they are used in buildings. It is in connection with phosphorus poisons that claims that they dry up the corpses are most often associated, but as previously explained there are no valid grounds for such statements.

Phosphorus poisons however suffer from several disadvantages—they are of course definitely very dangerous to other animals and the dead rats, for some considerable time at any rate, would likewise be a source of danger. There is also some risk of fire being caused by their use, especially in the case of those containing more than 2 per cent. of phosphorus and they are rather unpleasant preparations to handle.

Once the preparation is exposed to air the phosphorus in them slowly oxidises and when this is complete they are no longer toxic.

Barium Carbonate

This is a mineral substance which is obtained in a crude form by grinding the native ore Witherite; thus prepared it is a heavy grey gritty powder and contains from 85 per cent. to 95 per cent. Barium Carbonate. It can also be prepared in a pure form by dissolving the ore and precipitating out the Barium Carbonate—this form is a heavy white homogeneous powder.

Except as a source of other Barium Salts and as a poison for rats, Barium Carbonate has no manufacturing uses, but some of the other salts are used in pyrotechny for green fires and Barium Sulphide is frequently used in depilatory preparations. Cases of poisoning by Barium Salts are somewhat rare, partly because it requires fairly large doses to kill and partly because they are not generally known to or used by the public in the same way, for instance, as are arsenic and phosphorus.

Until the promulgation of an Order in Council dated February 26th, 1925, amending the Pharmacy Acts, Barium Salts were not officially poisons, but since that date they have been

included in part two of the Schedule to the Act and so can only be sold by chemists, but the purchaser need not be personally known to the vendor as is the case with poisons in part one. It may be added that Barium Sulphate used in white paints and as test meals for X-ray work in medicine is excluded, since it is quite insoluble and therefore innocuous.

Barium salts have occasionally been used medicinally, large doses being given and the recorded cases of poisoning indicate that quite large amounts are required to kill, varying from 60 grains upwards.

The symptoms which arise are mainly those of an irritant such as vomiting, pain in the stomach, colic and diarrhœa. There are also as a rule nervous symptoms such as paralysis or convulsions while the heart also may be affected.

The action on rats is similar, some purging occurs and paralysis is usual, death taking place after two or more hours.

For the purpose of rat poisons only Barium Carbonate is used for it is both tasteless and odourless and in most respects very closely approaches the ideal rat poison, its only disadvantage being that excessive quantities will undoubtedly kill larger animals.

This substance differs chemically from the three previously described, for being the carbonate

of a heavy metal it is insoluble in water but readily soluble in acids; when ingested it is only absorbed in the stomach which is acid—any remaining unacted on and passing into the alkaline intestines, is then excreted unchanged. Its poisonous action is dependent on the quantity converted into soluble compounds by the acid secretions of the stomach, for merely "as Carbonate" it would probably have no effect whatever.

The action of Barium Carbonate on rats is somewhat variable owing to the fact that the whole of it may not always be absorbed in the stomach. A considerable amount of information is available on the action of Barium Carbonate on rats and the average dose required has been investigated in the United States and India as well as in England.

Schwartze* found that the average lethal dose for rats when given by the mouth was 750 milligrams per kilogram of body weight or in other words rather less than 3 grains for a rat weighing ½ lb.; if Barium Chloride was used the dose was 533 milligrams per kilogram or just under 2 grains for a ½ lb. rat. Chitre† found that 3 grains killed an average Rattus rattus while it took 6 grains for a full grown Rattus

* *Bulletin* 915, United States Dept. of Agriculture.

† Quoted by Kunhardt, *ibid.*

norvegicus. He also mentioned that it was difficult to induce rats to take baits containing soluble Barium salts and this is in accordance with the author's own experience on this point. Experiments carried out by the author gave very similar results to those recorded by Schwartze; there is much variation but the average lethal dose was about 550 milligrams per kilogram or equivalent to 2 grains for a ½ lb. rat. One point noted in many experiments was the large amount of Barium recovered in the fæces of rats which did not succumb, practically the whole dose in some cases being found, especially with baits containing a large proportion of fat. It is probable that if too much fat is taken with the bait it may mask the Barium in the stomach and carry it through with it into the intestines. It seems safe to assume that 5 or 6 grains would suffice to kill the majority of rats but 100 per cent. deaths is unlikely even with very full doses. The usual percentage recommended in baits is 20 to 25 per cent., and each bait should be about 20 to 30 grains weight—giving a dose of 5 to 7½ grains of the poison. It will be seen therefore that this poison requires a much greater relative and absolute dose to kill rats than do those previously described. This is also the case for other animals and although the relative dose per kilo. of body weight is less than for rats, the

differences are very considerable and most animals would have to take a large number of baits or many dead rats to get a lethal dose. The following amounts have been recorded as fatal for various animals :—

Sheep *	...	92 grains	(Barium Chloride)
Horse *	...	230 ,,	,, ,,
Dog *	...	11 to 14 ,,	,, ,,
Chicken *	...	20 ,,	(Barium Carbonate)
Cats †	...	5 to 15 ,,	,, ,,
Fowls †	...	10 to 20 ,,	,, ,,
Dogs †	...	40 to 140 ,,	,, ,,
Pea Fowls ‡	...	9 to 22 ,,	,, ,,

In interpreting these results it should be noted that Barium Carbonate is less toxic than Chloride in the proportion of 4 to 5. It is evident from these figures that two average rat baits would be dangerous doses for both cats and poultry and experience supports the view that accidents to both may arise from the use of Barium baits.

It is generally agreed that Barium Carbonate is a valuable rat poison, for if sufficient is taken by rats the resulting proportion of kills is adequate

* Quoted by Schwartze, *ibid.*
† Chitre, quoted by Kunhardt, *ibid.*
‡ Investigation by author.

though it is certainly below 100 per cent. There is no doubt some risk to cats and poultry, but in general it has a much larger safety margin than the other three described. It is very easy to use, for it is readily mixed with meal of any kind, or with fats and meal to form pastes and has no deterrent effect on the rats taking the bait—in fact experience shows that rats readily take such baits. As it is slow in action and also causes diarrhœa and thirst, the rats usually die with their digestive tract empty and therefore are not likely to smell and the result of the thirst and discomfort is to cause the rats to go out to seek water. There was perhaps a tendency to over-estimate its freedom from risk of accidents, but experience shows that with reasonable precautions, baits containing it can be used with freedom in many situations where the use of more dangerous ones would be undesirable. Owing to its cheapness, attractive baits can be freely used for baiting refuse tips and sewers on a large scale but they should be used with caution on farms and other places where there are domestic animals.

Red Squill

Red Squill is very different from all the other poisons which have been described for unlike them, it is not a definite chemical substance but

an entire plant. Botanically it is known as *Urginea maritima* and it grows wild in various countries on the shores of the Mediterranean Sea. It is a large bulbous plant something like a large onion, covered with reddish scales, the interior scales varying from light yellow to deep purple, and bears a flowering stem and leaves at different periods of the year. Commercially only the bulbs are used.

This drug has been used in medicine and as a rat poison for many years but it is only recently that it has come into general use for the latter purpose. It would appear certain that there are two species of Squill on the market, that used in medicine in this country which is white and that used for rat poisons. The pharmacological description however, conforms more to the red species but bulbs of both sorts were grown at Kew for the Ministry of Agriculture and there seems no doubt the white bulbs are a different species and experiments carried out by the author showed that these are not toxic to rats even in very large doses.* In most continental countries however, the red species is the official drug for medicinal use.†

Since Red Squill bulbs are not an article of

* C. L. Claremont. "Notes on the Analysis and use of Red Squill in Rat Poisons," *Analyst*, 1922.

† Evers—"Chemistry of Drugs"—states that White Squill is the official drug of the United States Pharmacopœia.

retail commerce and in fact are not regularly obtainable even on the London Drug market, Red Squill is usually only sold to the public in the form of preparations of the drug, generally under fancy names, though of course this applies to most proprietary rat poisons whatever the active ingredient may be. It comes on the market either in the form of the whole original bulb or as part dried scales and it is from these that the preparations are made, the majority being in the form of Liquid Extract of Red Squill which requires mixing with bread, but " ready for use " solid baits containing this drug are also obtainable.

For these reasons Red Squill as such is not readily obtainable in a form suitable for mixing with meal, etc., as is the case with most of the other poisons described and this has lead to a certain amount of misunderstanding on the part of the public, who rather naturally expected to be able to go to the chemist and buy a substance they could mix themselves. Even preparations of Red Squill are not as yet regularly stocked by all retail chemists and often have to be procured direct from the manufacturers.

Very little is known of the chemistry or pharmacology of Squill, and owing to the confusion between Red and White Squill it is uncertain to which variety the recorded information refers.

The chemical identity of the actual poisonous constituents of Red Squill is doubtful, at any rate it is not an easily separated substance such as the alkaloid strychnine obtained from Nux Vomica seeds.

It has an action on the heart similar to that of digitalis and is a gastro-intestinal irritant and also acts as an expectorant and diuretic. Syrup of Squills is a common constituent of cough mixtures but otherwise it is not much used in medicine since digitalis is better understood and is more reliable.

Merck stated that Squill contained three glucosides, scillipicrin, scillitoxin and scillin, while Abderhalden describes two substances, scillin and scillain, the latter of which had toxic properties.

Nothing is definitely known as to the lethal doses for human beings or other animals though Abderhalden gives the following for scillain—rabbits 2.5 milligrams, cats 2.0 milligrams, dogs 1.0 milligram—all being per kilogram of body weight; as however there is no information as to the percentage of scillain in the whole drug the results are not of much practical value, but they would certainly represent large doses of the bulb. Kobert says that horses can take 450 grains of the bulb and pigs and dogs up to 30 grains but these figures must be taken with considerable reserve.

The action of this drug on rats however, was investigated by the author at the Rat Research Laboratory of the Ministry of Agriculture,* and the average toxicity was found to be 605 milligrams per kilo. of body weight, using the dried and powdered bulb (equivalent to about five times the same weight of original bulb). This corresponds to about 2 grains of dried powdered drug for a rat of ½ lb. weight. Liquid Extracts which are generally prepared by macerating one part of bulb in two parts of water should be toxic to an average rat in doses of about 1.3 cubic centimetres or ½ of a fluid drachm (= 20 minims) and this was found to be the case. Its action on rats is slow, the first symptoms are excessive purging and obvious signs of thirst and general discomfort, these are followed by paralysis and sometimes convulsions. Death takes place in from 5 to 10 hours and appears to be hastened if the rat drinks.

The preparation of suitable baits was also investigated and it was found that for solid baits it was preferable to dry and grind the bulbs and use the powder thus made as the basis rather than the chopped bulb itself, for though baits containing the latter are toxic and can be made quite attractive they soon go mouldy, whereas those containing powder keep quite well.

* C. L. Claremont, *Analyst*, *ibid.*

Contrary to what was previously supposed it was found that both Liquid Extract and Powder if properly prepared and stored keep quite well. In making the latter the greatest care has to be taken to control the temperature and conditions of drying, otherwise the toxicity may be much reduced or even destroyed though the reason for this is not understood. The powder when made should be kept in airtight containers, for if not, some powders show a tendency to cake and lose their toxic properties. This is the main reason why Red Squill Powder is not generally sold for direct preparation of baits.

Extended experience of Red Squill shows that on the whole it is a reliable and useful poison for rats, capable of incorporation into many attractive forms of bait. Its application as Liquid Extract in particular, offers an extremely attractive variety of bait which is unique, for none of the other poisons described could be easily adapted into liquid preparations, indeed three of them are actually insoluble in water. Owing to the symptoms described the rats usually leave their haunts to try to get air and water and hence smells are unlikely and for the same reason the dead rats are not necessarily found in the vicinity of the baiting.

On the ground of safety it offers even greater advantages for though there is no direct evidence

of its harmlessness to other animals there is circumstantial evidence that this is the case. Poultry have been observed to take Squill Rat Baits without any illness or death resulting and there are no records of fatal accidents due to the use of this drug as a rat poison. Statements have been made however, that it is also an effective poison for moles.

There are therefore reasonable grounds for regarding Red Squill for all practical purposes, as harmless to human beings and domestic animals and in other respects it also closely approaches the ideal rat poison.

While the selection of a suitable poison is of the greatest importance, its ultimate success depends, not on its toxicity but on whether it is presented in a form which is acceptable to and readily taken by the rodents. In laboratory experiments on poisons it is not always necessary to depend on the rats taking the baits since the necessary doses can be administered by tubes while the animals are under an anæsthetic but in the field the practical success of a poison is determined entirely by this factor. Apart from mere palatability several other points which are frequently overlooked need investigation, such as the most suitable size for an average bait and the amount of poison it is necessary to add to it to ensure a lethal dose being taken.

On the average, caged tame rats eat about $\frac{1}{10}$ of their body weight in 24 hours,* each bait therefore should be of such a size that a hungry rat will eat it all and should contain such an amount of poison that one complete bait will kill and a portion, say half, still give a reasonable chance of success.

An average rat of say $\frac{1}{2}$ lb. weight should eat about 350 grains ($\frac{5}{10}$ oz.) of food daily and a bait of 30 to 60 grains—approximately $\frac{1}{12}$ to $\frac{1}{6}$ of a day's intake should be readily eaten by a rat even when not particularly hungry. In preparing poison baits it is evident that the higher the proportion of poison, the less a rat need take to ingest a lethal dose, but on the other hand the danger to other animals is increased; the percentage of poison added then, should be just sufficient to give a certain lethal dose for an average sized bait. Experience has shown that baits based on these calculations give good results and the following table gives suitable proportions for the poisons discussed:—

Arsenic 5 per cent. of poison—each bait 20 grains, containing 1 grain of poison.

Strychnine 1 per cent. of poison—each bait 20 grains, containing $\frac{1}{5}$ grain of poison.

* Experiments by the author.

Phosphorus* 2 per cent. of poison—each bait 5 grains, containing $\frac{1}{10}$ grain of poison.

Barium Carbonate 25 per cent. of poison—each bait 30 grains, containing $7\frac{1}{2}$ grains of poison.

Red Squill (dry powdered bulb) 20 per cent. of poison—each bait 25 grains, containing 5 grains of poison.

In the practical preparation of rat baits on a large scale the following points should be aimed at, as it will be found they simplify the application of the bait and reduce the risk of accidents.

If possible the bait should be ready for use and easy to apply by means of a long handled spoon or piece of flattened wood. Operations such as spreading on bread are undesirable and should be avoided if possible—especially with the more dangerous poisons, as carelessness in leaving about the implements with which this is carried out may cause accidents. It is a great advantage if the baits are in the form of tablets or pellets so that guessing the amount required for each individual bait is unnecessary—and where this is not the case the amount should be clearly stated in common measures such as teaspoonfuls.

* N.B.—Phosphorus baits are almost invariably used by spreading on bread and therefore the bait is diluted considerably in practice.

Baits should of course be attractive to the rats (or mice, as the case may be), and this can only be decided by experiment and observation on a laboratory scale followed by actual field trials. Baits should be as fresh as possible, as rats generally refuse baits which have been left lying about or which have become sour or musty. Each toxic agent should be made up into a variety of different baits, so that if one kind is not taken another kind can be tried.

Rat baits are frequently given either as powder or as pastes. In the former case the poison is incorporated in the proper proportion with meal, which may be wheat or barley meal, oatmeal, ground malt, or indeed any cereal which experience shows will be acceptable. Sugar is sometimes added as well but it is doubtful if rats really are attracted by it; Chitre definitely stated that baits with sugar were less acceptable, presumably to Rattus rattus, than those without.* Other useful additions to a meal bait are fish meal, desiccated coconut, meat meal, dried milk powder, and other possible variants will suggest themselves. Fresh breadcrumbs also form an attractive bait for rats and mice but on a large scale are rather troublesome to prepare.

In making pastes the most usual vehicles are oatmeal and fat—it is important to use fresh

* Quoted by Kunhardt, *ibid.*

fat, and good quality sweet butcher's dripping, is by far the best to use. Commercial tallow is sometimes rancid and does not seem to be so attractive, but margarine is fairly satisfactory. Too much fat is a mistake and 25 per cent. should be sufficient to prepare a good firm paste. Just as in the case of powders, similar materials can be substituted for part of the oatmeal to increase the attractiveness.

An excellent preparation is a biscuit bait made as follows. The proper proportion of poison is mixed with flour and enough fat rubbed in to "shorten" the pastry, it is then worked up into a moderately stiff dough with water and rolled out into a flat sheet which is cut up into suitable sized biscuits and then lightly baked in a quick oven. This method is specially applicable to Red Squill and Barium Carbonate, and such biscuits have given excellent results in practice.

It is usual to add a few drops of aniseed to baits which have no natural odour and within reason this does no harm but it is very doubtful if rats really like aniseed and at the best it only serves to indicate to them that there is something worth investigating near by—excess seems to act rather as a deterrent than otherwise and if baiting is properly carried out it seems to make but little difference if it is added or not.

The foregoing hints apply to baits containing Arsenic, Barium Carbonate or Red Squill (Powder) and to a certain extent Strychnine. The latter however, Phosphorus and Liquid Red Squill require special treatment.

In using Strychnine for mice the bait is best made by incorporating the drug with a thin paste of lard and oatmeal and sugar (or syrup) and spreading this between very thin slices of bread, or even better, the two halves of a butter puff biscuit split down the centre. For this bait the amount of Strychnine should be increased to 5 per cent.

Phosphorus is as stated, nearly always sold as a ready-made thin paste; this can be spread in the same way as the Strychnine paste just described. Bread and butter is a very good general bait, and powders and any soft pastes can often be given by incorporating them with the butter before spreading.

Liquid Extract of Red Squill is given soaked up on bread; this is best done by cutting up the bread (preferably stale) into slices ½ inch thick and then cutting these again so as to form cubes of about ½ inch side. These cubes are then placed in a bowl or pail and sufficient of the Liquid Red Squill added to just thoroughly soak them, gently stirring with a stick to ensure proper admixture without breaking up the cubes.

The soaked cubes are then laid in the rat holes. In the case of proprietary preparations any special directions or hints given for using them should be adhered to.

The above directions and suggestions for preparing baits have purposely been given in a general form because there is no such thing as a special and unfailing bait for rats and it is a mistake to rely too much on the magical effect of any one particular bait—for it is neither fair to the user nor the maker. All are based on practical experience and can be relied on to give useful results—sometimes however it will be found, even with a bait which usually gives excellent results, that the rats refuse to take it—if so all that can be done is to try again with a different variety.

It should be noted that *Rattus rattus* as a rule does not take baits so readily as *Rattus norvegicus* and therefore more difficulty will be found in devising attractive baits for it—experience indicates that they prefer dry baits to wet ones and biscuit form to pastes, but no general rule can be laid down. In India, Chitre* reports that they almost always take the local grain best of all, thus Poona rats took bajri dough better than any other grain including wheat, while Madras rats preferred rice and so on.

* Quoted by Kunhardt, *ibid.*

In general the experience in this country, with *Rattus norvegicus* especially, is that it is best to give a bait quite different to their staple food—Liquid Red Squill soaked up on bread is almost always taken anywhere, otherwise it is best to try, say fish baits in a butcher's shop and meat or plain meal in fish shops; in granaries or poultry farms where there is much grain, ordinary meal or even biscuit baits do not always get taken very well, but fish flavoured baits and pastes in general are fairly successful.

Mice undoubtedly are harder to deal with by baiting than are rats and as a rule powder baits give the best results, but it is sometimes advisable to increase the proportion of poison as they eat so very little bait at a time.

Apart from any specific instructions given for using the particular bait chosen, a campaign of poisoning should be planned on the following lines if really successful results are to be obtained.

In the first place the scene of operations should be thoroughly reconnoitred beforehand and all holes and runs noted in advance, while useful information can often be collected from farm hands, storekeepers and others on the spot.

Particular attention should be given to any clues which will serve to identity the species present, and in the absence of other signs the dejecta, which as stated differ, should be specially noted.

It is preferable but not essential, to lay the bait towards evening as this ensures the rats getting it fresh and there is less likelihood of it being accidentally disturbed, but in the case of large areas it is usually impossible to arrange this.

If the bait requires any sort of preparation, as for instance when using Liquid Squill, spreading a Phosphorus bait, or even breaking up stiff pastes, the estimated quantity of bait required should be got ready just beforehand.

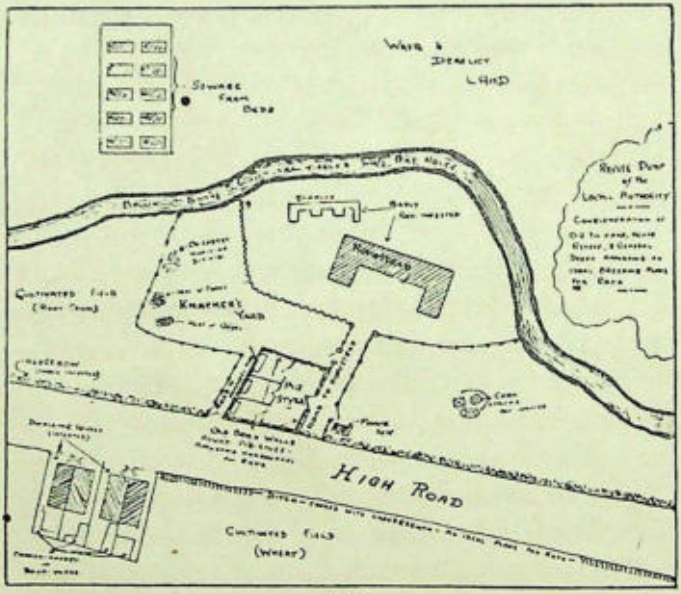


Fig. 2

Diagram showing a typically rat infested area, with refuse tip, stream, knackers' yard, all attracting rats, whence they spread to the surrounding area.

(Reproduced by permission of the Ministry of Agriculture.)

This saves time and enables more attention to be applied to the actual baiting when going round the area. In the case of large areas, it is best to prepare as much bait as can be conveniently carried and while this is being laid an assistant can be preparing a further supply. Every hole and run should be well baited with several baits and supplies should also be put in likely places near where rats are known to congregate.

It is not desirable to bait in the immediate vicinity of large collections of fresh dejecta—such places, especially in buildings, are more or less reserved by the rats, who make a habit of using one place for this purpose.

It is most important to be thorough and it will be found that it is more economical in the long run to err by laying too much than too little, for as explained the aim of baiting is to kill off as many rats as possible at the first attempt. If possible the whole area should be dealt with in the one day, for casual baiting here and there each day will not give such good results as the intensive method described. It is an excellent plan to lay always a fixed number of baits say 4, 6, or 8 as occasion suggests, in each place, this enables an approximate count to be made of the number of baits taken and, where the slower poisons are used, is helpful

in arriving at an estimate of the results of the treatment, for the dead rats are not always found in the immediate vicinity of baiting.

When bait has to be laid in runs above ground or in exposed positions, it should always be placed along walls, etc., for as explained rats run along such rather than across the open. If there is any likelihood of other animals getting at the bait it can be protected by putting it behind boards, bins, etc., or by arranging wood, tiles, bricks, etc., against the wall so as to form a tunnel open at "both" ends in much the same way as was described for run traps. This precaution is desirable with ANY bait, however safe, but is essential when using the more dangerous ones.

After the baits have been down 2 or 3 days it is advisable to collect all the unconsumed accessible ones and BURN them, as this much reduces possibilities of accidents; like the previous precaution this is essential when using dangerous poisons.

If the treatment has been successful there should be an obvious diminution of the nuisance and fewer rats should be observed. It is not reasonable to judge entirely by the number of dead rats found for it does not follow they will always be obvious, particularly when using the slower and safer poisons.

If further treatments are necessary they should be carried out at intervals of 2 to 3 weeks or longer according to the success achieved, reducing the amount of bait if this seems indicated. In such cases it is often desirable to vary the bait (not necessarily the poison) from time to time, and some firms stock several varieties of baits for this purpose but in any case variation can be applied to most preparations in the many ways already indicated.

This method of carrying out rat poisoning has been proved over and over again to be sound. It largely overcomes the difficulty of rats becoming poison shy, for if relatively few baits are laid some rats take them and after a short time the remaining rats seem to avoid them, probably because they have sufficient intelligence to associate the unusual food with unusual mortality. If however the baiting is really adequate a very large proportion of the rats take it and succumb and the considerable interval elapsing before the next attack renders this association less obvious to the survivors.

It is true the method involves a certain amount of trouble but good results can no more be achieved without care and attention when dealing with rats than in other phases of human endeavour—what is worth doing is worth doing well.

Although the method just described will be

successful in the vast majority of cases, occasionally it may be found that the rats refuse to be tempted by any of the baits.

In such cases it is best to try preliminary baiting with unpoisoned feed as already mentioned under arsenic. For this purpose practically only a bait in powder form is available, as the poison can then be introduced easily without any apparent change in appearance and any meal such as crushed corn or malt, rolled oats, oatmeal, sharps, etc., can be used.

If the method is to be applied where there are domestic animals or out of doors in exposed positions, it is best to place the meal in a shallow box or tin and then invert over it a large box in which there are two holes, one cut at each end sufficiently big to admit a rat easily while other animals could not get inside. The box must of course be large enough to make it impossible for poultry or game to get the bait by craning their necks inside the holes and it is preferable if it is fixed down so that it cannot get accidentally displaced.

The feed should be put down nightly and the amount taken noted, and this process continued until the rats have become accustomed to feeding; when this is the case the poisoned feed is substituted. With these precautions, this method can be used without much risk other than that

due to the corpses of the poisoned rats and will sometimes give results when other means fail.

Virus Method, or Artificial Infection with Disease.

This method has now been before the public for several years. On its introduction it was hailed as a great advance in scientific rat destruction but unfortunately these hopes have not been altogether realised. The method depends on laying baits containing live disease germs which are capable of causing fatal disease in rats without being dangerous to human beings or domestic animals. Of course, as with ordinary poisons, the method is ultimately dependent on the attractiveness of the bait.

The method arose in the following way: in 1890 the tame mice in the Laboratory of Professor Loeffler (a well known bacteriologist) suffered from a severe epidemic and on investigation Loeffler traced the disease to a bacillus which he named *Bacillus typhi murium*. It was found to be capable of causing heavy mortality among mice but had no effect on other animals, including rats, when given by the mouth.

Other workers then proceeded to grow this organism in artificial culture media and it was used with fair success in several cases of mouse plagues. Attempts were then made to extend

its use to rats and after much experimenting its virulence was increased until it killed rats.

Ultimately three organisms were introduced for use against rats—namely Danysz' bacillus, Neumann's bacillus and Issatchenko's bacillus. These organisms are not identical but all belong to the group of intestinal, fever-causing organisms and are classed with such organisms as Bacillus enteritidis of Gaertner, para-typhoid bacillus and others known to cause symptoms of illness in man and/or animals.

The Virus preparations on the market at the present day usually contain either Danysz' or Neumann's bacillus or variations of them, and the makers claim that these preparations are entirely innocuous to human beings and all domestic animals and that the disease is propagated from rat to rat among the colony infected.

The Virus method in general has been subjected to very severe criticism on the part of many medical officers and others officially concerned with rat destruction, and both the Ministry of Health and Ministry of Agriculture* are disinclined to recommend its use. The United States Department of Agriculture also take the same view.†

The chief reason for this criticism is that there

* "The Destruction of Rats." Ministry of Agriculture and Fisheries Leaflet, 244, page 7.

† U.S. Department of Agriculture *Bulletin* 896, page 20.

is grave doubt whether the organisms used are invariably and consistently non-pathogenic to all human beings and other animals, for cases have occurred in which illness has been traced to the use of these viruses. In one case in the City of London (1909), several employees in a building were taken ill with severe enteritis which was attributed by Dr. Klein to infection with germs contained in a virus which had been used to destroy mice. More recently (1921) Dr. Hans Wreschner investigated this question at the request of the Berlin Police Authorities and in his report quotes several cases of illness and some actual deaths which he attributed to the use of these viruses. He also examined a large number of virus preparations sold in Germany and says that comparatively few contained pure cultures of the correct organisms of the para-typhoid Gaertner group.

At first sight it might appear that even if these virus preparations were in fact pathogenic to human beings and other animals, the risk is at least no greater than with poisons, providing similar precautions are taken in each case, but the two cases are not quite the same. Poison bait is fixed where it is laid and so long as it is in fact, not accidentally or deliberately taken, is within these limitations, perfectly harmless even with the most virulent poison; but a virus

culture bait containing living germs is rather different, for the germs wherever they fall on a suitable medium go on multiplying, especially inside the rat, and they are scattered here and there in the dejecta of the rat which are seriously contaminated with the germs, hence it is quite possible for food and water supplies to become infected. For this reason consumed baits inside the rats are potentially more dangerous than unconsumed ones, for in the case of the latter the chances are that the germs will soon die from exposure to light and from desiccation of the medium.

It should be noted however that *prima facie*, it does not of necessity follow that these germs which are pathogenic to rats will be also pathogenic to man and other animals, for many organisms are absolutely specific, that is cause one disease in one sort of animal only.

It may be too, that some of these cases of illness, while really due to the virus preparation, were not due to the actual organism specific to rats (or mice) but were due to organisms which got in accidentally during the manufacture, for it seems that some, at any rate, of these preparations are by no means pure cultures, or possibly even, might be due to a stray germ falling on the medium after the bait had been laid and multiplying thereon. Apart from this

question of whether the organisms used are really specific to rats and mice they also suffer from other inherent disadvantages.

It is a commonplace that human beings vary greatly in their resistance to diseases caused by germs and also that slight attacks of some diseases confer a certain amount of immunity to future ones. This is no less the case with rats and consequently it may be expected that some of the rats, even when infected with full doses of the germs, will resist them and survive and that rats getting doses too small to kill them will acquire a certain amount of immunity. There can be but little doubt that such is indeed the case and therefore 100 per cent. deaths can hardly be expected with virus, though perhaps in this respect it is at no great disadvantage as compared with poisons, at any rate from the practical point of view, but the added disadvantage of conferring immunity makes the chance of repeating the attack less likely to be successful than when using repeat attacks of poison. A somewhat serious practical disadvantage is that these germ cultures deteriorate with age and as mentioned the germs soon die after exposure so that to be effective the bait must be taken very soon after it is put down.

It has been suggested also, that there is a possibility of the germs (even if originally non-

pathogenic to man) developing an increased virulence after passage through the rat and so becoming more dangerous, but though such cases are not unknown, this is not very likely.

It must not be supposed from these criticisms that virus as a method, is necessarily ineffective; on the contrary it frequently gives excellent results and it has an advantage that no other method possesses in that its effect is not confined solely to the rats which take the bait, for to a certain extent at any rate, the disease is spread among a colony. It is not however a contagious infection passed from rat to rat by contact or by germs carried in the air, but the dejecta of infected rats may and no doubt do, often infect their food and water supplies and more often still the sick rats and corpses of rats which die of the disease are devoured by the survivors, thus spreading the germs from rat to rat.

Like most diseases the symptoms do not develop immediately and it takes some few days before the disease reaches a stage at which the rats become ill and eventually die. The symptoms are not unlike those of irritant poisons; diarrhœa, gastric discomfort and doubtless feverishness occur, with the result that there is a tendency for the rats to go out for air and water in much the same way as they do after taking the slower poisons; there is therefore on the whole

reasonable freedom from smells and in the same way success must not be gauged solely by the number of dead rats found.

These virus preparations are sold in various forms; some are gelatine cultures which require mixing with warm (not hot) water to remove them from the tube, others are cultures suspended in a liquid broth medium, and as a rule separate ones are sold for rats and mice, respectively.

The method of application is similar, the gelatine cultures after opening and stirring up in warm water are mixed with bread, as are also the liquid broth ones. The soaked bread is then laid down like any other bait and as a rule these baits are taken quite well, for the culture medium itself is an appetising mixture. Since the disease spreads itself to a certain extent, baiting need not be on so thorough a scale as is the case with poisons for it is not so necessary for each rat to get a bait since in any case there is no result until the germs have grown and multiplied in the rat.

While the cogency of these criticisms of the virus method cannot be denied, it must be admitted that it is a human adaptation of Nature's own method of reducing an excessive rat population, though as will be seen, Nature's method—the Plague—is terribly efficient and fraught with vast suffering and loss to the human race in addition. It may be however, that future research

will produce an organism which is free from some of the more serious objections.

Weighing all the evidence, it seems reasonable to conclude that the use of virus is undesirable in all places where human foodstuffs are prepared, manufactured and stored, particularly in restaurants, kitchens and dairy farms. For other situations, it is unlikely that there is much more risk than is attached to most poisons and in these, it must stand or fall, like any other method, on its efficiency. Dr. Hans Wreschner in his report went much further, advocating that its use and preparation in kitchens should be prohibited and suggesting that trade in virus should be ended and that only authorities such as Chambers of Agriculture should make and distribute them.

This concludes the survey of the methods used for practical rat destruction and it has been shown how the use of poison is of far more general application than any of the methods described in the previous chapter. The poisons in common use for this purpose have been critically examined and compared one with another and the chief criterion in making a choice between them has been shown to be that of Safety. "Safety First" is a rather hackneyed phrase, but is quite a good slogan for a rat poison and so far as our present knowledge goes Red Squill must be regarded as best deserving it.

CHAPTER V

CO-OPERATION IN RAT DESTRUCTION

Rats and Mice (Destruction) Act, 1919

An Act to make further provision for the destruction of Rats and Mice (23*rd December*, 1919)

BE it enacted by the King's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:—

1. Any person who shall fail to take such steps as may from time to time be necessary and reasonably practicable for the destruction of rats and mice on or in any land of which he is the occupier, or for preventing such land from becoming infested with rats or mice, shall be liable on summary conviction to a fine not exceeding five pounds, or, where he has been served with a notice under this Act requiring him to take such steps, not exceeding twenty pounds.

2.—(1) The following local authorities shall execute and enforce this Act; that is to say:—

(*a*) In the city of London, the common council;
(*b*) In any metropolitan borough, the borough council;
(*c*) In any administrative county (other than the county of London) or county borough (except any part thereof which is a port sanitary district), the council of the county or borough;
(*d*) In any port sanitary district, the port sanitary authority:

Provided that the London County Council shall, to the exclusion of any other authority, be the local authority for the purpose of executing and enforcing this Act with

respect to the sewers vested in, and the sludge vessels belonging to, that council; provided also that a county council may, with the consent of the council of any borough or county district in the county, delegate its powers and duties under this Act to that borough or district council, and, where powers and duties have been so delegated, the borough or district council shall be the local authority for the purposes of this Act.

(2) The expenses incurred by the local authority under this Act shall be defrayed in the case of a county out of the general county fund, and in the case of a port sanitary authority as part of their expenses as a port sanitary authority, and in any other case as expenses incurred by the local authority in the execution of the Public Health (London) Act, 1891, or the Public Health Act, 1875, as the case may be.

3.—(1) Where a local authority having power to enforce this Act fails, in respect of land of which it is the occupier, to comply with the provisions of section one of this Act or fails, in respect of land for which it is the local authority under section two of this Act, to execute or enforce any of the provisions of this Act, the Board of Agriculture and Fisheries may by order empower the person therein named to enter upon such land and to execute and enforce those provisions or to procure the execution and enforcement thereof.

(2) The expenses incurred by or on behalf of the Board by reason of any such default of a local authority shall be paid to the Board on demand by the treasurer or other proper officer of that local authority, and in default of payment the Board may recover the amount of such expenses (except in so far as such expenses are otherwise recoverable under this Act) from the local authority; and any sum paid by a local authority under this section shall be defrayed as expenses under this Act.

(3) For the purposes of this section, any statement contained in an order of the Board that a local authority has failed to comply with, execute, or enforce any of the provisions of this Act shall be conclusive evidence of such default, and a certificate by the Board of expenses

incurred under this section shall be conclusive evidence of such expenses.

4. A local authority having power to enforce this Act may from time to time, by public notice within its area, give instructions as to the most effective methods that can be adopted, both individually and collectively, with a view to the destruction of rats and mice.

5.—(1) Where a local authority having power to enforce this Act is of opinion that the occupier of any land in its district has failed to take such steps as are required by section one of this Act, such local authority may either serve a notice on the occupier requiring him to take such steps as are prescribed in the notice within a time specified therein, or, after not less than twenty-four hours' previous notice to the occupier, enter upon the land and take such steps as are necessary and reasonably practicable for the purpose of destroying the rats and mice on the land or of preventing the land from becoming infested with rats and mice, and may recover any reasonable expenses so incurred from the occupier of the land summarily as a civil debt.

(2) A local authority in the exercise of its powers under this section shall, as far as possible, take or secure collective action for the destruction of rats or mice.

(3) The powers of a local authority under this Act may be exercised by any committee of the local authority to which the exercise of those powers may be delegated.

(4) Any person authorised in writing by a local authority under this Act, or by a person empowered to act in default of a local authority, may enter any land in the district of such local authority for the purpose of ascertaining whether the steps required by section one of this Act are being taken or of executing and enforcing this Act in any other respect. Any such person must produce the document by which he is authorised if so required.

(5) Any person who shall obstruct or impede an officer or other person authorised as aforesaid in the execution of his duties or powers under this Act, or who, being the occupier of any land, shall fail to comply with any reasonable requirement of any such officer or other authorised

person for facilitating the execution of his duties or powers, shall be liable on summary conviction to a fine not exceeding twenty pounds.

6.—(1) This Act shall apply to a vessel as if the vessel were land, and the master of the vessel shall be deemed to be the occupier thereof.

(2) A local authority having power to enforce this Act may, by notice served on the master of a vessel in its district, require him to take such necessary and reasonably practicable steps as are prescribed by the notice for preventing the escape of rats and mice from the ship, and, if a master fails to comply with the requirements of any such notice served on him, he shall be liable on summary conviction to a fine not exceeding twenty pounds.

7.—(1) A prosecution for an offence under this Act shall not be instituted except by or with the authority of the Board of Agriculture and Fisheries or the local authority: Provided that this section shall not apply to Scotland.

(2) In any proceedings under this Act a notice purporting to be signed by the clerk of a local authority shall, unless the contrary is proved, be deemed to have been signed by the clerk with the authority of the local authority.

8. In this Act—

The expression "occupier" means, in the case of land not occupied by any tenant or other person, the owner of the land;

The expression "land" includes any buildings and any other erection on land, and any cellar, sewer, drain or culvert in or under land.

9.—(1) This Act shall apply to Scotland with the following modifications:—

(*a*) The Board of Agriculture for Scotland shall be substituted for the Board of Agriculture and Fisheries;

(*b*) The section of this Act relating to the enforcement of the Act shall not apply, and in lieu thereof the following provisions shall have effect:—

(i) The local authority for executing and en-

forcing this Act shall be the local authority under the Diseases of Animals Acts, 1894 to 1914;

(ii) The expenses incurred by any local authority under this Act shall be defrayed in like manner as expenses incurred by a local authority under the Diseases of Animals Acts, 1894 to 1914.

(2) This Act shall apply to Ireland with the following modifications:—

(*a*) Any reference to the Board of Agriculture and Fisheries shall be construed as a reference to the Local Government Board for Ireland;

(*b*) Subject to the exercise of the powers of delegation given to a county council by this Act, the local authorities for the purposes of this Act shall be as respects so much of any administrative county or county borough as is not included in a port sanitary district, the council of the county or borough, and as respects any port sanitary district the port sanitary authority;

(*c*) The expenses incurred by a local authority under this Act shall be defrayed, in the case of a county council, out of the poor rate as a county at large charge; in the case of a port sanitary authority as part of their expenses as such authority; and in the case of any other local authority as expenses incurred in the execution of the Public Health (Ireland) Acts, 1878 to 1919.

10. The powers conferred by this Act shall be in addition to and not in derogation of any powers conferred on any Government department or local authority, and all such powers may be exercised concurrently in respect of any land.

11. Any notice under this Act may be served either personally or by registered post.

12. This Act may be cited as the Rats and Mice (Destruction) Act, 1919, and shall come into operation on the first day of January nineteen hundred and twenty.

these three parties, and its successful consumma- [illegible]pends largely on how far the Act requires [illegible]mits these authorities to take such action [illegible]best bring this about. It is desirable then [illegible]mine the Act carefully, section by section, [illegible]ee how they allocate duties and responsi- [illegible]ties to these various parties, pointing out the [illegible]ractical difficulties which may arise and the interpretations which have been placed upon the wording.

Section 1 places the onus for taking the necessary steps to destroy rats and mice on infested premises or land, upon the "occupier" and further requires that steps shall be taken to prevent such land becoming infested. The penalties for non-compliance with the section are prescribed.

It is to be noted that the Act itself does no[t] define what the steps shall be, save that it quali[fies] "necessary" by the words "reasonably p[ra]cticable."

Section 1 presents two practical difficul[ties] firstly it might be difficult to define in s[ome] cases what "necessary and reasonably practic[able] steps" might be and on this point, so far as w[e] are aware, there has been no legal decision. Th[e] second difficulty is the question of "occupier"; this arises in the case of large blocks of offices, warehouses and flats split up among many

tenants, and in tenement dwellings where the tenants can hardly be expected to do m[illegible] their own account. The legal position [illegible] clear in the first case at any rate, but the p[illegible] difficulty of getting uniform action and [illegible] co-operation remains. It has been often p[illegible] out that in many cases the infestation ma[illegible] due not so much to the tenant as to the landlo[illegible] or owner failing to keep the premises in proper repair. Under this Act the tenant has no remedy, and unless such default constituted either a "nuisance" under the Public Health Acts or could be dealt with under the Housing Act, 1925, or there were grounds for a civil action for damages, he must do his best to comply with the Act as it stands.

Section 2 is an important one; subsection (1) [illegible] down the authorities which are responsible [illegible]he execution and enforcement of the Act. [illegible]pecial comment is necessary but attention [illegible]be drawn to the provision under which [illegible]y Councils may delegate their powers [illegible]- the Act to any Borough, Urban or Rural [illegible]rict Council within the county, subject to the [illegible]nsent of such minor authorities. This pro[illegible]ision is quite clear as to what authority is responsible for enforcing the Act in any particular area, and it may be added that some 486 minor authorities have accepted delegation of

powers from the various County Councils in [illegible]nd and Wales.

[illegible]ection (2) specifies the funds from which [illegible]s incurred by authorities under the Act [illegible]e defrayed; except for Counties and Port [illegible]ry Authorities these expenses are regarded [illegible]xpenses within the meaning of the Public [illegible]ealth Acts, 1875 and 1891, while in the case of the former they are met from the County Fund and expenses as a Port Sanitary Authority respectively. Minor authorities which have accepted delegation sometimes take exception to the effect of this clause, in that they not only bear the cost of enforcing the Act within their own area as expenses under the Public Health Acts, but also contribute to the general County Rate from which any county expenses in connection with the Act are met.

Section 3. This section provides that [illegible] authority within the meaning of the Act [illegible] to carry out the provisions of the Act [illegible] Ministry of Agriculture may empower any [illegible] to enter in and enforce the Act in lieu [illegible] authority. It is to be specially noted [illegible] subsection (1) of this section infers that [illegible] authorities have the same duty in respect [illegible] land or premises they occupy in their corporate capacity as any other occupier.

The Ministry as yet, has not put this section [illegible]

into operation and it is a permissive clause only.

Section 4 provides that local authorit[ies] by "public notice" give instructions as [to] most effective methods that can be a[dopted] "individually and collectively" for the de[struc]tion of rats and mice. It is a permissive cl[ause] and does not appear to contemplate the givi[ng] of oral advice by one of the officers of the local authority, which in actual practice is what very many authorities are quite ready to provide, either at the officer's office or on the site of the infestation.

Section 5 defines more exactly the powers of local authorities. Subsection (1) states the procedure which may be taken when the occupier [is] "in the opinion" of the authority failed to [take] proper steps under Section 1 of the Act, [and] provides that they may either serve a notice [on] e occupier to take such steps "as are [pre]ibed" in the notice within a specified time [or] ernatively, after not less than 24 hours' [notice], may enter in and take the necessary steps [themselves] selves and may recover any reasonable [expe]nses incurred from the occupier.

Subsection (2) provides that the authority "shall" take or secure collective action for the destruction of rats and mice.

Subsections (3) and (4) are of administrative

interest only, but it is to be noted that by the [illegible] section "any person" duly authorised in [illegible] by an authority under the Act may be [illegible]ed to supervise the due observance of [illegible]n 1 of the Act and such person therefore [illegible] not be an existing temporary or permanent [illegible]cer of the authority and might be authorised [illegible]r this special purpose, or even in respect of a particular case or investigation.

Subsection (5) provides for penalties for obstruction of such officer or person in the execution of his duties under the Act.

Section 5, apart from Section 1, is the most important one of all, for the practical working of the Act really depends on the interpretation of this section and what views the local authority holds of its responsibility under the secti[illegible] In the first place the wording is permissive [illegible] there is nothing to force an authority t[illegible] any action whatever, save the possibility [illegible] Ministry of Agriculture entering in. It [illegible] evident that, subject to any legal decision [illegible] point which may arise in the future, n[illegible] is the authority sole judge of whether an oc[illegible] has failed to comply with Section 1, but als[illegible] power to prescribe what steps an occupier [illegible] is in default shall take, providing of course t[illegible] comply with the words "necessary and reasonal[illegible] practicable."

Although the wording of subsection (1) is permissive, legal opinion would probably interpret "may recover any reasonable expenses" as "shall," so that when an authority takes alternative course and enters in after 24 hours' notice they would not be justified in taking steps to recover the cost from the occupier.

Subsection (2) seems capable of very wide interpretation and here the word "shall" is used, presumably with intention. The wording seems to contemplate that circumstances might arise in which the authority itself would "take" collective action, and probably this would cover the case of dealing with an area of slum property, irrespective of subsection (1), and might also cover any area where concerted action would be desirable, subject of course to 24 hours' notice to occupiers as required by subsection (1) and recovery of any reasonable expenses, if it be finally held that there is no power to waive them.

Section 6 provides for ships, which are treated as if the vessel were land—the master is deemed to be the occupier. In this connection, by arrangement with the Ministry of Agriculture and Fisheries, responsibility for administration of the Act, so far as Port Sanitary Authorities are concerned, has been assumed by the Ministry of Health.

Section 7 requires that before a prosecution be ... the permission of the Ministry of ... or the local authority, as the case ... be obtained.

... merely interprets the terms "occu- ... land" and it is to be noted sewers ... are included with the land they are ...

... 9 provides for the Act in Scotland, the chief difference being that the authorities for enforcing the Act shall be the local authorities under the Diseases of Animals Acts (1894 to 1914) and that the expenses shall be defrayed as expenses incurred under these Acts.

Sections 10–12 are of no practical importance.

Although the Act on the whole defines fairl... clearly the duties of these three parties, it gi... but little indication of the practical mean... which they are to be carried out, and wi... exception of Section 4 gives no suggest... to how that co-operation so essential for su... rat destruction, shall be brought about.

No special procedure is laid down wh... authorities should follow in carrying out ... duty of executing and enforcing the Act, ... authorities need not have any officer w... special duty it is to supervise the administrat... of the Act, though they are urged by the Mini... of Agriculture to appoint an officer, either ...

their existing staff or otherwise for this purpose. The Sanitary Officers Order, 1922, issued by the Ministry of Health, provides that Sanitary Inspectors to whom the Order applies shall be directed by the relative local authority to act as officers under the Rats and Mice (Destruction) Act, 1919. In this respect it must be remembered with the Public Health Acts which require Authorities to appoint Sanitary Inspectors or Inspectors of Nuisances, for undoubtedly this omission is a serious defect in the Act, though it is now partially remedied by the Order just referred to.

Owing to the lack of definite directions in the Act relative to its administration, there is no uniformity among the responsible authorities in the manner of carrying out their duties, but generally speaking, each authority has either appointed a special Rat Officer or has assigned the work of supervision to one of their existing staff, in most cases a Sanitary Inspector.

Although the duty of the Ministry of Agriculture under the Act is solely that of acting if and when an authority is in default, it was considered that something more was necessary if the Act was to fulfil its object, for not only was it desirable to inform the public in general as to the necessity for the Act, but also as to the means available for carrying out the duties of

rat destruction laid upon them by the Act. [illegible] same time it was equally necessary that [illegible]orities under the Act should be advised [illegible]best means of carrying out the Act. [illegible]purpose the Ministry appointed a [illegible]lviser whose duty is to act gen- [illegible]dviser to both authorities and the [illegible]oon after the Act was passed the [illegible] also established a Rat Research Labora- tory where investigations on the scientific ques- tions involved in practical rat destruction wer carried out. Owing to the need for econom this laboratory was closed in 1922, but not befor a certain amount of useful work had been accomplished.

It has already been pointed out that there great variation in the manner in which the is applied by the different authorities, a authoritative procedure can be laid down even the Ministry has no power to anything of an authority except that th fact " execute and enforce " the Act.

When the Act was first passed a good authorities appointed whole time Rat and schemes were arranged whereby act destruction would be carried out on repa by staffs under the control of th Although such schemes are possib supporting basis, they are now

owing partly to the urgent need for economy which arose later, and partly to legal diffi in the interpretation of Section 5 (1), these authorities ceased to employ w Rat Officers or special staffs for carry estruction duties. The Act does no rovide for authorities maintaining a ractical rat destruction to be at the fre f occupiers and even if such a servic ided, apparently it can be applied only to cupiers who are in default and after 24 hours' otice, the reasonable expenses of any treatment pplied being recoverable.

It should be noted that though many of these hemes are no longer in operation, there were still are very good reasons for them, these firstly the difficulty which occupiers, arly outside the larger towns, experience ig a satisfactory service for dealing with lem and secondly these schemes ensured llective action" which it is the duty of s to secure (Section 5 (2).)

ew of these difficulties most authorities point Rat Officers whose duties are lvisory and as a rule this work is carried existing officers of the authority. Counties int one of their agricultural staff, other authorities appoint Sanitary ough sometimes officers of the

cleansing or Surveyor's department carry out
y. The appointment of Sanitary In-
o carry out this duty, in urban areas
, is undoubtedly sound, provided they
cessary time and knowledge to attend
the matter, for much of their othe
rk already brings them into contac
upiers whose premises are liable t
n by rats.

A good many authorities interpret their dutie
rather more widely and supply suitable rat poiso
to occupiers on repayment or in the case of po
class property make a free issue, in
er to mak
certain of some serious attempt
llec
action.

In general, if all occupiers of
including local authorities, d
their duties under Section
efficiently, there is no doubt t
a very great improvement, and
has been brought about in those
the Act has been energetically applie
by straining its wording—neverth
be admitted that it leaves some
desired in so far that the pow
authorities are ill defined.

In the opinion of many officer
for administering the Act it m
siderably strengthened in several

towns especially, some provision for dealing with "owners" as an alternative to "occ... is desirable in order to get over the d... poor class property, and the still gre... 'rat proofing" where such involve... terations or repairs for which the... ot only not normally liable, but mig... nulcted in damages by the landlord, w... efinite powers to provide poisons and ... purpose of taking those reasonable and ... steps required by the Act are also ...neral principles, it may perhaps ...or authorities to trade in this ...e public as a whole are better ...he principles of practical rat ...pply of suitable poisons or ...ore generally available, some ...l not be unreasonable.

... after all is a complicated ...it seems difficult to obtain really ...peration without some such cen... ...m of supply in each area. It has ...out also that more definite legisla... ...e to deal with the financial question ... though Section 2 (2) indicates the ... which expenses incurred shall be ...e is nothing in the Act to indicate ...penses may be incurred.. There is ...ise any special sum for the purpose

Whether there be any relation between the two circumstances or no, it would certainly seem worth while for the authorities concerned to seriously consider the advisability of drastic rat destruction on any infected farm before or at the same time as the disinfection.

This chapter would not be complete without some reference to a possible connection between rats and cancer.

Rats are undoubtedly susceptible to cancer and though as yet the cause of this disease is unknown, it has been suggested by Professor Sambon that there is a causal relation between cases of cancer and houses which are infested with cockroaches and rats. The evidence is circumstantial, but Sambon quotes many cases to support the theory. He is of opinion that a parasitic worm, *gongylonema*, is a predisposing cause of cancer in rats and that where this is common in rats it may also have some influence on human cases. Certainly cancer is on the increase according to the Registrar General's returns but there are no figures available to show whether the decease is more prevalent in places known to be rat invested.

In general the connection between rats and disease does not specially react on Public Health Officials in this country and where it does

do so, provision has already been made for dealing with the contingency.

It has been shown that they already had powers to deal with rats in the event of plague and to deal with those purely sanitary measures which in themselves would protect the community against trichinous pork.

The Rats and Mice (Destruction) Act, 1919, does not apply to Public Health Departments as such, save in the case of Port Sanitary Authorities and those places to which the Sanitary Officers Order applies, but in actual practice, the majority of local authorities in urban, and a good many in rural, areas do in fact delegate the administration of this Act to the Public Health Department and require Medical Officers or Sanitary Inspectors to carry out the duties of Rat Officers. As a matter of practical convenience this works very well, though it must be admitted that where the work is added to the existing duties of these officers, especially in areas employing but one Inspector, a zealous and keen officer must find it difficult to do the work thoroughly. If in the future, an extension of the scope or requirements of the Act were to come into force, the services of officers who could specialise in this branch of work would have to be considered.

CHAPTER VII

THE RAT MENACE UNDER CONTROL

IN dealing with the future it is certainly undesirable to dogmatise and not too wise to prophesy, for the fate of prophets is well known. It is however, permissible to speculate on how the rat menace may in time be brought under control and what the conditions should be to ensure that it remains in this state.

The problem of rat suppression is in some ways not unlike that of the eradication of diseases (especially those due to specific organisms) and as has been shown in the particular case of plague the two problems are intimately connected.

In both cases complete success may be and probably is, impossible, but during the past hundred years great progress has been made in dealing with the latter problem and many diseases once common in this country are now almost unknown and there is every reason to anticipate that in dealing with rats—given the will, the time and the money—such a measure of success is possible that they will cease to present a serious problem.

It may be instructive therefore, to inquire into the factors which have assisted in bringing about this practical disappearance of disease and see whether they throw any light on the problem. Both problems are essentially biological but it would be unwise to press the analogy too far, for in the first case the protagonist is an intelligent and adaptable animal while the organisms causing disease are non-sentient and can only exist under certain well defined conditions.

It will be sufficient to consider a very few of the most striking examples of diseases which, once common in this country, are now so rarely met with that they are hardly considered as native diseases at all—plague, typhoid (enteric fever), cholera and malaria (ague)—serving the purpose very well.

Plague has already been fully considered and it was shown that its virtual disappearance from Western Europe was largely due to the changed conditions in life bringing about an almost complete alteration in the species of rat in this area. It was certainly not due in any way to improvement in curative medicine, for it took place before modern medicine had developed to any extent. This disease then, is an instance of the influence of environment, which not only affected the rat population but at the same time was instrumental in removing a devastating disease.

Typhoid, cholera and malaria—like plague—all began to disappear from this country before any marked improvements were available for treating them medicinally, though in the case of malaria, the value of quinine as a specific has been known for many years, and other causes must be sought to account for this. Typhoid and cholera are water borne diseases and there is no doubt that they have become rare mainly, if not entirely, because of the improvements in general sanitation, particularly the provision and control of pure drinking water supplies and the more adequate disposal of sewage matter. In other words, the environment has become unsuitable for the continued existence of these diseases, while modern resources enable them to be readily controlled, for even during the Great War the casualties from diseases of the enteric group were insignificant.

Malaria has largely disappeared for similar reasons—this disease is due to an organism which spends a period of its existence inside the mosquito, and malaria control is synonymous with mosquito control, and it is since the fens and marshes, once common in all low lying land, have been reclaimed and drained that this disease has ceased to be common in England, though it must be admitted that still more remains to be done in this direction, for even if this particular

disease is not usual, mosquitoes are still very prevalent in some parts and their bites cause a great deal of annoyance and a certain amount of definite disease.

It is a curious reflection that these diseases are now often described as tropical diseases. The reason for this in the case of plague has been shown to be due, mainly, to the fact that the rats in many tropical countries live in close association with the native population and in fact Glen Liston* describes plague as a disease of "primitive civilisation." The same might equally be said of these other diseases, which are not strictly due in any way to tropical conditions as such.

It is not unreasonable therefore to suggest that environment is just as important a factor in dealing with these other diseases as it is with plague.

To revert to the main problem, that of rat suppression, there are very good grounds for attributing the disappearance of R. *rattus* from Europe more to the environment becoming unsuitable than to the actual war waged against it by R. *norvegicus* and there are many other instances of the gradual disappearance of animal species which must have been due to similar causes. Glen Liston* refers to dis-

* *Ibid.*

appearance of ravens, carrion crows and kites mentioned by James Ritchie in his book "The Influence of Man on Animal Life in Scotland" and suggests that this is due more to changes in the habits of man than to deliberate destruction of the species, for they are still common in those parts of the world where conditions provide them with ample food in the way of carrion.

Morewood Dowsett,* the well known traveller and big game shot, in discussing the conservation of wild life, draws attention to the fact that big game is becoming scarcer for somewhat similar reasons and is not entirely due to destruction by hunters.

On general grounds therefore, it is evident that environment, taken in its widest sense, is a potent factor in determining the survival or disappearance of an animal.

In the particular case of the rat the environment has been mainly provided for it by the human race in its gradual development into civilised communities. In the wild state, rats could only increase to an extent dependent on the amount of food and shelter naturally obtainable and abnormal increase would be promptly checked by nature.

R. rattus as we have seen, thrives mainly in the environment incidental to the more primitive

* J. Morewood Dowsett: "Big Game and Big Life," 1925.

forms of civilised life, while the more highly developed life of modern civilisation provides ample opportunities for R. *norvegicus*, so that on the whole man himself is indirectly but unconsciously responsible for the rat problem, rather than nature.

In the future, man who at present is a favourable rather than unfavourable factor in the existence of rats, must deliberately so order his environment that it becomes unsuitable for rats.

In Europe this has already taken place so far as R. *rattus* is concerned and we may perhaps anticipate that the first definite step forward will be a gradual victory over this species as conditions of life in India and other Eastern countries more nearly approach European standards.

Balfour and Scott in speaking of the mastery over plague say "it never will be complete until we take plague seriously and regard its presence as a stigma upon our sanitary escutcheon. . . . Plague is or rather should be, an anachronism in the twentieth century. . . . There is however reason to hope that ere the close of the century plague, if not extinct as the dodo, will at least be as rare as is yellow fever at the present day."*

* Andrew Balfour and Henry H. Scott: "Health Problems of the Empire." 1924.

These words apply no less truly to the rat than to the plague for which it is responsible and though the disappearance of plague from the human race does not postulate the entire destruction of R. *rattus* it does mean that conditions will be such that it will find far fewer opportunities for comfortable existence. If the above estimate seems unduly optimistic it must be remembered that it took less than two hundred years to displace this rat from Europe and that without any deliberate action by the human race.

The problem presented by R. *norvegicus* is rather more difficult to deal with. Owing to its adaptability it is capable of existence under far more varying conditions than is possible for R. *rattus* and since the spur of a direct menace to health does not arise, neither the public nor authorities are inclined to press forward in the organised war against them.

The importance of environment has been pointed out and the main advance must be expected in the direction of rat-proofing and improved construction of all classes of buildings so that it will become increasingly difficult, if not impossible, for rats to gain entrance either above or below ground.

As the provision of properly bricked and concreted basements, especially in the smaller class of building, becomes more general, the

subterranean rat population in sewers and old drains will have fewer opportunities of emerging into comfortable surroundings, where there is abundant food and shelter—this in itself will soon act as a check on the increase of rats in sewers.

As this improvement proceeds above ground, similar improvements might be expected in sewer works, old disused portions being gradually removed or sealed off.

With the gradual advent of really rat-proof buildings in large towns the opportunities for rats will be far more circumscribed and they will be forced to exist mainly in the more open situations which it is inevitable, will be still available in all towns. Fortunately these can generally be treated without much difficulty and with proper attention the rat population should be then easily kept down.

Progress along these lines seems more likely than in the direction of marked improvement in actual methods of direct destruction, though it is to be hoped there will be very great advance in the direction of more consistent and intelligent use of the methods already available. It is true that they do not really get at the root of the matter but more extended use of them would be of the greatest value while the slower process of making a land unfit for rats was being carried out.

In the countryside we may anticipate a future when rat-proof farmhouses, granaries and the larger buildings will be general—but it hardly seems conceivable that there is any possibility of completely eradicating the rat from the country, but it ought not to be impossible to reduce them to the level of a rat population which can exist on the resources of nature.

It is perhaps permissible to pause and speculate as to whether the complete extermination of rats from the countryside is so desirable as is generally assumed. It may be, that if this did take place, so great a change would upset the balance of nature in some other direction, possibly by making room for vastly greater numbers of mice and voles which might prove to be an even more difficult problem to solve.

While there is reasonable probability that future progress can only come about as the result of action on the lines suggested—there seems but little prospect of such action being undertaken systematically in the immediate future.

Until the public in general and those responsible for the repair and construction of buildings in particular, are better educated in all that the rat problem involves, progress in this direction will be slow and far more attention will have to be paid to the provision of

propaganda directed to this end, before much definite improvement can be looked for.

The existing legislation on the matter has been fully discussed and while it would perhaps serve the purpose, given the willing assistance of occupiers, it may be anticipated that some strengthening of the powers of local authorities will be necessary, before any such progress as that suggested can be brought about. The new legislation provided in the Housing Act, 1925 and Town Planning Act, 1925 should be of much indirect assistance, for the former gives local authorities very wide powers for dealing with insanitary property of the smaller sort and in the case of new housing schemes many of the conditions predisposing to rat infestations should be absent.

The possible extension of legislation and the further education of the public in this matter would seem to indicate that the officers of local authorities in the future will have to give far more time and attention to dealing with rat infestations and cognate matters. Doubtless in many cases, an increased staff will be required and larger numbers will have to specialise more or less in the theory and practice of rat destruction, and the author ventures to hope that this little book will prove of some small service in assisting those on whom this duty may fall.

APPENDIX

FORMULÆ OF RAT BAITS

Arsenic Baits

1. White Arsenic (powder) ... 1 part by weight
   Oatmeal (or other meal) ... 19 parts ,, ,,
   Aniseed Oil ... ... q.s.

Mix the two dry ingredients thoroughly and add sufficient aniseed oil to give a faint smell.

2. White Arsenic (powder) ... 1 part by weight
   Meal (as above) ... ... 14 parts ,, ,,
   Dripping ... ... 5 parts ,, ,,
   Aniseed Oil ... ... q.s.

Mix the dry ingredients, heat the fat separately until just melted and quickly pour on to the powders, stirring well with a spoon until a stiff paste is produced. Add the aniseed oil just after the fat.

Barium Carbonate Baits

3. Barium Carbonate (Commercial Powder) ... ... 1 part by weight
   Oatmeal (or other meal) ... 3 parts ,, ,,
   Aniseed Oil ... ... q.s.

Prepare as for No. 1 Arsenic Bait.

4. Barium Carbonate (Commercial Powder) ... ... 1 part by weight
   Meal as above ... ... 2 parts ,, ,,
   Dripping ... ... 1 part ,, ,,
   Aniseed Oil ... ... q.s.

Prepare as for No. 2 Arsenic Bait.

5. Barium Carbonate (Commercial Powder) ... ... 1 part by weight
   Flour ... ... 2 parts ,, ,,
   Fat ... ... 1 part ,, ,,

Mix the dry ingredients thoroughly, shred the fat and knead it well in, then add sufficient water to make a moderately stiff dough. Roll out the dough into a sheet about ¼ in. thick and cut into about 1,000 biscuits for each lb. of Barium Carbonate used. Bake in a quick oven.

Phosphorus Paste

6.	Ground Rice	3 oz.
	Water	1 pint
	Sugar	4 oz.
	Lard	3 oz.
	Phosphorus	½ oz.
	Carbon Disulphide (pure)	½ to 1 oz.

A simple phosphorus paste can be made with the above ingredients as follows :—

Mix the ground rice and sugar in a bowl and add 4 oz. of the water, stirring up until a thin cream is made.

Place the rest of the water in a saucepan preferably aluminium, iron ones should not be used, and bring to the boil over a gas ring, remove from the flame and quickly add the rice-sugar cream, stirring the contents of the saucepan as it is added—then replace over the gas and boil gently with constant stirring until a thick paste is made, taking care not to burn the contents and to prevent the formation of lumps. Remove from the gas and add the lard, stirring it well in, and continue stirring from time to time while the contents are cooling.

Now weigh out the phosphorus as follows :—

Place a cup containing a little water on the pan of the scales and weigh it, then place a ½ oz. weight on the other side and with wet fingers remove a stick of phosphorus from under the water in which it is kept, break off a small portion and add it to the cup containing water and repeat until ½ oz. has been obtained—now pour off the water and drain out the cup without letting the phosphorus fall out. To the cup add from ½ to 1 fluid oz. of pure carbon disulphide, this will readily dissolve the phosphorus.

As soon as the contents of the saucepan have cooled down sufficiently add, little by little, the solution of

phosphorus in carbon disulphide, and stir it in very thoroughly until the phosphorus is well mixed with the paste; the carbon disulphide will evaporate and great care must be taken not to breathe its vapour and to carry out this latter operation at a distance from all naked lights or heat.

As carbon disulphide is exceedingly inflammable great care must be taken to avoid risk of fire and it must not be added while the paste is hot as this may cause it to ignite; it is also important to adhere to the amount of phosphorus stated.

Red Squill Baits

7. Red Squill Powder ... ... 1 part by weight
   Oatmeal (or other meal) ... 4 parts ,, ,,
   Aniseed Oil ... ... q.s.

   Prepare as for No. 1 Arsenic Bait.

8. Red Squill Powder ... ... 1 part by weight
   Meal as above ... ... 2¾ parts ,, ,,
   Dripping ... ... 1¼ parts ,, ,,
   Aniseed Oil ... ... q.s.

   Prepare as for No. 2 Arsenic Bait.

9. Red Squill Powder ... ... 1 part by weight
   Flour ... ... 2¾ parts ,, ,,
   Fat ... ... 1¼ parts ,, ,,

   Prepare a dough as described for No. 5 Barium Carbonate Bait, but cut into about 1,400 biscuits for each lb. of Squill Powder used.

N.B.—In using the above formulæ it is very necessary to be sure that the Red Squill Powder has been suitably prepared and is of full toxic value.

Liquid Extract of Red Squill

10. Red Squill Bulbs ... 1 part by weight
    Water ... ... 2 parts ,, ,,
    (N.B.—1 gall. = 10 lb.)
    Salicylic Acid ... ... 2½ oz. to every 10 gall.

Chop up the bulbs as finely as possible and place in a suitable receptacle (not iron or galvanised). Heat the

water to boiling and pour it on to the bulbs, add the necessary quantity of salicylic acid (a preservative), stir up occasionally and let stand for several hours. When cold pour off the liquor, straining it through fine muslin if necessary, pressing as much out from the bulbs as possible. Store in the dark in well stoppered vessels.

STRYCHNINE BAITS.

11.	Strychnine (powdered Alkaloid)	1 part by weight
	Sugar	24 parts ,, ,,
	Meal	75 parts ,, ,,
	Aniseed Oil	q.s.

Mix the strychnine with the sugar. This is best done as follows: Place the strychnine in a mortar with a little sugar and grind the two thoroughly together, adding more sugar from time to time until all is added and the whole well ground. Now mix in the meal and flavour with aniseed.

12.	Strychnine (as above) ...	1 part by weight
	Sugar	3 parts ,, ,,
	Meal	6 parts ,, ,,
	Lard	10 parts ,, ,,

Mix the strychnine and sugar as described for No. 11 bait. Then add the meal, now work in the lard a bit at a time by means of a palette knife, rubbing the whole mixture together until a soft paste is obtained. This preparation is particularly useful for a mouse bait and is intended for spreading in bread sandwiches or between biscuits.

Note.—The majority of the above formulæ can be made additionally attractive, if desired, by the addition of one or more of the ingredients suggested in the text (chap. iv, page 100).

INDEX

INDEX