



# **HANDBOOK of PEST CONTROL**

*The Behavior, Life History, and Control of Household Pests*

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**Sixth Edition**

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TO  
PROFESSOR E. O. ESSIG  
and  
MR. A. E. DAVIE

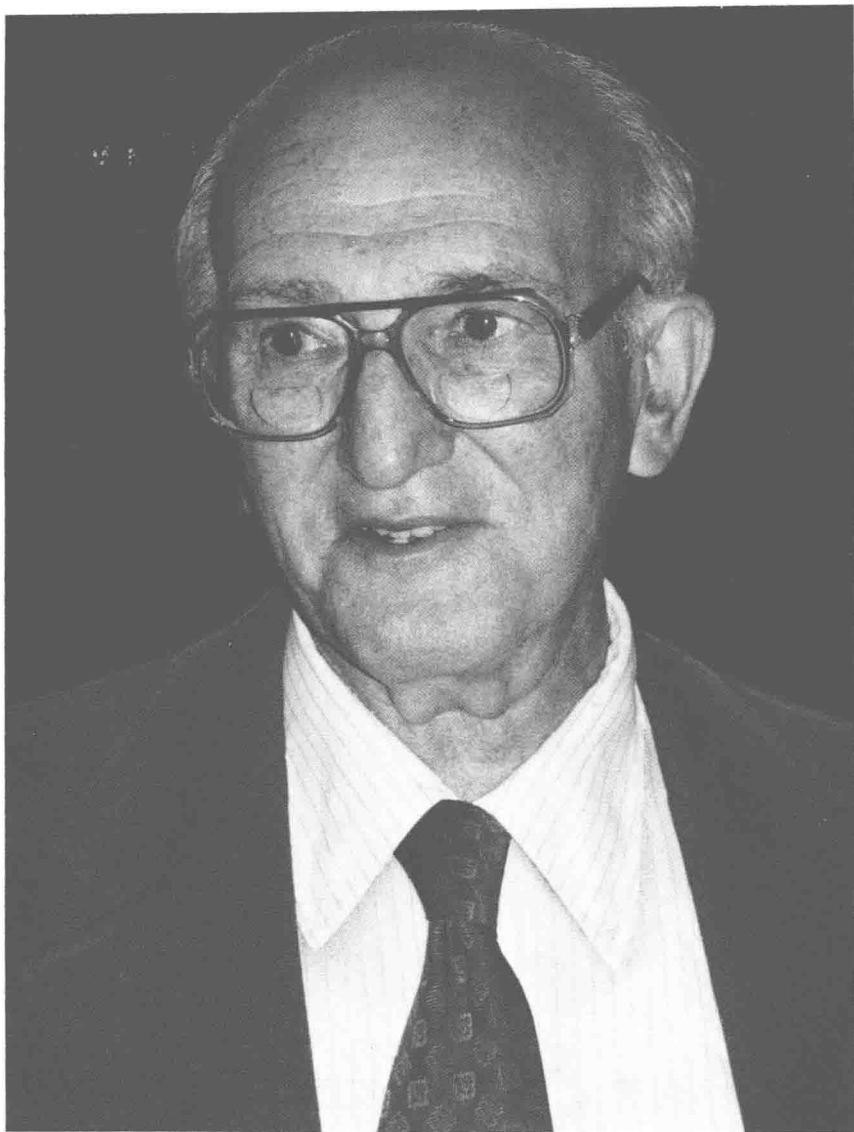
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## ARNOLD MALLIS

*Mallis is the author of the Handbook of Pest Control, American Entomologists and numerous papers on household insects, household insecticides and the history of entomology. The Handbook of Pest Control has become the standard reference book of the pest control industry and, like Arnold himself, has played a vital role in helping people understand and respect pests and deal with pest problems in a rational manner.*

## PREFACE TO THE SIXTH EDITION

In 1937, a salesman for a pest control firm in California mentioned the need for a comprehensive work on household pests and their control. This suggestion sparked the idea for the first edition of the *Handbook of Pest Control* which I started in 1938 and submitted to the original publisher, MacNair-Dorland Co., Inc., in 1942. Because of war-time conditions, publication of the first edition was delayed until 1945. Subsequently, four other editions appeared: the second edition in 1954, the third edition in 1960, the fourth edition in 1964, and the fifth edition in 1969.

For each edition I attempted to incorporate the latest information on pest biology and control. A comparison between the sixth edition and the fifth edition illustrates the remarkable progress made in the last decade in developing new products and techniques. But just as noteworthy have been the changes in pest control philosophies. The sixth edition reflects this evolution in our thinking and includes integrated pest management and pest eradication approaches, though for continuity I have kept the original title of the book.

For a variety of reasons I have not been able to revise the sixth edition entirely by my own efforts, and instead, I have been fortunate to have the cooperation of 16 other authors in the preparation of this edition. These authors, well-known in pest control, have updated the text and given it a modern, fresh look. Several chapters are new and have added a great deal of pertinent information to the book. For these reasons I wish to thank each of the authors, whose names head the chapters, for their contributions to the sixth edition.

I am especially indebted to Keith Story, who assembled the authors, edited and coordinated their efforts, and did all this with great competence in record time. I wish to acknowledge the initiative of Richard J. W. Foster and the work of Dan Moreland, Franzak & Foster, Co., and *Pest Control Technology* magazine for achieving publication of the sixth edition of the *Handbook of Pest Control*.

ARNOLD MALLIS  
1982

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## PREFACE TO THE FIRST EDITION

**T**his handbook concerns itself with household pests other than man, classical examples of which are the cockroach and bedbug. In numerous instances the author wanders from the immediate vicinity of the threshold to pay his respects to an ant, sowbug, or similar pest whose permanent abode is other than the home of its unhappy host.

Emphasis is laid on the control of household pests since this is the primary purpose of the work. During the last 10 years entomologists and chemists have devoted unusual attention to the control of household pests, and the author has taken particular pains to include these advances in the text. Various individuals have remarked to the author, "What we need is just ONE good method of control for each group." The author can merely reply that this is a Utopia as yet unattained, and some reasons for this are indicated below:

(a) No ONE good method of control is as yet known, e.g., against the black carpet beetle.

(b) No ONE good method of control is effective against all the species in a group, e.g., against both the German and the Oriental cockroaches.

(c) No ONE good method of control is effective against the same species in different localities, e.g., against the Argentine ant.

(d) No ONE good method of control is always the most applicable, e.g., fumigation against mice.

(e) Insecticides for the ONE good method of control are not always available, e.g., pyrethrum powder under present circumstances.

In some instances the author has separated the material on control into a concise introductory portion, for the benefit of those who are in a hurry, and a more detailed discussion, for those desiring additional information.

If the author has on occasion treated the introductory material lightly, it must be remembered that the entomologist and pest control operator in time spin about themselves a protective cocoon of humor to fend off the good-natured jests directed at their profession.

The author desires to express his gratitude to Professor E. O. Essig for constantly advising and encouraging him in the preparation of this work, and to Mr. A. E. Davie for his kind cooperation. Mr. Jack Schwartz, Dr. and Mrs. R. M. Bohart, and Dr. W. M. Hoskins, all rendered valuable assistance. Original photographs were furnished by Mr. R. J. Pence and Mr. J. C. Elmore. The following individuals and organizations have given the author permission to either use their illustrations or to quote from their works: W. S. Patton, Paul Griswold Howes, The British Museum of Natural History, The University of California Press, The Science Press, Smithsonian Institution Series, Inc., The Comstock Printing Co., The National Geographic Magazine, C. C. Thomas, Publisher, Little, Brown & Co., Charles Boni & Sons, Inc., American Cyanamid & Chemical Corporation, Zonite Products Corporation, Innis, Speiden & Co., E. I. du Pont de Nemours & Co. (Inc.).

ARNOLD MALLIS  
1945

TO  
PROFESSOR E. O. ESSIG  
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MR. A. E. DAVIE

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## AUSTIN M. FRISHMAN



**D**r. Austin M. Frishman gained his bachelor's and master's degrees from Cornell University and his Ph.D. from Purdue University. Frishman has had broad experience in the pest control industry. Prior to establishing his current consulting company in 1980, his work has ranged from pest control technician for a New York State PCO to a distinguished teaching career at the State University of New York (SUNY) at Farmingdale. For 14 years he was professor of biology at SUNY during which time he wrote several scientific and popular books on pest control and authored or co-authored more than 60 articles for scientific and trade journals. Currently he writes a column in the magazine Pest Control Technology magazine.

Frishman is well known for his entertaining lectures and during his career has addressed more than 50,000 people engaged in pest control.

Frishman has been active as a consultant in the food industry, developing pest control programs and manuals for several major food manufacturers and processors. In addition, he has worked closely with local, state and federal government agencies and played a major role in writing the state examination in three of the subcategories currently used in New York State.

Frishman is a member of the honor societies Phi Kappa Phi, Pi Chi Omega and Sigma Xi. He is a member of various professional associations including the National Pest Control Association and the Entomological Society of America. He is an honorary member of the Indiana, Long Island and Empire State Pest Control Associations.

## CHAPTER ONE

# Rats and Mice

Revised by Austin Frishman<sup>1</sup>

"..... Rats!  
They fought the dogs, and killed the cats,  
And bit the babies in the cradle,  
And ate the cheeses  
out of the vats,  
And licked the soup from the cook's own ladles . . ."

—Robert Browning

In Japan, the rat has the honor of having the first year of the oriental zodiac named after it. The rat is often associated with the God of Wealth — Daikoku, one of the seven gods of luck.

The Chichineca-Jonaz, in the Mexican state of Guanajuato, were eating rats as part of their basic diet (Hirschhorn 1974) as late as 1950. Several veterans returning from Vietnam and others visiting the Philippines and other Asiatic countries have told the author of children bringing rats home for dinner. Rat meat brought a good price in 1798 in the French garrison at Malta (Zinsser 1935). Rats also serve as scavengers feeding on the garbage of man.

Both roof rats, *Rattus rattus*, and Norway rats, *Rattus norvegicus* serve as excellent research animals for a host of physiological, behavioral and other scientific studies. The acute oral toxicity of all pesticides is based on tests conducted with laboratory strains of Norway rats.

Also, rats can be conditioned so their brain waves show a response to TNT (Egelhof 1978). Thus rats have been trained to search out bombs. So much for the desirable contributions of these animals. The rest of this chapter is devoted to how to control rats.

The remarkable ability of the rat to adapt itself to nearly every environment, along with its natural cunning, have made it one of the most successful of all animals. Man continually must fight these animals to protect himself, his food-stuffs and his property from destruction. The war between man and rats is unrelenting since the victories achieved are of a temporary nature, only very rarely resulting in a long-lasting reduction of rat populations.

**Rats as enemies of mankind.** Rats are extremely important pests on the farm. Hamilton, Jr. (1947) states, "On the farm, rats eat incredible quantities

<sup>1</sup>President, AMF Pest Management Services, Inc., Farmingdale, N.Y.; Extension Specialist, State University of New York, Farmingdale, N.Y.

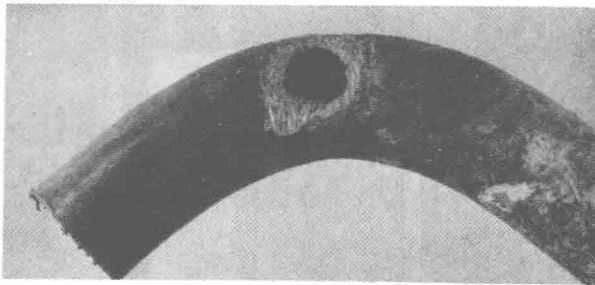
of foodstuffs, destroy poultry, lay waste the stored fruits and vegetables, and riddle buildings with their sharp teeth. Rats tear down growing corn, eat melons, pumpkins, and tomatoes on the vines, and even take an appreciable toll of cherries, climbing the tree in search of the fruit." Rats also are a major problem to the poultryman. They destroy feed, carry disease and kill chicks.

Hamilton, Jr. (1947), speaking of the depredations of rats on wildlife, notes, "In America, game keepers and conservationists might well look to the rat as one of the chief predators of game. Rats victimize the nests of robins and ground-nesting birds, insular colonies of terns have been completely destroyed by rats, and rat destruction of quail chicks in the South is well known. On game farms, the abundant supply of feed attracts hordes of rats, which in turn kill the young pheasants and other birds. Rats ate the legs off 40 young black ducks on a Long Island game farm. A single rat destroyed, in three nights, 120 pheasant chicks. In rural areas, rats are not restricted to the farm. The author has seen them in the dense woods of the Adirondacks, miles removed from habitation. In these areas it is obvious that some of the food consists of wildlife."

The young of pigs and lambs are not immune from their depredations, and it has been reported they will on occasion gnaw holes in the bellies of swine, tear the nipples from a farrowing sow, and otherwise attack animals. A circus owner in Germany was forced to kill three elephants because the rats gnawed the feet of these animals, and a pest control operator observed rats to gnaw on the hides of living alligators in a Los Angeles alligator farm.

Rats are responsible for damage in the home and warehouse. Here they gnaw upholstery, bolts of silk, papers, books, and like materials for nesting material. They gnaw hard substances such as bone, aluminum, lead, and similar materials (Fig. 1-1). It was believed this was to maintain their ever-growing incisors at the proper length. However, gnawing is not necessary for rats to keep teeth worn down; the incisors work like opposing chisels. In a hospital on the edge of the Mohave Desert, they gnawed for water through lead drains in the plumbing. Rats also can chew through plastic water pipes and garbage cans.

Accounts of the rat's ability to start fires by carrying matches to their hiding places, as well as by causing short circuits through the gnawing of electrical wires, are commonplace. Hamilton, Jr. (1947) notes rats "carry matches to their nests and gnaw the phosphorus or paraffin coating, causing the match to burn. Their nests of highly inflammable material are often composed of oily rags and other substances which encourage spontaneous combustion. By gnawing through electric wiring and lead gas pipes, a not uncommon practice, rats jeopardize human life through fire or asphyxiation."



**Fig. 1-1.** Rat gnawings on a piece of lead pipe.

The mere presence of rats reduces the rental value of apartments and stores. The noise they make as they climb between the walls and floors of buildings often keep the inhabitants from sleeping. But historically their effects have been of little import compared to the diseases they carry. Richter (1946) studied the incidence of rat bites and rat bite fever in Baltimore. He concluded that in an area of less than two square miles at least 93 individuals were bitten by rats from 1939 to 1943. Seven of the 65 individuals treated in Johns Hopkins Hospital developed rat bite fever — none died. Sixty percent of those bitten were under one year of age. Most of the bites were mere punctures on the hands and face, although some were more serious. The rats regard the sleeping infant or adult as a source of food, and in most instances the first bite awakened the victim, and the rat ran away. Possibly, once a rat bites a human being it is apt to bite other human beings. Individuals dwelling in areas where housing and living conditions are poor are more apt to be bitten.

Nor are rats averse to attacking man as this report from Hogarth (1929) so well certifies: "In the Walker colliery, near Killingsworth, in which many horses were employed, the rats had accumulated in great multitudes. It was customary at holiday times to bring to the surface the horses and the fodder, and to close the pit for a time.

"On one occasion, when the holiday had extended to 10 days or a fortnight, during which the rats had been deprived of food, on reopening the pit, the first man who descended was attacked by the starving rats and speedily killed and devoured."

More recently, *Newsday* (1979) reported the following under the headline, **RATS GNAWED ON MAN**, 45.

"An indigent man who had lain in the garbage-strewn basement of a Chicago apartment building for two weeks while rats chewed on him was reported in fair condition yesterday after having both of his legs and two fingers amputated.

Cook County Hospital said David Hallman, 45, was transferred from Loretto Hospital early Saturday and underwent surgery later in the day. The hospital reported Hallman's legs were amputated below the knees, and that two fingers were removed from his left hand.

Police discovered Hallman in the basement of a West Side apartment building Friday night. He had rat bites on both legs and hands and one of his ankles was bare to the bone, police said.

A resident of the building said she had heard moans and screams for about two weeks, but didn't call authorities because 'she thought we would think she was crazy,' police said."

## DISEASES CARRIED BY RATS

Although we have listed some of the depredations of the rat, these are minor when compared to the dread diseases conveyed and spread by this pest. Schwarz (1944), in evaluating the several species of rats as carriers of disease notes, "There are the true or exclusively domestic rats, the Black rat (*Rattus rattus* Linnaeus) and the Greybellied rat (*R. r. alexandrinus* Geoffroy); these are the chief carriers of infection, because their contact with man is of the closest. The other two commensal rats, the White-bellied rat (*R. r. frugivorus* Rafinesque) and the Norway rat (*R. r. norvegicus* Berkenhout), although associated with man and dependent on him for their existence, to a certain extent may live with the wild rodents, or act as go-betweens between them and the domestic rats. Therefore, they are primarily responsible for animal epidemics (epizootics)

and for the transport of infections over wide distances." Schwarz's taxonomic structure is no longer used. It is now standard practice to use only the terms *Rattus rattus* (with possible specific color phases) and *Rattus norvegicus*.

**Plague.** The great plague of London that killed more than half of the city's inhabitants, and the "black death" that devastated Europe for more than 50 years in the fourteenth century, killing some 25,000,000 individuals, were in part due to the abundance of rats. The plague-infected rats carry plague-infected fleas which in turn infect man. Fortunately, such epidemics no longer devastate Europe, yet it is estimated that from 1898 to 1923 11 million lives were lost from the plague in India, China, Mongolia, and other parts of Asia.

The thousands of miles of water separating us from the Asiatic and the European shores are not sufficient to spare us from this dread scourge, for plague outbreaks have occurred in San Francisco in 1900, in Oakland and San Francisco in 1907 and 1908, in New Orleans in 1914, in Galveston in 1920, in Los Angeles in 1924, and in other cities since then.

Plague is a bacterial disease of the circulatory and respiratory systems. The germ *Yersinia pestis*, which invades the body, was discovered independently in 1894 by the Japanese investigator Kitsato and by the French investigator Yersin. At this time it was established that rat plague and human plague were identical.

In man, plague may manifest itself in four ways:

- **Bubonic plague.** Here the blood is infected and the bacilli are arrested in the glands, particularly in those of the groin and under the armpits, resulting in inflamed glands or buboes which suppurate. This is the most common form of plague and results from the bite of a flea. The mortality may range from 40 to 70 percent. It should be noted bubonic plague also can be contracted by contact of the abraded skin with infected dust and dirt.
- **Septicemic plague.** In more serious cases the glands fail to arrest the bacilli which appear in large numbers in the blood. Numerous hemorrhages occur under the skin, which turns black, accounting for the name "Black Death." This form of plague is spread by the bite of an infected flea, and since the disease in this case is very virulent, death nearly always results.
- **Pneumonic plague.** Here, where the bacilli are in the lungs, we have the most dangerous form of plague from a public health standpoint, since it is spread so readily through contact and coughing, as well as by the consumption of contaminated food. This form of plague nearly always results in a mortality above 90 percent.
- **Sylvatic plague.** This is a form of plague wherein the virulence is greatly diminished. Ground squirrels contracted the plague in San Francisco in 1900, so now it is endemic or established in this country. This form of plague was first discovered in 1908 and is gradually spreading throughout the West. It is now found in ground squirrels, wood rats, deer, mice, and woodchucks. Silver (1927) states, "The sylvatic form of the plague is apparently not highly contagious to man, as an average of only about one human case each year has been reported. The menace, however, remains a most disturbing one because of the ever-present possibilities that house rats may become reinfested in the population centers and that human cases of bubonic plague contracted from native rodents may develop the secondary, or pneumonic form, which is highly contagious directly from person to per-

son." Sylvatic plague is conveyed by contact with dead or dying rodents and less often by flea bites.

Plague is primarily a rat's disease, and the black rat, *Rattus rattus rattus*, is particularly susceptible to this disease which periodically reduces its numbers. Other rodents such as mice, the brown rat, *Rattus norvegicus*, and the California ground squirrel, *Citellus beecheyi*, are readily infected by the plague. Animals like the horse, dog, pig, and man himself, often fall victim to this dread disease. Since the black rat lives in closest association with man, plague may be present wherever the black rat is a serious household pest. In fact, it has been observed that an epidemic of plague is often ushered in by a noticeable mortality among rats. The fact that plague is no longer important in such cities as London, Marseilles, and Rome may in part be attributed to the fact the black rat and its plague-carrying flea, *Xenopsylla cheopis* (Rothsch.), have been largely replaced by the brown rat and its flea, *Nosopsyllus fasciatus* (Bosc.).

The black rat has been driven away by the competition of the stronger, more ferocious, more adaptable, and more prolific brown rat. The black rat is now, for the most part, limited to seaports and ships, where because of its superior climbing ability it can successfully compete with the brown or Norway rat. Of late, the black rat has been making a "comeback" in England and other parts of the world, largely due to the ratproofing of buildings which successfully excludes the brown rat, but not the more agile black rat.

As long as rat and flea control is neglected, the menace of plague remains. The danger is greatly reduced because of the scientist's knowledge of the cause of plague, as well as by modern sanitation and medication. Moreover, introduction of plague-infected animals has been almost completely curtailed by the inspection and fumigation of ships.

The San Bruno Mountain region of California has been extensively studied in plague outbreaks (Hudson and Quan, 1975). Plague transmission can take place when wild rodents come into contact with urban rats. On one hog farm in which wild rodents and rats were present together, many animals were trapped including rats, voles, mice, a rabbit and two weasels. Close study of the animals showed flea exchange took place between the Norway rat and some wild rodents (deer mice and voles).

## OTHER DISEASES WHICH MAY BE CONVEYED BY RATS

**Murine typhus fever.** USPHS (1948) states there are two kinds of typhus fever, "epidemic or European, and endemic or murine. The epidemic form is transmitted from person to person by body lice, while murine typhus is contracted from domestic rodents, probably both rats and mice; rats being the more active in spreading the infection. If louse-infested individuals contract murine typhus, the infection may then be transmitted by the patient's lice to other people."

Andrews and Link (1947) note the oriental rat flea is an important agent of transmission of the disease. "It must be emphasized, however, that rickettsiae have been found in the excrement of rat fleas and in the urine of rats. Thus, the possibilities of transfer to man by inhalation of dried flea feces in dust, or by the consumption of food or drink contaminated by flea feces or rat urine must be considered as well."

In the United States, in the 1940's, murine typhus was most prevalent in the South and Southeast including parts of Texas. Eskey (1943) notes 3,700 cases

were reported in 1942, and he says he believes the disease is much more common than is indicated by official records.

**Infectious jaundice or Weil's disease.** Although this is a common disease in the Orient, what is not so well known is its prevalence in the United States. The disease is caused by the spirochaete, *Leptospira icterohaemorrhagiae*, which is found in the blood and urine of the rat. Human beings may become infected "by handling or eating things contaminated with rat urine. It is also contracted by swimming and wading in contaminated water." USPHS (1948) states the disease "does not usually cause death, but is very debilitating, confining the patient to his home for a week or longer. 'Yellow jaundice' may be caused by a number of conditions, but rats are probably responsible for many undiagnosed cases." Storer (1948) notes the disease has caused epidemics among city dogs in California.

**Rat-bite fever.** As was previously noted, Richter (1946) showed seven of 65 cases treated for rat bites in Johns Hopkins Hospital in Baltimore developed rat-bite fever. The symptoms of this disease may develop after the wound has healed. The infected individual may have a relapsing type of fever for weeks or months. Larson (1941) showed in Washington, D.C., that rat-bite fever is due to the two bacterial organisms, *Spirillum minus* and *Streptobacillus moniliformis*.

Jellison, et al. (1949), have the following to say in discussing a case in Montana where a girl was bitten by mice: "Rat-bite fever is most frequently communicated to man by the bite of rats, *Rattus* spp., occasionally by the bite of other rodents, and rarely by the bite of dogs, cats, or ferrets which presumably have become contaminated by eating infected rodents." The disease is particularly dangerous to babies and small children since they are the ones most frequently bitten by rats.

**Trichinosis.** This disease of man is caused by a minute worm, *Trichinella spiralis*. Rats and mice are the principal agents in the dissemination and the perpetuation of the disease. Large numbers of *Trichinella* in the adult or sexual state are most commonly present in the intestine of man, pigs, and rats. The worms may be found encysted in the muscles of mammals and birds. It has been estimated the flesh of an infected human being contained 100,000,000 encysted worms.

While encysted, the worms suspend animation and undergo no further development. Further development of the encysted and sexless worms will only take place if the infected flesh is eaten by another animal in which the worm is capable of living, e.g., man, pig, or rat. Once this is done, the cysts are dissolved by the digestive juices, the worms escape, become sexually mature, mate, and migrate, producing the disease again.

Rats become infected by feeding upon excrement or meat infected with these worms. Pigs eat the rats and mice, or food fouled by the excrement of the rodents. Man eats the trichinous pork and becomes infected when the meat is not properly cooked.

**Food poisoning.** USPHS (1948) notes both "rats and mice suffer from intestinal infections that are communicated to man, who is infected from eating foods contaminated by the excreta of infected rodents. Acute food poisoning of this type is probably much more common than generally realized, and many involve a large number of persons at one time." This same source states it is possible for man to contract amoebic dysentery by eating food contaminated with rat excreta.

**Chorio-lepto meningitis.** USPHS (1948) notes this acute infectious disease of the nervous system "is caused by the excreta of mice contaminating food and dishes. The infection is a rather mild meningitis that causes disability for a number of days. It is caused by a virus."

**Poliomyelitis.** According to USPHS (1948), two different types of poliomyelitis may be contracted through domestic rodents. "Recently, cases of this disease have been definitely associated with an infection of mice found on the premises of the sick person. The more common type of poliomyelitis, or infantile paralysis, is believed to result from rats contaminating food with organisms from human excreta with which they may come in contact in privies, sewers, or on the ground. In this case, the rat is simply a mechanical carrier of the infection and is not infected with the disease. It is possible that rats may act also as mechanical agents in the transmission of typhoid fever and dysentery."

**Rabies.** USPHS (1948) notes "the possibility that rats may play an important part in the dissemination of rabies or hydrophobia. Rats have not been found infected with rabies in nature, but they are susceptible to the infection. Recently an individual developed rabies a couple of weeks after being bitten by a rat, and two incidents have been reported of dogs developing hydrophobia after being bitten on the nose by rats. These dogs were shut up and had no known contact with other dogs.

To date, however, we have no documented cases rats carry the rabies virus.

## HISTORY OF THE RAT

There is apparently great disagreement among pest control historians as to just when the rat arrived in Europe. Zinsser (1935) states, "De L'Isle believes that the black rat (Fig. 1-2), *Rattus rattus rattus*, originated from *Rattus rattus alexandrinus* and that it did not become parasitic on human beings until the seventh century, and that prior to this time, it lived a wild existence, possibly in the Arabian deserts. Moreover, De L'Isle was of the opinion that the brown rat became domesticated at the time of the Crusades, when it accompanied man everywhere by ship, and thus spread through the Mediterranean ports.



Fig. 1-2. The black rat, *Rattus rattus rattus*.