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FEDERAL SECURITY AGENCY
Public Health Service
Communicable Disease Center
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CONTENTS

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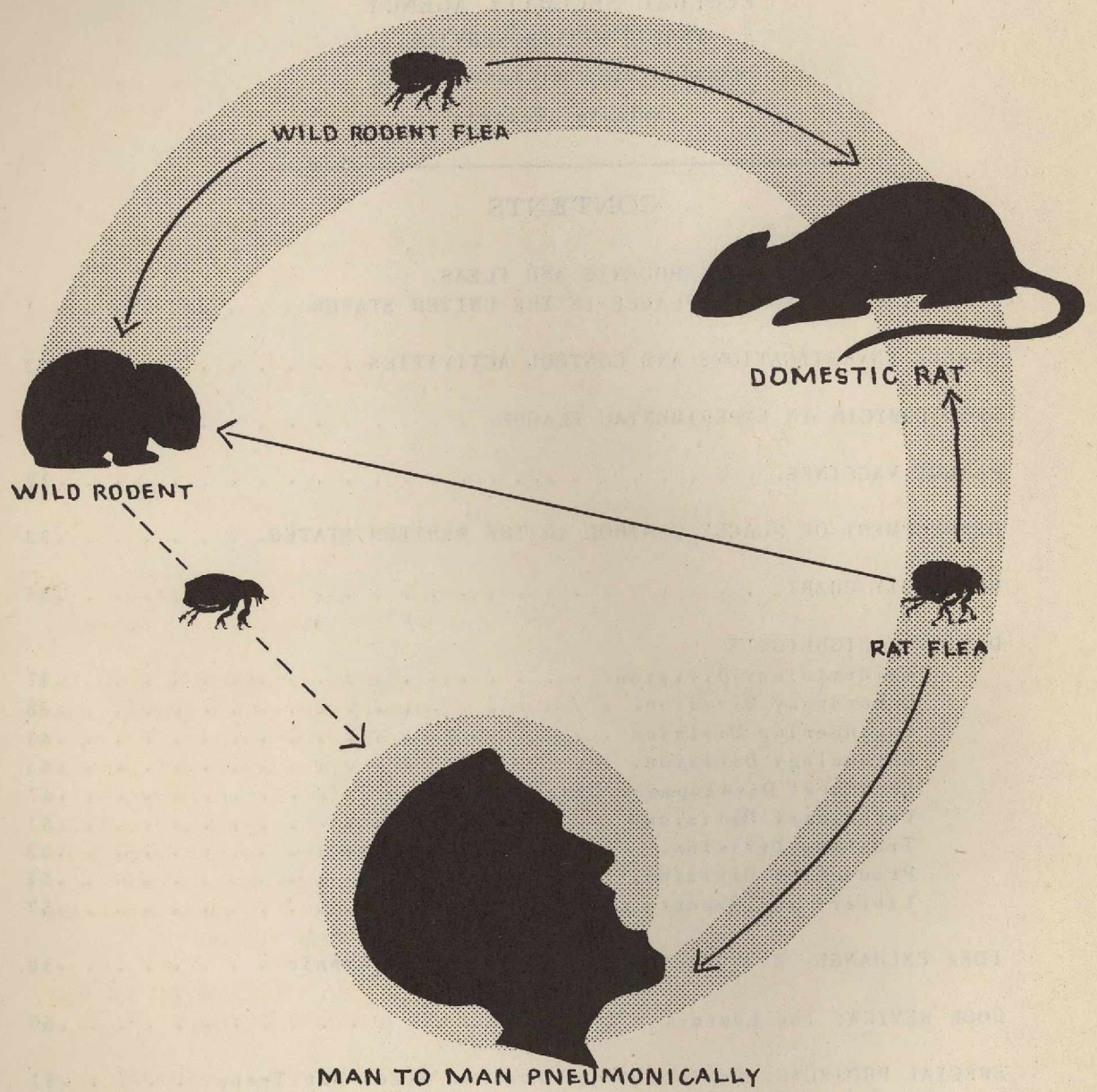
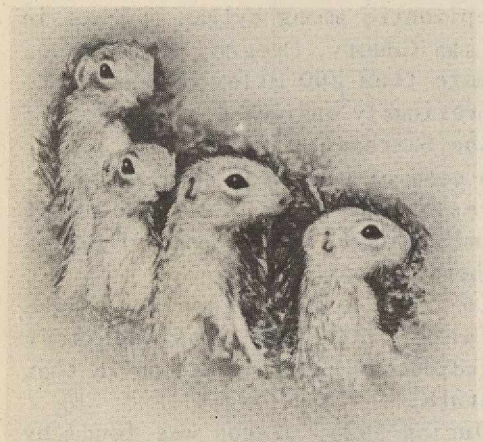
TRANSMISSION OF PLAGUE



Plague bacilli may be transmitted by fleas from wild rodents to domestic rats or from domestic rats to wild rodents. Domestic rat fleas commonly transmit plague to human beings in those parts of the world where domestic rat fleas are particularly abundant. Wild rodent fleas also occasionally transmit plague bacilli to man. Man may also acquire plague infection by handling diseased rodents and by sputum infection from persons ill with pneumonic plague.

DOMESTIC RATS, FLEAS and NATIVE RODENTS



In Relation To Plague

In The United States

By Entomologist Carl O. Mohr**

INTRODUCTION

Bubonic plague is a rodent and rodent-flea disease caused by the plague bacillus *Pasturella pestis* which is transmitted from animal to animal and thence to man by fleas. It is highly fatal. At least half of the human cases result in death without modern medication. (Table I — last two columns). Because of their close association with man, domestic rats* and their fleas, especially the oriental rat flea *Xenopsylla cheopis,* are responsible for most human epidemics. Only occasional cases are caused by bites of other fleas or by direct infection from handling rodents.

Infection due to bites of fleas or due to direct contact commonly results in swollen lymph glands, called *buboes,* hence the name *bubonic* plague. Infection may progress to the blood stream causing septicemic plague, and finally to the lungs causing pneumonic plague.

Pneumonic plague is extremely fatal and highly infectious when sputum droplets pass direct from person to person. The death rate due to it is practically 100 percent.

Plague is dreaded particularly where living conditions are such as to bring human beings into close contact with large oriental-rat-flea populations, and where crowded conditions permit rapid pneumonic transmission from man to man.

ANCIENT AMERICAN DISEASE OR RECENT INTRODUCTION

Two widely different views exist concerning the arrival of plague in North America. The prevalent view is that it was introduced from the Orient into North America at San Francisco through ship-

* *Rattus rattus* and *Rattus norvegicus.*

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borne rats and their fleas about 1900. Facts supporting this view:

1. The first cases were recognized in the Chinese section of San Francisco region during that year.
2. Succeeding human cases were recognized, first near San Francisco, and, as the years went by, at increasingly greater distances as plague presumably spread northward and inland.
3. Results of plague surveys in wild rodents revealed the presence of plague in an ever-widening area after its original recognition in California. For example, in 1935, after it was learned that animals in other western states were infected, examinations were extended to all of the Rocky Mountain states as far as the great plains. No infection was found in the plains states until after a lapse of several years.
4. Plague occurred in Pensacola, Florida; in New Orleans; and at Beaumont, Port Arthur and Galveston from 1914 to 1921, apparently having been introduced by shipping, thus giving support to the theory that the San Francisco outbreak had occurred in the same way.

The other view, perhaps not so widely held, is that plague is a characteristic disease of colonial rodents in North America, for it is also found in very closely-related species in Asia. Therefore, it must have been present on this continent in those rodents and their fleas thousands of years before modern shipping. Facts supporting this view:

1. It is a common occurrence for diseases as well as parasites to accompany their hosts into new territory. Mammalogists generally agree that ground squirrels and meadowmice are Asiatic in origin. Since plague is a common disease of these animals in Asia it may therefore have arrived with them during prehistoric times.
2. A considerable number of single human cases or epizootics have occurred in areas far in advance of those in which plague had been suspected. Plague, therefore, may have been present there from ancient times. The following instances may be cited:
   a. In 1908 a case in Los Angeles County, California was the first warning of its existence there.
   b. The death of a sheepherder and an epizootic among sylvan rodents in Lake County, Oregon, in 1934 was more than 200 miles north of the previously suspected area south of the Sacramento River.
   c. A case of bubonic plague in southwest Utah in 1935 was the first indication of the presence of plague there.
   d. In 1937 a human case near Lake Tahoe, in Nevada, was the first indication of its presence in that state.
   e. During 1935, plague was found by federal personnel studying rodent diseases in Montana far removed from any areas in which plague was previously suspected.

HISTORY OF HUMAN CASES

Epidemics of plague have struck in North America in the past and can strike again if protection is relaxed in present danger zones or is not extended promptly to new danger spots as they develop. America's recent record has been good in this respect. During the 21 years between 1925 and 1946, only 21 reported human cases occurred in the vast western half of this continent (see back cover) where plague was known to be present among wild rodents. (Table I). No human cases have been reported in the eastern states since 1921. This fine rapport has not always existed; our earlier plague history illustrates how outbreaks can take place if watchfulness is relaxed and protection not provided in danger areas. Its manner of striking in the future may resemble that of the past.

As previously stated, the disease was first recognized in North America during 1900 (Hampton 1945) in the San Francisco area. From that date until 1924, it struck repeatedly and disastrously in California

TABLE I

CASES OF, AND DEATHS FROM, PLAGUE IN THE UNITED STATES (HAMPTON, 1945)

YEAR	CASES									TOTALS	
	CALIF.	WASH.	LA.	FLA.	TEX.	OREGON	UTAH	NEV.	IDAHO	CASES	DEATHS
1900	22									22	22
1901	30									30	26
1902	41									41	41
1903	17									17	17
1904	10									10	8
1905-06										0	0
1907	178	3								181	90
1908	8									8	5
1909	3									3	1
1910	3									3	1
1911	4									4	1
1912										0	0
1913	2									2	2
1914	1		30							31	10
1915	1		1							2	1
1916-18										0	0
1919	13		15							28	18
1920	1		7	10	33					51	27
1921	3		3							6	4
1922	2									2	0
1923	1									1	0
1924	41									41	34
1925	1									1	0
1926										0	0
1927	1									1	1
1928	3									3	2
1929-32										0	0
1933	1									1	1
1934	1					1				2	1
1935										0	0
1936	3						1			4	0
1937	1							1		2	1
1938										0	0
1939							1			1	0
1940									1	1	1
1941	2									2	2
1942	1									1	0
1943	1*									1	1
1944	1									1	0
1945-46**										0	0
TOTAL	397	3	56	10	33	1	2	1	1	504	318

* Case acquired in laboratory

** 1945-1946 data from Public Health Reports for 1945, 1946, and 1947. One case occurred in California in 1947

Roof rat. Domestic rats, being closely associated with man and bearing at least one highly plague-susceptible flea, are largely responsible for most epidemics.

until the general public and public officials became sufficiently aware of the hazard to support protective measures. From 10 to 41 cases occurred annually in San Francisco up to 1904. Then for two years none was recognized and the city was declared to be free of detectable plague. During 1907, however, plague struck that city again. Total cases numbered 178, of which 87 were fatal. Eight cases were reported from San Francisco in 1908; since then, none has been detected in that city*. However a few human plague cases were reported from California nearly every year until 1919 when 13 recorded cases of pneumonic plague occurred in Oakland. All patients died. A 41-case epidemic, 34 fatal, occurred in Los Angeles during 1924. From that date onward, control and good fortune have held the rate down, as noted above.

While California — chiefly in San Francisco and surrounding cities — was having these difficulties, New Orleans, Pensacola, Port Arthur, Beaumont, and Galveston also had outbreaks. Thirty cases of plague occurred in New Orleans during 1914. After years of survey and control measures, the last reported case occurred during 1921. Florida and Texas cities had a few cases during 1920, but having been forewarned by the experience of San Francisco and New Orleans, they quickly instituted sufficient control measures and eliminated plague from their borders.

SOURCES OF PLAGUE OUTBREAKS

DIRECTLY FROM NATIVE RODENTS OR FLEAS

Plague among rodents of fields and woods is known as sylvatic plague. Sixty-six human infections in rural western areas (with a 63 percent death rate) have been traced to contact with rodents or to bites from their ectoparasites (Meyer 1947). Many of these cases were traced to non-domestic rodents. From 1934 through 1943, cases were reported only in California, Oregon, Idaho, Utah, and Nevada.

One outbreak due to contact with ground squirrels is described as occurring in Oakland in 1919. The first patient in the series is thought to have acquired plague from squirrels which he had shot and prepared for eating. The disease developed pneumonic phases. Thirteen of the persons who visited or attended him acquired the pneumonic infection from him, became ill with the disease, and died. Deaths included two doctors and two nurses.

Most of the sylvan-acquired plague has not, however, spread beyond the first contact, (principally because the patients are more or less isolated) and pneumonic plague has not resulted.

DIRECTLY FROM DOMESTIC RATS OR THEIR FLEAS. Domestic rats dying from plague are the most common sources of infection. Their blocked, plague-infected fleas feed

* With the exception of one case acquired in an experimental laboratory.

on man as opportunity is offered and thus pass the disease from their rat hosts to him.

An incident is described by Kellogg (1920) in which the first case was a Mexican woman in Los Angeles who set up a train of pneumonic cases following her infection. Forty-one deaths resulted. These included the patient's husband, an ambulance driver, nurses, a priest, and many of the patient's visitors.

The rats implicated in this chain of deaths are believed to have acquired infection from native rodents.

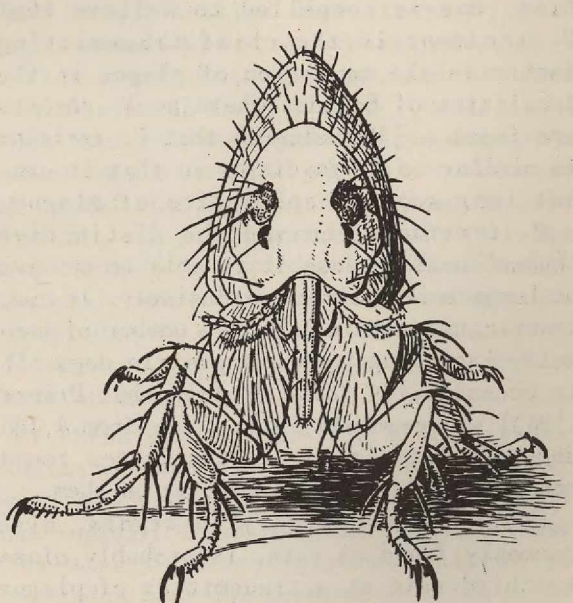
Cases in Pensacola, New Orleans, Beaumont, Port Arthur, and Galveston were apparently urban-acquired from domestic rat fleas. Most of the cases in San Francisco were also urban-acquired. Some might have originated in ground squirrels handled as food in San Francisco.

RELATIVE IMPORTANCE OF DOMESTIC RAT FLEAS AS PLAGUE VECTORS

The degree of potential infection in any community usually depends upon the kind and abundance of rats and fleas present; the amount of contact between diseased animals and man; and, if pneumonic phases develop, upon the amount of contact between diseased persons and susceptible persons. Plague among human beings is generally uncommon where suitable domestic rat fleas are uncommon. With the exception of the Oakland outbreak, in which the basic case was apparently acquired by direct contact with native rodents, plague outbreaks have been most disasterous where domestic rats and certain species of their fleas are abundant. These fleas will be considered separately.

ORIENTAL RAT FLEA. It is generally conceded that the oriental rat flea, *Xenopsylla cheopis,* is a most efficient carrier. It is prevalent on domestic rats throughout most of the world plague belt; experiments on its ability as a vector put it high on the list of vectors; and development of plague organisms within its digestive tract is great. According to Eskey (1938) it causes sharp but short epidemics in any one community due to rapid infectibility, quick transmission, and early deaths of the fleas which become infected.

NORTHERN RAT FLEA. *Nosopsyllus fasciatus,* is generally regarded as a second-rate carrier. Of it, Eskey wrote in 1938: "insofar as is known, plague epidemics have never occurred in communities where *N. fasciatus* existed alone and were not associated with *X. cheopis.*" He adds that if *N. fasciatus* were as efficient a vector of this disease as *X. cheopis,* California outbreaks would have been much more severe than they were, and that these outbreaks would have been comparable with a Guayaquil, Ecuador, outbreak where: (1) *X. cheopis* alone of rat fleas was present; (2) Its index on rats was about twice that of *X. cheopis* in San Francisco; (3) Many more human cases occurred than in San Francisco.



A "head on" view of the oriental rat flea, *Xenopsylla cheopis,* the most dangerous plague transmittor of domestic rat fleas. (Mohr).

He believed, however, (1938) that *N. fasciatus* was important in *prolonging* epizootics of plague among rats in more northern climates in the presence of *X. cheopis* even though relatively few human cases would result. He cited as an example

the Seattle plague epizootic during 1907. Plague smouldered slowly among rats for at least 10 years with only three human cases officially reported. The recent discovery of plague among rats in Tacoma (1942) without human cases is probably due to similar conditions. It may have been a continuation of the 1907 epizootic in the Puget Sound area.

Experiments conducted by Eskey showed *N. fasciatus* to be only slightly susceptible to infection. When infected, however, this species may carry the infection for two or more months in contrast with *X. cheopis,* which is much more easily infected and which dies in a matter of only a week or two.

HUMAN FLEA. *Pulex irritans* is also regarded as a second-rate carrier in spite of the fact that it commonly lives in close contact with man. Eskey (1930) concluded that, "By the process of elimination, one is compelled to believe that *P. irritans* is the chief transmitting factor in the causation of plague in the localities of Ecuador where no *X. cheopis* are found..." He believes that *P. irritans* is similar to *N. fasciatus* in that it cannot long support epizootics of plague.

P. irritans received the distinctive "human" name because it is able to survive on human beings almost exclusively. It can, however, maintain itself on a number of mammals, including hogs and prairie dogs. It is occasionally found on rats, but Prince (1943) who examined 5,785 fleas from 4,188 domestic rats in 13 western states found none, attesting to its scarcity on them.

MOUSE FLEA. *Leptopsylla segnis,* also commonly found on rats, is probably close to third-rate as a transmitter of plague to human beings.

STICKTIGHT FLEA. *Echidnophaga gallinacea,* is abundant on rats in certain sections of North America. It probably is a third-rate carrier of plague, although it has been found naturally infected with a virulent strain of this disease (Wheeler, Douglas and Evans, 1941). *E. gallinacea* acquires and transmits plague readily under experimental conditions (Burroughs, 1947). Unlike the oriental rat flea which feeds upon a large number of individual hosts during the course of its life, the sticktight is inclined to be monophagous. Illingworth (1916) found that adults attach themselves firmly to their hosts and engorge with blood. He found that the males move around during the night and may be found attached in different positions each morning. Females, as a rule, do not change host or their position of attachment. Even the more restless male makes few host-changes. Parman (1923) found that adults were inactive during the first few days after emergence and usually did not attach themselves to hosts until the fifth or eighth day. The females became engorged and oviposition began in from six to 10 days after attachment. Practically all oviposition observed took place while fleas were attached to the host. Even copulation was observed to take place on the host with copulating fleas attached to the head of the hosts about a body-length apart. They remained attached to the host in the same place from four to 19 days.

Upon the death of their original host, or upon occasional transfer or other removal from the original host, the sticktight flea may transfer to another host and possibly infect it. However, possibility of exchange to plague-susceptible hosts appears to be slight. Burroughs found this flea to have a tick-like habit of feeding to repletion on only one individual.

The sticktight flea may accumulate in large numbers in the nests of predators where their infected feces and bodies may infect rodent contacts. This does not seem to be an important means of transmittal, however, because it is relatively difficult to inoculate animals without considerable abrasion of the skin.

MEANS OF POSSIBLE FUTURE SPREAD OF PLAGUE IN THE UNITED STATES

BY EPIZOOTIC WAVES AND MIGRATIONS. If plague was introduced into North America at San Francisco by oriental shipping about 1900, it has progressed inland, as the crow flies, for at least 1,125 to 1,175 miles in 47 years. This progression is at

Norway rat burrows in bluegrass. Meadowmice and ground squirrels are common in such habitats. Glove shows location of burrow.

a rate of about 25 miles per year. There can be little doubt that natural movements of infected mammals and their fleas could be partly responsible for such spread and that their transportation by predators might play a part. Transportation of infected man or other mammals by common carrier over land or water could cause plague, as it has in the past, to show up in unexpected places. Transportation by common carrier is perhaps the quickest method of transmission.

However, movement by most species of small plague-infected field rodents is not great; although young of the year do go forth annually to seek new and unoccupied territories, they generally move only a few hundred yards away from their points of origin.

In most cases, nature confines mammal populations to expansion within suitable habitats. This expansion, generally, is slow although some species and varieties of mammals are known to have extended their range. Norway rats, for example, have appeared in western states after a slow expansion of range, apparently from the west coast. The rate of this expansion, however, was long ago outstripped by plague if the disease was not originally present.

Domestic rats migrate locally from time to time. Zinsser (1935) reports as follows: "Dr. Lantz tells us that in 1903 hordes of rats migrated over several counties in western Illinois, suddenly appearing where for several years no abnormal numbers had been seen." But the waves of these migrations break themselves up on resistance offered by unsuitable habitats and territories already occupied by members of the same species. They are not repeated year after year. Such movements could hardly have served as dispersal factors in the spread of plague at the rate it appears to have spread.

In Canada, in the absence of an already-established rat population, Norway rats apparently did spread rapidly. Professor V. W. Jackson of the University of Manitoba states:

"The Norway rat entered our boundary at Emerson in 1903. In two years (it) had reached Winnipeg and two years later Portage La Prairie. By 1911 the rat had reached Brandon - a steady spread of 25 miles per year in all settled directions. By 1920 (it) was half way across Saskatchewan on a fairly even western front and reached Alberta about 1925."

The rate of this reported spread of rats in Canada was somewhat similar to the rate of spread of plague in the United States. However, it seems unlikely that plague could have been carried inland by rats from the west coast because its passage outstripped that of rats into Montana - (if plague were not present there as a native American disease).

BY PREDATORY MAMMALS AND BIRDS Wide-ranging predators, such as coyotes, hawks, owls, and eagles might transport plague more rapidly. It is no great feat for these creatures to carry large quantities of flea-laden prey for several miles in order to reach their young. It is conceivable that in 47 years plague might have been relayed the 1,175 miles from San Francisco to North Dakota and Kansas by this means, superimposed on epizootics at each new location.

Predators, particularly the mammals, commonly accumulate a variety of fleas from the prey which they eat or carry during the breeding season. Randolph and

Eads (1946) found seven species of fleas on 16 grey foxes; three species on four Texas red wolves; and six species each on 13 raccoons and 27 possums. With the possible exception of some of the human and sticktight fleas, which have catholic tastes, all were foreign: that is, belonging properly to such prey species as rabbits and tree squirrels. Coyotes are often heavily infested. They have been known to carry food a distance of eight miles to their young in the den. (Young, 1937).

Jellison (1939) gave some attention to the matter of plague-dispersal by scavenger and predatory birds. These birds, like the predatory mammals, appear quite resistant to plague. He found that scavenger birds such as crows and magpies seldom carry entire carcasses to their nests. He concluded that they are probably of slight importance in its dispersion by that means. Jellison found, by examination of 12 nests, only one rodent flea on 54 of these birds. However, the predatory birds such as owls, hawks, and eagles carry a considerable number of carcasses to their nests. Thus, they can scatter fleas along the entire route. Jellison found seven species of rodent fleas in the nests of these birds. In the nest of one burrowing owl, he found 109 rodent fleas, including six species. He quotes a Major Bendire as stating that burrowing owl nests invariably swarm with fleas. Movements of the burrowing owl are, however, decidely local.

Experiments with casts and droppings of scavenger and predatory birds indicated that these commonly were infected. Though Jellison was unable to transfer infection to experimental animals, results of his experiment are not necessarily conclusive.

Wayson (1947) reported finding infected fleas on weasels and badgers. Since no predators have been found plague-infected to date and since obligatory predatory-fleas are uncommon, it is likely that these infected fleas were acquired from the prey of weasels and badgers* in question. The species of fleas concerned were not identified.

Cotton rats are a numerous, inconspicuous species of small field rodent, common in the southeastern part of the United States. Fleas from western members have been found infected with plague. (Courtesy Typhus Investigations Laboratory, Thomasville, Ga.)

There can be little doubt that some of the fleas carried to other areas by predatory mammals and birds find new rodent hosts. If infected themselves, they pass that infection along to these hosts.

Wayson, who concluded that plague had spread eastward in the past, (1947) thinks that the rapidity of dissemination of plague which has occurred cannot be estimated. He asserts that further advancement eastward will be slow in terms of years. Eskey and Haas (1940) stated that it might at least progress into that section of this country occupied by ground squirrels. Wayson, however, indicates that meadowmouse, rice rat, and cotton rat populations of the eastern half of the United States may also become infected.

* The finding of two plague-infected ticks on a badger (Anon 1943) is an indication that this carnivore might be susceptible, since ticks do not frequently change hosts. African workers have found some vivirrine carnivorous mammals susceptible to plague.

MAMMALIAN RESERVOIRS

The genera of mammals, in addition to domestic rats, from which plague has been recovered in tissue cultures are:

GENUS	COMMON NAME
Oryzomys	Rice rats*
Microtus	Meadowmice
Peromyscus	Deer mice
Onychomys	Grasshopper mice
Mus	Housemice
Neotoma	Woodrats, pack rats
Citellus	Ground-squirrels
Marmota	Marmots
Cynomys	Prairie dogs
Eutamias	Western chipmunks
Tamiasciurus	Pine squirrels
Dipodomys	Kangaroo rats
Sylvilagus	Cottontail rabbits
Lepus	Jackrabbits

Plague was also reported from fleas only, in the following mammalian genera, though this does not necessarily incriminate the hosts as plague reservoirs:

Reithrodontomys	Harvest mice
Sigmodon	Cotton rats
Taxidea	Badgers
Mustela	Weasels

Eskey and Haas (1940) also report plague as present in fleas or tissues of flying squirrels (Glaucomys). Either fleas or tissues of harvest mice have been found to be plague-positive (Volume 62 of Public Health Reports).

Plague is not recorded from the following mammals or in fleas from them. Only a small, but unstated, number were examined:

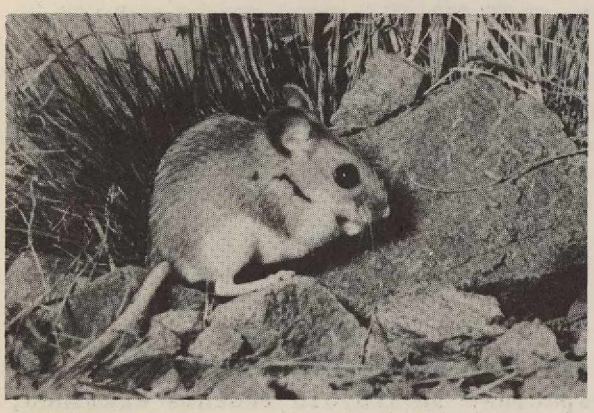
GENUS	COMMON NAME
Evotomys	Red-backed mice
Synaptomys	Lemming mice
Phenacomys	Rufous Tree mice
Zapus	Jumping mice
Ondatra	Muskrats
Castor	Beavers
Aplodontia	Mountain beavers
Erethizon	Porcupines
Blarina, Cryptotis, Sorex	Shrews
Scapanus, Neurotrichius	Moles
Didelphis	Possums

Most predatory mammals (*Carnivora*).

In popular literature it is common, when discussing ground-squirrels, to drop the prefix and refer simply to "squirrel." From a practical control point-of-view, it would be erroneous to assume that tree squirrels are largely involved in plague transmission simply on the basis of the popular misuse of the term "squirrel."

Few data are available for evaluating the *relative* importance of the many species of mammals as plague reservoirs, although a knowledge of this subject is patently important. Ground-squirrels were first suspected in America because they were more commonly shot and handled than were smaller or more nocturnal field rodents. While investigating the origin of a case of fatal plague contracted by a blacksmith in Contra Costa County, Rupert Blue suspected that ground-squirrels, which the patient had hunted, were the cause. By 1908, proof was obtained that conspicuous mortalities among this large, diurnal species were, in fact, often due to plague. Survey and control programs were accordingly concentrated upon them.

An indication of the amount of detectable plague that exists among ground-squirrels may be had from a report by the Surgeon



White-footed mice are commonly found plague-infected. Species of the genus *Peromyscus* are found nearly everywhere in North America. (Courtesy U. S. Soil Conservation Service).

* From the Annual Report of the Surgeon General, 1920.

Young prairie dogs. Prairie dogs are one of the more conspicuous plague-susceptible mammals, being diurnal, easily infected, and about as large as young cats. Numerous small wild rodents apparently transmit plague from one prairie dog colony to another. (Courtesy J. W. Jackson).

General (1927). Of 558,706 rodents examined between 1908 and 1927, chiefly ground-squirrels from California, 2,069 (0.4%) were plague-infected. This relatively high incidence was due, in part, to the selection of areas where plague was known to be present, or likely to be present. Therefore, it cannot be compared with the rate among ground-squirrels or other rodents from areas chosen at greater random. Much higher rates are recorded from more restricted areas and for shorter survey periods.

Again, from 505,097 rodents of all kinds and a "small number of other species" collected from many western states (1936-1945) 153 pools* of tissues were found infected (Wayson, 1947). Most of these rodents - exact number unstated - were ground-squirrels. Since the investigations were more random in nature and organs from several animals were frequently pooled, the percentage of infection was naturally lower (0.03). Thirty-seven pools of tissues from 85,414 prairie dogs taken during the last five years of the period were found infected. This is a rate of 0.04%. The difference is probably not significant but only indicative of the general rate of infection.

Investigators gradually became aware that other less conspicuous, but often more numerous, species were also plague-infected. During the period from 1941 through 1945, greater emphasis was shifted to such species. Of 188,815 rodents examined, 38,277 were kangaroo rats, 16,876 were grasshopper mice, 16,493 were meadowmice,

* A pool of tissue is a portion of the tissues of each of one or more animals of the same species, collected at one hunting area on the same day.

and 4,465 were marmots. Although 85,414 prairie dogs, 2,411 variegated ground-squirrels, and other species were included, the rate was low. Only twelve pools of tissues (0.006%) were found infected (Wayson, 1947).

From 1,186,777 fleas taken from the 505,097 rodents during the entire ten year period, 308 pools were found infected. Ground-squirrels were still commonly regarded as primary reservoirs of plague from which stemmed the epizootics that destroyed their colonies and neighboring species of mammals.

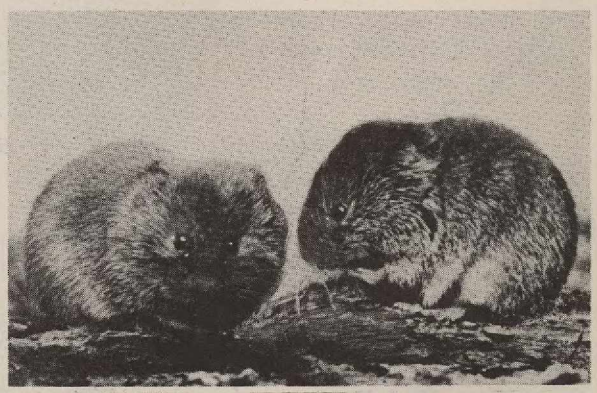
From the time of the earliest surveys wood rats were occasionally caught by investigators. Possibly because of their obvious relationship to domestic rats, their tissues — and finally their fleas — were tested for plague. Some were found to be infected. In 1940 the desert wood rat, *Neotoma desertorum,* was cited as a primary reservoir of plague in certain areas. Plague had been found among desert wood rats where there were almost no ground-squirrels and where other native rodents had consistently failed to show infection (Eskey and Haas, 1940).

The role of prairie dogs is in doubt. Although plague epizootics sweep through prairie dog colonies, almost, if not entirely, wiping many out, the plague quite obviously might have been acquired from one or more of the mice or ground-squirrels which form a bridge from one colony to another. It is probable that prairie dogs, like other conspicuous diurnal species, were over-suspected.

Meadowmice are frequently infected and loaded with fleas. They are commonly found to be plague-infected along with rats. According to Meyer (1947) they have been found to harbor plague in the absence of ground-squirrels. Like ground-squirrels, these mice attain large absolute numbers, varying from a few per acre, where present at all, to over 800. However, their usual number is in tens or scores of individuals to the acre (Mohr, 1947).

Meyer informed the writer that plague is generally not self-maintaining in ground-squirrel populations (as few as five to the acre) in the absence of other capable reservoirs. Therefore, wherever meadowmice are present, they must be considered as an important factor because their numbers are generally high and their habits colonial. A control aimed specifically at them may be called for in a large number of cases if any sylvan control is deemed necessary. Mice of other genera are also involved and often more numerous than ground-squirrels.

Wayson found a pool of infected fleas on cotton rats which may or may not incriminate the animal itself. Cotton rats, like meadowmice, attain large populations and are therefore suspect where large populations of susceptible species are an indicator of danger. Also, cotton rats frequently inhabit outbuildings and therefore can serve as a considerable source of contact with domestic rats. Wayson (1947) minimizes the possible role of population-size as having any relation to persistence of a plague focus. He states: "Neither the persistence of a focus from year to year nor its primary discovery has shown any correlation with the total population of rodents..." Here he is probably referring to extensive areas at least several miles across rather than to smaller units. He stresses the role of colonial rodents as common reservoirs of plague.



Meadowmice *(Microtus)* are frequently found infected and may be primary plague-reservoirs in many localities. They are abundant and widely distributed in western and northeastern states. Note that the ears do not show, being characteristically hidden by fur. *Microtus* is an extremely abundant genus of mammals, very susceptible to plague and frequently found infected on the outskirts of towns where rats are infected. (Courtesy U. S. Fish and Wildlife Service).

IRREGULAR OCCURRENCE OF PLAGUE EPIZOOTICS

Plague epizootics are extremely spotty among rodent populations. The period during which plague will persist in rodents of a given area has not been determined by systematic investigations under properly controlled circumstances (Wayson, 1947). Wayson claims plague has been found in specimens collected from one locality during each of four successive "animal seasons." On the other hand, plague was not found again during four other successive seasons (after having been detected in a given area) in spite of collections made from the same area where it had previously been found.

Byington (1940) recorded similar experience; no plague was observed among native rodents during two years of close observation of an area where plague had decimated the rodents during one season. Years of negative results do not necessarily mean that plague is not, or has not, been present.

Meyer (1942) gave a description of local spottiness of detectable plague areas. According to him, preliminary field studies on the course of plague epizootics were made in Kern County (California) during 1934 and plague was found present (Figure 1). Annual surveys thereafter gave negative results until 1941 when plague was found again among ground-squirrels and their fleas. It was present in at least five separate and distinct localities, each at least 15 to 20 miles distant from any other, located within the foothill area. Meyer concluded that focal occurrence and discontinuous distribution is apparently one of the characteristics of sylvatic plague.

Meyer also discussed seasonal distribution of detected plague. The first specimens of ground-squirrels positive for plague were collected on April 24. The last specimens were taken on July 17. Subsequent surveys yielded neither infected fleas nor rodents. The duration of detectable active disease in ground-squirrel fleas was therefore short. In the ground-squirrels themselves, the duration was even shorter, though on one ranch the disease had involved as much as 90% of the ground-

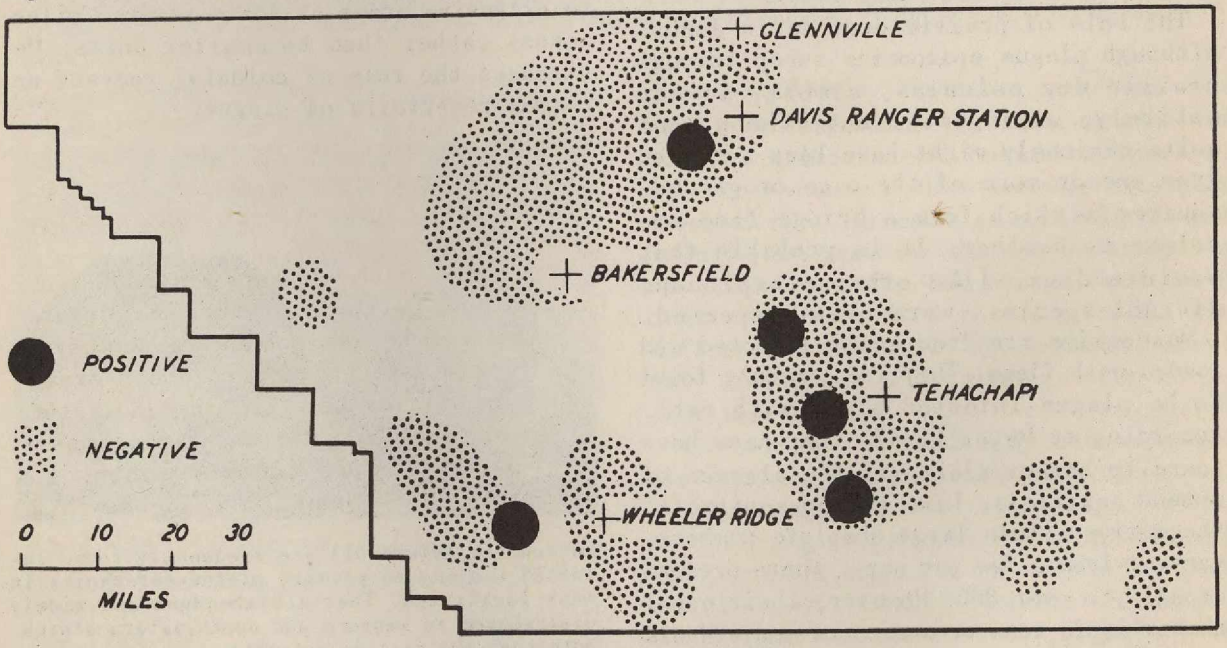


FIGURE I. Plague was found present among ground squirrels in five areas but not among those from areas shown in gray in 1941. None had been discovered in this area during seven years previously although some surveys, most of them intensive, were made there annually.

squirrel population. It may be latent in native rodents in a form difficult to detect by our present methods; it may carry over in a relatively few fleas; or it may be carried over in some rodents not heretofore examined thoroughly during inter-epizootic periods.

AMOUNT OF EFFECTIVE CONTACT BETWEEN DOMESTIC RATS AND NATIVE RODENTS

The amount of effective plague-exchanging contact between domestic and native rodents can be measured roughly by the rate of exchange of fleas between them. Other means of exchanging plague, say pneumonically, by direct contact of mammals (with living or dead individuals) or contact with infected feces, nesting material, or other matter, seems unlikely.

Several faunistic lists record sylvan-rodent fleas on domestic rats. The records of Prince (1943) however, are especially informative because they are based on 5,785 fleas from 4,188 rats caught in 13 states. In addition to the usual rat fleas, Prince recorded the following fleas which are normal parasites of the species of mammals shown below:

FLEA	MAMMAL
Megabothris abantis	Meadowmice*
Megabothris lucifer	Meadowmice*
Malareus telchinum	Deer mice*
Monopsyllus wagneri	Deer mice
Orchopeas nepos	Tree squirrels
Orchopeas sexdentatus	Pack rats
Amoniopsyllus spp.	Pack rats
Diamanus montanus	Ground-squirrels
Hoplopsyllus anomalus	Ground-squirrels
Opisocrostis labis	Ground-squirrels
Thrassis petiolatus	Ground-squirrels
Oropsylla rupestris	Probably ground-squirrels
Thrassis fotus	Probably ground-squirrels or native mice
Thrassis howelli	Marmots
Foxella ignotus	Pocket gophers

* And possibly other native rodents.

Eskey (1938) found 48 *Malareus telchinum* on 3,027 Norway rats.

Ground-squirrel fleas, pack rat fleas, and meadowmouse fleas are most common of the "foreign" fleas on rats. Rarely is more than one of these found at a time on domestic rats. Normal prairie dog fleas, including *Pulex irritans,* are absent from the list.

FLEA - ECOLOGY SURVEYS

INLAND WESTERN AND PACIFIC-COAST STATE SURVEYS. A few surveys of domestic rat fleas have been made in inland western states and in three Pacific-coast states. These surveys show the numbers of sylvan-rodent fleas as well as the number of rat fleas found on domestic rats. Data on the domestic-rat fleas are recorded by states (Table IIA&B). Although it is acknowledged that conditions in each state may vary so widely that this method is too crude to serve maximum usefulness, it will indicate regional tendencies. Furthermore, this is about all we have in the way of data. Where a breakdown appears to be desirable the publication by Prince (1943) should be consulted.

The conditions under which these surveys were made were described as follows: Norway and roof rats were collected by trapping and shooting in rural areas and cities during a six-year period from 1935 through 1941. Surveys were made chiefly during the summer months.

Although data show *cheopis* present from Washington to California, this flea appears to be relatively uncommon in the northern-most section of the Pacific coast area. The 23 localities examined in Washington and Oregon show only two in which *cheopis* is present. The 21 farther south, in California, show ten with *cheopis*. This may account in part for the fact that relatively fewer cases (only three from Seattle) of plague have been reported from these northern states in contrast with the record in California. The data also show that *cheopis* was found in relatively few localities of the dry northern and southern states. Of 28 localities from Idaho to

TABLE IIA

NUMBER OF INLAND LOCALITIES SURVEYED AND NUMBER WITH FLEAS (PRINCE, 1943)

STATE	NUMBER OF LOCALITIES:				
	SURVEYED	WITH *CHEOPIS*	WITH *FASCIATUS*	WITH *GALLINACIA*	WITH *SEGNIS*
Wash.	8	2	5	0	1
Idaho	2	0	1	0	0
Mont.	8	0	2	0	0
Ore.	15	0	7	0	1
Wyo.	3	0	1	0	0
Calif.	21	10	10	7	9
Nev.	2	0	2	0	0
Utah	3	1*	2	0	0
Colo.	7	1**	4	0	0
Nebr.	3	0	3	0	0
Ariz.	4	2	0	0	0
N.Mex.	8	2	3	3	1
Texas	3	0	2	1	0

TABLE IIB

NUMBER OF RATS EXAMINED AND NUMBER OF FLEAS CLASSIFIED

STATE	NUMBER OF RATS EXAMINED	NUMBER OF FLEAS+			
		CHEOPIS	*FASCIATUS*	*GALLINACIA*	*SEGNIS*
Wash.	503	76	305	6	6
Idaho	246	0	62	0	0
Mont.	321	0	16	0	0
Ore.	171	0	40	0	5
Wyo.	110	0	1	0	0
Calif.	411	735++	42	139	39
Nev.	40	0	15	0	0
Utah	371	475*	18	0	0
Colo.	910	45**	133	0	0
Nebr.	272	0	128	0	0
Ariz.	147	10	0	0	0
N.Mex.	411	30	27	35	3
Texas	128	0	10	1	0

\+ Calculated from author's figures. These figures are not usable for calculating indices but only to compare relative abundance of fleas.
++ 350 of these from San Diego.
* Salt Lake City.
** Denver.

Nebraska and Nevada to Wyoming, only two were found to have *cheopis*. Jellison, Kohls, and Mills (1943) found *fasciatus* but no *cheopis* in Montana. Of 15 localities in New Mexico, Arizona, and in the drier parts of Texas, only four showed *cheopis*. The writer's experience in the arid Brownfield, Texas, area was similar. Of several hundred Norway rats observed from December 1946 through August 1947, only two or three bore *cheopis*, none bore *fasciatus*, but many bore *gallinacea*.

Ewing and Fox (1943), summarizing data from other authors, record *cheopis* from Indianapolis, Indiana; St. Paul, Minnesota; Ames and Des Moines, Iowa; from Illinois and Ohio; Nashville, Tennessee; and Washington, D. C. It is probably distributed over a somewhat wider range; the localities named above are in or near university areas where collecting is fairly concentrated. It seems likely that this flea accompanied domestic rats and that its numbers in any area where rats are present depend considerably on climate and housing. *X. cheopis* populations can build up to large proportions under highly artificial conditions in cities and garbage dumps of areas otherwise apparently uncongenial. This is shown by records from Salt Lake City where 475 *cheopis* were found on 295 rats caught in dairies, markets, garbage dumps, and stockyards. That rats are visited by fleas from native rodents is shown by Prince. He recorded 18

of such species as having been found on domestic rats during the course of his survey. However, past records show that danger from plague outbreaks in cities in such areas has been small. Not a single case occurred in dry inland cities and few in northern cities anywhere.

The rat flea *N. fasciatus*, another possible vector of plague, has a numerical distribution somewhat different from that of *cheopis*. This species was found in about half of the 23 localities in Washington and Oregon and in all of the 21 California localities. It was found in about half of the dry northern-state localities and occurred less frequently in the dry portions of the southern areas. Its position as a possible plague-vector has already been discussed. It is reluctant to bite man and difficult to infect.

PORT-CITY SURVEYS. Results of domestic-rat flea surveys made by other authorities in cities in coastal areas are summarized in Tables III, IV, and V. The more useful summaries stress the percentages of rats found infested.

Data for western cities in these tables conform with the general pattern indicated by Prince's data; only 50% of the rats examined in Seattle had fleas, and the *cheopis* index was only 0.7. In Tacoma, during the winter months, only nine *cheopis* were found on 2,648 rats. Farther south, at San Francisco, 64% of the rats had fleas. Rats averaged seven fleas each and 20% were *cheopis*. At Los Angeles the *Cheopis* index was 0.9 during a survey extending from December through August. (The authors had examined only 331 rats for fleas and did not record the percentage of rats with *cheopis*).

At Galveston, *cheopis* was the most prevalent rat flea during the plague outbreak during the 1920's. It was also the most prevalent at Mobile and at Jacksonville, 67 to 72% of the rats bearing them. At New Orleans, where the percentage of rats with *cheopis* was not recorded, the *cheopis* indices were fairly high (2.7 for the year). Farther north, Philadelphia had a small average number of *cheopis* per rat (0.03 to 4.2).

A number of these surveys are inadequate by present standards and needs. This is partly due to irregular distribution of samples during the season and partly because percentages of rats infested by each species of flea are not recorded. They do show, however, that cities which suffer from real plague outbreaks had a high proportion of rats infested with *cheopis*.

TABLE III

PERCENT OF RATS WITH FLEAS (YEAR)

CITY	ALL FLEAS	*CHEOPIS*	*FASCIATUS*	*SEGNIS*	*GALLINACEA*
Seattle	50	—	—	—	—
San Francisco	64	—	—	—	—
norvegicus	—	27	58	28	0
rattus	—	34	11	15	0
Berkeley and Oakland	77	—	—	—	—
New Orleans	87	—	—	—	—
Mobile	—	67*	14	14	10
Jacksonville	—	72**	6	27	19
Norfolk	57	—	—	—	—
New York	35	—	—	—	—
Providence	57	—	—	—	—
Boston	43	—	—	—	—

* Varied from 26 to 94
** Varied from 16 to 92

TABLE IV

DURATION, DATA AND DESCRIPTION OF CITY SURVEYS

CITY	AUTHORITY	NO. OF RATS EXAMINED	SPECIES COMPOSITION: % *Norvegicus*	DURATION OF SURVEY
Seattle	Fricks, 1936	261	--	Apr. '27 — Aug. '29
Tacoma	Hundley & Nasi, 1945	2,048	72	Nov. '42 — Mar. '43
San Francisco	Eskey, 1938	3,027	75+	1936 — 1937
Berkeley and Oakland	Mitzmain, 1910	4,916	—	Jan. — Dec. 1909
Los Angeles	Trimble & Sherrod, 1935	231	97	Dec. '31 — Aug. '32
Galveston	Boyd & Kemmerer, 1920	46,623**	—	June — Dec. 1920
Galveston	Surgeon General, 1921	46	23	July '20 — June '21
Galveston	Surgeon General, 1922	56	—	July '20 — June '21
New Orleans	Surgeon General, 1916	1,268	71*	July '15 — June '16
New Orleans	Surgeon General, 1921	2,144	—	Nov. '22 — June '23
New Orleans	Surgeon General, 1922	3,839	90+*	July '21 — June '22
New Orleans	Fox and Sullivan, 1925	1,661	86*	July '20 — June '21
Mobile	Cole & Koeppke, 1946	6,123	95	Jan. — Dec. 1934
Pensacola	Surgeon General, 1921	752	91	July '20 — June '21
Jacksonville	Rumreich & Wynn, 1945	4,853	93	Jan. — Dec. 1934
Savannah	Fox, 1931	387	—	Feb. — Mar. 1927
Savannah	Fox, 1931	500	—	Sept. — Oct. 1927
Norfolk	Hasseltine, 1929	1,561	99+	Mar. '27 — Mar. '28
Philadelphia	Vogel & Cadwellader, 1935	2,765	99+	May '32 — Dec. '33
New York	Fox & Sullivan, 1925	4,756	99+	Apr. '23 — Feb. '25
Providence	Robinson, 1913	342	—	July — Dec. 1912
Boston	Fox & Sullivan, 1925	1,524	—	Dec. '22 — Nov. '23

* Calculated from author's figures.

** Most of the rats were caught dead in snap traps.

TABLE V

CITY	SPECIES-COMPOSITION OF FLEA INFESTATIONS (PERCENT) AVERAGE NO FLEAS PER RAT					
	CHEOPIS	*FASCIATUS*	*SEGNIS*	*GALLINACEA*	ALL SPECIES	*CHEOPIS*
Seattle	22	67	11	0	3	0.4
Tacoma	**	95+	0	0	1.2	--
San Francisco	20*	66*	**	0	7	--
Berkeley and Oakland	—	—	--	--	2.8	—
Los Angeles	31*	++	***	—	1.0	0.9
Galveston '20	***	**	—	—	25	—
Galveston '21	90	7	3	0	—	—
Galveston '22	***	0	**	**	—	—
New Orleans '16	74*	2*	30*	**	3.5	1.0-7.7
New Orleans '21	—	—	—	—	3.3	—
New Orleans '22	37	0	58	0	4.8	1.7
New Orleans '25	72	0.5	27	**	2.3	1.2-3.2
Mobile	64	9	9	16	7	2.6-9.4
Pensacola	54*	7*	2*	+	11	5
Jacksonville	58	2	19	20	6	1.6-7.5
Savannah	51	20	26	3	4.6	2.3-7.2
Norfolk	82	18	0	0		0.02-8.4
Philadelphia	60	32	**	**	1.6	.02-2.3
New York	30	70	*	0	0.9	0-0.8
Providence	75	22	3	—	4-10	
Boston	33	64	*	0	1.0-1.4	0.1-1.0

\+ *Gallinacea* not recorded but *Pulex irritans* recorded as making up about 20%.
++ Some of these surveys were intended chiefly to determine *cheopis* indices hence other species of fleas were not recognized or not counted. Percentages are therefore not monobasic but give only general indications. They also vary in accordance with the type of habitat, the species-composition of the rat sample and with the method of interpretation of the seasonal data.
* Calculated from author's total figures.
** Present, but in small numbers
*** Was most prevalent, numerous, or predominant flea.

SOUTHEASTERN STATES SURVEYS

Surveys in connection with murine typhus control by nine southeastern states, cooperating with the Communicable Disease Center, have resulted in the addition of considerable data.

Of these states, Texas is of particular interest because, as in California, the presence of plague in native rodents is close to a dangerously high population of *cheopis* on domestic rats. Analysis of 1946 and 1947 data shows that rats in southeastern Texas (east of the 100° west longitude and somewhat south of the Dallas-Fort Worth level) have a very high incidence of cheopism. Even during winter, when the level is low, more than 20 percent of the rats examined bore this flea. During summer more than 60 percent bore it. Past records indicate that plague will flourish in southeastern Texas if it bridges the few score miles from west Texas. Plague has existed among domestic rats in Galveston, Beaumont, and Port Arthur. Also, plague appears to flourish where murine typhus flourishes. A high incidence during all seasons of the year extends eastward through the typhus belt.

Data from Dallas and Fort Worth are not distributed widely enough through the year for analysis by months. Indications are, however, that the percentage of rats infested is fairly high. Between 27 and 39 percent of 297 rats captured in these two cities bore *cheopis*. In western Texas, however, the percentage of rats with *cheopis* is considerably smaller. Less than 14 percent of some 522 rats taken at all times of the year from El Paso and from panhandle counties were infested during 1946 and 1947.

East of Texas, the incidence of cheopism is high in southern states, particularly in the typhus belt (see page 65). It is lower in northern areas. Its seasonal peak of abundance varies: in more southern states it occurs in summertime; in more northern states in the fall.

The northern rat flea is quite uncommon in Texas, but the sticktight flea is extremely common. West of the 100th degree west longitude, the sticktight flea is by far the most abundant rat flea on farms and on outskirts of cities.

TEMPERATURE, LATITUDE, AND PLAGUE

The possible effects of temperature on occurrence of rat-borne and human plague are discussed by Robertson (1923) who generalized as follows:

1) Bubonic plague is essentially a disease of hot climates. Once introduced into tropical countries, it tends to persist indefinitely.

2) Outside of the immediate tropics, this disease is rather definitely limited in the extent to which it will spread.

3) In countries with a mean midwinter temperature of 45° F. or below, bubonic plague is occasional, accidental, and distinctly self-limited. It seems possible for it to occur in the colder regions only for short periods under unusual conditions.

When evaluating these generalizations, it is important to keep in mind that little was known concerning the distribution of *sylvatic* plague when Robertson wrote them. Also, his conclusions applied, and still apply, only to rat-borne and human cases. He found that the area of incidence of such plague was bounded roughly by the thirty-fifth parallel both north and south of the equator. In Europe, however, the 45° north latitude probably described the northern boundary more accurately. This northerly occurrence is due mostly to the tempering effect of the warm waters of the Mediterranean.

Robertson discussed some apparent exceptions to the rule of temperature, which may be of interest in the United States. One of the most impressive was an outbreak of 50,000 cases of pneumonic plague in Manchuria during the winter of 1911. The basic causes of this outbreak are ascribed to contact with a sylvan rodent, the tarbagan. Like our American marmots, the tarbagan harbored plague. Poor Manchurian peasants and fur-hunters who skinned hundreds of thousands of tarbagans, contracted plague. Crowded together in poor

shelters, they passed it on pneumonically to fellow inhabitants, friends, and relatives. Such an extensive outbreak could hardly occur in America under our present eating and living conditions. A limited number of cases have occurred under circumstances very similar to it, however, namely 13 in Berkeley and 41 in Los Angeles, California.

It is Robertson's theory that the chain of plague-transmission from rat to rat is broken in northern latitudes by early onset and long duration of cold weather. Winter weather reduces the numbers of *cheopis* on rats to such a low point that plague dies out. Fricks' (1936) findings in Seattle, and previously-mentioned findings in Tacoma, apparently support this thesis. He states that rat plague existed in Seattle for at least 10 years, the first infected rat having been found there in November 1907, the last in March 1917. Fricks adds that it is interesting to speculate on the length of time plague may have existed prior to its discovery in 1907. His reasons: only one case of flea-borne plague (the other two officially-reported human cases were pneumonic) is known to have occurred in Seattle; and rat plague existed for almost 10 years subsequently without another human case. He points out that of two campaings to eradicate plague in Seattle, the first, which followed promptly the discovery of the human cases, was discontinued after a few months of activity. The second, which followed a great increase in rat plague discovered in October 1913, was discontinued after three years. However, surveys continued to June 1933. Fricks concluded that probably no extensive infection of rats would result if plague were again introduced. His premise: the uniformly low flea index observed (and he might have added low flea-infestation-incidence); and the pronounced improvement in sanitary conditions during the past two decades. Fricks states that although Seattle climate favors development of pneumonic

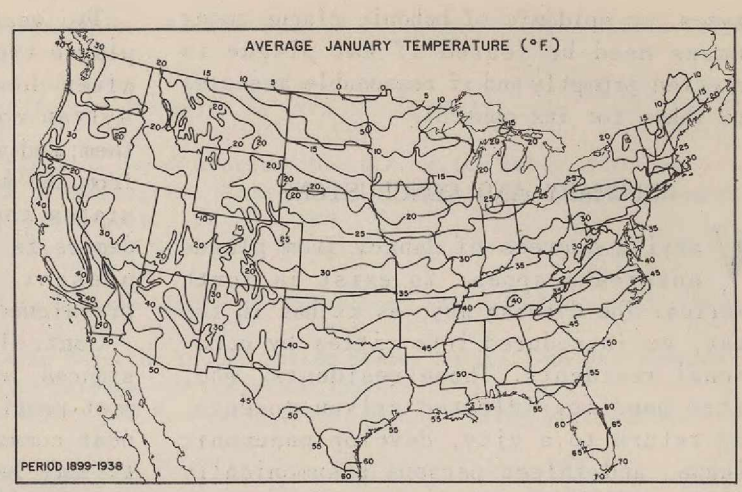


FIGURE 2. Average January temperature in the United States for the period 1899-1938 as shown in Yearbook of Agriculture for 1941. Both plague and murine typhus have attacked man in the more humid, warm regions.

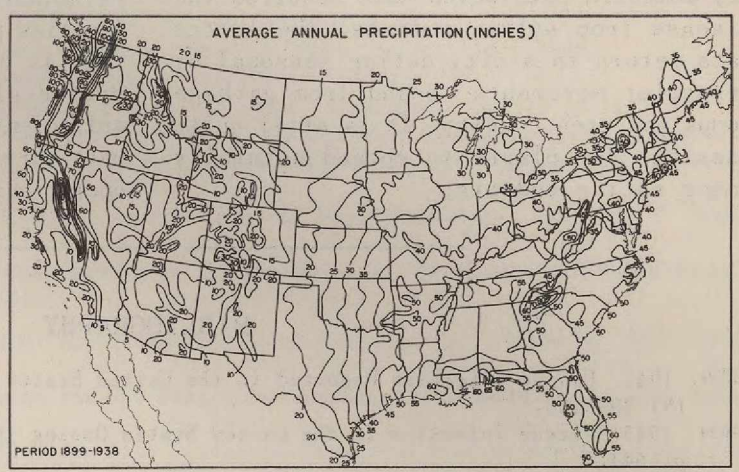


FIGURE 3. Average annual precipitation in the United States for the period 1899-1938 as shown. Severely dry climates suppress the numbers of *cheopis* fleas.

phases, no epidemic of bubonic plague among humans need be feared if rat plague is detected promptly and if reasonable measures are taken for its control.

SUMMARY AND CONCLUSIONS

Varying degrees of danger from plague outbreaks appear to exist in North America. The disease may, as it has in the past, be introduced into cities by occasional residents. These residents, who, after handling infected sylvan rodents, may return to a city, develop pneumonic plague, and infect persons pneumonically by means of droplet infection. Plague may, as it has in the past, be introduced among resident rats in cities by: (1) domestic rats from ships or other common carriers; (2) domestic rats which have acquired the disease from sylvan rodents. The latter rats return to a city during seasonal or irregular movements to and from garbage dumps and open country. It is still quite possible for plague to spread naturally among native rodents.

Two weak links in the entire chain of plague transmittal exist: the stage when, after domestic rats acquire plague from sylvan rodents, it is maintained among them; and when plague is finally transmitted from the rats to human beings. Eskey (1938) states that the intensity of plague epidemics is regulated by the species of flea present. It is also governed by the prevalence of that flea.

Control, except under unique circumstances, will probably be aimed largely and most profitably at domestic rats inside and near communities, though in limited areas it may be extended to certain easily controllable native rodents.

Permanent control of rats and rat fleas in communities where plague would exist among them prevents its gaining a foothold. Permanent control in non-infected communities prevents its spread to them.

It is believed well worth while to conduct ecological surveys of rat fleas in sufficient proportion to measure and delineate varying types of danger areas wherever operations for control are undertaken.

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COUNTIES PRE-APPROVED FOR TYPHUS CONTROL OPERATIONS — 1948 SEASON

Computed from (1) counties with 10 or more cases of human typhus per year for 5-year period 1943-1947; (2) counties with 10 or more cases for year 1947.

ALABAMA (14 Cos.)
- Barbour
- Calhoun
- Coffee
- Covington
- Crenshaw
- Dale
- Dallas
- Geneva
- Henry
- Houston
- Jefferson
- Mobile
- Montgomery
- Pike

ARKANSAS (1 Co.)
- Pulaski

CALIFORNIA (1 Co.)
- Los Angeles

FLORIDA (9 Cos.)
- Dade
- Duval
- Escambia
- Hillsborough
- Nassau
- Orange
- Pinellas
- Polk
- Volusia

GEORGIA (30 Cos.)
- Appling
- Bibb
- Bulloch
- Chatham
- Coffee
- Colquitt
- Crisp
- Decatur
- Dodge
- Dooly
- Dougherty
- Fulton
- Glynn
- Grady
- Jenkins

Georgia (Con't)
- Laurens
- Mitchell
- Richmond
- Screven
- Sumter
- Tattnall
- Telfair
- Terrell*
- Thomas
- Tift
- Ware
- Wayne
- Worth
- Berrien
- Irwin

LOUISIANA (5 Cos.)
- Caddo
- Calcasieu*
- Iberia*
- Orleans
- Washington

MISSISSIPPI (2 Cos.)
- Harrison
- Pike

N. CAROLINA (3 Cos.)
- Craven
- New Hanover
- Wilson

S. CAROLINA (2 Cos.)
- Charleston
- Orangeburg

TENNESSEE (1 Co.)
- Davidson

TEXAS (43 Cos.)
- Angelina
- Bastrop
- Bexar
- Caldwell
- Camerson
- Colorado
- Comal

Texas (Con't)
- Dallas
- DeWitt
- Erath
- Fayette
- Galveston
- Gonzales
- Guadalupe
- Harris
- Henderson*
- Hidalgo
- Howard*
- Jasper
- Jefferson
- Lampasas
- Lavaca
- Lee
- McLennan
- Madison*

Texas (Con't)
- Milam
- Nueces
- Runnels
- Tarrant
- Tom Green
- Travis
- Vistoria
- Waller
- Washington
- Webb
- Wharton
- Willbarger
- Wilson*
- Jim Wells
- Falls
- Harrison
- Liberty
- Robertson

*No cases reported in 1947

COUNTIES REPORTING 10 OR MORE CASES — 1946

ALABAMA
- Autauga

FLORIDA
- Gadsden

GEORGIA
- Emanuel
- Evans
- Schley
- Turner
- Randolph

LOUISIANA
- Lafayette
- St. Landry

NORTH CAROLINA
- Harnett

TEXAS
- Anderson
- Bosque
- Comanche
- Fisher
- Grayson
- Grimes
- Hunt
- Nolan
- Refugie

Plague Investigations and Control Activities

by Sanitary Engineer John S. Wiley

As a result of the discovery of plague in California field rodents in 1908, the Office of Plague Suppressive Measures, USPHS, San Francisco, and several state health departments in the West, began conducting plague surveys. Teams operating from mobile field laboratories collected field rodents, rats, hares and some predators. These were combed to remove all ectoparasites, consisting principally of fleas, which were sent to the laboratory for determination of the presence of plague organisms. Tissues from some of these animals were also submitted for similar determinations. Positive findings have been reported in weekly *Public Health Reports*. Survey teams have operated at greatly increasing distances from the West Coast as plague in field rodents has been found farther and farther east. Since 1939, plague infection has been reported in 116 counties of 15 Western and Pacific Coast States. The easternmost areas in which plague has been found are:

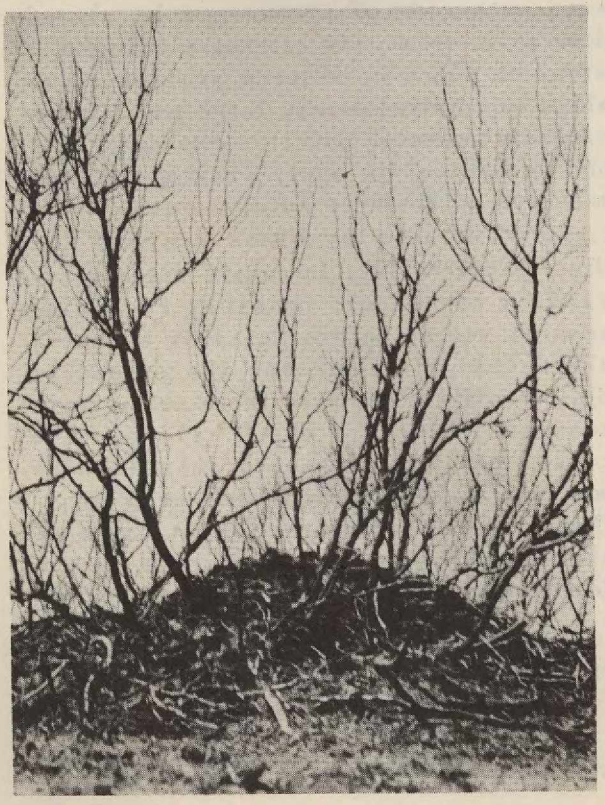
STATE	COUNTY
North Dakota	Divide
Kansas	Scott
Kansas	Logan
Kansas	Cheyenne
Kansas	Morton
Oklahoma	Cimarron
Texas	Cochran
Texas	Dawson

Future survey work may discover plague infection farther east than is known at present, suggesting greater potentialities for human infection than exist in the sparsely settled plains states. The eastward extension of plague may be slowed down as it encounters extensive cultivated areas in place of western grazing areas which support relatively large populations of field rodents. But it seems desirable and economical to apply limited control measures in the near future, rather than to wait until plague has reached the Mississippi Valley. Intensive field study will be necessary, possibly requiring several years, before suitable measures are developed to prevent the spread of plague in field rodents. There are certain measures, however, which will protect cities against such outbreaks as have occurred in San Francisco and New Orleans. These are the procedures now utilized in murine typhus control in cities in the South and Southeast. They are:

(1) Ratproofing and rat eradication in existing business buildings.

(2) General sanitation.

Sanitary Engineer John S. Wiley is Chief of the Typhus Control Branch, Engineering Division, Communicable Disease Center, Atlanta, Georgia.



(Upper) Setting a baited wooden trap for pack rats. *(Lower left)* Pack rat *(Neotoma)* nest.

(3) Rat poisoning.

(4) Ratproof construction of new buildings.

If the above rat control measures are conducted with continued maintenance in a permanent program, there is no reason to fear outbreaks of plague, typhus or other rat-borne diseases. Such programs also are usually popular and, to a large extent, self-supporting because of the savings resulting from the elimination of rat damage.

PRESENT PLAGUE INVESTIGATIONS AND CONTROL ACTIVITIES

Plague-positive findings in fleas of field rodents from four ranches in Cochran County, Texas were reported in the spring of 1946. Since typhus existed in the same section of the Texas Panhandle, a combined plague-typhus control project was established in an eight-county area during the

fall of 1946. Headquarters were originally at Lubbock but are now at Brownfield, Texas. Because plague bacilli were recovered from fleas of prairie dogs on a ranch in Dawson County in the spring of 1947, this county was added to the original eight counties. The project is operated, like other CDC programs, by the State Department of Health and local health departments.

The Plague-Typhus Project has a two-fold operational plan. The first is typhus control and plague prevention by rat and rat-ectoparasite control, both urban and rural, in the nine-county area. This involves the four measures mentioned above plus DDT dusting. The following progress has been made to date:

(a) Six counties have hired permanent rodent control men and furnished their transportation and poisoned baits.

(b) Mobile typhus control units have inaugurated DDT dusting and rat poisoning in eight counties. These units trained personnel mentioned above in these activities.

(c) Complete county-wide cycles of dusting and poisoning have been accomplished at least once in six counties.

(d) Dusting has been evaluated by means of rat ectoparasite prevalence studies and murine typhus complement-fixation tests on rats as in regular typhus control projects.

(e) Ratproofing and rat eradication in the existing business buildings of Morton, Seminole, and Brownfield are essentially completed. A dozen other cities and towns have officially committed themselves to undertake ratproofing programs as soon as trained health department personnel are available.

The six counties mentioned under (a) are Hockley, Gaines, Terry, Lubbock, Yoakum and Dawson. These counties deserve special mention because they contribute everything except DDT dust and very limited supervision, pay travel expenses of mobile units while present, and conduct their own evaluation trapping. This is remarkable because all except Lubbock County are small and several of the counties had no local health service whatever until the Plague-Typhus Project began.

The second phase of the plan consists of plague investigations. These involve studies and collections of field rodents, rats, hares, predatory mammals and birds. A panel-body truck equipped as a special field laboratory, is manned by two or three men who hunt and trap these animals, remove their ectoparasites, autopsy them and obtain tissue specimens. Pools of ectoparasites and of tissues are forwarded to the Texas State Health Department Laboratory in Austin where they are examined for the presence of the plague bacillus. Also, ectoparasites are identified, counted, and examined bacteriologically. The Officer in Charge at Brownfield, Entomologist Virgil I. Miles, directs the studies and the sampling. The studies involve the distribution and abundance of the various hosts (rodents) and vectors (ectoparasites) as well as the interrelations of host and

Fleas in the mouth of prairie dog burrows are collected on a moving cloth, placed in vials, and examined for plague in the laboratory.

vectorial species. This is a large task presenting many problems. A major problem is the enormous numbers of specimens required by present laboratory procedures to produce one positive plague finding.

The Texas State Health Officer announced that on December 23, 1947 plague organisms were found in a pool of 141 fleas from pack rats (*Neotoma microphus*) collected on October 2 and 3, 1947, eight miles west of Lamesa in Dawson County. This is the first report of a positive plague finding by the Plague-Typhus Project in Texas. The previous report of plague in this county was by the Office of Plague Suppressive Measures, plague having been proved in a pool of 50 fleas from six prairie dogs on May 28, 1947. The two positive areas are only approximately nine miles apart in Dawson County.

PROPOSED RAT CONTROL AND PLAGUE INVESTIGATIONS PROJECTS

Plague is or has been present in scattered areas from the West Coast to the western North Dakota — Kansas — Oklahoma — Texas line. Some of the areas contain cities and towns having appreciable rat problems. It is apparent that plague is occasionally transferred from field to domestic rats resulting in a human plague outbreak. Control of field rodents or even of field rodent plague over nearly an entire third of the United States obviously is impractical. It is feasible, however, to prevent plague outbreaks in cities and towns by rat control and, possibly, by developing and conducting limited field rodent or ectoparasite control either surrounding the cities or surrounding any nearby plague foci. The latter must be carefully studied from biological and entomological aspects in each specific area before control procedures can be formulated.

It is proposed in fiscal year 1949 to continue the Brownfield Plague-Typhus Project and to develop and utilize all findings to the greatest extent possible. As an extension of the Brownfield studies, it is proposed that about four rat control-plague investigations projects be established in other states in the 1949 fiscal year. Six areas with both a domestic rat problem and the hazard of sylvatic plague nearby have been tentatively selected. One of these areas is located in each of the following states: Wyoming, Colorado, New Mexico, Utah, Washington and California. Although each area will present different problems, preliminary plans include: (1) permanent rat control consisting of the four previously enumerated measures and (2) the sampling and ecological studying of field rodents and their ectoparasites together with laboratory determinations of plague.

The plague survey units of the Office of Plague Suppressive Measures will continue to operate in order that public health officials may be kept informed, as accurately as possible, of the areas in which plague can be demonstrated in field rodents or their ectoparasites throughout the United States.

Mobile laboratory unit for plague investigations work.

Streptomycin in EXPERIMENTAL PLAGUE

STUART F. QUAN, LUCILE E. FOSTER, ADELIEN LARSON, AND KENNETH F. MEYER
From the George Williams Hooper Foundation, University of California, San Francisco, California.

In July, 1944, Dr. Selman A. Waksman invited a study of therapeutic properties of streptomycin in *Pasteurella pestis* infections. Preliminary tests with a one gram sample of the crude antibiotic gave very promising results. Subsequently, larger lots of streptomycin were obtained through generosity of Dr. I. M. Carlisle, Merck and Co., Inc., Rahway, N. J. A confidential report of results was made in 1945 to the committee on Medical Research of the Office of Scientific Research and Development. Publication times for that report and later studies are indefinite, but the more significant results are summarized here.

(1) RESULTS OBTAINED IN VITRO. Streptomycin in hormone broth (1,250 μg/cc) kills 100 million virulent *P. pestis* (Shasta) in 15 minutes. The same number of organisms are destroyed in 4, 12, 24, 48, and 120 hours, respectively, by 313 μg/cc, 78 μg/cc, 39 μg/cc, 29 μg/cc, and 5 μg/cc. One hundred thousand organisms of a recently isolated human strain (Modoc) were killed by 0.2 μg/cc, and an equal amount of the "Shasta" strain by 1.9 μg/cc in 72 hours. Amounts varying from 0.4 to 4.0 μg/cc proved bactericidal to six plague strains of Hawaiian, Egyptian, Indian, and Californian origin in five days. From one to 16 units/cc of dihydrostreptomycin are required to sterilize these strains in five days. Avirulent strains are more resistant: for example, the E. V. 76 plague bacillus (Girard)[1] is killed in the presence of 16 units/cc/five days, strains 14 and 1122 (Jawetz and Meyer)[2] by eight units/cc and the Tjiwidej strain (Otten)[3] by four units/cc. In the presence of 10% blood serum, 40 units/cc were required to kill 10,000 virulent *P. pestis* "Yreka" in 48 hours. Other factors, such as chemical composition of pH of the suspending medium, concentration of antibiotic, and age and density of culture, influence bactericidal activity of streptomycin on *P. pestis*. Five thousand μg/cc in broth destroyed 22,000 million virulent *P. pestis* (Yreka)/cc, while the same concentration sterilized 33,000 million/cc in physiologic saline. Four virulent strains trained to resist streptomycin in the amount of 5,000 μg/cc were avirulent and resisted only 2,500 units/cc dihydrostreptomycin.

(2) EFFECT ON MICE AND GUINEA PIGS INFECTED SUBCUTANEOUSLY. Relative sensitivity of *P. pestis* to streptomycin per-

This work, recommended by the Committee on Medical Research, was done in part under a contract between the Office of Scientific Research and Development and the University of California. The paper was presented by Dr. Kenneth F. Meyer on December 2, 1947 before the 43rd Annual Meeting of the American Society of Tropical Medicine at the Biltmore Hotel, Atlanta, Georgia.

"Streptomycin in Experimental Plague" was published in the "Proceedings of the Society for Experimental Biology and Medicine", Volume 66, Number 3, December 1947. The paper appears in the "CDC Bulletin" by kind permission of Dr. Meyer and the Council of the Society.

[1] Girard, *Bull. office int. d'hyg. publ.*, 1936, 28, 1078.
[2] Jawetz and Meyer, *J. Infect. Dis.*, 1943, 73, 124.
[3] Otten, *Indian J. Med. Res.*, 1936, 24, 73.

mits effective therapy of experimental bubonic disease caused by 100 to 1,000 multiples of the M.L.D. in highly susceptible (ABC) mice. Treatment usually begins on the 48th hour after subcutaneous introduction of the bacilli, when infection is generalized, a bacteremia is well established in 40 to 60% of the animals, and the immunity mechanism is partially damaged by toxins. Irrespective of dosage or frequency of administration, sulfonamides save an average of only 35% of mice at this stage of infection. In 70 separate experiments, treating as many groups of 20-50 mice with varying amounts of streptomycin, advanced experimental bubonic plague was completely cured with 500 μg/three hours for three days, or a total of 12,000 μg (12.0 mg.). The median effective dose was 1,000 to 1,250 μg for a 20 g mouse, or 50 to 62 μg/g when one intraperitoneal injection was given on the 48th hour of infection. Bacteriological autopsies demonstrated that on the 14th hour after injection of the antibiotic, the spleens of four mice sacrificed were sterile; however, plague bacilli could be cultured from the heart blood of 2/4, the livers of 3/4, and the lymph nodes of 4/4. Organs of control mice showed heavy growth of *P. pestis* in cultures and microcopically. Begun on the 48th hour of infection, 100 μg of streptomycin injected at six-hour intervals for 192 hours, or 32 injections in all (a total of 3.2 mg of streptomycin per mouse), always sterilize the blood stream, spleen and liver; but since the infection persists in lymph nodes, about 40% of the animals ultimately succumb. The rate of survival in mice is directly proportional to the amount of streptomycin administered. A large dose of antibiotic at the outset of infection probably kills or injures the bacillus, inhibits its multiplication and enhances receptivity to phagocytosis, which effects its removal from the circulation. There is a possibility that the regional bubo, with its abundant necrotic tissue and large number of plague bacilli, is not immediately affected, and thus serves as a seedbed for relapses and a continuous source of toxin when the immunity mechanism is not completely mobilized. The larger the dose, the greater the possibility for streptomycin to diffuse into necrotic areas, and the shorter the course of therapy needed. In the mouse the greatest dose, or that determined by toxicity, is more than ten times the effective dose that was used in the treatment of plague infections.

Bubonic plague infections which have progressed to an extent comparable to 48-hour infections in mice occur in guinea pigs 120 hours after subcutaneous injections of 1,000 multiples of the M.L.D. With a streptomycin dose of 20,000 μg/kg or approximately 10 mg per day, a total of 100 mg over a period of 10 days, 80 to 100% of the 40 guinea pigs used in experiments were cured. It requires less streptomycin to cure guinea pigs in a stage of mild septicemia than to cure mice, on the basis of units of antibiotic to grams of body weight. Administration of 25,000 to 50,000 μg/kg in three doses, or a daily injection of 37,500 to 75,000 μg/500 g guinea pig of early streptomycin preparations proved toxic, but recent lots of the antibiotic in the same doses are well tolerated.

In the tests under consideration, and those of Wayson and McMahon[4], persistence of plague bacilli in regional buboes despite large doses of the antibiotic suggested local chemotherapy. Guinea pigs with well-developed buboes on the 120th hour after subcutaneous administration of 100,000 *P. pestis*, were injected around the local swelling with 12,500 μg in 0.5 cc of physiologic saline at 12-hour intervals for 10 days. All were cured and plague lesions were sterilized. Sodium sulfamerazine administered in the same manner in the amount of 500 mg/kg/12 hours was inhibitory but not bactericidal, and cured no more than 40% of infected animals. Local injections of streptomycin proved very irritating, and even though buboes became rapidly sterile, necrotic areas were much larger than

[4] Wayson and McMahon, *J. Lab. and Clin. Med.*, 1946, 31, 323.

DYNAMICS OF STREPTOMYCIN ON EXPERIMENTAL SEPTICEMIC PLAGUE IN MICE
(INTRAPERITONEAL INFECTION) EXPERIMENT 97

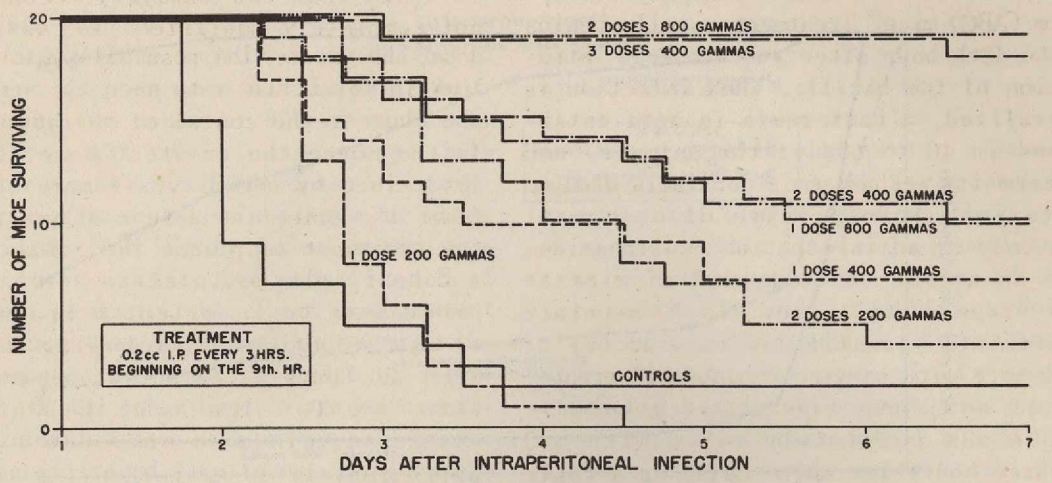


FIGURE I.

STREPTOMYCIN IN THE THERAPY OF THE 36-HOUR INTRANASAL PLAGUE

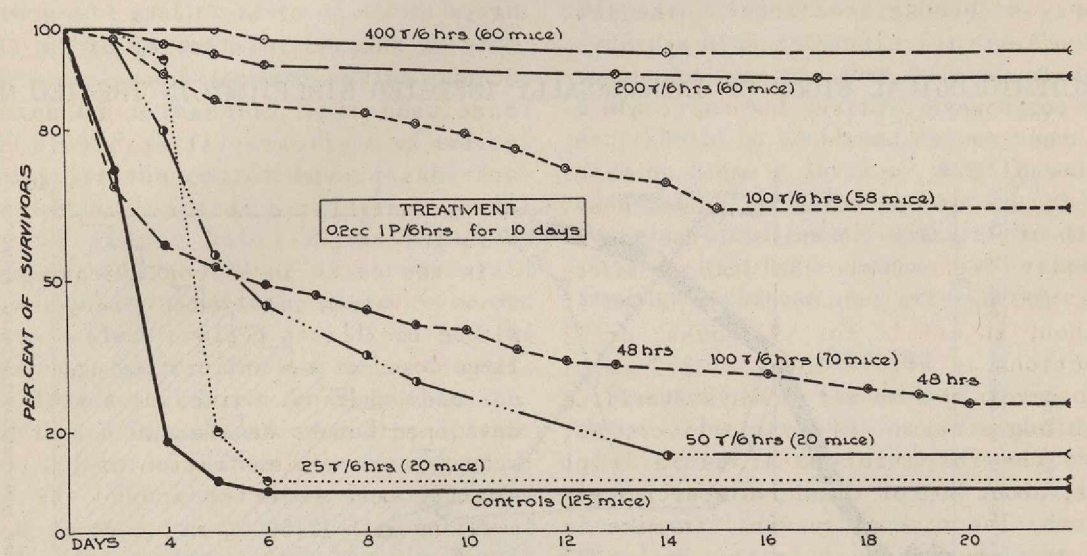


FIGURE II

those of controls or of animals treated systemically.

(3) EFFECT ON SEPTICEMIC PLAGUE IN MICE. To establish maximum effectiveness of streptomycin, a rapidly progressive SEPTIMIC infection was produced in slightly-resistant Swiss mice by intraperitoneally injecting 2,000 *P. pestis*. Bacteremia and toxemia exist in such mice by the 9th-12th hour after infection, and death takes place in 34 to 72 hours. In some respects, this infection model resembles the clinical form of human septicemic plague induced by direct blood stream infection through several flea bites. Repeated tests of the kind shown in Fig. 1 conclusively demon-

INTRANASAL PLAGUE TREATED WITH SERUM AND SULFADIAZINE

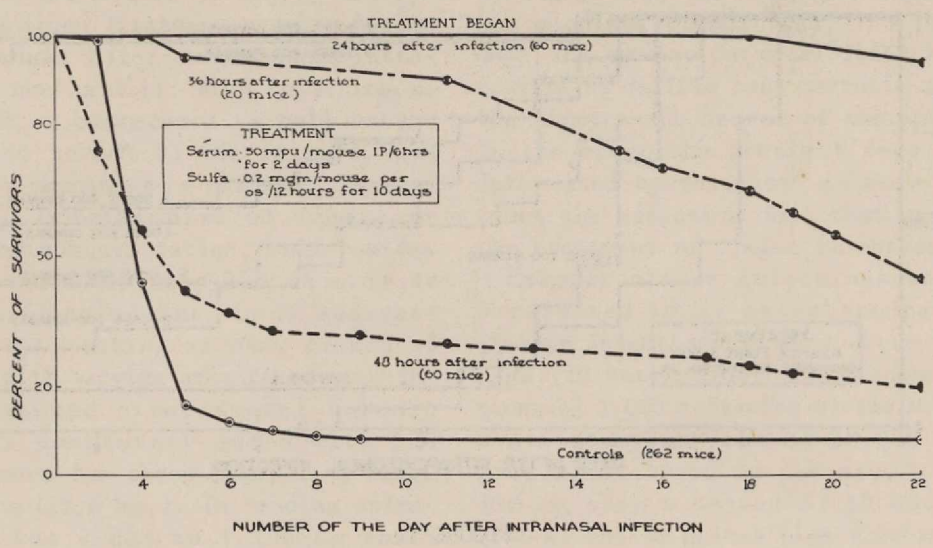


FIGURE III

BACTERIOLOGICAL STUDY OF INTRANASALLY-INFECTED STREPTOMYCIN TREATED MICE

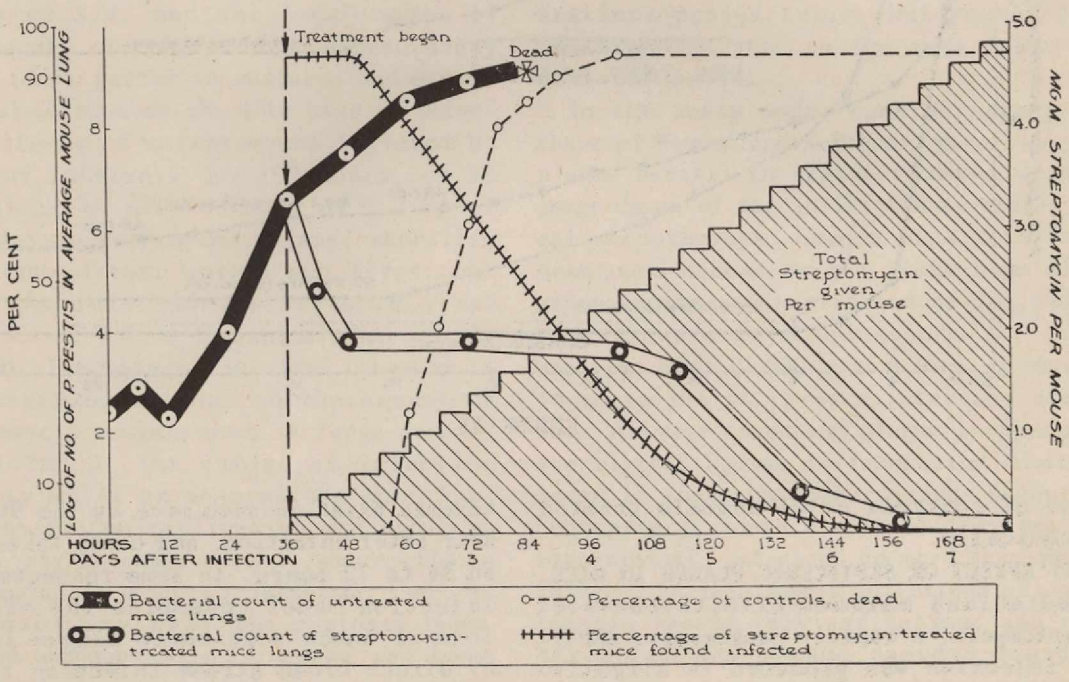


FIGURE IV.

strated that two to three large doses of 400 to 800 μg at three-hour intervals, or a total of 1,200 to 1,600 μg, cured 80 to 90% of non-bubonic septicemic plague infections. Small doses merely delay death. If treatment is postponed until the 18th or 24th hour, two doses of 800 μg each cure only 25 to 45% of infected mice. Only early treatment with large doses of streptomycin cures septicemic plague in mice. Sulfadiazine and highly potent antiplague serum proved ineffective under identical experimental conditions. There is at present no evidence that sulfonamides synergistically enhance the remedial action of streptomycin. On the other hand, numerous experiments furnished data that potent anti-plague serum administered simultaneously with small doses of streptomycin increased the percentage of cures. Finally, active immunization with plague antigens potentiates the action of streptomycin both in mice and in guinea pigs and the partial immunity so gained allows use of smaller doses of streptomycin.

(4) EFFECT OF PNEUMONIC PLAGUE IN MICE. Pneumonic plague infections may be produced in mice by intranasal instillation of 2,500-5,000 *P. pestis* in 0.05 cc of saline; lobular lesions recognizable on the 36th hour after infection contain several million plague bacilli. As might be expected, 200 to 400 μg of streptomycin hydrochloride or sulfate, given every six hours, effectively cure 90 to 95% of infections. Smaller doses or delayed treatment reduces the chance for cures (Fig. 2). Sulfadiazine in combination with antiplague serum is less effective than streptomycin (Fig. 3). The remarkable bactericidal action of streptomycin is fully documented by periodic bacteriological autopsies of treated and untreated mice (Fig. 4). Six hours after treatment with 200 μg had begun, the number of plague bacilli found in the lungs of treated mice was reduced to approximately 60,000, while in untreated animals it had advanced to 10,000,000. By the 12th to 24th hours of treatment, the spleen became sterile and 5000 or less organisms were counted in the lungs. By the 96th hour after infection, when all untreated mice had died, the lungs and bronchial lymph nodes of treated mice were either sterile or contained only a few thousand plague bacilli in the abscess-like patches of pneumonia. No plague bacilli have been isolated from lungs or lymph nodes 100 hours after treatment with streptomycin. These results fully attest to the remarkable therapeutic efficacy of a total of five mg of streptomycin in experimental plague of mice. They justify an exception that it will be equally effective in human pneumonic plague if administered early and in adequate dosage.

(5) SUGGESTED SCHEDULE OF TREATMENT IN HUMAN PLAGUE. Streptomycin is the most effective therapeutic agent thus far discovered for the treatment of bubonic, septicemic and pneumonic experimental plague infections in mice and guinea pigs. It is recommended that human plague be treated as soon as diagnosed with daily doses of two g of streptomycin in bubonic plague, and four to six g in the septicemic and pneumonic diseases; injections should be given at four-six hour intervals for the first two days. The dose may then be reduced, but in order to prevent clinical recurrences treatment should be continued for at least eight days on a one g level or substituted with adequate sulfadiazine therapy. In profound toxemia, simultaneous administration of a potent antiplague serum, to assist the immunity mechanism, may prove beneficial.

SUMMARY

Streptomycin in the amounts of 0.4 to 4.0 μg/cc is bactericidal for different strains of *P. pestis* in five days. Advanced experimental bubonic plague in mice is completely cured with 500 μg/three hours for three days, or a total of 120 mg. Between 80 to 90% of the mice in a state of septicemic plague may be saved with a total of 1,200 to 1,600 μg. The remarkable bactericidal action of streptomycin is best demonstrated on experimental pneumonic plague; five mg of the anti-biotic sterilize lungs and lymph nodes within 100 hours after treatment has been instituted. It is recommended that human plague be treated as soon as diagnosed with two to four g of streptomycin daily depending on the state of infection.

PLAGUE VACCINES

A report on living antiplague vaccines (virus-vaccines) was presented at the Fourth Congress of Tropical Medicine by Dr. Georges Girard, Chief of the Plague Service of the Pasteur Institute of Paris and former Director of the Pasteur Institute of Madagascar.

Since 1934, living vaccines have replaced killed vaccines in the immunization of man against plague in Madagascar and Java.

Having observed that, while killed vaccine was ineffective, a single dose of E. V. virus-vaccine produced a solid and lasting immunity in the guinea pig, Girard and Robic carried out inoculations of the same vaccine in man in Madagascar in 1932-1934. Otten made similar observations at the same time in Java with the Tjividej strain. Differences in immunizing power of these two strains led to the hypothesis that there are at least two antigens in these virus-vaccines, one active for the guinea pig, the other for the rat. The practical conclusion is that, for man, a combination of both strains would be desirable.

A living plague vaccine must be innocuous for man, but this can be demonstrated only in man. It need not be devoid of all pathogenic power for animals in order to be harmless for man. Only by animal inoculation can a virulent strain be distinguished from an AVIRULENT strain. So-called AVIRULENT strains are merely strains with weakened virulence. The virulence may vary according to the animal used, the method of inoculation, and the dose. The antigenic properties may become less, but under natural conditions never become greater. An avirulent strain may have no antigenic power. Each strain has its own individual behavior on this point. There is no sure-fire method for obtaining a stable virus-vaccine from a virulent strain. Various methods require varying lengths of time.

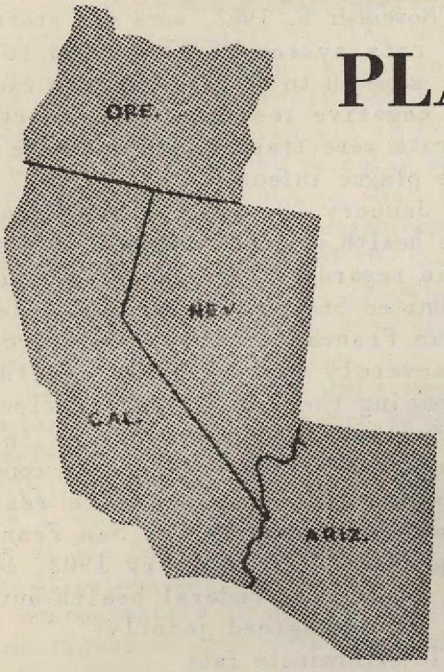
To be effective for man, a virus-vaccine must have the following characteristics: maintenance of a certain degree of virulence for the guinea pig and persistence of the toxicity of the microbial bodies. Any plague strain to be used for human inoculation must be subject to regular control. Conservation on nutritive gelose, at 2-4°, with annual reinoculation has been successful for the E. V. strain. Its characteristics have remained intact for fourteen years. Passage through the guinea pig, with seeding of the tissues of certain organs, will serve for occasional reinforcement of antigenic properties.

A living vaccine must be prepared as needed and cannot be stocked. Because of the importance of inoculating the maximum of viable bacteria, the period of validity has been fixed arbitrarily at one month, provided the ampoules are kept under refrigeration. The bacterial content may vary widely according to the strain used. A single dose of one cu. cc. is inoculated. Because killed vaccines can be stocked and quickly controlled, virus-vaccines should be reserved for strongly endemic areas with annual epidemics, where effective etiological prophylaxis is impossible. Mass vaccinations with virus-vaccine reduces morbidity by 80%. A booster inoculation is advised before the annual epidemic; protection is acquired on the fifth day and is not preceded by a negative phase. No accidents have been reported; reactions are slight.

Over seven million human inoculations have been done in Africa, Asia, and the U.S.S.R. with various avirulent strains. Several strains have been studied in Madagascar and Java and others are now being studied at the G. W. Hooper Foundation.

The reactions produced in animals by living vaccines indicate that the process of immunity in plague is cellular rather than hormonal. This is supported by work done on the defense mechanism of the lung following inhalation of virus-vaccines, which also suggests the possibility of a more effective protection against plague pneumonia. Work in progress on the antigens of *P. pestis* and the isolation of several fractions, one of which protects the guinea pig, may lead to greater choice of vaccinal strains, and, perhaps, to eventual substitution of chemical antigens for the present vaccines. Until then, virus-vaccine represents a proved method of plague prevention which has already spared many lives in Africa and Asia.

DEVELOPMENT OF PLAGUE CONTROL IN THE WESTERN STATES



by
SURGEON
VERNON B. LINK

Plague Suppressive Measures Laboratory[1], San Francisco, California

On March 6, 1900, a Chinese man died in the basement of the Globe Hotel in San Francisco and a police surgeon reported to the city health officer that he suspected bubonic plague as the cause of death. Arrangements were made to have the diagnosis confirmed at the Angel Island Quarantine Station. On March 11, animal inoculation and bacteriologic study of autopsy specimens verified this as a case of plague. There followed a period of lack of cooperation which led to inability to properly cope with the situation when responsible officials first tried to act.

An attempt was made by city officials to isolate Chinatown but the lack of funds tended to minimize municipal efforts. On May 15, after the occurrence of the fourth proven case of plague, the Surgeon General of the U. S. Marine Hospital Service recommended the following:

1. Concerted anti-plague efforts under direction of one person
2. Isolation of suspected area
3. Inspection of transportation facilities leaving San Francisco in an effort to stop exodus of Chinese
4. House-to-house inspection of Chinatown with administration of Haffkine vaccine
5. Establishment of a pest hospital
6. Isolation of suspected cases
7. Disinfecting corps
8. Destruction of rats
9. Investigation of suspicious illnesses in adjacent cities.

On May 19, the local board of health officially announced the existence of plague. Efforts were made to forestall an exodus of Chinese. Haffkine vaccination was supposed to have been required for an exit permit but there was considerable unwillingness on the part of the Chinese to be vaccinated.

[1] Federal Security Agency, Public Health Service.

Federal inspectors were placed on trains leaving San Francisco and at points of exit on the state border at Ashland, Oregon; Reno, Nevada; Needles, California; and Yuma, Arizona, to prevent San Francisco Chinese from leaving the state. Launches were used in a 24-hour patrol of the San Francisco waterfront for the purpose of preventing Chinese from leaving the city.

On May 29, the board of supervisors gave legal backing to the board of health authorizing such measures to be taken as may be necessary for the prevention and spread of disease and ordered an immediate cordon around Chinatown. Because of the magnitude of the job and the lack of funds, the effort was not effective. On June 4, the governor of California refused a request for aid from the state board of health. On June 6, the quarantine of Chinatown was ordered lifted on the basis of severe and oppressive racial discrimination. This was the result of a suit brought in the United States court to test the validity of the 1890 Federal law governing movement of Asiatics. The service officer in charge of Federal participation was ordered to appear in court to show why he should not be punished for contempt. Although not held in contempt, all active anti-plague efforts had been suspended and were not resumed. However, cases of plague continued to be diagnosed and confirmed by laboratory examinations.

Early in 1901, the Secretary of Treasury appointed a commission of three members, Simon Flexner, F. G. Novy, and Llewelyn F. Parker, to investigate the plague problem in San Francisco. In a report dated February 26, 1901, they presented unquestionable evidence of the existence of plague. As a direct result, representatives from California discussed the report in Washington on March 9, and on March 22, agreed in San Francisco to raise funds for immediate work as follows:

1. To disinfect all infected houses
2. To provide a hospital for all suspects
3. To provide a detention house
4. To provide a morgue.

By June 21, 1901, when the work was discontinued, 1,180 houses had been disinfected using sulphur dioxide, steam, and bichloride of mercury. Plague continued to occur in 1901 and 1902.

On November 8, 1902, work was started to trap rats systematically. (Up to that time, some 50 to 60 rats had been examined with negative results.) In a short time 481 rats were trapped. Fifteen were found to be plague infected.

On January 19, 1903, a conference of state health officers was held in Washington in regard to the plague situation in the United States with special reference to San Francisco. The plague progress was severely criticized in resolutions condemning the lack of cooperation with the Service and the resultant lack of progressive action possible to cope with the situation. This pressure resulted in sanitary measures for San Francisco being adopted in February 1903, by the city, State, and Federal health authorities. It was agreed jointly:

1. To exterminate rats
2. To clean streets
3. To remove garbage
4. To report cases.

This time the work was carried on in an amicable manner. A year later the last case of plague had been reported and two years later, on April 13, 1905, the Federal Plague Laboratory was closed. One hundred and twenty-one cases and 113 deaths had occurred during the period.

In August 1907, three cases and deaths occurred in San Francisco and on September 4, the mayor requested the service to assume charge of measures to eradicate and prevent spread of bubonic plague in that city. There was no lack of action this time and cooperation was immediately given on all sides. The city had not completely recovered from the earthquake and fire of 1906 and conditions were favorable for an epidemic outbreak. On October 3, 1907, Oakland, Alameda, and Berkeley made similar requests to the Service. During the first year, efforts were limited to measures taken to diagnose plague and to prevent its spread by action taken against the domestic rat. Then, on August 5, 1908 a plague infected ground-squirrel was

found in the northern part of Contra Costa County on a ranch where a plague death had occurred on July 15. This finding changed the concept about the animal reservoir of infection and eventually led the Service into all of the western states in its search for other reservoir hosts. The existence of plague epizootic in Contra Costa County was suspected as early as the summer of 1903. In August of that year, two fatal cases of human infection occurred in widely separated sections of the county. Investigations indicated an association with ground-squirrels which, however, was not confirmed at that time.

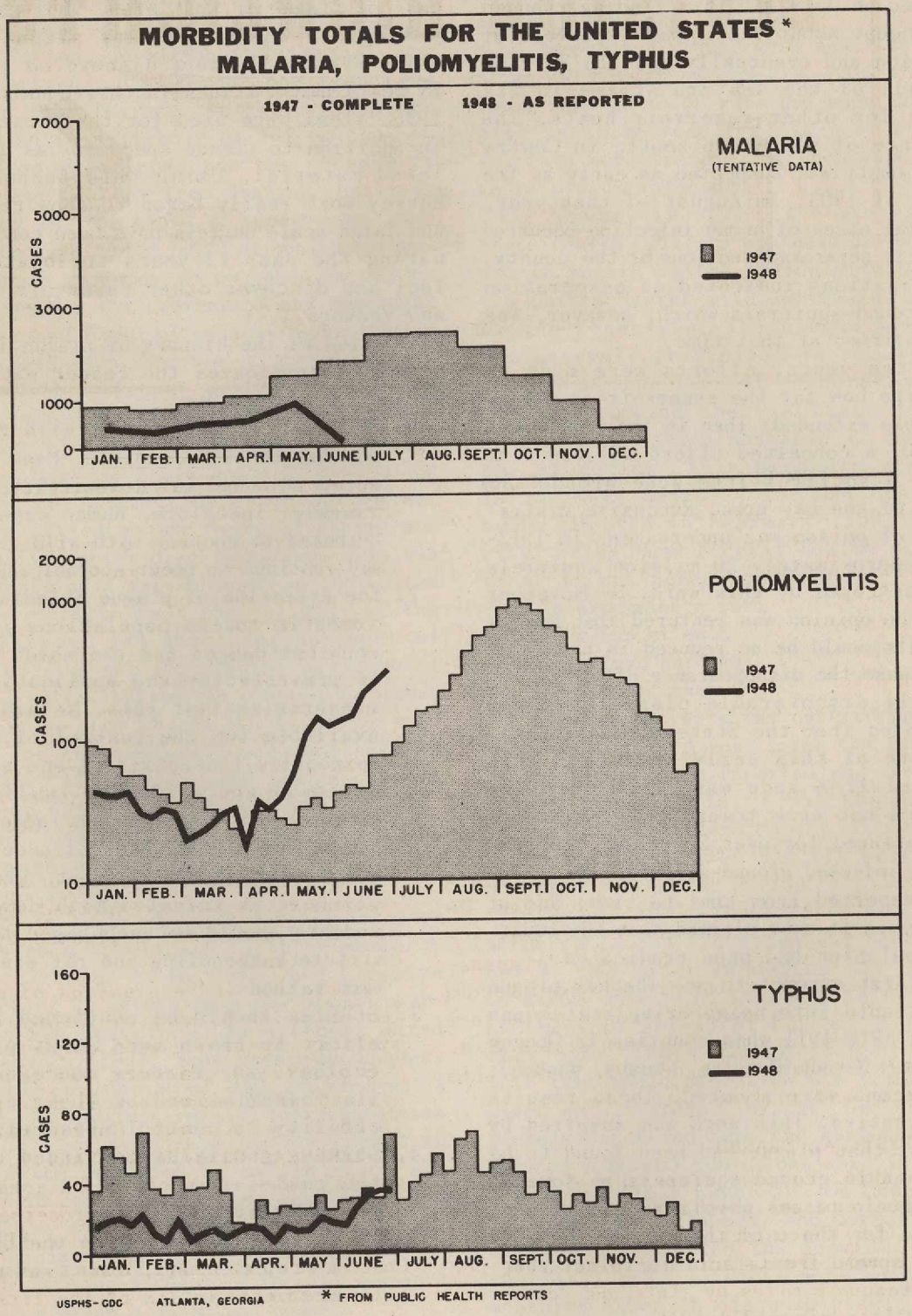
For two years, efforts were made to determine how far the reservoir in ground-squirrels extended. Then in the early part of 1910, a concerted effort was begun to create a squirrel-free zone around the cities of the bay area. Extensive distribution of poison was undertaken. In 1913-1914, approximately 20 million squirrels were destroyed by this work. By November 1914, the opinion was ventured that ground-squirrels could be so reduced in number so as to cause the disappearance of plague and that all discoverable plague had been eradicated from the State of California. In spite of this early optimism, this squirrel-free zone was never actually attained but work toward this objective was continued for over 26 years. Needless to say, infected ground-squirrels continued to be reported from time to time, and at no time was it ever claimed that the squirrel population had been eradicated.

The first attempt to see whether plague had extended into neighboring states was made in 1910-1911 when counties in Oregon (Jackson); Nevada (Douglas, Ormsby, Washoe); and Arizona were scouted. These results were negative. This work was inspired by the fact that plague had been found to be prevalent in ground-squirrels in some of the mountain passes which would be natural pathways for the infection to follow if it were to spread from California to neighboring states.

In 1935, a renewed search was made for plague foci in other states. A mobile unit was created which began investigations in Lake County, Oregon, and the adjoining part of the State of Nevada because of a case of plague in that area. Thus began a new era in the search for plague foci which eventually were discovered in the 15 westernmost states in this country. In 1936, fleas were used for the first time in addition to tissue specimens as inoculated material. Using this technique, survey work really began to show results and large-scale surveys have been conducted during the past 12 years to locate new foci and discover other reservoir hosts and vectors.

A review of the history of plague in the United States leaves the reader with the following impressions:

1. Eradication of the vast wild rodent population is impossible. Even if it were, it would be economically inadvisable. Therefore, human cases attributed to contact with wild rodents may continue to occur sporadically.
2. The extension of plague infection to domestic rodent populations is the apparent danger and one which could be prevented by the application of measures against rats. Methods are available for the control of acute epizootics (insecticides and rodenticides) and epidemics (sulfa and streptomycin) in domestic rodent and human populations but reliance upon them should not be too great. Instead, communities infested with domestic rodents should be encouraged to institute ratproofing and rat eradication methods.
3. Studies should be continued in an effort to learn more about plague ecology, the factors concerned in its transmission and their applicability to control measures.
4. Surveys should be continued as in the past—
   a. to locate new foci
   b. to stimulate state and local interest in rodent control activities
   c. to remind physicians to consider plague as a diagnosis whenever indicated.



Epidemiology Division

THE RINGWORM EPIDEMIC IN NORTH CAROLINA

An epidemic aid call was received from Dr. Carl V. Reynolds in connection with a ringworm epidemic in North Carolina. Assistant Surgeon L. K. Bishop assisted the state in setting up control measures and conducting surveys. He instructed local personnel in the use of Wood's Lamp as a diagnostic aid and loaned the state a lamp.

MALARIA RECORD FORMS DISTRIBUTED

The Malaria Case Appraisal Record Form was printed and distributed to malaria personnel. The form was previously discussed with various state health department officials concerned and approved by them. The form is being used at present in Mississippi, South Carolina, Georgia, Arkansas, and Alabama. As additional personnel become available it is contemplated that the form will be used in other Southern states. S. A. Surgeon Griffith E. Quinby will direct this program and analyze future reports.

STATISTICAL BRANCH

MALARIA. Current recording of malaria, typhus, and poliomyelitis cases received from the Office of the Surgeon General was continued. The malaria mortality rate per 1,000 square miles by state and county was calculated for 1932-1946.

Consultation service was given to the South Carolina State Board of Health in establishing machine procedures for processing data of malaria investigations on the Manning project.

Extensive analyses of malaria data for the United States and gross malaria data of Canada and Arkansas were prepared.

TYPHUS FEVER. Reports of cases and rates for selection of areas in which control measures are to be done were provided. Consultation was given on statistical criteria for eliminating areas from operational activities. Statistical consultation was also provided for the typhus investigation project in Thomasville, Georgia, and to other field programs.

POLIOMYELITIS. Current reports of poliomyelitis by states were plotted. Epidemicity of this disease was evaluated by control chart methods.

Tabulation and evaluation of data collected in the Wilmington, Delaware, poliomyelitis experience were completed.

Statistical guidance was provided in evaluation of entomological data collected in Florence, Alabama, during 1946.

DIARRHEAL DISEASE MORTALITY. Data of special tabulation of the National Office of Vital Statistics were processed.

Consultation service to the Dysentery Control Project, Pharr, Texas, was provided. Life experience tables of the first year's experience on this project were completed. The Medical Officer in Charge at Pharr was supplied with copies of completed tabulations and intricate statistical analyses of the

project. Progress was made on processing data from March 1947 through August 1947.

Record forms and statistical procedures for handling data of dysentery investigations in Albuquerque, New Mexico, were prepared.

Statistical consultation services were provided to the Executive Office and to five CDC divisions.

Further detailed statistical information was kept on malaria, typhus, poliomyelitis, encephalitis, diarrhea, and dysentery.

VIRUS BRANCH TRANSFERRED TO ATLANTA

The Virus Branch was transferred to Atlanta during the quarter. Actual transfer of personnel and equipment was almost completed. Personnel changes of the project were:

S. A. Surgeon Griffith E. Quinby — Atlanta, Georgia, Epidemiology Division

Engineer (R) Joseph H. Coffey — Atlanta, Georgia, Engineering Division

Insect Control Specialist Sidney Richter — Pharr, Texas

S. A. Engineer (R) S. A. Lacy — Alabama CDC program

Joseph T. Grimsley — Arkansas CDC program

Assistant Surgeon Lindsey K. Bishop — Montgomery, Alabama, Laboratory Division

Assistant Surgeon (R) Ralph S. Paffenbarger, Dysentery Control Program

Entomologist Ernest V. Welch — Entomology Division

S. A. Sanitarian (R) Harold R. Dodge — Entomology Division

TYPHUS INVESTIGATIONS

Three human cases of murine typhus fever were confirmed in Grady County; one case was confirmed in Decatur County.

Trends in abundance of rats positive to the typhus complement fixation test remained essentially the same. Decatur and Grady were somewhat over 20 percent, while Thomas and Brooks Counties were held down to less than 4 percent.

In the supplemental survey of typhus, no miscellaneous animals were found positive to the murine typhus complement fixation tests during this quarter.

Fleas still appear to be under control in dusted counties. The percent of rats infested with *L. Segnis* in Thomas County is showing the species to be on the increase; thus predicating a recurrence approximating normal flea populations during the second season (1949) following discontinuance of dusting operations in 1947.

Continued slight suppressive of *L. bacoti* in Thomas and Brooks may be noted. *P. spinulosa* seems to have returned to normal abundance levels in these two counties.

By Fiscal Year 1949, this project will be a surveillance type of study. This phase of the study should be most interesting to epidemiologists and to others responsible for determining the need for instituting murine typhus control operations. This work may demonstrate the period of grace expected to exist between satisfactory control of murine typhus by DDT dusting and the relative periods of time elapsing before the following epidemiological factors are reestablished at previous levels:

1. Abundance of various rat ectoparasites.
2. Prevalence of murine typhus in rats as evidenced by the typhus complement fixation test.
3. Human incidence of murine typhus fever.

Laboratory Division

MILLER ATTENDS MEETING OF APHA'S CO-ORDINATING COMMITTEE ON LABORATORY METHODS

Dr. Seward E. Miller attended a March conference in New York as a member of the newly formed Co-ordinating Committee on Laboratory Methods of the APHA. A subcommittee of the Committee on Research and Standards, this committee has the important function of assuming leadership among existing Laboratory Methods Committees. Its duties: to establish laboratory methods committees and appoint chairmen; to assure competent, adequate group review of laboratory methods; to promote the preparation of new laboratory methods; to review existing reports; to

resolve controversial questions; to establish uniform style, format, etc. followed in preparation of any laboratory method; and to present to the Committee on Research and Standards completed manuscripts with assurance that competent group judgment was obtained in their preparation.

LABORATORY PROGRAM REVIEWS COMPLETED

Dr. Miller and Dr. Tiffany completed program reviews of the Georgia Department of Health laboratories and the South Carolina State Board of Health laboratories in January. The laboratories of the West Virginia State Department of Health were surveyed by Dr. Tiffany in March. Dr. Miller surveyed the Connecticut State Health Department's laboratories in March. Program review reports were submitted to the District Directors, at whose request the surveys were made.

RECRUITMENT FOR LAB COURSES IS SUCCESSFUL

Indications are that courses in all subjects for the remainder of 1948 will be over-subscribed. Considerable assistance in recruitment has been given by notices in professional and scientific journals.

270 LABS NOW SERVED BY EXTENSION SERVICE

The Extension Service has continued to maintain its schedule of monthly shipments, the recipient list of laboratories now numbering 270. Plans are underway to institute shipment of specimens prepared by the mycology and tuberculosis sections in the near future.

PARASITOLOGY BRANCH

TRAINING IN PARASITOLOGY

The tenth six-weeks course in the Laboratory Diagnosis of Parasitic Diseases was given January 12 -- February 20, 1948. Eighteen students from 14 states, Puerto Rico, and Canada attended.

The second two-weeks course for laboratory directors and senior staff members in the same subject was given March 8 -- March 19, 1948. Fourteen persons from seven states, Columbia, and China attended.

A series of ten lectures and demonstration periods on hematology and hematological techniques was given to eight CDC laboratory workers to help establish uniform techniques in this laboratory.

Seven hundred and seventy-three sets of specimens were prepared for the Extension Service. Slides included *Dermacentor andersoni; Ornithodoros moubata; Leishmania donovani; Microfilariae; E. histolytica* trophozoites and cysts.

Collections of 25 slides were loaned to six states.

Parasitological specimens were received from our unit in Puerto Rico and from the Army Medical School. Malaria blood smears for teaching purposes were made by our technicians through courtesy of the N.I.H. Laboratory at Milledgeville. Nine hundred tick specimens (for the Extension Service) were received from the Rocky Mountain Laboratory. Approximately 1,400 other entomological specimens were received from various sources for the museum collection.

INSTRUCTION IN THE DIAGNOSIS OF AMOEBIASIS GIVEN IN CLEVELAND, MISSISSIPPI

In March two days of lectures and laboratory instruction were given to 38 technicians and 30 physicians at the Delta State Teachers College in Cleveland, Mississippi. The subject: diagnosis of amoebiasis.

COURSE ON THE DIAGNOSIS OF INTESTINAL PARASITES GIVEN IN JACKSONVILLE, TAMPA, AND MAIMI, FLORIDA

A request for assistance in evaluating the performance of diagnostic parasitological laboratory techniques was received from the Florida State Health Department, This request was made for state and private laboratories. In order to obtain cooperation of private laboratories it was decided to give their personnel special instruction first. Accordingly, two officers gave a series of lectures, with supplementary laboratory study, on the diagnosis of intestinal parasites in Jacksonville, Tampa, and Miami. Facilities of central and branch laboratories of the State Health Department

were used. Over 250 state and private technicians and physicians attended.

LABORATORY INVESTIGATIONS LISTED

1. Several stains were used to stain cultures of *T. cruzi* and the leishmanias in bulk. Giemsa stain seemed to be best of those tried.

2. Studies were carried out to determine whether Offutt's medium permitted the "textbook" picture of development of *T. cruzi*. Also, the morphological changes that could be expected in aging and in stock cultures on this medium were determined.

3. Studies of the effect on amoebae of different types of preservatives used in bacterial examination of stools were carried out.

4. Further studies of the polyvinyl alcohol-fixative technique were carried out to determine the effect of prolonged exposure of smears to the wet mixture of alcohol and fixative. Deterioration studies continued.

5. The effect on helminth eggs of prolonged exposure to deep freeze temperatures was studied.

6. The effect of varying the flotation time in the modified Zinc Sulfate Centrifugal Flotation technique was studied.

7. Preliminary results are promising in studies aiming at the cultivation of various blood parasites by inoculation of insect pupae.

8. Blood smears sent by Dr. Walker of Tulane University were stained by his technique to determine whether or not there would be transfer of malarial parasites.

9. Various methods were used to stain known positive and normal thick blood films in attempts to find a method which would prevent transfer of malarial parasites. Preliminary results are promising.

10. Favorable results were obtained in studies using polyvinyl alcohol-giemsa stain for all types of blood parasites.

11. A study was made of the pupae of all genera of mosquitoes found in the United States which included 13 of the 15 species of anopheline mosquitoes. Twelve plates were drawn showing distinctive characters of the different genera.

12. Experiments were continued using methyl methacrylate plastic to embed arthropods and larger animals. Some success was obtained with mounting a white mouse.

13. A pictorial key --"A Pictorial Key to the Genera of Female Mosquitoes in the United States" was completed. Two others have been started.

REFERENCE DIAGNOSTIC SERVICES PERFORMED

Diagnostic services were carried out for various agencies upon request. These services are summarized as follows:

DIAGNOSTIC SERVICE		STATE OR LOCAL P.H. DEPTS.	CDC CLINIC	PRESB. HOSP. BABY CLINIC	TOTAL
Feces	Exam. for intestinal parasites	30	2	149	181
	Culture for protozoa	3			3
	Culture for bacteria		2		2
Blood	Exam. for malaria	1	1		2
	Exam. for microfilariae	1	1		2
	Exam. for *L. donovani*	1	1		2
	Culture for *L. donovani*	1	1		2
	Animal inoculation for *L. donovani*	1	1		2
	Routine counts hemaglobin and differential		97		97
Urine	Routine Urinalysis		83		83
Arthropods	Identification	125			125

SURVEY	NUMBER OF SLIDES EXAMINED	NUMBER POSITIVE	PERCENT POSITIVE	REMAINING AT END OF QUARTER
Lab. Evaluation Survey (Mississippi)	58	14	24.1%	
South Carolina	3,504	6	.17%	1,841
Dominican Republic	378	22	5.8%	
Jamaica	968	263	27.1%	

Diagnostic services were also provided for various agencies on malaria survey slides as indicated in the above chart.

VIRUS AND RICKETTSIAL BRANCH

DIAGNOSTIC SERVICE AND EPIDEMIC AID

1. Neutralization tests were carried out on sera from many parts of the country. One (4.3%) of 23 human sera was positive against EEE virus; five (8.5%) of 59 were positive against WEE virus; none of 31 were positive against St. Louis E virus; and one (50%) of two was positive against LCM virus.

2. Neutralization tests were done on sera from 169 animals and fowl from Tennessee and Louisiana. Positive tests for EEE and WEE were found in several chickens, ducks, geese, pigeons, Canadian ring necked doves, dogs, cows, horses, and mules. There were 40 positive tests of 171 sera tested.

EXPERIMENTAL AND PRODUCTION WORK

Experimental and production work was carried on as follows:

1. Because of the transfer of the rickettsial serology unit to the bacteriology section, reorganization is taking place in the complement fixation unit. Work is now being done preparing virus antigens and antisera to carry out the necessary complement fixation tests.

2. Work is continuing on the use of antibiotics as an aid in the isolation of virus.

3. Successful transfer of poliomyelitis to other monkeys has been accomplished through injection of intestinal mucosa of poliomyelitis monkeys.

4. Attempts are being made to identify a virus recently isolated from a cotton-rabbit which does not give the usual reactions with any of the tests used so far.

5. Work has been completed identifying a virus isolated from the brain of a fatal case (Nixon) of encephalitis in Birmingham, Alabama. It proved to be a strain of Herpes Simplex Virus.

6. Several additional strains of poliomyelitis and herpes viruses have been received from other workers.

7. Further work has been done with the Newcastle Disease Virus. Neutralization tests were done with several sera received by the laboratory. (See chart, page 42).

8. Inoculation of various lots of insects into mice for recovery of viruses is continuing. Fourteen lots of mosquitoes from Louisiana and 15 lots of mosquitoes from Galveston, Texas, produced no viruses.

9. The histopathology unit embedded and sectioned 232 specimens for various units of CDC.

10. Experiments are continuing in attempts to improve agglutination tests for viruses using suspension of virus-coated particles.

11. The insectary for use in experiments with insect transmission of viruses has begun functioning.

12. The preparation of various antigens, antisera, and animals necessary for the work of the section is continuing.

13. One thousand four hundred thirty-three mice and 12 hamsters were raised in the laboratory this quarter.

BACTERIOLOGY BRANCH

Streptococcus diagnostic antisera will be made available through a joint project

LOCATION	ENCEPHALITIS CASES NO. TESTED	NO. POS.	NO. WEAKLY POS.	% POS.	NON-ENCEPHALITIS CASES NO. TESTED	NO. POS.	NO. WEAKLY POS.	% POS.
Nashville, Tenn.	32	13	2	47				
Shelbyville, Tenn.	2	1	1	100				
Wilmington, Del.					1	0	0	0
Louisiana	5	0	0	0				
Mississippi	4	1	2	75				
C. D. C.								
Virus Laboratory					5	1	0	20
TOTAL	43	15	5	34.6%	6	1		16.6%

with the New York State Board of Health Laboratory. The sera will be prepared by them and distributed on a reginal basis, partly by them and partly by CDC.

RICKETTSIAL SEROLOGY UNIT

This laboratory was transferred from Montgomery, Alabama to Atlanta and began functioning here at the beginning of the quarter.

Preparation of new and better lots of antisera for host preference serology has been partically held up because of difficulty in securing satisfactory rabbits.

Complement fixation tests for rickettsial diseases were done as shown:

		MURINE TYPHUS	RMSF	RICKETTSIAL POX	Q FEVER
Human Sera	No. Tested	142	6,142	142	142
	No. Positive	36	3	4	1
	Percent Positive	25.3	2.1	2.8	0.70
Rat Sera	No. Tested	7,168	160	160	576
	No. Positive	869	1	11	0
	Percent Positive	12.1	0.62	6.8	0

Weil-Felix tests were run as shown below:

		0 x 19
Human Sera	No. tested	141
	No. positive	79
	% positive	56%

Sera from VD-TB surveys tested for murine typhus gave the following results:

No. Tested	No. Positive	% Positive
1,566	36	2.2%

In one suspected case of murine typhus isolating of the rickettsia by guinea pig inoculation of the patient's blood was successful.

MYCOLOGY SECTION

The Mycology Laboratory was transferred from Duke University to Atlanta in January. It is now permanently located in its own quarters at Lawson Hospital after occupying temporary quarters in the Tuberculosis Laboratory.

DIAGNOSTIC SERVICES

A total of 285 cultures and specimens were examined. From these cultures the following pathogenic fungi were isolated and identified:

54 strains of *Microsporum andionni*
9 strains of *Candida albicans*
1 strain of *Microsporum canis*
1 strain of *Tricophyton rubourn*

RESEARCH

1. Investigation of the effect of T.B. concentration techniques on the pathogenic fungi is now well underway. Preliminary results seem to indicate that the majority cannot survive treatment with sodium hy-

droxide although many withstand treatment with sulphuric acid and trisodium phosphate.

2. Preparations have begun for the study of nutritional requirements of pathogenic fungi in order to devise new and better media.

TRAINING

Plans are being made for a training course in medical mycology to be given in the fall. Histological slide material and slide culture mounts of fungi (made permanent by use of polyvinyl alcohol) are being prepared for use in the course.

Dr. Cummings gave several lectures at a postgraduate course in thoracic diseases sponsored by the American Trudeau Society at Duke University School of Medicine.

REFERENCE DIAGNOSIS

Thirteen specimens from Alaska and Massachusetts were received for organism type identification. A total of 1,168 routine specimens were received from Lawson Veterans Hospital, Veterans Hospital No. 48, Gerogia State Public Health Laboratories, and Battey General Hospital. There were 999 sputa, 106 body fluids, and 83 gastric washings. They were examined microscopically, culturally, and by animal inoculation.

RESEARCH

1. A study was started comparing the concentration of tubercle bacilli from sputum by xylene flotation, chloroform precipitation, Hank's flocculation, clorox and heat coagulation, and sodium hydroxide digestion.

2. Several projects promoting better understanding of media are in progress.

a) Studies are continuing to determine the nature of an apparent growth-promoting factor discovered in potato flour studied in earlier evaluation experiments.

b) Studies to determine the effect of temperature on media sensitivity are underway.

c) The effect of carmelization of sugar on media sensitivity is being determined.

d) The amount of unsaturated fatty acids in media prepared at different temperatures and their effect on the growth of tubercle bacilli are being studied.

3. Experiments are being conducted to determine the best type of stopper for tuberculosis culture media tubes. The amount of air necessary in the tube for optimal results with culturing is also being determined.

4. Injection of chosen specimens into mice was started in an attempt to adapt the mouse to routine diagnostic procedures.

5. Additional work has been done on the relative toxicities of different sputa digestants. Trypsin, oxalic acid, hydro-chloric acid and antiformin were added to the list of agents already under investigation.

6. Media evaluation is continuing. The comparison of modified Lowenstein's medium with the Trudeau Committee medium was completed. Work began comparing Petragnani's medium with modified Lowenstein's medium.

7. Work was started on evaluation of media for streptomycin sensitivity tests.

CONSULTATION

The Temple University Tuberculosis Laboratory was given aid in problems of culture diagnosis.

Engineering Division

BUDGET ESTIMATES MADE

Budget estimates for fiscal year 1950 were prepared. Justifications for malaria, murine typhus fever, and fly control; plague investigations; and District and Engineering Division activities were also prepared. Malaria and typhus field activities are scheduled to continue at approximately the fiscal year 1949 level. By 1950 it is expected that plague evaluation activities will be sufficiently advanced to determine whether or not control measures among wild rodents should be undertaken.

MALARIA CONTROL ACTIVITIES

Residual spraying operations were initiated in eight states during March (see Table I). With the exception of Georgia and possibly portions of two or three other states, only one spray application will be made during the coming season. Therefore,

most states will complete the spraying program early in July. It is expected that operations for the 1948 season will be undertaken in approximately 350 counties. Only 90 counties will be operated on a less than county-wide basis. Operational maps for the 1948 season showing areas of proposed operations were prepared.

Experience in the 1947 season indicated that it is difficult to obtain the desired residue of 200 mg. of DDT per square foot of surface sprayed with a 5 percent emulsion. Therefore, it was recommended to the states that emulsion strength be increased from 5 to 7½ percent during the 1948 season. This recommendation has been adopted by a majority of states.

It is interesting to note from Table I that 1,311,911 house spray applications were made during the 1947 season at an average cost of $2.88. South Carolina had the lowest per application cost ($2.06), while Kentucky had the highest ($6.13). Total house spray applications for the

Table I

SUMMARY OF DDT RESIDUAL SPRAY OPERATIONS

January 1 — March 31, 1948

STATE	NO. COS.	NO. HOUSES SPRAYED	LBS. DDT	MAN-HOURS			LBS. DDT PER HOUSE	M.H. PER HOUSE	M.H. PER LB. DDT	CUMULATIVE JULY 1, 1947-MARCH 31, 1948	
				CDC	LOCAL	TOTAL				TOTAL HOUSE SPRAY APPLIC.	TOTAL LBS DDT
Alabama	32	15,707	13,182	20,434	3,070	23,504	0.84	1.50	1.78	62,638	58,903
Arkansas	—	—	—	19,278	322	19,600	—	—	—	80,742	67,465
Florida	12	8,213	5,747	4,932*	10,196	15,128*	0.70	1.84	2.63	42,873	40,040
Georgia	1	251	377	4,200	159	4,359	1.50	17.37	11.56	90,056	72,011
Kentucky	3	48	78	3,080	2,261	5,341	1.63	111.27	68.47	4,745	5,377
Louisiana	12	3,317	3,859	2,190	5,376	7,566	1.16	2.28	1.96	10,857	11,223
Mississippi	17	11,777	12,615	12,296	10,520	22,816	1.07	1.94	1.81	65,770	40,118
Missouri	—	—	—	3,280	—	3,280	—	—	—	39,222	22,943
North Carolina	—	—-	—	2,880*	—	2,880*	—	—	—	19,442	15,816
Oklahoma	—	—	—	1,120	—	1,120	—	—	—	15,802	16,469
South Carolina	—	—	—	12,480	—	12,480	—	—	—	100,800	87,011
Tennessee	4	537	1,297	7,163	6,545	13,708	2.42	25.53	10.57	4,264	6,776
Texas	1	579	489	5,550	899	6,449	0.84	11.14	13.19	47,523	50,203
Sub-Total Cont. U. S.	82	40,429	37,644	98,883	39,348	138,231	0.93	3.42	3.67	584,734	494,355
Puerto Rico & Virgin Is.	—	2,422	1,693	2,139	654	2,793	0.70	1.15	1.65	7,819	5,405
GRAND TOTAL	82	42,851	39,337	101,022	40,002	141,024	0.92	3.29	3.59	592,553	499,760

* Includes estimated man-hours

Table II

CUMULATIVE SUMMARY OF LARVICIDING

January 1 — December 31, 1947

TYPE	NO. OF STATES	GALLONS	POUNDS	HUNDRED FT. TREATED	MAN-HOURS	GALLONS	POUNDS	ACRE APPLICATIONS	MAN-HOURS	MAN-HOURS		
										CDC	LOCAL	TOTAL
DDT Hand Spray	6	20,728	--	840,658	45,045	17,153	—	10,152	32,160	39,547	37,658	43,530
DDT Power Spray	3	13,418	—	259,610	6,457	5,136	—	3,453	1,595	2,141	5,911	8,052
Fuel Oil, etc.	7	119,725	—	217,735	20,279	7,953	—	1,301	3,082	4,637	18,724	23,361
Paris Green	5	—	192	815	217	—	1,179	215	612	410	419	829
Airplane	2	—	—	—	—	1,706	—	6,737	43	28	15	43
Sub-Total Cont. U.S.	8	153,871	192	1,318,818	71,998	31,948	1,179	21,858	37,492	46,763	62,727	109,490
Puerto Rico:												
DDT Hand Spray	—	20,261	—	1,626,637	56,831	5,952	—	3,407	27,969	72,766	12,034	84,800
DDT Dust	—	—	—	—	—	—	70	70	176	168	8	176
Paris Green	—	—	8,683	17,681	10,859	—	2,777	1,251	6,131	16,415	575	16,990
GRAND TOTAL	—	174,132	8,875	2,963,136	139,688	37,900	4,026	26,586	71,768	136,112	75,344	211,456

1947 season represent an increase of 145,446 over the 1946 season.

State and local participation in both malaria and typhus programs increased over the previous quarter.

Table III

CUMULATIVE SUMMARY OF DRAINAGE AND MAINTENANCE
January 1 — December 31, 1947

TYPE	NO. OF STATES	LINEAR FEET	CUBIC YARDS	MAN-HOURS		
				CDC	LOCAL	TOTAL
Drainage	7	37,758	12,987	5,618	7,081	12,699
Clearing	8	1,838,270	--	13,482	17,491	30,973
Clearing	Not classified prior to July 1, 1947					
Sub-Total Cont. U.S.	8	1,876,028	12,987	19,100	24,572	43,672
Puerto Rico:						
Drainage		816,925	342	10,973	119,070	130,043
Clearing		685,113	—	17,368	21,774	39,142
GRAND TOTAL		3,378,066	13,329	47,441	165,416	212,857

TYPHUS CONTROL

Evaluation activities during the quarter consisted mainly of tabulating statistics of rat typhus, rat ectoparasites and human typhus by isothermal zones of Southern states. A study of climatological factors in typhus epidemiology was begun in January and continued through the quarter. New techniques in measuring rats and of brushing rats to collect ectoparasites were tested. Recommendations for adoption of these techniques were forwarded to field stations.

FLY CONTROL BRANCH ACTIVATED

The Fly Control Branch of the Division was activated during the quarter. Engineer (R) Joseph R. Coffey, formerly attached to the Virus Branch of the Epidemiology Division, Montgomery, Alabama, was placed in charge.

Entomology Division

ORGANIZATIONAL CHART REVISED

A revised organizational chart for the Entomology Division has been prepared which includes six branches as follows: (1) Malaria Survey and Evaluation Branch, (2) Ectoparasite-Borne Disease Branch, (3) Encephalitis Investigations Branch, (4) Malaria Investigations Branch, (5) Dysentery Control Branch, and (6) Fly-Control Disease Branch.

WATER-HYACINTH INVESTIGATIONS

The Corps of Engineers allocated monies for investigations relative to effects of water-hyacinth eradication on public health. Funds are available to the Public Health Service for this study and preparation of a report due August 1, 1948. Scientist (R) F. Earle Lyman was assigned as coordinator of this project. He reports that certain hyacinth-infested ponds at Mulberry, Florida, have been selected as principal sites for investigational work during the coming summer.

ECTOPARASITE-BORNE DISEASE BRANCH

Evaluation data for determining results of DDT dusting for control of rat ectoparasites have been summarized for the last quarter of 1947. These show that the percentage of rats infected with *cheopis* fleas from dusted premises varied from 5 in December to 14 in October while rats from untreated premises showed from 34% to 40% infestation during the same months. Rats infested with lice varied during the year from a low of 28% to a high of 40% in dusted premises. Comparable percentages in untreated premises were 41 to 48. Data on the effect of dusting on mites show that the seasonal range in the percent of rats infested with *bacoti* varied from 8 to 13 in dusted and from 17 to 20 in untreated premises; with *echidninus*, from 7 to 12

percent in dusted and from 13 to 21 percent in untreated premises; and with *nuttalli*, from 6 to 12 percent in dusted and from 15 to 38 percent in untreated premises. Thus a degree of control is indicated for all ectoparasite species. During 1948 attempts will be made to adjust dusting programs more closely to seasonal flea cycles in an effort to make control even more effective.

Little, if any, practical difference was observed between the percentages of rats positive for typhus from dusted and from untreated premises. However, only 332 human cases of typhus occurred during the quarter which was less than half the number recorded during the equivalent quarter of 1946.

DYSENTERY CONTROL PROJECT — PHARR, TEXAS.

Expansion of the Dysentery Control Project to include study areas at Albuquerque, New Mexico, and Thomasville, Georgia, is under way. Fly surveillance to lay a basis for later control work has been carried on in these areas since early in the fall of 1947. The organizational structure of the project remains essentially unchanged; i.e., it is a cooperative undertaking between the National Institute of Health and the Communicable Disease Center. Dr. James Watt, Surgeon (NIH), is Medical Officer in Charge, and S. A. Scientist Dale R. Lindsay (CDC) is in charge of the Vector Control program. By the end of the fourth quarter, the project will have four study areas as follows:

1. Pharr, Hidalgo County, Texas.
2. Albuquerque, New Mexico, and vicinity.
3. Thomasville, Thomas and adjacent counties in South Georgia.
4. New Orleans, Louisiana (a research investigation of diarrhea of the newborn in cooperation with the Louisiana State University Medical School and Charity Hospital).

Activities in the Albuquerque area include control studies in the city proper, six smaller towns, and eight Indian pueblos. Comparisons of control methods and fly index levels as evaluated by epidemiological measurements will constitute the bulk of the work. Operational activities are planned for only the one current season, and resources therefore are being concentrated on this project in an effort to insure success. Headquarters in Albuquerque are in the Indian Affairs Building, State Fairgrounds. Dr. Mary Walton, Surgeon (CDC) is Medical Officer in Charge. Third quarter activities have included the establishing of administrative, operational, and laboratory facilities in order that the season's work may be in full swing early in the fourth quarter.

Fly surveillance studies will continue throughout this season in various towns in the Thomasville, Georgia, area and epidemiological studies will begin during the fourth quarter. Additional comparable towns, probably in Colquitt and Mitchell Counties in Georgia, will be selected for study during the fourth quarter. The objective of this work is to secure entomological and epidemiological data over a full season prior to institution of control for subsequent comparative purposes. Research in fly evaluating methods consisting of parallel measurements by different methods is planned in this area which is particularly well suited for such research in that methods found suitable will be applicable in general to the Southeastern states.

Activities in the Hidalgo County, Texas, area were somewhat retarded by unusually prolonged cold during the third quarter. Since this project is the parent organization, its facilities have been used extensively in setting up the work in the new study areas. It will continue to serve as a source of personnel, a training center, and as a clearing house for administrative functions. Dr. Richard P. Dow, S. A. Scientist, reported to the Pharr project on March 4, 1948, and assumed functions of the Project Entomologist. In addition to supervising routine work, Dr. Dow will begin intensive studies of the biology and control of eye-gnats (*Hippelates* species) in that locality.

MALARIA FIELD INVESTIGATIONS, MANNING, SOUTH CAROLINA

Progress was made during the quarter toward bringing several years of human blood survey records up to date. This has included the transferring of parasitemia

data for 1944-46 to IBM cards. The back-log of unexamined 1947 slides is being reduced rapidly by the State Board of Health Laboratory. Current examinations are to be made of smears submitted to the Laboratory Division, CDC, this season so that up-to-date information on current malaria incidence will be available. This is essential for present studies.

Examinations of slides so far reported for January have shown a 0.17% positive rate for malaria. Reports on human parasitemia rates for 1947 which became available this quarter include: October, 0.4%; November, 0.9%; and December, 0.2%.

Anopheles quadrimaculatus adults were observed actively feeding during a week of warm weather following February 15. Eggs laid by these over-wintering females probably accounted for three males and four females collected on March 26. A large population of first stage larvae, probably quads, was found on March 23. In 1947 very few *quadrimaculatus* appeared before mid-April.

More than 15,000 winter larvae of *A. crucians* were collected for experimental purposes beginning in mid-January. While there was a variation of about two weeks in the pupation date for most of the larvae collected from the individual ponds or areas of large ponds, the data show that mass emergence of *crucians* from the breeding areas began in mid-February and was concluded by the middle of March; virtually no larvae smaller than the third stage were found during the first half of March; and practically no fourth stage *crucians* larvae or pupae were present in any pond during the latter half of March; but first stage and many second stage *crucians* were abundant and widely distributed during this period. From the foregoing it was concluded that *crucians* adults probably do not hibernate in this area.

Adult female *A. punctipennis* were more common this winter than during the two prior winters. Larvae and adults may be collected without difficulty, although in small numbers, every month of the year. This was reported in 1947 and may now be regarded as confirmed.

More than 400 *crucians*, as well as a few quads and *punctipennis*, were dissected in March. The sporozoite rate of *crucians* in March was zero.

Some progress was made on trials attempting infection of *crucians* with bird malaria. Infections of *Plasmodium relictum, elongatum,* and *circumflexum* from various common sparrows were inoculated into canaries. When gametocytes appeared in numbers in the peripheral blood, reared *crucians* were fed individually upon the canaries. The mosquitoes were then held for two weeks at 70°—80° F. after which dissections were made. No infected specimens were found in a total of more than 230 examined. During the coming season it is planned to extend trials to two or three other bird malaria species commonly found last year. Comparative experiments are now being made with *Aedes aegypti*. The negative results with *crucians* agree with those of last year when sporozoites from wild *crucians* likewise failed to infect canaries. Both kinds of evidence, showing doubt on the theory of avian provenience for sporozoites from *crucians*, emphasizes the need for further surveys of animal malarias and their infectivity for *crucians*.

Technical Development Division

INSECTICIDE INVESTIGATIONS BRANCH

INVESTIGATIONAL WORK ON ADULT MOSQUITOES

STUDIES ON EXPOSURES OF INDIVIDUAL MOSQUITOES TO DDT RESIDUES. The minimum time of exposure to DDT residues necessary to render adult mosquitoes incapable of normal activity has been investigated. During 20-minute study periods of individual mosquitoes in glass tubes, an average of 11 minutes was spent in contact with treated surfaces.

Initial observations over 20-minute

periods have given the following picture: on the initial contact the mosquito holds all feet on the treated surface; after one to four minutes there is evidence of some irritation as the insect starts to walk over the surface or breaks contact entirely; in from two to three minutes the insect commences to probe the surfaces and continues this activity over the entire period of observation; first tremors are observable in from two to ten minutes with an average of 4.5 minutes after contact; partial paralysis of hind legs is noted six to 15 minutes after contact. None of the mosquitoes tested as yet have been dead at the end of 48 hours after exposure. And most of the adults were still able to fly at the end of this time.

STANDARD PANEL TESTS WITH MOSQUITOES. Standard panel tests with deposits of a 75-percent-DDT water-wettable powder formulated as a 5-percent-DDT suspension and applied at the rate of 200 mg. per square foot have continued to give excellent results. Results from 60-minute exposures with residues of varying ages: 30 weeks — 96 percent; 33 weeks — 99 percent; 36 weeks — 98 percent; 39 weeks — 97 percent; and 42 weeks — 96 percent. On surfaces which were protected from outside weathering conditions deposits from water-wettable powders have shown retention of residual toxicity much longer than DDT-xylene residues.

INVESTIGATIONAL WORK ON BLOW FLIES AND ADULT HOUSE FLIES

RELATIONSHIP BETWEEN EXPOSURE TIME AND MORTALITY. Three-day-old adult *Callitroga macellaria* have been shown to be the most resistant specimens for comparative insecticidal investigations. Results indicate that male adults are more susceptible than females and that 30 and 60 minute exposure periods are applicable for short and long-range evaluation of insecticides by standard panel tests. These exposure periods are longer than those used for house fly studies (15—30 minutes) indicating greater resistance of *C. macellaria* to DDT.

RESIDUAL EFFECTIVENESS OF WATER-BASE PAINT CONTAINING DDT. Samples of a water-base paint containing 5 percent DDT have been evaluated for residual effectiveness against house flies. One coat of paint was applied by brush to glass panels and allowed to dry thoroughly. Residual effectiveness of the paint was compared to that of a DDT kerosene solution pipetted on glass plates to give similar amounts of DDT per square foot (approximately 200 mg.). Tests with 15 and 30 minute exposure periods were made 1, 6, and 12 weeks after application of coatings. Not only was the residual effectiveness of DDT in the coating tested at intervals after application, but also to determine results of repeated exposures of a given area. Different numbers of exposures were made on specific portions of test panels.

In general, where the number of tests made on a single section of the plate was a maximum, paint panels gave evidence of rapid removal of paint by flies. At the 12-week test period the DDT-kerosene residue was somewhat superior to the paint, as shown by the 30-minute studies. Where tests on each section of the plates were at a minimum, a decreased efficiency of water-base paint was indicated only after 12 weeks and at the shorter exposure period of 15 minutes.

COMPARISON OF RESIDUAL TOXICITY OF VARIOUS CHEMICALS. Sets of standard panels were prepared with agricultural and refined grades of chlordane using kerosene and xylene as solvents in each case. Results of 30-minute exposures of adult female *M. domestica* to deposits of 200 mg. chlordane per square foot of the above formulas showed: formulation with kerosene as the solvent to be slightly superior to the xylene formulation with the refined grade of chlordane; very little difference in the residual toxicity between the two grades of chlordane.

CONTROL METHODS AND EVALUATION BRANCH

HOOKWORM CONTROL INVESTIGATIONS

LABORATORY TESTS. Dosage rates of 1,000

and 2,000 pounds of calcium or sodium cyanamide per acre have been compared in laboratory tests. The culture was treated by sprinkling larvicide on the soil surface immediately after infestation with ten grams of infected feces. After treatment, the culture was covered with a glass plate and set aside for 21 days. Other tests, intended to show comparative effects of different application techniques, were of three types: the relative action of the larvicide when raked into the surface of the soil was tested by working the chemical into the upper one inch of the soil with a spatula in a series of covered cultures; the larvicide was left on the soil surface but the cover was left off the cultures to reduce possible fumigating action of the larvicide and to simulate field conditions more closely; to test the lasting or residual action of the larvicide, the chemical was applied to the surface of the soil and the dish set aside for 28 days before the infested feces were added.

Application at the rate of 2,000 pounds per acre of Ca CN_2, whether granular, pulverized, or micropulverized, is clearly more effective than similar applications at the rate of 1,000 pounds per acre. This is particularly true when comparisons are made of cultures where infestations are delayed. Similar results were obtained with Na_2CN_2 only in tests of the latter type. Results suggest that field applications should consist of applications of not less than 2,000 pounds per acre where a residual action is needed.

Cultures in which the treatment was raked or mixed into the upper level of soil produced essentially the same results as those in which the larvicide was sprinkled on the soil surface.

Recoveries of hookworm larvae from cultures set up without covers were greater than from covered cultures in tests where pulverized or granular $CaCN_2$ was applied at the rate of 1,000 pounds per acre. When treatment was doubled, recoveries obtained from uncovered cultures were as low as those from covered cultures and raked-in treatments. Tests run so far with micropulverized $CaCN_2$ and Na_2CN_2 showed a rather different picture. Recoveries from uncovered cultures with 1,000 and 2,000 pounds per acre treatments were essentially the same. Treatments of uncovered cultures with these substances may be slightly superior to similar treatments of covered cultures.

ANOPHELINE LARVICIDE INVESTIGATIONS

EFFECTS ON WILDLIFE OF ROUTINE APPLICATIONS OF DDT LARVICIDES APPLIED BY AIRPLANE. Intensive studies in 1946 and 1947 were carried out to determine effects of DDT sprays and aerosols, applied by airplane, on both aquatic and terrestrial organisms. Work was carried on in cooperation with the U. S. Fish and Wildlife Service. More than fourteen hundred acres in the Savannah River Migratory Water Fowl Refuge were under study. Check areas consisted of 850 acres; 600 acres were treated. All treatments were made at the discharge rate of 0.1 pound of DDT per acre. Applications were made at weekly intervals beginning about the middle of April and ending in September. DDT larvicides showed no appreciable effects on terrestrial insects, bottom, or surface organisms.

RODENT AND ECTOPARASITE CONTROL BRANCH

INSECTICIDE AND ACARICIDE INVESTIGATIONS

LABORATORY STUDIES. Over 100 chemical compounds have been tested in an effort to find a suitable acaricide for control of rat mites. Four types of standardized tests are used: deep and fine dust tests are used for materials submitted as dusts; test tube and spray tests are used for liquid materials. Thirteen materials gave consistent effective kills of 90 percent or more. Dusts containing pyrethrum and piperonyl butoxide with and without DDT are being field tested.

RODENTICIDE STUDIES

RAT POPULATION STUDIES. Further tests were made for determining the value of the "Elton Feeding Station" method for determination of rat populations. In tests carried out in artifically stocked build-

ings, a smaller and simpler feeding box and a cigar box were used. Rats fed more readily from these than from the more complicated box used previously.

Yellow corn meal has proven to be the best food tried to date in acceptance tests. There is however, a great fluctuation in the amount of meal consumed from day to day. Rats appear to have a preference for new foods. When other foods are available, consumption of corn meal drops off for a time.

FOOD PREFERENCE STUDIES. Several materials have been mixed with yellow corn meal in an effort to increase its acceptability. Yellow corn meal proved more acceptable when mixed with fish oil alone than when mixed with fish meal. Quaker Yellow Corn Meal, which is a coarser grind, was more acceptable to rats than the regular grind.

RATPROOFING STUDIES

ALUMINUM ALLOYS. All aluminum samples reported upon have been penetrated. Some, however, have been resistant to gnawing and have been penetrated only after a considerable time.

VECTOR-TRANSMISSION INVESTIGATIONS BRANCH

TRANSMISSION OF ENDEMIC TYPHUS

TEST RESULTS. In investigations on arthropod transmission, seven experiments with 682 mites and 52 test animals have produced no successful results. Six experiments with 321 fleas and 41 test animals have produced 14 positive results. It is not difficult to get transmission with fleas. These data are not presented, however, as an indication of absolute efficiency of fleas as vectors. Results merely show that the technique successful with fleas has thus far brought only failure with mites.

No final conclusions are justified from any of the work so far. However, it is strongly implied that *Liponyssus bacoti* does not transmit endemic typhus. Experimental results are in violation of theoretical expectations. It would seem more reasonable if mites did transmit typhus. Other research workers have said that they do. Further, they transmit other rickettsial diseases. Work is still in progress to test the ability of mites to transmit typhus under a wider range of circumstances than those yet studied.

ECOLOGY STUDIES

Ecology studies were made to determine what meterologic conditions exist in rodent burrows and the relation of these conditions to fluctuations in ectoparasite populations.

From available information, the following observations were made:

1. Burrows located in the open and unprotected areas exhibited lower daytime temperatures during the winter than those in protected locations.
2. Temperature changes in burrows of both types lagged behind the temperature fluctuation of the external environment. In the early morning, temperatures were noticeably higher than those existing outside. In the afternoon, after the external temperatures had risen, the temperature within the burrow was several degrees lower.
3. Relative humidity was always higher in the burrows than on the outside. With few exceptions, values above 90 percent relative humidity existed.
4. Reduction of the relative humidity outside the burrows resulted in lower relative humidity in the accessible part of the burrows.

ECTOPARASITE STUDIES

During the report period, 34 wild rats were trapped at a stockyard and in undusted barrack-type buildings. These animals were bled for typhus complement fixation and combed to determine what ectoparasites each carried. These arthropods were separated according to species, ground in saline, and injected intraperitoneally into normal white rats. The purpose was to determine which parasites are involved in typhus transmission. Results were checked by complement-fixation tests.

Of 34 animals trapped, only three showed a positive complement-fixation test for

typhus. Combings of rats produced the following ectoparasites: *Echinolaelaps echidninus, Polyplax spinulosa, Xenopsylla cheopis,* and *Laelaps nuttali. E. echidninus* and *P. spinulosa* were the two species found in greatest abundance.

Intraperitoneal injection of ground ectoparasites produced no indication of endemic typhus in any animal. None of the rats with positive complement fixation had enough ectoparasites to warrent injection into other rats.

Veterinary Division

The division continued its activities in rabies investigations at Montgomery, Alabama; brucellosis in Indiana, Arizona and Utah; *Salmonella* diseases in Michigan; histoplasmosis in Kansas; and a general program in Colorado.

Q FEVER IN CALIFORNIA

In response to an urgent request from State Veterinarian Dr. A. E. Carr, a visit was made to California to determine the extent of Q fever and what assistance could be rendered to the state in developing a program. The result of this survey is a cooperative study at Hamilton, Montana. Dr. Herbert Stoenner of the Veterinary Division is assigned to this project. He is attempting to determine the extent of the disease in the udders of cattle. Other investigations are being carried on; namely, complement fixation and agglutination titers of animal serum.

DATA ON PSITTACOSIS COLLECTED

Late in the second quarter, the responsibility of collecting data on the incidence of psittacosis was placed on this division. Arrangements were made with all field personnel to take surveys of their respective states. All surveys have been completed. Results have been forwarded to the States Relations Division, Washington, D. C. The survey indicated there was much objection to the interstate quarantine regulations which prohibit the interstate shipment of psittacine birds. In many areas of the country, new aviaries were developed within states, especially in northern states, that have not been able to compete previously with western states in bird production. In some states that have formerly been exporting areas, the number of bird aviaries has diminished. No new information was obtained about any epizootics of psittacosis in birds, nor were any additional human cases revealed. A study is being carried on at the St. Louis Medical School which may give information about human cases. This school is conducting a survey of 5,000 serums which were obtained from atypical pneumonia patients in the St. Louis area during the winter of 1947 and 1948. This information should be available by the fall of 1948.

MUSTARD GAS RABIES VACCINE STUDIES COMPLETED

The rabies laboratory completed its studies with mustard gas rabies vaccine. Preliminary reports indicate that this vaccine is not as effective as the present phenol treated vaccine. Studies were also carried on with various types of rabies challenging agents in white mice. Other studies are being continued in pseudorabies (Aujeszky's disease) in mice. Dr. Ernest S. Tierkel is the first investigator to report adoption of Aujeszky's virus to experimental mice.

RABIES IN MEMPHIS, TENNESSEE

Late in the quarter, an urgent request was received from the Tennessee Department of Health for assistance in an outbreak of rabies in Memphis. Dr. Tierkel spent two weeks in Memphis organizing an immunizing program for vaccinating 23,000 animals during that period. It is too early to determine what its effect has been. Following the publicity of this campaign, many other

states and cities have requested the services of Dr. Tierkel. He has also appeared on numerous programs, and has been requested to write articles for farm, livestock, and pet magazines.

BRUCELLOSIS STUDIES MADE IN ARIZONA

Brucellosis studies in Arizona revealed that about 5 percent of the population were reactors and that 7½ percent of the animals were infected. The result of this survey was a demand for the enactment of legislation to control the disease. Proposed laws would require the testing of all animals producing milk for raw consumption. Animals that were found to be infected were to be quarantined until they were sent to slaughter. At first, this request aroused considerable antagonism. But after public interest was aroused, all opposition disappeared.

SERUM STUDIES IN UTAH COMPLETED

A study of 25,000 human serum samples was completed in Utah. Epidemiological investigations were delayed because of Dr. Stoenner's work with Q fever. But they are expected to be completed this summer.

RURAL SURVEY OF BRUCELLOSIS COMPLETED IN INDIANA

In central Indiana, the U. S. Bureau of Animal Industry assigned two veterinarians and their mobile laboratory to a rural survey of brucellosis in central Indiana. These reports have just been completed. Data will be available for the annual report. These surveys can only be carried on from late fall until early spring when blood serum can be collected from farm people.

MONIES ASSIGNED FOR WISCONSIN *BRUCELLA* INVESTIGATION PROJECT

In Wisconsin, the Children's Bureau assigned monies to the *Brucella* investigations project. It has been difficult to obtain a man for the position who is trained in epidemiological methods.

DOG INVESTIGATION PROJECT COMPLETED IN MICHIGAN

At the *Salmonella* project in Michigan, the dog investigation work was completed. Data is now being analyzed and will be available for the next report. Preliminary information indicated about 20 percent of the dogs could become carriers of the disease with no clinical symptoms. Some experiments were carried on with very young puppies. The mortality was no different than with adult animals. But when secondary conditions were present, the disease was very fatal in puppies. Dr. Wolff investigated a number of food poisoning epidemics which are now under study.

HISTOPLASMOSIS INVESTIGATIONS MADE IN KANSAS

Histoplasmosis investigations were made in various parts of Kansas. The incidence of animal reactors closely correlated with human reactors. In Eastern Kansas, no human reactors were found. In East Central Kansas, around Topeka, about 5 percent of the cattle tested were reactors. This is on the border of the area where there is considerable human infection. An additional case of histoplasmosis in a dog was reported by the veterinary clinic at Kansas State College, Manhattan, Kansas. Some dog experimental work was also inaugurated. Preliminary results indicated that dogs could be infected very readily, provided a sizeable challenging dose is used.

COLORADO INAUGURATES FIRST REPORTING SYSTEM OF ANIMAL DISEASES BY VETERINARIANS

The Colorado general program inaugurated the first reporting system of animal diseases by veterinarians to the state health authorities. Since this project has been announced, many other inquiries have come in from other states asking about its operation. Georgia has also inaugurated a similar reporting system.

In Colorado, Dr. Baum has seen two rabies outbreaks during the past quarter. These were combatted from the state level by having the state provide free vaccine and having local veterinarians contribute their time. Dr. Baum assisted in a considerable number of clinics. In some areas, he has immunized dogs where there are no veterinarians. Dr. Baum also investigated a major food epidemic in which 200 people became

ill. Meat loaf from which paracolon organisms were isolated caused the epidemic. These organisms are now under study by Dr. Edwards at the *Salmonella* testing center. Dr. Baum has been appointed by the governor to report on the public health aspects of brucellosis in Colorado and make recommendations to him. He has also reported the occurrence of listerellosis in cattle and sheep in North Central Colorado. This disease causes encephalitis in animals and has been reported as the cause of disease in man. It is a bacteria and can be readily grown on blood agar. Dr. Baum delivered a number of lectures to agricultural and veterinary groups in Colorado and neighboring states during the third quarter.

THREE STATES INAUGURATE VETERINARY PROGRAMS

Three additional states inaugurated veterinary public health programs during the past quarter. Ohio, Illinois, and Florida employed full-time public health veterinarians. Assistance was requested by these states in developing their programs. During the quarter, seven additional states asked for the assignment of personnel to develop veterinary programs. These were: Texas, Nebraska, Wisconsin, Iowa, West Virginia, Maryland, and South Carolina.

Training Division

TRAINING STARTED IN HOUSING EVALUATION METHODS

Practical field training in housing evaluation methods began in January. Allan Twichell, Consultant on Housing, spent several days during February assisting with housing training in cooperation with the Atlanta City Health Department. As Technical Secretary of the American Public Health Association Committee on the Hygiene of Housing, Twichell approved housing training methods developed by S.A. Engineer Ross Buck.

NEW YORK STATE-RENSSELAER COUNTY TRAINING CENTER BEGUN

The New York State-Rensselaer County Public Health Training Center started on January 5, 1948, under direction of Training Officer Joseph F. O'Brien. A twelve weeks training program for sanitary inspectors was the first course offered. Ten trainees from up-state New York attended. Cooperation received from District Office No. 1, from the New York State Health Department, and from the Troy-Rensselaer County Health Department was outstanding.

TRAINING OPERATIONS STARTED AT CINCINNATI

During March, the first training program at the Water and Sanitation Investigations Station at Cincinnati, Ohio was organized and conducted. S. A. Engineer (R) Donald J. Schliessmann, Training Officer, reported a successful course in stream pollution control in which sanitary engineers from 18 states participated.

LOAN OF TRAINING OFFICERS TO STATES IS SOUND POLICY

It became evident during the quarter that the policy of cooperation with state training stations, through loan of training officers to states was a sound one. Training Officers Ralph Barnes and Clyde Fehn assisted Louisiana with training programs for insect and rodent control.

PLANS INITIATED FOR TRAINING EVALUATION

Miss Mary Garretson was placed in charge of evaluation of field training activities. Forms were developed in cooperation with the several field training stations. These will be used to follow up each trainee through state health departments. It is hoped that the worth of practical field training as a supplement to academic study will be demonstrated.

INSECT AND RODENT CONTROL BRANCH

The four weeks training course in Rat-

Borne Disease Prevention and Control for the period February 15 — March 12 was attended by twenty-one men. Fourteen were from the United States; seven were from China. The group included representatives from state and local health departments, the pest control industry, the Chinese Quarantine Service and the Chinese Plague Prevention Bureau.

A special one week course in insect control was given March 22 — 26 for the seven trainees from China. Two trainees from Detroit also took this course. It consisted of field work on DDT residual spraying; mist larviciding; identification and control of flies, mosquitoes, bed bugs, lice, roaches, sandflies, ticks, and mites.

Fifteen men from health departments of five foreign countries received training in the Insect and Rodent Control Branch during the quarter.

DECENTRALIZED TRAINING PROGRAMS

Two decentralized training courses in insect and rodent control were held during the quarter in Norfolk, Virginia and in New Orleans, Louisiana. Courses were given in cooperation with respective state health departments and PHS Districts No. 2 and No. 4. Representatives of the New Orleans City Health Department also aided in arranging and conducting this training.

ACTIVITIES OF FIELD TRAINING STATIONS

FIRST COURSE COMPLETED AT THE WATER AND SANITATION INVESTIGATIONS STATION, CINCINNATI, OHIO. A three weeks training course for state sanitary engineers, or other persons charged with over-all organization and operation of state stream pollution abatement programs, was carried out. Fifteen full-time trainees took the course. Four other trainees attended classes for a period of one week.

Plans were completed for the two weeks course for bacteriologists in charge of milk analyses or food utensil examinations in state health departments. A registration of 15 persons was accepted for the April course. The number of applications received for the course warrants the rescheduling of it in the next fiscal year. The milk and food work will be supplemented by a week on water bacteriology.

SAVANNAH FIELD TRAINING STATION, SAVANNAH, GEORGIA

A three months program of field training for three health educators was started. Arrangements were concluded for accepting graduate public health education students from the Schools of Public Health of the University of North Carolina, Minnesota, and Yale in June, July, and August.

TOPEKA FIELD TRAINING CENTER, TOPEKA, KANSAS

In February a two weeks course combining field trips and seminars was conducted for selected members of the Kansas State Board of Health and the Milk Control Division of the Kansas State Board of Agriculture. Eight individuals participated in the course.

In March, the three months course for sanitarians was started.

Production Division

PRODUCTIONS RELEASED:

1. 4-056.0 Diagnosis of Tuberculosis with an Improved Culture Medium
2. 4-063.0 Schistosomes, Adults in the Veins
3. 4-064.0 Cercariae of *Schistosoma mansoni*
4. 4-065.0 The setting of Endemic Schistosomiasis in Puerto Rico
5. 4-068.0 Pathology of *Schistosoma mansoni*
6. 4-069.0 Malaria Control in the Kentucky reservoir (Composite of 4 chapters)
7. 5-022.0 Hospital Commission Report
8. 5-030.0 Life Cycle of Malaria Parasite
9. 5-035.0 The Lung
10. 5-040.0 Falciparum Malaria
11. 5-043.0 Vivax Malaria
12. 5-073.0 Hookworm Disease and Hookworm Infection
13. 5-085.0 Closing In
14. 5-090.0 Spread and Prevention of Trichinosis
15. 5-095.0 Worms in Your Muscles
16. 5-101.0 Field Training Stations

17. 5-105.0 Laboratory Diagnosis of Rabies
18. 5-106.0 The Liver
19. 6-001.0 Rabies Exhibit
20. 7-002.0 Mycobacterium Tuberculosis on Specific Culture Media
21. 9-006.0 Mycobacterium Tuberculosis on Specific Culture Media
22. 9-105.0 Laboratory Diagnosis of Rabies
23. 10-004.0 Cancer Series-Techniques of Cancer Nursing (Series A—March 5, 1948)
24. 10-004.1 Cancer Series-Techniques of Cancer Nursing (Series A—April 5, 1948)
25. 10-004.2 Cancer Series-Techniques of Cancer Nursing (Series A—June 5, 1948)
26. 10-005.0 Cancer Series — The Visiting Nurse and Cancer (Series B-April 5, 1948)
27. 10-009.0 Cancer Series-Techniques of Cancer Nursing (Series C—April 10, 1948)

PROJECTS RELEASED:

1. 1-001.0 Film Organization
2. 2-001.0 Entomological Chart—Mosquito Larvae of U. S.
3. 2-002.0 Organizational Chart (Stacktype) of the Production Branch.
4. 2-003.0 Distribution Charts for Utilization Branch
5. 8-002. 0 "Flea" Photographs Ordered by Editorial Branch
6. 8-003.0 "Colonnades" Photographs Ordered by Editorial Branch
7. 8-005.0 Photograph for CDC Bulletin (July-August-September)
8. 8-006.0 Seven Contact Prints Ordered by Editorial Branch
9. 9-001.0 Appearance of Different Types of Tubercle Bacilli on Different Culture Media
10. 9-002.0 Film Organization
11. 10-001.0 Appearance of Different Types of Tubercle Bacilli on Different Culture Media
12. 10-002.0 Appearance of Pathogenic Fungi on Culture Media
13. 10-003.0 Film Organization
14. 10-008.0 Fifty-six Lantern Slides of Field Training Stations.

PROGRAM ACTIVITIES OF THE PROJECT DEVELOPMENT BRANCH

Three conferences were held with project supervisors during January on check-control points of script development. A working manual of progressive check-points was prepared and is now in use. Subsequent conferences on production and utilization check-points have been planned.

Following a series of March conferences with Floyde E. Brooker, U. S. Office of Education, there was begun a re-examination of criteria used for film initiation, production flow patterns, successful utilization, etc. A project supervisor's check list, resulting from these conferences, is in process of being developed.

A black and white experimental category film strip on diagrams contained in the Hospital Commission Report is in production. This strip is being prepared in conjunction with the Conference of Professors of Preventive Medicine. The experimental filmstrip is designed to supply slide material to teachers of preventive medicine. It is being used as a test project for future handling of similar material.

Several experimental study films were completed. They were designed for advanced students of parasitology and produced as a by-product of the biology unit, "Manson's Blood Fluke." Manuals to accompany these films are being prepared. This constitutes an experiment in utilization of waste footage and an experiment in small audience utilization.

Initiation of the series on anatomy and pathology film strips was begun. These film strips are being made in pairs. One is made on the normal anatomy of an organ and the other on the pathology of a communicable disease involving that organ. Both film strips will be released simultaneously.

The experiment on film shorts is continuing, and certain biological subjects are in production.

A series of film shorts on epidemiology, being made particularly for professors of preventive medicine and public health, has begun.

Collaboration with the T. B. Control Division and with the Laboratory Division was completed on "Diagnosis of Tuberculosis with an Improved Culture Medium." The production was released during March.

PROGRAM ACTIVITIES OF THE PRODUCTION BRANCH

A Technical Services Section was activated in order to coordinate all efforts in processing of motion picture films and film

strips. By processing locally, production schedules will be accelerated on all releases. A great deal of Motion Picture and Still Laboratory equipment was secured during the quarter. Eventually, after installation of other equipment, the Production Branch will be independently free from all outside contractual services.

PROGRAM ACTIVITIES OF THE UTILIZATION BRANCH

Distribution of 858 films was accomplished during the quarter as compared with 340 films distributed during the second quarter. Distribution rates will probably continue to climb as more medical and other authorized agencies learn of the availability of films and as the number of releases increases.

In accordance with an agreement between members of the Interdepartmental Committee to exchange prints between agencies concerned, one print of each of our films was placed on deposit with the Army, Navy, Air Forces, and Veterans Administration. These films are for reference purposes and not for distribution.

PRODUCTION PROGRAM FOR THE VENEREAL DISEASE DIVISION

Work on a series of film strips and motion pictures on syphilis and other venereal diseases was begun and is progressing satisfactorily. The films are being made for showing to medical students, private physicians, and venereal disease control personnel.

Motion picture and still photography of venereal disease cases, in both black and white and in color, is continuing at the Public Health Service Medical Center, Hot Springs, Arkansas. Greater emphasis is on coverage of still pictures. This photography is being done by a Public Health Service cameraman temporarily assigned to Hot Springs.

A great deal of picture material on venereal disease cases, both motion picture and still, was shipped to the CDC Production Division for editing, indexing, and filing. Summarized case histories of patients photographed were also sent.

Teaching films for physicians and medical students are being designed to cover diagnosis and treatment in various stages of syphilis and other venereal diseases. Priority is given to film strips on syphilis.

Non-technical film strips and motion pictures for showing to venereal disease control personnel are planned. They will cover such subjects as contact investigation practiced by county health personnel in various counties of the South and will show results obtained.

ACTIVITIES OF THE INTERDEPARTMENTAL COMMITTEE

The Chief of the Division attended meetings of the Interdepartmental Committee on Medical Training Films in January and March. Current production of films and Fiscal Year 1949 schedules were cleared.

The Interdepartmental Committee continued to cooperate with the Audio-Visual Committee of the AAMC in promoting organization of the Medical Film Institute. A Director for the Institute was selected. Activation of the program awaits the raising of sufficient funds.

A distribution policy was agreed upon. Air Forces, Army, Navy, and VA will send one print of each new release to CDC for the permanent files. CDC will forward for retention one print of each new release to the Washington offices of the four agencies mentioned above. Each Washington office will circulate a print of each of its new releases to the other Washington offices concerned; then retain it in the originating office where other agencies can readily obtain it for future loan needs.

FOURTH INTERNATIONAL CONGRESSES ON TROPICAL MEDICINE AND MALARIA

The Chief, Production Division, served in Washington during February as a member of the Exhibit Conference, Fourth International Congresses on Tropical Medicine and Malaria. He also served on the film selection board for films to be shown at this conference.

Library and Reports Division

EDITORIAL BRANCH

An orientation manual for new employees and newly commissioned officers of the service issued during the quarter has met with wide acceptance among component activities. Published under the title "...for the Nation's Health", the manual is an attempt to cover authoritatively and interestingly the many aspects of this problem for those desiring a recapitulation. From Denver, Colorado, New York City, and other state agencies statements have been received that the manual is being found generally comprehensive for its intended purposes.

The report of activities of the Communicable Disease Center during the fiscal year 1946-1947 is now in the hands of the printer and will be issued in the near future.

Theodore G. Thress, formerly of the Veterans Administration, replaced S. A. Sanitarian (R) Melvin H. Goodwin, Jr., as Chief of the Library and Reports Division on March 1. Goodwin was appointed Chief of the Malaria Investigations Branch of the Entomology Division.

LIBRARY BRANCH

Librarians began work on a catalogue for the library of the Technical Development Division in Savannah. At the end of the quarter 1,558 cards were completed.

A survey has been completed of duplicate volumes received from various sources as gifts. A list of this duplicate material has been sent to the Medical Library Association with the view of exchanging volumes.

During the quarter, 355 books were cataloged and 2,862 cards were typed and filed. The following is a selected list of new books in the library:

American Can Company, "The Canned Food Reference Manual," 3rd edition, 1947.
American Society of Mechanical Engineers, "Rules for Construction of Unfired Pressure Vessels," 1947.
Bamford, Frank, "Poisons, Their Isolation and Identification," 1947.
Besterman, Theodore, "A World Bibliography of Bibliographies," Vol. 1, 2nd ed., 1947.
Brady, George Stuart, "Materials Handbook," 6th ed., 1947.
Brumpt. Emile, "Travaux Pratiques of Parasitologie," 4th ed., 1946.
Engeln, Oscar Diedrich von, "Geomorphology; Systematic and Regional," 1948.
Flesch, Rudolf Franz, "Art of Plain Talk," 1946.
Fradkin, William Zev, "The Diagnosis and Treatment of Diarrheal Diseases," 1947.
Great Britian Ministry of Health — "National Health Service," 1944.
Gruber, Charles Merl Michael, "Handbook of Treatment and Medical Formulary," 1948.
Kellog, Charles Edwin, "Soils That Support Us," 1947.
Kraetzer, Arther Furman, "Procedure in Examination of the Lungs with Special Reference to the Diagnosis of Tuberculosis," 3rd ed., 1947.
Lillie, Ralph Dougall, "Histopathological Technique," 1948.
MacKee, George Miller, "Skin Diseases in Children," 2nd ed., 1946.
May, Charles Henry, "Manual of Diseases of the Eye," 19th ed., 1947.
Mycopathologia, (Periodical-Current Subscription)
National Association for the Prevention of Tuberculosis, Tuberculosis Index and Abstracts of Current Literature. (Periodical — Current Subscription)
Neuner, John Joseph William, "Office Management and Practices," 2nd ed., 1947.
Osuna, Aníbal, "La difteria en Caracas durante el quinquenio," 1941 a 1945.
Oudemans, Anthonie Cornelia, "Kritisch Historisch Overzicht der Acarologie," 8 volumes, 1926-37.
Polonovski, Michel, "Biochimie Medicale," 3rd ed., 1947.
Rafferty, Theodore Newell, "Artificial Pneumothorax in Pulmonary Tuberculosis," 1947.
Richter, Victor von, "Organic Chemistry," 4 volumes, 1934-47.
Rigler, Leo George, "The Chest — A Handbook of Roentgen Diagnosis," 1946.
Robinson, Harry Maximilian, "Practical Dermatology and Syphilis," 1947.
Ross, Herbert Holdsworth, "The Mosquitoes of Illinois, (Diptera Culicidae)," 1947.
Sanchís-Olmos, Vincente, "Skeletal Tuberculosis," 1948.
Smillie, Wilson George, "Public Health Administration in the United States," 3rd ed., 1947.
Stone, Moses Jacob, "Diagnosis and Treatment of Pulmonary Tuberculosis," 1946.
Swingle, Deane Bret, "General Bacteriology," 2nd ed., 1947.
"Thomas Register of American Manufacturers," 1948.
Tubercle (Periodical — Current Subscription)
Turner, Clair Edsmere, "School Health and Health Education," 1947.
U. S. Office of Scientific Research and Development. Committee on Medical Research, "Advances in Military Medicine," 1948.
U. S. Bureau of the Census, "County Data Book," 1947.
"War Reports of General Marshall, General Arnold, Admiral King," 1947.
Wechsler, Israel Spauer, "Textbook of Chemical Neurology," 6th ed., 1947.
ZoBell, Claude Ephraim, "Marine Microbiology," 1946.

IDEA EXCHANGE

A SYNTHETIC RESIN EMBEDDING TECHNIC

by
ENTOMOLOGIST RICHARD H. FOOTE
CDC Laboratory Division

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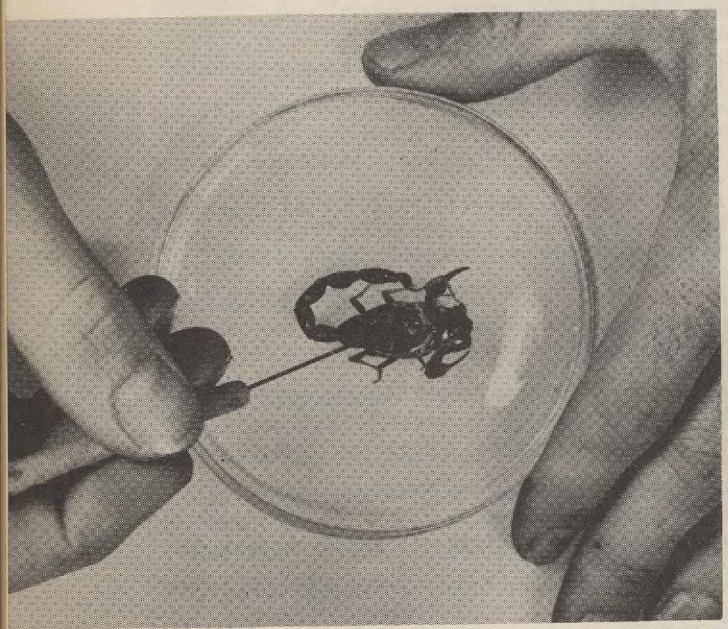

Although biological specimens have been embedded in synthetic resins for several years, many early preparations had the disadvantage of removing color from specimens. They also required a long and complicated curing process. In some cases, clouding made it difficult to see the specimen after the resin cured.

Recently, commercial houses have perfected several new synthetic compounds which are relatively easy to use, do not remove colors from specimens, and do not produce much shrinkage. The new media have been found to be useful in preserving such arthropods as insects, spiders, scorpions, centipedes, millipedes, ticks, and other specimens frequently used in teaching medical entomology. Plant specimens may also be preserved for display purposes.

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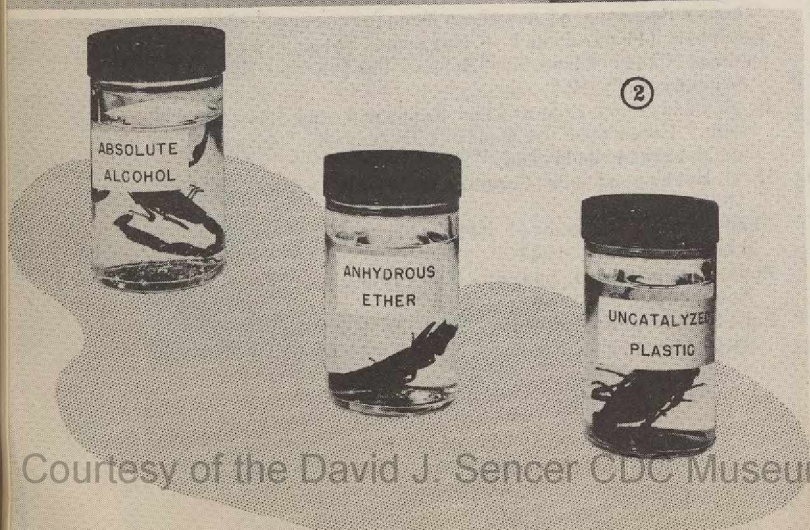

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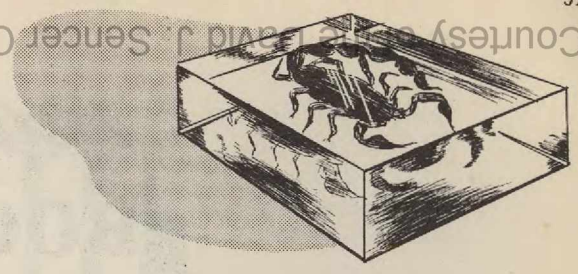


1. After specimen is collected in the field and preserved in 70 to 95 percent alcohol, it is necessary to make openings in the body cavity. This is done with a needle or insect pin in order to obtain thorough penetration of fluids involved and to allow complete impregnation of the specimen by the synthetic resin. The holes thus made are not visible in the finished block.

2. After pricking, specimen is placed first in absolute alcohol, then in anhydrous ether. Each of these steps requires from one hour (for small arthropods) to 24 hours (for larger forms) and are necessary to remove all traces of water from the specimen, since moisture will cause the block to become cloudy. Immersion in plastic follows.

3. Specimen is transferred to uncatalyzed plastic directly from anhydrous ether, and placed in a desiccator under reduced pressure of 500 to 700 mm. This evaporates all of the ether in the specimen, and aids in plastic impregnation. The desiccation must be accomplished slowly. It is completed when all the small bubbles have stopped rising to the surface.

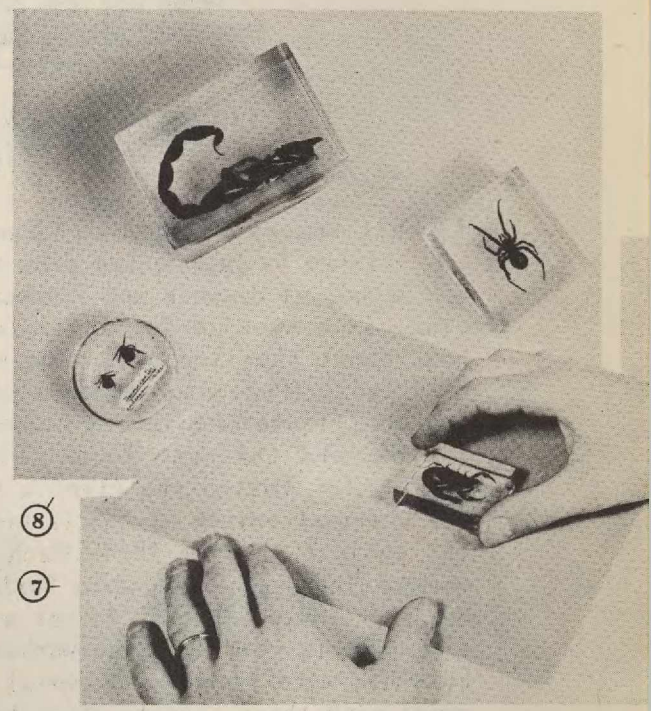
4. To the amount of plastic required to fill mold, add one to five drops of catalyst and stir thoroughly. After all of the bubbles have risen to the surface, the base layer (Step 5) is poured and the remaining catalyzed plastic is stored in a refrigerator to inhibit polymerization until the base layer has "set" at room temperature.

5. The base layer is poured into the mold to the depth indicated below by the top dark line in the picture and allowed to "set" at room temperature. The plastic containing the specimen is then catalyzed in the manner shown in Step 4. Specimen is lightly grasped with forceps and gently moved with a circular motion until specimen is surrounded by catalyzed plastic, then specimen is oriented in the mold and enough catalyzed plastic is poured in to completely cover it.

6. The mold is set aside until all the plastic has gelled at room temperature. It is then baked in an oven at 125 — 140° F. until the plastic has been completely cured. This is accomplished when the plastic becomes hard and readily separates from the glass mold. Higher curing temperatures cause air bubbles to form around the specimen, giving it an opaque silvery sheen.

7. After curing is complete, a thin soft layer of plastic will remain on the surface exposed to the air. This may be removed by sanding. The block is sanded first with coarse sandpaper (#1 or #2), and then with fine (00) sandpaper. It may be given a final polish with jewelers rouge or pumice on a soft cloth or buffing wheel.

8. Specimens ready for display.



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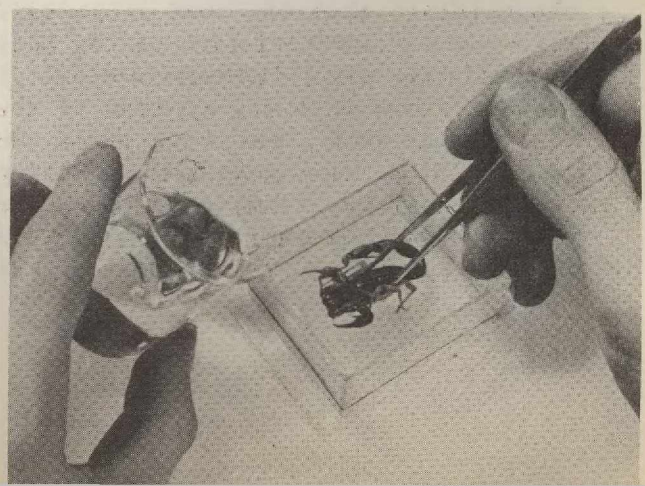

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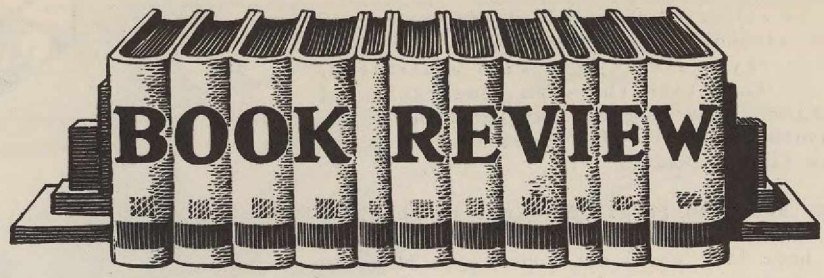


THE LOUSE by Patrick A. Buxton; the Williams and Wilkins Co., Baltimore; 1946; 47 figs.; 14 tables; 164 pages; $3.25.

This second edition of "The Louse" written by Dr. Buxton from the London School of Hygiene and Tropical Medicine, is a most useful and informative book about the lice affecting man: the head louse (*Pediculus humanus capitis*), the body louse (*Pediculus humanus corporis*), and the crab louse (*Phthirus pubis*). Dr. Buxton has given a thorough and critical review of the literature on the subject through 1944. Much Russian work on louse control during World War II has been included which is not available elsewhere to most American workers. Many comments were based on personal experiences with these insects which he reared on himself during 1917 and "again (not continuously, but most of the time) from 1934 to the present date (1944)."

The first three chapters cover general taxonomy, biology, external and internal anatomy, well illustrated by excellent figures, and individual and collective biology, much of which is based on Buxton's personal researches with these insects in England, Africa, and India. Buxton follows current usage in recognizing only one taxonomic species of the head and body lice (*Pediculus humanus*). He disagrees, however, with contemporary entomologists who maintain that the head louse will assume the characteristics of the body louse (larger size, lighter color, etc.) when confined in boxes applied to the skin of the body, and vice versa. He states, "After many generations of being reared under identical conditions the head and body lice remained distinct in general appearance", and "inasmuch as the differences between them seem greater in biology than in anatomy they should be referred to as biological or physiological races...they might be called 'species in the making'".

Chapter IV deals with the "Medical Importance of *Pediculus humanus*". Human lice are known to transmit typhus fever in Europe, Africa, China, India, and Central and South America. There is a good account of epidemic and endemic typhus and the possibility of one type gradually becoming the other. American typhus workers designate the causative agent of endemic typhus as *Rickettsia prowazeki* de Rocha Lima (1916), *Rickettsia typhi* Wolbach and Todd (1920), or *R. prowazeki var. mooseri* Monterio (1931). Buxton rather consistantly calls this organism *Rickettsia muricola* which dates from 1932. The author emphasizes that the rickettsiae causing typhus fever are transmitted to man thru the louse feces, rather than the insect bite, although "it is not possible to state which of these routes, through broken skin, the eye, or the respiratory tract, is the commonest under natural conditions". In discussing relapsing fever he states that the "spirochaeta is in the body cavity of the louse from which it can only escape if the insect is torn or crushed" During World War I the "cootie", or body louse, was the vector of Trench Fever which apparently has disappeared since 1914-1918.

Chapter V on "The Control of Lice" deals thoroughly with the earlier insecticides and mass delousing programs. The lousicides used at the beginning of World

War II (such as the thiocyanates) are discussed. Also, the American A. L. 63 and MYL and various insecticides used in Russia's war-wrecked cities are considered. The section on DDT is quite adequate. There is a good discussion of the powder and its use in mass delousing programs, clothing impregnation, and the use of a DDT hair emulsion for head lice. There is no account, however, of the use of DDT in the Naples typhus epidemic or its use in preventing wide-spread dissemination of typhus by delousing DP's and other war refugees. The book was finished in 1945 before this information was generally available.

Vaccine preparation by the laborious Weigl technique, which involves rectal infection of lice with rickettsiae, is mentioned in the final chapter. No mention is made of vaccines prepared from the chick embryo, which were used extensively in the Naples typhus epidemic; or of vaccines made from infected mouse or rabbit lung tissue, which was used in Mexico.

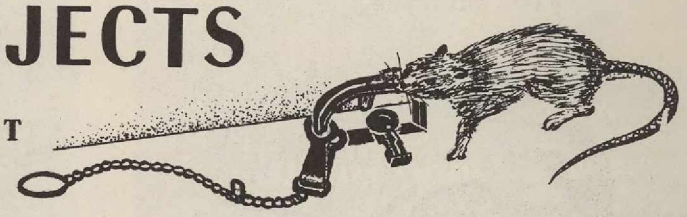
The bibliography and index appear to be satisfactory and complete.

"The Louse" is a valuable contribution to medical entomology and a book which every worker in public health would do well to have in his library.

— Harry D. Pratt

SPECIAL PROJECTS

PREVENTION OF RUST ON STEEL RAT TRAPS

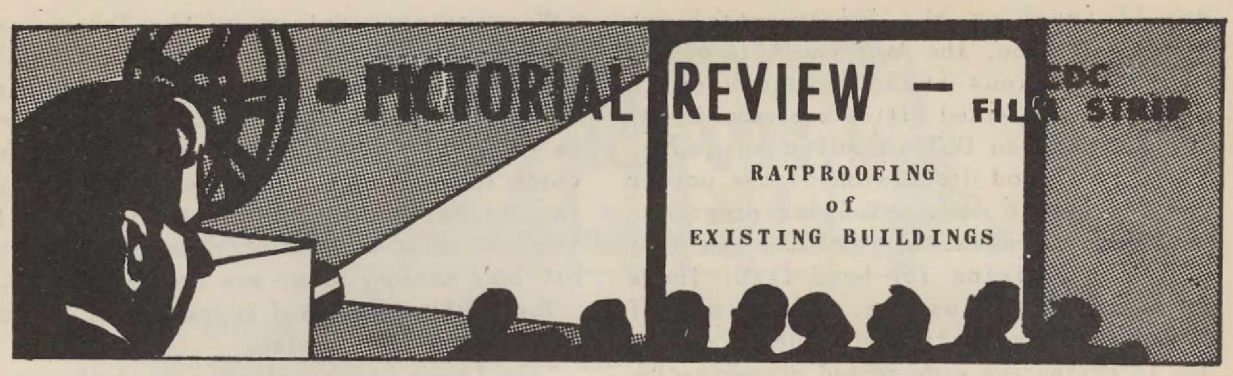


Methods for protecting steel traps against rusting and for removing rust from them have long been sought by rat trappers. Numerous suggestions have been made. Buffing followed by wiping with kerosene soaked cloths, or dipping in melted paraffin are two methods of protection. One of the most practical methods evolved has been the dipping of traps in a 17 percent solution of phosphoric acid. This not only removes rust but provides a coating somewhat resistant to further rusting.

Recently, two new suggestions have been made: dipping traps in a rubber-base plastic called Paraspray, and plating traps with cadmium. The former appears to provide good protection against rust when the traps are in storage, provided that traps are rust-free when dipped. Paraspray coating is not durable, however, and readily chips from traps which are in use, and metal surfaces are thus exposed to rusting.

Cadmium plating proved an economical as well as a satisfactory way of rust-proofing traps. These traps cost only 65 cents per dozen more than the cost of unplated traps. In a weathering test at Savannah, Ga., cadmium-plated traps and phosphoric acid-Paraspray dipped traps were exposed for a period of nearly five months. Rainfall was frequent during this period; therefore, traps were subject to periodic wetting. At the end of the test, cadmium-plated traps gave no evidence of rusting. Dipped traps were rusted in spots, although they were not in bad condition.

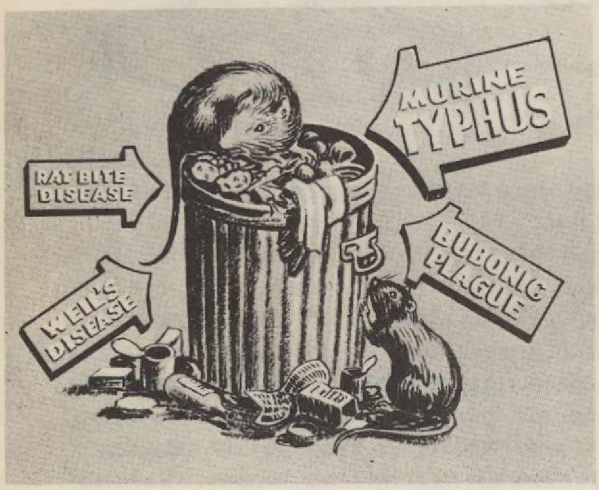
On the basis of small-scale trapping tests, no significant difference was detected in the efficiency of cadmium-plated traps as compared with that of phosphoric acid-Paraspray dipped traps for capturing *Rattus norvegicus*.



Production Number: 5-093.0 **Running Time: 14.4 minutes, 80 frames**

Ratproofing means the sealing of all possible building entrances to rodents. First, all entrances and possible means of entry are determined. Then appropriate steps are taken to eliminate each as a possibility of entry by rats. Thereafter, periodic inspections are made to maintain the effectiveness of the measures taken.

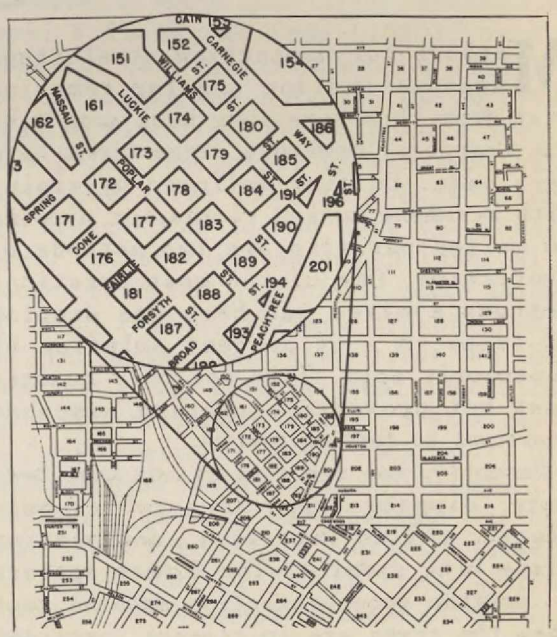
The film strip conveys advantageous "know-how" to field personnel working with ratproofing projects. Numerous examples are given for easy guidance.



1. These diseases and many so-called food infections are caused by rats.

2. Rat gnawing into food parcels and eating or damaging the contents causes an appalling annual economic loss in the United States.

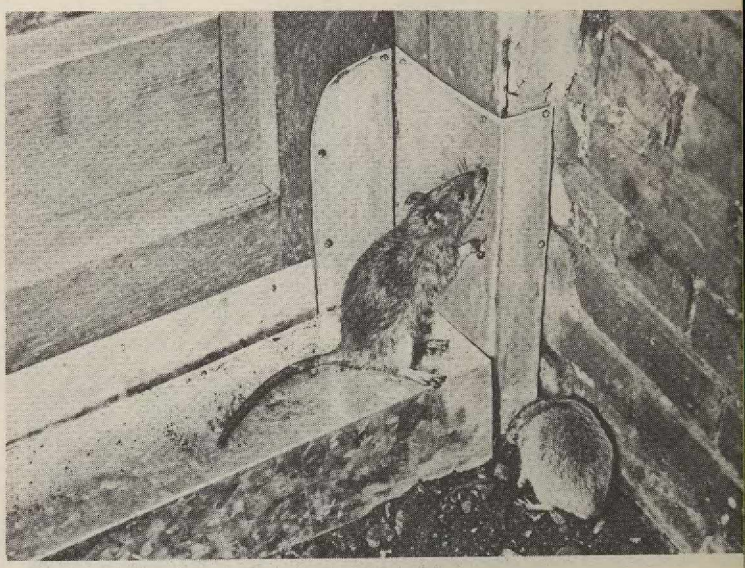
3. In effective rat control programs, the ratproofing of existing buildings is best planned and carried out on a "block by block" basis.



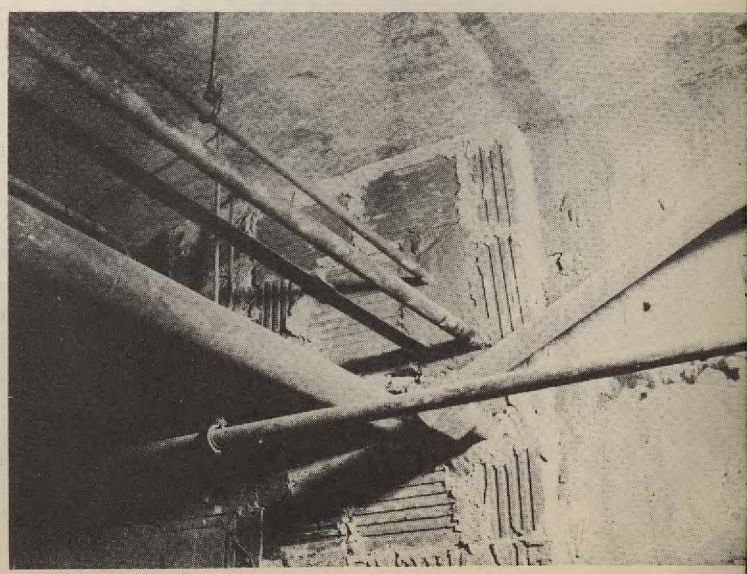
4. Building occupants are interviewed to determine rat infestation and damage, before each building is thoroughly checked for evidences of rat infestation. An estimation record is kept, as well as notations on a diagram of the building of items to be ratproofed.

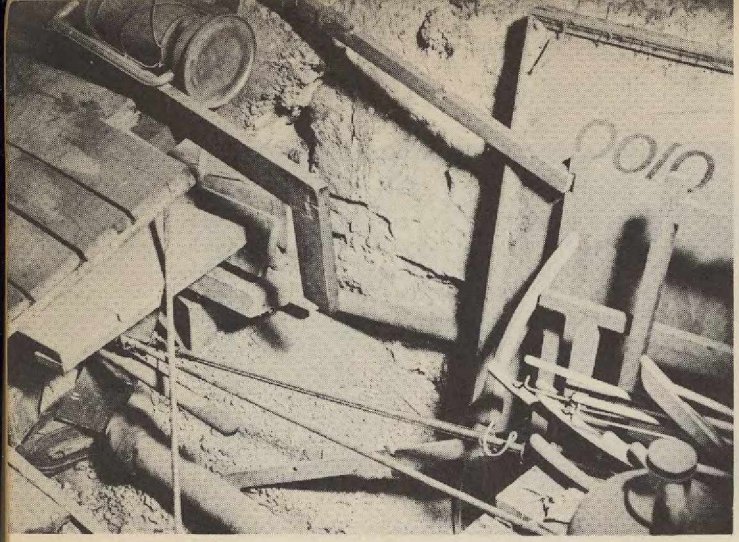
5. The gnawed hole in the door and the burrow under the wall typify rat entrances.

6. The same door, after a metal cuff and channel have been added, ratproofing that particular entrance.

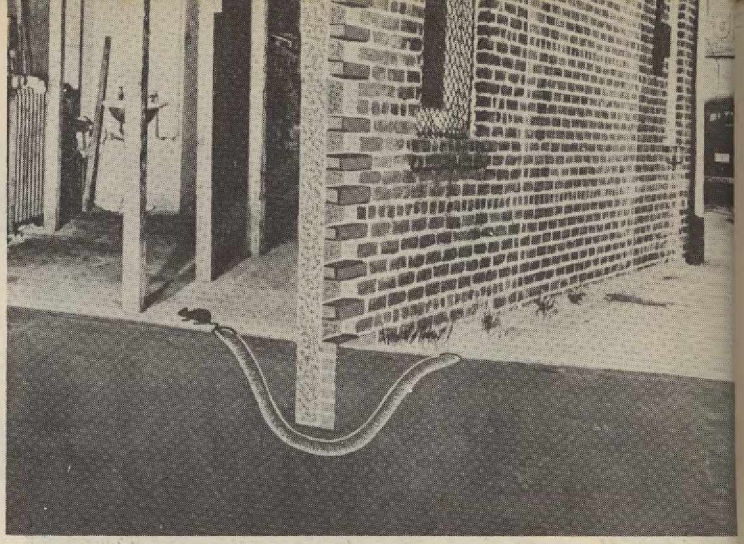


7 & 8. Plumbers often forget to completely close holes in walls where they have installed new piping. These rat entrances are closed by sealing with cement or mortar.

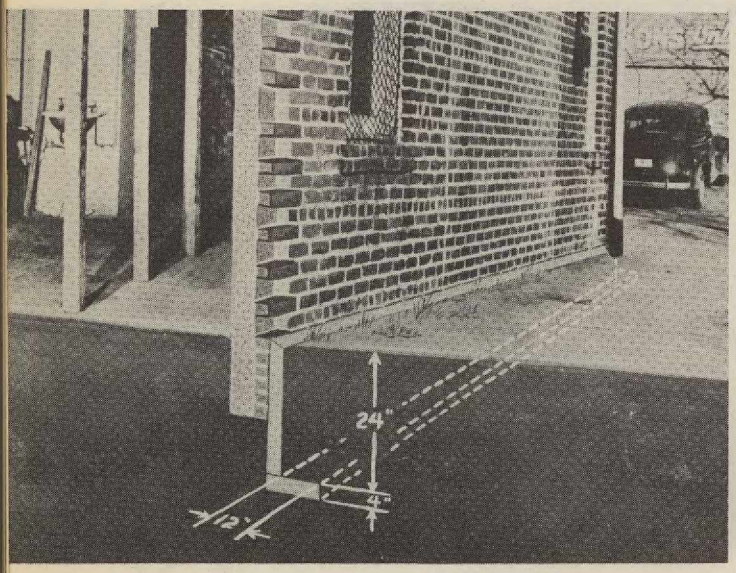




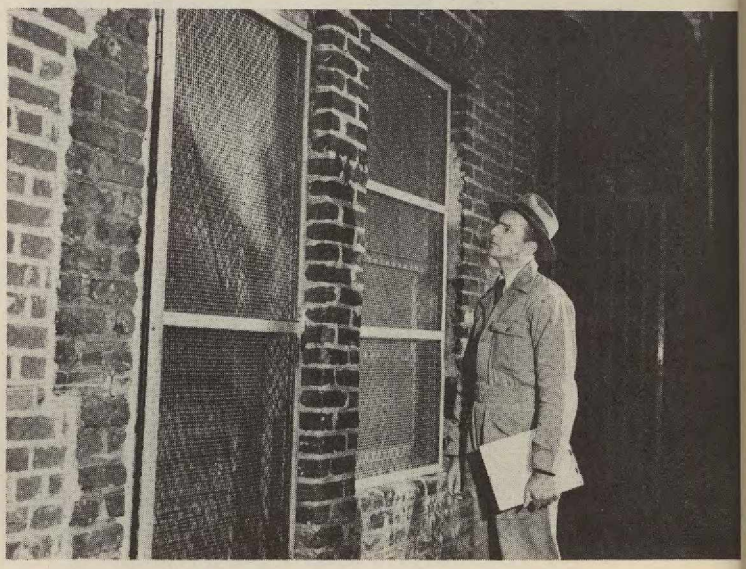
9. Accumulated debris in basements conceals rat entrances, and acts as rat harborage. Cooperation of the occupant of the premises in removing debris facilitates finding and sealing of rat entrances.



10. Rats will burrow under tight masonry foundation walls to gain entrance to a building.



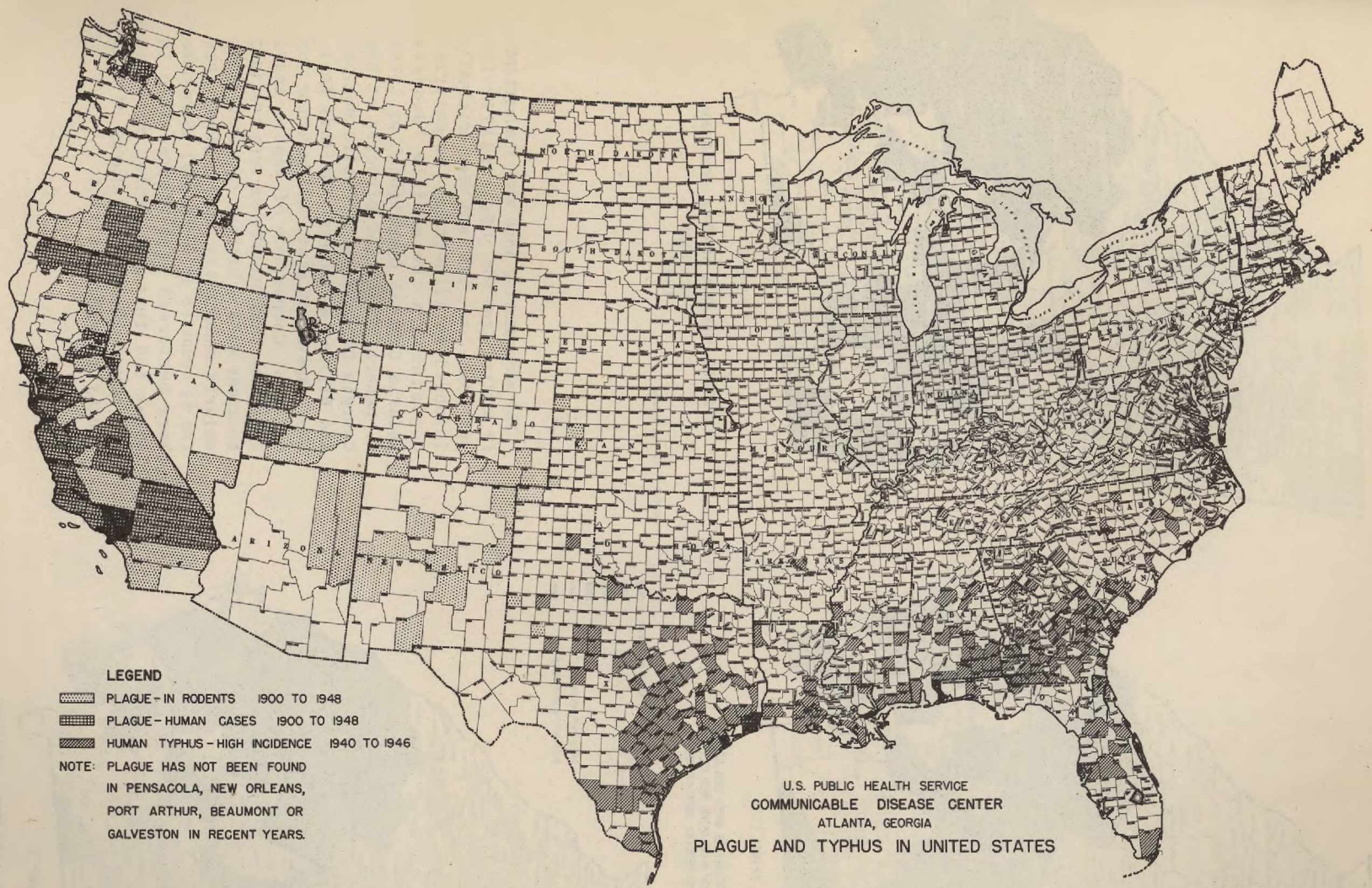
11. An "L" shaped wall on the outside of the building foundation discourages rats from burrowing by simulating an impervious floor.



12. Ratproofing effectiveness is maintained by periodic inspections every 30 to 45 days.

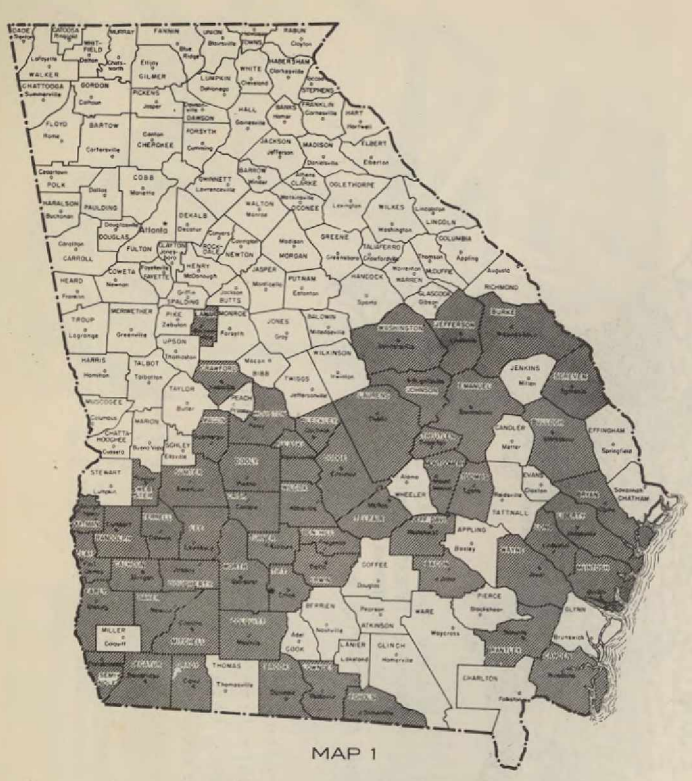
To obtain this film, address request to:

Production Division
Utilization Branch
605 Volunteer Building
Atlanta 3, Georgia



It should not be inferred that this map gives the complete picture or delineation of the actual area where plague infection has been or is present among wild rodents in western states. Nor does this map give a quantitive measure of infection. It merely shows where plague has been found.

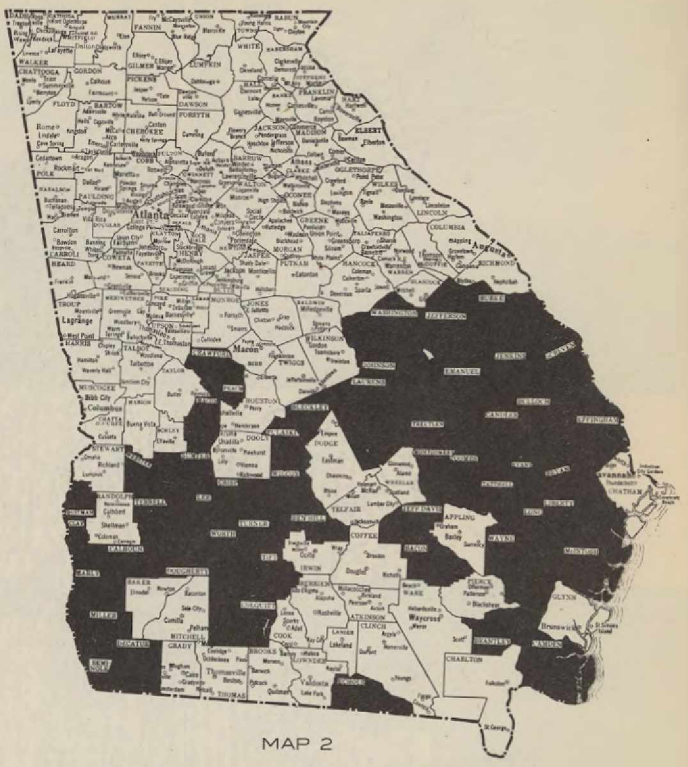
Forces engaged in field surveys, areas covered each year, and seasonal periods favorable for conducting surveys are limited.



MAP 1

55 GEORGIA COUNTIES WITH MALARIA
DEATH RATES OF 5 OR MORE PER 100,000
DURING THE PERIOD 1938—1942

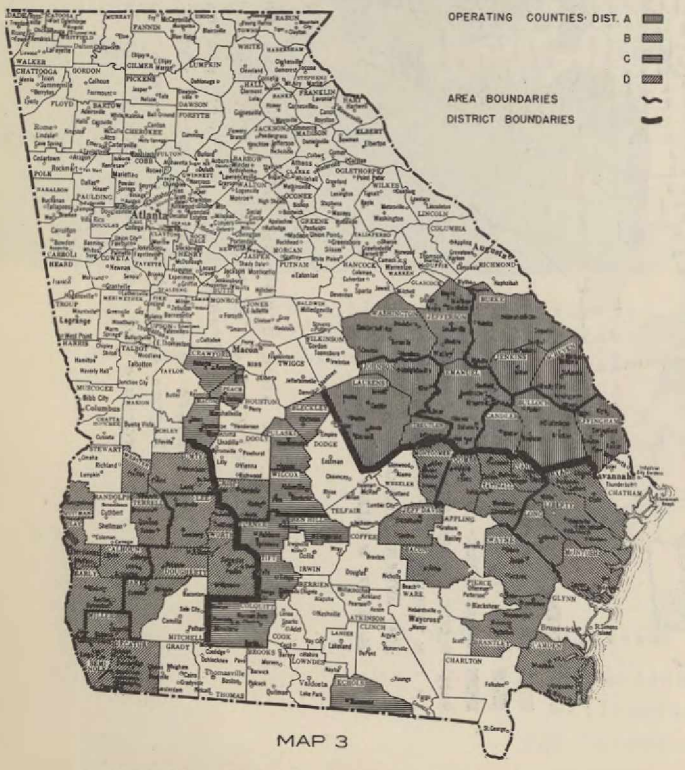
FSA PHS CDC ATLANTA, GEORGIA



MAP 2

EXTENDED MALARIA CONTROL PROGRAM
OPERATIONS
1947

USPHS-CDC ATLANTA, GEORGIA



MAP 3

EXTENDED MALARIA CONTROL PROGRAM
OPERATIONS
1947

USPHS-CDC ATLANTA, GEORGIA

The accompanying maps were inadvertently omitted from the *CDC BULLETIN* for April-May-June, 1948 and were originally intended to illustrate the material contained in the article "Georgia Malaria Control Operations" by Louva G. Lenert, State CDC Director of the Georgia Department of Public Health, and William A. Legwen, Sanitary Engineer, Assistant State CDC Director for Georgia. Comparison of Maps 1 and 2 indicates that operations were confined to areas with a history of significant malaria endemicity. Map 3 shows that the 51 counties in which 1947 operations were performed were grouped into 16 areas and four districts, with one supervisor employee in charge of each county area and district.