Rat, Flea, and Murine Typhus Recurrence Following Eradication Measures

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AN EXPERIMENTAL attempt to eradicate murine typhus was made in the rural southeastern quarter of Grady County, Ga., between July 3, 1953, and May 4, 1954. The experiment was considered a success and has been reported by Mohr and Smith (*1*).

The chief eradication measures used were intensive poisoning of commensal roof and Norway rats, *Rattus rattus* (Linnaeus) and *Rattus norvegicus* (Erxleben), and applying 10 percent DDT dust in rat runs to reduce the numbers of oriental rat fleas, *Xenopsylla cheopis* (Rothschild). Though lack of time for extensive studies and application of special treatments made it impossible to eliminate rats completely at about 5 percent of the farms in the experimental area, it was believed that eradication of murine typhus would not require complete elimination of rats and oriental rat fleas.

For 3 years after the eradication program, the experimental area was inspected periodically to determine the rates at which commensal rats, rat fleas, and murine typhus reestablish themselves. The results of these inspections are reported here.

Methods and Procedure

During the period July 13 to August 5, 1954, a preliminary inspection was made of 306 premises closest to the 5.5 percent from which it had not been possible to eradicate all rats. More extensive inspections were made annually during the months of March through May in 1955, 1956, and 1957. It was not possible each year to inspect every one of the premises originally inspected and grouped according to infestation status under the eradication program. Each annual inspection, however, covered a representative number of premises in each of the three groups that had been set up under the eradication program (table 1).

The farm premises were examined for signs of rats such as fresh droppings, burrows, trails, and gnawing. Occupants were questioned as to whether or not rats were present. If there was doubt as to the existence of an infestation, dust patches were used and the premises were reinspected until a definite decision could be reached.

Unbaited No. 0 steel traps were set in runs wherever it appeared that rats might be caught. Rats obtained alive were brought to the laboratory where they were identified, sexed, killed by bleeding from the heart, and brushed and searched for ectoparasites. Blood serums from these rats were sent to the Communicable Disease Center Virus and Rickettsia Disease Laboratory in Montgomery, Ala., where they were tested by complement fixation for the presence of murine typhus antibodies. Rats found dead in the traps were identified and recorded, but they are excluded from discussion and data presented in this paper.

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Although eradication measures were employed until May 4, 1954, many premises had been cleared of rats before that date. For purposes of discussion, the 1955, 1956, and 1957 inspections are considered to have been completed, respectively, 1, 2, and 3 years after the eradication program ended.

Rat Reinfestations

The preliminary inspections made in the summer of 1954 showed that 16 (5.2 percent) of the premises nearest the farms at which it had not been possible to eliminate rats had become infested again. Practically all of the 306 premises inspected at that time were within three-fourths of a mile of such farms.

The results of the last three annual inspections are shown in table 1. Of the premises cleared of rats under the eradication program and inspected each year, 70.6 percent remained uninfested at the end of the first year (1955), 67 percent at the end of the second year, and 58.3 percent at the end of the third year. In 1955, 25.4 percent of the premises inspected again had rats, and another 4 percent had become infested but were clear of rats at this inspection. In 1956, 17.2 percent of the premises inspected were reinfested, while 15.8 percent had had rat infestations since the end of the eradication program but were uninfested at the time of inspection. Inspection in 1957 showed 29.9 percent reinfested, and another 11.8 percent which had been reinfested since 1954 but were clear at this inspection.

Table 1. Commensal rat infestation of experimental area, Grady County, Ga., 1, 2, and 3 years after eradication program ending May 4, 1954

Infestation status on May 4, 1954, and subsequent changes	1955	1956	1957
Premises cleared of rats by eradication [1]			
Number inspected	221	221	198
Percent:			
Still clear	70. 6	67. 0	58. 3
Infested	25. 4	17. 2	29. 9
Had become infested, but clear at annual inspection	4. 0	15. 8	11. 8
Premises uninfested at time of eradication [2]			
Number inspected	282	282	266
Percent:			
Still clear	91. 5	89. 4	85. 5
Infested	6. 7	3. 5	6. 7
Had become infested, but clear at annual inspection	1. 8	7. 1	7. 8
Premises not cleared of rats by eradication [3]			
Number inspected	29	29	29
Percent:			
Still infested	44. 8	24. 1	21. 4
Clear	55. 2	72. 4	46. 4
Had been clear, but reinfested at annual inspection	0	3. 5	32. 2

[1] 232 premises.
[2] 297 premises.
[3] 31 premises.

Table 2. Incidence of typhus antibodies among commensal rats trapped in eradication area, Grady County, Ga., 1954–57

	1954	1955	1956	1957
Number of farms where rats were trapped	28	57	41	66
Number of rats:				
Trapped and examined	70	139	142	148
With typhus antibodies	3	1	4	0
Percent of rats with typhus antibodies	4. 3	0. 7	2. 9	0. 0

Premises uninfested at the time of eradication changed little from year to year, as shown by the high proportion of these premises which remained clear over the 3-year period—91.5 percent of those inspected in 1955, 89.4 percent in 1956, and 85.5 percent in 1957 (table 1).

The greatest changes of infestation status occurred in the small group of infested premises which had not been cleared of rats by eradication efforts. In 1955, 55.2 percent of the premises inspected in this group were uninfested at the time of inspection. By 1956, the percentage of premises inspected that had been clear of rats at some time since 1954 had changed to 75.9, and by 1957, to 78.6.

Typhus Antibodies in Rats

Tests of serums from 70 rats trapped immediately after eradication at 28 uncleared prem-

ises showed that 3 rats had typhus antibodies (table 2). These 3 rats came from 2 premises well within the study area. At the end of the first year after eradication, only 1 rat with typhus antibodies was found among the 139 rats trapped from 57 premises. This rat was taken from a farm at the edge of the eradication zone and was believed to have moved in from the adjacent untreated region. At the end of the second year, 4 of 142 rats taken from 41 farms showed typhus antibodies. These 4 rats came from 2 farms, one of which was near the border and the other well within the eradication area. At the end of the third year, none of the 148 rats trapped from 66 farms revealed any typhus antibodies.

Ectoparasite Abundance

Data on ectoparasite infestations of the rats examined from 1954 through 1957 are shown in table 3. In 1955, 1956, and 1957, the percentages of rats examined which were infested with *X. cheopis* were 0.0, 8.5, and 4.1, respectively. *X. cheopis* indexes (average per rat examined) were 0.0, 0.2, and 0.4 for those years. In the same years, the sticktite flea (*Echidnophaga gallinacea*) was the most abundant flea species, with averages of 6, 7.4, and 3.9 per rat examined. The most common mite was *Bdellonyssus bacoti* with annual averages per rat of 7.8, 1.1, and 2.3. The spined rat louse (*Polyplax spinulosa*) was found on 57.5, 62, and 83.2 percent of the rats examined in these years; its annual indexes were 7.2, 6.8, and 9.9, respectively.

Discussion

Two to three months after typhus eradication measures were terminated, about 5 percent of the farm premises which had been cleared of rats during the operational period had become reinfested. All were within 1 mile of rat-infested farms. This relatively high rate of reinfestation, including those premises that had become infested but were clear at annual inspection, increased to 29.4 percent, 33 percent, and 41.7 percent of premises inspected in 1955, 1956, and 1957, respectively (table 1). The reinfestation rate was undoubtedly influenced greatly by the proximity of premises susceptible to rat

Table 3. Ectoparasite infestation of commensal rats in eradication area of Grady County, Ga., 1954–57

Year and ectoparasite species	Ectoparasite concentration		
	Average per rat examined[1]	Percent of rats infested	Average per rat infested
1954			
Xenopsylla cheopis	0.0	0.0	0.0
Echidnophaga gallinacea	3.1	35.3	8.8
Bdellonyssus bacoti	.2	2.9	2.7
Polyplax spinulosa	1.5	17.6	6.9
1955			
Xenopsylla cheopis	0	0	0
Echidnophaga gallinacea	6.0	26.6	22.7
Bdellonyssus bacoti	7.8	19.4	40.5
Polyplax spinulosa	7.2	57.5	12.5
1956			
Xenopsylla cheopis	.2	8.5	1.9
Echidnophaga gallinacea	7.4	32.5	21.0
Bdellonyssus bacoti	1.1	12.7	8.3
Polyplax spinulosa	6.8	62.0	11.0
1957			
Xenopsylla cheopis	.4	4.1	8.9
Echidnophaga gallinacea	3.9	27.0	14.5
Bdellonyssus bacoti	2.3	18.3	12.9
Polyplax spinulosa	9.9	83.2	11.9

[1] Numbers of rats examined for ectoparasites in the years 1954–57 were 34, 139, 142, and 148, respectively, and are identical with numbers of rats trapped each year except for 1954, when 70 rats were trapped (table 2).

infestation to those where some rats remained. Emlen and others (*2*) found that populations of Norway rats in urban situations recovered at the rate of 2 to 6 percent per month when reduced to as low as 10 percent of their original level.

Reinfestation of cleared premises, again including those that had become infested but were clear at annual inspection, increased very little (by 3.6 percent of premises inspected) between the 1955 and 1956 inspections. Possibly the increase in reinfestation was small in the second year because the emigrant rats were reestablishing colonies in the new situations and had not increased in numbers sufficiently to supply impetus for further extensive emigrations. In the third year, however, reinfestation increased by 8.7 percent (table 1). Emlen and his co-work-

ers (*2*) noted in their study that 2 years elapsed before reinfestation occurred in one location where all Norway rats had been destroyed.

Since only one survey of the study area could be made each year, progressive emigrations and reinfestations could be determined only in a general manner. Few premises which were reinfested during the first year were as far as a mile from one of the premises not entirely cleared of rats. The manner and causes of rat migration to new premises were not determined, but in addition to the ecological factors, such as dwindling food supplies and harborage removal, commonly believed to motivate emigrations, inherent wandering tendencies—particularly in roof rats—appear to be influential.

Rural premises which are uninfested by commensal rats are generally incapable of supporting or harboring these rodents. If the farm is a poor one, little or no foodstuff is likely to be available to rats, and the usual small, openly constructed buildings do not afford suitable harborage. Another deterrent is activity constant enough to disturb rats attempting to settle. In the eradication area, rat control measures on farms were rarely extensive enough to prevent reinfestation. In a few cases, however, the intensive efforts of individual farmers apparently accounted for complete freedom from commensal rats, at least for short periods. For these varying reasons, uninfested premises tended to remain uninfested (table 1).

Farms at which rat eradication was impossible were least stable with relation to changes in rat infestation. At the end of each of the 3 years after eradication measures ceased, 55.2 percent, then 75.9 percent, and finally 78.6 percent of inspected premises were free of rats. Smith (*3*) recorded a natural decline of approximately 65 percent in farm premises infested with commensal rats in neighboring Thomas County, Ga., over the past decade. In addition to the natural environmental factors which would account for part of the decrease in the number of rat-infested farms within the eradication area, it is believed that certain other factors stemming from the typhus eradication program also were contributory. These factors are: (*a*) individual actions resulting from the creation of desire in the farmer to get rid of rats, and (*b*) the program's reduction of the number of rats to the point where differences in age and sex composition prohibited reproduction of those remaining. The latter factor was believed by Emlen and his colleagues (*2*) to be responsible for the very slow recovery of Norway rat populations which had been reduced to a few individuals.

Complement fixation tests of rat blood serums indicated that antibodies to murine typhus had disappeared from the rats in the eradication area by the end of the first year, although one rat with typhus antibodies was taken at the border adjoining a known typhus-infected premise. Three of the four rats with typhus antibodies trapped at the end of the second year (1956) came from a farm in the heart of the eradication area. This farm had had a roof rat infestation which eradication measures had failed to dislodge. One of the three rats with antibodies taken from this farm was a Norway rat, indicating the possible reintroduction of typhus infection from an outside source. At the end of the next year, no evidence of rat infestation could be found at this farm, possibly because of poisoning attempts by the owner. The fourth rat with typhus antibodies (1956) was trapped at a farm near the southern edge of the experimental region. It had probably emigrated from outside the zone since several other rats taken from the same farm had no antibodies to murine typhus. The supposition that typhus was not being transmitted from rat to rat in the experimental area was further strengthened by the absence of any evidence of previous typhus infection in the rats trapped at the end of the third and final year.

A recently published paper by Smith (*4*) comparing seasonal prevalence of typhus antibodies in rats with seasonal occurrence of important commensal rat ectoparasites indicates the importance of the oriental rat flea, *X. cheopis*, as the natural vector of murine typhus among rats and the relative unimportance of other common ectoparasites. Prior experience has shown that an average of at least 1 *X. cheopis* per rat trapped usually accompanies successful transmission of typhus from rat to man. No such estimate has been postulated for rat-to-rat transmission, but the averages of 0.2 and 0.4 *X. cheopis* per rat trapped in the experimental area at the end of 2 and 3 years follow-

ing eradication indicate the practical elimination from the area of the hazard to humans of typhus transmission from rats. Although the oriental rat flea and the tropical rat mite infested more rats at the end of the second year than at the end of the first or third years (table 3), this may have been due to weather conditions toward the end of the second year which favored these ectoparasites. In fact, no case of murine typhus in humans is known to have occurred in the typhus eradication area of Grady County since the cessation of eradication measures on May 4, 1954.

Summary

During a 10-month operational period, an attempt was made to eradicate murine typhus fever from the rural endemic foci in the southeastern quarter of Grady County, Ga. Intensive rat poisoning and applications of 10 percent DDT dust to rat-infested farm premises were the chief eradication measures used.

Four extensive inspections were made within the area after eradication measures ceased on May 4, 1954. A preliminary inspection made within 2 months after the eradiction program ended indicated reinfestation of 5.2 percent of the farms nearest to those where rats were not completely eradicated. More complete inspections of the farms in the eradication area at intervals of 1, 2, and 3 years after eradication showed that rats had reinfested 29.4, 33, and 41.7 percent of the farms from which rats had been cleared.

Typhus antibodies were found in 3 of 70 rats trapped in the area immediately after the eradication program. At the end of 1 year, the 1 rat with typhus antibodies among 139 rats trapped was believed to have emigrated from adjoining untreated territory. Four rats of a total of 142 trapped at the end of the second year had antibodies to typhus, while none of 148 rats taken at the end of the third year revealed typhus antibodies. No human cases of murine typhus are known to have occurred in the experimental area since the cessation of operational procedures on May 4, 1954.

REFERENCES

(1) Mohr, C. O., and Smith, W. W.: Eradication of murine typhus in a rural area. Preliminary report. WHO Bull. 16: 255–266 (1957).

(2) Emlen, J. T., Stokes, A. W., and Winsor, C. P.: The rate of recovery of decimated populations of brown rats in nature. Ecology 29: 133–145 (1948).

(3) Smith, W. W.: Factors influencing the decline in commensal rat infestations in a rural area of southwestern Georgia. J. Mammalogy 38: 270–271 (1957).

(4) Smith, W. W.: Populations of the most abundant ectoparasites as related to prevalence of typhus antibodies of farm rats in an endemic murine typhus region. Am. J. Trop. Med. & Hyg. 6: 581–589 (1957).

Studies on Radiation Hazards Scheduled

A new program to study the hazards of radiation will be initiated in 1958 at the New York University-Bellevue Medical Center through a $500,000 grant from the Rockefeller Foundation.

According to Dr. Norton Nelson, director of the Center's Institute of Industrial Medicine, who will direct the activities of the program, attention will be given to radiation hazards for the general population as well as to special risks in industrial use.

publications

Domestic Agricultural Migrants in the United States (map and table)

PHS Publication No. 540. 1957. 25 cents.

Prepared as a basis for planning health services, the map indicates the peak demand in 902 counties which were estimated to have 100 or more migrant workers from outside the county at the peak of the normal crop season. The table gives the population of these counties and the estimated number of migrants needed by each.

The basic data were obtained from the U. S. Departments of Labor and Agriculture and were checked by State health agencies.

Urban Fringe Sanitation

A selected bibliography

PHS Publication No. 583 (Public Health Bibliography Series No. 18). 1958. By Warren F. Smith. 27 pages. 15 cents.

One hundred annotated references have been prepared to assist sanitary engineering personnel. The bibliography is organized under four subjects: water supply, sewerage, refuse, and planning, with further breakdowns as to administrative, economic, and technical articles for the water and sewerage portions.

Rabies: Methods in Laboratory Diagnosis

PHS Publication No. 568. 1957. By Ernest S. Tierkel and Helen O. Neff. 42 pages; illustrated. 25 cents.

Designed to provide a practical guide for workers concerned with routine rabies diagnosis, this manual presents techniques selected for their simplicity, dependability, and economy.

The subjects cover preparation of suspected tissues for laboratory diagnosis, microscopic examination for Negri bodies and performance of the biological diagnostic test. Information on packing and shipping specimens and regulations covering their transportation plus a sample animal history form and a list of selected readings are included.

Control of Domestic Rats and Mice

PHS Publication No. 563. 1957. By Bayard F. Bjornson and Charles V. Wright. 25 pages; illustrated. 25 cents.

This training handbook describes briefly rodent-borne diseases, such as murine typhus, plague, rat-bite fever, salmonellosis, and rickettsialpox, and discusses identification and biology of domestic rats and mice.

The role of sanitation, including proper storage, collection and disposal of refuse, as well as methods of rodent killing, trapping, rodenticides, and burrow gassing, are emphasized. Simple methods of ratproofing, formulas for common rodenticides, and methods of controlling rodent ectoparasites are given.

Patients and Personnel Speak

A method of studying patient care in hospitals

PHS Publication No. 527. 1957. By Faye G. Abdellah and Eugene Levine. 33 pages. 30 cents. (Checklist forms for patients and personnel, $3.00 per 100.)

The technique used successfully by 60 American Hospital Association member hospitals to evaluate their nursing services has been refined and made available in this manual.

The booklet discusses the value of studying patient care, how to get started, the responsibilities of study personnel, and how to tabulate and analyze the data.

Forms for gathering data and a tested checklist on which hospital patients, doctors, administrators, and nursing staffs can state their personal observations of gaps in service are included.

Information Leaflets

GOOD TEETH. *PHS Publication No. 405. (Health Information Series No. 83) Revised 1957. 11 pages. 10 cents.* Gives pointers on dental care for children from infancy through childhood. Discusses the value of fluoridation and tells at what ages topical applications of fluoride should be made.

SIMPLE GOITER. *PHS Publication No. 100. (Health Information Series No. 56.) Revised 1957. Leaflet. $2.00 per 100.* Describes briefly cause, effect, prevention, and treatment of simple goiter.

GALLSTONES AND GALL BLADDER DISEASE. *PHS Publication No. 99. (Health Information Series No. 58.) Revised 1957. Leaflet. $3.00 per 100.* Describes gallstones, the symptoms they produce, and emergency treatment. Discusses importance of consulting a physician.

This section carries announcements of new publications prepared by the Public Health Service and of selected publications prepared by other Federal agencies.

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The Public Health Service does not supply publications other than its own.

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