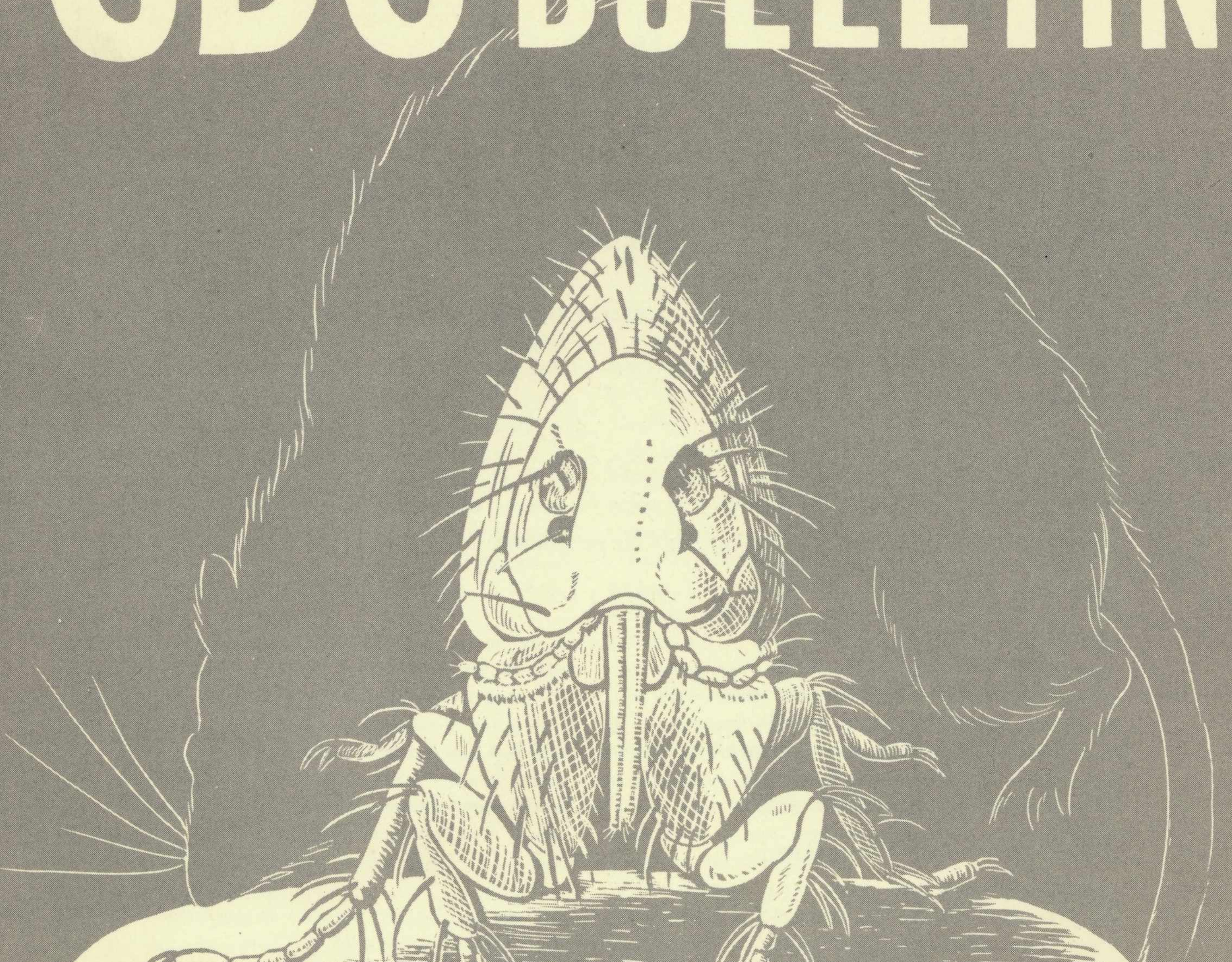
CDC BULLETIN

APRIL 1950



FEDERAL SECURITY AGENCY
Public Health Service
Communicable Disease Center
Atlanta, Ga.

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RESULTS OF COOPERATIVE STATE-FEDERAL TYPHUS CONTROL PROGRAMS

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Murine typhus fever in North America is a rickettsial disease of domestic rats which is transmitted in some manner from rat to rat, and from rats to human beings by the oriental rat flea. It is not often fatal but is so severe that patients generally complain of experiencing the worst headache that they ever have known. "The most serious aspect of this disease is the long period of physical non-effectiveness associated with it. While the acute phase is generally concluded within twelve to fifteen days, the patient is so depleted that he is rarely able to leave his bed for another week. It is a month or two more before he can return to work and even then he is apt to be nervous and depressed for some time. All told, the non-productiveness of its victims usually extends over two or three months" (1).

This disease long has been known to occur in the Southeastern and Gulf Coast States, but it was not until 1926 that it was recognized as probably rat-borne. In that year Dr. Kenneth Maxcy suggested that "a reservoir exists other than in man, and that this reservoir is in rodents, probably rats or mice, from which the disease is occasionally transmitted to man" (2, 3). Dr. Maxcy suspected that fleas, mites, and possibly ticks might transmit the disease.

Some experimental studies suggested by Dr. Maxcy, and designed to test this theory, were already in progress in the hygienic laboratory of the Public Health Service when Dr. Maxcy's report was published. When several cases of typhus occurred in Baltimore in the fall of 1930, northern and oriental rat fleas were obtained from rats and their nests in the vicinity, ground up, and injected into guinea pigs and rabbits. These animals became sick with murine typhus. Other experiments further confirmed the transmitting powers of the oriental rat flea (4, 5, 6, 7).

Feces of oriental rat fleas, infected with murine typhus organisms by feeding on infected rats, later were crushed and rubbed into scratches on the skin of guinea pigs. The guinea pigs contracted murine typhus fever (8). Similar experiments indicated that, in the laboratory, the northern rat flea and the dog flea also could transmit typhus (9, 10).

The workers failed in repeated attempts to transmit typhus by the bite of infected fleas (7, 10). Cat fleas apparently transmit typhus under special conditions when near infected rats.

As a result of this work and that of others, evidence was quite conclusive that fleas, at least, were transmitters of murine typhus from rats to human beings, most likely by way of their feces.

Studies comparing the distribution of murine typhus in both rats and man revealed that it occurred almost invariably in those sections of the country where oriental rat flea populations were at once large and widespread and that it was uncommon where those fleas were uncommon. Futhermore, it was acquired almost invariably in buildings where oriental rat fleas were numerous and at those times of the year when they were numerous. It was rare or nonexistent where those fleas were scarce or absent even though other ectoparasites might be quite abundant.

The ground work thus was laid for effective recognition and control of typhus. Following its recognition in 1926, more and more cases were reported until, in 1944, the total for the year stood at 5,213 (fig. 1), most of them occurring in 10 Southeastern States (fig. 2). It is probable that if all cases were known the total would be much larger.

Perhaps of greater concern was the fact that the number of cases occurring annually gave every sign of continuing to increase. Prospects were that, over a period of years at such rate, most families in counties with the highest infection rates eventually might have one or more members or close friends affected.

Health authorities were not willing to let this happen. As soon as it was known that domestic rats and their fleas were the reservoirs of the disease, rat-poisoning campaigns, clean-up campaigns, and ratproofing programs were intensified in order to suppress the number of cases. WPA rat-poisoning campaigns also were aimed at suppression of the disease, with possibly some favorable results (fig. 1, 1934 and 1935).

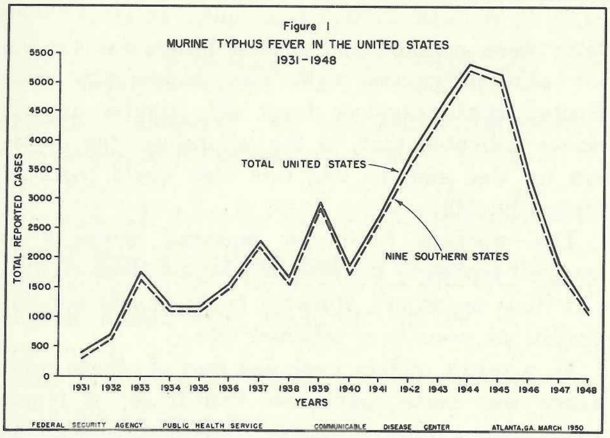

Figure 1
MURINE TYPHUS FEVER IN THE UNITED STATES
1931-1948

It is difficult to judge the results of such programs over state-wide areas, although the good effects were apparent on a local scale where ratproofing of certain buildings and subsequent elimination of rats, forestalled occurrence of further cases of them alone. Their effectiveness was further obscured by the fact that, following the discovery of the identity of murine typhus and means of diagnosing it, some of the apparent rise was due simply to an increase in knowledge concerning it with consequent increased reporting. Without a doubt, the poisoning and ratproofing programs did prevent the occurrence of many cases, but they could not be practiced on a wide enough scale to prevent a continued increase. Some more rapid and effective method of control was necessary.

Since DDT was effective in controlling many kinds of insects, and since ecological, experimental, and epidemiological work had shown conclusively that the oriental rat flea is a transmitter, members of the Communicable Disease Center (11, 12) initiated field studies in the early part of 1944 and 1945 to determine the effect of DDT on rat ectoparasites as a means of controlling endemic

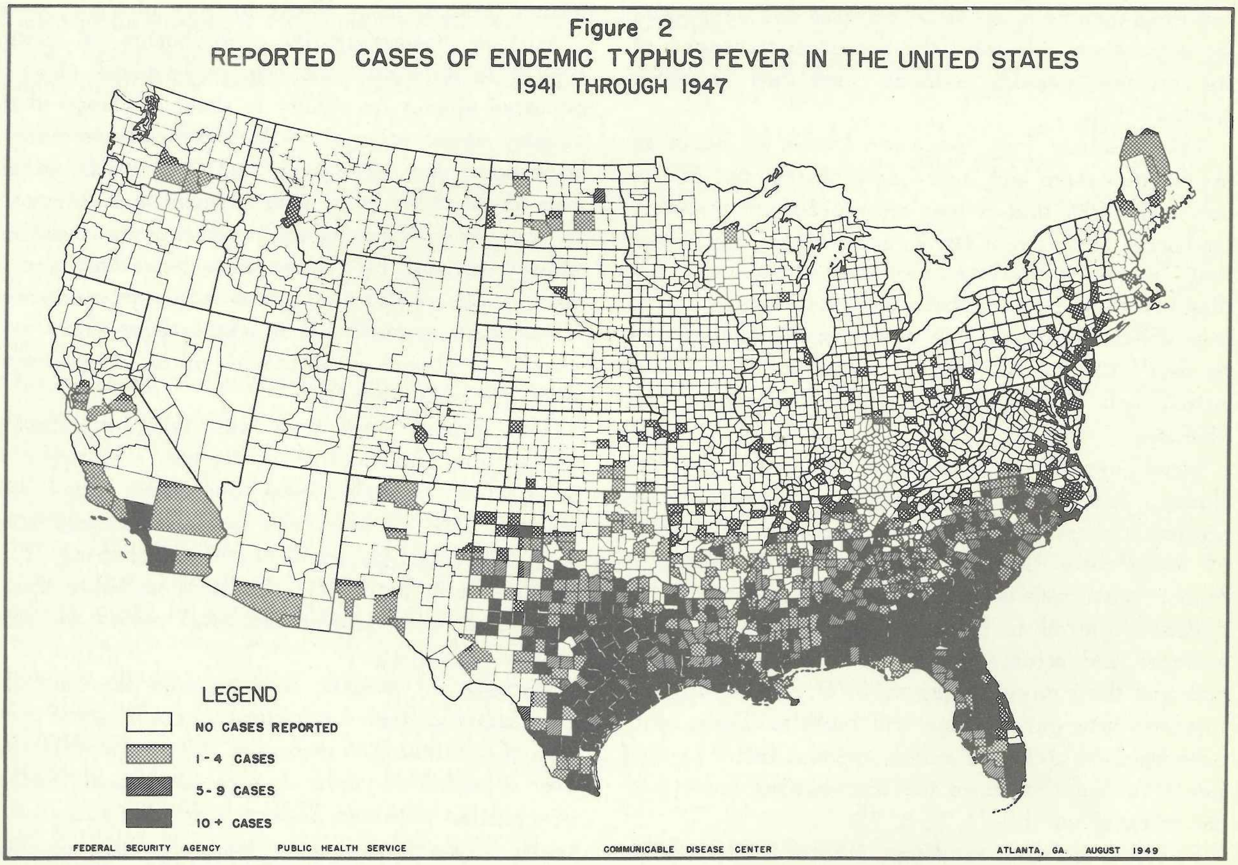

Figure 2
REPORTED CASES OF ENDEMIC TYPHUS FEVER IN THE UNITED STATES
1941 THROUGH 1947

typhus fever and to develop equipment for the application of the insecticide. A powder consisting of 10 percent DDT and 90 percent pyrophyllite was distributed along runways and blown into burrows of the rats.

Spectacular and consistent control of the oriental rat flea resulted from this field experiment in 11 establishments. In San Antonio, marked reduction of human typhus was obtained (11). The results were so good that plans were made for extension of experimental applications through aid to State and local health departments in the typhus zone of the United States to determine to what extent reduction of flea populations would reduce the number of human typhus cases. On July 1, 1945, an expanded program was inaugurated through assistance to State health departments in recruiting and training personnel and in conducting promotional activities (13). A few dusting projects were established in July, and more were added rapidly, so that by March 1946, a full program was in operation. Dusting projects were operated by 122 of the highest typhus-reporting counties in nine States during 1946 and have continued on a diminishing scale with the reduction in number of typhus cases.

Results in reduction of human typhus cases were marked. Even though most dusting projects were begun so late in 1945 that one could not expect maximum effectiveness, the number of typhus cases occurring in counties with such projects dropped about 10 percent from the number that had occurred during the preceding year. On the other hand, in counties without such dusting projects, the number of cases actually rose slightly.

By the end of 1946, the drop was more marked; in counties in which dusting was done, the number of cases dropped to about half the number that had occurred in 1944, whereas in the undusted counties the drop was only one-fourth. The favorable decline has continued to date.

Observations were made concurrently on methods of improving the timing of applications. Dustings were adjusted in such a way as to anticipate the seasonal rise of flea populations and to space the dustings so as to take maximum advantage of the residual effect of DDT in suppressing the flea populations and the disease among the rats. Whereas during 1945 and 1946 premises were dusted two, three, and even four times in most States, the number of dustings in succeeding years was reduced to one per year or one in alternate years, or even less frequently.

Results varied with the number of years succeeding the initial dusting. Whereas the number of reported cases in counties with organized cooperative dusting programs in the typhus States in which no dusting was done dropped only about one-half by the end of 1948 (as compared with the number of cases that occurred in the same counties in 1944), the number of cases in counties in which dusting was done during 2 years (1945 and 1946) dropped by more than three-fourths. Even when dusting was done during only 1 year (1947), the drop by the end of 1948 was nearly as great (cases in 1948 compared with those in 1946).

Increasingly also, advantage was taken of the long-term control, to do "pin-point" dusting. Instead of relying on the original wide coverage of affected counties, increasing attention was given to dusting only in premises in which the occurrence of human typhus, large oriental rat flea populations, or heavy rat infestations indicated that dusting was needed. Reliance was placed in past applications, in surveillance, and certain rat-control measures to prevent recurrence of human cases in many of the premises formerly productive of typhus.

Generally speaking, the typhus problem from the viewpoint of control of fleas and rats has four phases, dependent on whether or not it is acquired in the following locations:

- Artificially heated premises
  - Urban business establishments
  - Urban residences
  - Rural residences
- Unheated premises
  - Rural farm buildings

Applications of dust, followed by control measures for the rats, are made after appraisal of the nature of the typhus problem, and appraisal of effectiveness of dusting being done in those types of premises that gave signs of being troublesome. In this way, it is possible to reduce the number of typhus cases almost 100 percent in certain counties. This frequently is done more easily in the northernmost of the States in which typhus is common, because the cases generally are acquired in a relatively few premises which are heated artificially. It is more difficult in the more southern areas because the numbers of infested fleas are distributed more widely, cases occurring in unheated as well as heated buildings.

Whereas the greatest number of reported typhus cases originally occurred during August and amounted to more than 800 during 1944, the peak has been reduced to less than one hundred – and during the peak month which is now July (fig. 3).

In the meantime, permanent control measures aimed at suppression of domestic rat populations were continued in the hope that the more-or-less temporary relief, achieved by destruction of the fleas, might be prolonged by suppression of rat populations. Ratproofing and back-lot and alley-sanitation programs were carried to many new communities. Forty-eight cities and towns had ratproofing and attendant antirat projects in operation during 1949. One hundred and twenty-one had completed their programs and were maintaining both the proofing and back-lot and alley sanitation under guidance and assistance of the Public Health Service and the State health services through cooperative programs (fig. 4).

This program also has proved instrumental in reducing the danger of occurrence of plague among domestic rats in mid-Texas, where plague occurs among native wild rodents, as well as in reducing the number of cases of murine typhus during the years since initiation of the program.

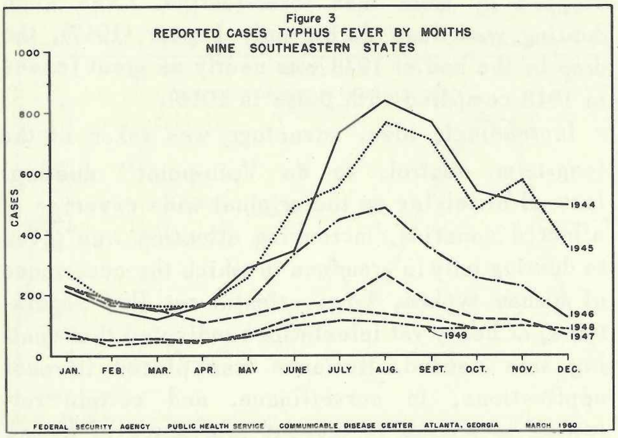

Figure 3
REPORTED CASES TYPHUS FEVER BY MONTHS
NINE SOUTHEASTERN STATES

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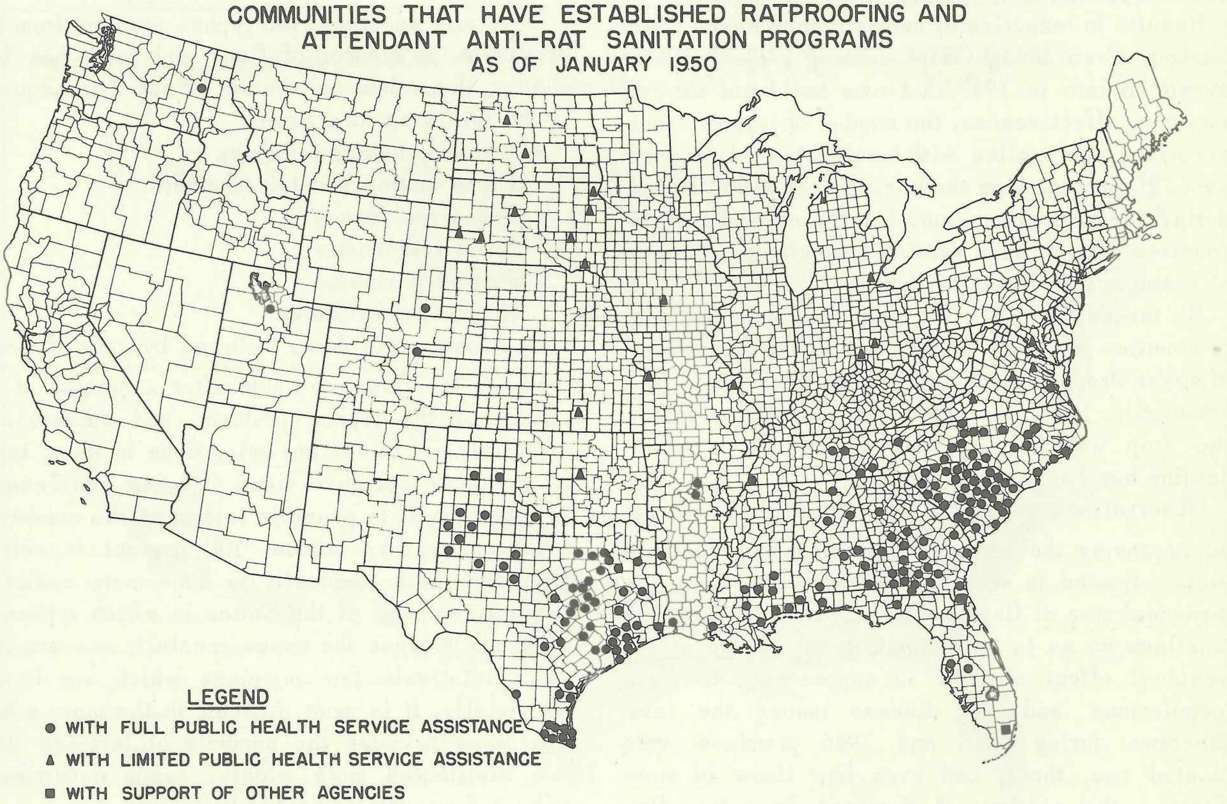
Figure 4
COMMUNITIES THAT HAVE ESTABLISHED RATPROOFING AND ATTENDANT ANTI-RAT SANITATION PROGRAMS AS OF JANUARY 1950



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EFFECTIVENESS OF DDT DUSTING IN CONTROLLING RAT ECTOPARASITES AND TYPHUS INFECTION IN RATS

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Scientist (R)

The effectiveness of DDT dusting operations in reducing the hazard of transmission of murine typhus to man is measured by two methods: (1) the reduction in rat ectoparasites and (2) the reduction in typhus infection in rats. The effect of this work in reducing human typhus can be measured of course only in the reduction occasioned in the number of reported human cases. Reduction in rat ectoparasites usually takes place within 1 or 2 days after dusting, whereas a year or more may elapse before the full import of the reduction in human typhus is apparent. Typhus in this country is a disease of rats which man acquires by accident. During the period 1945-49 approximately 18 percent of all rats tested proved positive for typhus. During these same years, an average of 2,485 human cases was reported per year in the nine Southeastern States (including and south of North Carolina and Tennessee, plus Louisiana and Texas), for an over-all average case rate of 92 per 10,000 or 0.009 percent. Thus it is observed that typhus is approximately 2,000 times more prevalent in rats than in man. This comparison is justified if one considers that rats probably live only about 1 year in nature and that most infections therefore are more or less recent. Since infection rates in rats are so much higher, they are considered to be much more significant statistically in measuring present typhus reduction and also in indicating probable future typhus incidence in man.

Eight species of ectoparasites commonly infest rats in the Southern States. These include three species of nonsticktight fleas, *Xenopsylla cheopis*, *Leptopsylla segnis*, and *Nosopsyllus fasciatus;* the sticktight flea, *Echidnophaga gallinacea;* three species of mites, *Liponyssus bacoti*, *Laelaps echidninus*, and *Laelaps nuttalli;* and the rat louse, *Polyplax spinulosa*. Other species, such as the cat flea, *Ctenocephalides felis*, also may be taken on rats. Any or all of these species of ectoparasites possibly may be involved in the transmission of typhus from rat to rat. However, only the oriental rat flea, *X. cheopis*, appears to be of any great importance in transmitting murine typhus to man; at least control of *X. cheopis* is correlated directly with a lowered typhus case rate in man. The degree of control obtained of this flea, therefore, is of particular significance in any evaluation of the effectiveness of typhus control operations.

THE CONTROL OF RAT ECTOPARASITES BY DDT DUSTING

Ten percent DDT dust in pyrophyllite, applied to rat runs and burrows, has been used on a large scale since the latter part of 1945 for the control of rat ectoparasites. During all of this period of more than 4 years, rats have been trapped systematically in both dusted and nondusted premises in each of the Southeastern States, and their ectoparasites removed and identified. Data on rats examined during the period from September 1945 through September 1949 are now available.

There is considerable variation in the effectiveness of DDT dust against the different species of rat ectoparasites. Fortunately, the ectoparasites which are the most important vectors of murine typhus (*X. cheopis* and the other nonsticktight rat fleas) are the ones against which DDT dust is most effective. In general terms it may be stated that 10 percent DDT dust, as applied for reduction of human typhus, gives very good control of each of the nonsticktight rat fleas, *X. cheopis*, *L. segnis*, and *N. fasciatus*; poor to fair control of the sticktight flea, *E. gallinacea*; good control of the mite, *L. nuttalli*; but only fair control of the other rat mites, *L. bacoti* and *L. echidninus*; and very poor results against the rat louse, *P. spinulosa*. Cat and dog fleas are affected little by ordinary typhus control dusting methods but can be controlled if the dust is concentrated in the places frequented by dogs and cats. Control of the sticktight flea, likewise, might be improved by the dusting of chicken houses, which are the most common habitat of this flea.

The natural abundance of rat ectoparasites depends largely upon the season and the type of weather. Thus we find an increase of *X. cheopis* during the warm season and a decrease during the colder part of the year. The abundance of rat ectoparasites likewise varies from year to year. *X. cheopis* did not become as numerous in the summers of 1947 and 1948, each of which was preceded by a cold winter, as in the summer of 1946. On the other hand, there was an unusual increase in the abundance of this species, and of other fleas, in the latter part of the warm 1948-49 winter. The yearly and seasonal trends in both dusted and nondusted areas are shown in figure 1.

Figure 1 shows that marked reduction was obtained for the first 6 months after dusting at all seasons of the year during each of these 4 years. Data on individual months, however, show that in 1 month in each of the years 1945 through 1948 the average number of *X. cheopis* per rat commonly referred to as the "*X. cheopis* index," exceeded 0.9 but was in no instance higher than 1.3. During 1949 the highest *cheopis* level was more satisfactory, being 0.5 per rat.

Averages for the entire year for the years 1946 through 1948, and for the first 9 months of 1949 are as follows:

Application of dust	1946	1947	1948	1949 (9 months)
Nondusted	2.8	2.1	2.3	2.7
Dusted within 6 months	0.4	0.4	0.3	0.2
Dusted more than 6 months previously	1.1	1.1	0.5	0.7

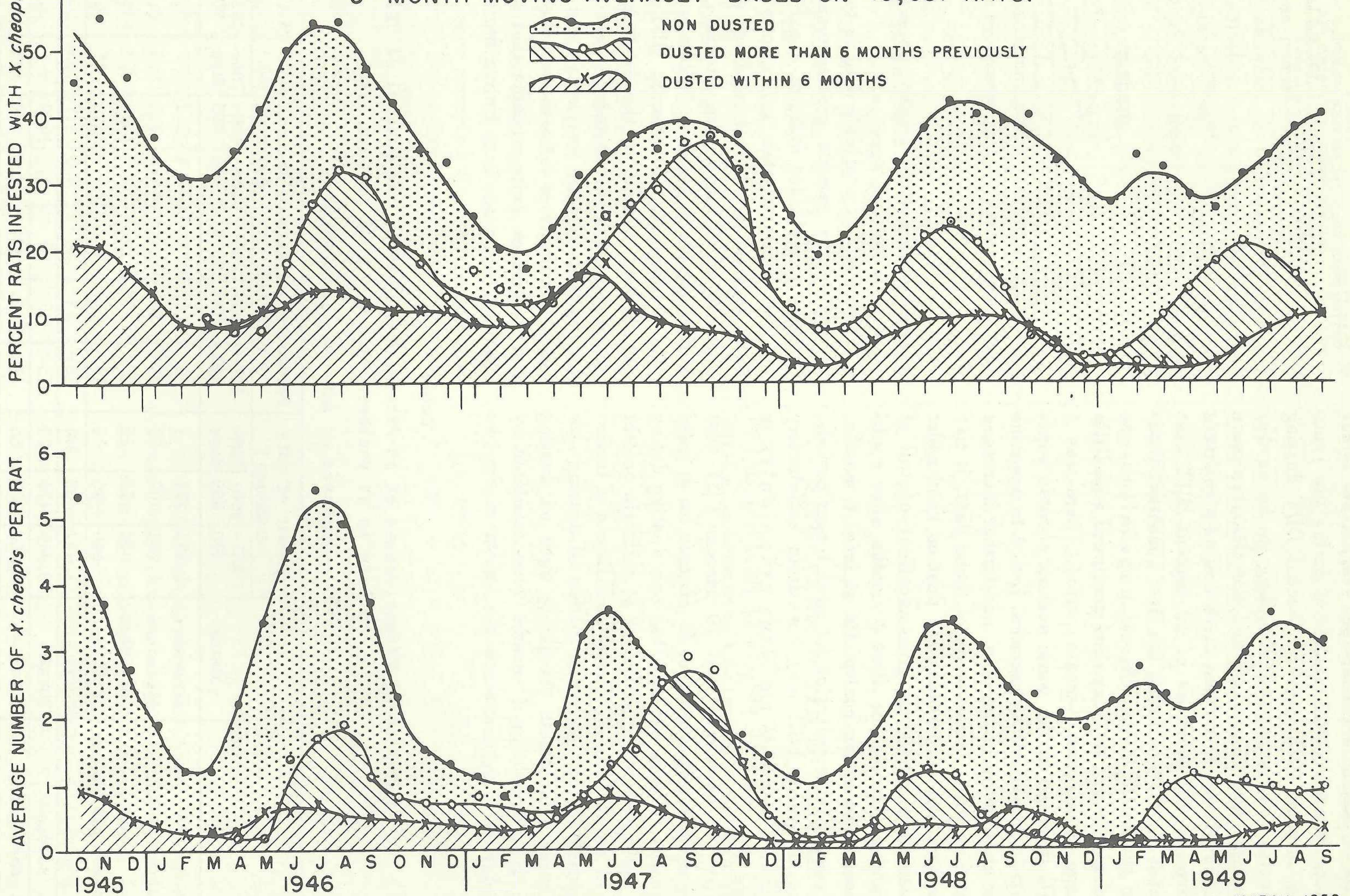
In percentages, these figures represent reductions for the first 6 months after dusting of 84, 79, 87, and 94 percent respectively for these 4 years. It is encouraging to note that the degree of control improved in both 1948 and 1949. This would appear to indicate either increased skill in dust application or a cumulative effect from repeated applications. It appears to indicate also that any development of resistance to DDT by *X. cheopis* under field conditions, which may have occurred, is not a factor of importance, as yet.

The duration of effectiveness of 10 percent DDT dust is of great practical significance, since upon this point, together with the associated factor of duration of reduction of typhus infection in rats, depends the frequency of dusting or the number of

FIGURE I

CONTROL OF THE RAT FLEA, *X. cheopis*, BY 10% DDT DUSTING IN NINE SOUTHERN STATES

3-MONTH MOVING AVERAGE. BASED ON 49,657 RATS.



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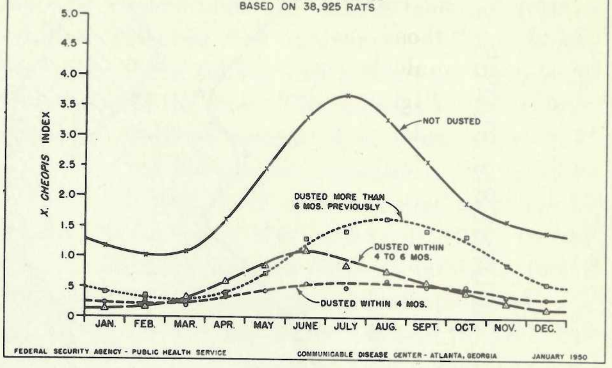
cycles of dusting necessary per year, or per 2-year period. Data on 38,925 rats, taken during the years 1946 through 1948 from 10 percent DDT dusting projects, were separated according to the number of months after dusting and the results were analyzed. It was found that there was no significant change in effectiveness of 10 percent DDT dust against *X. cheopis* during the first 4 months. Maximum reduction in the *cheopis* population was reached in from 1 to 7 days and continued with little change during this 4-month period. There was a small increase in the warm season *cheopis* population in the following 2 months, i. e. 4 to 6 months after application of the dust, and further increases after 6 months. On the basis of these data, it may be stated that 10 percent DDT dust as used under actual field conditions gives excellent control of *X. cheopis* during the first 4 months after application, satisfactory control for at least 6 months, and considerable reduction for much longer periods, some of which still may constitute satisfactory control. These data are shown graphically in figure 2.

FIGURE 2
DURATION OF CONTROL OF THE RAT FLEA, *XENOPSYLLA CHEOPIS* BY DDT DUST
AVERAGE NUMBER OF *X. CHEOPIS* PER RAT
NINE SOUTHERN STATES - 1946 THROUGH 1948
3-MONTH MOVING AVERAGE
BASED ON 38,925 RATS



With the assurance that 10 percent DDT dust gave satisfactory control of *X. cheopis* for at least 6 months, it was evident that one dusting during the spring would be sufficient to maintain control for an entire season. The possibility of a further reduction in the number of cycles of dusting now is being considered. Available data on dusting periods greater than 6 months were tabulated by 100-day periods, and since the habits of the two species of rats differ greatly, separate tabulations were made for each species.

The amount of available data is too small, particularly in the periods greater than 400 days, to provide a basis for definite conclusions on this subject. However, the indications would appear to be that (1) in areas or buildings where roof rats only are found, dusting in alternate years may be sufficient; (2) in areas or buildings where Norway rats predominate, 10 percent DDT dusting gives satisfactory control in the Southern States as a whole up to approximately 1 year after dusting. Insufficient data are available for a further breakdown by climate or temperature zones at this time, but it appears quite probable that in the northern portions of the southern United States, i. e. above

Table 1

Duration of Effectiveness of 10 Percent DDT Dust in the Control of "X. cheopis" on Rats in 11 Southern States,* 1946 through 1949

Based on data on 4,835 rats

Rat	Month	Number of rats examined			Percentage of rats infested			Av. no. per infested rat			Av. no. per rat examined		
		181-399	400-699	700+ days	181-399	400-699	700+ days	181-399	400-699	700+ days	181-399	400-699	700+ days
Rattus rattus and *Rattus norvegicus*	Jan.-Mar.	1,203	277	1	8	8	**	4.4	2.2	**	0.4	0.2	**
	Apr.-June	1,298	107	72	15	14	44	5.0	4.9	8.5	0.7	0.7	3.8
	July-Sept.	901	173	55	23	12	29	4.5	12.3	6.3	1.0	1.5	1.8
	Oct.-Dec.	640	96	12	15	27	**	3.6	16.6	**	0.6	4.5	**
	Total	4,042	653	140	15	13	36	4.5	9.7	7.5	0.7	1.2	2.7
R. rattus	Total	2,989	476	75	15	15	31	4.9	10.8	6.6	0.7	1.6	2.0
R. norvegicus	Total	1,053	177	65	15	6	42	3.3	2.9	8.2	0.5	0.2	3.4

*Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia.

**Number of rats examined is too small to determine percentage and average.

Table 2

Control of "X. cheopis" by 5 Percent DDT Dust
(and Comparison with 10 Percent DDT Dust Results)

Quarter	No. of rats examined	Percentage of Rats infested			Av. no. of "X. cheopis" per infested rat			Av. no. of "X. cheopis" per rat examined		
		Non-dusted	Dusted 1-180 days	Dusted 181-600 days**	Non-dusted	Dusted 1-180 days	Dusted 181-600 days**	Non-dusted	Dusted 1-180 days	Dusted 181-600 days**
1948										
Jan.-Mar.	761	6	5	0*	2.1	2.0	0*	0.1	1.1	0*
Apr.-June	1,199	22	12	18	8.4	4.1	9.2	1.9	0.5	0.6
July-Sept.	1,689	37	15	9	6.4	5.0	1.7	2.4	0.7	0.2
Oct.-Dec.	1,581	29	8	11	3.7	2.7	6.1	1.1	0.2	0.7
1949										
Jan.-Mar.	2,387	19	5	4	3.8	2.4	1.5	0.7	0.1	0.1
Apr.-June	1,183	31	15	12	5.6	5.8	5.3	1.7	0.9	0.6
July-Sept.	1,818	27	15	33	8.0	6.2	6.1	2.2	0.9	2.0
Total or Average	10,618	25	11	9	5.6	4.8	5.3	1.4	0.5	0.5
Average for 10% DDT dust for same period	17,154	33	7	12**	6.6	3.5	4.1**	2.2	0.3	0.5**

*Based on only 47 rats. Other figures are based on examinations of from 74 to 1,660 rats. The total number of rats examined by dusting periods is: nondusted – 3,312; dusted 1-180 days – 6,131; dusted 181-600 days – 1,175.

**Ten percent DDT dust data include records on rats from premises dusted 6 months to 3 years.

33° north latitude, dusting in alternate years may be sufficient. A condensed tabulation of these data is given in table 1.

The possibility of reducing the cost of dusting operations by the use of 5 percent instead of 10 percent DDT dust prompted its experimental use in 1946 and 1947. These comparatively small-scale tests appeared to indicate that 5 percent DDT dust was as effective as 10 percent dust for periods up to 3 or 4 months. Accordingly, large-scale use of 5 percent DDT dust was started, particularly in Georgia and Alabama, at the beginning of the 1948 season. During the early part of 1949, field observations indicated that unsatisfactory results were being obtained with 5 percent dust, and a swing back to 10 percent DDT dust took place. Data on examinations of 10,618 rats taken in 5 percent DDT dust areas over a period of nearly 2 years are given in table 2.

In premises dusted with 5 percent DDT the average number of *X. cheopis* per rat for the first 6 months after dusting, based on data from 1,789 rats, averaged 0.9 during the months of April through September 1949. The corresponding figures for 10 percent dust areas, based on data from 1,915 rats, is only 0.3 per rat.

It should be noted also that control appeared to be much poorer during the second year of dusting with 5 percent DDT than during the first year. This suggests the possibility that the use of dust with a low percentage of DDT may have permitted the development of a minor amount of resistance to DDT by *X. cheopis*.

A direct comparison of the amount of reduction in the *X. cheopis* population obtained by 5 percent and 10 percent DDT dust shows that poorer reduction was obtained by 5 percent than by 10 percent DDT dust during the first 6 months after dusting, both in the percentage of rats infested and in the average number of fleas per infested rat (table 3).

A comparison of these two dusts for the groups dusted more than 6 months previously, which are not entirely comparable since the data for 10 percent dust include many rats from premises not dusted for more than 600 days, shows that there was no difference in the percentage of rats infested but that 5 percent dust gave poorer results in regard to the average number of *cheopis* per infested rat and also, therefore, in the average number per rat examined.

Table 3

Percentage of Original Infestation of "X. cheopis" Found after Dusting
Comparison of 10 Percent and 5 Percent DDT Dust, Based on 27,772 Rats

Period or Quarter	Percentage of rats infested				Av. no. of "X. cheopis" per infested rat				Av. no. of "X. cheopis" per rat examined			
	1-180 days		181+ days		1-180 days		181+ days		1-180 days		181+ days	
	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%
1948												
Jan.-Mar.	17	78	37	0*	37	96	46	0*	6	Inc.	17	0*
Apr.-June	23	53	53	84	92	49	Inc.	Inc.	22	26	73	32
July-Sept.	24	41	52	26	35	78	44	27	9	31	23	7
Oct.-Dec.	20	29	16	37	Inc.	73	39	Inc.	26	21	6	61
1949												
Jan.-Mar.	9	26	9	21	15	63	23	38	1½	16	21	8
Apr.-June	16	49	42	37	14	Inc.	32	94	22	51	14	3
July-Sept.	24	57	41	Inc.	55	77	72	77	13	44	29	93
Average for 21 months	21.7	44.6	37.1	37.0	53.6	85.7	62.2	94.4	11.6	38.2	23.1	34.9

*Based on only 47 rats.

REDUCTION IN TYPHUS INFECTION IN RATS BY DDT DUSTING

The rat is by far the most important animal reservoir of murine typhus and, therefore, any reduction in the percentage of rats infected would result in the infection of a smaller percentage of fleas with the rickettsia and should be reflected in a reduction in human typhus. Thus the determination of the percentage of rats showing typhus antibodies in the blood can be used as a second method of measuring the effectiveness of DDT dusting operations for the control of transmission of murine typhus to man (table 4).

In the preliminary analyses made to date, a complement fixation test of 1:4 has been considered positive. However, there is considerable doubt regarding the significance of titers of 1:4 or even of 1:8, and a reconsideration of what constitutes a positive titer may be necessary. This test, of course, shows past infection and cannot be evaluated correctly when using the same periods after dusting as for ectoparasite infestation. Typhus antibodies do not begin to appear in the blood until the 12th to 18th day after exposure but, after appearing, are present at least for several months. Reduction by DDT dusting, in the percentage of typhus infection in rats is not as striking as the reduction of ectoparasites. Many factors in addition to the reaction factor just discussed must be segregated before definite conclusions can be drawn. The following table is of a preliminary nature and the important factors, such as age of rat, have not been considered. Nevertheless, a fair reduction in the percentage of rats infected is shown. Data on rats caught within 30 days after dusting have not been considered because of the probability that most of the rats found positive for typhus in this group acquired the infection before the time of dusting.

The data on typhus infection in rats presented above are rather variable and hardly can be interpreted satisfactorily without further break-down of the contributing factors. However, they do show a steady decrease in the natural typhus infection in rats, some of which may be due to natural factors such as weather conditions, but a large part of which undoubtedly is due to actual interchange of rats between dusted and nondusted premises, and to a systematic and successful reduction in typhus in the areas of highest endemicity.

A good percentage of reduction of typhus infection in rats, 50 percent, is shown for 10 percent DDT dust areas, and a somewhat smaller percentage of reduction, 41 percent, for 5 percent dust areas during the period 1 to 6 months after dusting in 1948 and 1949. However, for periods greater than 6 months after dusting, no such consistency was evident; results show almost no reduction, 1 percent, in the 10 percent dust areas but a good reduction, 52 percent, in the 5 percent dust areas. No

Table 4

Effect of 10 Percent and 5 Percent DDT Dusting Operations on the Percentage of Rats with Typhus-Positive Complement Fixation Titers

11 Southern States - Based on 41,170 Rats

Year	Quarter	10 percent DDT dust			5 percent DDT dust		
		Nondusted	Days after dusting		Nondusted	Days after dusting	
			31-180	181+		31-180	181+
1945	Oct.-Dec.	51	31	-			
1946	Jan.-Mar.	33	34	0*	No data		
	Apr.-June	30	21	5**			
	July-Sept.	35	21	30			
	Oct.-Dec.	29	18	28			
	Total 1946	32	23	27			
1947	Jan.-Mar.	23	24	27	No data		
	Apr.-June	22	18	21			
	July-Sept.	15	14	25			
	Oct.-Dec.	22	13	16			
	Total 1947	21	18	23			
1948	Jan.-Mar.	18	8	30	15	11	40**
	Apr.-June	16	8	17	18	15	20
	July-Sept.	15	8	10	19	9	8
	Oct.-Dec.	14	7	10	18	9	6
	Total 1948	16	8	18	18	10	17
1949	Jan.-Mar.	10	2	10	15	4	2
	Apr.-June	11	12	10	16	9	7
	July-Sept.	16	6	8	9	11	9
	Total Jan.-Sept. 1949	13	7	9	14	8	4
4-year Total		22.4	16.2	18.3	-	-	-
Total 1948-1949		15.1	7.6	14.9	15.6	9.1	7.5
Percentage of reduction 1948-1949***		-	50%	1%	-	41%	52%

*Based on less than 20 rats.

**Based on 20-49 rats.

***Based on 20,239 rats as follows: 10 percent dust areas: nondusted - 6,215; dusted 1-180 days - 4,298; dusted 181+ days - 2,213. 5 percent dust areas: nondusted - 2,839; dusted 1-180 days - 3,684; dusted 181+ days - 990.

explanation for this sharp reversal in trend is offered. It is hoped that additional data and more critical analyses may give a clearer picture of the effect of DDT dusting on typhus infection in rats.

CONCLUSIONS

1. Ten percent DDT dust applied to rat runs and burrows is very effective in controlling the oriental rat flea, *Xenopsylla cheopis*, the principal vector of murine typhus to man.

2. The effectiveness of DDT has not decreased during the 4 years it has been used for this purpose.

3. The residual effect of DDT or the duration of its effectiveness against *X. cheopis* appears to be as follows: very effective for 4 months, satisfactory for 1 year, and probably satisfactory for 2 years on roof rats and, in the northern parts of the typhus area, on Norway rats also.

4. Five percent DDT dust has been definitely less satisfactory than 10 percent dust in the control of *X. cheopis*.

5. Analyses of, and interpretations of the importance of, reductions in typhus infection in rats to date are preliminary only. A fair percentage of reduction in typhus infection in rats is shown for both 10 percent and 5 percent DDT dusted areas during the 6 months after dusting. For longer periods, the data at hand appear to be too inconsistent to permit valid interpretations.

RECENT DATA FROM THE THOMASVILLE, GEORGIA, TYPHUS INVESTIGATION PROJECT

Bernice Utterback
Statistician

A review of recent data from the Thomasville Project shows that the incidence of human typhus has continued at a low level for more than 2 years after the last DDT dusting.

The present summary supplements findings previously reported by Hill and Morlan (1), Dent, Morlan, and Hill (2), and Morlan, Hill, and Schubert (3). The study has been carried on in cooperation with the Georgia State Department of Health through C. D. Bowdoin, M.D., Director, Division of Preventable Diseases, and Roy J. Boston, Director, Typhus Control Services.

The Thomasville Project was established in 1945 to determine the effectiveness of DDT dusting as a murine typhus fever control method. Three counties in southwest Georgia were included. Populations in 1940 were: Thomas, 31,256; Brooks, 20,476; and Grady, 19,665. Rat runs in and near buildings in Brooks and Thomas Counties were dusted with five applications of 10 percent DDT in pyrophyllite during the period April 1946 through September 1947; Grady County was not treated.

Records of human typhus cases were obtained through reports from State and local health departments, hospital records, laboratory records, contact with physicians, and supplementary information which the project personnel obtained informally from families in the study area. It should be pointed out that these data on incidence of typhus include many cases which would not be reported through routine channels. A complement fixation test yielding a titer of 1:4 or higher was considered evidence of the presence of typhus antibodies.

It has been shown in earlier reports (1) that incidence of typhus was lower in the year following DDT dusting operations in Thomas and Brooks Counties than in the year preceding dusting. No significant change occurred in untreated Grady County. Figure 1 shows that in the 2 years subsequent to cessation of dusting, the incidence of typhus was minimal (four cases in each of the two dusted counties); while during the same period, a total of 53 confirmed cases was recorded for the undusted county.

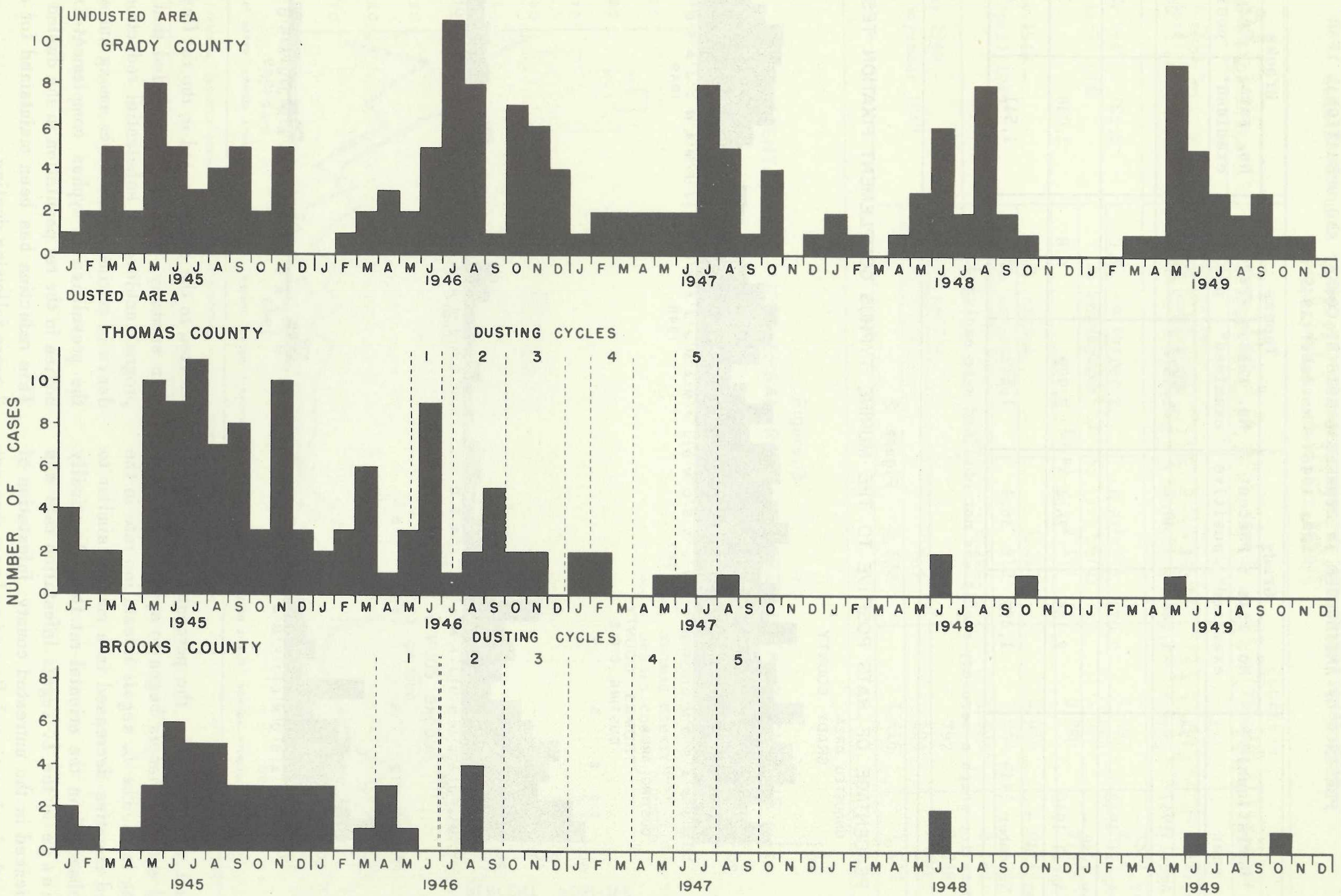
During the year after dusting, murine typhus antibody prevalence reached a low level of 3-7 percent in rats examined from dusted counties and remained at this level for nearly 2 years (table 1). Current data (fig. 2) show a slight rise in 1949.

An average of 175-200 rats per month was trapped in each county during the period of study (table 2). As previously reported (1, 3), a change in the rat population occurred during the course of the project. Initially, *Rattus rattus* appears to have been the predominant domestic rat species in the three counties; but by the third year, *Rattus norvegicus* had increased in number so that the ratio of *R. rattus* to *R. norvegicus* was 2:1 or less in Thomas and Grady Counties. In Brooks, there was a noticeable absence of *R. norvegicus* until November 1947 and relatively few were trapped subsequently.

More than 96 percent of the total number of ectoparasites collected in the three counties were among four species: *Xenopsylla cheopis*, the oriental rat flea; *Leptopsylla segnis*, a second rat flea; *Liponyssus bacoti*, the tropical rat mite; and *Polyplax spinulosa*, a rat louse.

The percentage of rats infested with *X. cheopis* is shown in table 3. Hill and Morlan (1) reported that a greater reduction in flea infestation occurred in the dusted counties than in the undusted. Recent data indicate that this reduction was maintained for approximately 1 year after dusting was completed. The infestation rate also declined in untreated Grady County during the same period, but the relative decrease was small in comparison with that observed in the treated counties. During

Figure 1
INCIDENCE OF HUMAN TYPHUS FEVER BY MONTH OF ONSET IN THE UNDUSTED AREA, GRADY COUNTY, AND IN THE DUSTED AREA, THOMAS AND BROOKS COUNTIES



FEDERAL SECURITY AGENCY PUBLIC HEALTH SERVICE COMMUNICABLE DISEASE CENTER ATLANTA, GEORGIA MARCH 1950

Table 1

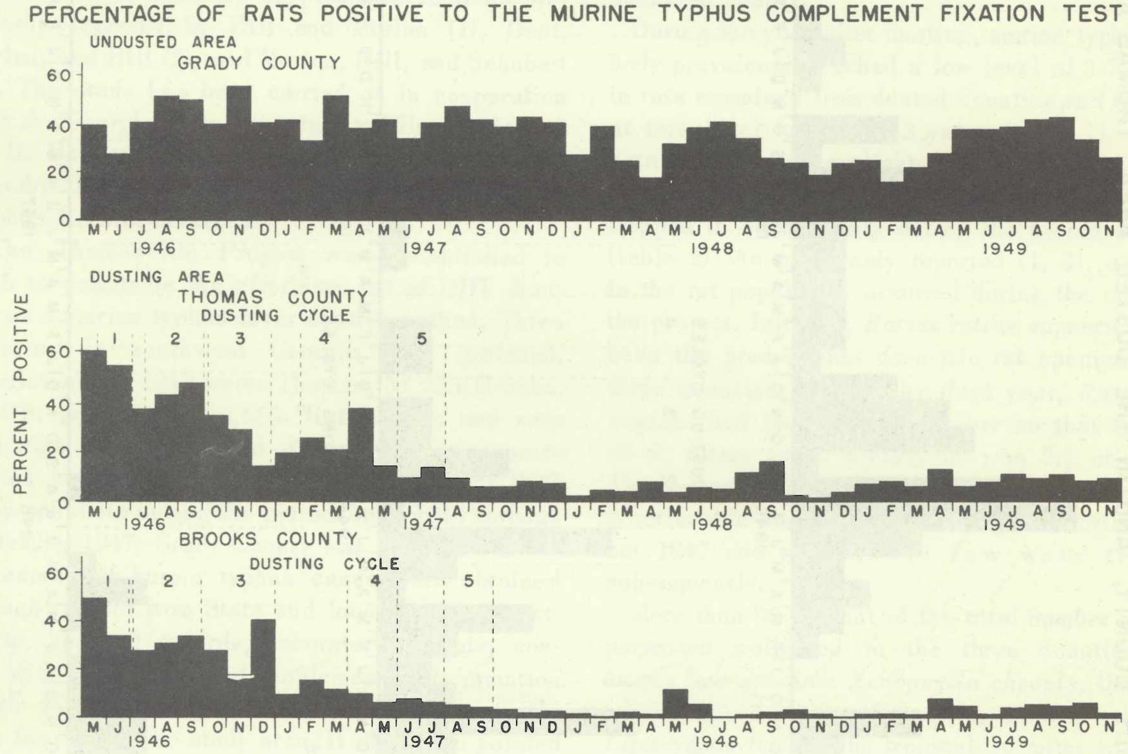
PRESENCE OF ANTIBODIES IN COMMENSAL RATS BY COUNTY AND OPERATIONAL YEAR
May 1946 - November 1949

Operational year	Grady		Thomas		Brooks	
	No. rats examined*	Percent positive	No. rats examined*	Percent positive	No. rats examined*	Percent positive
May 1946 - April 1947	1,240	40.7	1,537	39.7	1,483	24.7
May 1947 - April 1948	2,073	36.0	2,190	7.0	2,220	3.3
May 1948 - April 1949	2,136	26.4	2,992	6.8	3,088	3.0
May 1949 - November 1949	1,499	36.4	1,579	8.9	1,541	4.0

*Rats for which a serology result was not obtained were excluded.

Figure 2

PERCENTAGE OF RATS POSITIVE TO THE MURINE TYPHUS COMPLEMENT FIXATION TEST



the last year of study, the percentage of rats infested with *X. cheopis* began to approach the predusting level. The *L. segnis* infestation rate in the treated counties decreased in a manner similar to that observed in the oriental rat flea. Practically no change in the *L. segnis* infestation rate was experienced in the untreated county. Infestation of rats with *L. bacoti* and *P. spinulosa* was not affected to the extent noted in the rat fleas.

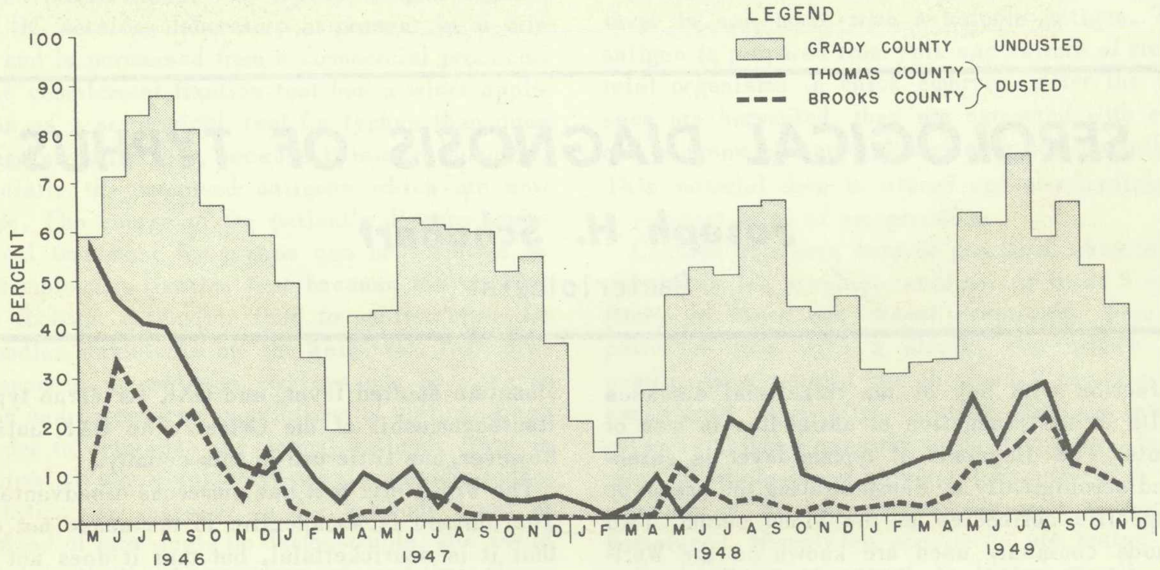
In summary, it may be concluded that the DDT program achieved a substantial reduction in incidence of murine typhus fever among humans and in the prevalence of typhus complement-fixing antibodies in the rat population in the dusted counties. This reduction has been maintained for more than 2 years following dusting.

Table 2

SUMMARY OF RATS TRAPPED BY SPECIES, COUNTY, AND OPERATIONAL YEAR
May 1946 – November 1949

Operational year	Species	Counties: Grady	Thomas	Brooks
May 1946 – April 1947	*R. rattus*	1,178	1,441	1,919
	R. norvegicus	352	327	0
	Total	1,530	1,768	1,919
May 1947 – April 1948	*R. rattus*	1,494	1,697	2,267
	R. norvegicus	676	583	49
	Total	2,170	2,280	2,316
May 1948 – April 1949	*R. rattus*	1,312	2,036	3,018
	R. norvegicus	912	1,060	164
	Total	2,224	3,096	3,182
May 1949 – November 1949	*R. rattus*	762	792	1,318
	R. norvegicus	761	824	255
	Total	1,523	1,616	1,573

Figure 3
PERCENTAGE OF COMMENSAL RATS INFESTED WITH X. CHEOPIS



FEDERAL SECURITY AGENCY PUBLIC HEALTH SERVICE COMMUNICABLE DISEASE CENTER ATLANTA, GA. MARCH 1950

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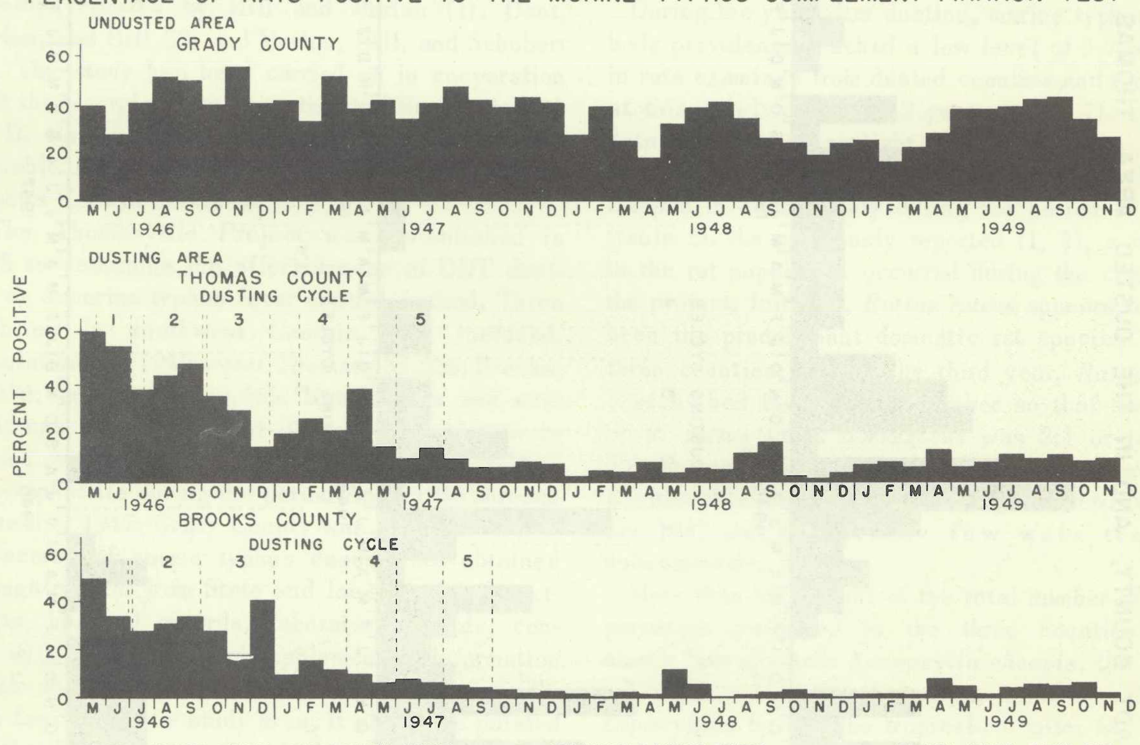

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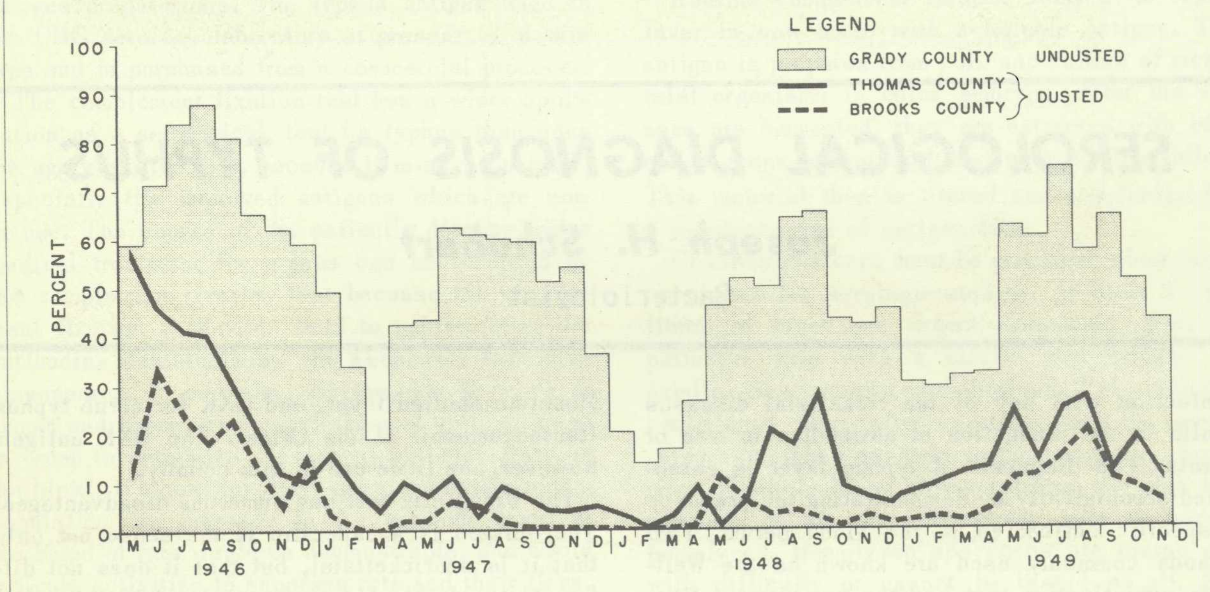
Figure 3

PERCENTAGE OF COMMENSAL RATS INFESTED WITH X. CHEOPIS



FEDERAL SECURITY AGENCY PUBLIC HEALTH SERVICE COMMUNICABLE DISEASE CENTER ATLANTA, GA. MARCH 1950

Table 3

"XENOPSYLLA CHEOPIS" INFESTATION OF COMMENSAL RATS BY COUNTY AND OPERATIONAL YEAR
May 1946 - November 1949

Operational year	Grady	Thomas	Brooks
	Percent infested	Percent infested	Percent infested
May 1946 - April 1947	60.7	28.4	13.2
May 1947 - April 1948	41.4	5.2	1.8
May 1948 - April 1949	42.1	11.2	3.6
May 1949 - November 1949	59.0	19.1	11.6

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SEROLOGICAL DIAGNOSIS OF TYPHUS

Joseph H. Schubert

Bacteriologist

Infection with any of the rickettsial diseases results in the production of antibodies in man or rodents. The diagnosis of typhus fever is established serologically by demonstrating the presence of specific antibodies in the blood serum. Two methods commonly used are known as the Weil-Felix agglutination test and the complement fixation test.

The use of *Proteus* OX19 in an agglutination test for typhus stems back to 1915 when Weil and Felix observed that serum from typhus fever patients would agglutinate in certain strain (OX19) of *Proteus* bacilli. Since that time other *Proteus* antigens, OX2 and OXK, have been found useful for the agglutination test in rickettsial diseases. The OX2 strain was reported as specific for Rocky Mountain spotted fever, and OXK for scrub typhus (tsutsugamushi) of the Orient. The OXK antigen, however, has little use in this country.

The Weil-Felix test has numerous disadvantages. The antigen is nonspecific in the sense not only that it is nonrickettsial, but that it does not differentiate clearly between certain rickettsial diseases. For example, it was found that 70 percent of the sera from cases of Rocky Mountain spotted fever agglutinated the OX19 antigen which is used primarily for typhus, although usually not in very high dilutions. The OXK antigen, useful for diagnosing scrub typhus, agglutinates to high titers in serum from patients with louse-borne relapsing fever. Q fever and rickettsialpox infections fail to develop agglutinins in significant amounts to agglutinate *Proteus* antigens. Patients having infections with *Proteus* organisms may give falsely positive reactions for typhus with the Weil-Felix test. These disadvantages have stimulated study of other tests and more specific antigens for the diagnosis of rickettsial infections, including typhus fever.

Modifications of the Weil-Felix agglutination test have been made by using suspensions of specific rickettsiae in place of *Proteus* antigens. Comparative studies made with the rickettsial antigens and *Proteus* antigens have shown little advantage of one over the other. The greater expense and difficulty in preparing rickettsial suspensions has made them impractical for use in routine testing.

The complement fixation test first was applied to the diagnosis of typhus in 1936, by Castaneda in Mexico. The antigen used by him was prepared from peritoneal washings of X-rayed, infected rats. Upon the introduction of the embryonated egg yolk sac culture technique of Cox, it became possible to grow large numbers of rickettsial organisms for antigen preparations. The typhus antigen used in the CDC serology laboratory at present is of this type and is purchased from a commercial producer.

The complement fixation test has a wider application as a serological test for typhus than does the agglutination test, because it is more specific, especially the improved antigens which are now in use. The course of the patient's disease under medical treatment for typhus can be followed by the complement fixation test because the complement fixation antibodies tend to persist after the antibodies detectable by the Weil-Felix test have disappeared. In addition, surveys can be made of human and rodent (rat) populations of various areas in order to determine the normal antibody level in the blood. If a new epizootic develops in the rodent population, an increase in the antibody level of the blood of rats would be demonstrable, and would indicate activities to suppress rats and their fleas. The fleas transmit the infection among rats and from rats to man.

As a rule, the complement fixation test does not become positive in man until about the second week of infection. The Weil-Felix test is generally positive in the first week of infection. In some 322 cases studied by Bengtson in 1941, about 24 percent gave positive results with the complement fixation test whereas the Weil-Felix test was negative.

Specimens of serum are often sent to the laboratory with the request that a diagnosis be made. Since certain low levels of antibodies are often found in normal sera, it is not possible to report any single titer as diagnostic. A RISING TITER, however, is strong evidence of active rickettsial infection. Such information could only be obtained from successive specimens of serum taken 5 to 10 days apart in the early phase of the disease. It is strongly recommended that, wherever possible, such pairs of serum ("acute" and "convalescent") be sent in for diagnosis.

The persistences of antibodies resulting from typhus infection have been studied in great detail by many workers. Antibodies can act as indicators of such infection for periods up to 3 or 4 years following illness. Average positive titers taken at yearly intervals show no pronounced loss of titer with passage of time, according to some recent work.

Routine complement fixation testing for typhus fever is now made with a soluble antigen. This antigen is prepared from yolk sac culture of rickettsial organisms in chick embryos. After the yolk sacs are harvested, they are extracted with ether and benzene and precipitated with sodium sulfate. This material then is titered and standardized to a constant level of antigenicity.

Considerable care must be practiced when taking specimens for serologic studies. At least 5 milliliters of blood are drawn aseptically from the patient's vein with a sterile, dry syringe and needle. Best results are obtained if the blood is centrifuged soon after clotting, and the sterile serum is shipped promptly to the laboratory. Specimens of whole blood shipped during the high temperature of the summer months tend to become hemolyzed. Hemolyzed specimens are tested only with difficulty or cannot be tested at all. Sera from rats and other rodents must be collected with great care to avoid contamination. Sera which become contaminated will generally be anticomplementary when they are tested in the laboratory. Specimens should be shipped at the beginning of a week, to prevent lay-over in post offices during week ends.

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ACUTE CONJUNCTIVITIS IN THE SOUTH

Dorland J. Davis and Margaret Pittman *

Along the southern border of the United States, a severe form of conjunctivitis, generally known as "sore eyes," exists during the warm months of the year. This disease affects many thousands of children annually, and in certain places is the chief cause of school absences and a major public health problem.

Since October 1947, we have been studying the disease first in Hidalgo County, Tex., and more recently in Thomas County, Ga. The investigation has been a joint enterprise of the National Institutes of Health and the Communicable Disease Center, using the services and personnel of both these branches of the Public Health Service with the cooperation of State and county health departments.

This disease is not new but has been observed for many years by various physicians. Dr. Carl E. Rice of the Public Health Service, in the course of a survey on trachoma in Texas in the early 1930's, had observed it and distinguished it from trachoma. Similar conjunctival disease has been reported from southern California by Schneider in 1927 and in Georgia by Bengtson in 1933. Because it occurs so frequently, is self-limited, and leaves no serious sequelae, it thus far has not attracted much concern in comparison to other diseases which, though more serious in outcome, may not be so prevalent.

Clinically, the disease begins with watering and irritation of one eye soon followed by vascular injection, pain, and purulent discharge. On the second or third day, the lids may be edematous and the other eye may become affected. In a few severe cases, the conjunctivae are severely inflamed, sometimes with ecchymoses, and the patient is incapacitated by the pain and swelling. The condition usually continues about a week, but may persist for as long as a month or 6 weeks. It frequently recurs, and some children are reported by their parents to be attacked every month or so.

Our first investigations in Hidalgo County, Tex., were directed toward determining the cause of the infection. From the affected eyes of 24 of 45 patients studied bacteriologically, a small gram negative bacillus belonging to the *Hemophilus* group was cultured in large numbers. Similar organisms also were seen in smears of the secretions. No evidence of the presence of a virus or other microbiological agent was obtained by examination of stained smears of the conjunctival scrapings and secretions, or with material that was taken to the laboratories of the National Institutes of Health in Bethesda, Md., in the frozen state and inoculated into monkeys, rabbits, mice, and embryonated eggs.

Despite the frequent occurrence of the hemophilic organism, the question remained whether this bacillus by itself could induce conjunctivitis or whether it was incidental or accessory to an undetected cause. Through the cooperation of the Department of Corrections, District of Columbia, eight adult human volunteers were inoculated with a broth culture of a strain that had been isolated from a 7-year-old school child. In six volunteers acute conjunctivitis, clinically resembling that seen in Texas, became manifest in less than 24 hours, and an organism indistinguishable from the one used for inoculation was recovered from the affected eyes.

Preceding the inoculations the organisms were observed to be sensitive in the test tube to streptomycin. These patients were treated topically with streptomycin; clinical improvements promptly followed; and 24 hours later, the bacteriological cultures were negative.

Following the establishment of the evidence that this organism caused the disease in humans, and could be effectively treated with streptomycin, further bacteriological studies have been undertaken in Texas and are now under way in Georgia. Although occasionally other pathogenic organisms are recovered from affected eyes, organisms belonging to the *Hemophilus* group have been found consistently. After considerable study, we were able to separate the *Hemophilus* strains into two groups. One group consisted of strains of *Hemo-*

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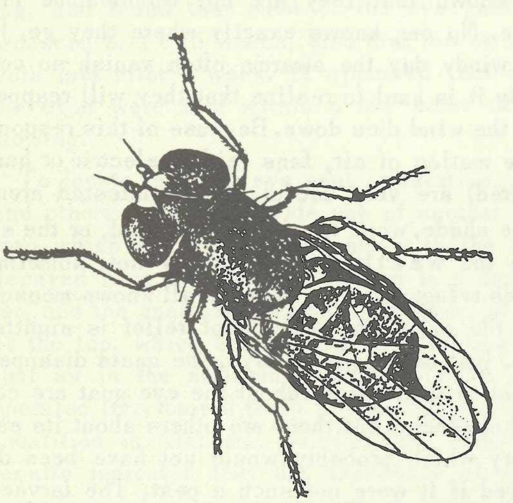
philus influenzae (Pfeiffer's bacillus) nearly all of which were nontype-specific. The other group consisted of strains which resembled *H. influenzae* in certain respects but differed from it in others, and corresponded to the original descriptions of the Koch-Weeks bacillus. These two organisms have been confused in the literature and textbooks and have been the subject of much controversy. Our detailed studies of these two types of *Hemophilus* have established cultural and serological methods of differentiation which may help in elucidating the epidemiology and pathogenesis of the disease.

An important problem is the mode of transmission. Most physicians and others who have had experience with it in these areas feel that the eye gnat, *Hippelates pusio*, is important in the transfer of infection from one individual to another. These



The adult eye gnat, *Hippelates pusio* (after Hall).

gnats are particularly abundant during the spring and fall and seem to be especially common in agricultural areas. They are attracted by the moist mucous membranes of man or animals, especially the eyes. Frequently they become lodged in the conjunctival sac and are a source of great annoyance. Around and on the lids of infected eyes they often swarm in large numbers and, of course, in infants they are continually clustered about the eyes. These insects are not blood sucking or biting flies; and if they serve as a vector, it is probably by a mechanical transfer of the causative organism. To date there is no experimental evidence on this mode of transfer and, furthermore, its importance, if established, will have to be considered in relation to other possible avenues of spread. The disease is especially prevalent in families in crowded, unhygienic surroundings where the opportunity for transfer of infectious material by fingers, clothing, or towels is ample. It may be that both means of transfer play a role in the spread of the disease.

It is of interest to note that a similar and probably identical disease is world-wide in distribution though limited largely to warm climates. In Egypt it is endemic, and there are numerous reports of epidemics of acute conjunctivitis from various parts of Europe. It is also present in Central and South American countries. It is interesting to speculate whether the disease at one time had a wider distribution in the United States. Weeks in 1886 described many cases in New York City and environs which corresponded to those seen in Texas; but insofar as can be determined, this disease now is seen rarely, if at all, there or in any part of the central United States.

The observations on the use of streptomycin in the experimental disease encouraged the employment of it in the clinic on naturally occurring cases. The antibiotic was used as a 0.1 percent solution in physiological saline and instilled directly onto the conjunctiva while the patient was in the clinic. For comparison, a 0.25 percent solution of zinc sulfate was used similarly on another group of patients. In both groups the treatment appeared to be effective as judged by clinical improvement and failure to recover organisms after treatment. The recent reports of the use of aureomycin by Braley and his associates add another therapeutic agent to the treatment of conjunctivitis caused by hemophilic organisms. There are of course other antibacterial agents which also have acquired favor with physicians. It appeared to us, however, that the method of administration was of extreme importance. When care and effort by the nurses was taken to make sure the therapeutic solution was properly instilled, the results were much better than if the parents were trusted to administer it as best they could.

The control of the disease would appear to depend on the solution of the problem of mode of transmission and also a better understanding of the pathogenesis and epidemiology of the disease based upon careful etiological studies. In the meantime, proper use of therapeutic agents at hand will do much to relieve the disability caused by the infection.

THE EYE GNAT PROBLEM

Richard P. Dow
Scientist*

Everyone who has been annoyed by the common eye gnat of the southern United States will agree that this insect *(Hippelates pusio)* is a problem in itself. For a pest which does not sting and whose beak can only rasp human flesh, it torments man out of proportion to its often tremendous numbers. Sometimes there is only one gnat buzzing around the head like a mosquito or lighting on an eyelid, but often it is a whole swarm effectively preventing any consecutive effort unless one hand can be used to fan the face.

The eye gnat is also a problem from the viewpoint of disease, for it appears to transmit a severe conjunctivitis, commonly known as sore eyes, which occurs in the same geographical area. Recent studies of this disease by Drs. Dorland J. Davis and Margaret Pittman of the National Institutes of Health show that it probably is caused by a single species of bacteria. Whether the gnat is an important carrier of this organism remains to be determined. Certainly the habits of the adult gnats suggest that they might be vectors of an eye disease because they commonly feed on the moist secretions of the eye. They also are attracted by sweat, open cuts and sores, and various animal secretions. It is not known whether some odor or group of odors draws them to these different sources of food, or whether there is a visual response to glistening objects.

Fortunately, the eye gnat is usually troublesome outdoors only. Though it is less common in houses, this fact does not appear to have any particular relation to the kind or condition of the screening. When gnats are abundant, one has only to open a can of sardines or try to shuck shrimp to find that they soon will be swarming over the food. The ability of gnats to pass through tiny openings can be demonstrated by placing them in a jar covered with fine screening and directing the jar toward light. In one test lasting 5 minutes, four-fifths of the enclosed gnats escaped through wire mesh with 20 openings to the inch. Ordinary house screening has 14 or 16.

If one cannot avoid the swarms of gnats by going indoors, the newer types of mosquito repellent are helpful in keeping them at a distance. These liquids will cause a severe smarting if they get in the eyes, and this misfortune is all the more likely when one is hot and perspiring and the gnats are really bad.

In regions where the gnats are abundant, it is well known that they are not troublesome in a breeze. No one knows exactly where they go, but on a windy day the swarms often vanish so completely it is hard to realize that they will reappear when the wind dies down. Because of this response to the motion of air, fans (either electric or hand-operated) are very useful in gnat-infested areas.

The shade, when the weather is cool, or the sun, when the weather is extremely hot, sometimes affords refuge from the gnats. If all known measures fail, the only other source of relief is nightfall. Then, just as on windy days, the gnats disappear.

Most of these facts about the eye gnat are common knowledge, but there are others about its early history which probably would not have been discovered if it were not such a pest. The larvae of some members of the same family (Chloropidae) feed in or about the stems of grasses, for example, the well-known wheat-stem maggot (*Meromyza americana*). Others appear to live as scavengers in decaying parts of plants. The genus of the common eye gnat, however, seems to prefer organic matter in an advanced state of decomposition. By rearing eggs laid by caged females, Dr. David G. Hall, working in California, obtained the largest percentage of adults from human excrement, though well-rotted figs and oranges were nearly as favorable. He found that fermenting media were not so advantageous, and considered fecal pollution an important factor.

Taking a different line of attack, John T. Bigham, in Florida, sought to discover what type of habitat produced the most gnats. He used emer-

*Eye Gnat Studies, Entomologic Services, Thomasville, Ga.

gence traps a foot high and a yard square which were covered with light canvas and had a fruit jar inserted in one corner. The object of the fruit jar was to catch those gnats which, having come from the ground, would be trapped by their tendency to move toward light. Sixty-nine settings of these traps were made over grass and weed sod, leaf. mold, rotting fruit or vegetables, duff in pine woods, and other situations where the soil had not been disturbed by plowing, harrowing, digging, or other procedures. No gnats were recovered in any of these places. Over four hundred other settings were made where the soil had been disturbed in some way, usually by agricultural practices. These produced an average of 24 gnats per setting. Following this lead, Bigham set emergence traps over plowed soils at different intervals after the plowing, and found that most of the eye gnats were produced in 3 to 6 weeks, also that few or no eggs were laid after 1 week. It appeared that most of the eggs were laid within a few hours after the plowing.

To locate areas of eye gnat infestation, Bigham and others have made wide use of another kind of trap which attracts adult gnats with the odor of decayed liver. The bait is placed in a dark shelter, and the gnats are caught in a glass jar placed at the top, which operates as a collecting device just as in the emergence trap. In 1938, Bigham operated liver-baited traps of this type in numerous localities in Alabama, Georgia, and Florida. His results indicated that the abundance of gnats is closely related to the amount of sandy or muck land under active cultivation. Similar observations had been made previously by R. W. Burgess in California. Thus it seems reasonable to believe that the soil-inhabiting larvae feed on organic matter which has been made accessible by cultivation.

The various studies of eye gnats made up to the present time have not been confined to obtaining information on their life history or examining their relation to the prevalence of conjunctivitis. Much work has been done on methods of control, but without the discovery of any completely satisfactory or economical means of reducing their numbers. Traps baited with decayed liver will catch eye gnats by the thousands, and have been recommended for use in small areas such as around houses. Space spraying with insecticides has been given numerous trials, but regardless of any immediate success it does not produce lasting results. Besides these measures against the adult gnats, experiments have been made with soil poisons and with special methods of cultivation directed against the larvae. It has been found that in areas where subirrigation is used, flooding will completely prevent gnat breeding. To date, however, no single measure has been proved universally effective.

Nevertheless, because of the suggestive relation of eye gnats to the spread of conjunctivitis in the southern United States, as well as the great loss of time and effort caused by their annoying habits, further studies of eye gnats and conjunctivitis now are being conducted at the CDC Activities Station in Thomasville, Ga.

The first objective of the entomological work is to study the life history and habits of the gnat in the hope of uncovering new information leading to the development of feasible and economical measures for its control. One of the big gaps in our present knowledge is the question of where the adult gnat rests at night and during cold or windy weather. In this connection it is interesting to recall that, whereas anopheline mosquitoes once were controlled commonly by larviciding, DDT has made it more practical to kill adults in their natural resting places. Other unknowns in the biology of the gnat are the precise conditions necessary for oviposition and the food requirements of the larvae. Thoughtful investigation of such questions ultimately may suggest control methods unsuspected at the present time.

The second entomological objective is, briefly, to devise methods for measuring populations of gnats and making reliable indexes thereto. This will have a double purpose: to evaluate measures which are being tested or used for control, and to provide data for epidemiological studies and evaluations regarding conjunctivitis. At present the standard method of sampling adult populations is to operate traps baited with liver and to compare the resulting catches. Such collections vary greatly in size, partly as a result of meteorologic conditions. Other factors are probably involved, such as lack of uniformity in the bait, and the possibility that the traps reduce the numbers of gnats to such an extent that they are no longer merely sampling the population.

Another aspect of this part of the investigation is the determination of the numbers of larvae occurring in the soil, and the relation of larval abundance to adult prevalence in respect to both time and place. At present there seems to be no practical method for counting the larvae in samples of soil.

Finally, when promising leads on control procedures have been determined and have proved their value in small-scale tests, the entomological phase of the project will undertake to control gnats in one or more towns severely affected by conjunctivitis. In this way it will be possible to study the effect of a reduced population of eye gnats upon the incidence of sore eyes. This is preferable to evaluating the incidence of conjunctivitis in terms of natural populations of eye gnats because it is an experimental method which can be employed in different places and at different times, and begun or discontinued at will.

Though it is surprising that a pest as common as the eye gnat has failed thus far to yield to the efforts made by entomologists to find an effective means of control, there is hope for the future in the fact that there are still many facets of its life history which are unknown. Man's experience with other insects which formerly were considered inevitable should offer encouragement both to those who still endure eye gnats and those who are trying to do something about them.

ANIMAL CONJUNCTIVITIS

Kenneth S. Young

Veterinarian (R) *

Whenever infectious conjunctivitis is considered in either human or animal medicine, the infective agent predominately present is the *Hemophilus* organism known in human medicine as the Koch-Weeks bacillus. From fowl coryza to pinkeye of humans, and whether the symptoms are primarily systemic as in equine influenza or more localized as in pinkeye of cattle, the gram-negative, small, rod-shaped bacillus is usually present in the early stages as an early secondary invader. Later, other secondary invaders change the picture from acute to chronic keratoconjunctivitis. The work of Reid and Anigstein (1945) and of Farley, Kliewer, Pearson, and Foote (1950) clearly indicates the role the *Hemophilus* organism plays in affecting the economy of the livestock industry. The disease always has been a serious problem in Texas in cattle, sheep, and goats, particularly in white-faced cattle. The white hairs reflect the ultraviolet rays of the sun into the eye, increasing the photophobia always present in pinkeye. The effect is similar to snow blindness in man. Some stockmen are endeavoring to develop cattle with a dark pigmentation around the eye. Even in dairy cattle, pinkeye is more serious in the white animals. Every Texas veterinarian knows that in middle to late summer he can expect many cases of pinkeye, although it can occur at any time of the year. The hot Texas sun, and dust and wind are physical factors influencing its prevalence and severity. The practicing veterinarian will describe the disease symptoms as unilateral or bilateral photophobia, lacrimation, opacity of the cornea, in some cases protrusion of the cornea, vascular congestion, and mucopurulent discharge. The acute stage lasts about 3 days. The spread of the disease is by direct or indirect contact, although some insects are thought to be mechanical carriers.

The veterinarian has a different problem with beef than with dairy cattle. In beef cattle, it may be more desirable to provide shade, food, and water, and not handle the animals — isolation in a flyproof, shady place being more effective than treatment. Shade is essential if the disease is not to progress into the chronic form, with loss of the eyesight after rupture of the eyeball. Attacks of the disease always are increased greatly in severity where shade is lacking.

* Texas State Health Department, Austin, Tex.

Condition of the animals, food supply, and mineral intake seem to have little or no effect on infectious pinkeye, well-nourished animals having the disease in equal severity to the poorly nourished. The temperature is elevated from 1 to 3 degrees during the acute stage. Secondary invaders include *Escherichia coli, Bacillus pyogenes, Bacillus subtilis, Pasteurella,* and *Staphylococcus.* When one considers the bacteriological picture with the gram-negative *Hemophilus* organism predominating in the early stages and gram-positive types predominating in the later stages, the reasons for the treatments used by Texas veterinarians become evident. In the past, silver nitrate in 1.5 percent solution, argyrol, boric acid, calomel, and both sulfa ointment and powder have been used. At present, streptomyçin is being used, particularly in the early stages, and penicillin is used in both acute and chronic stages. The successful use of penicillin requires that it be used frequently in order to get the full benefit of the contact therapy. Foreign protein always is used, either sterile milk or hog cholera serum, with many veterinarians using more hog cholera serum for its foreign protein action than is used in the treatment of hogs.

In poultry there is a *Hemophilus* variety causing an acute fowl coryza that does not seem to be associated with a virus, as in the case of equine influenza. Fowl coryza is a very serious and widespread disease causing a heavy economic loss to the poultry industry.

Equine influenza is called pinkeye or epizootic cellulitis as often as it is called flu. It is an acute, highly contagious, generalized disease affecting equines. It is especially prevalent when large numbers of horses are gathered together, as they were in the World Wars. It is quite similar to influenza in man.

Swine influenza is a disease in which eye symptoms are not marked, and secondary invaders of the eye are seldom described.

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CDC Training Courses

Listed below are training courses, sponsored by Services of the Communicable Disease Center, to be held in the near future. Further information on the courses may be obtained from the *Bulletin of Field Training Programs* issued by the Center.

TRAINING SERVICES

1. **ENVIRONMENTAL SANITATION FIELD TRAINING**, April 10 to June 30, 1950. Twelve weeks. Amherst, Mass.

2. **ENVIRONMENTAL SANITATION FIELD TRAINING FOR GRADUATE SANITARIANS**, July 10 to September 1, 1950. Eight weeks. Amherst, Mass.

3. **FIELD SURVEY AND EVALUATION METHODS FOR MEASURING QUALITY OF HOUSING ENVIRONMENT**, June 5-10 and August 7-12, 1950. One week. Atlanta, Ga.

4. **FIELD SURVEY AND EVALUATION METHODS IN HOUSING SANITATION**, May 15 to June 16 and July 17 to August 18, 1950. Five weeks. Atlanta, Ga.

5. **FLY CONTROL**, May 15-19, 1950. One week. Atlanta, Ga.

6. **INSECT AND RODENT CONTROL TRAINING FOR FOREIGN PUBLIC HEALTH PERSONNEL**, June 5-16, July 5-18, and July 31 to August 11, 1950. Two weeks. Atlanta, Ga.

7. **ORIENTATION COURSE FOR SANITARY ENGINEERS IN WATER POLLUTION AND INDUSTRIAL WASTE SURVEY METHODS**, April 17 to May 26, 1950. Six weeks. Cincinnati, Ohio.

8. **GENERAL SANITARY ENGINEERING FIELD TRAINING**, June 19 to September 8, 1950. Twelve weeks. Columbus, Ga.

9. **PUBLIC HEALTH ORIENTATION FOR GRADUATE VETERINARIANS**, June 19-23, 1950. One week. Denver, Colo.

10. **INSECT AND RODENT CONTROL**, June 19-24, 1950. One week. Pittsburgh, Pa.

11. **FIELD SURVEY AND EVALUATION METHODS FOR MEASURING QUALITY OF HOUSING ENVIRONMENT**, June 19-24 and August 21-26, 1950. One week. Syracuse, N. Y.

12. **FIELD SURVEY AND EVALUATION METHODS IN HOUSING SANITATION**, May 29 to June 30 and July 31 to September 1, 1950. Five weeks. Syracuse, N. Y.

13. **ENVIRONMENTAL SANITATION FIELD TRAINING**, August 21 to November 11, 1950. Twelve weeks. Topeka, Kans.

14. **PRACTICAL COURSE IN COMMUNITY FLY CONTROL**, May 1-5, 1950. One week. Topeka, Kans.

15. **SPECIAL TRAINING PROGRAM IN MILK SANITATION**, May 15-27, 1950. Two weeks. Topeka, Kans.

LABORATORY SERVICES

1. **LABORATORY DIAGNOSIS OF BACTERIAL DISEASES**, May 22-26, 1950. One week. Atlanta, Ga.

2. **LABORATORY DIAGNOSIS OF MYCOTIC DISEASES**, May 29 to June 2, 1950. One week. Atlanta, Ga.

3. **LABORATORY DIAGNOSIS OF TUBERCULOSIS**, June 5-9, 1950. One week. Atlanta, Ga.

4. **LABORATORY DIAGNOSIS OF PARASITIC DISEASES**, June 12-16, 1950. One week. Atlanta, Ga.

5. **LABORATORY DIAGNOSIS OF MYCOTIC DISEASES; Part 1, Cutaneous and Subcutaneous Fungi**, July 24 to August 4, 1950. Two weeks. Atlanta, Ga.

6. **LABORATORY DIAGNOSIS OF MYCOTIC DISEASES; Part 2, Systemic Fungi**, August 7-17, 1950. Two weeks. Atlanta, Ga.

7. **LABORATORY DIAGNOSIS OF TUBERCULOSIS**, August 14-31, 1950. Two weeks. Atlanta, Ga.

VETERINARY SERVICES

1. **LABORATORY DIAGNOSIS OF RABIES**, May 8-12, 1950. One week. Atlanta, Ga.

PICTORIAL REVIEW

Climbing Ability of Norway Rats

PRODUCTION NO.: CDC 4-057, Released 1948

DATA: Motion Picture; 16 mm., Silent, Black & White; Length: 120 Feet; Time: 3 Minutes

GRAPHIC FORM: General Photography.

PURPOSE

To depict the climbing ability of Norway rats.

AUDIENCE

Public Health Service personnel, pest control industry, and other groups engaged in or interested in rodent control programs.

CONTENT

Introduction explaining that the climbing ability of Norway rats approaches that of roof rats: Norway rat on a flat roof; Norway rat climbs a sloping sheet metal roof; Norway rat readily climbs a burglar guard over a window; from the burglar guard the rat climbs a vertical wall and disappears down a ventilator shaft.

COMMENTS

This short film demonstrates that the climbing ability of Norway rats approaches that of roof rats and therefore, regardless of the type of rat present, ratproofing should be carried beyond the first floor in all buildings.

Identification of Some Common Sucking Lice

PRODUCTION NO.: CDC 5-097, Released 1948

DATA: Filmstrip; 35 mm., Sound, Black & White; Length: 60 Frames; Time: 9 Minutes.

GRAPHIC FORM: Drawings.

PURPOSE

To teach morphological characteristics used to identify six genera and eight species of the more common lice occurring in the United States.

AUDIENCE

Entomology students, entomological technicians, and advanced entomological inspectors.

CONTENT

The first half of the flimstrip includes basic information and general discussion of morphological terms; it delineates the important species of lice affecting man – i.e., the body, head, and crab lice. It is designed for use with classes in medical entomology. The second half of the filmstrip depicts those species of lice which have been collected on rats by members of the CDC Typhus Control Program. It illustrates and discusses the various species and stages of the rat lice. A schematic key employing simply and easily observed structures is used throughout the filmstrip.

COMMENTS

This is a filmstrip in the typhus series of productions.

Recognition of Rat Signs for DDT Dusting

PRODUCTION NO.: CDC 5-027, Released 1946

DATA: Filmstrip; 35 mm., Sound, Black & White; Length: 70 Frames; Time: 11 Minutes

GRAPHIC FORM: Photographs, Drawings.

PURPOSE

To depict rat habits and rat signs, and to show the use of DDT dusting in the control of rodent ectoparasites.

AUDIENCE

Public Health Service personnel, pest control industry, and other groups interested in rat eradication and typhus control.

CONTENT

Motivating introduction showing increase in typhus fever in the United States, its location, and mode of transmission through rats, via fleas, to humans; summary of methods of eliminating rats; methods of eliminating rat ectoparasites by DDT; survey of conditions encouraging rat invasions; evidence of rat runways; applying DDT dust to rat runways.

COMMENTS

Related filmstrips are "Control with DDT" and "Rat Eradication Measures on Ratproofing Projects."

Rat Eradication Measures on Ratproofing Projects

PRODUCTION NO.: CDC 5-068, Released 1947

DATA: Filmstrip; 35 mm., Sound, Black & White; Length: 78 Frames; Time: 13 Minutes

GRAPHIC FORM: Photographs and Charts.

PURPOSE

To depict the steps taken in the complete eradication of rats from a ratproofed building and the importance of maintaining such a building in a rat-free condition.

AUDIENCE

Public Health Service personnel, pest control industry, and other groups engaged in or interested in rat eradication programs.

CONTENT

Enumeration of steps involved in a ratproofing and eradication project; ratproofing and preliminary steps of poisoning; survey for evidences of rat infestation; poisoning with 1080 water; preparing and using poison bait; traps and trapping technique; 7-day check for complete eradication before building is declared rat free; reinspection each 30- to 45-day period; and eradication of any new infestation.

COMMENTS

Other filmstrips of this series are CDC Nos. 5-026, 5-124, 5-067, and 5-027.

Ratproofing of Existing Buildings

PRODUCTION NO.: CDC 5-067, Released 1947

DATA: Filmstrip; 35 mm., Sound, Black & White; Length: 80 Frames; Time: 14 Minutes

GRAPHIC FORM: Photographs, Drawings, and Forms.

PURPOSE

To depict methods by which existing buildings can be ratproofed and maintained in a rat-free condition.

AUDIENCE

Public health personnel, pest control industry, and other groups interested in or engaged in ratproofing operations.

CONTENT

Motivating introduction showing habitat, diseases carried, and types and extent of economic loss due to rats; surveying the need for ratproofing in a given area; the preventive measures used in completely ratproofing a building and its surroundings; periodic inspection to insure effectiveness of ratproofing.

COMMENTS

Other filmstrips of this series are CDC Nos. 5-026, 5-124, 5-068, and 5-027.

The Epidemiology of Murine Typhus

PRODUCTION NO.: CDC 4-049, Released 1948

DATA: Motion Picture; 16 mm., Sound, Black & White; Length: 665 Feet; Time: 18 Minutes

GRAPHIC FORM: General Photography and Animation.

PURPOSE

To aid in teaching basic understanding of epidemiological procedures of murine typhus and their relations to prevention and control.

AUDIENCE

Public Health Service personnel, physicians, medical students, nurses, laboratory technicians, and professional personnel interested in the control of rat-borne diseases.

CONTENT

The three elements of a murine typhus epidemic: animal reservoir (rats) to vector (rat fleas) to man; human incidence of murine typhus including geographic distribution, age, sex, and social-status distribution, and seasonal characteristics; character of rat reservoir of infection including mode of perpetuation and mode of transmission; the relation of the vector to the reservoir and to humans; the role of the doctor in diagnosis, serological confirmation, and reporting of murine typhus; the role of the public health officer in locating foci of infection, instituting continuous control measures, and cooperating with the Public Health Service analysis and control of epidemics; the role of P.H.S. epidemiologists in locating infectious rats, confirming by complement fixation tests, counting and identifying ectoparasites, analyzing data, and instituting control measures; brief visualization of key control activities including DDT dusting, rat poisoning, and ratproofing of buildings.

COMMENTS

The first film of a series on the epidemiology of infectious diseases. Demonstrates the pattern: animal reservoir to vector to man.

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CORRECTION

The data pertaining to Puerto Rico as shown in the Quarterly Summary of Residual Spray Operations which appeared in the January 1950 issue of the CDC Bulletin, p. 35, disagrees with project records. This discrepancy resulted from a change in handling Puerto Rico Payroll Period Progress Reports on a fiscal year basis to a calendar year basis, and to the exclusion of Payroll Period Progress Report No. 16 from the tabulation. A revised summary of Puerto Rico program accomplishments, together with a correct grand total, is presented below.

Possession	House Spray Applic.	Lb. DDT	Operation Man-hours CDC	Operation Man-hours Local	Operation Man-hours Total	Lb. DDT per Applic.	M.H. per Applic.	M.H. per Lb. DDT
Puerto Rico	1,730	723	616	976	1,592	0.42	0.92	2.20
Grand Total	282,104	330,916	89,417	261,321	350,738	1.17	1.24	1.06

BOOK REVIEW

MEDICAL ENTOMOLOGY

Robert Matheson

New York State College of Agriculture, Cornell University, Ithaca, N.Y., Second Edition, 1950, pp. 1 – 612, Comstock Publishing Company, Inc., Ithaca, N.Y.

This complete revision of Dr. Matheson's MEDICAL ENTOMOLOGY is a most useful reference for the student, the entomologist, and the public health worker. The identification, life histories, habits, disease-bearing potentialities, distribution, and control of insects and other arthropods of medical importance are presented in a very effective manner.

The general make-up of the first edition has been followed closely in this revision. Nevertheless, the subject matter has been presented more effectively by the addition of subtitles, technical improvement of the drawings and photographs, and the addition of new drawings, photographs, and text materials. There is a wealth of keys, many of them new to this edition, with others expanded or modified. As in the previous edition, the reader will find more than adequate figures and text to clarify the important key characteristics. Dr. Matheson wisely has restricted his use of keys to the basic ones lying within the scope of this volume. The references will prove invaluable to the student desiring to obtain detailed keys to species. References at the end of each chapter are starred to indicate articles with bibliographies and double starred to indicate extensive bibliographies.

Information on the order Orthoptera has been included in this edition with biological data and a key to common species and control methods. The encephalitides and Q fever and their vectors also are treated. Control measures for arthropod vectors of disease have been revised completely in the light of knowledge available at the beginning of 1949. The tables have been revised to present recent information on the distribution and breeding sites of disease vectors.

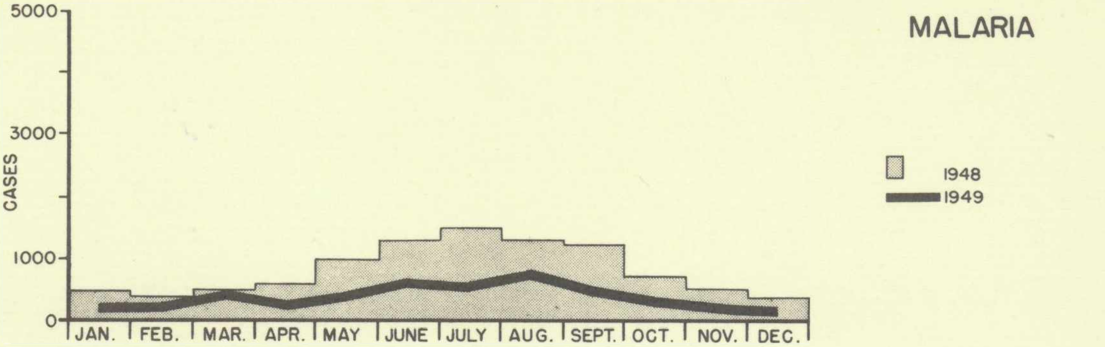
Dr. Matheson's text is noteworthy for its excellent organization and precise presentation of the subject. It is not merely a mixture of the new and the old; much new material has been added, and the old text revised in accordance with present information. This textbook on medical entomology soon should earn for itself the enviable position accorded its predecessor.

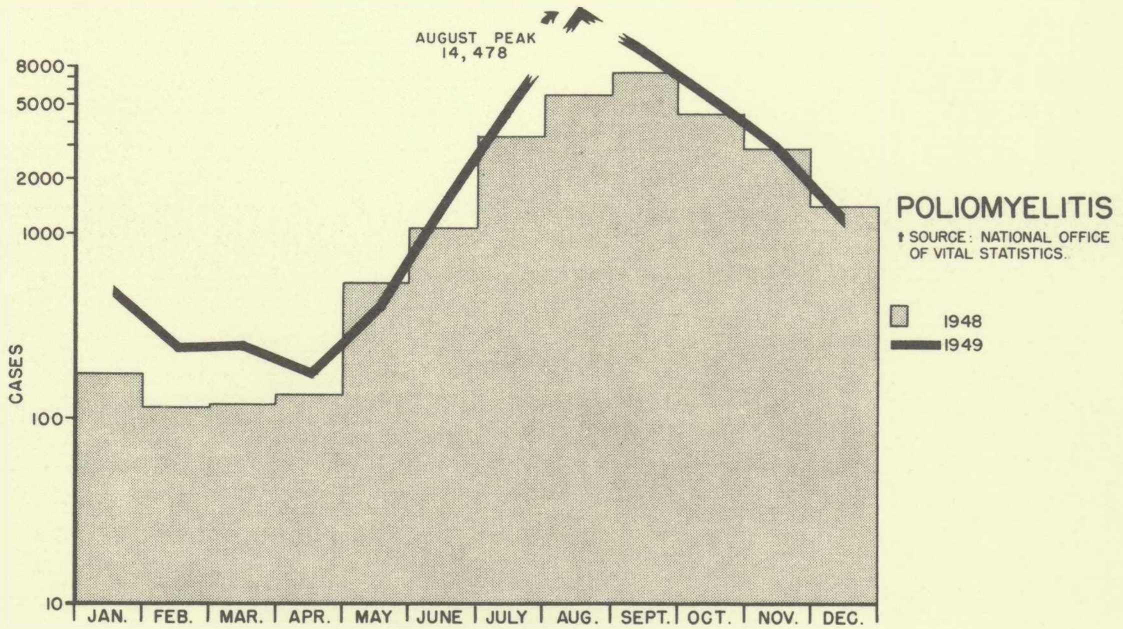
Kent S. Littig, Sanitarian (R)

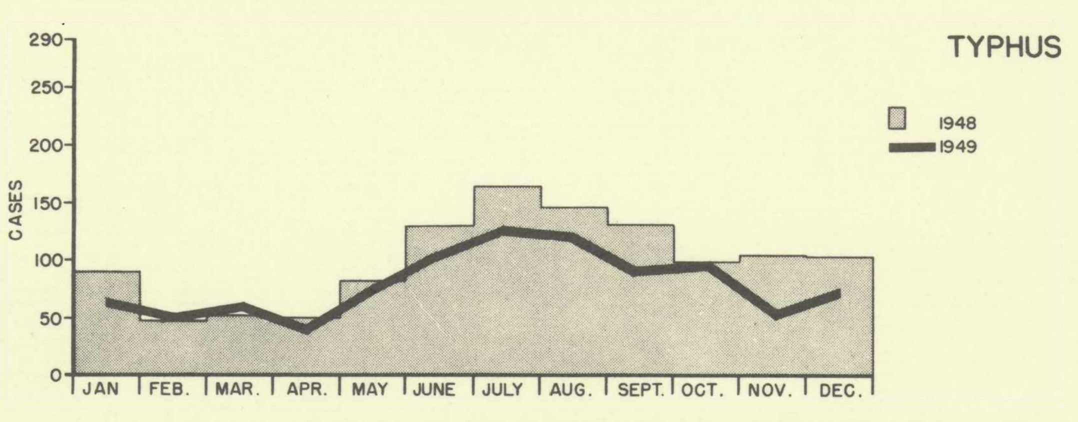
U. S. GOVERNMENT PRINTING OFFICE : O—1950

MORBIDITY TOTALS FOR THE UNITED STATES *
MALARIA, POLIOMYELITIS, TYPHUS

1948 - INCOMPLETE 1949 - AS REPORTED







FSA PHS CDC ATLANTA, GEORGIA

* MORBIDITY DATA WERE ASSEMBLED FROM TABULATIONS FURNISHED BY THE NATIONAL OFFICE OF VITAL STATISTICS, PUBLIC HEALTH SERVICE, AND THEY ARE VIRTUALLY COMPLETE.