Evaluation of County-Wide DDT Dusting Operations in Murine Typhus Control (1946 through 1949)*†

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IN 1944, murine typhus fever was a growing public health problem throughout much of the southern part of the United States. The 5 year period ending that year had seen a steady increase in reported cases from the nine most heavily affected southern states, with 1,790 cases in 1940 ranging upward to 5,275 in 1944. Studies made in 1944 and 1945 suggested that actual incidence was at least three times as great as reported incidence.[1, 2] Although the case fatality rate is only about 1 or 2 per cent (2 to 7 per cent when based on reported incidence[1]), the period of prostration and disability is prolonged. In the average case treated symptomatically, the period of prostration is ordinarily about 17 days and the individual is usually unable to return to normal activity for a total of about 50 days. While aureomycin treatment reduces this period of prostration by about 7 days and the period removed from normal activities by about 28 days,[3] the murine typhus fever patient still experiences considerable discomfort, disability, expense, and loss of productivity.

By 1945, laboratory studies and limited field trials suggested that DDT (2, 2 Bis-parachlorophenyl-1,1,1 Trichloroethane) might be effective in breaking the chain of transmission of murine typhus fever from its rat reservoir to man by destroying certain rat ectoparasites.[4-6] Coincident with the establishment of extensive murine typhus control programs utilizing DDT dusting as one of the principal control procedures, a study project was begun to evaluate the effectiveness of 10 per cent DDT in pyrophyllite when used as the sole community-wide means of controlling murine typhus fever.[2, 7, 8] When this evaluation study was started, there was no assurance that this procedure, when applied in nature, would be as effective as laboratory studies might suggest.[9]

OBJECTIVE

The objective of this study was, first, to determine whether or not 10 per cent DDT in pyrophyllite when applied to rat runs and rat harborage on a county-wide basis would significantly reduce the human incidence of murine typhus fever; and second, if significant reductions were obtained, how long such results might persist after dusting operations were terminated.

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TABLE 1

Pilot Study Data—1945 Murine Typhus Fever Morbidity Rate, Prevalence of Antibodies in Domestic Rat Reservoir and Ectoparasite Abundance Prior to May, 1946

County	Murine Typhus Fever Morbidity Rate (Per 100,000) 1945	Prevalence of Murine Typhus Complement-Fixing Antibodies in Domestic Rats		Ectoparasite Infestation of Domestic Rats				
					Per cent Infested with			
		Rats Exam.	Per cent Positive	Rats Exam.	X.c.	L.s.	L.b.	P.s.
Grady *	274	241	46.5	260	45.4	65.0	49.6	51.9
Thomas †	202	454	53.7	584	38.2	59.9	43.8	63.9
Brooks †	218	434	48.4	657	31.5	53.0	56.5	60.0

* To be left untreated
† To be treated with 10% DDT in pyrophyllite

STUDY METHODS

For the purposes of this study, Brooks, Thomas, and Grady Counties located in the southern part of Georgia were selected. As explained in a previous paper reporting data collected in the first part of the study, three types of quantitative measurements based upon objective laboratory confirmation were available.[2] Comparable sampling methods were employed in all three counties in the study. Trends of data representing the three main factors involved in the epidemiology of murine typhus fever were recorded for each county in order to study normal seasonal variations and to compare trends in the untreated county (Grady) with those in the two DDT dusted counties (Brooks and Thomas). These epidemiological factors which were subjected to continuous measurement were human incidence of murine typhus fever (each case being confirmed by complement-fixation tests), prevalence of complement-fixing antibodies in the rat population, and the abundance of the various species of rat ectoparasites.[2] Retrospective human incidence studies for 1945 and pilot reservoir and vector studies showed these three epidemiological factors to be reasonably comparable in the three counties as shown in Table 1.

In 1945, the morbidity rates for Grady, Thomas, and Brooks Counties were 274, 202, and 218, respectively. There were 46.5, 53.7, and 48.4 per cent of rats positive to the murine typhus complement-fixation test during the pilot studies, October, 1945, to April, 1946. Also, during the same period, a similar degree of comparability for the percentage of rats infested with each of the four principal rat ectoparasites existed among the three counties.

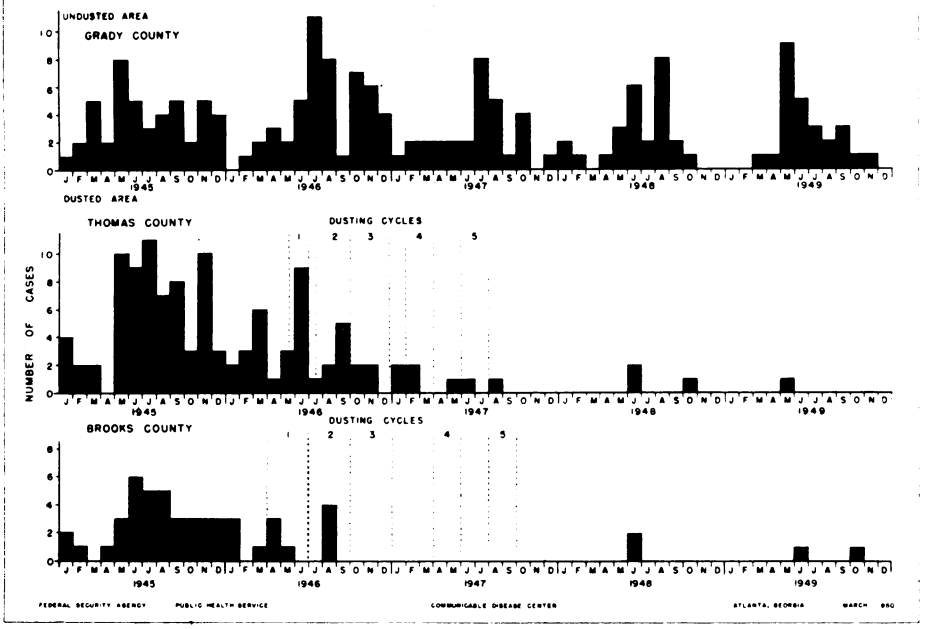
The human incidence studies endeavored to approach 100 per cent sampling as nearly as possible. A serological survey of prevalence of murine typhus complement-fixing antibodies, made possible by an extensive serological survey of syphilis prevalence in Thomas and Grady Counties, indicated that our sampling objective in the human incidence studies was reasonably attained. Rat reservoir and vector studies were based on monthly samples of the rat populations from 16 geographically representative trapping stations in each county plus additional rats secured from areas peripheral to the stations.[2]

While monthly quotas of 10 rats from each station and 5 from the periphery of each station were not consistently secured, it is believed that sufficient numbers of rats were obtained to give reliable and representative county-wide comparisons.

CONTROL PROCEDURE

Ten per cent DDT in pyrophyllite was distributed in such a manner that rats traversing customary paths from

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



harborage to food and water passed through patches of the dust. Five rounds of dusting operations were accomplished in each of the treated counties between April 1, 1946, and September 30, 1947. Sixty to 96 per cent of premises received treatment in separate county-wide cycles of dusting activity. In Brooks County, the first round of DDT dusting was begun April 1, 1946, while in Thomas County the first round was begun May 13, 1946.

RESULTS

Thomas and Brooks Counties murine typhus morbidity experience, in contrast with experience in undusted Grady County, represented significant decreases subsequent to DDT dusting operations. The minor decrease in Grady County during 1947, although not significant for the county as a whole, was significant in the county seat where a locally sponsored clean-up campaign was conducted. This campaign was mainly intended to remove rubbish in and around premises of the city and did not specifically include any other rat or typhus control activities (see Figure 1).

Although some of the 8 cases found in Thomas and Brooks Counties in 1948 and 1949 could be traced epidemiologically to exposure outside of these counties, they were charged to the county of residence, as was the procedure for all other cases. Even with these few sporadic cases, significant suppression of murine typhus incidence has persisted for over 2 years following the last county-wide DDT dusting operations in July and September of 1947. By careful, well timed and thorough dusting, it might be possible to accomplish, with fewer applications of DDT, results similar to those achieved with 5 rounds (see Figure 1).

Following dusting operations (Table 2 and Figure 2), a marked and sustained reduction in the percentage of rats positive to the murine typhus complement-

TABLE 2

Presence of Antibodies in Domestic Rats by County and Operational Year May, 1946–November, 1949

Operational year	Grady		Thomas		Brooks	
	No. rats examined *	Per cent positive	No. rats examined *	Per cent positive	No. rats examined *	Per cent 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.

TABLE 3

Summary of Rats Trapped and Ectoparasite Infestation

	Grady					Thomas					Brooks				
		Per cent Infested					Per cent Infested					Per cent Infested			
	No. Rats	X.c.	L.s.	L.b.	P.s.	No. Rats	X.c.	L.s.	L.b.	P.s.	No. Rats	X.c.	L.s.	L.b.	P.s.
May, 1946–April, 1947	1530	60.6	41.6	30.4	71.4	1768	28.4	21.2	27.3	61.3	1919	13.2	11.7	24.1	58.5
May, 1947–April, 1948	2170	41.4	34.5	27.5	76.6	2280	5.2	6.0	10.6	63.1	2316	1.8	1.6	8.2	51.0
May, 1948–April, 1949	2224	42.1	41.3	30.4	73.7	3096	11.2	10.8	12.1	72.8	3182	3.6	3.9	9.2	72.6
May, 1949–Nov., 1949	1523	59.0	26.9	27.1	69.1	1616	19.1	5.0	14.8	70.7	1573	11.6	2.7	10.2	63.8

fixation test was observed in Thomas and Brooks Counties. In 1949, 2 years after completion of the last dusting cycle, a continued suppression of antibody prevalence in rats from treated areas was a striking observation; yet during the year a noticeable upward trend in positive rats from treated counties presaged a gradual return to pre-dusting levels.

In Table 3, a summary of rats collected and ectoparasite infestation is given for three comparable operational years plus data from the fourth year, until temporary discontinuance of observations in November, 1949. Seasonal variation in ectoparasite abundance data summarized for May–November, 1949, does not permit valid comparison with rates for previous full years. However, monthly trends in ectoparasite abundance, shown in Figure 3, do permit valid comparisons to be made throughout the study. The oriental rat flea, *Xenopsylla cheopis* (Rothschild), was reduced to a low level of abundance during 1947 in dusted counties. The slight upward trend evident in these areas in 1948 and 1949 was still considerably under recorded abundance in untreated Grady County.

Following dusting operations, abundance of the mouse flea, *Leptopsylla segnis* (Schönherr), was reduced in a degree similar to that of *X. cheopis*. The peak of seasonal abundance of *L. segnis* occurred in early spring as contrasted with a late summer peak of *X. cheopis* abundance. This variation caused a noticeable difference of a seasonal nature, but in general *L. segnis* abundance was suppressed more during the 1948 seasonal peak than during a like period of 1949. Data for the 1950 seasonal peak were not obtained.

The tropical rat mite, *Bdellonyssus bacoti* (Hirst), also known as *Liponyssus bacoti*, was not controlled very suc-

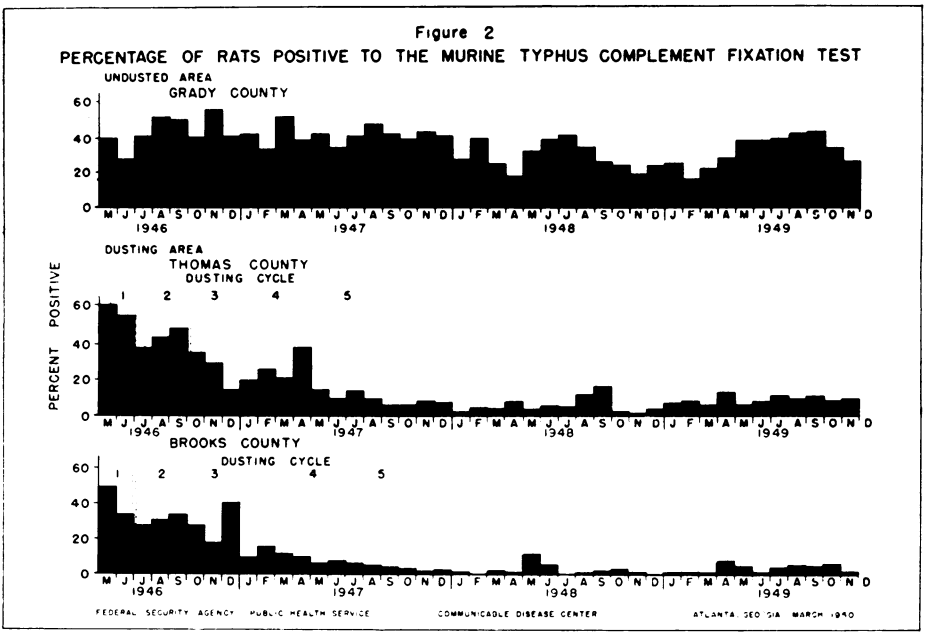


Figure 2
PERCENTAGE OF RATS POSITIVE TO THE MURINE TYPHUS COMPLEMENT FIXATION TEST
UNDUSTED AREA
GRADY COUNTY
DUSTING AREA
THOMAS COUNTY
DUSTING CYCLE
BROOKS COUNTY
DUSTING CYCLE
PERCENT POSITIVE
1946
1947
1948
1949
FEDERAL SECURITY AGENCY PUBLIC HEALTH SERVICE COMMUNICABLE DISEASE CENTER ATLANTA, GEO GIA MARCH 1950

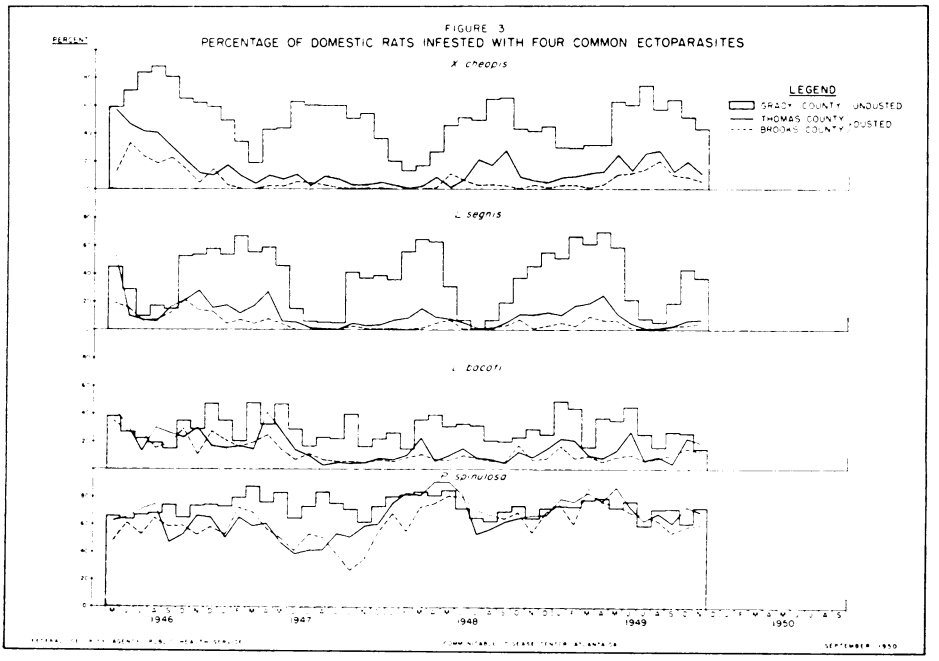


FIGURE 3
PERCENTAGE OF DOMESTIC RATS INFESTED WITH FOUR COMMON ECTOPARASITES
X cheopis
LEGEND
GRADY COUNTY UNDUSTED
THOMAS COUNTY DUSTED
BROOKS COUNTY DUSTED
L segnis
L. bacoti
P. spinulosa
1946
1947
1948
1949
1950
SEPTEMBER 1950

cessfully by the dusting operations. A reduction in abundance of this mite on rats from dusted areas was observed in 1947, followed by a gradual return to an abundance which by late 1949 closely approached the rate in the untreated area.

A slight reduction in abundance of the common rat louse, *Polyplax spinulosa* (Burmeister), was noted on rats from dusted areas during 1947. By June of 1948, *P. spinulosa* was as abundant in both treated counties as in the untreated county. Return to near equal levels of abundance as compared to the untreated county occurred about 3 months earlier in Thomas than in Brooks County.

While trends were similar in the two dusted counties, better control of the four principal ectoparasites was obtained in Brooks than in Thomas County (see Figure 3). Factors contributing to better control in Brooks County included:

1. The last dusting cycle was 2 months later in Brooks than in Thomas County.
2. In the case of *X. cheopis* the timing of the fourth and fifth dusting cycles was better in Brooks than in Thomas County.
3. Amount of 10 per cent DDT distributed on premises in Brooks County averaged 4.7 lbs. while in Thomas County the average was only 3.5 lbs.
4. Dusting cycles in Brooks County averaged 86.9 per cent of premises treated, while in Thomas County the average was 79.1 per cent.

SUMMARY AND CONCLUSIONS

1. Incidence of human cases of murine typhus fever, prevalence of complement-fixing antibodies in the domestic rat reservoir, and the abundance of rat fleas were significantly reduced as a result of county-wide DDT dusting of rat runs and harborage.

2. These suppressions of human incidence, reservoir prevalence, and vector abundance have persisted for over 2 years following the last county-wide treatment of two counties in southern Georgia.

3. As a whole, no significant change in the three epidemiological factors mentioned above was noted in the untreated county.

4. A clean-up drive in the county seat of the "untreated county" did produce a significant reduction in human incidence in that one town during 1947.

5. A moderate rise in prevalence of murine typhus complement-fixing antibodies in the domestic rat reservoir in the two treated counties in 1949 accompanied by a moderate increase in abundance of rat fleas suggests the necessity for further surveillance.

6. The rationale of including DDT dusting procedures in the murine typhus control program is supported by the findings of this evaluation study.

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