Effect of Fly Control on Diarrheal Disease In an Area of Moderate Morbidity

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IN AN EARLIER study in Hidalgo County, Tex., flies were shown to be vectors of *Shigella* infections in an area of high diarrheal disease morbidity and mortality rates (*1*). The high rates and other features peculiar to that area were recognized as factors which might limit the applicability of this method of reducing such enteric infections in the more frequently encountered areas of low to moderate morbidity and negligible mortality. This paper presents the results of a study, very similar to the Texas study, made in such an area of low to moderate morbidity from diarrheal disease. The area selected is in southern Georgia. Its small communities are characteristic of the rural South in size, climate, and agricultural practices favorable to fly breeding and in community sanitation that allows flies ready access to human excrement.

Plan of Study

Fly control investigations were begun in Thomas County, Ga., in 1949. Of the six rural towns used in the study, Boston, Pavo, and Ochlochnee were selected for chemical treatment. Barwick, Coolidge, and Meigs, located between the treatment towns, were selected as untreated checks in an effort to equalize differences due to geographic location or agricultural practices (fig. 1).

Fly populations in the two groups of towns were measured by the Scudder fly grill method (*2*), and a minimum of the five highest grill counts per sample block was recorded. In the treated towns, all blocks were sampled weekly, to pinpoint areas in need of re-treatment. In untreated towns, representative blocks constituting only 10 to 20 percent of the total number of blocks were similarly sampled. The validity of this economy in sampling was established by comparable figures obtained when indexes of similar 10- to 20-percent samples, chosen by lot from the total samples of treated towns, were matched against the indexes of the total samples, as well as by supporting studies (*3*).

A town was re-treated when the average of the five high grill counts of flies exceeded three flies in any block. This lower re-treatment index, as compared with that used in the Texas study (*1*), was arbitrarily used in order to compensate for obvious differences in the two study areas. Blocks in the Georgia towns were much larger than those in the Texas towns, and numbers of fly attractants per block were higher. Thus larger populations of flies per index unit were represented. Comparison of the third high count averages in the Texas and Georgia areas indicated that the overall degree of fly

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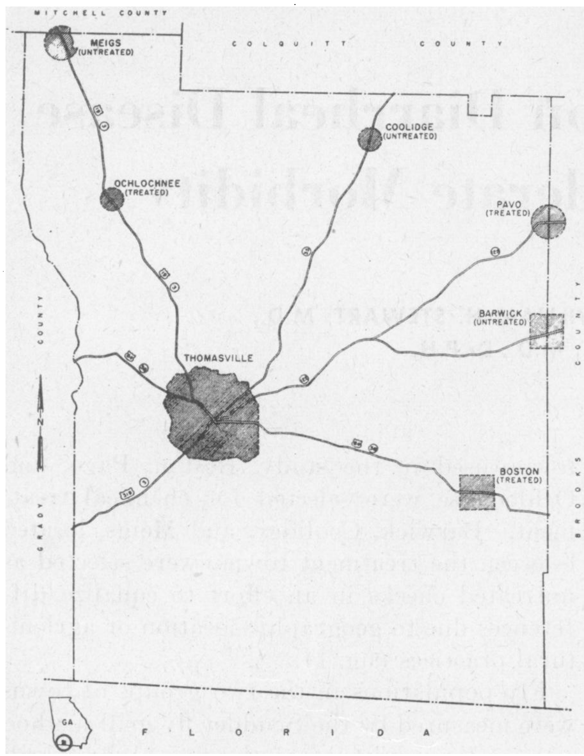
Figure 1. Location of study towns in Thomas County, Ga.



control achieved was comparable in the two areas. The third high count was used as an index, rather than the single high count, because it minimized vagaries due to single high concentrations of flies which sometimes were found.

Fly control in the treated towns was first accomplished by application of 5-percent DDT emulsion, using both space and residual spray methods. After 10 months of treatment, the high degree of DDT resistance which developed in the housefly (*Musca domestica* L.) population precluded further effective control with DDT. Dieldrin was therefore substituted in Pavo and in Boston. It was applied as a residual spray emulsion at rates of 50 mg. and 25 mg. of dieldrin per square foot of spray surface, respectively. Chlordan was substituted in Ochlochnee and was used as a residual spray emulsion applied at the rate of 100 mg. of chlordan per square foot of spray surface.

The effect of fly control on the prevalence rate of infection with *Shigella* and *Salmonella* organisms and on the rate of diarrheal disease was measured by comparing the rates found in comparable population samples in the treated and untreated towns before, during, and after fly control. These rates were established by obtaining monthly rectal swab cultures from all children under 10 years of age in the samples, and monthly histories of diarrheal disease occurring in their families. Mortality rates from diarrheal disease were not used as a measure of the effect of fly control, because there were too few deaths for significant comparison.

The populations studied within the towns were in those neighborhoods having the highest proportion of children under 10 years of age. A disproportionate number of this age group was included since it has the greatest incidence of infection and disease due to *Shigella* organisms. The population figures for 1950 in the treated and untreated towns and in the samples selected in these groups of towns are given in table 1. The total populations of treated towns and untreated towns were approximately equal. The sample population included slightly less than one-half of the total population in each group of towns.

Results of Fly Control

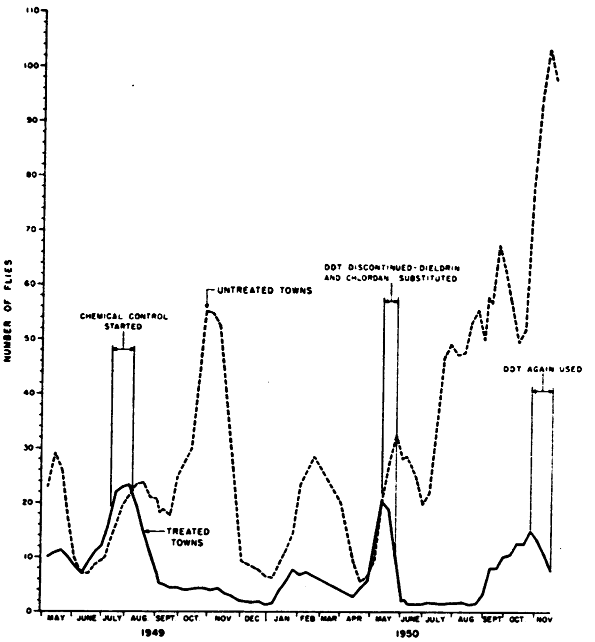
Effects of the chemical control operations upon all common species of flies, considered as a group, are shown in figure 2. A 3-week moving average of the median or third high grill counts for all survey blocks is used as an index of the fly populations observed in the two groups of towns. Weekly fly counts were made for approximately 3 months before control op-

Table 1. Population for 1950 in the treated and untreated towns and in the samples selected in these groups of towns

Towns	Total population of towns [1]	Total population of sample [2]	Children under 10 years of age in sample [2]
Treated	2, 344	983	239
Untreated	2, 325	1, 007	260

[1] Preliminary report 1950 census, U. S. Bureau of Census.
[2] Census taken in study.

Figure 2. Effect of chemical control operations on all species of flies (3-week moving average of third high fly count).

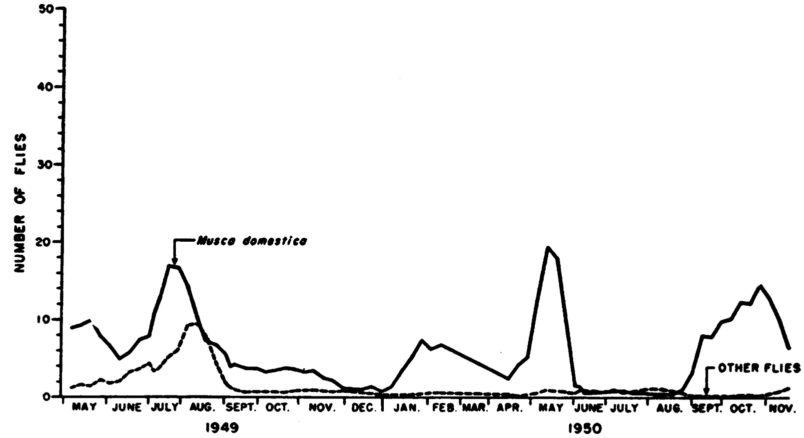


erations were begun, and, except for the first 3 weeks, index trends for both groups were very close. Control operations for 1949 began on July 18 in Pavo, on August 1 in Ochlochnee, and on August 10 in Boston. The intervals between these dates were taken up with the original treatment of the new town and retreatment, as needed, in the town or towns previously treated. The fly population index of the treated group declined as each of the towns came under operational control. Normal seasonal increases in the fly population in the untreated towns continued into November 1949, when cool weather curbed fly activity and breeding.

Warming weather in January and February 1950 resulted in rising population indexes in both groups of towns during January and forced intensification of operational control in the treated towns during February. The results of this control intensification can be seen clearly in comparing index lines for February in figure 2. Cool weather in March and early April held both fly breeding and activity in check and did not permit the taking of reliable population indexes through March. During the first 2 weeks of May the indexes for both groups rose sharply in spite of heavy reapplications of DDT in the treated towns.

Concurrent field observations and laboratory tests showed that houseflies (*M. domestica*) had become highly resistant to DDT, and with the rising mean temperature the ineffectiveness of DDT increased in accordance with principles established by Lindquist and associates (*4*, *5*). This trend toward housefly resistance to DDT was established by laboratory tests of wild flies taken from the treated towns before it was reflected by increased grill counts in the field. As a result of these laboratory tests, conducted according to a standardized procedure reported by Lindsay and Haines (*6*), substitute insecticides for DDT were on hand when needed. These insecticides, dieldrin and chlordan, were applied as described in the plan of study between the dates of May 16–26. Good control was maintained in the treated towns until late August 1950, compared with an increased fly

Figure 3. Number of *Musca domestica* compared with other flies in treated towns of Ochlochnee, Pavo, and Boston, Ga. (3-week moving average of third high fly count).



population index for the untreated towns during July and August.

Throughout June and July 1950, the degree of fly control achieved by using dieldrin and chlordan was so nearly perfect that it was difficult to find individual flies, and concentrations of two or more flies were only rarely encountered. In late August, scarcely 12 weeks after the initial application of dieldrin and chlordan, it became evident from laboratory tests that housefly populations had gained immunity to these insecticides, as well as to DDT. Large populations were not found, as evidenced by the low fly index for the treated towns throughout August, but laboratory tests on small representative collections of these populations revealed a high degree of resistance to dieldrin and chlordan. These tests showed that dieldrin and chlordan selected houseflies with the same resistance factors. Chlordan resistance was found where only dieldrin had been used and dieldrin resistance where only chlordan had been used. After a high degree of dieldrin or chlordan resistance had been attained in field populations of houseflies, no dead or dying flies could be found as a result of the reapplications of these insecticides, and laboratory tests of wild flies showed no appreciable differences in the mortality of flies subjected to heavy residuals of dieldrin and of flies in the untreated checks.

Although DDT used against resistant houseflies would not produce satisfactory fly control, both dead and dying flies were easily found in the field following reapplication of DDT during October and November 1950, and the mortality of wild flies in laboratory tests against DDT residuals was significantly higher than in the untreated checks. Fly control by various field combinations of insecticides and of application methods was then attempted, and the decline shown in the treated towns' index during November was due mainly to reapplication of DDT sprays, probably enhanced by cool weather (*4, 5*).

As previously found in the Texas study, all marked failures in fly control operations were due to inability to control the common housefly. This fact is illustrated in figures 3 and 4, presented on scales identical to those in figure 2. The major role played by the housefly in developing resistance to insecticides is quite apparent in figure 3. It was the only species that increased significantly during the use of the insecticides.

In the three untreated towns all index points above 10 for species other than the housefly were due to seasonal increases in the single subtropical species *Sarcophagula occidua* Fabr. of the family Sarcophagidae (fig. 4). This species breeds abundantly in animal excrement and reaches its peak of breeding in late fall. An abundance of favorable media in the rural towns under study permitted large-scale breeding.

When considered in terms of habits and control difficulties, houseflies appear to be the primary species concerned as *Shigella* vectors. Results of ecological studies by Haines (7) of the

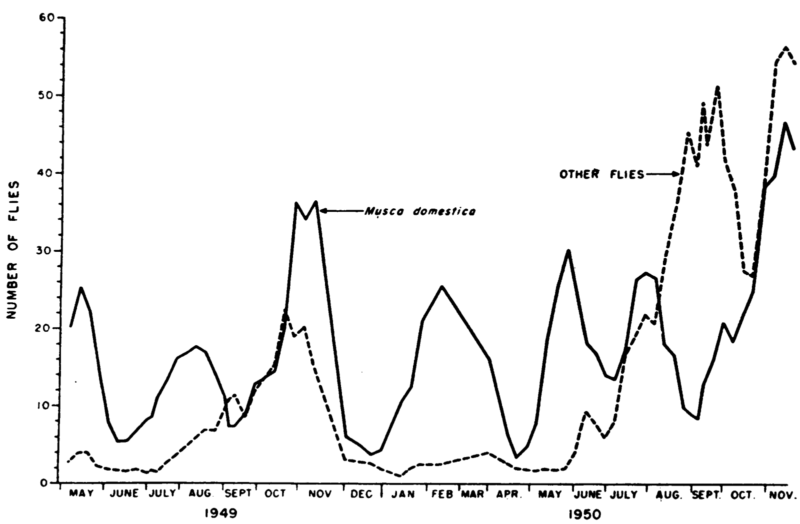


Figure 4. Number of *Musca domestica* compared with other flies in untreated towns of Meigs, Coolidge, and Barwick, Ga. (3-week moving average of third high fly count).

commonly occurring flies showed that houseflies were highly adaptable in using a wide variety of naturally occurring refuse as breeding media. Refuse was classified by source and nature into approximately 20 categories, and investigation revealed that houseflies bred in all categories, sometimes in numbers far smaller than the species most favored, but nevertheless in significant quantities. Since by qualitative standards the types of media most favorable to housefly breeding, such as animal excrement and bedding in stables, were also highest in frequency of occurrence and in volume in the study area, the greater relative abundance of houseflies at all seasons, as compared to that of other species, is to be expected.

Diarrheal Disease

Data on the prevalence of *Shigella* infections in children under 10 years of age in treated and untreated towns are grouped in two ways: by quarters of years and by periods covered before, during, and after fly control (table 2). At the beginning of the study, prevalence rates in the two groups of towns approximated one another. With the beginning of fly control operations in July 1949, the prevalence rate in the treated towns fell, and remained low, whereas the rate in the untreated towns continued high. This relationship remained during the period of good fly control from September 1949 to late August 1950. When effective fly control was lost, after August 1950, the percentage of

Table 2. Prevalence of *Shigella* infections in children under 10 years of age in the treated and untreated towns, April 1949 to December 1951

Period: Month culture done	Treated			Untreated			Probability "P"
	Number of cultures	Number positive	Percent positive	Number of cultures	Number positive	Percent positive	
Before fly control:							
April–May	220	8	3. 6	398	20	5. 0	0. 26
June–August	478	14	2. 9	623	23	3. 7	
Total	698	22	3. 2	1, 021	43	4. 2	
During fly control:							
September–November	417	6	1. 4	595	15	2. 5	. 0001
December–February	451	2	. 4	609	20	3. 3	
March–May	437	2	. 5	681	11	1. 6	
June–August	487	4	. 8	679	14	2. 1	
Total	1, 792	14	. 8	2, 564	60	2. 3	
After fly control:							
September–November	379	17	4. 5	565	25	4. 4	. 06
December–February	271	9	3. 3	346	7	2. 0	
March–May	393	10	2. 5	506	6	1. 2	
June–August	366	15	4. 1	449	11	2. 4	
September–November	294	14	4. 8	226	9	4. 0	
December	84	2	2. 4	77	1	1. 3	
Total	1, 787	67	3. 7	2, 169	59	2. 7	
Grand total	4, 277	103	2. 4	5, 754	162	2. 8	

Shigella infections in treated towns rose until, in October 1950, it exceeded the rate in untreated towns. For the next 12 months, rates in the treated and untreated towns remained on a level similar to that before fly control started. The percentage of *Shigella* infections before, during, and after fly control is shown in figure 5.

The number of isolations of *Salmonella* organisms during this study was quite small. However, there were just as many isolations made in treated towns as in untreated towns during effective fly control. This lends weight to the previous report (*1*) that fly control did not influence the spread of these organisms in the same way that it did the *Shigella* group.

The crude and standardized attack rates per 1,000 a year for reported diarrhea in children under 10 years of age were almost identical in the treated and untreated towns for the 8 months before fly control operations began (table 3). During the year fly control was maintained, the rate of reported diarrheal disease was appreciably lower in the treated towns, but showed little change in the untreated towns. After fly control was lost, the rate of diarrheal disease in treated towns rose to slightly below that in untreated towns. The significant change in the attack rate of diarrheal disease in treated towns during the fly control period is shown in figure 6.

Reversal of the treated and untreated towns in order to duplicate the effect of fly control on diarrheal disease was impracticable because of the relatively high insecticidal resistance in the previously untreated towns. This resistance, detected by laboratory tests, could have resulted from widespread individual use of household and agricultural chemical insecticides.

Figure 5. Prevalence of *Shigella* infections in children under 10 years of age before, during, and after fly control.

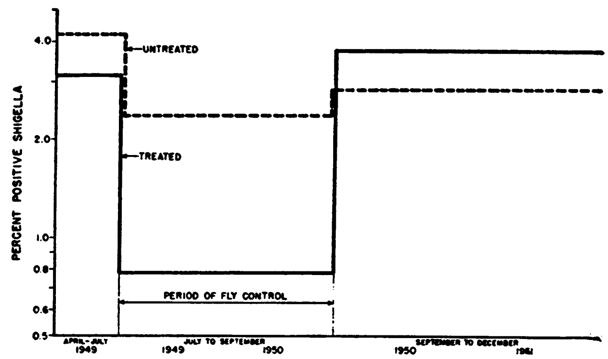


Figure 6. Standardized attack rates for diarrhea in children under 10 years of age before, during, and after fly control.

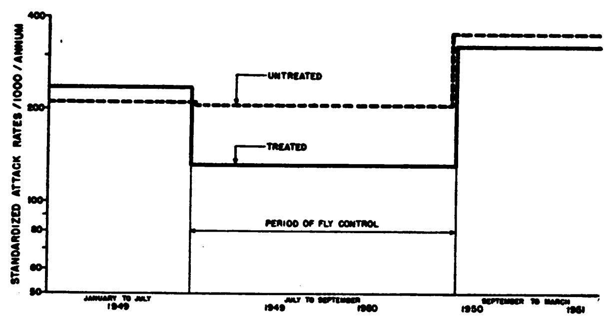


Table 3. Crude and standardized attack rates for reported diarrhea in children under 10 years of age before, during, and after fly control

Period	Treated					Untreated					Probability "P"
	Person-months observed	Cases	Crude rate [1]	Expected cases	Standard rate [1]	Person-months observed	Cases	Crude rate [1]	Expected cases	Standard rate [1]	
Before fly control: Jan. 1949 through Aug. 1949	2, 258	39	207	44. 2	235	2, 660	46	208	46. 8	211	0. 99
During fly control: Sept. 1949 through Aug. 1950	3, 084	29	113	34. 0	132	3, 511	57	195	60. 8	208	. 015
After fly control: Sept. 1950 through Jan. 1951	790	17	258	21. 3	324	896	25	335	25. 6	355	. 40

[1] Per 1,000 a year.

The fact that the period of effective fly control was the only time during the 32 months of this study that the prevalence rate of *Shigella* infection was significantly lower in the treated towns than in the untreated towns is convincing evidence that flies were vectors of *Shigella* organisms. The lowering of the attack rate for diarrheal disease during the period of fly control indicates that a significant portion of this diarrhea resulted from infection with *Shigella* organisms, and again points out the importance of *Shigella* infections as a cause of diarrheal disease.

Summary

Results of this study demonstrated that during effective fly control in an area of moderate diarrheal disease morbidity, the prevalence rate of *Shigella* infections and the morbidity rate from diarrheal disease were significantly lowered.

Chemical insecticides of the residual type were used for control of adult flies. The development of housefly (*M. domestica*) resistance to the DDT initially used resulted in its ineffectualness in maintaining fly control after 10 months. The dieldrin and chlordan sprays substituted for DDT resulted in excellent fly control for about 3 months. After that period these insecticides became even less effective than DDT.

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Vending Stand Program Aids Blind

More than 1,700 blind vending stand operators and employees earned over $3.6 million during 1952, according to figures released by the Office of Vocational Rehabilitation, U. S. Department of Health, Education, and Welfare. These are the highest net earnings ever recorded by the blind men and women who operate vending stands under the guidance of the Nation's State-Federal program for rehabilitating disabled civilians. Gross sales exceeded $18.6 million.

The vending stand program provided in 1952 self-sustaining work for 1,513 blind operators, 196 blind assistants, and 412 other workers employed by the operators.

Five hundred and fifty-eight of the 1,479 vending stands are operated under the program in Federal buildings. The others are on private or non-Federal public premises. The investment in equipment and merchandise totals more than $2.3 million.