

TREASURY DEPARTMENT
UNITED STATES PUBLIC HEALTH SERVICE

PUBLIC HEALTH BULLETIN No. 88

SEPTEMBER, 1917.

MALARIA CONTROL:

A REPORT OF DEMONSTRATION STUDIES CONDUCTED IN
URBAN AND RURAL SECTIONS

By

R. C. DERIVAUX

Assistant Surgeon
United States Public Health Service

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H. A. TAYLOR AND T. D. HAAS

Field Directors

PREPARED BY DIRECTION OF THE SURGEON GENERAL



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Malaria

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FOREWORD.

The following report is descriptive of a series of experimental demonstrations of malaria control carried on in cooperation with the International Health Board consequent on its request for the Public Health Service to test the relative efficacy of control measures and to study their practical application in the presence of conditions common to the Southern States.

In accordance with a provisional outline submitted by the board, a plan for these studies was prepared by the late Surg. R. H. von Ezdorf, formerly in charge of the malarial investigations of the Public Health Service, and active field operations were begun in April, 1916, under the immediate supervision of the writer. The sudden death of Surg. von Ezdorf in September, 1916, denied him the satisfaction of witnessing completion of the studies, and necessitated their continuation to a conclusion by his associates. To his plans and able direction are due whatever successes may have been achieved.

R. C. DERIVAUX.

TABLE OF CONTENTS.

	Page.
Introduction:	
Purpose of demonstrations and selection of units.....	7
Some factors in the epidemiology of malaria in southeastern Arkansas.....	8
The town unit, Crossett, Ark.:	
General description.....	11
Preliminary operations.....	13
Control measures.....	16
Results.....	25
Acknowledgments.....	33
The rural units, vicinity of Lake Village, Ark.:	
General description.....	34
Preliminary operations.....	35
"Negative" control group.....	38
Control measures.....	39
Results.....	45
Acknowledgments.....	54
Summary.....	54

ILLUSTRATIONS.

FIGURES.

1. Condition of important stream prior to control operations.....	13
2. Vegetation overgrowth on streams prior to clearing.....	13
3. Log pond, upper corner.....	13
4. Fish pond—Character of vegetation.....	13
5. Cremer pond, a detail.....	13
6. Type of borrow pit.....	13
7. Barrel.....	13
8. Pit near mill (later drained).....	13
9. Street ditching.....	17
10. Street ditching.....	17
11 and 12. "Pot hole" elimination on ditch E.....	17
13 and 14. Treatment of Anopheles breeding place.....	17
15 and 16. Treatment of Anopheles breeding place.....	17
17. Effect of storm.....	23
18. A drained borrow pit, formerly a prolific breeding place.....	23
19 and 20. A railroad borrow pit, before and after filling.....	23
21. Draining a borrow pit.....	23
22. Seepage interception.....	23
23. Oil can on stream B.....	23
24. Knapsack sprayer in use.....	23
25. Borrow pit.....	35
26. Barrels.....	35
27. Type of door screen used.....	35
28. Type of window screen used.....	35

	Page.
29. Type of tenant house.....	35
30. Type of tenant house.....	35
31. Tenant house, structural details.....	35
32. Chimney protection.....	35

CHARTS.

1. Total professional visits for malaria and other conditions, Crossett, 1916....	29
2. Calls for malaria, 1915 and 1916, Crossett.....	31
3. Reported cases of malaria, Crossett, 1916.....	32

MAPS.

1. Index map, antimalaria operations, 1916, Crossett.....	17
2. Spot map showing house distribution of reported cases of malaria, 1916, Crossett.....	26
3. Plantations in vicinity of Lake Village, Ark., antimalaria operations, 1916..	41
4. Yellow Bayou plantation, portion included in antimalaria operations, 1916..	42

MALARIA CONTROL: A REPORT OF DEMONSTRATION STUDIES CONDUCTED IN URBAN AND RURAL SECTIONS:

INTRODUCTION.

PURPOSE OF DEMONSTRATIONS AND SELECTION OF UNITS.

The extensive prevalence of malaria and its untoward influence have made the problem of its control foremost among the questions engaging the attention of sanitarians and economists in the Southern States. It is doubtful whether the losses due, directly and indirectly, to malaria are possible of accurate computation, but from studies under special conditions and from gains following control campaigns, it is evident that the economic losses are very large, and that there occurs annually an appalling amount of preventable illness.

The desirability of determining more definitely the relative values of the several known methods of malaria control with reference to conditions in the United States has long been appreciated because of the widely varying conditions of which malarial incidence is a resultant. Demonstrations at a number of places in the United States have amply proved the economic practicability of malaria control, notably at Roanoke Rapids, N. C., and at Electric Mills, Miss.,¹ where substantial results were obtained following the systematic application of combined measures. In neither of these places, however, has the influence of any single procedure been determined.

Division of problem.—For the purposes of these studies a division of the problem into two sections was made, as follows: A town or community unit, in which antimosquito measures alone would be applied, and a rural unit, in which each family or house would receive individual consideration and be protected through the use of screening or quinine in “immunizing doses,” supplemented by the “sterilization” treatment of proven carriers upon detection by blood examination.

Selection of localities.—Two localities were selected after preliminary surveys of a number of places and reference to data accumulated in

¹ “Demonstrations of Malaria Control,” von Ezdorf, R. H. Reprint No. 328 from Public Health Reports (Mar. 10, 1916).

Service investigations of malaria in the Southern States. It was believed that the flat country of the Mississippi Delta region would provide the conditions best suited to the requirements of the problem as an intensive study; accordingly, selection was made of two points in southeastern Arkansas—i. e., Crossett, Ashley County, as a "town unit," and a group of plantations in the vicinity of Lake Village, Chicot County, as a "rural unit."

SOME FACTORS IN THE EPIDEMIOLOGY OF MALARIA IN SOUTHEASTERN ARKANSAS.

Throughout southeastern Arkansas malaria is widely prevalent in severe form, and exerts a sinister influence on the sanitary and economic well-being of a large population, more especially in the flats of the Arkansas and Mississippi River Valleys and of their tributary streams and bayous. In the rich water-laid soil of the so-called "bottoms" vegetation is prolific, and valuable agricultural and timber resources could be fully utilized were it not for the well-known insalubrity of these regions; histories of families suffering repeated attacks of malaria annually are common, and instances are known where farming and lumber enterprises have been abandoned because of decimation of the working personnel by malaria. Favorable climatic conditions, a high rate of endemic infection, ample opportunities for *Anopheles* propagation and access to people, the almost total absence of efficient protective measures, and a preponderance of agricultural industries all contribute toward making malaria the chief cause of all illness in this region and responsible for a high proportion of pernicious attacks, hemoglobinuric fever, and deaths.

In connection with investigations conducted by the United States Public Health Service, the prevalence of malaria in Arkansas has been determined through the issuance of circular postal cards to physicians and health officers throughout the State. In 1914 there were issued 24,000 cards, of which 4,153, or 17.3 per cent, were returned and 23,941 cases of malaria reported; this would be equivalent to about 138,000 cases for the State, or about 8 per cent of the total population of 1,686,480 for the same year, had 100 per cent of the cards been returned and the same proportion maintained.

The parasite index of endemic infection, as determined by thick film blood examinations in connection with Service investigations, has been found to vary in Arkansas between 1.97 and 22.49 per cent. Of a total of 3,996 specimens examined, taken from 11 places, parasites were found in 463, or 11.58 per cent.

Anopheles mosquitoes.—Three species of *Anopheles* occur commonly in southeastern Arkansas, and all have been incriminated as transmitters of malaria. In their order of frequency and importance these are: *Anopheles quadrimaculatus* Say, *Anopheles punctipennis*

Say, *Anopheles crucians* Wiedemann. In addition to the above named, two others, i. e., *Anopheles walkeri* Theobald, and *Coelodiazesis barberi*, are reported by Thibault ¹ as taken by him in Pulaski and Lonoke Counties (central Arkansas).

Climatic and seasonal conditions.—Climatic conditions are favorable to the production of malaria for about six months of the year, beginning ordinarily in May and terminating with the advent of the first frosts, usually in October.

The greatest incidence of malaria is attained during August, September, and October, and it is unusual for hemoglobinuric fever and other severe types of malaria to be seen outside of these months.

The annual rainfall for the section measures about 52 inches, and the mean annual temperature is approximately 64° F. The following tables, compiled from data collected at Portland (Ashley County), Ark., Huttig (Union County), Ark., and Greenville (Washington County), Miss., where observation stations of the Weather Bureau are maintained, are believed to be illustrative of conditions for the region generally:

TABLE 1.—*Climatologic data, Portland (Ashley County), Ark.*

[Elevation, 122 feet.]

Year.	Temperature (Fahrenheit).					Precipitation (inches).					Killing frosts.	
	Annual mean.	Highest.	Month.	Lowest.	Month.	Total for the year.	Greatest monthly.	Month.	Least monthly.	Month.	Last in spring.	First in autumn.
1910.....	63.4	97	Aug...	13	Feb...	48.63	7.25	July...	0.73	Sept..	Apr. 25	Oct. 22
1911.....	65.8	102	June..	9	Jan...	65.37	15.51	Dec...	.84	Sept..	Feb. 23	Nov. 3
1912.....	61.7	99	Sept..	11	Jan...	46.29	11.91	Mar...	1.20	Oct...	Mar. 16	Do
1913.....	63.4	105	Aug...	21	Jan...	58.67	8.67	Jan...	1.53	June..	Mar. 28	Oct. 21
1914.....	63.7	106	July...	13	Dec...	45.51	7.12	Mar...	.38	Oct...	do	Oct. 28
1915.....	62.9	106	June..	20	Jan...	52.96	9.82	May...	.84	Sept..	Mar. 31	Oct. 10
1916.....	63.5	98	Aug...	13	Jan...	45.24	9.05	Jan...	1.40	Feb...	Apr. 9	Oct. 21

TABLE 2.—*Monthly precipitation, Portland, Ark., 1910 to 1915.*²

	1910	1911	1912	1913	1914	1915	Average. ²
January.....	5.52	4.23	2.29	8.67	1.26	5.03	4.5
February.....	3.37	5.13	1.95	5.96	4.80	5.90	4.51
March.....	3.05	3.19	11.91	5.60	7.12	2.67	5.59
April.....	2.94	8.62	6.15	4.94	4.59	1.32	4.76
May.....	6.36	1.38	4.16	4.69	6.65	9.82	5.51
June.....	6.52	5.68	3.37	1.63	1.87	4.76	3.95
July.....	7.25	8.75	3.81	3.19	3.28	4.99	5.21
August.....	2.64	6.86	1.36	3.08	4.86	3.91	3.78
September.....	.73	.84	1.41	7.62	.75	.84	2.03
October.....	2.52	1.87	1.20	5.47	.38	3.03	2.41
November.....	.93	3.31	2.19	3.95	3.66	4.60	3.1
December.....	4.80	15.51	6.49	3.97	6.29	6.09	7.19
Total.....	46.83	65.37	46.29	58.67	45.51	52.96	.....

Average, 52.9 inches annual mean.

¹ Thibault, "Notes on the Mosquitoes of Arkansas," Proc. Entomologic Society, Washington, Vol. XII, 1910.

² These monthly averages are given in the absence of "Normals," which have not as yet been established.

TABLE 3.—*Climatologic data, Huttig (Union County), Ark.*

[Elevation, 85 feet.]

Year.	Temperature (Fahrenheit).					Precipitation (inches).					Killing frosts.	
	Annual mean.	Highest.	Month.	Lowest.	Month.	Total for the year.	Greatest monthly.	Month.	Least monthly.	Month.	Last in spring.	First in autumn.
1910.....	64.6	98	Aug...	10	Feb...	48.53	8.32	June..	0.91	Mar...	Apr. 25...	Oct. 29
1911.....	66.8	104	June..	8	Jan...	50.59	12.50	Dec...	.03	Sept..	Feb. 25...	Nov. 2
1912.....	63.4	99	July... 11		Jan...	50.12	12.87	Mar...	.56	Nov...	Mar. 25...	Do.
1913.....	64.4	102	Sept.. 21		Jan...	65.17	14.11	Sept.. 1.42		June..	Mar. 28...	Oct. 28
1914.....	64.4	103	July... 14		Dec...	42.91	8.90	Mar...	.75	Jan...	Mar. 23...	Do.
1915.....	64.2	100	July... 19		Jan...	47.11	6.77	May...	.73	Sept..	Mar. 31...	Nov. 15
1916.....	64.6	100	July... 14		Jan...	42.38	8.49	Jan...	.41	Feb...	Mar. 4....	Oct. 22

TABLE 4.—*Climatologic data, Greenville, Miss.*

Year.	Temperature (Fahrenheit).					Precipitation (inches).				
	Annual mean.	Highest.	Month.	Lowest.	Month.	Total for the year.	Greatest monthly.	Month.	Least monthly.	Month.
1910.....	64	97	July.....	13	February.	47.50	6.58	January...	0.20	March.
1911.....	66	103	June.....	7	January...	72.84	19.97	December...	1.21	May.
1912.....	63	101	September	10	January...	52.48	11.95	March.....	.82	July.
1913.....	65	102	August....	23	February..	57.91	10.95	September	1.02	August.
1914.....	64	102	June.....	15	December.	47.97	7.69	March.....	.57	October.
1915.....	64	100	July.....	22	January...	45.91	7.25	February..	1.36	April.

THE TOWN UNIT, CROSSETT, ARK.

R. C. DERIVAUX and H. A. TAYLOR.

GENERAL DESCRIPTION.

Crossett, selected as the "town unit" for the demonstration of malaria control through the application of antimosquito measures (control of production), is situated in Ashley County, southeastern Arkansas, about 12 miles north of the Louisiana line. The town was built 16 years ago by the Crossett Lumber Co. in a rich pine region, and has since developed into one of the best known and most prosperous lumber communities in the South. Of the total population of 2,029, the lumber mills require about 750 men for their operation and constitute the sole industrial organization; they are supplied from two logging camps in the woods, 16 and 26 miles south of Crossett, respectively, and are said to have a daily output of about 300,000 feet of lumber.

Crossett lies at the edge of the "uplands" of Ashley County, at an elevation of 165 feet above sea level. The topography of the town site is fairly flat, with gentle undulations, and natural drainage is toward the east, south, and west. The soil is almost uniformly of a light brown color, and has been classed as "Richland silt loam."¹ Together with its subsoil it is of moderately compact texture, and is fairly pervious. Climatic conditions for the past two years are illustrated in Tables 5 and 6, prepared from the Weather Bureau annual reports for the Arkansas section:

TABLE 5.—*Monthly mean temperatures, Crossett, Ark.*

	1915	1916		1915	1916
	° F.	° F.		° F.	° F.
January.....	49.7	52.2	July.....	81.0	80.8
February.....	46.1	47.8	August.....	77.8	.....
March.....	66.2	58.2	September.....	77.2	72.8
April.....	74.2	63.0	October.....	64.8	64.8
May.....	79.5	72.9	November.....	56.4	54.8
June.....		77.2	December.....	49.1	49.7

¹ "Soil Survey of Ashley County, Ark." Bureau of Soils, U. S. Department of Agriculture, Mar. 13, 1914.

TABLE 6.—*Precipitation, Crossett.*

	1915	1916		1915	1916
	<i>Inches.</i>	<i>Inches.</i>		<i>Inches.</i>	<i>Inches.</i>
January.....		7.81	August.....	4.76	2.89
February.....	4.51	.50	September.....	.62	5.26
March.....	3.49	1.98	October.....	1.84	3.91
April.....	1.29	2.80	November.....	6.56	1.66
May.....	7.03	5.79	December.....	5.12	2.67
June.....	3.92	8.61			
July.....	4.24	3.93	Total.....		47.81

Crossett is accurately laid out and occupies an area measuring about one-half by 1 mile. The lumber mills and yards lie north of the Iron Mountain Railroad right of way and the town proper south. Streets and avenues, 90 feet in width, running north and south and east and west, divide the town symmetrically into blocks measuring 450 by 350 feet, each divided by a wide alley; the central street, Main, serves as a boundary line between the white and colored residential sections. The streets are unpaved but kept in condition by scraping and oiling. Some of the principal sidewalks are paved.

With the exception of the church and school properties, the town is owned and administered by the lumber company. The houses, which are of frame construction and contain from 3 to 10 rooms, are well spaced and supplied with water and electric light. Nearly all are fairly well screened with 16-mesh galvanized-iron wire screening.

The water supply is derived from 7 bored wells, between 110 and 140 feet in depth. The water is of excellent quality, and is distributed throughout the town at a pressure of 50 pounds for domestic use and 100 pounds for fire use.

The sewerage system is as yet incomplete. Two septic tanks receive the sewage from a part of the eastern half of town; in the remainder of the eastern half and in the western half, the colored section, dry earth privies of the open ("E") type are in use; these are limed frequently, and are cleaned at weekly intervals by a scavenger, the contents being hauled and buried. Garbage is kept in covered galvanized-iron containers, and is collected weekly for destruction by burning.

The medical staff of the Crossett Lumber Co. consists of a chief surgeon, Dr. J. T. Sparks, who is also health officer, and two associates, Dr. G. H. Setzler and Dr. C. L. Vines, the latter being resident physician at the camps. In addition, two physicians are engaged in private practice. A hospital of about 20 beds and a dispensary is maintained for the medical and surgical relief of employees and their families.

As may be seen from Map 1, p. 17, and figs. 1-8, facilities for mosquito propagation have been unusually abundant in Crossett, and have comprised almost every variety of breeding place. The town



FIG. 1.—CONDITION OF IMPORTANT STREAM, CROSSETT, PRIOR TO CONTROL OPERATIONS.

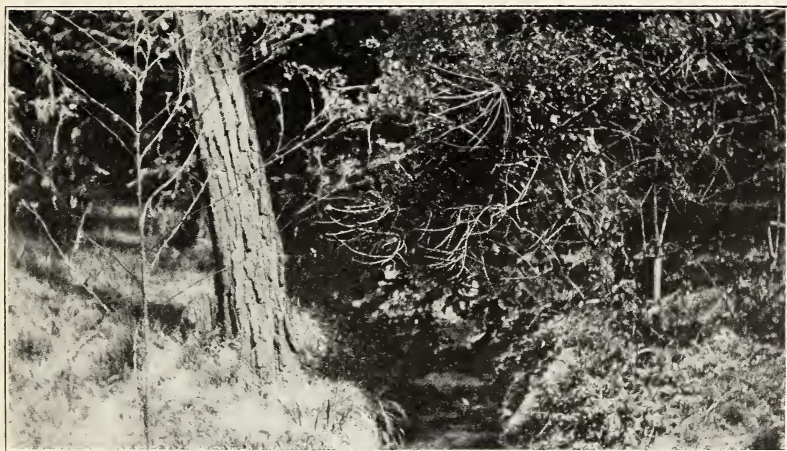


FIG. 2.—VEGETATION OVERGROWTH ON STREAMS PRIOR TO CLEARING.



FIG. 3.—LOG POND, UPPER CORNER, CROSSETT.



FIG. 4.—FISH POND; CHARACTER OF VEGETATION.



FIG. 5.—CREMER POND, CROSSETT, TYPE OF MOSQUITO-BREEDING AREA.



FIG. 6.—TYPE OF "BORROW PIT," CROSSETT.

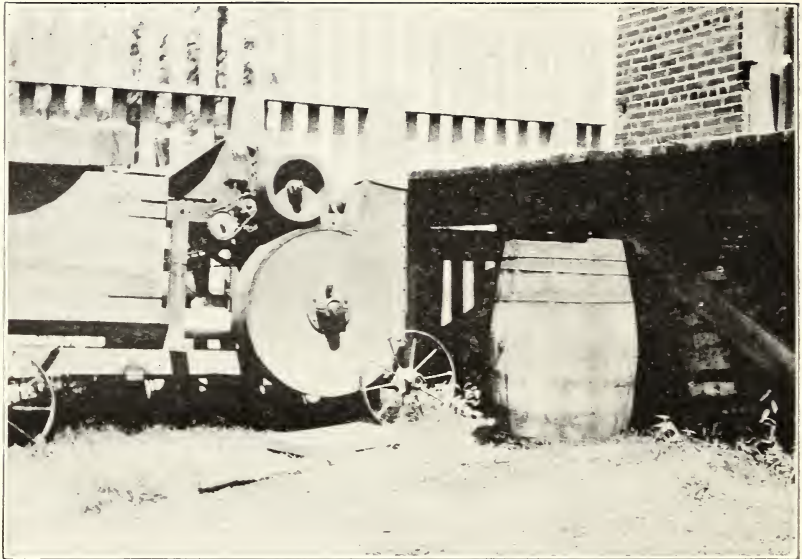


FIG. 7.—BARREL, FOUND BREEDING ANOPHELES.



FIG. 8.—BORROW PIT NEAR MILL, CROSSETT, LATER DRAINED.

proper is traversed by a number of street ditches serving as gutters and storm sewers and communicating with several large "branches," which course through and around the edges of the town; all of these have in the past contributed more or less extensively toward mosquito prevalence. Artificial ponds of several acres each lie north of the lumber mills, the nearer serving as a "log pond," and the farther, which has been well stocked with game fish, as a "fish pond." The log pond (fig. 3) has fairly clean edges, and its waters are somewhat agitated. These features, together with its minnow content, effectually prevent mosquito breeding. The fish pond (fig. 4) is separated from the log pond by a narrow dam, an earthwork embankment. Near the shores its waters are very shallow and thickly grown with coarse grass, lilies, willows, and other aquatic vegetation. In the protected portions mosquitoes were found to breed, though not profusely. A third pond, recently made, is situated about seven-eighths of a mile northeast of the mills, and a fourth, Cremer Pond (fig. 5), about three-fourths of a mile southwest of town; as no breeding was observed to occur in their waters, and because of their distance from town, it was not found necessary to include them in control operations. Other propagation places about Crossett included the borrow pits along railroad rights of way (fig. 6), the numerous water barrels placed throughout the lumber mills and yards for fire protection, and the usual containers found on premises.

PRELIMINARY OPERATIONS.

History index of malaria.—A sanitary census and a history index of malaria were taken of the entire town at the beginning of operations with a view to ascertaining general sanitary conditions about houses and premises, the amount and condition of screening, and to what degree malaria had prevailed during the preceding seasons. As will be noted in the summaries given later, most of the windows and doors, more especially in the section occupied by whites, are recorded as "screened." This screening, while better than the average, could be classed in but few instances as wholly efficacious.

During the census search was incidentally made for artificial containers serving, or likely to serve, as temporary breeding places of mosquitoes, and where such were found, corrective measures were recommended.

Table 7 gives the more important sanitary data elicited in this census. The data for Cremer Town is given separately. This place, formerly the village of the now closed Cremer Mill, is a collection of 16 houses, located about one-half mile southwest of Crossett. The residents are now employed in and about Crossett.

TABLE 7.—Sanitary data elicited in preliminary census.

	Crossett.			Cremer Town.
	White.	Colored.	Both.	
Total population.....	1,139	590	2,029	78
Number of houses.....	249	218	474	16
Number of occupied houses.....	242	214	463	16
Number of unoccupied houses.....	7	4	11	0
Number of families.....	242	214	463	.....
Percentage of houses occupied.....	97.2	98.1	97.6	100
Average length of occupancy..... years.....	3.7	3.5	3.6	18.7
Average number of occupants per house.....	4.7	4.15	4.3	4.8
Number of—				
Outbuildings.....	365	209	574	.....
Chicken yards.....	112	185	327	9
Privies.....	234	211	445	16
Stables.....	87	26	113	4
Hydrants.....	418	218	636	6
Windows—				
Total.....	2,419	1,179	3,598	123
Screened.....	2,378	835	3,213	79
Percentage screened.....	98.3	70.8	.....	64.2
Doors—				
Total.....	795	652	1,447	58
Screened.....	782	336	1,118	33
Percentage screened.....	98.3	51.5	.....	56.9
Flues—				
Total.....	451	251	702	36
Screened.....	5	0	5	0
Percentage screened.....	1.1	0	.....	0
Porches—				
Total.....	418	243	661	29
Screened.....	12	0	12	0
Percentage screened.....	2.9	0	.....	0

1 Months.

The history index of malaria is given in the following table:

TABLE 8.—History index of malaria.

CROSSETT.

	Total.	Giving positive histories of malaria.	History index.
			<i>Per cent.</i>
Total white and colored population.....	2,029	503	24.79
Males over 15.....	658	194	29.48
Females over 15.....	601	146	24.29
Males under 15.....	377	71	18.83
Females under 15.....	393	92	23.4
Total white population.....	1,139	254	22.3
Males over 15.....	329	94	28.5
Females over 15.....	322	63	19.5
Males under 15.....	244	45	18.4
Females under 15.....	244	52	21.3
Total colored population.....	890	249	27.9
Males over 15.....	329	100	30.3
Females over 15.....	279	83	29.7
Males under 15.....	432	26	19.6
Females under 15.....	149	40	26.8

CREMER TOWN.

Total.....	78	35	44.8
Males over 15.....	21	10	47.6
Females over 15.....	19	11	57.8
Males under 15.....	11	6	54.5
Females under 15.....	17	8	47.0

Parasite index.—A preliminary parasite index was made at the beginning of operations by examination of thick blood films obtained from a representative proportion of the population, chiefly school children. The technique observed was that in use in service investigations and described by von Ezdorf.¹ The results obtained in the preliminary index are presented in the following summary:

TABLE 9.—*First parasite index—Crossett, Ark., May, 1916.*

Age.	Number examined.						Total.
	White.			Colored.			
	Male.	Female.	Total.	Male.	Female.	Total.	
4 to 5.....	2	1	3	12	10	22	25
6 to 9.....	61	70	131	18	52	70	201
10 to 14.....	70	78	148	19	52	71	219
15 to 19.....	37	29	66	18	27	45	111
20 to 29.....	1	6	7	2	20	22	29
30 to 39.....	1	.....	1	5	8	13	14
40.....	.....	.....	.....	2	3	5	5
Total.....	172	184	356	76	172	248	604

Age.	Number positive.						Total.	Type of parasite.		
	White.			Colored.				Tertian.	Estivo-autumnal.	Total.
	Male.	Female.	Total.	Male.	Female.	Total.				
4 to 5.....	1	.....	1	1	.....	1	2	2	.....	2
6 to 9.....	6	2	8	2	1	3	11	9	2	11
10 to 14.....	11	11	22	4	4	8	30	26	4	30
15 to 19.....	5	2	7	7	4	11	11	11	.....	11
20 to 29.....	.....	1	1	.....	1	1	2	.....	2	2
30 to 39.....	.....	.....	.....	.....	1	1	1	1	.....	1
40.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total.....	23	16	39	7	11	18	57	49	8	57

	Per cent.
White index.....	10.95
Colored index.....	7.25
Total.....	9.43

Reported Incidence of Malaria.—In the opinion of local physicians, malaria has constituted about 60 per cent of all illness in and about Crossett. Of recent years, a progressive decrease, both as to number of cases and severity of type, is said to have occurred, and pernicious forms and hemoglobinuric fever are now uncommon, whereas formerly both were fairly frequent. Five cases of hemoglobinuric fever are recorded as having occurred in 1912, two in 1913, two in 1914, and none since.

¹"Malarial Index Work." Von Ezdorf, R. H. Reprint 159 from Public Health Reports (Dec. 26, 1913.)

The following table is compiled from the records of the Crossett Hospital, and exhibits such data with reference to malaria as were summarized for the chief surgeon's annual report for 1915:

TABLE 10.—*Professional visits and hospital admissions in 1915.*

	For malaria.	For other causes.	Total.	Percentage for malaria.
Admissions to hospital.....	50	178	228	22.0
Office consultations.....	788	5,782	6,570	12.0
Residence visits.....	1,664	2,716	4,380	38.0
	2,502	8,676	11,178	22.4

From the foregoing, it will be noted that of the total of 11,178 professional visits of physicians of the lumber company, 2,502, or 22.4 per cent, were because of malaria, clinically diagnosed; this does not represent the total amount of malaria actually occurring in Crossett in 1915, as it fails to include such calls as were made by private practitioners or such cases as failed to receive medical attention. An index, however, is provided for comparative purposes.

At the beginning of operations in April, 1916, the monthly distribution of the recorded visits for malaria during 1915 was determined by conference with the physicians and reference to available records. Chart 2 (p. 31) shows this monthly distribution contrasted with a similar distribution for 1916.

CONTROL OPERATIONS.

In Crossett the measures employed for the control of malaria have consisted exclusively of procedures directed against mosquito propagation, and have included drainage, clearing and training of streams, and control of artificial containers, etc., over an area about one-half mile square.

Active work was begun on April 10, 1916. After systematic survey of the locality, a detailed map of the town and its environments was prepared, showing all streams, ditches, borrow pits, and other breeding places. For purposes of accurate record and reference, each stream was designated by letter, and its subdivisions by sub-number (A2, D3, etc.), and so indicated on the maps; street ditches were designated as such, and borrow pits and other special breeding places were referred to by name or location. (Map 1.)

Ditching.—Under this heading is included all treatment of old streams and ditches, and the cutting of such new ditches as were required for the drainage of wet areas and borrow pits. (See figs. 9–12.) This work was performed by a gang of colored laborers, usually under the direction of the field director or sanitary inspector.



FIG. 9.—STREET DITCHING, CROSSETT.



FIG. 10.—STREET DITCHING, CROSSETT.



FIG. 11.—STREAM "E," "COLORED TOWN," CROSSETT, SHOWING "POT HOLES."



FIG. 12.—SAME STREAM AS IN FIG. 11, SHOWING RECHANNELING.



FIG. 13.—ANOPHELES BREEDING PLACE, "COLORED TOWN," CROSSETT.



FIG. 14.—SAME DITCH AS SHOWN IN FIG. 13, AFTER CLEARING.

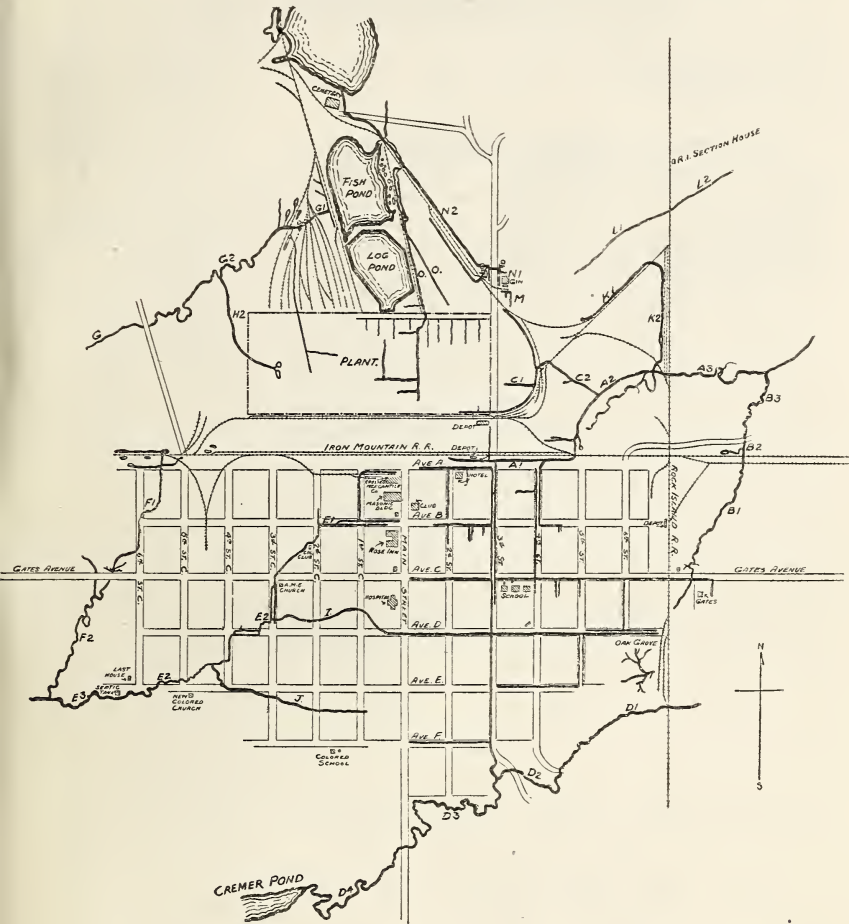


FIG. 15.—PROLIFIC SOURCE OF ANOPHELES, HORSE-LOT DRAIN, CROSSETT.



FIG. 16.—SAME AS FIG. 15, AFTER TREATMENT.

In old streams and ditches, all overhanging trees and brush were removed for a distance of from 2 to 8 feet from both banks, the edges and banks were cleared of vegetation and straightened, the bottoms freed of obstructions and recut to narrow channel of semi-elliptical cross section. In this way pools were eliminated and water concentrated for offflow or subsequent oiling if needed. For



MAP 1.—Index map, Crossett, Ark. Antimalarial operations, 1916.

borrow pit and wet area drainage and for the interception of seepage, a few narrow ditches were cut, usually communicating with one of the permanent watercourses. Street ditches were cleared of vegetation, and their channels recut to facilitate drainage. (Figs. 13-16.)

In the following tables are presented summaries of the ditching operations, with their respective costs, separated into "Old streams

and ditches," "New ditching," and "Street ditching." In the first two groups each stream or ditch is referred to by letter corresponding with its designation on the maps, the subdivisions being shown by number. All costs are charges to each subdivision for labor of first work, maintenance, and oil applied; the costs of the application of the oil are given separately.

TABLE 11.—*General summary of ditching operations.*

Old streams cleared and treated.....linear yards..	9, 244
New ditching installed.....do....	3, 177
Street ditch cleared.....do....	4, 844
<hr/>	
Total ditching (exclusive of maintenance).....do....	17, 265
Maintenance, recleaning of ditches.....do....	8, 261
Total area cleared, timber, brush, etc., removed on sides of stream, square feet.....	429, 626
Average depth of streams and ditches.....feet..	2 $\frac{3}{4}$
Average middle width.....do....	3 $\frac{1}{4}$

TABLE 12.—*Ditching operations, old streams and ditches.*

Stream.	Subdivision	Linear yards.	Average depth.		Average width.	Cost, first work.	Drip-can stands.	Drip cans.	Gallons oil, sprayed and dripped.						Total.	Cost of oil, at 12 cents a gallon.	Maintenance.		Total cost.
			Feet.	Feet.					June.	July.	August.	September.	October.	November.			Linear Yards reclaimed.	Cost.	
"A"	A1	425	3	3	3	14.00	1	1	40	15	20	20	10	10	19	115	425	\$7.00	\$113.125
	A2	275	3	3½	40.50	2	2	20	10	15	20	5	5	5	75	275	5.00		
	A3	297	4	4½	16.00	3	2	.....	.....	.....	.....	.....	.....	.....	.....	15	250	5.00
	Total	997				70.50	6	5	60	25	50	40	15	15	205	205	950	17.00	
"B"	B1	540	2½	2½	16.95	6	3	24	15	25	20	10	10	10	104	540	250	7.00	66.325
	B2	90	3	2½	7.00	1	1	16	10	10	15	.....	.....	.....	51	90	.....	.....
	B3	422	2	3	12.00	4	2	.....	.....	.....	.....	.....	.....	.....	.....	265	.....	4.00
Total	1,052				35.95	11	6	40	25	35	35	10	10	155	155	515	11.00	11.00	
"C"	C1	165	3½	3	11.00	1	1	10	5	5	10	5	35	165	100	4.00	37.625
	C2	142	2	4	13.00	1	1	10	5	.....	5	.....	.....	.....	20	142	100	2.75
Total	307				24.00	2	2	20	10	5	15	5	.....	.....	55	55	200	6.75
"D"	D1	383	3	6	12.25	3	1	20	15	15	10	5	5	5	70	383	383	9.00	101.02
	D2	320	4	7	11.00	3	2	30	10	30	30	15	15	15	130	320	320	11.00	
	D3	467	5	6	15.27	5	3	30	15	15	40	.....	.....	.....	100	467	447	5.00
	Total	1,170			38.52	11	6	80	40	60	80	20	20	20	300	300	1,150	25.00	
"E"	E1	275	2	3	6.00	2	2	10	10	20	15	5	5	5	65	275	71.825
	E2	325	3	4	14.00	2	2	30	15	30	20	10	5	10	110	300	300	7.00	
	E3	305	4	3	12.70	2	2	10	15	10	15	.....	.....	.....	50	200	200	4.00
Total	905			32.70	6	6	50	40	60	50	15	10	10	225	225	500	11.00	11.00	
"F"	F1	383	2	3	12.00	10	20	5	10	10	55	383	383	5.00	54.75
	F2	399	3	4	22.00	1	1	.....	.....	.....	15	.....	.....	.....	15	363	363	7.00
Total	782			34.00	1	1	10	20	5	25	10	.....	.....	70	70	746	12.00	12.00

TABLE 12.—Ditching operations, old streams and ditches—Continued.

Stream.	Subdivision.	Linear yards.	Average depth.	Average width.	Cost, first work.	Drip-can stands.	Drip cans.	Gallons oil, sprayed and dripped.						Total.	Cost of oil, at 12½ cents a gallon.	Maintenance.		Total cost.
								June.	July.	August.	September.	October.	November.			Linear yards reclaimed.	Cost.	
"G"	G1	275	<i>Pct.</i> 2	3	26.05	2							10		200	5.00	58.555	
	G2	500	3	4	16.63	4							15		350	7.75		
Total		775			42.68	6							25	3.125	550	12.75		
"H"	H1	600	2	3	11.00	4	1								525	7.00	59.00	
	H2	235	2	3	27.00	2									235	11.00		
Total		835													760	18.00		
"I"	I1	350	1	3½	18.00										100	3.25	51.00	
	I2	503	2	3	25.00										200	4.75		
Total		853			43.00										300	8.00		
"J"	J1	409	2	3	23.65										130	4.50	46.50	
	J2	350	2	3	11.00										300	7.35		
Total		819			34.65										430	11.85		
"L"	L1	319	3	4	17.00												21.00	
	L2	200	2½	3	4.00													
Total		519			21.00													
"O"	O1	200	2½	4	41.00												41.00	
	O2	9,211																
Totals					459.00	49	27	200	185	215	245	75	55	1,035	129.375	6,101	133.35	721.725
Miscellaneous reclaiming, after rains, weed removal, etc.																2,100	14.00	
Yard maintenance charged.																8,261	147.35	

NOTE.—Cost of application of oil by spray is not included.

TABLE 13.—*Ditching operations—New ditches.*

Stream.	Division.	Linear yards.	Average depth.	Average width.	First work, cost.	Gallons of oil sprayed and dripped.						Cost, oil at 12½ cents a gallon.	Total cost.
						June.	July.	August.	September.	October.	November.			Total.
"K".....	K1	200	4	3	\$17.00	30	10	.....	15	.....	55		
Borrow-pit drain.....	K2	195	2	2½	13.00	.....	10	.....	5	.....	15		
		395			30.00	30	20	.....	20	.....	70	\$8.75	\$38.75
"M" (horse-lot drain).....		272	2	2½	14.00	.....	.....	.....	.....	.....	.....		14.00
"N" (cotton-gin drain, etc.).....		975	2½	4	55.00	.....	.....	.....	.....	.....	.....		55.00
Oak grove crowfoot.....		320	1	1	26.00	.....	.....	.....	.....	.....	.....		26.00
Miscellaneous small laterals.....		1,212			78.50	.....	.....	.....	.....	.....	.....		78.50
Total.....		3,177			204.10	.....	.....	.....	.....	.....	.....	8.75	212.85

TABLE 14.—*Ditching operations—Street ditches.*

Total yards.....	4,844
First cost.....	\$195.12
Gallons of oil sprayed and dripped:	
June.....	35
July.....	52
August.....	60
September.....	43
October.....	35
November.....	33
Total.....	258
Cost of oil, at 12½ cents a gallon.....	\$32.25
Total cost.....	\$227.37

TABLE 15.—*Cost summaries, ditching and reclearing operations.*

	Total linear yards.	Total costs.	Cost per linear yard.	Cost per linear foot.
Old streams and ditches.....	9,244	\$459.00	\$0.04965	\$0.01655
New streams and ditches.....	3,177	204.10	.06424	.0214
Street ditching.....	4,844	195.12	.04023	.01342
Maintenance.....	8,261	147.85	.01783	.00594

Maintenance of streams and ditches.—Nearly all of the more important streams and ditches were re-cleaned throughout in midsummer (July), this work being charged to each stream subdivision in the summaries. In addition, such maintenance work was done as was necessary following storms (fig. 17) and damage by hogs and stock; passage of a "hog law in May," however, diminished damage from this latter source to an almost negligible amount.

In this section weed growth is rapid, and recutting was found necessary after three or four weeks' growth along the banks. In addition to the general reclearing in July, weeds were again cut in August on

two of the principal streams, "A" and "D," and in places along the courses of several of the lesser ones.

Borrow pits and their treatment.—Wherever possible borrow pits made in connection with construction enterprises were filled (figs. 19–20), otherwise drained (figs. 18 and 21) or oiled by spraying. All three of the railroads entering Crossett contributed to the success of the control operations by having a number of the pits situated along their respective rights of way filled by their section crews; the cost of these operations has been given by the several companies and is summarized in the following table:

Arkansas, Louisiana & Midland R. R.....	\$10.50
Iron Mountain R. R.....	100.00
Rock Island R. R.....	105.90

¹ 216.40

Fish-pond control.—Control operations were undertaken in but one of the four ponds in the vicinity, i. e., the "fish pond," of which the southern edge lay within flight range of town and in which the prolific growth of vegetation along the shallow edges caused a limited amount of mosquito production. Because of frequent fluctuations in the water level, protection of larvæ against fish was possible to some extent in the southeastern corner where the water was shallow and where barriers were left when the water level was diminished. Accordingly 1½ acres in this corner were cleared of grass and other growth and a few broad-channel shallow ditches, totaling 170 linear yards, cut to permit of free access of small fish at all times; the cost of this work was \$47.50.

Artificial container control.—Wherever possible artificial containers serving or likely to serve as mosquito-breeding places, were eliminated by removal or emptying. A large number requiring treatment remained, however, including the 311 water barrels on or about the trams or in the yards of the lumber mills. For these and other fire barrels control was secured through the use of a salt substance, so-called niter cake, a by-product of the manufacture of explosives consisting of anhydrous sodium sulphate and acid sodium sulphate. This material, a grayish hygroscopic salt, was found to be lethal to larvæ and pupæ and to prevent the development of ova in a dilution of 1:400. Accordingly, 1 pound was placed in each of the 311 fifty-gallon barrels and stirred into solution on May 29, 1916; at repeated subsequent inspections no propagation was at any time observed. This substance was also used to inhibit mosquito breeding in a brick cistern (a reserve fire-control water supply at the rear of No. 1 mill). This cistern, about 8 feet in diameter and containing about 14 feet of

¹ Since this expense represents corrections by the railroads of sanitary nuisances created by them in construction works, the propriety of inclusion of these costs in final compilations is questionable.



FIG. 17.—EFFECT OF STORM. CROSSETT.



FIG. 18.—A DRAINED BORROW PIT, CROSSETT, FORMERLY A PROLIFIC BREEDING PLACE.



FIG. 19.—RAILROAD BORROW PIT, CROSSETT.



FIG. 20.—SAME BORROW PIT SHOWN IN FIG. 19, AFTER TREATMENT BY FILLING.



FIG. 21.—DRAINING A BORROW PIT.



FIG. 22.—SEEPAGE INTERCEPTION, TOE AT FISH POND EMBANKMENT, CROSSETT.

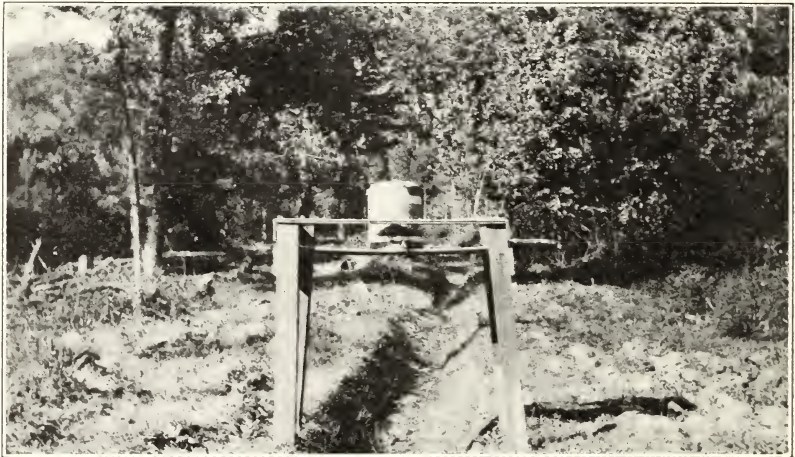


FIG. 23.—OIL CAN, DRIP, ON STREAM "B," CROSSETT.



FIG. 24.—KNAPSACK SPRAYER IN USE.

water, was formerly a prolific source of mosquitoes, principally *Culex*. It was treated once with 200 pounds of niter cake and required no further attention.

Oiling.—The extent to which oil was used in connection with control operations is indicated in the foregoing tables, showing the relative amounts and costs of oil applied to the several streams and ditches after preliminary clearing and training. In the amounts charged to "Street ditches" is included such oil as was used for spraying of temporary pools and other water collections following rains, and of which no separate cost records are given.

After trial of a number of samples of oils, including kerosene, a rather heavy black oil, graded by dealers as next below "fuel oil," was selected for routine use. When smeared in a thin layer or spread on the surface of water, it is of a very dark-brown color and is quite sticky. Its coefficient of "spread," although considerably less than that of the more expensive fuel oils, is higher than that of the crude oils, and is ample to permit of its use by dripping; the resulting film sticks tightly to ditch banks and is very resistant to evaporation.

To facilitate distribution the oil barrels were stored in small "oil houses" at several points about town. By this procedure a minimum of time and labor was required to replenish drip cans, and the men engaged in hand spraying could avoid carrying full cans for long distances.

Two methods were employed for the application of oil, automatic drip cans (fig. 23) and knapsack pump sprayers (fig. 24). For the former, 5-gallon galvanized-iron cans, equipped with adjustable screw stopcocks and sold by wholesale hardware dealers at 65 cents each, were used, and for the latter the Myer's pump knapsack sprayer with galvanized-iron tank. Stands built of scrub-oak saplings or "cut offs" from the lumber mills were used for the drip cans and were so arranged as to have the drops of oil delivered from an elevation of about 4 feet to some rapidly moving portion of the stream. On each stream of constant flow the cans were spaced about 200 yards apart and so adjusted as to deliver about 15 drops of oil per minute when the contents of the can became warmed during the day. After inspections, drip cans were in a number of instances cut off or removed where no mosquito propagation was observed or where it was found that sufficient oil adhered to the ditch banks to maintain a film.

Larvacide.—In the small runs and ditches in and about the lumber yards where oil could not be employed because of insurance restrictions, mosquito propagation was effectually controlled by the use of an emulsion of a phenol disinfectant compound, a proprietary preparation on sale in the open market at 80 cents per gallon. This compound forms a milky emulsion when mixed with water, and was found

to serve well as a larvacide, killing larvæ and pupæ in about three minutes at a dilution of 1-20.

Cost.—The following summary exhibits the costs of oiling operations:

TABLE 16.—*Costs of oiling operations.*

Oil and larvacide purchased: Oil, f. o. b. Crossett, twenty-seven 50-gallon barrels, \$168.25, or \$0.1246 per gallon. Larvacide, 34 gallons, \$27.28, or \$0.8023 per gallon.	
Oil distribution:	Gallons.
Oil applied to "old ditches".....	1,035
Oil applied to "new ditches".....	70
Oil applied to "street ditches".....	258
Total.....	1,363
Costs of oil and larvacide application:	
2 knapsack sprayers.....	\$14.79
50 drip cans.....	39.00
49 drip-can stands, construction.....	9.00
Labor, spraying.....	238.69
Total.....	301.48

Inspections.—During the season of active mosquito propagation routine inspections of the territory under observation were made at weekly intervals. For these inspections the town and its environments were divided into four districts and a chart was prepared on which were listed all streams and other known potential breeding places. The first four days of each week were devoted to systematic examination of each of the four districts by the sanitary inspector, whose findings were then recorded upon the chart together with any minor corrective or maintenance measures employed. The remaining two days of the week were utilized for such works as required a gang of laborers, of whom the sanitary inspector then acted as foreman. Supplementary inspections were made at irregular intervals, in addition to surveys for collection of biologic material, determination of mosquito prevalence outside of the controlled zone, and other special purposes.

Monthly malaria morbidity reports.—To follow the monthly incidence of malaria as influenced by the mosquito-control operations, tabular monthly reports were obtained from the chief surgeon of the Crossett Hospital at the end of each month during 1916, giving the name, age, sex, residence, and number of times seen of all cases receiving professional attention for malaria, clinically diagnosed, during the preceding month. From these reports a card index, by months, was made, and the calls and cases, grouped as to sex and color, were recorded on charts. The calls were entered, by corresponding months, on the chart of calls made in 1915 for malaria (see figure already given on p. 31).

These data were also utilized for the preparation of a "spot map" of known cases, each case being entered as reported, for the purpose of studying the distribution of the known cases and ascertaining their relation, if any, to each other. As may be seen from the completed map (map 2), the cases were found to be fairly uniformly distributed in the various parts of town, with about double the number reported for whites as for colored persons (v. tabular summary on p. 28).

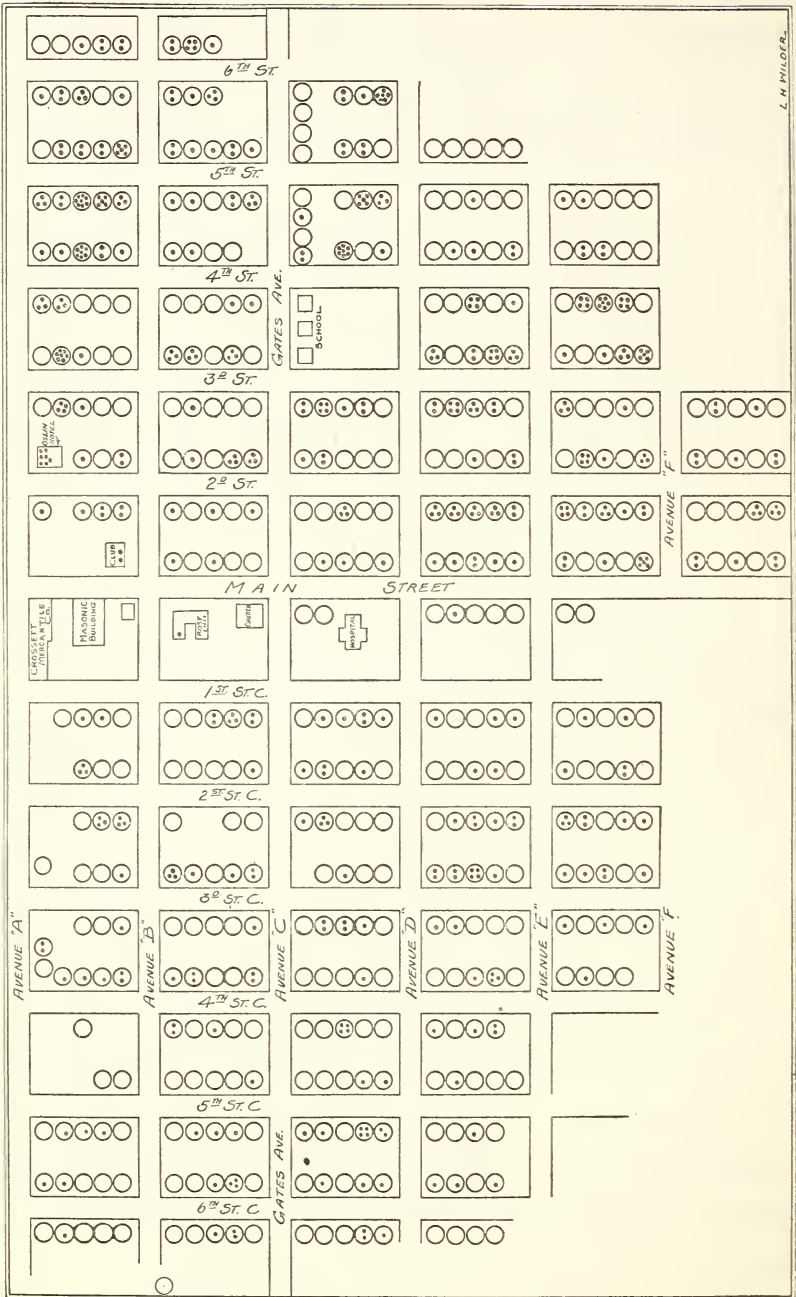
Educational measures.—For the purpose of enlisting the active interest and cooperation of the people, a number of lectures were delivered, usually accompanied by stereopticon illustrations. These were given in churches, schools, and other meeting places to both white and colored people at the beginning of operations and were probably of value in inviting attention to mosquito propagation in artificial containers. It is believed that in Crossett suppression of propagation of mosquitoes of all kinds was responsible for at least as much of the enthusiasm with which the work was popularly received as was malaria control through *Anopheles* elimination.

RESULTS.

The immediate results of the mosquito-control operations begun on April 10 were made evident, first, by an almost complete absence of mosquitoes of all varieties, and, then, beginning in May, by a progressive diminution in the incidence of malaria.

Mosquito prevalence.—The drainage of a number of the nearer wet areas, the clearing of streams and ditches of obstructions, and the filling of pits resulted in the early control of mosquitoes which would have caused the season's first seriously large broods; and as obstructions were removed from some of the town ditches, waters fairly alive with larvæ and pupæ, principally of *Culex*, were disposed of and the ditches allowed to dry. Complete mosquito control was secured at the end of May, and with the exception of a few *Anopheles quadrimaculatus* taken July 5-7, following hard rains, no invasions of more than occasional individual mosquitoes were observed or reported. At the outskirts of the community, however, and at the mills mosquitoes were several times noted during the first half of the summer.

Second parasite index.—A second parasite index was obtained in December to determine the change in endemic infection, the same technique being observed as in the preliminary index (v. p. 15); the findings in the second index are exhibited in the following table:



U. S. PUBLIC HEALTH SERVICE
 MAP 2.—Spot map Crossett, showing house distribution, reported cases of malaria, 1916.

TABLE 17.—Parasite index—Crossett—December, 1916.

Age.	Number examined.						Total.
	White.			Colored.			
	Male.	Female.	Total.	Male.	Female.	Total.	
4 to 5.....				10	5	15	15
6 to 9.....	55	69	124	36	26	62	186
10 to 14.....	76	57	133	35	30	65	198
15 to 19.....	31	33	64	26	10	36	100
20 to 29.....	20	15	35	20		20	55
30 to 40.....	5	3	8	11		11	19
Total.....	187	177	364	138	71	209	573

Age.	Number positive.						Total.	Type.		
	White.			Colored.				Tertian.	Estivo- autumnal.	Total.
	Male.	Female.	Total.	Male.	Female.	Total.				
4 to 5.....										
6 to 9.....	2	1	3	2	1	3	6	5	1	6
10 to 14.....	3	2	5	1		1	6	5	1	6
15 to 19.....		1	1	1		1	2	2		2
20 to 29.....										
30 to 40.....				1		1	1		1	1
Total.....	5	4	9	5	1	6	15	12	3	15

Total index.....	2.61
White index.....	2.47
Colored index.....	2.87

The summarized comparative findings obtained in the first parasite index, May, 1916, and the second series of examinations, December, 1916, are given in the following table, which also exhibits the reduction in parasite endemicity:

TABLE 18.—Comparative findings, first and second indices.

	White.	Colored.	Total.
First index May, 1916.....	10.95	7.25	9.43
Second index December, 1916.....	2.47	2.87	2.61
Reduction.....	77.45	60.42	72.33

Malaria control.—The incidence of malaria in Crossett during 1916 is illustrated in the following charts and tables, prepared from the data reported at monthly intervals from the Crossett Hospital; in these reports are included all professional consultations in which a clinical diagnosis of malaria was made by the physicians of the company, and comprise admissions to hospital, dispensary consultations, and residence visits. In view of the industrial nature of the com-

munity, it is believed that these records represent all but a very small proportion of the total malaria coming under professional notice during the year. Table 19 and Chart 1 are illustrative of the total calls for malaria, for conditions other than malaria, and for all causes, by months, in 1916:

TABLE 19.—*Total calls, by month, 1916, Crossett.*

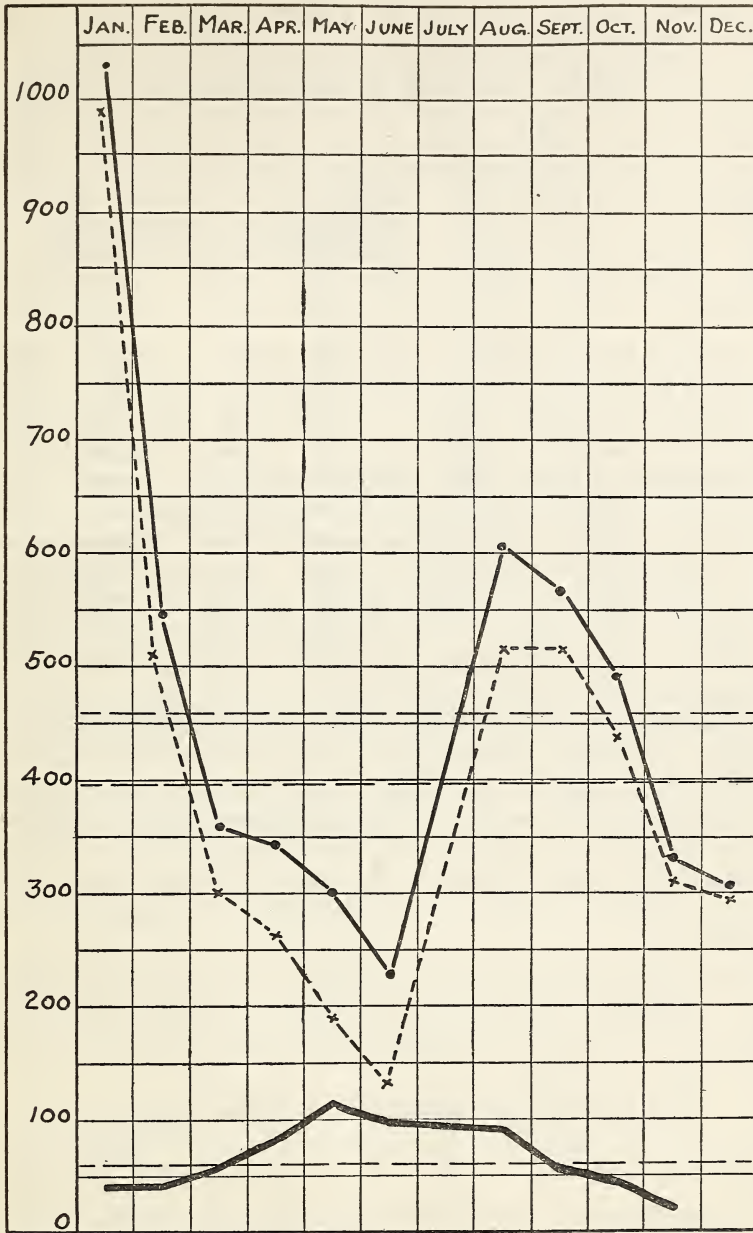
	For con- ditions other than malaria.	For malaria.	Total.
January.....	992	40	1,032
February.....	510	39	549
March.....	300	59	359
April.....	263	81	344
May.....	188	114	302
June.....	130	98	228
July.....	308	95	403
August.....	511	91	602
September.....	513	54	567
October.....	447	46	493
November.....	313	20	333
December.....	297	4	301
Total.....	14,772	2,741	5,513

¹ 86.56 per cent.² 13.44 per cent.

In the following tabular summary are shown the reported calls and cases of malaria in detail, by month:

TABLE 20.—*Hospital reports, calls and cases, malaria, 1916.*

Months.	Cases.						Calls.						Total.	
	White.			Colored.			White.			Colored.			Total cases.	Total calls.
	Male.	Fe- male.	Total.	Male.	Fe- male.	Total.	Male.	Fe- male.	Total.	Male.	Fe- male.	Total.		
January.....	25	1	26	9	.....	9	30	1	31	9	.....	9	35	40
February.....	15	6	21	7	.....	7	20	11	31	8	.....	8	28	39
March.....	20	13	33	10	5	15	33	11	44	10	5	15	48	59
April.....	23	16	39	9	5	14	41	24	65	10	6	16	53	81
May.....	39	21	60	19	7	26	48	35	83	24	7	31	86	114
June.....	32	17	49	10	11	21	50	21	71	14	13	27	70	98
July.....	32	15	48	4	18	22	52	20	72	6	17	23	70	95
August.....	19	16	35	13	10	23	34	26	60	17	14	31	58	91
September.....	14	12	26	4	6	10	22	16	38	4	12	16	36	54
October.....	8	8	16	11	3	14	17	11	28	15	3	18	30	46
November.....	6	2	8	3	2	5	9	4	13	4	3	7	13	20
December.....	3	1	4	.....	.....	.....	3	1	4	.....	.....	4	4	4
	237	128	365	99	67	166	359	181	540	121	80	201	531	741



L.H. HILDER

●——● TOTAL VISITS.
 x-----x VISITS FOR CONDITIONS OTHER THAN MALARIA.
 ————— VISITS FOR MALARIA.

U.S. PUBLIC HEALTH SERVICE

CHART 1.—Total professional visits for malaria and other conditions, Crossett, 1916.

The total calls for 1916 may be compared with those for 1915 as follows (see also chart 2):

TABLE 21.—*Calls for malaria, Crossett, 1915 and 1916.*

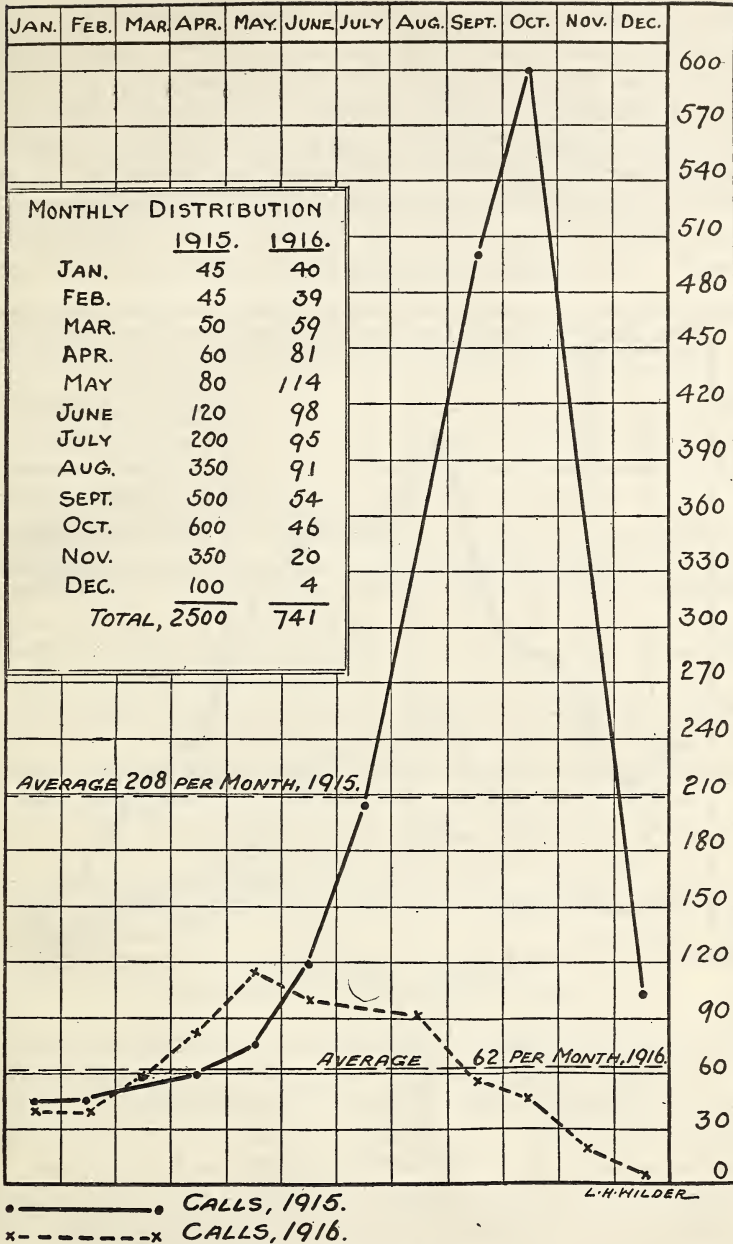
	1915	1916		1915	1916
January.....	45	40	August.....	350	91
February.....	45	39	September.....	500	54
March.....	50	59	October.....	600	46
April.....	60	81	November.....	350	20
May.....	80	114	December.....	100	4
June.....	120	98			
July.....	200	95		2,500	741

From the data graphically shown in charts 2 and 3 it will be observed that in 1916 the greatest incidence of malaria, as represented by the greatest number of cases and calls, was reached during the month of May, and consisted entirely, it is believed, of recrudescences. During May, effective control of mosquito propagation was secured, and it is questionable whether any new infections occurred or chronic cases entered Crossett from elsewhere prior to midsummer. From this "peak" of 86 cases reported for May a gradual decline occurred through the summer and autumn, the period of the year that, in the absence of control operations, should have been marked by a rapid rise in prevalence. The greatest decline was noted in September, at the end of which there were reported 22 cases and 35 calls less than are recorded for the previous month. In October, ordinarily one of the two most highly malarious months of the year in this section, there occurred approximately the same number of cases as were reported at the end of February, viz, 28 and 30 cases, respectively. The professional visits and consultations for malaria totaled in October of 1915 about 600 and in the same month of 1916 but 46, a reduction of approximately 92 per cent.

The net diminution obtained in Crossett as a result of the application of mosquito-control measures may be derived by comparison of the total calls made for this disease in 1915 with those of 1916 as follows:

TABLE 22.—*Diminution resulting from mosquito-control measures.*

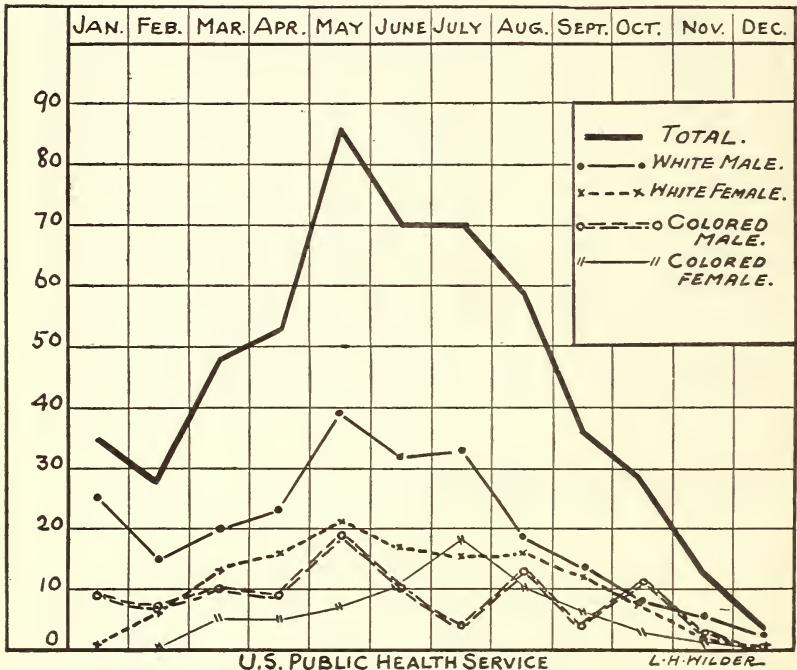
	1915	1916	Reduction.
Total professional visits and consultations for malaria.....	2,502	741	<i>Per cent.</i> 70.39
Professional visits from June to end of year (eliminating as possible the influence of recidives).....	2,220	408	82.07



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CHART 2.—Calls for malaria, 1915 and 1916, Crossett.

Condition of ditches, etc., at end of season.—After the termination of active operations winter surveys were made to ascertain the condition of the several streams and ditches and to what degree reclearing and other work would be required at the beginning of the next year to maintain the control instituted at its highest efficacy. In general, the problem should be much simpler and the necessary costs for labor and other items considerably less, as much of the first work of a more or less permanent character, such as removal of timber, filling of borrow pits, and drainage of wet areas would be obviated. A recleaning at the beginning of the season of the prin-



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CHART 3.—Reported cases of malaria, Crossett, 1916.

cipal streams and ditches of vegetation and obstructions, the use of oil by knapsack sprayers, and at a few points by drips, and a small amount of maintenance labor during the summer should, with careful systematic inspection, be all that is needed to continue the almost complete freedom of the town from malaria and mosquitoes. In accordance with recommendations embodying the above in detail, the suggested operations for continued control of malaria have been incorporated among the routine civic activities of Crossett.

Costs with reference to control gained and to population influenced.—The cost of the operations at Crossett are exhibited in the table given below, which has been prepared after analysis of the total disburse-

ments, and presents in summary the costs of such items as have direct reference to malaria control. In the preparation of this compilation there have been excluded all costs of administration, supervision (save that of the salary of the sanitary inspector), history, and parasite index determinations, and scientific investigations—activities which, while desirable for the purpose of the present work as an intensive study, bear no essential relation to the effectiveness of the malaria-control demonstration. The following is a summary table of costs:

TABLE 23.—*Costs in summary; Crossett, 1916.*

Salary sanitary inspector, 1 year.....	\$678.83
Labor as follows:	
Ditching old streams.....	459.00
Ditching new streams.....	204.10
Ditching street ditches.....	195.12
Pond clearing.....	47.50
Maintenance ditches.....	147.35
Artificial container treatment.....	14.00
Construction 49 stands for oil drip cans.....	9.00
Spraying oil.....	238.69
Amounts expended by railroads for borrow-pit fills, drainage, etc.....	216.40
Oils and larvacide.....	195.53
Niter cake, estimated cost of amount used.....	5.00
Tools, knapsack sprayers (2), drip cans (50).....	95.88
<hr/>	
Total.....	2,506.40

The reduction effected in the incidence of malaria in Crossett and the costs thereof with reference to population may be shown in summary as follows:

TABLE 24.—*Reduction in malaria and costs of control measures.*

Total cost malaria-control operations.....	\$2,506.40
Total population (census, April, 1916).....	2,029
Per capita cost.....	\$1.23½
Per family cost, average.....	\$5.31
Reduction in incidence of malaria as ascertained by repeated parasite indices.....	per cent.. 72.33
Reduction as ascertained by comparison of total calls for malaria in 1915 and 1916.....	per cent.. 70.39
Reduction as ascertained by comparison of calls during the active seasons of 1915 and 1916.....	per cent.. 82.07

ACKNOWLEDGMENTS.

Appreciative acknowledgment is made of the valued assistance of the citizens of Crossett, the officials of the city, and the officials of the Crossett Lumber Co., whose interest and cooperation contributed substantially to the success of the foregoing work.

THE RURAL UNIT, VICINITY OF LAKE VILLAGE, ARK.

R. C. DERIVAUX and T. D. HAAS.

GENERAL DESCRIPTION.

The locality selected for the demonstration studies in malaria prevention through the use of screening and quinine under rural conditions is situated in the alluvial lands of Chicot County, southeastern Arkansas, and consists of a group of 10 plantations lying close to Lake Chicot and Yellow Bayou, in the vicinity of the town of Lake Village. Conditions are representative of what is found in the more malarious sections of the South with reference to economics, population, and health.

Topographically, the country is flat, and has a mean elevation of about 126 to 130 feet above sea level. The less elevated portions consist largely of what is locally known as "bottom" or "swamp," and are, in the main, as yet uncleared, save that the more accessible of the plentiful timber is steadily being removed; in these swamps, the water table is very close to the surface of the ground, water accumulates in the sloughs and "breaks," and vegetation is prolific, the dense growth of underbrush being almost tropical in its luxuriance.

The soil consists of dark-brown loam and "buckshot" in the lower sections, heavy in texture and more or less impervious because of "silting" from the overflows of the Arkansas and Mississippi Rivers to which the region has been repeatedly subjected. In the higher sections, not usually inundated, the soil is of a lighter reddish-brown color, in places sandy, and is much more pervious. The cultivated land is fairly easily worked and is of a high grade of fertility. Cotton is the chief product; corn, oats, hay, etc., are raised to a lesser extent, and many of the plantation tenants, more especially the Italians, maintain gardens near their homes to supply their tables.

Opportunities for mosquito propagation are abundant (figs. 25-26). The numerous surface collections of water, swamp edge pools, ditches, and "borrow-pits" along the railroad rights of way (in addition to the many artificial containers on premises), provide plentiful facilities for breeding. During dry periods, however, many of the temporary propagation places disappear, with noticeable effect on mosquito prevalence.

Economic and sanitary conditions vary widely among the various groups of plantation residents, and bear an important relation to



FIG. 25.—BORROW PIT, ROADSIDE.



FIG. 26.—BARRELS. NOTE: IN THESE WERE FOUND BREEDING *Aedes calopus*, *Anopheles punctipennis*, AND A VARIETY OF *Culex*.



FIG. 27.—TYPE OF DOOR SCREENING INSTALLED, HOUSES OF GROUPS "A" AND "C."



FIG. 28.—TYPE OF WINDOW SCREENING INSTALLED, HOUSES OF GROUPS "A" AND "C."



FIG. 29.—TYPE OF TENANT HOUSE TOO COMMONLY FOUND.



FIG. 30.—TYPE OF TENANT HOUSE RENDERING DIFFICULT ANTIMALARIA MEASURES.



FIG. 31.—TENANT HOUSE, A STRUCTURAL DETAIL.

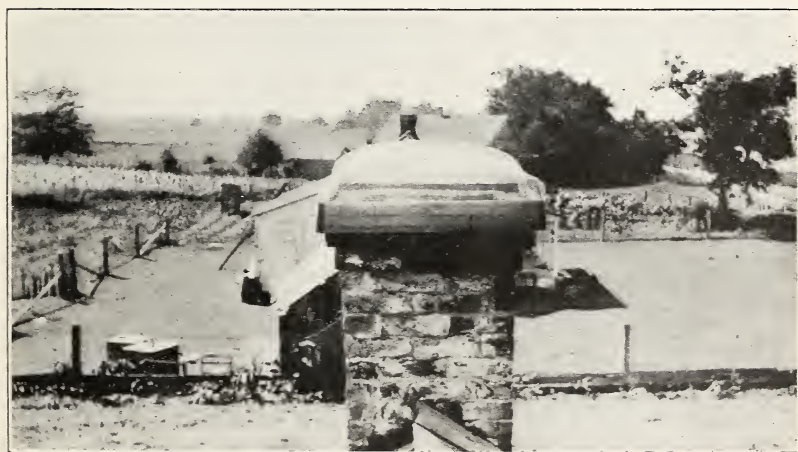


FIG. 32.—CHIMNEY PROTECTION, RURAL UNIT.



the prophylaxis of malaria. The houses of managers and owners are of a better class of construction, and while not perfectly screened, are much better protected against mosquito invasion than are those of the tenants or "hands." This latter group, comprising both whites and colored, is almost totally unprotected and represents the class in which the ravages of chronic malaria are more prominently manifested.

Most of the tenant houses (figs. 29-31) are single-story, shingle-roofed frame structures, with mud-and-stick or brick chimneys, and almost all present the appearance of having been built a number of years ago. The usual type of construction is that of a low building, containing a single large room, or two small rooms, with a "lean-to" at the rear, serving as dining room and kitchen. The floors of most are elevated above the ground from 1 to 4 feet, the sills of the flooring resting on upended blocks or sections of logs. The flooring proper is in some instances of "tongue-and-groove" material, in which cases if the wood is free of knot holes mosquito entry is effectually prevented as long as the wood remains sound. In the majority of cabins, the floors are laid with ordinary planks, the apertures along the edges, even in recently installed floors being occasionally as much as 2 inches, and commonly, from one-fourth to one-half inch. The siding of the houses is ordinarily of 1 by 6 inch planks, with strips nailed over the seams on the outside; in time these become detached and leave cracks through which the wind, rain, and mosquitoes enter freely, unless "chinking" with cotton or mud or papering is resorted to. Many of the more enterprising tenants line the interiors of their houses with paper, either torn from the pages of a mail-order catalogue or taken from magazines and newspapers. The number of occupants of these houses varies between 2 and 15, and evidences of crowding are common. Cooking is done either on stoves or on the open hearth. A distinctive feature of the houses of Italian farmers is the large baked-mud ovens in the yards.

Sanitary arrangements are, in general, crude. The water supply is generally obtained from bored wells, 15 to 30 feet in depth. A supply is taken directly from Lake Chicot by many of the families living along its shores. No toilet facilities other than surface latrines were noted, practically all of these being of the open or "E" type; many of the tenant houses had no toilet provision whatever.

PRELIMINARY OPERATIONS.

Sanitary census and history index of malaria.—As active operations were undertaken in each unit, a systematic survey was made, maps were prepared, and a census was taken to ascertain general sanitary conditions and to determine the history index of malaria.

Summaries illustrating the extent of operations and presenting the more important data obtained in connection with the census are given in the following tables:

TABLE 25.—Sanitary data obtained from census.

	Population.		
	White.	Colored.	Both.
Number of plantations in controlled units			10
Total area of controlled plantations	acres		4,540
Population	91	349	440
Number of houses	19	84	103
Number of families	19	87	106
Average number of rooms per house	3	3.1	3.1
Average number of occupants per house	4.8	4	4.2
Average length of occupancy	2.9	3.25	3.1
Number of—			
Outbuildings	43	90	133
Chicken yards			25
Privies	12	31	43
Percentage of houses having privies	63.1	36.9	41.7
Windows			453
Number of windows per house			4.3
Doors			310
Number of doors per house			3
Stables	24	37	61

TABLE 26.—History index of malaria.

	Number.	Giving positive histories of previous malaria.	History index.
White and colored population:			<i>Per cent.</i>
Total	440	274	62.3
Males over 15	145	92	63.4
Females over 15	142	98	69.0
Males under 15	82	43	52.4
Females under 15	71	41	57.7
White population:			
Total	91	60	65.9
Males over 15	29	20	68.9
Females over 15	25	18	72.0
Males under 15	24	15	62.5
Females under 15	13	7	53.8
Colored population:			
Total	349	214	61.3
Males over 15	116	72	62.0
Females over 15	117	70	59.8
Males under 15	58	28	48.2
Females under 15	58	34	58.6

First parasite index and spleen index of endemic infection.—At the time of taking of the sanitary census thick blood smears were obtained from almost all of the residents of the several plantations to determine the parasite index prior to control operations, and manual examinations were made of all under 16 years of age to ascertain the index of splenic enlargement. The technique observed in connection with the blood-smear examinations was that described by

Von Ezdorf,¹ and splenic enlargement was determined by palpation, usually in the prone position and with the abdomen exposed.

The findings obtained in the first parasite index and the spleen index, April-May, 1916, are presented in the following tables:

TABLE 27.—Parasite index—Rural unit—April-May, 1916.²

Age.	Number examined.						Total.
	White.			Colored.			
	Male.	Female.	Total.	Male.	Female.	Total.	
1.....	1		1	2		2	3
2 to 3.....	4	1	5	8	14	22	27
4 to 5.....	3	2	5	11	3	14	19
6 to 9.....	6	6	12	15	15	30	42
10 to 14.....	3	5	8	19	17	36	44
15 to 19.....	7	5	12	20	25	45	57
20 to 29.....	5	5	10	24	30	54	64
30 to 39.....	9	5	14	24	25	49	63
40 and up.....	8	4	12	55	44	99	111
Total.....	46	33	79	178	173	351	430

Age.	Number positive.						Type.			
	White.			Colored.			Total.	Ter-tian.	Estivo-autum-nal.	Total.
	Male.	Female.	Total.	Male.	Female.	Total.				
1.....				1	4	5	5	5		5
2 to 3.....				3	7	10	3	3		3
4 to 5.....				7	1	8	10	10		10
6 to 9.....	2	2	4	2	1	3	5	4	1	5
10 to 14.....		2	2	4	3	7	8	7	1	8
15 to 19.....	1		1	6	8	14	16	9	7	16
20 to 29.....	1	1	2	4	1	5	7	4	3	7
30 to 39.....	1	1	2	9	4	13	15	12	3	15
40 and up.....	2		2							
Total.....	7	4	11	36	22	58	69	54	15	69

	Per cent.
White index.....	13.92
Colored index.....	16.52
Total index.....	16.04

TABLE 28.—Spleen index, April-May, 1916.

	Number ex-aminated.	Positive.	Spleen index.
White.....	31	2	<i>Per cent.</i> 6.45
Colored.....	110	2	1.8
Total.....	141	4	2.8

¹ Von Ezdorf, R. H., "Malarial Index Work," reprint No. 159; Public Health Reports, Dec. 26, 1914, Washington.

² No specimens were obtained from 10 residents, 3 of these being recorded as unequivocal refusals, the remaining 7 not being found.

It is of interest to note here the proportionate relations of the history, spleen, and parasite indices in the groups of individuals less than 16 years of age in which the three determinations were made and are available for comparison:

TABLE 29.—*Comparison of history, parasite, and spleen indices.*

	Number ex- amined.	Number positive.	Index.
History index (under 15).....	153	84	<i>Per cent.</i> 54.9
Parasite index (under 14).....	135	23	17.0
Spleen index (under 16).....	141	4	2.8

From the foregoing it would appear that the true endemic index of malaria, which probably lies between the extremes of the history and parasite indices in this section, is in no way represented by the spleen index. This is believed to be due to the almost universal, although indiscriminate, use of quinine and quinine containing nostrums—a condition which does not obtain among the indigenous peoples of India, Africa, and other tropical places.

THE "NEGATIVE" CONTROL GROUP.

With a view of conducting parallel check observations, an additional group of families living under similar conditions on two near-by plantations, uninfluenced by preventive operations, were observed in the same manner with reference to sanitary conditions, parasite index, and sickness incidence, as were those where prophylactic measures were in effect.

A summary exhibiting the data elicited in the sanitary census of the negative control group is given in the following table:

Number of plantations in the negative control group.....	2
Total population (all colored).....	120
Total number of houses.....	27
Total number of families.....	27
Average number of rooms per house.....	3.1
Average number of occupants per house.....	4.4
Average length of occupancy..... years..	3.25
Number of houses having privies (59.2 per cent).....	16

TABLE 30.—*First parasite index, negative control.*

Age.	Number examined, colored.			Number infected, colored.			Type of infection.		
	Male.	Female.	Total.	Male.	Female.	Total.	Tertian.	Estivo- autumnal.	Total.
1 to 3.....	3	4	7	1	4	5	4	1	5
4 to 5.....	4	1	5	1	1	2	1	1	2
6 to 9.....	9	5	14	1	1	2	1	1	2
10 to 14.....	8	10	18	1	3	4	3	1	4
15 to 19.....	7	8	15						
20 to 29.....	6	10	16		4	4	3	1	4
30 to 39.....	9	7	16	1	1	2	1	1	2
40 and up.....	11	17	28	3	4	7	3	4	7
Total.....	57	62	119	8	18	26	16	10	26
Percentage.....				14.03	29.03	21.84			

CONTROL OPERATIONS.

As indicated in the introduction, the measures used for the prevention of malaria in connection with the rural studies comprised mechanical protection against mosquitoes through the use of carefully applied screens and the use of quinine administered in "immunizing" doses. Both methods were supplemented by the intensive treatment of carriers with quinine in "sterilizing" doses, upon detection by microscopic examination of the blood.

For the purposes of the present studies, the 106 families under observation were divided into three series or groups, with reference to the control measures applied to them or to their houses, as follows:

Group A, screen group: In this series protection was made available through the use of carefully applied screening. Quinine was administered to proven carriers only.

Group B, quinine group: In this series protection was made available through the use of quinine in "immunizing" doses to all occupants of unscreened houses, together with its administration in "sterilizing" doses to proven carriers.

Group C, combined screen and quinine group: In this series protection was made available through the use of screening and the use of quinine in "immunizing" doses to all occupants during the first half of the summer. Proven carriers received intensive treatment. This group was merged into the first (Group A) on August 1, 1916.

The number of houses, families, and individuals included in control operations in the several groups as described above may be summarized as follows:

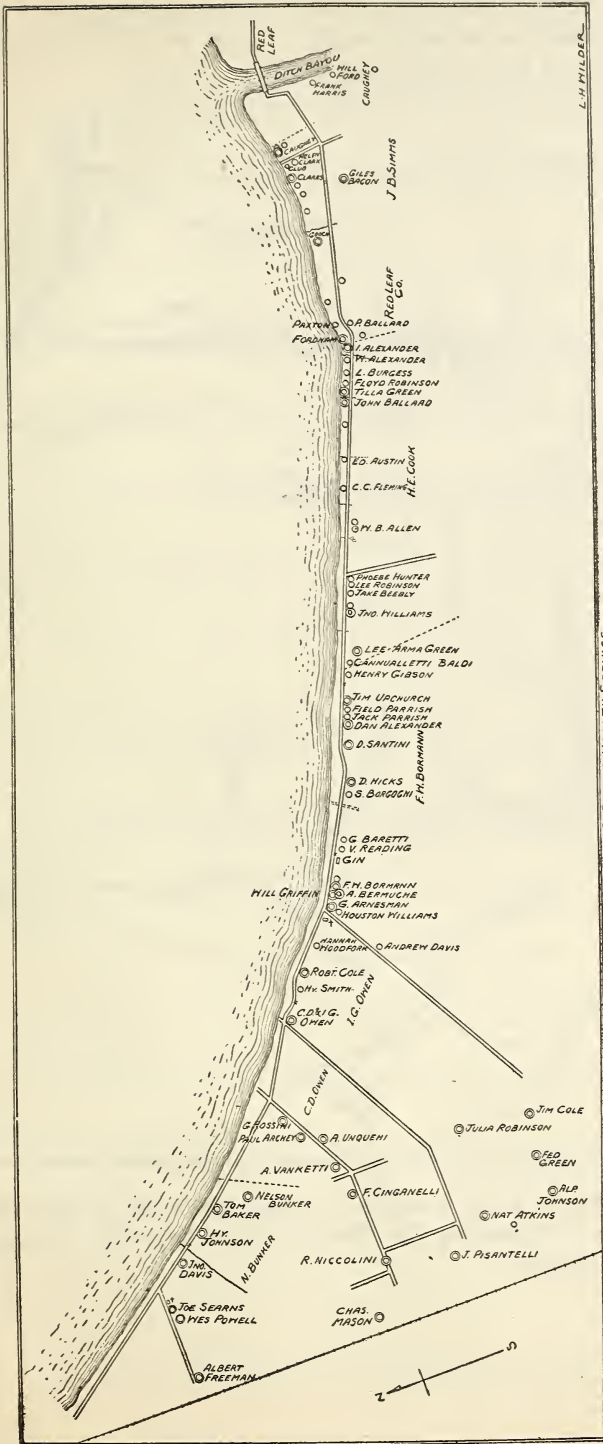
TABLE 31.—*Number of houses, families, and persons included in control operations.*

	Houses.	Families.	Persons.
Group "A," screen control (including 5 imperfectly screened managers' houses).....	32	32	150
Group "B," quinine control.....	65	68	267
Group "C," combined screen and quinine control.....	6	6	23
Total.....	103	106	440

As may be noted from the accompanying maps (Nos. 3 and 4), the houses included in the several groups are distributed over a wide area, no effort being made to restrict any group to any given section. In addition, a small number of the families selected for control under group "B" (quinine), are located far removed from either of the larger territories of operations; this disposition was made to avoid the possible influence of contiguity with areas in which opportunities for mosquito infection would be presumably diminished by reduction in number of infected persons.

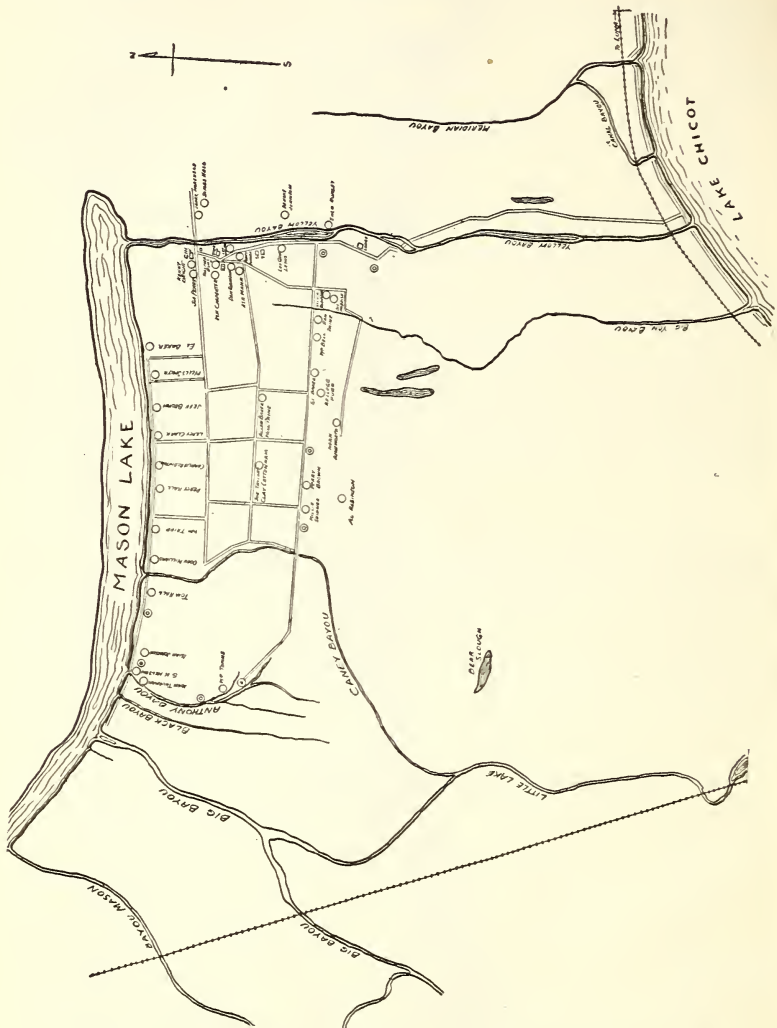
Screening.—As indicated in the summary, systematic observations were conducted with reference to the efficacy of house screening as a control measure for malaria in two groups of 32 and 6 houses, respectively, influencing a total personnel of 173 individuals. For these series there were selected five houses occupied by managers and owners and 33 additional houses which permitted of screening because of the absence of such structural peculiarities as would render the cost prohibitive. To secure data in this particular a test was made of two houses in obviously defective condition.

The installation of the screening of the 33 houses was performed by two sets of workmen, a carpenter and helper. In each case the necessary material had been previously delivered at each house. After inspection and preparation of estimates the only time lost was that required for transportation from one point to the next. In the "Cost summaries" this time has been equally divided and charged throughout as "labor." The material used was 16-mesh galvanized-iron wire cloth, purchased in rolls. A trial was made of a cheaper cotton cloth substitute in three instances, but as it was found totally unsatisfactory it was later replaced by galvanized-iron screen. All door frames were made of seasoned pine lumber and were built on the premises, as few doors were found alike in size and shape. In the case of windows the screen was tacked directly over the frame and secured with "beading." (Figs. 27 and 28.) All chimneys were



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 MAP 3.—Plantations in vicinity of Lake Village, Ark. Houses indicated by double rings, thus ©, are screened. Antimalarial operations, 1916.

“capped” with screen held in place by frames, (fig. 32) and where necessary apertures in walls, roofs, or floors were closed by patching with lath, sheet tin, or sheathing paper.



MAP 4.—Yellow Bayou plantation; portion included in antimalarial operations, 1916.

The following table exhibits in detail the cost of materials and installation of screening for the 33 houses screened in connection with these studies:

TABLE 32.—Distribution of screening costs for 33 houses.

House No.	Places screened.			Cost of materials.							Cost of labor.			Total cost.	
	Num-ber of rooms.	Win-dows.	Doors.	Chim-neys.	Screen. ¹	Lumber.	Paper.	Tin.	Door sots.	Nails.	Total.	Hours.	Rate per hour.		Cost.
1.....	4	7	3	1	\$4.52	22.15			\$0.65	\$0.25	\$7.57	22	\$0.50	\$11.00	\$18.57
2.....	3	7	2	1	3.44	2.15			.40	.20	6.19	12	.50	6.00	12.19
3.....	2	5	2	1	2.90	2.15			.40	.20	5.65	17	.50	8.50	12.15
4.....	2	5	2	1	2.90	2.15			.40	.20	5.65	17	.50	8.50	14.15
5.....	1	2	2	0	1.55	2.15			.40	.20	4.30	17	.50	8.50	12.80
6.....	2	2	3	1	2.63	2.15		\$1.00	.65	.20	6.63	15	.50	7.90	14.53
7.....	1	1	2	1	1.28	2.65	\$0.50		.40	.20	6.03	24	.50	12.00	18.03
8.....	2	2	2	0	1.55	2.65	.50	1.00	.40	.20	5.40	28	.50	14.00	19.40
9.....	1	2	2	1	2.46	2.40			.40	.20	5.46	40	.50	20.00	25.46
10.....	1	3	3	1	1.10	2.45			.65	.20	4.40	14	.50	7.00	11.40
11.....	3	5	3	1	3.17	2.90			.65	.20	6.92	18	.50	9.00	15.92
12.....	3	3	2	1	1.91	2.15			.50	.20	4.76	10	.40	4.00	8.76
13.....	1	3	2	1	1.91	2.15			.50	.20	4.76	10	.40	4.00	8.76
14.....	1	3	2	1	1.91	2.15			.50	.20	4.76	10	.40	4.00	8.76
15.....	1	2	2	1	1.66	4.90			.40	.20	7.16	11	.40	4.40	11.56
16.....	2	4	4	1	2.65	4.90			.90	.20	8.05	26	.40	10.40	18.45
17.....	2	2	4	1	2.66	4.90			.90	.20	8.66	22	.40	8.80	17.46
18.....	2	4	4	1	3.86	4.90			.90	.20	9.86	24	.40	9.60	19.46
19.....	1	2	3	1	2.36	1.95			.65	.20	5.16	16	.40	6.40	11.56
20.....	1	3	2	1	2.09	1.20			.40	.20	3.69	12	.40	4.80	8.09
21.....	1	2	3	1	2.36	2.40			.65	.20	5.61	13	.40	5.20	10.81
22.....	1	3	2	1	1.82	2.40			.40	.20	3.82	10	.40	4.00	7.82
23.....	2	4	4	1	3.44	2.40			.90	.20	6.94	19	.40	7.60	14.54
24.....	2	4	4	1	3.98	2.70			.90	.20	7.87	20	.50	10.00	17.87
25.....	1	2	2	1	1.82	2.44			.40	.20	4.86	14	.50	7.00	11.86
26.....	1	2	2	1	1.82	3.11	.50		.40	.20	6.03	14	.50	8.50	14.53
27.....	2	4	4	1	3.99	3.00			.90	.20	9.48	24	.50	12.00	21.48
28.....	3	4	5	2	3.98	3.40			1.15	.20	8.73	25	.50	12.50	21.23
29.....	2	2	4	1	1.05	2.40			.40	.20	4.05	13	.50	6.50	10.55
30.....	1	4	4	1	1.43	2.90			.90	.20	5.43	25	.50	12.50	17.93
31.....	2	2	2	1	1.41	1.90			.50	.20	4.01	20	.40	8.00	12.01
32.....	2	4	4	1	3.16	2.80			.90	.20	7.06	20	.40	8.00	15.06
33.....	3	7	3	1	3.16	1.90			.65	.20	5.91	17	.40	6.80	12.71
Total.....	56	108	92	32	81.93	88.80	2.00	2.00	21.10	6.75	201.67	.....	.....	207.75	469.42
Average cost.....	.....	.....	.....	.....	2.48	.....	2.81	.....	.61	.20	6.11	.....	.....	8.11	14.22

¹ The cost of galvanized-iron screen is uniformly charge 1 at \$3 per 100 square feet.

² \$0.65 extra time.

Quinine prophylaxis.—Quinine was used for two purposes in connection with these studies, "immunization" (i. e., to prevent the development of infection), and "sterilization" (i. e., to eliminate carriers by destruction of sexual forms of parasites).

Quinine was issued for administration in "immunizing" doses to the members of the 68 families included in group "B," beginning with the organization of the group and ending November 1, 1916. Two forms of the drug were dispensed—3 and 5 grain capsules of quinine sulphate, and an emulsion of quinine sulphate in chocolate, containing 2 grains to each dram. The method of administration was as follows: For adults, two doses of 5 grains each, to be taken in the morning and evening of two successive days each week, preferably on Saturday and Sunday, making a total of 20 grains per week; for individuals less than 15 years of age the dosage was reckoned at 1 grain for each three years, children less than nine years receiving the emulsion, as did also a few older persons who "couldn't swallow capsules." In each case the method of administration was carefully explained either to the individual or, in the case of children, to older members of the family. Each member of every family received an individual issue of quinine, plainly marked with name and directions, usually 32 capsules—a seven weeks' supply—of which record was kept at subsequent inspections.

For sterilization, quinine was issued to all individuals in the three groups in whom parasites were demonstrated upon microscopic examination of the blood in connection with the first parasite index. Adults were given 10 grains daily, in two doses of one 5-grain capsule each for 30 consecutive days; children received proportionate dosages, two a day for the same period. Each carrier received an individual issue of quinine sufficient to last two weeks, and record was kept of it. No reexaminations were made upon completion of treatment, determination of the sterilization being provided for in repetition of the general parasite index.

Inspections and surveys.—Systematic inspections of the entire territory under observation were conducted by the sanitary inspector until the termination of active operations on November 1, 1916; following this, further inspections were continued at irregular intervals during the winter, as road and other conditions permitted.

In the course of inspections, each house or family was visited at least once in each week, and record was made of the following conditions: The taking of or failure to take quinine as recommended; the condition of screening material and its efficacy; incidence of illness and its nature; cost of medical attention and medicine, if any; the amount of time lost. In all cases in which a suspicion of malaria existed a report was made to the field director, and the blood was examined for parasites.

At intervals of two weeks a mosquito survey of all premises was conducted and a "hand catch" made in the buildings of the controlled groups, to ascertain the variation in *Anopheles* incidence, to determine the degree of infestation of dwellings, and to check up the efficacy of screening measures. Conditions in the various breeding places of mosquitoes were also observed, and collections of larvæ and other biologic material were made from time to time to obtain data as to mosquito production.

Educational measures.—Detailed explanation of the various phases of the operations and their purpose was made to almost all adult members of the groups of individuals concerned, to enlist their interest and active cooperation, and during the early part of the summer supplementary lectures with projectoscope illustrations were delivered in churches and other meeting places. These lectures were well attended and, it is believed, were productive of much good.

RESULTS.

In general, malaria and other illness, with attendant economic loss, have been markedly less on the plantations under control than in the negative group and in the adjacent country where no prophylactic measures were in use, and the managers of the former have expressed themselves to the effect that health conditions among their tenants have been much improved. In other sections of Chicot and in the adjacent counties malaria has prevailed in 1916 to about its usual degree, although but few cases of unusual severity have been seen; four cases of hemoglobinuric fever are recorded as having occurred between July 1 and November 1, not far from Lake Village.

Anopheles prevalence.—In connection with routine mosquito surveys, *Anopheles quadrimaculatus* was constantly taken, and in the past summer it has been the only species present in sufficient numbers to have been of sanitary importance. This anopheline was found present in varying numbers in and about all dwellings and other buildings and was repeatedly reared from larvæ taken from the more important breeding places of the territory. In April, 1916, a single example of *Anopheles crucians* was captured on a gallery, and during the summer one *Anopheles punctipennis* was taken from an outbuilding. These, with two additional *Anopheles punctipennis* bred from larvæ, were the only anophelines other than *A. quadrimaculatus* noted during the year's work.

In the screened group ("A") a total of 52 *Anopheles quadrimaculatus* was taken in the 38 houses systematically examined between June and the end of November, although this species was constantly present in the outhouses, privies, and stables; in the unscreened group ("B") the species was captured regularly from dwellings and

the other buildings in about the same numbers, an average of between five and six at each inspection being the usual capture.

To determine more specifically the results obtained and the degree of malaria control effected following the use of the different measures, a second parasite index was made of the entire series, including the negative control group, in December, 1916; from this reexamination, together with tabulation and analysis of the data obtained in connection with inspections and blood examinations of reported cases of illness, have been determined the several results.

Second parasite indices.—The technique observed in preparation of the second indices was the same as that used at the beginning of the work, and effort was made to reexamine the individuals who were included in the first index and remained in the units; in these general indices, however, are included a few newcomers, partially replacing the number that moved to other places or were repeatedly missed at their homes.

TABLE 33.—*Second parasite index, protected groups "A" and "B," December, 1916.*

Age.	Number examined.						Total.
	White.			Colored.			
	Male.	Female.	Total.	Male.	Female.	Total.	
1.....				1		1	1
2 to 3.....	4	2	6	10	10	20	26
4 to 5.....	3	2	5	12	4	16	21
6 to 9.....	8	6	14	14	10	24	38
10 to 14.....	2	6	8	20	22	42	50
15 to 19.....	7	4	11	10	22	32	43
20 to 29.....	5	4	9	22	25	47	56
30 to 39.....	6	5	11	21	29	50	61
40.....	6	2	8	48	42	90	98
Total.....	41	31	72	158	164	322	394

Age.	Number positive.						Total.	Type.		
	White.			Colored.				Tertian.	Estivo- autumnal.	Total.
	Male.	Female.	Total.	Male.	Female.	Total.				
6 to 9.....		1	1	2		2	3	2	1	3
10 to 14.....				2	1	3	3	2	1	3
15 to 19.....	2		2	1	1	2	3	2	1	3
20 to 29.....				1	1	2	2	2		2
30 to 39.....				1	3	4	4	4		4
40.....				5	2	7	7	4	3	7
Total.....	2	1	3	11	8	19	22	16	6	22

	Per cent.
White parasite index.....	4.16
Colored parasite index.....	5.90
Total parasite index.....	5.58

TABLE 34.—*Second parasite index negative control, colored, December, 1916.*

Age.	Number examined (colored).		Total.	Number positive (colored).		Total.	Types.		Total.
	Male.	Female.		Male.	Female.		Ter-tian.	Estivo- au- tum-nal.	
1 to 3.....	2	4	6	.....	2	2	1	1	2
4 to 5.....	1	2	3	.....	.....	.....	.....	.....	.....
6 to 9.....	10	8	18	3	2	5	4	1	5
10 to 14.....	8	11	19	2	1	3	3	.....	3
15 to 19.....	5	3	8	3	.....	3	2	1	3
20 to 29.....	4	7	11	.....	1	1	1	.....	1
30 to 39.....	5	7	12	1	1	2	2	.....	2
40.....	13	14	27	2	2	4	3	1	4
Total.....	48	56	104	11	9	20	16	4	20
Percentage.....	.....	.....	.....	.....	.....	19.23	80	20	.....

Total parasite index, 19.23 per cent.

Summarizing the parasite indices begun in May, at the beginning of work, and December, at its termination, in the controlled groups "A" and "B," parallel with those of the "Negative" group, the following table is obtained which illustrates the reduction in endemicity:

TABLE 35.—*Comparison of first and second indexes.*

	The controlled groups "A" and "B."			The negative group, colored.
	White.	Colored.	Total.	
First index, May, 1916.....	<i>Per cent.</i> 13.92	<i>Per cent.</i> 16.53	<i>Per cent.</i> 16.04	<i>Per cent.</i> 21.84
Second index, December, 1916.....	4.16	5.90	5.58	19.23
Reduction.....	70.12	64.42	65.22	11.95

The efficacy of screening operations, group "A."—On all of the 38 houses included in group "A," 33 of which were especially screened in connection with these studies, the materials used maintained their original efficiency throughout the period during which observations were conducted, and required but a negligible amount of minor repair, despite hard usage under difficult conditions. No replacement of screen was found necessary, save in the referred-to instance of three houses experimentally screened with a cotton substitute for wire screening material. Because of rotting, and shrinkage following wetting by rains, tears and rips developed in this material, which so diminished its effectiveness as to necessitate replacing by galvanized-iron screen, after a service of three months (June 1 to Sept. 1). The other minor repairs included patching of tears in a few instances, caused by careless moving of furniture, and straightening of three doors warped by rain.

The costs of the foregoing are given in the following table:

TABLE 36.—Cost of replacement of cloth screening material by galvanized-iron wire.

House No.	Cost of materials.			Cost of labor.			Total cost.
	Screen.	Nails.	Total.	Hours.	Rate per hour.	Cost.	
28.....	\$1.47	\$0.15	\$1.62	3	\$0.25	\$0.75	\$2.37
29.....	1.68	.15	1.83	4	.25	1.00	2.83
30.....	3.55	.20	3.75	5	.25	1.25	5.00

TABLE 37.—Repairs to screened houses involving no replacement of materials.

House No.	Labor.	Amount.
6.....	1 hour, at 25 cents.....	\$0.25
8.....	do.....	.25
11.....	do.....	.25
13.....	do.....	.25
16.....	do.....	.25
17.....	do.....	.25
23.....	do.....	.25
33.....	do.....	.25
Total.....		2.00

Of the 173 individuals in the combined "A" and "C" groups at the beginning of operations, 142 were included in both parasite indexes.¹ The following table exhibits the comparative parasite findings of these individuals before and after the active malaria season.

TABLE 38.—Malaria control, screen group.

	Number examined.	Number positive.	Index.
First index, May, 1916.....	142	17	<i>Per cent.</i> 11.97
Second index, December, 1916.....	142	5	3.52
Reduction.....			70.6

Use and efficacy of quinine, group "B."—The issue of quinine was begun in connection with these studies on June 1, 1916. As stated in the summary on page 39 the drug was issued for sterilization to all proven carriers, to all members of group "B" (the quinine group), and to all members of group "C" (combined group, later merged into "A") during the months of June and July. The numbers of individuals receiving quinine are shown in the following table:

¹ In this and subsequent specific summaries taken from the general indexes, only those individuals have been included whose residence in their respective groups has been continuous and who have been examined in both the first and second series of examinations.

TABLE 39.—*Number of persons receiving quinine.*

	Total personnel.	Number receiving quinine for sterilization.	Number receiving quinine for immunization.
Group "A".....	150	16	.....
Group "B".....	267	52	215
Group "C".....	23	1	22
Total.....	440	69	237
Received quinine, total.....			306

Of the total of 306 to whom quinine was issued, accurate records are available for 60 of the proven carriers and 195 of those receiving the drug for immunization alone, a total of 255; the remaining 51 of the original total personnel are not included in further tabulations, having moved to other plantations or died (1, uremia), or because of incomplete data (10).

Because of the superstitious ignorance of plantation negroes as a class, it was not without the usual difficulty that the routine use of quinine was obtained; by a few the drug was thrown away or used as a medium of barter, and by others taken as a medicine for every conceivable condition other than or besides that for which it was recommended. By dint of repeated visits, however, and, as no ill effects were noticed, its fairly general use was obtained.

The degree of regularity with which the issued quinine was used is illustrated in the following tables, taken from the summarized quinine records. In these are shown the proportionate amounts of quinine taken by 255 individuals, to 195 of whom it was issued for purposes of immunization (174 in group "B" and 21 in group "C"), and to 60 of whom it was issued for sterilization (43 in group "B," 16 in group "A," and 1 in group "C"):

TABLE 40.—*Proportionate amounts of quinine taken for immunization, based on total issue to each.*

- 4 individuals took no quinine whatever.
- 5 individuals took 1 to 9 per cent of the quinine issued them.
- 3 individuals took 10 to 19 per cent of the quinine issued them.
- 8 individuals took 20 to 29 per cent of the quinine issued them.
- 10 individuals took 30 to 39 per cent of the quinine issued them.
- 13 individuals took 40 to 49 per cent of the quinine issued them.
- 18 individuals took 50 to 59 per cent of the quinine issued them.
- 25 individuals took 60 to 69 per cent of the quinine issued them.
- 41 individuals took 70 to 79 per cent of the quinine issued them.
- 34 individuals took 80 to 89 per cent of the quinine issued them.
- 10 individuals took 90 to 99 per cent of the quinine issued them.
- 24 individuals took 100 per cent (their entire issue).

TABLE 41.—*Proportionate amount of quinine taken for sterilization, based on total issued to each individual positive in first index.*

4 carriers took 20 to 29 per cent of the quinine issued to them.
 1 carrier took 30 to 39 per cent of the quinine issued to them.
 4 carriers took 40 to 49 per cent of the quinine issued to them.
 4 carriers took 50 to 59 per cent of the quinine issued to them.
 2 carriers took 60 to 69 per cent of the quinine issued to them.
 10 carriers took 70 to 79 per cent of the quinine issued to them.
 7 carriers took 80 to 89 per cent of the quinine issued to them.
 7 carriers took 90 to 99 per cent of the quinine issued to them.
 21 carriers took 100 per cent (their entire issue).
 2 data incomplete.

The degree of malaria control obtained through the use of quinine in group "B" has been ascertained by comparison of findings in connection with the first and second parasite indices (see footnote, p. 48) of the same 225 individuals. In this number are included 182 to whom quinine was issued for immunization alone,¹ and 43 to whom the drug was given for both sterilization, after detection of parasite, and immunization.

The comparative findings of the first and second indices for this group "B" are as follows:

TABLE 42.—*Malaria control, group "B," quinine.*

	Number examined.	Number positive.	Index.
First index, May, 1916.....	225	45	<i>Per cent.</i> 20.00
Second index, December, 1916.....	225	16	7.11
Reduction.....			64.45

Sterilization of parasite carriers.—Of the 69 persons in whom malarial parasites were demonstrated at the beginning of operations, 62 remained in the territory under observation throughout the studies and were reexamined after the termination of active operations. The relative amounts of quinine taken by 60 of these has been shown in Table 41. In the second index (December) 22 persons were found to harbor parasites. Of this number 3 had been detected in the first index (May) and given quinine for sterilization purposes. The use made of the quinine was as follows:

¹ 8 persons are here included whose "quinine record" is incomplete or uncertain; they have accordingly been omitted from Table 40.

TABLE 43.—Amount of quinine given to those found to harbor parasites in second index.

Name.	Age.	Type of infection.	Amount of quinine taken.
Milton H.....	7	Estivo-autumnal..	43
Willie A.....	23	Tertian.....	27
Mattie S.....	23	do.....	(¹)

¹ Data incomplete.

The foregoing are classed as failures of sterilization; in two, symptoms developed during the summer, though no loss in working time resulted, and the third remained free of manifestations. As shown in Table 33, on page 46, a total of 22 infections was found on re-examination, of which the above 3 were detected in the first index, and the remaining 19 are recorded as infections occurring during the summer despite preventive measures. The degree of sterilization obtained among the original 69 known carriers and the 62 observed throughout the period of these studies, together with the relative diminution in proven carriers prior to and following control operations, is shown in the following summaries:

TABLE 44.—Degree of sterilization secured among carriers.

Positive in the first index, May.....	69
Remaining under observation.....	62
Positive in both first and second indexes.....	3
Positive in second index, negative in first.....	19
Total positive in second index, December.....	22
Percentage Reduction in Incidence of 62 of Original Carriers.....	95.17
Diminution in Incidence of proven Carriers at beginning and end of observations.....	68.12 per cent.

The combined use of screens and quinine, group "C."—As described on page 39, the 6 tenant houses of one of the smaller plantations were screened and their 23 occupants furnished quinine for immunization during the months of June and July, at the end of which the group was merged into "A," the screen group; one carrier was also furnished quinine for sterilization. Although malaria is said to have been annual among the members of this group, no observations as to illness are recorded for the past summer; in view of the small numbers, no attempt is made to determine what has been the separate influence of the two measures employed.

Economics.—The economic losses due to the influence of malaria have been ascertained in connection with these demonstrations by comparative study of records of time lost from work and of expense incurred for medical attention and drugs by members of the several protected groups and by residents in the "negative area." Although data obtained by this method are incomplete in that they fail to

include minor impairments of efficiency and such slight disabilities as go without professional care, it is believed that a valuable index is provided whereby results may be fairly accurately gauged.

In the summaries here given, the labor of an adult male is arbitrarily valued at \$1.50 per day, that of an adult female at \$0.75 per day, and that of a child at \$0.50 per day. The following are tabulations of losses incurred in the protected groups, and in the negative area:

TABLE 45.—*Economic losses in the controlled groups, "A" and "B," in 1916.*

Total number of families.....	104
Total individuals.....	385
Number families incurring loss because of malaria.....	3

Family.	Expense, physicians and drugs.	Time lost, in days.				
		Man.	Woman.	Child.	Cost.	Total.
Jim U.....		8			\$12.00	\$12.00
Millie S.....			3		2.25	2.25
Chas. P.....		7			10.50	10.50
Total.....		15	3		24.75	24.75

Average cost per family.....	\$0.237
Average cost per individual.....	0.06

TABLE 46.—*Total losses in the "negative" group, 1916.*

Total number families.....	27
Total individuals (all colored).....	120
Number families incurring loss because of malaria.....	19

Family.	Expense, physicians and drugs.	Time lost, in days.				
		Man.	Woman.	Child.	Cost.	Total.
William W.....	\$15.00	7	7	0	\$15.75	\$30.75
Ed. W.....	3.50		1	21	11.25	14.75
Anthony A.....	1.50	0	0	0	0.00	1.50
Dave C.....	14.00	0	11	0	8.25	22.25
Dan F.....	4.00	0	0	0	0.00	4.00
Will J.....	4.00	0	3	0	2.25	6.25
Dave R.....	0.00	7	0	0	10.50	10.50
Henry R.....	0.00	1	0	0	1.50	1.50
Geo. S.....	3.00	3	0	0	4.50	7.50
Morgan S.....	0.00	5	0	0	7.50	7.50
Robert W.....	2.00	14	0	0	21.00	23.00
Chas. P.....	2.00	14	0	0	21.00	23.00
Lou. Gene L.....	0.00	0	0	2	1.00	1.00
Marshall C.....	15.50	3	0	4	6.50	22.00
Walter B.....	9.00	2	0	42	24.00	33.00
Nat W.....	0.00	0	3	0	2.25	2.25
Joe S.....	1.00	0	0	90	45.00	46.00
Josh T.....	25.00	10	2	0	16.50	41.50
Will T.....	4.50	0	0	0	0.00	4.50
	104.00	66	27	159	198.75	302.75

Average loss per family.....	\$11.21
Average loss per individual.....	2.52

TABLE 47.—Comparative tabulation, losses in 1916.¹

	Con- trolled groups.	Negative groups.
Average loss per family.....	\$0.23	\$11.21
Average loss per individual.....	0.06	2.52

¹ In the above tabulations no attempt has been made to estimate and include the economic losses due to (a) the time consumed by other members of a family in the care of the sick, or (b) diminished efficiency during convalescence from an attack of malaria, both of which would be proportionately greater in the negative group.

Investigation of reported cases of illness.—During the period of observations a total of 63 reported cases of illness occurring in the controlled groups were investigated and a clinical diagnosis of malaria made in 1; blood smears from 47 others were examined, of which 5 were found to contain parasites, making a total of 6 authenticated cases of malaria recorded. This number does not represent the total amount of malaria occurring, as in all likelihood some number of parasite examinations prove negative because of the use of quinine; the above data, however, are of interest particularly when considered in connection with the economic tables.

Condition of screens at termination of operations.—At the completion of observations at the end of March, 1917, a reexamination was made of the screening installed on 33 houses of group "A" with a view of determining the probable duration, with reasonable care, of its efficacy. All screening was found to be in excellent condition, save that with the continued use of fireplaces at the beginning of winter it was found necessary to remove most of the chimney caps because of retardation of smoke due to closure of the apertures of the screen by soot. It was recommended in each case that the caps be replaced before the beginning of the active mosquito season, and that wire, rather than wooden frames, be used to secure the screen, to obviate the risk of fire through overheating of the chimney. It is believed that, with ordinary care, protection should be had from the screening installed for at least two additional years.

Costs, with reference to control gained, and population influenced.—The approximate distributed costs of the rural malaria control operations in the present studies have been derived after analysis of the total costs of drugs, screening materials, and labor, and their comparative study with reference to the numbers of people protected by the several measures.

For the screened series, group "A," the average cost of installation of well applied galvanized iron screens on 33 houses (Vide p. 43), was \$14.22, and, including the distributed costs of minor repairs, \$14.59. As the duration of this material, with very ordinary care, should be at least two years, probably three, it is believed entirely justifiable to consider the "per house" cost at one-half of the latter

figure, or \$7.29½, for a group diminution of malaria of 70.6 per cent as determined by repeated parasite indices. For purposes of comparison, a per capita rate of \$1.758 may be obtained; but inasmuch as all occupants of a house derive protection from its screening, and the cost per house would be, roughly, the same for large or for small families, the per house rate would appear to be more desirable.

For the series in which quinine was used, the per capita cost of the total quinine issued for both immunization and sterilization was about \$0.57, for which was obtained a group reduction of malaria of 64.45 per cent, as ascertained by repeated parasite indices, and a sterilization rate of carriers detected in the first index of 95.17 per cent.

Although only approximate, the above costs are of interest for comparison with the per capita and per family economic losses from malaria, more especially in the negative group. In the following table are presented a compilation of the average approximate costs of control, the degree of control gained, and the average economic losses in the controlled and negative groups:

TABLE 48.—Comparative table of costs of control, control gained, and economic losses.

	Screen group.	Quinine group.	Negative group.*
Per capita cost.....	\$1.75½	\$0.57	.....
Per family of house cost.....	\$7.38½	\$2.39	.....
Degree malaria reduction gained..... per cent..	70.6	64.45	.....
Average loss per capita from malaria.....	\$0.06		\$2.52
Average loss per family from malaria.....	\$0.23		\$11.21

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SUMMARY.

Demonstration studies in malaria control were conducted during 1916 in two highly endemic localities in southeastern Arkansas by representatives of the United States Public Health Service in cooperation with the International Health Board.

Town or community unit.—At Crossett, Ark., a lumber town of 2,029 inhabitants, measures directed against mosquito production

were instituted, consisting of clearing, drainage, filling, and the use of oil and larvacides.

As ascertained by repeated parasite indices, a reduction of 77.33 per cent was obtained, and a reduction of the total visits for malaria, as compared with records of the previous year, of 70.39 per cent; for the "active" season, comprising the months from and including June to December, a reduction of visits of 82.07 per cent was obtained from the number made in the same period of the year before.

The total costs of the control operations aggregate \$2,506.40, a per capita cost of \$1.23½; control work is to be continued, and, much of the first work being of a permanent character, should cost substantially less.

Rural units.—On a number of plantations in the vicinity of Lake Village, Chicot County, studies of the efficacy of house screening and of quinine in immunizing and sterilizing doses were conducted.

A group of 33 houses were carefully screened at an average cost of \$14.77, and their occupants carefully observed, all known carriers being given quinine for sterilization. As shown by repeated parasite indexes, a reduction of 70.6 per cent was obtained among 142 occupants; as the life of the screening installed should, with ordinary care, be at least two years, the per family cost of screening is estimated at \$7.38½ per family, or \$1.75¼ per capita.

In a second series, quinine was given 237 persons for immunization, and a reduction in malaria of 64.45 per cent obtained as ascertained by repeated parasite index examinations; the per capita cost for quinine issued was \$0.57.

Of the 69 carriers to whom quinine was given for sterilization, 62 remained under observation and were available for re-examination; of this latter number, 3 were found to have remained infected, a reduction or "sterilization rate" of 95.17 per cent.

The economic losses suffered by a negative group of 120 persons averaged \$11.21 per family, or \$2.52 per capita, whereas among the members of the groups under control the family loss averaged \$0.23, and that per capita \$0.06.

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