MALARIA IN RURAL SETTLEMENTS IN PALESTINE.

1. INCIDENCE AND ETIOLOGY OF MALARIA.

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(With Plates VI–IX, 5 Charts and 1 Map.)

Introduction.

The impression has always prevailed, that malaria is the most common disease in Palestine, and that it is more or less highly prevalent in all of rural Palestine. This impression, based as it is on mass experience, is in general correct; but it lacks the certainty derived from statistical data.

In 1921 Kligler and Weitzman (3) made a study of the malaria conditions in two selected areas in lower Galilee and conducted control demonstrations in those areas with very satisfactory results. In 1922 the work was extended to include two areas in Judea. In 1923 a more comprehensive comparative study was undertaken of the malaria prevalence in various sections of the country and control demonstrations were organised in nine typical districts located in different parts of Palestine.

The principal aim of this work was to ascertain (1) the actual prevalence and cause of malaria in different sections of rural Palestine; (2) whether it was possible to bring the disease under control at a reasonable cost.

The purpose of this paper is to summarise the results of these studies. We shall attempt to present as briefly as possible the information obtained regarding (1) the incidence and etiology of malaria in rural Palestine; (2) the value of blood and spleen examinations as indices of malaria prevalence; (3) the nature of the swamps and the types of mosquitoes responsible for the high malaria incidence; and (4) the method of organisation of the demonstration areas, the methods of control employed, the effects of the control measures and the cost of control.

Incidence of Malaria. In a highly malarious country like Palestine, where the public is more or less habituated to the disease and uses quinine freely for any form of fever, it is exceedingly difficult to obtain reliable statistics of malaria incidence. This difficulty is even greater in the rural than in the urban communities. Consequently there are few reliable figures available indicating the actual incidence of the disease.

One of our tasks when the work was started was to organise regular reporting of malaria cases. At the commencement of the work in a given section, we obtained the doctor's records, the laboratory findings, if any were

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Chart 1. Comparison of Percentage Malaria incidence in the Demonstration Areas in 1922 and 1923.

1922–1923 חשואה של אחוזים מקרי המלריה במחוזי הקונטדולה בשנות

New
Total

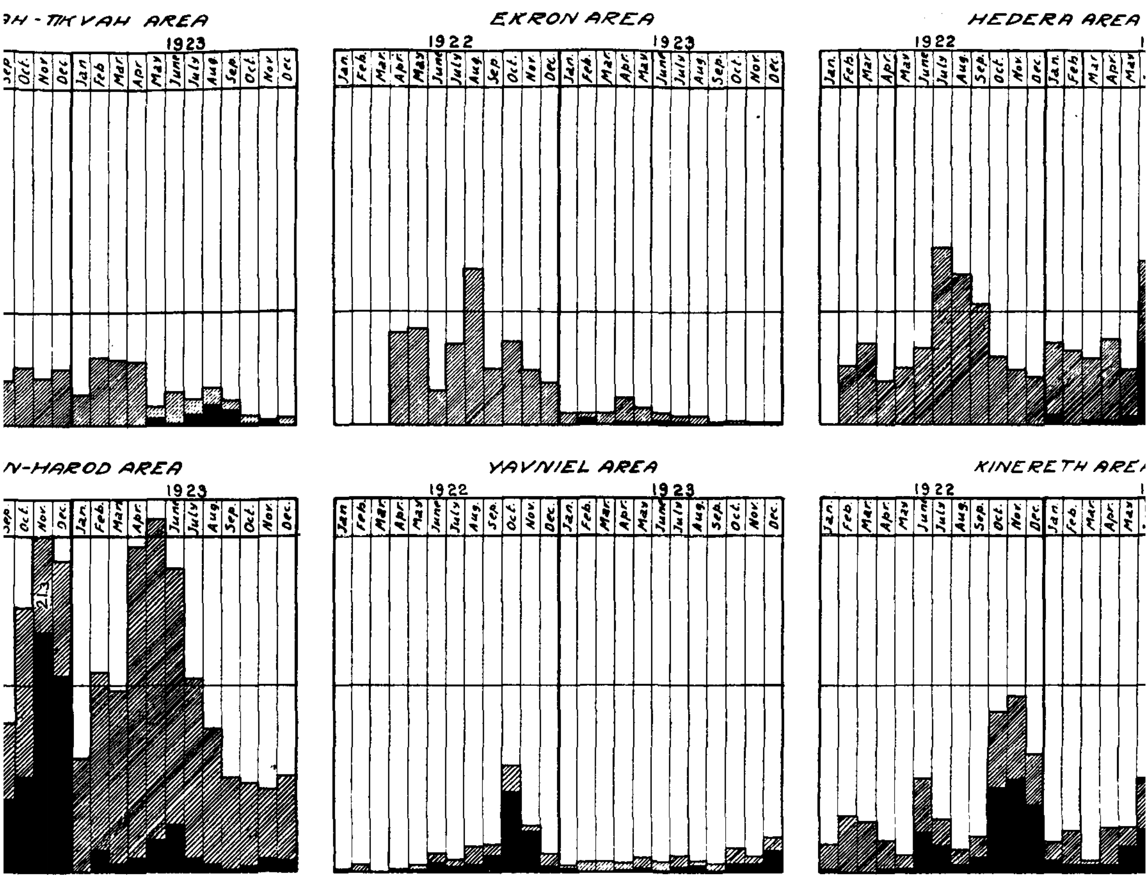

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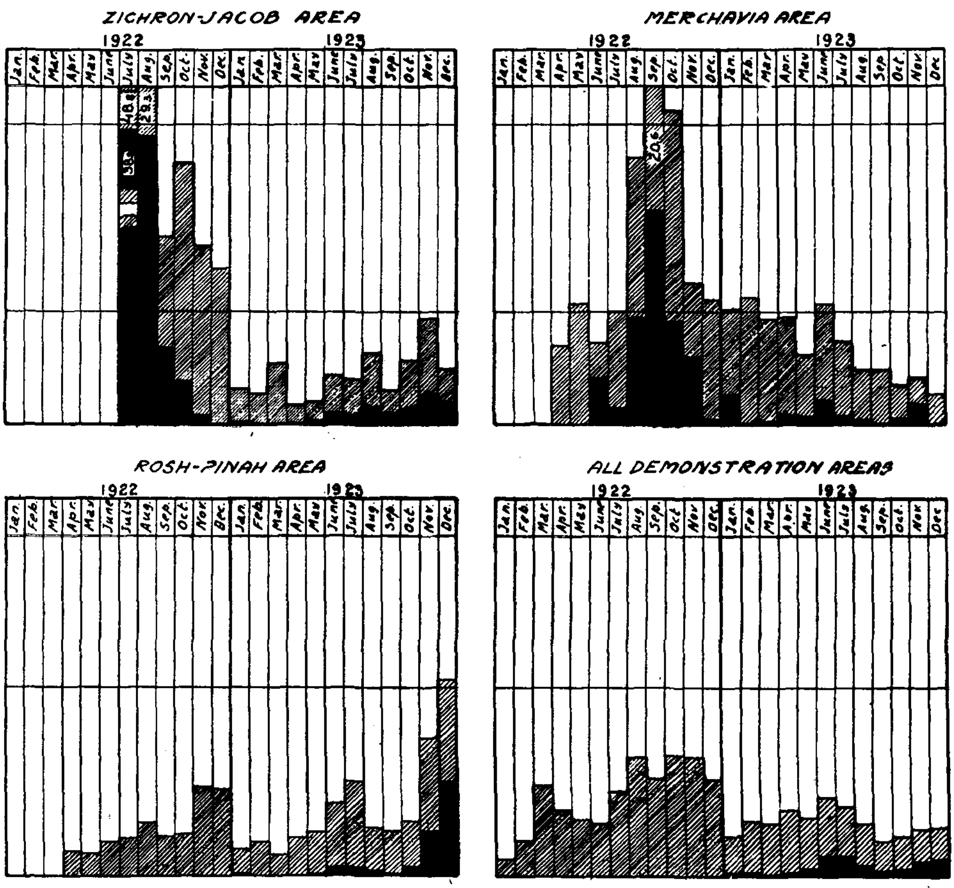
Chart 1—*continued*



Note. In 1922 the returns were not always differentiated into primary and secondary cases. Where such information was obtained it is indicated in the chart; where not, only the total incidence is given. For 1922 the incidence is given only for those places from which reliable records were obtained.

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available and the personal history of each inhabitant. Malaria cards were prepared for each individual. In this manner we obtained a composite record of the malaria cases during a greater or lesser period prior to the commencement of our work. Thereafter the malaria inspector paid regular weekly visits to the doctors or nurses of each village or settlement and obtained from them the names of all the malaria cases. These individuals were interviewed and their histories obtained. Our work was facilitated by the fact that nearly every Jewish settlement or group of smaller settlements, consisting of over 100 population, had a resident doctor or nurse.

Thus it was possible during 1922 and more effectively in 1923 to gather fairly accurate data of the malaria incidence in the Jewish villages included in our demonstration areas. Similar data could not unfortunately, for obvious reasons, be obtained from the Arab villages within those areas; but since the Jewish population formed about 65 per cent. of the total, and the incidence tables for 1923 are based on a total population of over 10,000, these figures may be considered as representative. The records for 1923 are naturally more complete and more accurate than are those for 1922. But despite the lack of completeness in certain details, the 1922 figures give a good picture of the prevalence of malaria in the various demonstration areas before active control was organised and serve as a satisfactory basis for estimating the degree of effectiveness of the control measures carried out during 1923.

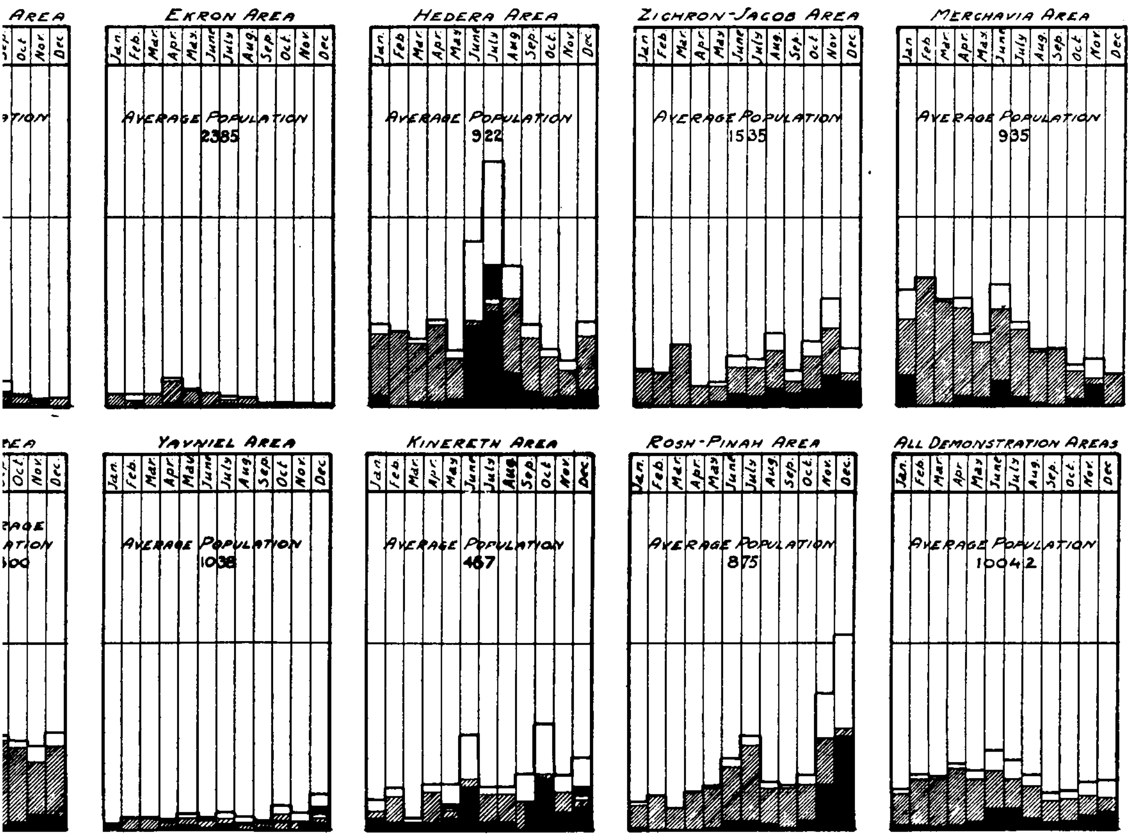
The total monthly percentage incidence of all forms of malaria in the various demonstration areas are shown in a series of tables and charts. In Chart 1 is presented the total monthly percentage incidence of malaria in 1922 and 1923. Wherever the data was sufficiently reliable the incidence of primary cases is also given.

In Tables I and II and their corresponding charts (Charts 2 and 3) are presented more detailed analysis of the incidence data for 1923. In the former are given the incidence of primary and secondary cases and in the latter the relative frequency of occurrence of the various types of malaria parasites. It is not an easy matter to differentiate between primary and secondary cases of malaria in people, who have already had an attack before. We usually based our judgment on certain definite criteria. During the winter and early spring primary cases may be practically, though not completely, excluded; during this period relapses of benign tertian malaria commonly occur among those who have had malaria during the previous summer and fall. All such cases may, therefore, be safely classed as relapses. All cases of malignant tertian malaria in the summer and fall months were considered new infections, if it was the first attack of that form of malaria during that season. Benign tertian cases were considered new infections if the patient had had no attack of malaria for a year prior to the present illness. We believe that this basis of differentiation corresponds fairly closely with the facts and yields a reason ably accurate classification of cases.

The differentiation of the various types of parasites was made, whenever

Monthly percentage incidence of primary and secondary cases of Malaria in the Demonstration Areas. Year 1923.

אחוזים חדשיים של מקרי מלריה חדשים וחוזרים במחוזי הקונטרולה בשנת 1923



באור:
מקרים חדשים
„ חוזרים
סהכ

Note. Average population = mean monthly population for the entire year = sum of the population of each month divided by the total number of months.

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Table I.

Area	Pet. Tikvah			Ekron			Hedera			Z. Jacob			Merchavia			E. Harod			Yavniel			Kinereth			R. Pinah			All Dem. Ar.		
Form	New	Relapse	Total	New	Relapse	Total	New	Relapse	Total	New	Relapse	Total	New	Relapse	Total	New	Relapse	Total	New	Relapse	Total	New	Relapse	Total	New	Relapse	Total	New	Relapse	Total
Jan.	0.0	1.7	1.7	0.0	0.6	0.6	0.5	3.8	4.3	0.1	1.8	1.9	1.6	4.6	6.2	0.0	6.1	6.1	0.2	0.1	0.3	0.6	1.0	1.6	0.1	1.3	1.4	0.2	1.9	2.1
Feb.	0.0	3.6	3.6	0.3	0.3	0.6	0.0	3.9	3.9	0.0	1.7	1.7	0.0	6.8	6.8	1.2	9.6	10.8	0.0	0.6	0.6	0.4	1.8	2.2	0.0	1.8	1.8	0.2	2.7	2.9
Mar.	0.0	3.5	3.5	0.0	0.6	0.6	0.2	3.3	3.5	0.0	3.2	3.2	0.1	5.5	5.6	0.5	9.2	9.7	0.0	0.6	0.6	0.4	0.2	0.6	0.0	1.1	1.1	0.1	2.7	2.8
Apr.	0.0	3.4	3.4	0.1	1.3	1.5	0.2	4.3	4.5	0.0	1.0	1.0	0.5	5.2	5.7	0.8	16.8	17.6	0.1	0.4	0.5	0.4	2.0	2.4	0.0	2.0	2.3	0.2	3.3	3.5
May	0.4	0.6	1.0	0.1	0.8	0.9	0.4	2.5	2.9	0.2	1.0	1.2	0.4	3.3	3.7	1.8	17.2	19.0	0.2	0.6	0.8	1.4	1.0	2.4	0.1	2.2	2.3	0.4	2.7	3.1
June	0.1	1.6	1.7	0.2	0.5	0.7	4.2	4.4	8.6	0.6	2.0	2.6	1.3	5.1	6.4	2.6	13.8	16.4	0.1	0.5	0.6	2.3	2.7	5.0	0.5	3.4	3.9	1.1	3.1	4.2
July	0.6	0.8	1.4	0.1	0.4	0.5	7.5	5.4	12.9	0.5	2.0	2.4	0.4	4.0	4.4	0.8	9.7	10.5	0.3	0.6	0.9	0.4	1.9	2.3	0.5	4.5	5.0	1.1	2.7	3.8
Aug.	1.1	0.9	2.0	0.0	0.4	0.4	1.7	5.8	7.5	0.9	2.9	3.8	0.1	2.8	2.9	0.5	7.2	7.7	0.4	0.3	0.7	0.4	1.9	2.3	0.4	2.2	2.6	0.6	2.3	2.9
Sept.	0.8	0.5	1.3	0.0	0.1	0.1	0.7	3.6	4.3	0.6	1.3	1.9	0.0	2.9	2.9	0.2	4.8	5.0	0.1	0.4	0.5	1.5	1.5	3.0	0.1	2.2	2.3	0.3	1.5	1.8
Oct.	0.1	0.5	0.6	0.0	0.1	0.1	0.4	2.6	3.0	0.8	2.6	3.4	0.3	1.8	2.1	0.4	4.4	4.8	0.5	0.8	1.3	2.7	3.0	5.7	0.5	2.4	2.9	0.4	1.6	2.0
Nov.	0.2	0.1	0.3	0.0	0.1	0.1	0.5	1.9	2.4	1.6	4.1	5.7	1.1	1.4	2.5	0.8	3.7	4.5	0.5	0.5	1.0	0.9	2.0	2.9	2.4	4.9	7.3	0.8	1.8	2.6
Dec.	0.0	0.4	0.4	0.0	0.1	0.1	0.8	3.7	4.5	1.2	1.7	2.9	0.0	1.6	1.6	0.7	4.5	5.2	1.2	0.6	1.8	2.3	1.6	3.9	5.0	5.4	10.4	0.9	1.7	2.6

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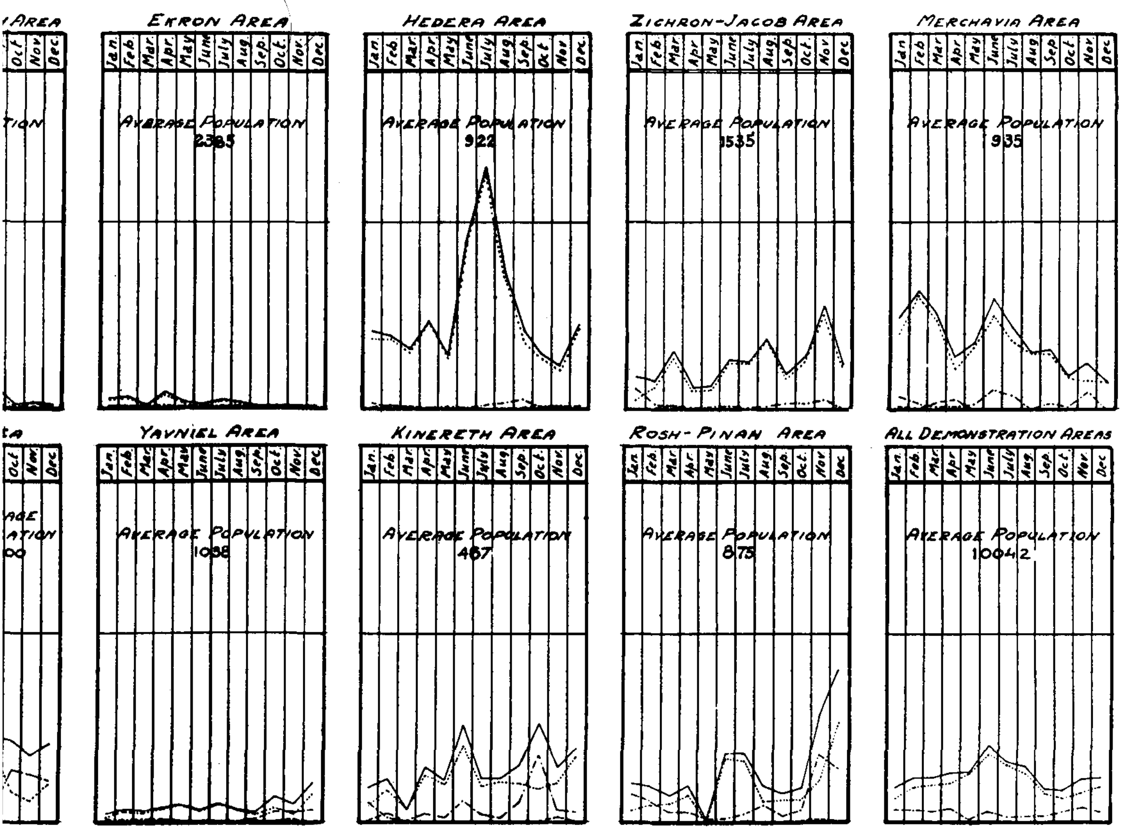
rt 3. Monthly percentage incidence of the three types of Malaria in the Demonstration Areas. Year 1923.

1923 אחוזים חדשיים של שלשת מיני המלריה במחוזי הקונטרולה בשנת



nd. באורד :

.... מלריה שלשית

-.-.-.-.-.- " טרופיקה

— — — — " רבעית

———— סהכ

Note. Incidence is based on populations of settlements where reliable records were available. The monthly incidence is based on the population of that month. The average population = total of monthly populations divided by twelve.

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Table II.

Area	Pet. Tikvah				Ekron				Hedera				Z. Jacob				Merchavia			
Type	Tertian	Tropica	Quartan	Total	Tertian	Tropica	Quartan	Total	Tertian	Tropica	Quartan	Total	Tertian	Tropica	Quartan	Total	Tertian	Tropica	Quartan	Total
Jan.	1.5	0.1	0.0	1.7	0.5	0.1	0.0	0.6	3.8	0.4	0.0	4.2	0.5	1.1	0.1	1.7	4.0	0.7	0.1	4.8
Feb.	3.6	0.0	0.0	3.6	0.5	0.0	0.1	0.6	3.8	0.0	0.1	3.9	1.1	0.4	0.0	1.5	6.0	0.3	0.0	6.3
Mar.	2.0	0.3	0.0	2.3	0.1	0.0	0.0	0.1	3.1	0.0	0.1	3.2	2.7	0.2	0.2	3.1	4.7	0.1	0.3	5.1
Apr.	3.4	0.0	0.0	3.4	0.7	0.2	0.0	0.9	4.6	0.0	0.0	4.6	1.0	0.1	0.0	1.1	2.1	0.1	0.5	2.7
May	0.3	0.0	0.0	0.3	0.3	0.1	0.0	0.4	2.7	0.1	0.0	2.8	1.1	0.2	0.0	1.3	3.2	0.2	0.0	3.4
June	1.8	0.0	0.0	1.8	0.2	0.1	0.0	0.3	8.8	0.0	0.0	8.8	2.4	0.2	0.0	2.6	4.9	1.0	0.0	5.9
July	0.9	0.2	0.0	1.1	0.4	0.1	0.0	0.5	12.6	0.3	0.0	12.9	2.4	0.0	0.0	2.4	3.6	0.7	0.0	4.3
Aug.	1.5	0.4	0.0	1.9	0.3	0.1	0.0	0.4	7.0	0.4	0.0	7.4	3.7	0.1	0.0	3.8	2.9	0.0	0.0	2.9
Sept.	0.7	0.3	0.0	1.0	0.1	0.0	0.0	0.1	3.7	0.6	0.0	4.3	1.6	0.3	0.0	1.9	2.8	0.3	0.0	3.1
Oct.	0.2	0.1	0.0	0.3	0.1	0.0	0.0	0.1	2.7	0.2	0.1	3.0	2.6	0.3	0.0	2.9	1.7	0.1	0.0	1.8
Nov.	0.3	0.1	0.0	0.4	0.1	0.0	0.0	0.1	2.1	0.2	0.1	2.4	5.0	0.5	0.0	5.5	1.5	0.9	0.0	2.4
Dec.	0.2	0.1	0.0	0.3	0.1	0.0	0.0	0.1	4.3	0.0	0.2	4.5	2.3	0.1	0.0	2.4	1.4	0.0	0.0	1.4

Area	E. Harod				Yavniel				Kinereth				R. Pinah				All Dem. Ar.			
Type	Tertian	Tropica	Quartan	Total	Tertian	Tropica	Quartan	Total	Tertian	Tropica	Quartan	Total	Tertian	Tropica	Quartan	Total	Tertian	Tropica	Quartan	Total
Jan.	1.7	1.6	0.0	3.3	0.2	0.1	0.0	0.3	0.8	1.0	0.0	1.8	0.6	1.4	0.0	2.0	1.2	0.6	0.0	1.8
Feb.	1.2	4.2	0.0	5.4	0.5	0.1	0.0	0.6	1.6	0.2	0.4	2.2	0.8	1.0	0.0	1.8	1.8	0.6	0.0	2.4
Mar.	4.5	3.9	0.0	8.4	0.4	0.1	0.0	0.5	0.6	0.0	0.0	0.6	0.9	0.5	0.0	1.4	1.9	0.5	0.0	2.4
Apr.	6.5	4.7	0.0	11.2	0.6	0.1	0.0	0.7	2.4	0.4	0.0	2.8	1.4	0.5	0.0	1.9	2.0	0.6	0.0	2.6
May	17.6	0.0	0.0	17.6	0.8	0.0	0.0	0.8	2.0	0.2	0.0	2.2	0.0	0.1	0.0	0.1	2.5	0.1	0.0	2.6
June	13.5	3.2	0.0	16.7	0.6	0.0	0.0	0.6	4.0	1.1	0.0	5.1	3.4	0.2	0.0	3.6	3.6	0.5	0.0	4.1
July	4.8	0.9	0.0	5.7	0.9	0.0	0.0	0.9	1.9	0.4	0.0	2.3	3.2	0.4	0.0	3.6	2.9	0.3	0.0	3.2
Aug.	6.5	0.6	0.0	7.1	0.6	0.0	0.0	0.6	2.1	0.2	0.0	2.3	1.1	0.8	0.0	1.9	2.5	0.3	0.0	2.8
Sept.	4.0	0.5	0.0	4.5	0.4	0.1	0.0	0.5	2.0	1.0	0.0	3.0	1.1	0.3	0.0	1.4	1.5	0.3	0.0	1.8
Oct.	1.6	2.7	0.0	4.3	0.7	0.5	0.0	1.2	1.7	3.5	0.0	5.2	1.1	0.6	0.0	1.7	1.2	0.5	0.0	1.7
Nov.	1.0	2.5	0.0	3.5	0.4	0.4	0.1	0.9	2.0	0.7	0.2	2.9	2.1	3.5	0.1	5.7	1.5	0.7	0.0	2.2
Dec.	1.9	2.2	0.0	4.1	1.4	0.6	0.0	2.0	3.4	0.5	0.0	3.9	5.2	2.8	0.0	8.0	1.8	0.5	0.0	2.3

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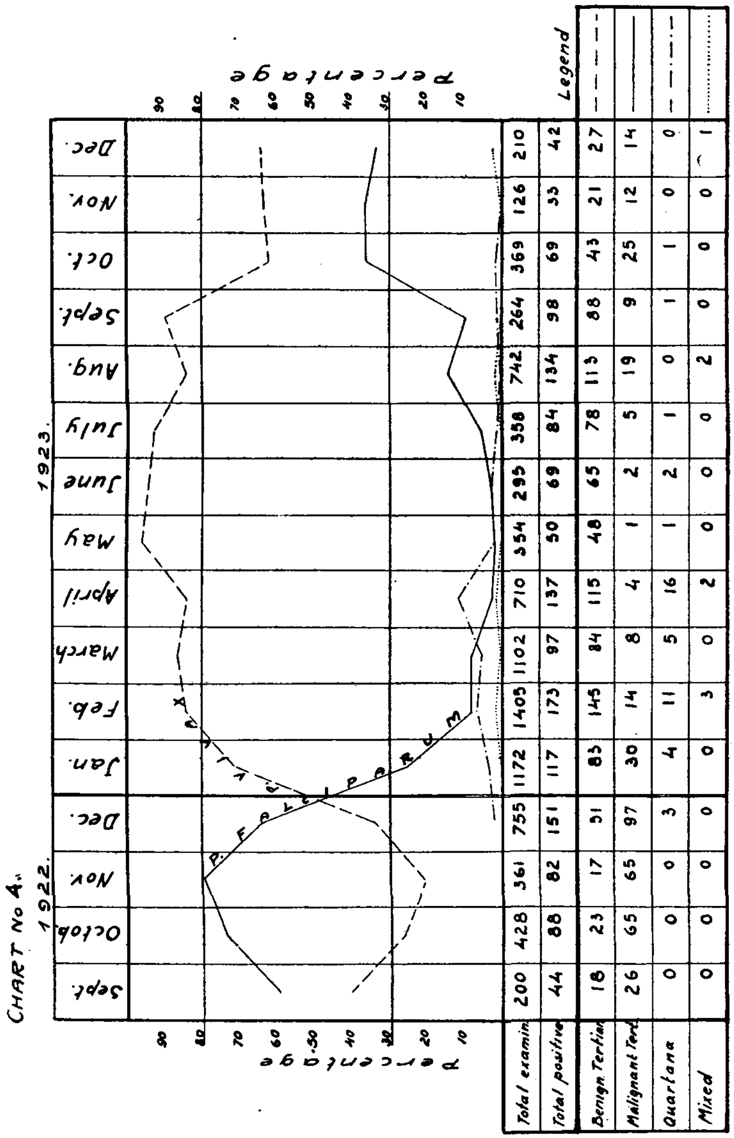
possible, from the thick drop which we used in all our routine work. But usually both thick drops and smears were taken, and in case of doubt the smear was also examined. The relative frequency of occurrence of the various malaria parasites as shown in the chart summarising our laboratory findings (Chart 4) may, therefore, be considered as typical.

An examination of these tables and charts reveals a number of important facts regarding the incidence and epidemiology of malaria in rural Palestine: (1) During 1922 malaria was highly prevalent, particularly, wherever control was not being carried out. (2) In all of the districts malaria was endemic, and in most of them it was also epidemic during 1922. (3) In some of the areas (Hedera, Zichron), the epidemics occur in June and July; in others (Yavniel) they occur in October and November; while in some (Ein Harod, Kinereth) during both of these periods. (4) The benign tertian form of malaria is present throughout the year, but is relatively more abundant than the malignant type during the months of January to September than during the last months of the year; the malignant tertian or tropical form of malaria is most common in the late summer and autumn—October to December inclusive. (5) Malaria relapses occur throughout the year, but mostly during the winter and spring months—February to May inclusive; corresponding with the high prevalence of the benign tertian form of malaria.

Prevalence of Malaria. The high prevalence of malaria in all of the Demonstration Areas prior to our control is clearly indicated in Chart 1. In nearly all, except the control districts, the average monthly incidence for 1922 was 4 per cent. or over, indicating a minimal annual malaria incidence of 50 per cent. and an incidence of over 100 per cent. in at least three of the districts. There can be little doubt, therefore, that malaria was the most prevalent disease in these districts.

Endemic and Epidemic Malaria. The noteworthy fact is that malaria exists in both endemic and epidemic form. Endemic malaria exists throughout the year. It represents the residue of uncured malaria, which recurs periodically, but most frequently during the winter and spring months. Epidemic malaria occurs at two distinct periods, with a short interval of quiescence between them. The first epidemic period is from the middle of June to the end of July or middle of August, and consists chiefly of the benign tertian form of malaria. The second epidemic period extends from the end of September, or early October, to about the middle of December and consists mainly of tropical or malignant tertian malaria. In Hedera, Petach Tikwa and Zichron districts, situated in the Coastal Plain, the epidemics usually occur in the summer. In the Yavniel districts the principal epidemic is in the fall. In the Valley of Esdraelon and Kinereth regions, epidemics are apt to occur both in the summer and autumn (see Charts 1 and 2).

Seasonal Prevalence of Benign and Malignant Malaria. A study of Table II and Chart 3 reveals the fact that there is a distinct periodicity in the prevalence of benign tertian and malignant or tropical forms of malaria. This is brought out even more emphatically in the graph (Chart 4), showing the results of the blood examinations in our laboratory from September 1922 to December 1923. There are apparently three distinct periods. The first period, covering the months of February to June (corresponding with the period of



	1922 Sept.	Octob.	Nov.	Dec.	1923 Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Total examin.	200	428	361	755	1172	1405	1102	710	354	295	358	742	264	369	126	210
Total positive	44	88	82	151	117	173	97	137	50	69	84	134	98	69	33	42
Benign Tertian	18	23	17	51	83	145	84	115	48	65	78	113	88	43	21	27
Malignant Tert.	26	65	65	97	30	14	8	4	1	2	5	19	9	25	12	14
Quartana	0	0	0	3	4	11	5	16	1	2	1	0	1	1	0	0
Mixed	0	0	0	0	0	3	0	2	0	0	0	2	0	0	0	1

Chart 4. Incidence of *P. vivax* and *P. falciparum* in laboratory examinations.

relapses, with only sporadic primary cases), consists almost entirely of benign tertian malaria. The second period (corresponding with the first epidemic period) extends from the middle of June to the end of August and consists chiefly of benign tertian, with occasional cases of malignant tertian, or tropical, form of malaria. In the third period, the last three months of the year, there is a sharp rise in the cases of malignant tertian, or tropical malaria, with a proportionate fall in the incidence of the benign tertian form of the disease. This last period corresponds with the second epidemic season. Quartan malaria was rare, but was found in considerable numbers during the months of March and April, in the course of the general blood examinations.

This seasonal incidence of the different types of malaria corresponds closely with that reported by Wenyon (5) for Macedonia. Wenyon found that *P. falciparum* constituted about half of the total positive laboratory findings in November and fall to about 2 per cent. in March. The incidence chart (Chart 3) of the control areas and particularly the one showing our laboratory findings (Chart 4) show practically the same relationship. The laboratory chart shows also a marked difference between the periods September to December 1922 and 1923, respectively; this difference is due to the greater prevalence of malignant tertian epidemics in 1922.

The explanation of this phenomenon which seems to us most tenable, is the one proposed by Wenyon (5). A similar explanation was also advanced by us (3). This explanation is based on the difference in the reaction of the benign and malignant tertian parasites and their respective gametes to quinine (1, 2, 4, 5). The greater resistance of the benign tertian chizonts to quinine seems fairly well established. This resistance accounts for the abundance of relapses during the winter and early spring months, when mosquitoes are not yet fully active, and new infections rare. With benign tertian the only existing type of malaria, it is clear why the summer epidemic consists chiefly of benign tertian malaria. With continued subjection to quinine, however, the benign tertian gametes become uninfective for the mosquito, while the malignant gametes remain unaffected. Consequently the tropical form of malaria increases, first slowly then more rapidly, reaching a peak in November, and then as rapidly declines partly because of treatment, but mainly perhaps because the mosquitoes cease their activity about the beginning or the middle of December, according to the onset of the rainy season. It is also possible that the decrease in benign tertian cases during the autumn is only apparent, due to the masking action of the tropical form of malaria. That this is more than a mere supposition is indicated by the usual appearance of large numbers of tertian relapses after an epidemic of malignant malaria.

Summary.

Statistical and laboratory data are presented, which bear on the incidence and epidemiology of malaria in rural Palestine. These data indicate that the annual incidence of malaria ranged between 50 and 100 per cent., and that in the areas where no control was effected in 1922 it was always considerably higher than the minimum figure. They also show that malaria is both endemic and epidemic and that there are two epidemic periods, one in the summer and one in the fall of the year. In the winter and spring there is little or no

primary malaria. The parasites most frequently encountered are *P. vivax* and *P. falciparum*; *P. malariae* is uncommon. The *P. vivax* is found throughout the year, but constitutes about 98 per cent. of the total malarias in February to June and only 50–60 per cent. during October to December.

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2. THE PARASITE AND THE SPLEEN RATES.

BY I. J. KLIGLER, J. M. SHAPIRO AND I. WEITZMAN.

IT is fairly generally acceded that parasite and spleen (1, 2, 3) rates are reliable indices of the prevalence of malaria in a given community. Consequently, at the commencement of our control work in 1922 and 1923, we made a general blood and spleen examination of groups of inhabitants in each of the Demonstration Areas. The object of these examinations was: first, to obtain supplementary evidence as to the prevalence and distribution of malaria in the Control Zones and second, to detect and treat as many of the carriers as possible, as a first step in our control work.

It was impossible, for various reasons, to examine all of the 20,000 inhabitants in the control areas. The size of the task was too large and, moreover, the native population does not readily submit to examination either of blood or spleen; women as a class have to be excluded, almost entirely, and men are often away for days or weeks in the fields. We examined over 5000 blood preparations and over 3000 spleens. From the Jewish population we examined representative groups of men, women and children. Among the Moslem population we examined most of the children and as many men as could be mustered together for the show. Blood and spleen examinations in a Moslem village in Palestine is a special event which begins with sitting about in the Sheik's house, talking, drinking coffee and talking some more. Only after these preliminaries are over and after the first man, brave enough to have himself stabbed for blood, has been found, does the work begin in earnest. The first "victim" is always sure to bring others.

All of the examinations were made during the months of February, March and April. These months were selected intentionally, because they are the

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months when recurrences of malaria are most common, and when new infections can be practically excluded. Examinations made during these months furnish, therefore, a better picture of the actual extent of the latent malaria in a community.

For the blood examinations we used the thick drop method, stained with Giemsa. Usually only drops were taken; but frequently both drops and smears were taken, but the smears were examined only when the differentiation of the parasite was doubtful. Many of the examinations were made in the field, but more often the slides were brought to the laboratory.

The spleens were examined with the patient reclining, and the knees flexed. The enlargements were designated as palpable, one, two, etc., according to the number of finger breadths from the border of the spleen to the costal margin. All spleens that were definitely palpable were classed as enlarged.

The results of these examinations are summarised in Tables III and IV. The first of these tables contains the total blood and spleen incidence of Jews and Arabs in each demonstration area. The second table gives a more detailed comparison of the blood and spleen rates among the Jews and Arabs in the same locality. In Table III the blood rates are given for the population as a whole, but in Table IV they are analysed for age groups; the spleen rates are given separately for adults and for children below fourteen.

It is difficult to analyse these figures and arrive at any definite conclusions. Both the high blood and spleen rates, independently and together, point to a high malaria incidence. On superficial analysis they also suggest that the malaria incidence is higher among the Arab than among the Jewish population. A closer examination, however, of the figures obtained in different settlements in the same locality throws doubt on this interpretation. There is no justification for assuming that two groups of people living at equidistance from the same swamp would be differently affected. But this would be the case with the villages listed in Table IV, if we were to accept the blood and spleen rates as indices of the relative prevalence of malaria.

It is apparent, therefore, that in Palestine, at least, there are factors other than malaria incidence, which modify the validity of either the blood or the spleen rate as an index of malaria prevalence. The parasite rate, for example, may be greatly affected by the quinine consumption, either as a prophylactic, or for treatment. In a number of settlements, which had a high malaria incidence in 1922 but received good, intensive, treatment we found a low parasite rate. Conversely, other places, which had a relatively lower malaria incidence in 1922 and received poor treatment gave a higher parasite rate. The same criticism applies to the spleen rates. The spleen rate is affected not only by the incidence of malaria and the effectiveness of treatment, but also by the length of time exposed to infection.

As a result of our findings we believe that either blood or spleen rates are of value as general indices of malaria prevalence in the Arab communities, but this is not the case in the Jewish villages. The peasant or fellah uses very little quinine prophylactically, and the treatment he receives is largely sporadic and symptomatic. He rarely receives thorough, systematic, treatment. Consequently the children have a high parasite rate and a high or low spleen rate, according to the length of time exposed to the infection; while the older people who slowly develop a resistance to the parasite have a lower parasite rate than the children, and sometimes even a lower spleen rate, due to the hard shrivelled spleen which is not palpable. The Jewish farmers, on the other hand, use quinine very freely, seek medical aid frequently, especially for their children, and as a rule obtain fairly good treatment. The effect is registered in relatively lower blood and spleen rates. In both groups of the population, blood

Table III.

Comparison of Blood and Spleen Rates in Various Districts. February–March, 1923.

Blood Index.

	Number examined			Number positive			Percentage positive		
District	Jews	Arabs	Total	Jews	Arabs	Total	Jews	Arabs	Total
Ecron	679	296	975	39	54	93	5·7	18·2	9·5
Petach Tikwa	628	42	670	36	8	44	5·7	19·0	6·6
Hedera	441	0	441	24	0	24	5·4	—	5·4
Zichron	177	0	177	32	0	32	18·1	—	18·1
Merchavia	762	221	983	48	57	105	6·3	*25·8*	*10·7*
Nuris	338	0	338	30	0	30	8·9	—	8·9
Yavniel	410	146	556	9	2	11	2·2	1·4	2·0
Kinereth	403	0	403	17	0	17	4·2	—	4·2
Rosh Pina	631	100	731	16	16	32	2·5	16·0	4·4

Spleen Index.

		Jews	Arabs	Total	Jews	Arabs	Total	Jews	Arabs	Total
Ecron	Adults	327	66	393	65	46	111	19·9	69·7	28·2
	Children	157	217	374	36	179	215	22·9	82·5	57·5
	Total	484	283	767	101	225	326	*20·9*	*79·5*	42·5
Petach Tikwa	Adults	445	14	459	148	14	162	33·3	100·0	35·3
	Children	135	28	163	57	27	84	42·2	96·4	51·5
	Total	580	42	622	205	41	246	*35·3*	*97·6*	39·6
Hedera	Adults	237	0	237	123	0	123	51·9	—	51·9
	Children	96	0	96	14	0	14	14·6	—	14·6
	Total	333	0	333	137	0	137	41·1	—	41·1
Zichron	Adults	112	0	112	47	0	47	42·0	—	42·0
Merchavia	Adults	346	58	404	72	10	82	20·8	17·2	20·3
	Children	79	58	137	15	30	45	19·0	51·7	32·9
	Total	425	116	541	87	40	127	*20·5*	*34·5*	23·5
Nuris	Adults	88	0	88	22	0	22	25·0	—	25·0
Yavniel	Adults	173	0	173	22	0	22	12·7	—	12·7
	Children	121	0	121	29	0	29	24·0	—	24·0
	Total	294	0	294	51	0	51	17·4	—	17·4
Kinereth	Adults	254	0	254	78	0	78	30·7	—	30·7
	Children	62	0	62	13	0	13	21·0	—	21·0
	Total	316	0	316	91	0	91	28·8	—	28·8
Rosh Pina	Adults	205	23	228	58	15	73	28·3	65·2	32·0
	Children	83	51	134	28	35	63	33·7	68·6	47·0
	Total	288	74	362	86	50	136	*29·9*	*67·6*	37·6

and spleen rates misrepresent the actual condition; in the one they exaggerate, in the other they minimise the actual degree of prevalence of the disease.

The analysis of our figures with a knowledge of the malaria conditions as obtained from the incidence records leads us to believe that, while the blood and spleen when used independently are not satisfactory indicators, they may be of considerable value when they are correlated with respect to the age groups in the community.

Table IV.

Comparison of Blood and Spleen Indices among Jews and Arabs of the same locality. February–March, 1923.

Blood Index.

Place		Number examined			Number positive			Percentage positive		
		Adults	Children	Total	Adults	Children	Total	Adults	Children	Total
Ecron	Jews	215	110	325	17	11	28	7·9	10·0	8·6
	Arabs	52	139	191	6	42	48	11·5	30·3	25·1
Gedera	Jews	77	43	120	3	4	7	3·9	9·3	5·9
	Arabs	2	46	48	0	5	5	0·0	10·9	10·4
Ein Ganim	Jews	255	118	373	10	6	16	3·9	5·1	4·3
	Arabs	14	28	42	1	7	8	7·1	25·0	19·0
Merchavia	Jews	162	0	162	16	0	16	9·9	—	9·9
	Arabs	185	0	185	54	0	54	29·2	—	29·2
Yessod	Jews	155	83	238	2	9	11	1·3	10·8	4·7
	Arabs	36	38	74	3	9	12	8·4	23·7	16·2
Ayeleth	Jews	50	0	50	1	0	1	2·0	—	2·0
	Arabs	13	13	26	1	3	4	7·7	23·0	15·4

Spleen Index.

Place		Adults	Children	Total	Adults	Children	Total	Adults	Children	Total
Ecron	Jews	160	85	245	14	8	22	8·7	9·4	9·0
	Arabs	43	139	182	39	131	170	90·7	94·2	93·4
Gedera	Jews	73	38	111	27	14	41	37·0	36·8	36·9
	Arabs	5	47	52	4	43	47	80·0	91·5	90·4
Ein Ganim	Jews	247	116	363	95	50	145	38·5	43·1	40·0
	Arabs	14	28	42	14	27	41	100·0	96·4	97·6
Merchavia	Jews	32	95	127	24	4	28	25·3	12·5	22·0
	Arabs	58	58	116	10	30	40	17·2	51·7	34·5
Yessod	Jews	155	83	238	55	28	83	35·5	33·7	34·9
	Arabs	15	39	54	11	29	40	73·3	74·4	74·0
Ayeleth	Jews	50	0	50	3	0	3	6·0	—	6·0
	Arabs	8	12	20	4	6	10	50·0	50·0	50·0

In general the following relationships are indicated by our results:

(1) A continually high malaria incidence manifests itself by a much higher parasite rate among children and an equally high spleen rate among both adults and children. This condition is exemplified in the Arab villages Fejaz, Naaneh, Katra, Tiel and the Jewish settlements Katra, Yessod and Mishmar.

(2) In an area where malaria was highly prevalent and recently brought under control the blood rate is equally low and the spleen rate equally high among adults and children, or higher among adults, according to the duration of the control period. This condition is illustrated by Ein-Ganim, Nachlat Yehuda and Kinereth.

(3) In a place where malaria had been prevalent but had been under temporary control, or where a year of low prevalence is followed by an epidemic, both the blood and spleen rates are higher among children than among adults. Examples of this are Yavniel, Nehalal, Solim.

In places where there are no children the same correlation can be obtained between old settlers and recent immigrants. The underlying principle is the comparison of the blood and spleen rate of the susceptible, or new, and unsusceptible, or old, part of the population.

The conclusions to be drawn from this survey of over 5000 inhabitants of rural Palestine are:

(*a*) Taking the population as a whole, over 5 per cent. of the rural Jewish and over 15 per cent. of the rural Arabic population examined, actually carried parasites in their blood. Among the Jews the parasite rate in the Galilee settlements was a little below (4–5 per cent.), in Judea and Samaria a little above (6–7 per cent.) and in the Valley of Esdraelon more than double the average for the entire population. Among the Arabs the only notable exceptions which fell below the average were the village Hartuf and the Arabs living in the Jewish colony Yavniel; all the other villages gave a parasite incidence of 15–25 per cent. (The last figure is, however, higher than the average for the total population would normally be, because practically none of the adult females were examined.) The effect of so large a number of parasite carriers on the malaria prevalence is apparent.

(*b*) The blood and spleen rates taken by themselves indicate a high prevalence of malaria; but they are not a satisfactory indicator of the relative prevalence of malaria in adjacent communities, living under different conditions, and having different standards of life. In other words, there are other factors besides malaria prevalence which affect the blood and spleen rates of a community, which must be taken into account in the interpretation of the results of the examinations.

(*c*) More valuable information with regard to the malaria history of a place may be obtained from a correlation of the blood and spleen indices of the children and adults of the community, or of the new and susceptible and old and unsusceptible elements of the population.

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3. TREATMENT OF MALARIA.

By J. M. SHAPIRO and I. J. KLIGLER.

In this country, as everywhere else, the treatment of malaria is the most mooted question. The common practice is to treat the febrile attack by intramuscular injections and leave the after treatment to the good will of the patient. The result is that the subsequent treatment is greatly neglected. At present most of the physicians here realise the importance of systematic treatment, but in civil practice it is extremely difficult to carry this into effect.

The presence of our malaria inspector in each of the demonstration areas made it possible to carry out systematic treatment of parasite carriers, under careful supervision, and to note the effect of such treatment on the occurrence of relapses. Most of the carriers under treatment were infected with *P. vivax*. Even the small number of individuals who were infected with *P. falciparum* at the examination, subsequently relapsed with the benign form of tertian malaria.

A uniform procedure was followed. The individuals who were to receive treatment were classified into two main groups:

(1) Those who actually had one or another species of plasmodium in the blood.

(2) Those whose blood was negative, but who had enlarged spleens, a history of a recent attack of malaria, or both.

Only one method of treatment was employed. All the adult patients were given 2 gms. of quinine sulphate daily, in three 10 grain doses, for a period of five days. Children received proportionate doses according to age. This part of the treatment was carried out under the direct supervision of a physician. Subsequent to that the malaria inspector administered 10 grains of quinine daily to each individual under treatment, for a period of one month. After that the patient was kept under observation and relapses recorded. It should be added that the quinine was in tablet form and was always given *per os*.

The treatment was started in February and March so that new infections could be almost definitely excluded during the first two or three months subsequent to treatment. The greater number of the cases were under supervision from six to eleven months.

The results are indicated in the table below (Table V). Altogether 358 people were treated. 260 of them actually had parasites in the blood at the time treatment commenced; the others either suffered from chronic malaria or had not received proper treatment at the time of the attack. All groups of cases showed a maximum percentage of relapses during the first four months following treatment, but relapses continued to appear to the end of the observation period. The total percentage of relapses varied according to the group under treatment. Among the parasite carriers 30–40 per cent. of the cases relapsed. The highest incidence of relapses occurred in the group designated "Clinical Malaria." This group consisted of individuals suffering from chronic malaria which had already resisted other forms of treatment. The relatively low percentage of relapses among the cases in group 5, indicates that many of these cases had probably been cured by the previous treatment; at the same time the figures also show that many of the people who have a recent malaria history, are likely to be carriers, and should be treated as such, even though the blood and spleen are negative.

Table V.

Treatment of Chronic Malaria.

Type of carrier	Number treated	During or after treatment	Percentage relapses following treatment, Months after					Percentage cases without relapses, Months observed		
			1–2	3–4	5–6	7–10	Total	4–6	6–11	Total
P. vivax	213	3·3	9·4	8·9	3·8	4·7	30·0	4·7	65·3	70·0
P. falciparum	42	2·4	16·6	16·6	2·4	0·0	38·1	—	61·9	61·9
P. malariae	5	20·0	0·0	0·0	20·0	0·0	40·0	—	60·0	60·0
Clinical malaria	14	21·4	14·3	14·3	7·1	0·0	57·1	—	42·9	42·9
Malaria history*	26	3·8	7·7	3·8	0·0	0·0	15·4	11·5	73·1	84·6
Enlarged spleen	58	6·9	12·1	0·0	5·2	5·1	29·3	—	70·7	70·7
Total treated	358	4·8	10·6	8·1	3·9	3·7	31·1	3·6	65·4	69·0

* Cases with history of an attack within four months prior to the examination; but blood and spleen both negative.

Table VI.

Comparison of the Therapeutic Value of Quinine and Quinidine.

Drug	Patient	Number treated	Percentage relapses following treatment: During or soon after treatment	1–4 months	Total
Quinine	Children	32	6·3	25·0	31·2
	Adults	21	5·0	19·0	23·9
	Total	53	5·6	22·7	28·5
Quinidine	Children	25	0·0	28·0	28·0
	Adults	20	10·0	15·0	25·0
	Total	45	4·4	22·2	26·6

The results obtained with this method of treatment are not as good as those reported by Kligler and Weitzman (4) who used the Bass or Standard Method (3). They do, however, compare favourably with those obtained by Anderson (2), using various methods of treatment. It seems to us that the important feature in the quinine treatment of malaria is the systematic administration of moderately large doses of quinine, over a long period (at least one month) subsequent to the treatment of the febrile attack. The methods may vary in detail without modifying the results, provided the general principle of systematic administration of the drug over a long period forms the basis of the method.

Comparative Value of Quinine and Quinidine. Acton (1) and his associates have reported results, which indicate that quinidine is as effective as quinine in the treatment of malaria, particularly the benign tertian variety. We had occasion to test the effect of these drugs under comparable conditions in an epidemic which occurred in Hedera. The causative parasite was almost exclusively *P. vivax* and the patients were a group of children in an orphanage and a group of labourers. Each group was divided into two parts without selection. The form of treatment was that outlined above; one set receiving quinine sulphate, the other quinidine sulphate. The dosage is indicated below:

QUININE:

Adults. Five days 2 gms., thirty days 0·6 gm.
Children. 11–15 years, five days 1·2 gms., thirty days 0·5 gm.
6–10 years, five days 1 gm., thirty days 0·3 gm.

QUINIDINE:

Adults. Five days 1·5 gms., thirty days 0·6 gm.
Children. 11–15 years, five days 1·2 gms., thirty days 0·5 gm.
6–10 years, five days 1·0 gm., thirty days 0·3 gm.

The treatment was started in August, and the observations continued until the end of January: the results are tabulated on p. 297 (Table VI). Although the number of individuals observed is small, it is sufficient to indicate that quinidine is at least as satisfactory as quinine and is also perhaps a shade better, since smaller quantities of the drug yielded the same results as did the quinine treatment.

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4. BREEDING PLACES AND TYPES OF ANOPHELES.

BY I. J. KLIGER.

Influence of Topography on Breeding Places. In order to understand the nature of the breeding places in rural Palestine, it is necessary to be somewhat familiar with the topography of the country. So much has already been written on the topography of Palestine that it will suffice to sketch briefly those characteristics responsible for the breeding places and the malaria.

Topographically, Palestine is divided into four main divisions: (1) *The Coastal Plain*; a strip of land varying from four to twenty miles in width and extending from Haifa at the north to Gaza at the south. (2) At Haifa the Coastal Plain turns eastward into a plain extending from the coast of the Mediterranean to the valley of the Jordan. This plain is known as the Valley

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of Esdraelon. It is a narrow strip of land, only a few miles in width which cuts the hills transversely and joins the Valley of the Jordan to the east with the Coastal Plain and the Mediterranean to the west. (3) Along the Jordan is the valley of the river extending from Lake Kinereth at the north, to the Dead Sea at the south. The greater part of this valley is less than a kilometre in width and lies in a ravine between two ranges of hills. (4) Between the Coastal Plain and the Jordan Valley, lies the range of hills which bisects the country longitudinally into two plains, distinct from each other in climate, habit, etc. These hills are chiefly of limestone formation. They rise slowly from the western and northern plains, through foot-hills, to the highlands of Judea, Samaria and Galilee; they then drop more sharply on the east to the Jordan.

This peculiar topography of the country and the seasonal rainfall account for the prevalence of malaria throughout Palestine. There are few large bodies of water. There are only three lakes (Kinereth, Merom and the Dead Sea), and a few narrow streams called rivers; but besides the Jordan they deserve that name only when they are filled by the winter torrents. The real causes of the malaria in the country are the seasonal rainfall, the limestone hills, and the sand dunes. The heavy winter rains which fall during December, January and February partly rush down the slope of the hills to the sea, and partly sink into them. The waters which rush into the plain run along winter wadis, eroding deep holes in their beds and giving rise to pools which remain all year. As the water approaches the sea it often finds its exit blocked by sand dunes, or outcrops of sandstone, and spreads out on the flat land, causing a series of extensive swamps at various points along the Coastal Plain. These swamps are known as the Coastal Marshes. The waters which penetrate into the hills, crop out at the foot-hills in the form of numerous springs which run along in overgrown, neglected, creeks, or wadis, for greater, or lesser, distances, according to the volume of water issuing from the spring. On the top of the hills the inhabitants supply the lack of natural storage by building cemented cisterns which catch and store the rain water.

The sources of the mosquitoes and the consequent malaria in the various regions of the country—hills, foot-hills and plains—are thus obvious. In the hills, *e.g.* Jerusalem, Safed, etc., the cistern is the habitat of the anopheles and is the principal cause of malaria. In the foot-hills the numerous springs (only few of which are utilised), and their overgrown wadis constitute the chief source of trouble (districts of Ekron, Merchavia, Nuris, Beisan, Yavniel, etc.). In the flat plain, along the coast, the erosion holes in the wadi beds tapping the ground water, and the waters blocked by sand dunes (Kishon, Cabara, Rubin), or obstructions caused by sandstone along the sea (Athlit, Tantura, Atta in Hedera), constitute the breeding places of mosquitoes and the sources of malaria.

Aside from these breeding places there is one bad swamp of great magnitude—the Huleh Marshes above Lake Merom. This marsh is the worst and

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most extensive in Palestine and makes the surrounding plain at the head-waters of the Jordan and Lake Meron uninhabitable.

Classification of Breeding Places. Most of the anopheles breeding places are due either to century old neglect by man, or to man's carelessness. There are the numerous springs mentioned above, with an abundance of water which runs to waste and forms overgrown streams (perennial wadis), and swamps, offering all kinds of ideal conditions for anopheles breeding. There are also numerous watering holes and primitive leaky irrigation ditches, which are responsible for a goodly portion of the malaria in Palestine. Large swamps in the true sense of the word exist as indicated above only in Huleh, in the low flat areas of the Jordan and in the Coastal Plain.

For convenience the principal breeding places have been grouped into four categories. These are given below, approximately, in the order of their relative importance, in so far as the causation of malaria is concerned:

(1) Uncontrolled springs and seepage areas, and their resulting wadis.

(2) Irrigation canals.

(3) Accumulation of stagnant rain or ground water, holes in winter wadis, etc.

(4) Breeding places along receding shores of natural streams and lakes and natural low lying swamps.

(1) The breeding places of the first category are found in practically all of the settlements located in the foot-hills. There is always a spring, or a larger, or a smaller seepage area (series of springs) which is partially or wholly uncontrolled. The excess water runs off in a wadi, seeps through gravel beds and zigzags for long distances; the wadi is shallower in some parts and deeper in others, is badly overgrown along its whole length and presents a variety of excellent breeding places more or less difficult to control.

(2) The irrigation canals present a serious problem. They are in reality poorly constructed ditches, too shallow to hold all the water they carry, and too pervious to exclude seepage along their entire length. In a short time the ditch itself becomes overgrown. The long, overgrown, open ditch, the swampy areas resulting at low lying points from seepage through the walls, and the marshes caused by the overflow of the canal, give rise to a large number and variety of breeding places. This problem has become more serious recently, since almost everywhere irrigation is being employed more extensively for vegetables, tobacco, etc.

(3) Stagnant accumulations of water exist almost everywhere, but are particularly abundant in the highlands and in the plain near the coast. These accumulations take the form of cisterns, wells or reservoirs, watering holes along dry wadis, deep erosion holes in winter wadis tapping ground water, accumulations of rain water which find their way to the sea blocked by sand dunes or other obstacles and others of similar character. Inland they are usually small and easily controlled by cleaning and oiling, but near to the

coast they assume the characteristic appearance of the coastal swamps caused by the sand dunes, or sandstone outcroppings, and present serious difficulties. The Cabara swamps, the old Athlit swamps, Birket Atta, are examples of this type of breeding place.

(4) The breeding places of the fourth class are practically limited to the Huleh swamp, Lake Merom and the Jordan. They are a serious menace, and can only be got rid of by drainage.

From the standpoint of control we may say, by way of anticipation, that malaria caused by the breeding places of the first two and some of those belonging to the third categories can be readily controlled, and will be completely eradicated as soon as the level of intelligence of the native population is raised, and as soon as the country is so well developed that all the spring waters are properly and intelligently exploited. The large coastal marshes, however, can only be controlled by radical drainage. One of these swamps at Athlit, has already been drained by a company which has received a salt concession and the I.C.A. has agreed to drain the largest of them, the Cabara swamp, on the basis of a land concession given them by the Palestine Government.

Types of Anopheles. Eight species of anopheles have been found in Palestine. One, *A. bifurcatus,* is mainly a cistern breeder, and is found almost exclusively in urban centres. *A. hyrcanus* and *A. algeriensis,* are swamp dwellers which do not enter houses and are, therefore, not to be considered as malaria vectors. *A. pharoensis,* the Egyptian anopheles, is very rare in Palestine. *A. multicolor,* breeds only in salt water and its distribution is, therefore, fairly limited. This leaves three important rural mosquitoes all of which are widely distributed and known to be malaria vectors. These are: *A. elutus* (*maculipennis*), *A. superpictus* (*palestinensis*), and *A. sergenti* (*culicifacies*).

Character of Breeding Places. The character of the swamp usually determines the type of mosquito which will breed there. This is at times so clear cut that one can almost predict with certainty from the character of the swamp the types of anopheles and *vice versa.* Stagnant pools in winter wadis, stagnant water overgrown with ranunculi, wells and reservoirs overgrown with algae invariably breed *A. elutus.* The partially stagnant swamps caused by overrunning irrigation ditches and streams, breed either *A. elutus,* or *A. sergenti,* or both. Very slowly moving streams, such as open seepage canals and sluggish parts of wadis, seepage under rocks and pebbles, etc., will almost invariably harbour *A. sergenti* (*culicifacies*); at times they may also be associated with *A. superpictus.* Steadily flowing streams, emanating from springs, breed almost exclusively *A. superpictus.* Salt water, containing from 1–3 per cent. salt, harbours only *A. multicolor.* In sheltered and badly overgrown, stagnant, muddy swamps, one finds *A. hyrcanus* or *A. algeriensis* or both. *A. bifurcatus* is exclusively a cistern breeder, although Buxton found it once breeding out of doors. *A. pharoensis* is rare in Palestine, but

DESCRIPTION OF MAP.

Rosh-Pinah Area. Population 2349. Area 69·4 sq. kil.

	Index: Blood	Spleen Adults	Spleen Children
Jews	2·5 %	28·3 %	33·7 %
Arabs	16·0 %	65·2 %	68·6 %

Yavniel Area. Population 1385. Area 98·8 sq. kil.

	Index: Blood	Spleen Adults	Spleen Children
Jews	2·1 %	12·7 %	23·9 %
Arabs	1·3 %	—	—

Kinereth Area. Population 915. Area 22·6 sq. kil.

	Index: Blood	Spleen Adults	Spleen Children
Jews	4·2 %	30·7 %	20·9 %
Arabs	—	—	—

Merchavia Area. Population 1420. Area 87·6 sq. kil.

	Index: Blood	Spleen Adults	Spleen Children
Jews	6·3 %	20·9 %	19·0 %
Arabs	25·8 %	17·2 %	51·7 %

Zichron-Jacob Area. Population 2186. Area 80·6 sq. kil.

	Index: Blood	Spleen Adults	Spleen Children
Jews	18·1 %	42·0 %	—
Arabs	—	—	—

Ein-Harod Area. Population 2425. Area 51·8 sq. kil.

	Index: Blood	Spleen Adults	Spleen Children
Jews	8·8 %	25·0 %	—
Arabs	—	—	—

Hedera Area. Population 1390. Area 49·2 sq. kil.

	Index: Blood	Spleen Adults	Spleen Children
Jews	5·6 %	51·9 %	14·6 %
Arabs	—	—	—

Petah-Tikvah Area. Population 4990. Area 67·2 sq. kil.

	Index: Blood	Spleen Adults	Spleen Children
Jews	5·7 %	33·2 %	42·2 %
Arabs	19·0 %	100·0 %	96·4 %

Ecron Area. Population 4519. Area 106·1 sq kil.

	Index: Blood	Spleen Adults	Spleen Children
Jews	5·7 %	19·8 %	22·9 %
Arabs	18·2 %	69·6 %	82·4 %

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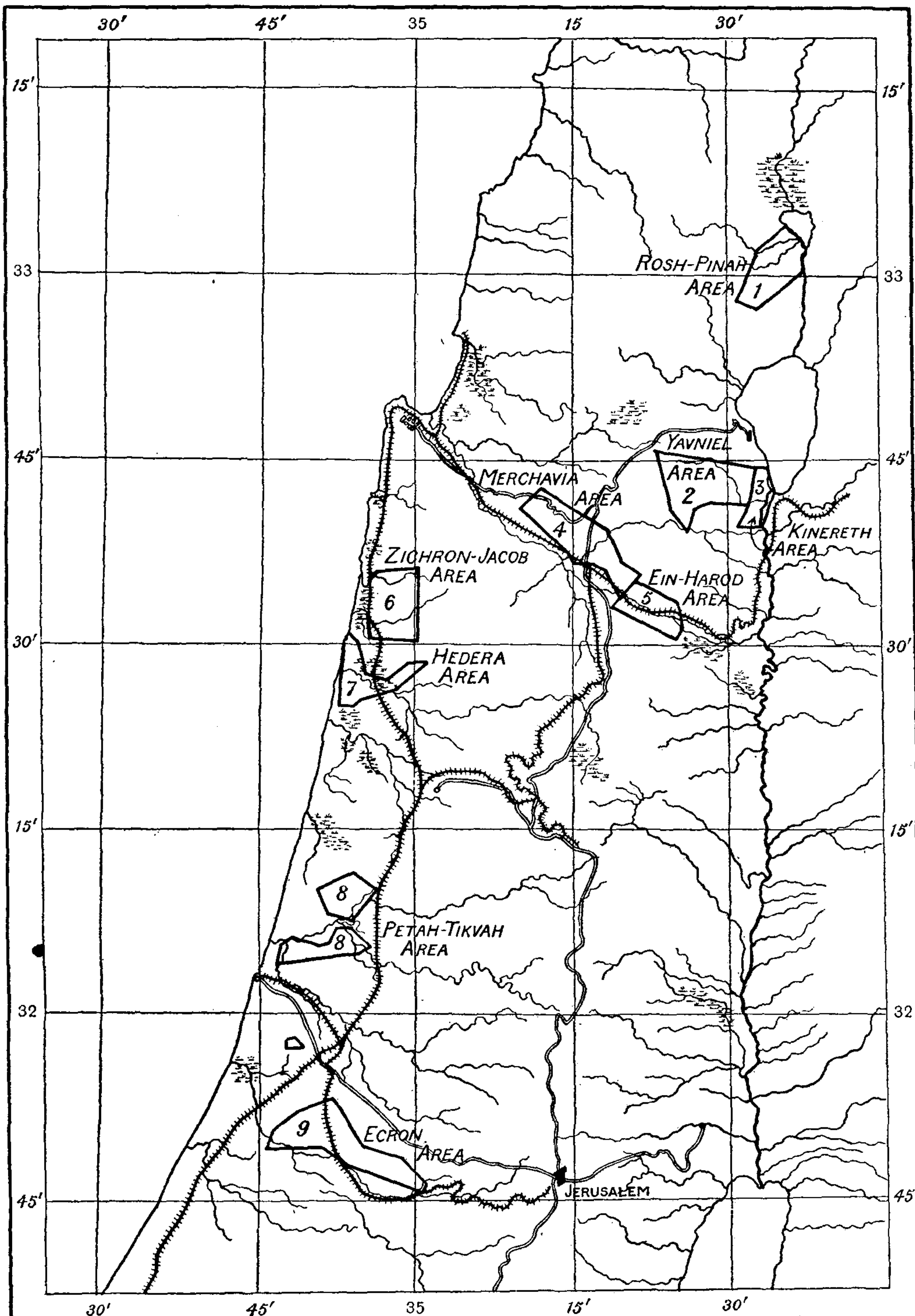

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we have found it breeding in the Cabara swamp where *A. elutus* is usually found.

Distribution of the Various Types of Anopheles. The anopheles are not uniformly distributed throughout Palestine; this difference in distribution depends not on climate but on the character of the breeding places prevailing in the various districts. Thus in Ein Ganim, Hedera, and elsewhere in Judea and Samaria, where the wadis shortly after the rains present the appearance of a series of isolated stagnant pools, *A. elutus* are found; while in wadis Melat and Musrara, also in Judea, which are fed by springs and consequently have a continuous slow-moving stream, *A. superpictus* and *A. sergenti* are found.

In *Judea* both *A. elutus* and *A. superpictus* are found, but the latter predominates where the breeding places are caused by springs (Ekron, Hartuf, Ramat Gan.), and the former is practically the only house visiting anopheles where the breeding place is a winter wadi (Ein Ganim).

In *Samaria* (Hedera Area), along the coast, *A. elutus* is practically the only house visiting anopheles; but *A. superpictus* is occasionally found and, rarely, also *A. pharoensis.*

In *Phoenicia* (Zichron Jacob and Athlit), *A. elutus* is the dominant type, but *A. multicolor* is found in the salt marshes, and *A. superpictus* in the spring wadis. The latter are, however, uncommon in comparison with *A. elutus.*

In the *Valley of Esdraelon*, *A. elutus*, *A. superpictus* and *A. sergenti* are all equally abundant. The former are more prevalent in the spring and late fall, and the last is most numerous in the late summer and fall.

In *Lower Galilee*, *A. superpictus* and *A. sergenti* are practically the exclusive species in the Yavniel District, where the only breeding places are the open seepage canals and flowing wadis. Along the Jordan and the Sea of Galilee *A. elutus*, *A. sergenti* and *A. superpictus* are equally common. *A. elutus* breeds along the shores of the Jordan, in the beds of ranunculi, or in the swampy areas where the low ground is flooded by the Jordan. *A. superpictus* breeds in the flowing wadis, and *A. sergenti* is found in the seepage from the irrigation canals and under pebbles and rocks in the wadis or in the Jordan.

In *Upper Galilee* (Rosh Pina Area), *A. elutus* is the principal species, but *A. superpictus* is commonly found. In the late summer and fall *A. sergenti* is also found but in relatively small numbers.

Occasionally one also finds the urban mosquito, *A. bifurcatus*, which breeds in cisterns. This mosquito was found by us in Hartuf (Ekron Area) and in Poria (Yavniel Area). We have never found it breeding out of doors.

Seasonal Prevalence. *A. superpictus* and *A. elutus* begin to breed at the end of March, or early in April, and continue throughout the year, until the beginning of the heavy rains at the end of November, or sometime in December. From about the middle of August to the middle of October, there is a decided diminution in the numbers of *A. elutus*, but at the latter period there is again a sharp increase. The season of activity of *A. superpictus* follows closely that of *A. elutus*, but there is no increase in their numbers in the fall as is the case with *A. elutus*. The active season of *A. sergenti* is not as yet well defined, but its larvae usually become evident in July or early in August and the adult remains the dominant mosquito throughout September and October. After that they are equally abundant with *A. elutus*. Breeding continues until the end of December and in warmer places even into January. The exact cause of this seasonal fluctuation is not clear, but there seems little room to doubt that it is chiefly a temperature relation. *A. algeriensis* breeds actively between November and June, while *A. hyrcanus* breeds more actively throughout the spring and summer months.

Active Period of Anopheles. There is no true hibernation in Palestine. The *adult* anopheles may be said to be active throughout the year. During the months of January to March one frequently finds anopheles with freshly ingested blood; while in the laboratory we have observed them laying eggs when the room temperature was between 16° and 17° C. *A. elutus* and *A. superpictus* do take winter quarters (store-houses and cellars), during the latter part of November and December; the prevailing low temperature (10–12° C. in the plains) throughout the winter, also greatly inhibits their activity. However, between rainy days there are often periods when the temperature rises to 16° and 18° C. and the anopheles may then resume activity. This accounts for the sporadic cases of primary infections which actually occur during the winter months. We are not certain as yet whether *A. sergenti* also takes winter quarters; thus far we have not found them.

The *immature* stages of all house visiting anopheles, excepting *A. bifurcatus*, are inactive during the winter. At no time during the months January to March were larvae of *A. elutus*, *A. sergenti*, *A. superpictus*, or *A. multicolor* encountered. During these months *A. algeriensis* is readily found breeding outside and *A. bifurcatus* in cisterns. This holds true at any rate for the plains and foot-hills. In the highlands breeding apparently ceases entirely; while in the Jericho region, where the climate is semi-tropical, Buxton reports breeding of *A. sergenti* throughout the winter period.

During the months of April to December anopheles are active in all stages. The larvae appear late in March and early in April and disappear after the first heavy rains, which usually come late in November, or early in December. Adults appear about the middle or end of April, and enter winter quarters in November and December.

Flight of Mosquitoes. We have performed no experimental flight tests; but have ample evidence that both *A. sergenti* and *A. elutus* have a much greater range of flight than is commonly supposed. In Hedera, *A. elutus* travelled a distance of 2·4 kilometres and caused a severe epidemic. In the Ekron district the Melat swamp has been proved to be the cause of malaria in Naaneh and Ekron, both two kilometres or more away. In Balfouria, *A. elutus* travelled from a well more than two kilometres away. In Beth-Alpha, *A. sergenti* came from a swamp 2·5 kilometres from the settlement.

These observations are definite, because no other breeding places could be found closer to the settlement to account for the mosquitoes and, with the control of the suspected breeding places, the mosquitoes disappeared.

An important fact regarding the flight of mosquitoes, generally overlooked, is that they do not come when the wind is strong, but when it is gentle, or when it has subsided. While strong winds are blowing the mosquitoes seek shelter and are not active. The range of flight, in so far as local anopheles are concerned, seems to be determined by factors which appear to us more important than the wind. The distance of flight depends on the number and density of settlements near the breeding places and on the intensity of breeding. In other words, the distance of spread from a breeding focus varies directly with the intensity of breeding and inversely with the density of the settlements and population. If there are no settlements near the swamps, or if the breeding is very heavy, the mosquitoes travel relatively long distances in order to obtain their food.

Relative Importance of the Various Anopheles as Malaria Vectors. Happily not all of the anopheles mosquitoes enumerated above are of equal importance as malaria vectors. We have not, as yet, sufficient information on this subject. It is fairly certain, however, that *A. hyrcanus* and *A. algeriensis* which are not house visitors, are negligible in so far as malaria transmission is concerned. *A. bifurcatus* is of great importance in the urban and semi-urban highland districts which depend on cisterns for their water supply; but it is relatively of little significance in the rural communities of the foot-hills and plains which derive their water supply from springs or wells rather than from cisterns. *A. multicolor* is a salt water species of comparatively limited distribution and, judging from epidemiologic evidence, is not seriously concerned in the spread of malaria. All of the three remaining common species of anopheles are probably important vectors, although *A. elutus* and *A. sergenti* appear from epidemiologic evidence to be of greater importance than is *A. superpictus*. Our experience in places having only *A. superpictus* (Ramat-Gan and Ayelet) was that there was very little malaria even when mosquitoes were abundant. Against this experience, however, is that of various other workers, and the fact that we have found an infected specimen in our dissections, which indicates that it is an important vector.

Incidence of Infected Mosquitoes. The number of dissections made in our laboratory thus far are not sufficient to warrant a definite conclusion with regard to the incidence of infected mosquitoes in nature. Enough work has been done, however, to show that the incidence is not higher than that found in Macedonia or other malarious areas. From October to the end of January we have dissected 630 *A. elutus* (*maculipennis*), 294 *A. sergenti* and 39 *A. superpictus*. Seven *elutus* and one *superpictus* were found infected, giving an incidence of 1·1, 0·0 and 2·6 per cent., respectively. The incidence of infection among the *A. elutus* for October, December and January were 1·3, 1·6 and 0·85 per cent., respectively.

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Infectivity of the Local Anopheles. A limited number of infection experiments have also been carried out. These have demonstrated that *A. elutus* can be infected with either *P. vivax* or *P. falciparum,* contrary to the suggestion recently made by Buxton that this mosquito carries only the parasite of benign tertian malaria. Under the conditions of our experiments, that is with single feedings, we failed to infect mosquitoes when fed on patients taking quinine, irrespective of whether the gametocytes were of *P. vivax* or of *P. falciparum.* The number of experiments is, however, small and these findings cannot, therefore, be considered as conclusive.

SUMMARY.

In this section we present briefly the main sources of anopheline mosquitoes, and describe the habits of the species more or less commonly found in Palestine. It is shown how the peculiar topography of the country, the limestone hills, the seasonal rainfall and the sand dunes lead to the formation of characteristic breeding places. Depending on the character of the breeding place one or all of the three common house visiting anopheles are widely distributed throughout rural Palestine. Two of these mosquitoes, *A. elutus* and *A. superpictus,* have thus far been found infected in nature, and the former has also been infected experimentally with *P. falciparum,* as well as *P. vivax.*

REFERENCE.

BUXTON, P. A. Personal Communication.

5. MALARIA CONTROL DEMONSTRATIONS.

BY I. J. KLIGLER AND J. M. SHAPIRO.

IN 1921 Kligler and Weitzman conducted malaria control demonstrations in two selected areas in the region of the Jordan and Lower Galilee. These demonstrations indicated the possibility of controlling malaria in those areas at a reasonable cost. It was desirable, however, to extend these studies and to determine the possibility of large scale malaria control in Palestine, at a moderate cost. One of the tasks, therefore, of the Malaria Research Unit, which was attached to the Palestine Health Department on Sept. 15, 1922, was to organise a number of malaria control demonstrations with this object in view. Tentative work was commenced immediately, but the organisation was not completed until the beginning of 1923.

Demonstration Areas. With the knowledge of the general topography of the country, the character of the breeding places, and the prevalence of malaria as a basis, nine malaria control demonstrations were organised in different parts of the country, including all varieties of topographic conditions (excepting highland settlements), population, etc. Table VII (p. 314)

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contains a summary of each area; populations, blood and spleen indices, incidence of malaria, and degree of control and costs.

Organisation. The demonstrations were organised as a unified scheme, under central direction. A specially trained anti-malaria inspector responsible for the carrying out all of the control operations, was placed in each demonstration area. The inspector lived in his district and had complete supervision of the breeding places, actual and potential. There were also, at first, two senior inspectors (later reduced to one), who visited the various districts from time to time, made thorough inspections, gave special instructions to the local inspectors and reported on the general situation and the effectiveness with which the work was carried out. The Field Medical Officer and the Controller of the Unit also visited the various areas from time to time, for special inspections and surveys, or when special problems arose. The field inspectors were required to send weekly reports, in the form of diaries, indicating concisely and clearly their daily activity, the breeding and malaria conditions, and the daily progress of the work. In this way the work was closely knit and the central office kept in constant touch with the work in the field.

Area. The total area under control amounted to over 600 square kilometres. The extent of the individual demonstration areas varied considerably, since the size of the areas was limited by the ability of a single inspector to carry out effective control of the breeding places. If the number of breeding places was large the area was of necessity small and *vice versa.*

Population. The population included in the Control Areas amounted to 21,230, of which 13,580 were Jews and 7650 Arabs. In other words the Control Areas contained approximately 5 per cent. of the total rural population and 93 per cent. of the rural Jewish population. All classes of population were included in the Demonstration Areas. There were old Jewish settlers in *Judea* and Galilee, who were saturated with and more or less resistant to malaria: and the newer settlers in the *Valley of Esdraelon* also saturated with malaria, but not as yet for a sufficient length of time to have acquired any resistance to the disease. There were included the crowded native villages with their backward inhabitants, as well as the more modern European settlements or colonies. This heterogeneous population naturally complicated the problem; some elements were more responsive and more easily influenced, others less so. On the whole, however, all sections of the population manifested some interest in the work, once the native suspicion was allayed.

Methods of Control.

Our efforts to control malaria were directed almost entirely towards eradication of anopheles mosquitoes, but the fight against the parasites was also employed as an aid in the campaign. The general plan of campaign in any given demonstration area consisted in the following steps: (*a*) a complete survey of the breeding places within a radius of two kilometres or more from

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the settlements; (*b*) a survey of the parasite and spleen rates, followed by intensive treatment of carriers; (*c*) systematic house to house search for and destruction of hibernating mosquitoes; (*d*) control of mosquito breeding by various devices to be described below. The first three steps were completed during the months of January to March, when there was no breeding. They were preparatory in nature, paved the way for the control work, and awakened public interest. The actual campaign was started in April with the commencement of anopheles breeding and continued until the heavy rains, which were unusually late this year, and did not come till late in December.

Quinine Prophylaxis as a Control Measure. Since the war the value of quinine as a malaria control measure has been the subject of a great deal of controversy. Most of the people who have had direct experience with quinine prophylaxis during the war are of the opinion that it is worthless. Our own experience in 1921 (2) and 1922 (3) has made us very sceptical as to the value of this measure as a method of control. In 1921 we have seen that even the fairly careful daily distribution of 0·6 gm. of quinine sulphate did not prevent the appearance of new cases of malignant malaria. In 1922 we had definite evidence that quinine merely prevented the appearance of symptoms, but that the infection remained latent, and so soon as prophylactic quinine stopped either relapses or primary attacks occurred.

There are other considerations which make it undesirable, except under circumstances where there is no other alternative, to rely on quinine as a method of control. Aside from the fact that the drug is relatively expensive it is always very difficult to organise systematic distribution of quinine, and even with the best organisation it is practically certain that a considerable proportion of the population fail to take the prophylactic regularly. With careful control and supervision, consisting of daily individual distribution of quinine, we could never be sure that more than 75 per cent. of the people actually took the quinine with any degree of regularity.

As a result of this experience it was decided to rely very little on quinine prophylaxis in the control of malaria. Regular quinine prophylaxis was not given anywhere. Quinine was used only as a temporary measure where mosquito control had broken down. Under these special conditions intensive quininisation in therapeutic doses, 2/3 gm., was employed during the period of prevalence of mosquitoes, and stopped soon after breeding was again under control and the adult anopheles index reduced to a safe margin. Used in this way quinine proved an effective aid in malaria control. But even with these large doses there were, in Kinereth, six primary cases within a week after the quinine distribution had been discontinued.

CONTROL OF MOSQUITO BREEDING.

Types of Breeding Places in the Control Areas. It would take us too far afield if we were to describe in detail the various breeding places encountered. In general the swamps found in the various control areas conformed to types as described above. In the *Ecron* area which is in the foot-hills of Judea we had to deal mainly with springs and seepage wadis and pits dug by shepherds along dry wadi beds. In the *Petach Tikwa* area, in the Plain of Sharon, we encountered the problems of erosion holes in winter wadis and of the numerous wells and reservoirs used in the irrigation of the orange groves. In both these areas control of breeding was comparatively easy and many of the important breeding places can be entirely eliminated at a relatively small sum.

In the *Hedera* area, which is in the Coastal Plain in the district of Samaria, the problem was more difficult. Here, we had to deal with all three types of swamps. In the settlements along the foot hills (Karkur, Gan Shmuel) there are seepage areas and spring wadis. In *Hedera* proper, there are the erosion holes in the winter wadi and a coastal marsh caused by sandstone obstructions. It was possible, by the various methods to be described below, to limit breeding in the wadis, but the coastal marsh remained out of control and was the cause of a serious epidemic in Hedera. Plans are under way to bring this marsh under control, by arranging to pump out the water for irrigation purposes.

The *Zichron* area, in the district of Phoenicia, also lies partly in the Coastal Plain, and presented problems similar to those encountered in Hedera. Control was effected in the wadis and irrigation canals, but we were helpless in so far as the extensive coastal marsh, Cabara, was concerned.

In the *Merchavia* and *Nuris* areas in the Valley of Esdraelon the chief problems were spring wadis, irrigation canals, and watering holes. The Valley of Esdraelon presents a unique picture. It is a narrow strip of land lying between two ranges of hills. At the foot of these hills, on either side of the valley, there are numerous springs, the waters of which, not being utilised for better purposes, spread out in winding wadis, flood low lying areas, and give rise to extensive swamps. Owing to the large number of these neglected springs the valley ranks among the most malarious regions in the country.

The ease, or difficulty, with which the control of these swamps was effected depended largely on the number of springs, or the extent of the seepage areas. As the number of settlements in the valley increases, more of the springs are being utilised, their streams regulated and the swamps caused by them eliminated. This year a considerable number of springs have been collected and brought under control in the Ein Harod and Merchavia areas, and large tracts of swamps have been dried. Part of the water from these springs is to be used for drinking and irrigation purposes, and the rest is run off in closed subsoil drains.

In the *Yavniel* district, the control depends entirely on the regulations of springs and their wadis, and the irrigation canals. These can easily be taken care of, provided the population is willing to co-operate. In most places this is the case and the results are quite satisfactory. We have been able to keep this district fairly free from malaria.

The problem of control in the *Kinereth* district centres in the Jordan and a few spring wadis. The greatest efforts had to be concentrated on the Jordan; with a good deal of hard work the breeding could be checked sufficiently to prevent the outbreak of any serious epidemics.

The *Rosh Pina* district may be divided into two parts. The section around Rosh Pina obtains its mosquitoes from seepage wadis, which can be readily controlled. Another group of villages are located around Lake Merom and the Huleh Marshes. There it is impossible to do anything against mosquito breeding and mechanical protection and quinine are the only protective palliatives available.

Methods of Control of Mosquito Breeding. The methods used to check breeding varied with the character of the breeding place. Whenever possible we resorted to drying. For this purpose two simple devices were utilised which proved very useful in Palestine, and may perhaps also be of use elsewhere: (1) Wadis originating from a single spring or spring head were dried intermittently by damming the stream near its origin and releasing the water every 5 to 10 days, according to the rate with which the basin behind the dam was filled. (2) Irrigation ditches and their swamps, wadis on flat areas which could not be dammed, and open drainage canals were dried by alternating or periodically deflecting the flow in another direction. In this way extensive breeding areas could readily be controlled with little effort and usually with only a small initial outlay. These methods were used in several demonstration areas (Zichron, Merchavia, Nuris, Yavniel and Kinereth) with excellent results.

In pools, erosion holes in winter wadis and similar accumulations of water, we resorted to the cleaning of vegetation with or without the subsequent use of a larvicide, according to the need. As a rule there was little or no breeding in clean pools free from vegetation.

We conducted an extensive series of experiments with various mixtures of kerosene and crude oil, with and without the addition of small quantities of vegetable oils and oleic acid. We also experimented with various mixtures of cresol. The larvicides which proved most useful for our purpose were: (1) a paraffin-crude-oil mixture containing 0·1 per cent. castor oil, (2) Paris Green, (3) a water solution of cresol.

After much experimentation we found that for practical purposes the best kerosene mixture consists of nine parts paraffin (kerosene) and one part heavy commercial crude-oil, to which 0·1–0·2 per cent. castor oil was added. The film produced by this mixture has greater penetrative power than that of paraffin alone, is more stable and most durable. The castor oil (4) greatly increased the spreading and penetrating power of the mixture and at the same time does not affect the tensile strength of the film. This mixture is also more economical since 10 c.c. are ample for one square metre, whereas 25 c.c. of paraffin alone or paraffin and crude-oil are required for the same area.

Paris Green proved particularly useful in overgrown pools and wadis, where paraffin (kerosene) mixtures are practically useless. The Paris Green was diluted with road dust or fine sand in the proportion of one part Paris Green to 100 parts of diluent and employed in the manner described by Barber (1). We found 10 gms. of the arsenical quite sufficient for 100 square metres of swamp. In other respects, such as the failure to affect culex larvae, the results were the same as those reported by Barber. We also found that anopheles eggs and pupae were not killed by the arsenical, and that consequently the powder had to be applied every 7 instead of every 10 days as in the case of oiling.

In the open irrigation wells and reservoirs in the orange groves we experimented with cyprinidons and with copper sulphate. The chief difficulty in these places are the algae, which grow rapidly and in abundance and provide the necessary shelter for anopheles larvae. Such wells when free from algae rarely breed. Control of breeding depends on the success with which the algae themselves are destroyed or their protective effect counteracted. Copper sulphate in a dilution of 1 : 1,000,000 was sufficient to destroy the algae and keep the tank free from vegetation for three to four weeks. The experiments with cyprinidon were not conclusive. They proved useful in some tanks, but in others they fell a prey to other fish, turtles, or water snakes, and restocking was required. It is too early as yet to say which of these methods is going to prove most useful under local conditions, but the experiments are being continued. We have also experimented with Gambusia, brought from the United States, but these experiments have not as yet passed the aquarium stage. So far our attempts to stock ponds have failed.

Factors complicating Malaria Control Work. There are several factors which make control of malaria in Palestine more difficult than it would ordinarily be. One is the nomadic Bedouin, the shepherd is another, and the primitive irrigation system a third. Early in the spring the nomads come in with their flocks from the east in search of pasture and water. They move across the plains, settling along wadis, changing camps with changing conditions, rarely remaining in one place all summer. Before the onset of the rainy season they return in the direction from which they came. These tribes are, as a rule, heavily infected with malaria; we have found among them parasite indices as high as 25 per cent. and spleen indices of 80 per cent. or over. Moving along the plains and living close to marshes they increase the incidence of infected mosquitoes and leave a trail of infection behind them, coming and going. Aside from that they continually create new marshes by damming up streams to facilitate the watering of their cattle or, if they are also semi-agricultural tribes, for primitive irrigation. Their cattle trample the banks of the creeks and before long the regular trimmed banks of the stream are converted into a hoof-marked bog, ideal for breeding of *A. sergenti* or *A. elutus*.

The shepherds complicate the problem in two ways. Like the Bedouin tribes they destroy the banks of regulated streams. Where there are no streams they dig primitive wells or watering holes along beds of dry wadis,

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for watering their flocks. These holes furnish excellent breeding places for *A. elutus*. We have had several small outbreaks of malaria, which were attributable to such holes opened in out of the way places and without knowledge of anyone.

The primitive irrigation canals are also the source of a great deal of worry. They are either too shallow for the amount of water they carry, or the walls leak or the water is too sluggish. Whether the fault be at one point or another they always breed and are always a serious source of trouble.

Result of the Control Measures. The effect of the control measures can best be seen from Chart 1, showing the malaria incidence in the control areas in 1922 and 1923. The difference in the malaria incidence for these years is brought out more effectively in Chart 5 and Table VII, giving the average monthly incidence for the period prior to control (where control was started in 1921 or 1922) for 1922 and 1923, respectively. It is evident that, excepting the Hedera and Rosh Pina districts, there was a decided decrease in the malaria incidence everywhere in comparison with 1922 as well as with the period prior to control.

In 1921 demonstrations were conducted in the districts of Kinereth, Menachemia and Yavniel. During that year malaria was reduced in Kinereth from an average monthly incidence of 9·4 to 1·4 per cent., in Menachemia, from 5·5 to 0·84 per cent. and in Yavniel from 4·2 to 0·4 per cent. In 1922 these demonstrations were continued with somewhat less intensity, and similar demonstrations were started in the Ecron and Petach Tikwa areas, in Judea.

In the Judea areas there has been a steady decrease in the malaria incidence from the time control began. During 1923 there were practically no primary infections, and relapses were steadily becoming fewer and fewer. The extremely low rainfall in the winter of 1922 and 1923 greatly facilitated the control work.

In the *Hedera* district steady progress was made in 1923 until there came an explosive epidemic in Hedera itself, caused by an uncontrolled coastal marsh (Birket Atta) 2½ kilometres from the settlement. This marsh was uncontrollable, and moreover we considered it beyond the normal flight of mosquitoes. Plans are now effected to control this marsh at a moderate cost and its control should enable us to bring about a considerable reduction in the malaria incidence in this area in 1924.

The *Zichron* area is skirted by the Cabara swamp, the largest of the Coastal Marshes which lies within 1·5 to 2·0 kilometres from the settlements. There, control of mosquito breeding was out of the question. The marked reduction in the malaria incidence in this area was achieved by three measures: (1) The reduction of the number of carriers by intensive treatment. (2) The elimination of breeding in the vicinity of the settlements. (3) The systematic destruction of adult mosquitoes in the houses. Despite the noted improvement it is evident that the elimination of malaria in this area is not possible by these half measures. This result can be achieved only when the Cabara swamps are completely drained.

In the *Valley of Esdraelon* the results were very encouraging. Despite the drainage operations which were going on in all the settlements, and despite the numerous potential breeding places, breeding was kept at a minimum, and the malaria incidence, particularly the incidence of primary infections,

Chart 5. Comparison of mean monthly incidence of Malaria prior and subsequent to control.

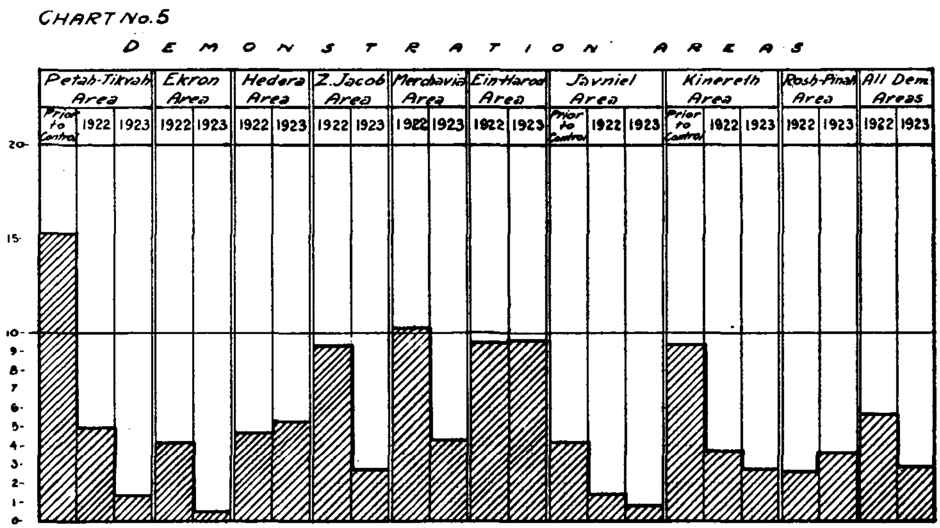

TABLE No. VII

Demonstration Areas	Petah-Tikvah			Ekron		Hedera		Z. Jacob		Merchavia		Ein-Harod		Javniel			Kinereth			Rosh-Pinah		All Dem Areas	
Year	Prior to Control	1922	1923	1922	1923	1922	1923	1922	1923	1922	1923	1922	1923	Prior to Control	1922	1923	Prior to Control	1922	1923	1922	1923	1922	1923
Average monthly Population	497	619	1086	714	2386	698	922	1548	1535	448	936	494	800	4.40	957	1038	319	454	467	820	875	6752	10042
Average monthly Cases	76	31	15	30	12	33	49	144	41	46	40	47	77	18	13	8	30	17	13	21	31	382	286
Average monthly Incidence	16.3	5.0	1.4	4.2	0.5	4.7	5.3	9.3*	2.7	10.3	4.3	9.5	9.6	4.2	1.4	0.8	9.4	3.7	2.8	2.6	3.6	5.7	2.9
Percent of Reduction 1923/Prior to Control	+90.9													+81.0			+70.3						
Percent of Reduction 1923/1922	+72.0			+88.4		-12.8		+71.0		+58.6		-1.1		+43.0			+24.4			-38.6		+49.0	

* This incidence is based on approximate figures from June to December, since full reports were not available.

was much lower than in 1922. At first sight it appears that in the Ein Harod area there was an increase in the malaria incidence. This increase is, however, only apparent since the bulk of the cases were relapses among those who had attacks during the 1922 epidemics. In so far as primary cases are concerned there was a decided reduction over 1922.

In 1922 the results of the control work in the *Kinereth* and *Yavniel* areas were not as satisfactory as they were in 1921. But in Kinereth the mean monthly incidence in 1922 was still only 3·7 per cent. as against 9·4 per cent. prior to control, and in the Yavniel area the average incidence for Yavniel, Bet Gan and Poria in 1922 was 1·7 per cent. against 4·2 per cent. for the same places during the ten months period before the control work began. In 1923 there was a further reduction in both the Yavniel and Kinereth areas as compared with the incidence of 1922, but the incidence still remained higher than in 1921. We believe that with a little more intensive work the incidence in both places can be brought down to the level reached in 1921.

In the *Rosh Pina* area control began in 1921 and malaria was practically absent in the group of villages near Rosh Pina. This condition continued until the month of November 1923, when there was a sudden influx of *A. elutus* from an unknown source. This district and that of Hedera are the only two which showed an increase in the incidence over that of 1922.

Table VIII.

Cost of Control Operations in the Demonstration Areas, 1923.

Demonstration Area	Population	Salary and travel*	Supplies	Casual labour and misc. ex.	Total	*Per capita*
Ecron	4519	P 24695·0	1601·0	446·5	26742·5	5·9
Petach Tikwa	4990	37555·0	2474·5	431·0	40460·5	8·1
Hedera	1390	22145·0	3750·4	122·0	26017·4	18·7
Zichron	2186	21895·0	12008·0	4192·0	38095·0	18·9
Merchavia	1420	30166·0	2030·5	212·0	32408·5	22·8
Ein Harod	2425	20484·6	3389·0	233·0	24106·0	9·9
Yavniel	1385	21284·6	2344·0	327·0	23955·6	17·3
Kinereth	915	23534·6	6833·0	1157·0	31524·6	34·4
Rosh Pina	2349	22822·6	2791·7	592·0	26206·3	11·1
Total	21579	P 224582·4	47222·1	7712·5	269517·0	12·5
Average		P 24953·6	4135·8	856·9	29946·3	

* Under this item are included also the salary and travelling expenses of the Senior Sub-inspectors.

Taking the results as a whole, it is evident that in seven of the nine demonstration areas there was a notable reduction in the malaria incidence. The percentage of reduction varied in the different areas, but it was sufficiently striking to indicate the possibility of malaria control. The average decrease for all the nine areas as compared with the incidence of 1922 was just short of 50 per cent.

Cost of Control. The question whether this measure of control can be obtained at a reasonably low cost is answered by the data given in the last two columns of summary in Table VIII. In those columns are given the total and *per capita* cost in each of the control areas. The total cost per Control Unit did not vary much for the different districts, since the principal item was the salary of the malaria inspectors. There is, however, a considerable variation in the *per capita* cost; it varied from a minimum of piastres P 5·0 ($0·23) in Ecron to a maximum of piastres 34·0 ($1·55) in Kinereth. This difference was to be expected, owing to the variation in the density of the population per Unit area. In Judea the density of the population is relatively high, while in the Valley of Esdraelon and Galilee it is very low. Since the total cost will remain the same or even decrease as the density of the population increases, it is apparent that the *per capita* cost of the control work will diminish progressively, as the population grows. Even at present, however, the *per capita* cost compares favourably with that of the Antimalaria Demonstrations in the U.S.A. (6).

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EXPLANATION OF PLATES VI–IX.

PLATE VI.

Figs. 1–3. The plain after a heavy rain. The rush of water from the hills fills the dry stream beds, which are converted into rushing rivers, whose banks overflow, and flood the country-side. The rush of water is so powerful that it dislocates bridges and tears immense holes in the wadi beds.

PLATE VII.

Fig. 1. A cleaned pool in a winter wadi. When cleaned of algae and water weeds the pool is no longer favoured by *Anopheles elutus.*

Fig. 2. Control of breeding by regulating a stream. This picture shows the same wadi as in Fig. 2, Pl. VIII, after it had been regulated.

Fig. 3. Control of a large spring swamp by alternation of flow. Two large channels were cut from this spring, one north and the other east, and the water sent alternately five days in the north and five days in the east channel. The water is also used for irrigation which is thus automatically regulated.

PLATE VIII.

Fig. 1. A deep pool in a winter wadi, eroded by the flood and remaining the entire year. This picture shows a pool immediately after the rains. The rains have an excellent scouring effect.

Fig. 2. A flowing spring stream, full of stones and overgrown with algae. The algae and pools under the stones offer excellent breeding places for *A. superpictus* and *A. sergenti.*

Fig. 3. Pools similar to the one in Fig. 1, overgrown with algae, ranunculus and marsh grass, and breeding *A. elutus* (*maculipennis*).

PLATE IX.

Fig. 1. Shepherds' watering holes—excellent breeding places for *A. elutus* (*maculipennis*).

Fig. 2. Another type of breeding place. A temporary pond formed in a blind pocket and remaining for two or three months after the rains; until June or July 1—long enough to be a serious cause of malaria.

Fig. 3. Vegetation in overgrown wadis. In such places Paris Green is the most effective larvicide.

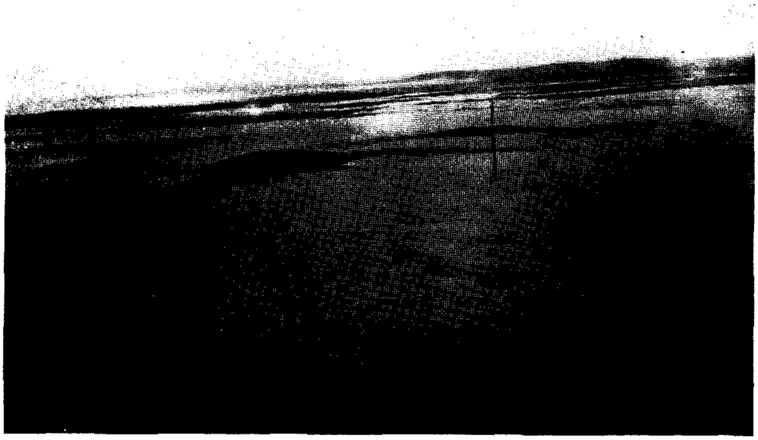

Fig. 1

Fig. 2

Fig. 3

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Fig. 1

Fig. 2

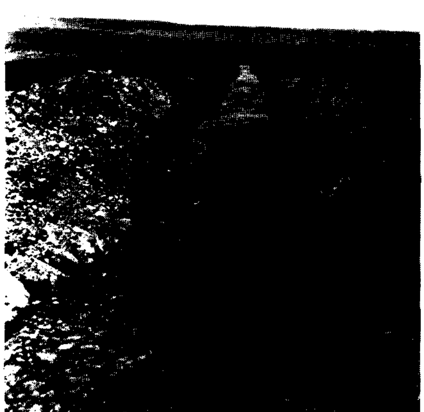

Fig. 3

https://doi.org/10.1017/S0022172400034215 Published online by Cambridge University Press

Fig. 1

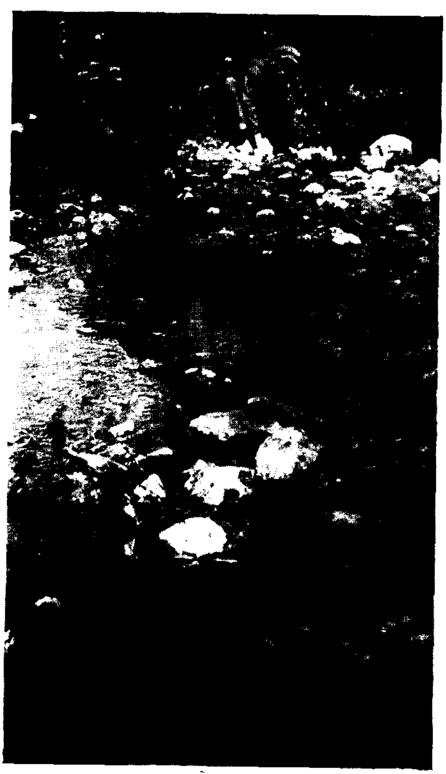

Fig. 2

Fig. 3

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Fig. 1

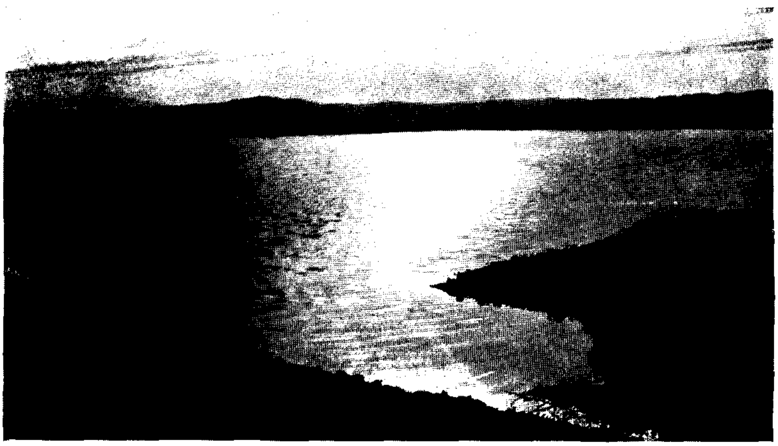

Fig. 2

Fig. 3

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