

A NINTH YEAR'S OBSERVATIONS ON MALARIA IN PANAMA, WITH REFERENCE TO THE OCCURRENCE OF AN EPIDEMIC FOLLOWING CONTINUED TREATMENT WITH ATABRINE AND PLASMOCHIN

H. C. CLARK, W. H. W. KOMP, AND D. M. JOBBINS

From the Gorgas Memorial Laboratory, Panama City, Panama, Post Office Box 5025, Ancon, Canal Zone

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The observations made during the past year (September 1938 to August 1939) are a continuation of those begun in 1930, and carried on uninterruptedly since that time. Our previous reports (1-8) contain the details of the location, terrain, the population involved, and their conditions of life, and should be consulted for these data. They also contain our observations on malaria as we have encountered it in the group of persons under observation, together with a description of the methods used in attempting to control the disease under field conditions. Our aim, as already stated, is to determine the feasibility of control by drug treatment alone, in an area in which anti-mosquito measures are too costly to be practicable. Commercial ventures in the tropical lowlands must operate in such areas as these, and from such populations they must draw their labor. Any method of controlling malaria, which is always the cause of the greatest morbidity among such a labor supply, to be practicable under such conditions must be easily applied and not too costly to offset the benefits it brings. We believe that a partial control, which is obtainable by the use of drugs in the manner outlined in our previous papers, is relatively easily attained.

Our previous reports should be consulted for the details of the methods used in attempting to control malaria in the area under observation. We have not varied these methods during the past year. The observations contained in the present report

simply continue those previously reported. In addition to the observations on malaria incidence during the year, we have been fortunate during the past year in obtaining information, lacking in previous years, as to the numbers of larval and adult *Anopheles* present in the area concerned, during the various seasons of the year. The new data have been compared with the monthly malaria rates in the various towns, and some interesting correlations, and some more interesting lack of correlation, have been found. The past year has been an exceedingly dry one, rainfall being much below normal in almost all parts of Panama. This has caused a diminution in the flow of the Chagres River, along the banks of which our towns are located. Backwater conditions in the river resulted, very favorable to mosquito breeding. High densities of these mosquitoes have been encountered, in some instances accompanied by high infection rates. In other areas, high infection rates were not accompanied by high incidence of *Anopheles* mosquitoes. In such cases, other factors besides mosquito density enter into the picture, and will be discussed later.

SURVEY METHODS

All the inhabitants of the towns who can be reached on survey days are surveyed every month, the thick-film technique of Barber and Komp (9) being used. The staining and examining of the films is done by experienced technicians, many of whom have been doing this work since the inception of our observations. In addition to the persons whose blood-films are taken on the regular survey days, many persons not then available have been surveyed by one of us during the remainder of the month, so that our records are somewhat more complete for all persons under observation than they have been during previous years.

TREATMENT METHODS

The following statement is taken with slight modifications from our previous annual report (8). "The population of the area under observation was divided into two groups. The first, living in the towns of Agua Clara, Santa Rosa, Guayabalito,

Las Guacas, and Gatuncillo, and comprising about 350 'regular' inhabitants, was treated with atabrine 0.1 gram three times a day for a period of five days (total 1.5 gram), followed by plasmochin simplex 0.01 gram twice a day over a succeeding period of five days. This treatment was administered to all those found positive in the monthly surveys. The second group consisted of approximately 550 inhabitants of New San Juan, a village situated on a small tributary of the Chagres River, about two miles from the nearest Chagres River village. Here, quinine sulphate, 15 grains daily for 5 days, is administered by two native women to all the positives found during the monthly surveys. During the following week, plasmochin simplex 0.01 gram twice a day for 5 days, is administered by a 'supervisor,' an intelligent native man who has been doing the same work for a number of years past. One of us visits all the towns one day a week, exclusive of the survey day, during the period of plasmochin administration, and another of us is in almost daily contact with the inhabitants of the Chagres River villages." In these latter villages, treatment is given to all clinical cases as the need arises, so that they are in a better position to profit from such anti-malaria measures than are cases occurring in New San Juan.

RESULTS OF MALARIA SURVEYS IN 1938-1939

Table 1 shows the monthly malaria parasite rate, compared with the rainfall as recorded at Madden Dam, a few miles north east of the area in which the villages are situated. Totals for three previous years are given at the bottom of the table. Again no correlation of malaria rate with rainfall can be noted. Five inches less rain fell in June 1939 than did in June 1938. The total rainfall for the year was 28.55 inches less than in the year previous. Mosquito production in our area is not directly dependent on rainfall, as most of the larvae are found in the vegetation-covered lagoons and backwaters of the Chagres River, which are full during the entire year.

A total of 1826 examinations were made during the year, and malaria parasites were found in 416 cases, a rate of 28.3 per cent, which is *somewhat higher* than the rate of 23.5 per cent found

TABLE 1

Monthly malaria parasite rates compared with rainfall at Madden Dam

MONTH	CHAGRES VILLAGES	NEW SAN JUAN	MADDEN HIGHWAY	RAINFALL* AT MADDEN DAM
September, 1938.....	4.0	6.8		7.45
October, 1938.....	5.5	5.6		15.52
November, 1938.....	4.7	16.0		12.73
December, 1938.....	3.2	13.7		14.25
January, 1939.....	6.9	14.8		0.02
February, 1939.....	11.8	12.0		0.01
March, 1939.....	5.5	8.1		0.06
April, 1939.....	5.4	5.5		0.11
May, 1939.....	5.4	9.9		3.29
June, 1939.....	8.1	4.6		11.16
July, 1939.....	6.9	6.7		7.05
August, 1939.....	17.5	6.5	20.8†	11.93
Totals.....	7.1	9.3	20.8	83.58
Totals, 1937-38.....	6.7	6.6	16.4	112.13
Totals, 1936-37.....	7.4	14.4	16.2	88.33
Totals, 1935-36.....	9.1	12.3	18.5	110.13

* Rainfall in inches.

† Buenos Aires school and village on Madden Highway.

290 children, 22.8 per cent positive. 85 adults, 16.4 per cent positive. 375 people, 20.8 per cent positive.

TABLE 2

Parasite index. Adults (over 15 years) versus children (15 years and under), cumulative result for the year

	ADULTS			CHILDREN		
	Examined	Positive	Per cent	Examined	Positive	Per cent
Chagres villages (5).....	353	91	25.7	294	81	27.5
New San Juan.....	303	74	24.4	269	92	34.2
Madden highway*.....	85	14	16.4	290	64	22.1
Totals.....	741	179	24.1	853	237	27.8

* A single survey in August of Buenos Aires located on Madden Highway.

during the previous 12 months of 1937-38, and is accounted for by the sharp rise in rates during the last months of the year.

Table 2 shows the parasite rate for 1219 persons, the average

number of "permanent" inhabitants in the two treated groups. The Chagres group received atabrine and plasmochin, and the population of New San Juan received quinine sulphate and plasmochin. These two groups are divided into adults and children, and the rates are cumulative for the year. That is, of the 353 persons examined during the year in the adult Chagres group, there were 91 positive examinations, giving a per cent of 25.7.

Table 3 shows the number of persons examined in the monthly survey one to five times, six to eleven times, and those examined in all the 12 monthly surveys during the year. This table in-

TABLE 3
Parasite index. Three survey groups. All areas

LOCATION	1 TO 5 SURVEYS			6 TO 11 SURVEYS			12 COMPLETE SURVEYS		
	Examined	Positive	Per cent positive	Examined	Positive	Per cent positive	Examined	Positive	Per cent positive
Chagres villages.....	349	59	16.9	216	80	37.0	82	34	41.4
New San Juan.....	345	64	18.5	167	75	44.9	60	27	45.0
Madden highway*.....	375	78	20.8						
Totals.....	1069	201	18.8	383	155	40.4	142	61	42.9

* School children of Buenos Aires and some neighborhood adults.

dicates that, as might be expected, the more times an individual is examined, the more often malaria parasites are apt to be found. The number examined in all twelve surveys during the past year was somewhat less than the number so examined in the previous year, 82 as against 92, but there was little difference in the rate of positives, 41.4 in 1938-39 as against 38.0 per cent in 1937-38. The slight rise noted in the past year is owing to the increase of positives found during the last few months of the period. The decreased number of those examined 12 times out of a possible 12 times, indicates that the population is becoming increasingly migratory, because of better transportation facilities, and this fact and its influence on our work will be referred to later. The increase in rate of positives during the past few months indicates

that we are passing out of the period of low incidence which has existed during the past several years, into a period of higher incidence.

In table 4 the cumulative malaria rate by age-groups is given. The total number of individuals examined is 1594. This includes many individuals examined only once during the course of the 12 monthly surveys, and includes the survey of school children and adults living in the former control areas of Chilibre, Buenos Aires, and Madden Dam Highway.

TABLE 4

Cumulative incidence of malaria by age groups. All areas combined

	CHAGRES			NEW SAN JUAN			MADDEN HIGHWAY			TOTALS		
	Examined	Positive	Per cent	Examined	Positive	Per cent	Examined	Positive	Per cent	Examined	Positive	Per cent
0-5 years.....	145	27	18.6	122	28	22.9	36	4	11.1	303	59	19.4
5-10 years.....	83	31	37.3	86	37	43.0	126	25	19.8	295	93	31.5
10-20 years.....	138	49	35.5	119	46	36.8	158	43	27.2	415	138	33.2
20-40 years.....	179	36	20.1	159	40	25.1	39	5	13.1	377	81	21.4
40-60 years.....	78	23	28.2	63	11	17.4	16	1	6.2	157	35	22.3
Over 60 years.....	24	6	25.0	23	4	17.4	0	0	0.0	47	10	21.2
Totals.....	647	172	26.6	572	166	29.0	375	78	20.8	1594	416	26.1
1937-8 totals.....	709	203	28.6	561	116	20.7	287	47	16.4	1557	366	23.5
1936-7 totals.....	639	223	35.0	600	222	37.0				1239	445	35.9
1935-6 totals.....	688	244	35.4	710	239	33.6				1398	483	34.5

Totals for the three previous years are given at the bottom of table 4. They indicate a slight but definite increase for the present year, to 26.1 per cent, from the low of 23.5 per cent in 1937-38. It is of great interest to note that the positive rate for the school children examined in the former control area was 20.8 per cent, which compares very favorably with the rate of 18.8 found among those in the treated villages, who were examined from 1 to 5 times only during the year. When it is considered that most of those examined in the former control areas were school children under 15 years, who normally have a higher

malaria rate than adults, who comprised the bulk of those examined 1 to 5 times in the treated areas, the difference in percentage of those found positive in these two groups is even less marked. Again it is noted that the highest incidence occurred

TABLE 5

Individuals surveyed 12 consecutive months. Entered by age groups

AGE GROUPS	CHAGRES			NEW SAN JUAN			TOTALS		
	Examined	Positive	Per cent positive	Examined	Positive	Per cent positive	Examined	Positive	Per cent positive
<i>years</i>									
0-5	38	14	36.8	28	12	42.8	66	26	39.4
5-10	17	9	52.9	17	8	47.0	34	17	50.0
10-20	5	2	40.0	5	2	40.0	10	4	40.0
20-40	14	7	50.0	6	3	50.0	20	10	50.0
40-60	6	2	33.3	1	1	100.0	7	3	42.8
Over 60	2	0	0.0	3	1	33.3	5	1	20.0
Totals..	82	34	41.4	60	27	45.0	142	61	42.9

TABLE 6

Individuals (61) showing malaria who were surveyed in 12 consecutive monthly surveys

NUMBER OF TIMES POSITIVE	CHAGRES VILLAGES (ATABRINE-PLASMOCHIN)	NEW SAN JUAN (QUININE-PLASMOCHIN)	TOTALS
1	16	23	39
2	5	7	12
3	2	3	5
4	3	0	3
5	0	1	1
6	0	0	0
7	1	0	1
Totals.....	27	34	61

in the age-group 10 to 20 years. Low rates were obtained in the age-group 0 to 5 years, showing that the increase in total malaria had struck hardest in the later age-groups.

Table 5 shows the cumulative malaria rate in the 142 persons who were examined in every consecutive survey over 12 months. The data are presented by age-groups. The number of persons

examined 12 consecutive times was somewhat less than in the previous year. Of the total of 142 persons, 81 or 57.1 per cent were negative for parasites at every examination. This is a somewhat lower per cent of negative cases as compared with the rate last year, 63.2 per cent, and it was obtained among a smaller sample of the population.

Table 6 shows the number of times 61 persons, examined 12 times, and found positive in at least one of the 12 consecutive surveys, were found parasite-positive during the 12 surveys. In this table, all persons, whether in the atabrine-treated or in the quinine-treated group, are included.

TABLE 7
Individuals (62) surveyed 10 or 11 monthly surveys

NUMBER OF TIMES POSITIVE	CHAGRES (ATABRINE-PLASMOCHIN)	NEW SAN JUAN (QUININE-PLASMOCHIN)	TOTALS
1	12	14	26
2	14	8	22
3	4	1	5
4	3	1	4
5	0	3	3
6	1	1	2
Totals.....	34	28	62

Table 7 shows the number of individuals examined in 10 or 11 of the 12 consecutive surveys during the year. There were fewer persons positive in successive months in the quinine-plasmochin treated village, New San Juan, than in the atabrine-plasmochin treated villages, although the numbers in each group are too small to be of much significance.

OBSERVATIONS ON TYPES OF MALARIA PARASITES, CRESCENT INCIDENCE, INTENSITY OF INFECTIONS, AND EPIDEMIC CONDITIONS

The results in table 8, which shows the species of malaria parasites found in individuals during the year, are based on the number of individuals found positive, instead of on the number of positive slides.

Table 9 shows the incidence of each species, whether or not it occurred mixed with another. It is interesting to observe that a great increase in number of quartan malaria positives occurred during the past year. This increase was sharply localized in the control areas surveyed only once during the year, in July 1939 (see table 8, column 3). It was also largely confined to children. It is believed that this increase in quartan malaria followed the introduction of new cases from Colombia and Haiti.

TABLE 8

Species of malaria parasites found in individuals during the year

SPECIES OF PARASITES	CHAGRES VILLAGES	NEW SAN JUAN	MADDEN HIGHWAY	TOTALS
<i>P. falciparum</i>	108	134	39	281
<i>P. vivax</i>	36	17	7	60
<i>P. malariae</i>	7	3	32	42
<i>P. falciparum</i> and <i>P. vivax</i>	14	11	0	25
<i>P. falciparum</i> and <i>P. malariae</i>	6	1	0	7
<i>P. vivax</i> and <i>P. malariae</i>	1	0	0	1
Totals.....	172	166	78	416

TABLE 9

Incidence of each species taken separately

SPECIES	NUMBER	PER CENT OF TOTAL
<i>P. falciparum</i>	316	69.9
<i>P. vivax</i>	86	19.0
<i>P. malariae</i>	50	11.1
Total.....	452	100.0

The percentage of *falciparum* infections decreased somewhat during the year, in spite of the sharp increase in positive rate during the last two months of the period.

Table 10 shows the incidence of crescents among the *falciparum* positives. The crescent rate in all *P. falciparum* infections was slightly less, 35.8 per cent, in 1938-1939 than the rate, 44.0 per cent, during the previous year. The percentage of crescents found in the atabrine-plasmochin treated towns was slightly

higher than in the quinine-plasmochin treated town, reversing the conditions found last year. However, the numbers were too small to be of great significance.

Table 11 gives the incidence of "heavy" infections found in the surveys. A "heavy" infection is one in which one or more

TABLE 10
Crescent rate in P. falciparum cases

LOCALITY	NUMBER OF P. FALCIPARUM CASES	NUMBER OF CRESCENT CARRIERS	PER CENT OF CRESCENT CARRIERS
Chagres Villages.....	128	50	39.0
New San Juan.....	146	52	35.6
Madden Highway.....	39	10	25.6
Totals.....	313	112	35.8

Feeder cases?:

Chagres villages.....	14 crescent carriers +
New San Juan.....	12 crescent carriers +
Madden Highway.....	3 crescent carriers +
	29 crescent carriers +

TABLE 11
Heavy infections found in surveys

LOCALITY	NUMBER OF INFECTIONS FOUND	NUMBER OF HEAVY IN- FECTIONS	PER CENT OF HEAVY IN- FECTIONS
Chagres Villages.....	172	37	21.5
New San Juan.....	166	32	19.2
Madden Highway.....	78	10	12.9
Totals.....	416	79	18.9

parasites are found in each thick-film microscopic field. The rate, 18.9, is somewhat higher this year than it was last year, 17.3 per cent. As will be mentioned later, in the discussion of epidemic conditions at the end of the year, there was a sharp increase in number of heavy infections at the beginning of the epidemic.

INFECTIONS IN INFANTS

Table 12 shows in tabular form the number of infants under 12 months of age surveyed during the year. Sixty-five infants are included, some of which were examined only once during their first year of life. Only one of these infants, a child from New San Juan, showed *P. falciparum* parasites in large numbers in its 7th and 8th months. The parasite rate for these infants was, therefore, 1.5 per cent for the year. Apparently the epidemic which will be described in the next paragraph had not extended to the infants and small children, by the end of the period covered by this report. In all the towns, 21 infants were examined, an average of 2 times during the months of July, August and September 1939, and all were found negative.

EPIDEMIC CONDITIONS DURING LAST MONTHS OF PERIOD

Table 13 shows the rates in all the villages for the 13 months, September 1938 to September 1939. It is necessary to include the last month in this discussion, as the epidemic did not appear in some of the towns until after the end of the year September 1938–August 1939.

In previous reports, we have stressed the possibility that epidemic conditions might arise suddenly in our population, which has been deprived of a great portion of its natural immunity as a consequence of the intensive treatment of all persons showing malaria parasites, which has been in effect in the past. Such an epidemic, long predicted and long overdue, has appeared during the last few months of the year. As will be noted in the malaria rates as shown in table 1 for the Chagres River villages (column 1), there was a sudden rise in August to 17.5 per cent, from a rate of 6.9 per cent during the previous month. This rise was owing to high parasite rates encountered during August in three of the four towns situated along the banks of the Chagres River, namely, Santa Rosa, Guayabalito, and Gatuncillo. This rise occurred most sharply in the two villages of Santa Rosa and Gatuncillo. In July the rates were respectively 5.4 and 4.3 in these two towns. In August the rates were respectively

29.6 and 21.4. There was nearly six times as much malaria in Santa Rosa in August as in July, and five times as much in August in Gatuncillo, as in the preceding month.

At the time of writing this report (October 1939), survey figures for September 1939 were complete, and show a marked rise in three towns, Las Guacas (12.0 per cent), Guayabalito (32.0 per cent), and New San Juan (21.8 per cent), in which increases in malaria rate were not noted in August 1939. This increase

TABLE 13
Chagres river villages

MONTH	LAS GUACAS	AGUA CLARA	SANTA ROSA	GATUN- CILLO	GUAYA- BALITO	TOTAL AVERAGE	NEW SAN JUAN
September, 1938.....	2.5	3.9	3.1	1.9	7.1	4.0	6.8
October, 1938.....	0.0	5.9	2.7	4.1	11.1	5.5	5.6
November, 1938.....	3.3	0.0	6.9	0.0	7.5	4.7	16.0
December, 1938.....	0.0	0.0	4.5	3.9	4.7	3.2	13.7
January, 1939.....	6.8	2.8	5.0	12.3	6.5	6.9	14.8
February, 1939.....	2.3	10.1	8.1	23.4	14.6	11.8	12.0
March, 1939.....	2.3	7.0	5.4	3.9	7.4	5.5	8.1
April, 1939.....	2.5	5.0	1.1	12.3	5.8	5.4	5.5
May, 1939.....	0.0	2.1	8.2	6.8	5.6	5.4	9.9
June, 1939.....	3.2	6.8	7.8	9.5	10.4	8.1	4.6
July, 1939.....	5.0	0.0	5.4	4.3	15.6	6.9	6.7
August, 1939.....	4.4	8.3	29.6	21.4	16.0	17.5	6.5
Totals.....	2.8	4.5	7.2	8.8	9.4	7.1	9.3
September, 1939.....	12.0	1.9	23.3	14.8	32.0	17.6	21.8

was greatest in New San Juan, where rates rose from 6.5 per cent in August to 21.8 per cent in September.

The epidemic of the summer of 1939 was slow in appearing, and from the figures given above, it is shown that it did not strike all towns with equal severity at the same time. In this respect the present epidemic differs from that described in our fifth year's report (5), in which all towns were affected simultaneously. However, rates in some of the towns were nearly as high as those encountered in the epidemic of 1935. For instance, the rate in January 1935 for Guayabalito was 34.4 per

cent. In the present epidemic, it was 32.0 per cent in September 1939.

A portion of the epidemic was undoubtedly owing to relapses from previous infections, but many new infections occurred in individuals previously negative throughout the preceding year. Thus in the months of July, August and September, Guayabalito had 22 new cases out of a total of 48 positives. In July and August, Santa Rosa had 20 new cases out of 28 positives. In August, Gatuncillo had 5 new cases out of 11 positives. In September, New San Juan had 30 new cases out of 52 positives. All these 77 new cases were in individuals previously negative throughout the preceding 12 months. In other words, during the three months of July, August, and September 1939, 55.4 per cent of all positives in these towns were new cases. This is conclusive evidence of epidemic conditions.

Another evidence of these conditions was the number of heavy infections encountered during this period. Santa Rosa had 9 heavy infections out of 28; Guayabalito had 8 out of 58; Gatuncillo had 3 out of 19. New San Juan, in September 1939 had 13 heavy infections out of a total of 52 positives, giving a rate of 25.0 per cent heavy infections. In 12 previous months there was a total of 277 positives, of which only 27 were heavy infections, a rate of 9.8 per cent heavy infections.

Unfortunately, no record was kept of the number of clinical cases of malaria which occurred during this epidemic, but it is known that such cases were much more frequently encountered among the population during surveys and at the visits made to the towns between surveys. In a population such as ours, many persons give little evidence of a malaria infection, and our visits are too few to make it possible to discover every clinical case as it occurs.

LOCAL CONDITIONS FAVORING ANOPHELES BREEDING DURING THE YEAR

Conditions on the Chagres River between Madden Dam and Gamboa with regard to mosquito breeding in 1939 were greatly different from those of previous years. Near the end of the rainy

season (on December 16, 1938) approximately six times the normal flow of water released from Madden Lake into the Chagres River. This increased outflow caused the washing away of vast areas of aquatic vegetation which supported mosquito breeding in the vicinity of the villages along the banks of the river. The floating plant, *Pistia stratiotes* (water-lettuce) in which *Anopheles bachmanni* breeds, was almost entirely swept away, and *Cabomba aquatica*, an attached floating plant, a favored breeding-place of *Anopheles albimanus*, was secured from the surface. Thus, in January 1939, at the beginning of the dry season, the Chagres River in the vicinity of the town of Santa Rosa was practically free from areas of anopheline production.

Water discharge from Madden Lake was continued through January and February at a rate greater than that of the previous year. This was done to raise the level of Gatun Lake previous to the passage of the United States Fleet through the Panama Canal. By the month of March, when outflow was reduced, the result of this earlier outflow was to leave the river with a low gradient between Madden Dam and Gamboa. This gradient was 18 per cent less than in March of the previous year. *Cabomba* appeared on the surface in quantity in the latter part of March, and numbers of *A. albimanus* larvae appeared in it. The low gradient of the river favored the persistence and spread of this aquatic plant. At the end of the long dry season in May, water usually enters the Chagres from Madden Lake. During the present season, however, water was held in storage in Madden Lake for more than four months after the beginning of the rains in May, and the Chagres during this period was put into a mild state of stagnation, which further favored mosquito production. The center of larval breeding shifted upstream toward the native villages.

Heavy emergence of *A. albimanus* came in the third week of April, approximately one month before the first rains. Emergence continued at a slightly reduced rate through the first part of the rainy season, supplying the villages of Santa Rosa and

Guayabalito with a quantity of both fresh and mature adult females.

The number of *A. albimanus* females taken in house collections in Santa Rosa, which is situated near the areas of intense anopheline production, during the months April through July averaged between 10.7 and 16.6 per house per collection, as compared with less than one anopheline per house per collection in New San Juan, which is located one and one-half miles from the Chagres River.

Table 14 shows the average numbers of Anopheles mosquitoes captured per house per day, in the town of Santa Rosa, from November 1938 to August 1939. This table shows that the peak

TABLE 14

Seasonal abundance of anophelines in Santa Rosa 1938-1939. Average number of mosquitoes per house per day

	1938		1939							
	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
All houses.....	8.6	3.4	4.8	5.4	4.6	10.7	16.6	*	12.0	9.3
All houses minus no. 23.	9.1	3.5	4.3	5.5	3.1	3.4	8.6		7.5	4.5
House no. 23.....			6.7	5.4	7.7	32.4	35.4	21.3	38.6	22.0

* Owing to unavoidable turnover in personnel, figures for June are incomplete, and are not included in the table.

of seasonal abundance in this town occurred in May 1939. It also shows the peculiar attraction of one house (No. 23) for Anopheles mosquitoes. This house was nearly three times as attractive as the average house in the rest of the community, during the months of greatest emergence of mosquitoes. Many factors worked together to increase the attractiveness of this house. It was an old cane-walled, thatched-roofed house, set in the midst of a grove of mango trees. It was in a damp location, and was kept more damp by the practice of throwing slops from the kitchen on the ground at the back door. It housed a population of 10 persons, many of whom were young children.

A rather direct correlation between the attractiveness of a

house to *Anopheles* mosquitoes, and the number of cases of malaria occurring in it, is shown in table 15.

Houses 23, 26, and 29 were the most attractive to mosquitoes of all the houses in Santa Rosa. It will be seen that all ten of the inhabitants of house 23 were positive at some time during the year 1938-1939, while less numbers were found positive in the other two houses which were less attractive. Of the 20 individuals living in these three houses, 17, or 85.0 per cent were positive for malaria during the year. Of the 59 remaining persons, living in the 20 other houses, only 20 were positive, or 34.0 per cent.

While the evidence seems rather conclusive that there is a correlation between anopheline abundance and malaria infec-

TABLE 15

The correlation between malaria positives and anopheline prevalence in Santa Rosa

HOUSE NUMBER	INHABITANTS	POSITIVE, 1938-1939	MOSQUITOES PER HOUSE PER COLLECTION. 3 MONTH AVERAGE. APRIL, MAY, JUNE, 1939
23	10	10	32.0
26	6	4	10.7
29	4	3	11.0
Remaining 20 houses	59	20	5.5

tions in Santa Rosa, the same correlation does not hold in the town of New San Juan. As mentioned in our second annual report (2) for 1931-1932, very few mosquitoes could be found in the houses in this town. This is also true of the present season. During 1932, the greatest number of *Anopheles* taken in a single house in New San Juan was 6, and the greatest total on any one day was 19, out of a total of about 90 houses examined. Yet the malaria rate in New San Juan was 18.1 per cent for the year September 1931-August 1932. During the present season, while complete figures on anopheline density were not obtained in New San Juan, it can be stated that there was no increase in numbers of mosquitoes per house, immediately preceding or during the sharp rise in malaria parasite rate which occurred in

September 1939. This rise brought the rate from 6.5 per cent in August to 21.8 per cent in September 1939.

SUMMARY

The present report is the ninth of a series of observations on malaria in a native population in Panama. This population has been under observation and treatment with various drugs since 1931.

As in previous years, no correlation with annual rainfall is shown in the monthly malaria parasite rates. The parasite rate, cumulative for the 12 months, shows that there was a small increase in the number of persons, examined at every monthly survey, who had parasites in their blood during the past year (41.4), as compared with a similar group in 1937-1938 (38.0). The slight increase is owing to the epidemic conditions which appeared during the last months of the period.

The incidence of the various species of parasites found was nearly the same as in previous years, although the percentage of *P. falciparum* decreased slightly, in spite of the epidemic at the close of the year. A focus of quartan malaria was discovered among the inhabitants of the former control area.

As an evidence of epidemic conditions, in which young children are not so heavily positive as in endemic areas, the parasite rate among 65 infants less than a year old was only 1.5 per cent. Among 21 infants examined an average of twice during the epidemic months of July, August, and September 1939, none was positive.

In spite of continuous treatment with three potent drugs an epidemic occurred during the last few months of the period of observation. This epidemic has been prophesied for a number of years past. Its occurrence gives additional point to the statements made in previous years concerning the necessity of having a knowledge of the local cycle of malaria, before evaluating control measures. Our monthly parasite rates show that little active malaria was present in our population before July 1939. Had our observations ceased at this time, we might have congratulated ourselves on the success of our treatment methods.

But again, as in the early months of 1935, an epidemic wave swept the parasite rates twice to three times as high as they were in preceding months. Along with this increase in parasite rate, there was a concomitant rise in number of new infections, and in number of heavy infections. Clinical cases also appeared in numbers. Epidemic conditions continued at the end of the present year of observation.

For the first time since our work began, data were obtained on the relation of mosquito density to malaria rates. In one town a close correlation appeared between numbers of *Anopheles* and numbers of positive cases. However, this correlation did not hold true in another town, where malaria was prevalent, although *Anopheles* were few.

A parallel between stagnant river conditions, increase of aquatic vegetation, and *Anopheles* production was found in the Chagres River area during the spring months. The increase in mosquitoes observed came somewhat earlier than did the increase in malaria rates in the river villages; but no increase in mosquitoes was noted in New San Juan, although this town also experienced epidemic conditions.

As the epidemic observed during the past season occurred during the last few months of the period, it is planned to continue our observations, to obtain further information regarding its course, and the relation of mosquito density to the malaria rates in the villages under observation.

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