

## A SIXTH YEAR'S REPORT ON MALARIA IN PANAMA (CHAGRES VALLEY) WITH REFERENCE TO DRUG CONTROL<sup>1</sup>

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The observations here reported have been in progress over a period of six years, and our annual reports on the subject (1, 2, 3, 4 and 5) will furnish the details regarding the location, inhabitants, homes, etc. The main object of this study is to find a suitable compromise in malaria control that can be placed in effect by business organizations operating in the lowlands of the tropics, who may not be able to apply satisfactory antimosquito measures. Our aim is to find a method to increase labor efficiency and help to stabilize labor forces by controlling malaria in such places. In our last year's report (5), we came to some rather definite conclusions regarding the possibilities and the limitations of the drug control methods we have been using. As these conclusions were based upon what, in the long run, may be considered a relatively short period of observation, it was deemed advisable to continue the observations under the same plan, until another cycle of malaria is accomplished.

All of the areas under study lie between the new Madden Dam and the eastern boundary of the Panama Canal Zone. Construction work at Madden Dam is now completed, and the effect of the newly-formed Madden Lake on localities immediately below it requires further observation. The same methods of survey and treatment have been used as were employed during the previous year's observations. We have divided the inhabitants in this region into three approximately equal groups. Two of

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these groups were used as controls on the other group, in which the main drug control effort was made. In this report these three groups will be known as Chagres, New San Juan, and Madden Highway.

#### CHAGRES

These people live on the banks of the Chagres river between the Madden Dam and eastern boundary of the Canal Zone, in four villages so close together that we consider them as one town in this report (Santa Rosa, Guayabalito, Gatuncillo, and Las Guacas). These people when found positive for parasites in the monthly surveys were treated with atebirin, 0.1 gram three times a day for a period of five days, followed by plasmochin simplex 0.01 gram twice a day over a succeeding period of five days. Severe clinical cases were given seven days of atebirin treatment instead of five days.<sup>4</sup>

A native girl in each of the four villages assists a supervisor in the administration of the drugs. The supervisor lives in Santa Rosa, so these four villages have almost constant access to him, and also receive three visits a month from one of our staff in addition.

#### NEW SAN JUAN

This village contains about the same number of people as are included in the four Chagres villages. It is located on the banks of the Gatuncillo river, a branch of the Chagres, and is about 2 miles, on an air line, north of the Chagres channel. This village is cared for by two native girls who receive assistance from the supervisor five days in each month, and one day a month from a member of our staff. Parasite positives were treated with 15 grains of quinine sulphate each day for five days followed by plasmochin simplex 0.01 gram twice a day during the following five days. The supervisor administers the latter drug. An

<sup>4</sup> This is the same dosage as was used in these villages last year; through an importunate typographical error on p. 110 of our Fifth report (5), the dosage of atebirin used was stated to be 1.0 gram given over five days. This should be 1.5 gram over a period of five days.

average of three to five clinical cases of malaria a month in this town were given Atebrin instead of quinine, since in some children quinine was not retained, or offered great difficulty in its administration.

#### MADDEN HIGHWAY

The villages of Chilibre, Buenos Aires and Aguas Buenas are all located on the southern slope of the Chagres valley, about 5 miles from the river channel; the elevation is 50 to 100 feet higher than that of the Chagres villages. These villages are right at the side of the concrete road known as Madden Highway, on that part of the highway nearest to Madden Dam, but within the Republic of Panama. It is an agricultural region traversed by small streams that empty into the Chagres. Due to the ease with which these people can reach Panama City by auto-bus it is difficult to find them regularly on survey days. The severe cases of malaria often leave this control area for treatment in Panama City. While not ideal for our purpose, it is the most available control group we could find; these people are simply surveyed once a month, the positive name list returned to the village officer of Chilibre, and free quinine sulphate also left with him. The people call at his office to learn whether they are on the positive list, and to secure enough quinine for a course of 15 grains daily over a period of five days, if they so desire. It is entirely voluntary whether they seek information regarding their blood test and whether they take treatment. Each year they take better advantage of this opportunity, and thereby reduce the value of the group as a natural control. None of us visit this area but once a year, except for a technician from our laboratory who takes the blood survey monthly and returns the name list and drug. Buenos Aires and Aguas Buenas were not included in the control area in 1935. The group surveyed in Buenos Aires contains a higher proportion of children under 14 than do Chilibre and Aguas Buenas. This tends to increase the parasite rate in the control area, and must be allowed for in interpreting the results of blood surveys.

## SURVEY METHOD

A monthly survey, near the middle of each month, is conducted in all three of these areas. The thick-film technique of Barber and Komp (6) has been used in all the surveys, and the preparation and examination of blood films is in the hands of experienced technicians.

The remainder of this report will be presented as far as possible by the use of tables. It is believed that this will make this year's record easier to compare with our former reports.

TABLE 1

*Monthly malaria parasite-index compared with Madden Dam rainfall.*

MONTHS	CHAGRES VILLAGES	NEW SAN JUAN	MADDEN HIGHWAY	MADDEN DAM RAINFALL
<i>1935</i>				
	<i>per cent</i>	<i>per cent</i>	<i>per cent</i>	<i>inches</i>
September.....	6.5	9.9	20.0	13.94
October.....	6.1	11.1	22.2	14.84
November.....	10.6	13.3	22.4	33.32
December.....	9.2	17.2	14.1	6.07
<i>1936</i>				
January.....	9.0	19.7	17.3	0.08
February.....	9.7	9.5	17.5	0.07
March.....	11.2	9.2	10.8	0.09
April.....	11.4	8.2	17.2	1.02
May.....	9.4	10.3	19.4	12.00
June.....	9.2	10.8	23.8	6.88
July.....	9.1	15.1	20.5	13.00
August.....	8.6	13.8	16.7	8.82
Total.....	9.1	12.3	18.5	110.13

The comparative rates for the three groups shown here present the striking feature that, as in all past years, the parasite index fails to drop significantly with the decline in rainfall during the dry season. The great epidemic experienced in 1935 occurred during the period from January to April inclusive, exactly coinciding with the period of least rainfall. Mosquito production in our areas is not dependent on rainfall, as most of the breeding occurs in the lagoons and backwaters of the Chagres River, which maintains a more or less constant level throughout the year.

The average permanent population of these three areas during the year is as follows: Chagres, 335; New San Juan, 297; Madden Highway villages, 290. If these numbers are kept in mind it will be easy, later, to understand the effect of transients in all these areas.

The consolidation of these figures shows a total number of 2248 of which 811 were parasite-positive, giving a rate of 36.1 per cent. Later tables will show that more than half of the total persons examined were transients. There seems to be no better way to present the facts connected with the number of people that have been under observation this year than to separate the inhabitants into groups; therefore, the individuals in each

TABLE 2

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

LOCATIONS	ADULTS			CHILDREN		
	Exam-ined	Positive	Index <i>per cent</i>	Exam-ined	Positive	Index <i>per cent</i>
Chagres.....	383	117	30.5	305	127	41.6
New San Juan.....	404	112	27.7	306	127	41.5
Madden Highway.....	276	63	22.9	574	265	46.1
Totals.....	1,063	292	27.4	1,185	519	43.8

area under observation will be divided into the following three groups: Those who were examined in the monthly surveys 1 to 5 times, those examined in the regular surveys 6 to 11 times, and those examined at every one of the 12 consecutive surveys. Table 3 will present these results.

It is easy to see in table 3 how the parasite index for the year builds up with the increasing number of surveys. It appears also that 6 well-spaced surveys would give almost the same result as 12 surveys. The number of permanent inhabitants is fairly well indicated in this table if the last two groups are combined. The transients are nearly all to be found in the group surveyed one to five times.

The 12-month period covered in this report was a time of low

incidence, a fact which must be taken into account in analyzing the results obtained from our work. Table 4 presents the cumulative incidence of malaria by age-groups; the entire population of the whole area, both in the treated groups and in the control, is included in the grand total of 2,248 persons.

TABLE 3  
*Parasite index. Three survey groups. All areas.*

LOCATIONS	1-5 SURVEYS			6-11 SURVEYS			12 COMPLETE SURVEYS		
	Exam-ined	Posi-tive	Per cent positive	Exam-ined	Posi-tive	Per cent positive	Exam-ined	Posi-tive	Per cent positive
Chagres.....	347	63	18.1	198	102	55.1	143	79	55.2
New San Juan.....	442	89	20.1	181	95	52.4	87	55	63.2
Madden Road.....	594	181	30.5	227	126	55.5	29	21	72.4
	1,383	333	24.1	606	323	53.3	259	155	59.8

TABLE 4  
*Cumulative incidence of malaria by age-groups. All groups combined.*

AGE	CHAGRES			NEW SAN JUAN			MADDEN HIGHWAY			TOTAL		
	Exam-ined	Posi-tive	Per cent positive	Exam-ined	Posi-tive	Per cent positive	Exam-ined	Posi-tive	Per cent positive	Exam-ined	Posi-tive	Per cent positive
<i>years</i>												
0-5	138	42	30.4	147	45	30.6	95	31	32.6	380	118	31.1
5-10	94	44	46.8	74	36	48.6	272	127	46.7	440	207	47.0
10-20	149	65	43.6	164	76	46.3	264	113	42.8	577	254	44.0
20-40	185	57	30.8	213	61	28.6	143	33	23.1	541	151	27.9
40-60	99	29	29.3	79	12	15.2	64	22	34.3	242	63	26.0
Over 60	23	7	30.4	33	9	27.2	12	2	16.6	68	18	26.5
Totals....	688	244	35.4	710	239	33.6	850	328	38.6	2,248	811	36.1

It is interesting to note that the highest malaria rate is in the age-group from 5 to 20 years. However, as the number included in this group (1017) is nearly as great as in all the other groups combined (1231), this fact may explain the apparent distribution of cases. A less number of young children may have been infected, because the period was one of low incidence, and there-

fore of decreased transmission. The high rate for the two groups over 40 years and over 60 years is remarkable, as these people have spent their entire lives in the valley of the Chagres River, and no doubt have had repeated attacks of malaria throughout childhood. They have acquired a respectable degree of tolerance, but they are by no means immune. Two clinical cases have occurred this year in persons over 60 years of age.

Table 5 presents the cumulative malaria rate in those persons in the entire population of 2,248, who were examined in every one of the 12 monthly surveys. Unfortunately, this number is very

TABLE 5

*Incidence of malaria by age-groups. Limited to people examined on 12 monthly surveys.*

AGE	CHAGRES			NEW SAN JUAN			MADDEN HIGHWAY			GRAND TOTAL		
	Exam-ined	Posi-tive	Per cent positive	Exam-ined	Posi-tive	Per cent positive	Exam-ined	Posi-tive	Per cent positive	Exam-ined	Posi-tive	Per cent positive
<i>years</i>												
0-5	46	24	52.3	22	12	54.5	9	6	66.6	77	42	54.5
5-10	38	23	60.5	21	17	80.9	11	8	72.7	70	48	68.5
10-20	26	20	76.9	15	13	86.6	9	7	77.7	50	40	80.0
20-40	18	7	38.9	17	8	47.0	0	0	00.0	35	15	42.8
40-60	12	3	25.0	7	3	42.8	0	0	00.0	19	6	31.6
Over 60	3	2	66.6	5	2	40.0	0	0	00.0	8	4	50.0
Totals....	143	79	55.2	87	55	63.2	29	21	72.4	259	155	59.9

small for the Madden Highway group, and here it consists very largely of school children, who are more easily followed throughout the year than is the general population.

This table shows that a parasite index of no mean proportions can exist throughout all age-groups, even among a tolerant race spending a lifetime under conditions favorable to the acquisition of immunity.

As no method is available which will accurately distinguish between a relapse and a new infection, if the type of parasite is the same, the question of the relative importance of the two factors is debatable. We can only draw conclusions as to their

relative weight by noting the rate in children in the first year of life, and also from our knowledge of the individual records of persons examined month after month during this year, and during the previous years of this study. Table 6 shows the number of times 155 positive individuals (see total positives in table 5), examined in 12 consecutive monthly surveys, were found with parasites during the course of these surveys.

The positive individuals found with parasites from 2 to 7 times in 12 consecutive surveys, in the Chagres and New San Juan groups, are those who have been consistently positive at intervals for years past, in spite of repeated courses of treatment with

TABLE 6

*Individuals (155) showing malaria—surveyed regularly for 12 consecutive months.*

NUMBER OF TIMES POSITIVE	NUMBER OF CASES			
	Chagres	New San Juan	Madden Highway	Grand total
1	33	24	1	58
2	24	10	5	39
3	14	7	5	26
4	3	7	2	12
5	4	2	2	8
6	1	3	4	8
7	0	2	0	2
8	0	0	1	1
9	0	0	1	1
Totals.....	79	55	21	155

the drugs in use. Our previous knowledge of these individuals incline us to believe strongly that relapse, rather than new infection, is responsible for their being repeatedly blood-positive.

In all groups, 259 persons were surveyed every month for 12 consecutive months; 155 were found positive one or more times. Of this number, 58 were positive only once, remaining negative at all other examinations. In the Chagres and New San Juan groups, 134 were found positive, 57 of them only once, so that 77 were found positive two or more times. Of the 21 persons surveyed for 12 consecutive months in the Madden Highway group, 20 were found positive two or more times. This information is



summarized in table 7, which also shows the average number of positive examinations per individual in each group.

The influence of supervision of treatment is well shown by the figures for the control group; the average number of positive examinations is twice as high for this group as it is for the well-treated Chagres group.

For their general interest, and for the light they throw on conditions in our area, it is thought desirable to present the individual records of all those 97 persons who were positive two or more times during 12 successive months. These are shown in tables 8, 9, and 10, giving the blood-findings by months in the three groups, Chagres, New San Juan, and Madden Highway,

TABLE 7

*Positive cases found positive two or more times in 12 consecutive monthly surveys. Treated group and unsupervised control group compared.*

GROUP	NUMBER OF CASES POSITIVE	NUMBER OF CASES POSITIVE MORE THAN ONCE	PER CENT OF CASES POSITIVE MORE THAN ONCE	AVERAGE NUMBER OF POSITIVE EXAMINATIONS PER INDIVIDUAL
Chagres (treated).....	79	46	58.2	2.0
New San Juan (treated).....	55	31	56.4	2.5
Madden Highway (control).....	21	20	95.2	4.0
Totals.....	155	97	62.6	

the control group. The initials and age of each individual is given, and certain symbols are used, as follows: E, *P. falciparum*; T, *P. vivax*; Q, *P. malariae*; ET, *P. falciparum* and *P. vivax*; c, crescent; r, rings; s, schizonts or segmenting forms; f, few; vf, very few; +, heavy infection (1 or more parasites to each thick-film field); ++, extreme infection; +++, very severe cases.

The tabulation of individual records shows that many of the positive films contained very few parasites, so few that, if examined by technicians having little experience with the thick film method, many of them would have escaped observation. It is certain that many carriers with few parasites in the peripheral blood are not disclosed in the monthly surveys, and equally cer-

TABLE 8

Chagres villages; atebirin and plasmochin area. Individuals surveyed 12 consecutive months; cases positive two or more times.

CASE	AGE	1935				1936								NUMBER OF TIMES POSITIVE
		September	October	November	December	January	February	March	April	May	June	July	August	
D. A.	8 yrs.							Ec +			Erf cl6			3
J. B.	15 yrs.							Ec f		Tsl r18				2
A. B.	9 yrs.			Ec5 r20					Er 12					2
F. B.	13 yrs.			Er vf			Ec 4							2
E. E.	20 yrs.			Er6	Er vf									2
M. N.	22 yrs.									Er +	Ec 8	Ec 6		3
T. R.	13 yrs.			Ec 16		Er 6		Er f						3
J. R.	7 yrs.		Er f		Ec 10									2
V. R.	3 yrs.										Er vf	Erf c4	Ec 6	3
J. S.	10 yrs.	Er 8				Er vf				Er +		Ecl		
P. S.	8 yrs.	Er +				Er +							Er1 c3	3
E. A.	1 yr.	Er 1				Er 4								2
A. B.	25 yrs.						Ec8 r10		Er +		Er 6		Er vf	4
I. H.	7 yrs.		Er +			Er 9		ETc+ S+ R+		Er vf		Er vf		5
C. L.	2 yrs.	Er +										Er6	Er1	3
D. L.	5 yrs.	Er +++			Er 18			Ec 3				Ec 2		4
C. V.	9 yrs.	T s10		Ec2 r8		Ec2 r+			Er f		Er ++			5
E. V.	5 yrs.	Er +			Ts+							Er 4		3
M. V.	14 yrs.		Er 38										Er 8	2
M. L. V.	2 yrs.					Er 11							Er f	2
J. M. C.	1 yr.								Er +		Ec 7			2
C. M.	16 yrs.					Er 13					Ec 1			2
J. M.	67 yrs.							Er 15			Er 23			2

TABLE 8—Concluded

CASE	AGE	1935				1936								NUMBER OF TIMES POSITIVE
		September	October	November	December	January	February	March	April	May	June	July	August	
J. M.	14 yrs.			Er 6		Er f		Er 21	Er 10			Er vf		5
D. T.	15 yrs.						Er 1						Ec44 rf	2
A. V.	3 yrs.		Ts +								Ts 4			2
G. A.	10 yrs.						Er 10		Er f					2
J. A.	6 yrs.		Ts 6	Er 5	Ts 8			Er+ cf	Er f				Er ++	6
M. A.	8 yrs.	Ts 1							Er +					2
P. B.	14 yrs.				Er 4				Er 3			Er 2		3
Ca. C.	2 yrs.			Er ++	Ec 2									2
Cr. C.	9 yrs.			Er 10		Er 7		Evf c19		Ts12 rvf			Ec 30	5
J. C.	7 yrs.				Er +			Er f			Ec 1			3
L. C.	11 yrs.	Er 2		Ec 41		Er 2								3
A. C.	13 yrs.				Er 12			Ervf c3						2
C. E.	8 yrs.							Er f				Ts3 r6	Ec 1	3
L. E.	8 yrs.						Er f		Er f					2
F. F.	8 yrs.			Er 33						Er 21				2
S. F.	11 yrs.		Er 2				Er +		Er +					3
A. G.	11 yrs.				Ec10 rf				Er +			Er 7		3
G. Ja.	9 yrs.				Ts4		Er +		Ec9 rf					3
G. Ji.	9 yrs.				Er 2							Er f		2
E. M.	7 mos.								Er +	Er+ cf				2
A. R.	22 yrs.			Tac f								Er +		2
A. V.	14 mos.				Er 60	Er 3					Er +			3
E. V.	16 yrs.						Er +				Er 8			2

Forty people 15 years or less of age and 6 above that age.

TABLE 9

*New San Juan; quinine-plasmochin area. Individuals surveyed 12 consecutive months; cases positive two or more times tabulated.*

CASES	AGE	1935				1936								NUMBER OF TIMES POSITIVE
		September	October	November	December	January	February	March	April	May	June	July	August	
A. A.	4 yrs.				Ts 15	Ts +		Ts 3					Er 10	4
CEA.	11 yrs.				Er 36			Er 2	Er 1				Er 8	4
I. A.	14 yrs.	Er 2				Er 1						Er 4		3
D. A.	25 yrs.											Er 1	Er +	2
B. B.	67 yrs.		Er 2										Er 5	2
A. D.	10 yrs.	Ec2 r78				Ec42 r4				Er 6		Ts1		4
N. E.	3 yrs.					Er f	Ec1 ff	Er f	Ec8 r+	Er 8		Ec5		6
B. E.	5 yrs.		Ts10 rf		Ec58 rf	Ec40 r+		Er 2			Er 9			5
M. G.	4 yrs.		Er 18		Er f									2
V. G.	1 yr.				E c+r+	Ec13 r+				Ec21 r+	Ec+ rf		Er 2	5
M. A. G.	36 yrs.			Ts1								Er 52	Er 26	3
J. L.	27 yrs.				Ts4 r3								Er f	2
M. L.	1 yr.			Er+	Ec3 r++							Ec4		3
M. L., Jr.	4 yrs.		Er 1		Er 6		Ec2							3
M. M.	10 yrs.		Er +			Er f								2
P. M.	12 yrs.			Ec21		Er 8								2
M. M.	9 yrs.			Er 2	Er f	Er f							Ec20 r4	4
C. M.	8 yrs.							Ec+ r+		Er +	Er f			3
E. M.	12 yrs.			Er 18		Er 6							Ec2	3
G. M.	10 yrs.			Er 1								Er vf		2
F. O.	7 yrs.	Ec1 r+	Er f		Er 1	Er +	Er 1			Er 48		Er 24		7

TABLE 9—Concluded

CASES	AGE	1935				1936								NUMBER OF TIMES POSITIVE
		September	October	November	December	January	February	March	April	May	June	July	August	
L. O.	8 yrs.				Er vf	Er +	Er f			Er vf				4
J. P.	36 yrs.		Er f				Ts 2							2
C. U.	7 yrs.									Er 10			Ec16 rf	2
Cat. U.	1 yr.	Ec1 rs	Er +	Er f	Er 4									4
E. U.	11 yrs.					Ec2 rf		Er f		Ec1 r+	Er +			4
Es. U.	10 yrs.				Ec1 rs		Er 3			Er +	Er f	Er f	Er 6	6
A. U.	8 yrs.		Er 1		Er f	Er 74			Er 16	Er +			Er f	6
L. U.	12 yrs.					Ec2 r2			Er 12					2
J. V.	11 yrs.	Er +		Er f	Er 1		Er 7	Er 28		ETs4 cl		Er 1		7
G. V.	8 yrs.					Ts 12					Er ++	Er 2		3

Thirty-one people 15 years or less of age and 5 individuals over that age.

tain that the group picture changes frequently during the month. In cases where the records show a shift from one species to another in successive surveys, three interpretations are possible: incorrect identification of species, new infection, or a hitherto dormant infection with another species becoming dominant. We incline to the latter view.

Table 11 shows the incidence of malaria parasite species in the 811 positives found in all the groups examined.

Infections with *P. falciparum* predominate in all three regions but *P. vivax* is slightly more common on Madden Highway than in the Chagres and New San Juan areas. The crescent carrier rates were as follows: Chagres, 31.1 per cent; New San Juan, 22 per cent; Madden Highway, 18.3 per cent; the average being 22.1 per cent. Strange to say, only five of these of these carriers were found at a time when they were good enough to serve for

TABLE 10

Madden Highway; control town—voluntary free guinine. Individuals 12 consecutive months; cases positive two or more times.

CASES	AGE	1935				1936							NUMBER OF TIMES POSITIVE	
		September	October	November	December	January	February	March	April	May	June	July		August
D. C.	9 yrs.		Ec3 rf					Ec2	Er 18			Er 5		4
A. D.	10 yrs.			Er 1								Er 10		2
C. F.	9 yrs.								Ec1 r20	Er vf	Er 12	Ec3 r14		4
G. F.	5 yrs.									Er vf	Ec1 rf			2
E. H.	15 yrs.		Er f	Er 10		Er 6		Er 6		Er 3		Er vf		6
G. H.	5 yrs.		Er 28		Er 4	Er 6		Er +	Ts18 r30	Ts 10	Ts18 r35	Er +		8
J. M.	10 yrs.							Er 6	Ec1 r9		Er 54			3
L. M.	5 yrs.	Er 2							Ec2 r8	Er f	Er 1	Er +		5
M. M.	8 yrs.							Er f					Er +	2
M. Mi	11 yrs.			Er 84						Er 3		Er 8		3
W. W.	16 yrs.								Ec4 r14		Er vf			2
J. P. M.	6 yrs.										Er f	Er 10		3
J. P.	12 yrs.		Ts6 r6		Ec 4			Er 2						3
O. Q.	13 yrs.		Er 6							Ts8 r2				2
L. R.	11 yrs.		Er 3	Er 1	Er 10			Er 7		Er 1				5
G. T.	8 yrs.	Er 1				Er 22	Er 5							3
L. T.	2 yrs.	Ts12 r6	Er 18					Ts+ r+		Er 4	Ts 5	Er f		6
J. T.	6 yrs.	Ec4 r8	Er f			Er 6	Er 83		Ec4 r10				Er 25	6
S. T.	3 yrs.	Ts1 r3				Ts6 r28	Ec 27 r3		Ts2		Er 29		Ec9 r32	6
Av.	14 yrs.	Er 5	Er +	Ec4 r8	Ec2 rf	Ec7 rf	Ts58 rf				Ts2 rf	Ec 18	Ec 10	9

Twenty individuals, all 15 years or under.

mosquito infection experiments; 3 of these came from the Chagres Villages. Heavy infections of malaria were as follows: Chagres, 17.1 per cent; New San Juan, 16.8 per cent; Madden Highway, 7.6 per cent; the average being 12.7 per cent. As stated earlier in this report, probably many of the more serious cases on Madden Highway went to Panama City for treatment, and therefore escaped our survey records.

TABLE 11

*Incidence of parasite species in 811 cases.*

SPECIES OF PARASITES	CHAGRES		NEW SAN JUAN		MADDEN HIGHWAY		TOTALS	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
<i>P. falciparum</i> .....	197	80.7	194	81.1	216	65.8	607	74.8
<i>P. vivax</i> .....	28	11.4	18	7.5	56	17.1	102	12.6
<i>P. malariae</i> .....	2	0.8	1	0.4	2	0.6	5	0.6
<i>Falcip.</i> and <i>vivax</i> .....	16	6.5	23	9.6	48	14.6	87	10.7
<i>Falcip.</i> and <i>malariae</i> .....	1	0.4	3	1.2	4	1.2	8	1.0
<i>Vivax</i> and <i>malariae</i> .....	0	0.0	0	0.0	2	0.6	2	0.2

TABLE 12

*66 babies one to twelve months old.*

LOCATION	NUMBER EXAMINED	NUMBER POSITIVE	PER CENT POSITIVE
Chagres.....	25	2	8.0
New San Juan.....	28	3	10.7
Madden Highway.....	13	1	7.7
Totals.....	66	6	9.1

We make a determined effort to survey every infant born in these locations from the time it is two weeks old. These baby surveys, made monthly to the end of the first year, offer us something in the way of a yardstick to measure the incidence of new infections. This year we have examined 66 babies; the findings are listed in table 12 according to the three locations.

Two of these infants had their first infection in the seventh month; one had its first infection in the eighth month, one in the ninth month, one in the tenth, and one in the twelfth month.

Four had *P. falciparum* infections, and two had *P. vivax* infections. This is the first year of our observations in which none was found infected until after the sixth month. Usually infections begin to appear in the third month, and become relatively common by the 12th month. This fact indicates that transmission was at a low ebb during the past year.

#### RELATION OF ACQUIRED TOLERANCE TO LABOR EFFICIENCY

All our work had as its object a search for a method of malaria control applicable to labor forces operating in tropical lowlands. The idea is widespread that tolerance to malaria infection is high in regions of high endemicity, and that the natives are little disturbed by clinical manifestations of the disease. There are two reasons for this belief. In the first place, natives living under such conditions do not know what freedom from malaria means, as they have been infected from infancy. At the beginning of our work five years ago, very few persons who had positive blood-films complained of illness at the time their bloods were taken. Now they recognize the difference between their former state and their present improved condition of relative freedom from malaria. They can now indicate with a fair degree of certainty what the result of their blood-film examination will be. They have been made malaria-conscious, and seek treatment. Even the control group on Madden Highway objects to the discontinuance of monthly surveys, and the distribution of free quinine. In the second place, individuals may be up and about, and appear to be in good health, while carrying on their usual activities, because they can do their farm work and hunting very irregularly and as they please. However, when infected adults are placed under the strain of heavy labor, to be performed regularly, and under all weather conditions, they will, with few exceptions, be unable to maintain a satisfactory standard of labor efficiency. Their acquired tolerance makes it comparatively easy to treat them as ambulatory patients, while they are pursuing their normal village life, but they will need medical attention when recruited as members of a regular labor force.

Our present method, using monthly surveys and treatment of



all positives, has shown itself in the past to be inadequate as a means of eradicating the disease. It is doubtful if the disease could be eradicated by a combination of all known methods, under our present conditions. However, we have no doubt that the method outlined in our previous report, namely, continuous inspection of the population, and immediate treatment of all those found clinically ill, is a method of great value to those who must use antimalaria measures of some sort in order to conserve the labor supply. We believe that any expenditures made will yield a return in the salvage of labor days commensurate to the financial outlay. Eradication of malaria and its control are two very different things. The latter can be accomplished with great benefit to business, by placing a small non-medical personnel in the field, to give immediate treatment, and supervised by a medical man really interested in preventive medicine, who will make weekly visits of inspection.

#### SUMMARY

Changed conditions in the area under observation, and the desire to check further the conclusions reached in the last annual report of this work (5), induced us to continue observations under the same plan as last year.

Monthly blood-parasite surveys in three groups treated with atabrine-plasmochin, quinine-plasmochin, both under adequate supervision, and with quinine sulphate under no supervision, gave average monthly rates for the year of 9.1, 12.3, and 18.5 per cent, respectively. The higher rate in the quinine control group was probably due to lack of supervision, and a higher percentage of children in this group (see table 2). As in the past years, the rates showed no correlation with monthly rainfall. The 12 months covered by this report were a period of low incidence, following the epidemic period of 1935, thus corroborating the views set forth in our fifth report concerning the cyclic nature of malaria incidence in Panama. The fact that our observations were made during a down-swing of the incidence curve must be considered in interpreting our results during the past year.

The parasite rate, cumulative for the 12 months, but limited

to those examined at every monthly survey, shows that slightly more than half of this group had parasites in the blood during the year (table 5). The same table shows that a rather high annual parasite rate can exist in all age-groups of a relatively tolerant people. The same phenomena in connection with relapse occurred during the past year as were noted in our previous reports, and we believe that relapse, especially during a year of low incidence, is responsible for a great part of the malaria rate observed.

The influence of adequate treatment in lowering the blood parasite rate during an interepidemic period is well shown in table 7.

Individual monthly records of all persons examined in 12 consecutive surveys, who were found positive two or more times, are given in tables 8, 9 and 10.

Table 11 shows the incidence of species of malaria parasite found in the 811 positives discovered during the year. Estivo-autumnal (subtertian) infections predominate, as in the past, and tertian infections are slightly more common in the control group. Few crescent-carriers were discovered in the surveys during the year. Heavy infections were somewhat more numerous in the two treated groups than in the control.

Sixty-six infants were examined at some time during their first year of life, some only once, some for a number of months. The combined rate was 9.1 per cent, which is comparatively low, and indicates a season of low transmission. During the previous year, in which an epidemic occurred, 28 infants examined an average of 5 times, gave an annual rate of 25.0 per cent.

We believe that infected adults, even though relatively tolerant to malaria infection, will not be able to support the strain of daily hard labor without the aid of medical attention. We believe this can be most economically given by supplying non-medical personnel in the field, to give immediate antimalarial treatment to those who become clinically ill; such non-medical personnel should be supervised by a qualified physician interested in tropical and industrial medicine, who should make weekly visits of inspection.

Our previous experience has shown the impossibility of eradicating malaria by reducing the "seed-bed" of infection in young children and adolescents by the use of drugs. However, we do not doubt that control of malaria to a point where it will interfere little with the supply of native labor is economically possible under our local conditions by the method outlined above.

Expenditures for such measures of control are economically justifiable, as they doubtless will result in increased labor efficiency, commensurable with the financial outlay involved.

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