NOTES AND REPORTS

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MALARIA CONTROL USING INDOOR RESIDUAL SPRAYS IN THE EASTERN PROVINCE OF AFGHANISTAN

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Laghman District of the Eastern Province of Afghanistan in which these studies were carried out is situated between 34° 30′ and 35° 00′ N. and 70° 00′ and 70° 20′ E. It is of considerable importance in the economy of the country being one of the chief rice-producing areas. Except for the recent report of Lindberg [1] there are no recorded data regarding either the endemicity of malaria or the anopheles species prevalent in the area. Lindberg gives a general outline of the prevalence of malaria in different parts of Afghanistan and its relation to climate and topography. The survey and the small-scale demonstration of malaria control reported here were perhaps the first of their kind undertaken in the area. The present work was preceded by a brief visit to the area by Dr. I. M. Puri in May 1949 for a preliminary reconnaissance and for selection of a suitable locality for the detailed investigations. The author's team started functioning in Laghman only in the middle of July 1949 and the field observations were completed by the end of October 1949. The epidemiological investigations and the control operations were carried out simultaneously in two adjoining groups of villages.

1. General Background

The district is mountainous with several peaks rising to over 10,000 feet (3,050 m) above sea level. The hills are extremely rocky and practically devoid of vegetation except for a few herbs. The valleys at elevations of about 2,000 feet (610 m) above sea-level are, however, well irrigated and maintain a fair amount of vegetation. The two chief rivers of the district are the Alingar and Alishing which meet and ultimately join the Kabul River. The flat terrain adjoining the two rivers is irrigated by a system of canals branching from one or the other of the rivers, without dams or reservoirs, at some convenient spot, of which there are many because of the steep gradient of the country.

The rivers are perennial, their water-supply being maintained by the melting snow of the upper hill ranges. The lowest flow occurs in late

[1] Lindberg, K. (1949) *Riv. Malariol.* 28, 1

October and early November and the highest in early spring. The rivers have for the most part rocky beds composed of innumerable rounded boulders and pebbles. At whatever level the water may be, the margin of boulders and pebbles always provides very good breeding-places for the vector anophelines.

The little rain that falls does so mainly during the winter. Only very occasionally, there may be a few thunderstorms during July and August, the extreme spearheads of the Indian south-west monsoon which sometimes manages to break through the hills and passes around Khyber.

The climate during most of the year is fairly dry. The maximum temperatures range from about 45.0°C (113°F) in midsummer to 21.0°C (69.8°F) in midwinter, with minimum temperatures of about 21.0°C (69.8°F) and −1.2°C (29.8°F) respectively. There are no meteorological observations recorded at Laghman itself, but the monthly maximum and minimum temperatures recorded in 1948 at Jalalabad, about 25 miles (40 km) south-east of Laghman, and having a very similar climate, are given below :

	Temperatures °C	
	Maximum	*Minimum*
January	21.5	0.0
February	23.8	1.2
March	28.9	3.2
April	39.5	10.4
May	42.0	17.0
June	45.3	19.0
July	45.3	21.8
August	41.9	21.6
September	39.3	14.0
October	35.5	4.9
November	27.6	1.5
December	22.0	0.2

The data collected at Laghman during the actual period of the work conform to the general trend of the climate as summarized above.

The valleys are intensely cultivated, the chief crops being rice in summer and wheat in winter. Fruits, mainly grapes and melons, are also grown in orchards, chiefly in the upper reaches of the valleys. The timetable of agricultural operations is roughly as follows :

November	Sowing of wheat
May-June	Harvesting of wheat
June-July	Irrigation of the fields and sowing of rice
October	Harvesting of rice

Wheat being a dry crop, the fields are irrigated only twice to wet them, but from June to October the fields retain standing water. During June

to August the irrigation is continuous, but during September and October an intermittent system is practised to enforce an equitable distribution of the rapidly diminishing water-supply in the rivers.

All houses are made of mud or of sundried bricks. Hardly 1% of houses have lime or cement plaster. The surface of the walls is very rough and extremely absorbent. The roofs are all flat and made of logs of wood covered with twigs and leaves and overlaid with a thick coat of mud. Because of this construction the lower side of the roofs presents a very large superficial area with numerous crevices and niches providing ideal resting-places for anophelines. The plan of most of the houses, however small they may be, is based on an imitation of a fort. There is a high rectangular mud wall on the outside with a single well-made door which leads into a large courtyard. All the rooms of the house open into this courtyard, their number depending on the position and wealth of the owner. Often more than one family live in such a house with a common courtyard. The houses are grouped together in the main villages, but almost every village has one or more outlying hamlets each of which may consist of only one or two such large houses.

Cattle are fairly numerous though not as abundant as in India. Sheep, goats, and poultry are reared in large numbers. Horses and asses are also common. Except in the houses of the more wealthy, cattle are not tethered in a separate place but are often tied in a part of the living-room itself or in an adjoining room having direct access to the living-room.

During the months of March to October, the entire human population sleeps outdoors because of the oppressive heat. Cattle are tethered in the open in the courtyard.

Water-supply for domestic purposes is abundant. A small channel is taken through the courtyard of almost every house and therefore the housewife rarely has to go beyond her own door to fetch water. Only a discriminating few fetch drinking-water from any one of the numerous natural springs abounding in the area, the rest being content to drink the water of the channel. Sanitary conditions are very poor.

2. Epidemiology

2.1 *Spleen-rates*

Malaria is hyperendemic in the entire area with childhood spleen-rates (age 2-9) of over 50% in almost all villages. In a pre-operational survey (table I) made during July and August 1949 in 15 villages, the average cumulative spleen-rate was 76.1% (571 out of 750), while again in the post-operational survey in 14 unsprayed villages during the last week of October 1949 (table II), the same rate was 89.0% (568 out of 638). The average enlarged spleen varied from 2.1 to 3.9, spleen sizes being measured according to Hackett's classification.

TABLE I. PRE-OPERATIONAL SPLEEN AND BLOOD SURVEY IN 15 VILLAGES, LAGHMAN DISTRICT, JULY-AUGUST 1949

Village	Date of examination 1949	Spleen				Blood					
		Number examined	Number positive	Spleen-rate (%)	Average enlarged spleen	Number examined	Number positive	Parasite-rate (%)	Species of parasite *		
									V	F	M
Chalmati . .	26 July	30	14	47	2.6	30	5	17	4	1	0
Chanduk . .	13 August	42	27	64	2.1	42	5	12	5	0	0
Chardhi . . .	17 August	40	25	62	2.8	37	11	30	11	0	0
Gumain . . .	1 August	50	34	68	3.0	49	8	16	8	0	0
Haiderkhani .	17 August	55	45	82	3.2	46	5	11	4	1	0
Haramal. . .	30 July	40	31	77	2.7	39	7	18	7	0	
Kalakot . . .	17 August	51	46	90	3.4	50	9	18	6	3	0
Mariam . . .	3 August	54	37	69	2.8	53	13	25	12	1	0
Maskura. . .	13 August	50	42	84	3.2	46	11	24	9†	2†	1
Navalum. . .	14 August	52	46	88	3.1	42	8	19	8	0	0
Navra	31 July	23	21	91	3.3	—	—	—	—	—	—
Pashai . . .	31 July	57	38	67	3.0	47	9	19	9	0	0
Sesada . . .	31 July	39	21	54	2.7	39	7	18	7	0	0
Tajkari . . .	3 August	40	36	90	3.1	40	8	20	7	1	0
Tigari	6 August	127	108	85	3.0	30	5	17	4	1	0
Total . . .		750	571	76.1	3.0	590	111	18.8	101†	10†	1

* V = *Plasmodium vivax*, F = *P. falciparum*, M = *P. malariae*
† One mixed *vivax* and *falciparum* infection

2.2 *Parasite-rates*

In the pre-operational survey of July-August (table I) the average cumulative parasite-rate in 15 villages was 18.8% (111 positive smears out of 590 examined). *Plasmodium falciparum* infections numbered only 10 out of 111, while the bulk of infections (101) were with *vivax* one smear showing *malariae*. In the post-operational survey of October (table III) the figures were : total number of smears examined, 482 ; number positive, 149 ; average cumulative parasite-rate 30.9%. The relative prevalence of the species was *vivax* 50, *falciparum* 99, and *malariae* nil.

2.3 *Infant parasite-rates*

No infant smears were examined in July-August, but in the last week of October they were collected in both sprayed and unsprayed villages

TABLE II. POST-OPERATIONAL SPLEEN SURVEY IN SPRAYED AND UNSPRAYED VILLAGES, OCTOBER 1949

Village	Date of examination October 1949	Age 2-5			Age 6-9			Total			
		Number examined	Number positive	Average enlarged spleen	Number examined	Number positive	Average enlarged spleen	Number examined	Number positive	Spleen-rate (%)	Average enlarged spleen
Sprayed villages :											
Chalmati	22	12	10	2.1	28	18	2.5	40	28	70	2.4
Chanduk	24	25	13	2.7	20	14	2.0	45	27	60	2.3
Gumain	22	21	7	2.0	22	10	2.3	43	17	40	2.2
Mariam	23	16	7	2.0	35	13	2.4	51	20	39	2.3
Maskura	24	25	19	2.4	30	22	2.6	55	41	75	2.5
Navalum	24	11	10	2.6	34	27	2.6	45	37	82	2.6
Pashai	21	19	6	2.0	23	15	2.6	42	21	50	2.4
Sesada	23	14	9	2.4	41	32	2.4	55	41	75	2.4
Tajkari	22	16	11	2.1	30	18	2.7	46	29	63	2.5
Tigari	21	13	6	2.0	29	13	2.6	42	19	45	2.4
Tigari (Kalajogi)	21	12	9	2.2	15	15	3.2	27	24	89	2.8
Schoolboys of sprayed villages	18	—	—	—	57	36	2.8	57	36	63	2.8
Total		184	107	2.3	364	233	2.6	548	340	62.0	2.5
Unsprayed villages :											
Alishing	24	8	8	2.7	80	69	2.7	88	77	87	2.7
Charbagh (school)	26	16	14	3.8	51	44	3.3	67	58	87	3.4
Chardhi	25	17	14	2.7	35	32	3.2	52	46	88	3.0
Dehziarat	21	14	13	2.3	21	18	3.2	35	31	89	2.8
Ferozabad	29	8	8	2.5	11	9	2.1	19	17	89	2.3
Haiderkhani	25	28	26	2.5	29	27	3.3	57	53	93	2.9
Haramal	23	7	6	2.8	36	32	3.5	43	38	88	3.4
Kakaj	29	8	5	3.2	6	5	3.2	14	10	71	3.2
Kalakot	25	23	22	3.5	32	30	3.6	55	52	95	3.6
Mandrawal (school)	26	—	—	—	44	41	3.0	44	41	93	3.0
Navra	25	13	12	2.9	31	30	3.4	44	42	95	3.3
Shahmangal	21	16	16	3.8	23	23	4.0	39	39	100	3.9
Umarzai	20	8	5	2.2	49	41	3.2	57	46	81	3.1
Schoolboys of unsprayed villages	18	—	—	—	24	18	3.1	24	18	75	3.1
Total		166	149	2.9	472	419	3.2	638	568	89.0	3.1

TABLE III. POST-OPERATIONAL BLOOD SURVEY IN SPRAYED AND UNSPRAYED VILLAGES, OCTOBER 1949

Village	Number of smears examined	Number positive	Parasite-rate (%)	Species of parasite		
				vivax	*falciparum*	*malariae*
Sprayed villages :						
Chalmati	40	3	7.5	3	0	0
Chanduk	46	8	17.4	2	6	0
Gumain	40	3	7.5	2	1	0
Mariam	50	6	12.0	4	2	0
Maskura.	43	4	9.3	4	0	0
Navalum	41	6	14.6	2	4	0
Pashai	39	2	5.1	2	0	0
Sesada	47	1	2.1	1 *	1 *	0
Tajkari	40	4	10.0	0	4	0
Tigari . . , . . .	40	8	20.0	7	1	0
Total. . . .	426	45	10.6	27 *	19 *	0
Unsprayed villages :						
Alishing	44	13	29.5	9	4	0
Charbagh (school).	50	17	34.0	12	5	0
Chardhi	43	15	34.9	0	15	0
Dehziarat	36	7	19.4	3	4	0
Haiderkhani	57	27	47.4	12	15	0
Haramal	30	4	13.3	3	1	0
Kalakot	50	23	46.0	0	23	0
Mandrawal (school)	40	4	10.0	1	3	0
Navra	43	9	20.9	7	2	0
Shahmangal . . .	39	15	38.5	0	15	0
Umarzai	50	15	30.0	3	12	0
Total. . . .	482	149	30.9	50	99	0

* One mixed *vivax* and *falciparum* infection

(table IV). Of the 70 infants examined in unsprayed villages, 49 were positive giving an extremely high infant parasite-rate of 70.0%. The species of plasmodia were 22 *vivax*, 19 *falciparum*, 1 *malariae* ; there were 7 mixed infections with *vivax* and *falciparum*. The ratio between *vivax* and *falciparum* therefore was 29 to 26. Gametocytes were seen in 17 smears (4 *vivax* and 13 *falciparum*).

2.4 *Dispensary statistics and morbidity data*

There is one public dispensary in the area and the number of malaria cases and all cases treated for each month from Hamal (March-April) 1947 are presented in table V. The diagnosis is entirely on clinical grounds and the variations in the number of patients treated depend on many extraneous factors. All the adverse factors now well known to influence such figures are exaggerated in Afghanistan and it is a moot question whether these data have any value at all.

There are no other morbidity data at all fit for recording, except the general observation made that in the middle of October every house in the unsprayed villages had at least 2-3 patients.

TABLE IV. BLOOD SURVEY OF INFANTS IN SPRAYED AND UNSPRAYED VILLAGES, OCTOBER 1949

Village	Number of infants examined	Number positive	Parasite-rate (%)	Species of parasite				Gametocytes	
				vivax	*falciparum*	*malariae*	mixed *vivax* and *falciparum*	*vivax*	*falciparum*
Sprayed villages :									
Chalmati	15	2	13.3	2	0	0	0	0	0
Chanduk	4	0	0	—	—	—	—	—	—
Gumain	13	0	0	—	—	—	—	—	—
Mariam	2	0	0	—	—	—	—	—	—
Maskura.	14	1	7.1	1	0	0	0	1	0
Navalum	7	1	14.3	1	0	0	0	0	0
Sesada	5	1	20.0	1	0	0	0	0	0
Tajkari	7	1	14.3	1	0	0	0	0	0
Tigari	5	0	0	—	—	—	—	—	—
Total. .	72	6	8.3	6	0	0	0	1	0
Unsprayed villages:									
Alishing	17	10	58.8	4	5	0	1	2	1
Chardhi	9	6	66.7	2	2	1	1	0	2
Haiderkhani . . .	9	8	88.9	2	3	0	3	2	5
Kalakot	12	12	100.0	7	3	0	2	0	2
Navra	6	4	66.7	3	1	0	0	0	0
Shahmangal. . .	7	3	42.9	1	2	0	0	0	1
Umarzai.	10	6	60.0	3	3	0	0	0	2
Total. .	70	49	70.0	22	19	1	7	4	13

TABLE V. MALARIA CASES AND ALL CASES TREATED IN LAGHMAN DISPENSARY, 1947-1949

Months	Malaria cases			All cases		
	1947/48	1948/49	1949/50	1947/48	1948/49	1949/50
Hamal (March-April)	228	251	100	1,157	1,031	710
Saur (April-May)	240	248	105	1,262	1,035	666
Jauza (May-June)	218	255	103	1,130	1,006	815
Saratan (June-July)	83	100	59	1,667	639	482
Asad (July-August)	200	161	75	1,471	619	497
Sambala (August-September)	800	252 *	227	2,408	689 *	930
Meson (September-October)	400	797	354	1,595	1,428	880
Akrab (October-November) .	200	526		1,238	701	
Cows (November-December)	87	116		1,402	442	
Jadia (December-January) .	203	129		1,027	412	
Dalv (January-February) . .	160	98		918	494	
Huth (February-March) . . .	100	67		727	556	
Total	2,919	3,000		16,002	9,052	

* Drug stocks low in dispensary. The highest incidence of malaria is normally recorded in this month.

2.5 *Anopheline species*

The following species of anopheles have been met during the entire period of the survey : *annularis, culicifacies, fluviatilis, hyrcanus, maculatus, moghuliensis, pulcherrimus, splendidus, stephensi, subpictus, superpictus, turkhudi,* and *vagus.* The number of adults of each species collected in random searches made in unsprayed villages is given in table VI. Adults of *culicifacies* and *stephensi* were the most abundant, being 42% and 34% of the total of all species collected. *Superpictus* though next in abundance was far behind these two, being only about 11% of the total. Other species were comparatively scarcer. These collections were all made only during the chief malaria season, i.e., August, September, and October, and it is not possible to state what their relative prevalences would be in other months. Even among individual villages, wide variations have been found to occur in the proportions of the different species. For instance, Alishing, a village to the north of the sprayed area, showed more *superpictus* than all others to the south. Similarly the more southern villages had more *culicifacies* than the northern ones.

2.6 *Vector species*

The results of dissections carried out in August, September, and October 1949 are also summarized in table VI. Because of an unfortunate contamination of all the rearing cages with DDT, it was not possible to keep mosquitos alive long enough for gut examination. Therefore only glands have been examined in most cases. *Culicifacies* and *superpictus* were found naturally infected with sporozoites ; 3 out of 768 *culicifacies* and 2 out of 454 *superpictus*. These two species may now be regarded as definitely proven vector species in the area. Further investigations are necessary to determine the status of *stephensi* and *fluviatilis*, both of which are proved vectors in several parts of India. *Fluviatilis* does not occur in sufficiently large numbers to be of much significance, but *stephensi* is extremely abundant and must be suspect till definitely proved harmless. It has to be noted in this connexion that the species has been incriminated in Baluchistan and Iran, both neighbouring countries of Afghanistan.

TABLE VI. ANOPHELINE ADULTS COLLECTED IN RANDOM SEARCHES IN UNSPRAYED VILLAGES, AND DISSECTED, AUGUST-OCTOBER 1949

Species	Number of anophelines collected			Number of anophelines dissected	
	Male	Female	Total	Total	Positive
annularis	12	45	57	4	0
culicifacies	729	1,918	2,647	768	3
fluviatilis	1	49	50	45	0
hyrcanus	1	3	4	0	0
maculatus	0	2	2	0	0
moghuliensis	0	5	5	0	0
pulcherrimus	0	17	17	1	0
splendidus	76	196	272	52	0
stephensi	524	1,607	2,131	252	0
subpictus	140	194	334	2	0
superpictus	120	587	707	454	2
turkhudi	0	14	14	1	0
vagus	0	2	2	0	0
Total	1,603	4,639	6,242	1,579	5

Only glands were examined in most of the specimens dissected ; those reported as positive were infected with sporozoites.

TABLE VII. COLLECTIONS OF FULL-GROWN ANOPHELINE LARVAE BY BREEDING-PLACES, SEPTEMBER-OCTOBER 1949

	Breeding-places							
	Rivers and streams	Irrigation channels and drains	Rice-fields, growing	Rice-fields, fallow	Springs	Swamps	Miscellaneous	Total
Number of searches	49	62	132	12	19	56	2	332
Number of positive searches	47	35	77	7	3	53	2	224
	Number of larvae collected and identified (in parentheses, number of times found)							
Vector species								
culicifacies	842 (42)	121 (19)	29 (8)	13 (4)	1 (1)	44 (12)	6 (1)	1,056 (87)
superpictus	306 (29)	0	5 (3)	0	0	0	0	311 (32)
Non-vector species								
annularis	25 (3)	0	27 (6)	6 (1)	0	32 (7)	0	90 (17)
fluviatilis	0	0	1 (1)	0	3 (1)	2 (1)	0	6 (3)
hyrcanus	55 (13)	195 (27)	642 (72)	23 (5)	0	198 (34)	1 (1)	1,114 (152)
splendidus	0	7 (4)	23 (7)	0	0	26 (8)	0	56 (19)
stephensi	221 (16)	105 (10)	29 (12)	8 (3)	1 (1)	54 (27)	0	418 (69)
subpictus	0	0	7 (3)	6 (2)	0	111 (26)	0	124 (31)
Total	1,449	428	763	56	5	467	7	3,175

The average time spent in each search was approximately 15 minutes.

2.7 *Breeding habits of vector species*

In table VII is presented a consolidated summary of the larvae data. 3,175 full-grown larvae were identified from collections made in 224 breeding places. Out of 332 total searches made 108 were negative for larvae. The chief breeding-places are :

Rivers and streams. They carry water for most part of the year, being at their lowest in October. All have rocky beds made up of a mixture of pebbles and boulders and provide ideal breeding-conditions for *culicifacies* and *superpictus* and to some extent for *stephensi.*

Irrigation channels and drains. There are many of these, which, as is usual in neighbouring parts of Pakistan and India, are good breeding-places for *culicifacies* and *stephensi.* Large numbers of *hyrcanus* have also been found in them, presumably because of the close association of the channels with rice-fields. Often the channels branch from rice-fields and one would expect many *hyrcanus* larvae to drift from the latter to the former. The channels have grassy margins, but sometimes the flow is too rapid for larvae breeding. A practice of intermittent irrigation is established from the middle of September which keeps many channels free from larvae.

Rice-fields. These are the most extensive breeding-places in the area. In conformity with findings elsewhere, *hyrcanus* predominates. It is interesting to note the occurrence of *culicifacies* in 8 of the 77 fields. These fields were those in which the growth of the paddy was poor or in which the plants were much scattered and of stunted growth. *Culicifacies* larvae have been found in a few fallow fields that happened to exist at the time of the survey. The importance of rice-fields in the epidemiology of malaria in this area has therefore been established.

Springs. These are few and far between and are not of much significance.

Swamps. There are several of these, mostly in the proximity of villages, created originally by taking earth for house-building. They contain stagnant water with much vegetation and *culicifacies* has been found to breed in them.

There are practically no other breeding-places of any significance. Roadside borrowpits and drains so characteristic of the Pakistan and Indian plains are practically non-existent.

An interesting point of difference from Indian conditions as regards the breeding-places is that rain has no direct influence whatever on the creation of new breeding-grounds. While in the plains of India and Pakistan malariogenic breeding-places come into existence soon after the onset of the south-west monsoon, in Afghanistan there is no rain during the summer and hence no such breeding-places arise. Winter rain, and more particularly snow, however, indirectly affect the epidemiology in that they are responsible for keeping rivers and streams in perennial flow.

2.8 *Resting and feeding habits of vector species*

Culicifacies and *superpictus* are both taken in very large numbers inside human dwellings and stables during the day. As none of the people sleeps indoors during the night, it is reasonable to presume that mosquitos enter the houses only for shelter. No night studies on the movements of mosquitos have been made, and so it is not possible to state in accurate terms the degree of nightly turnover. It has however been actually seen that large numbers of anopheline adults enter the dwelling-houses in the early morning. In a series of observations made on the gonotrophic condition of female anophelines resting indoors in the early morning (three days in September) the following results were obtained :

Group	Number of females	
	culicifacies	*superpictus*
A. Unfed.	52	18
B. Freshly fed	167	16
C. Partially digested blood—partially developed ova .	290	46
D. Gravid, but still with a trace of blood	45	6
E. Fully gravid.	11	6
F. Abnormal conditions	5	0
Total.	570	92

These figures in the absence of more precise information on the frequency of feeding should be interpreted with caution. But the climatic conditions were such that much of the feeding would have been taking place on alternate nights. The presence of a large proportion of group C would indicate that the degree of outdoor resting could not have been great. If the tendency of the majority of the females was to stay away from the houses in the day-time, the proportions of the group C would have been much lower, as the outward evening exodus, which is so characteristic of most mosquitos, would tend to reduce their numbers in the second morning after the night of feeding. If the numbers resting outdoors formed a very appreciable portion of the total population, the ratio of group B to group C would definitely be 1 to less than 1.

Several attempts to collect resting mosquitos outside houses in suitable places failed. Three mud pots of large dimensions were placed in the proximity of villages, but except for 3 females of *hyrcanus* and a few culicines they were not attractive to mosquitos. More work is undoubtedly required to determine the proportions of the vector species resting outdoors, but all the evidence available indicates that the proportion is probably not high.

The actual place of resting in the houses has been studied and it can be stated that all parts of the interior of the house, provided they are dark, are attractive. The roof, because of the nature of its construction, offers the most attractive place and generally yields the largest number.

3. Demonstration of Malaria Control

3.1 *Spraying operations*

A small-scale demonstration of malaria control by the use of DDT indoor residual sprays was carried out in Lagham District. Thirteen villages with a total population of approximately 14,000 were selected. All the selected villages were situated between the Alishing and Alingar rivers, just above their junction, in a total area of about 20 square miles (52 km²).

The villages were all sprayed between 1 and 15 August 1949. All indoor surfaces, walls, as well as roofs, and all domestic articles, except cooking vessels, etc., were sprayed. Two formulations of DDT,—DDT-Aromex[2]-soap emulsion and 50% water suspension of wettable powder, were used. The emulsion was sprayed in two dosages, 200 mg per square foot (2.15 g per m²) and 112 mg per square foot (1.21 g per m²) and the wettable powder only at the latter dosage. The names and populations of selected villages, dates of spraying, formulation and dosages, and the quantities of technical DDT used are given in table VIII.

Stirrup pumps to which were fitted a well-designed nozzle giving a fanshaped spray (made by Galeazzi, Rome) were used. The formula for the emulsion was as follows :—

Technical DDT.	100 pounds	(45.4 kg)
Aromex	25 gallons	(113.6 l)
Soap solution made from	9 pounds	(4.1 kg) of washing soap and
	4.5 gallons	(20.5 l) of water.

The usual method of preparing the mother emulsion by adding soap was found to lead to difficulties, including once a complete reversal of phase, so that a slight modification was adopted with extremely satisfactory results. The modification consisted of taking only the DDT-Aromex solution to the field and adding the requisite quantity of the soap in the field to individual buckets at the time of preparing the final emulsion. The intended final concentration was 5%, but in actual practice it was estimated that the strength was about 4.8%.

Before the labourers visited the villages, they were trained in the requisite speed of spraying to get the intended work done. But it has to be stated that the intended dosages were perhaps slightly exceeded or diminished in actual practice in most of the villages, in all but two the variations being not too great. In Pashai-Demalah and Chalmati, the intended dosage was 112 mg per square foot, but it was estimated that the actual dosages were 61 and 73 mg per square foot (0.66 and 0.79 g per m²) only. These two villages were given a second spraying on 1 and 2 October. The quantities of DDT sprayed in the second round are given in table VIII.

[2] Aromex is a trade name for medium kerosene extract and can dissolve DDT up to 45%-50% (probably rather a high estimate).

TABLE VIII. GENERAL INFORMATION ON DDT SPRAYING OF VILLAGES IN LAGHMAN DISTRICT, JULY-OCTOBER 1949

Village	Population	Date of spraying 1949	Formulation used	Dosage (g/m^2)	Quantity of technical DDT used (kg)
First spraying :					
"Kalatussiraj" (Headquarters of the team)	—	23 July	Wettable powder	1.21	6.4
Tigari	3,138	1, 3, 4, 5 August	Emulsion	1.21	145.3
Pashai-Demalah .	956	2 ,,	,,	,,	41.3
Gumain	1,288	4, 6 ,,	,,	,,	90.8
Gulkari	618	7 ,,	,,	,,	40.9
Tajkari	430	7 ,,	,,	2.15	35.0
Mariam	1,696	8, 9, 10 ,,	,,	,,	178.4
Chalmati	1,462	10 ,,	Wettable powder	1.21	54.0
Sesada	904	11 ,,	,,	,,	66.7
Chanduk	662	12 ,,	,,	,,	66.7
Navalum	640	14 ,,	,,	,,	50.9
Pashakhel	152				
Maskura.	1,624	15 ,,	,,	,,	41.3
Total	13,570				817.7
Second spraying :					
Pashai-Demalah. .	956	1 October	Emulsion	0.69	36.3
Chalmati	1,462	2 ,,	Wettable powder	0.45	36.7
Total. . . .	2,418				73.0

Galeazzi pressure sprayers were used during the second round with satisfactory results.

On the average daily labour employed consisted of 8 havildars (squad foremen) and 40 labourers. Each squad foreman had 5 labourers with him, four manning pumps and one for supply of materials.

3.2 *Effect on anopheline mosquitos*

In table IX are presented summarized data of the mosquito prevalences in houses in the sprayed and unsprayed comparison villages. Six routine adult collecting stations were established in each village and timed weekly collections for 20 minutes were made in each station, commencing at 10 a.m. On several occasions the stations in sprayed villages were later sprayed lightly with pyrethrin extract and the mosquitos knocked down,

if any, were collected on white sheets, to check the efficiency of the collection with the suction tube. The number so collected was negligible.

It can be seen that there was a very marked reduction in the numbers of anophelines resting indoors after the spraying operations and that the reduction persisted even up to the end of 12 weeks after spraying and also that there are no noticeable differences in the effects produced by the variations in formulations and dosages. Even in Pashai-Demalah and Chalmati where dosages were much below the intended 112 mg per square foot results were satisfactory. As malaria transmission may be expected to cease by the end of October the single application of DDT in the first half of August has been effective in keeping down mosquitos for the entire period. The data for unsprayed villages indicate that the natural densities of the vector species continued to be very high throughout the period.

3.3 *Effect on culicine mosquitos*

Table IX includes also the collection data for culicines. It may be noticed that culicine adults (most of which were *Culex fatigans*) returned in small numbers even earlier than anophelines.

3.4 *Spleen-rates*

The period elapsing between the pre-operational and post-operational surveys has been too short to expect any significant reduction in spleen-rates. The data for all the villages are given in table II, where it may be noted that the spleen-rates towards the end of the transmission season ranged from 71% to 100% in unsprayed villages and from 39 to 89% in the sprayed ones.

The average cumulative rates were 62.0% in sprayed and 89.0% in the unsprayed villages. The average enlarged spleen was of a much smaller size in the sprayed than in the unsprayed villages.

An analysis has been made of the spleen-rates and sizes among 198 children who were examined during both the surveys in the sprayed villages. The reduction in the spleen-rate among them was from 74% to 60%, in the average enlarged spleen from 2.9 to 2.5, and in the average spleen from 2.1 to 1.5.

3.5 *Parasite-rates*

The data for parasites are to be found in table III.

The average cumulative parasite-rate in the sprayed villages was only 10.6% as against 30.9% in unsprayed villages. While this difference is in itself significant, the fact that the childhood parasite-rate of unsprayed villages is only 30.9% when the infant parasite-rate is as high as 70.0% calls for some comment. In my view the lower parasite-rate among children is most probably due to the fairly high degree of immunity they have acquired as compared with infants. Such immunity, though acquired at high cost,

TABLE IX. ANOPHELINE AND CULICINE ADULTS COLLECTED IN ROUTINE CATCHING STATIONS, JULY-OCTOBER 1949 (EXPRESSED IN A PER-MAN-HOUR RATE)

Village	Mosquitos *	Per-man-hour rate of collection during week ending				
		July	August			
		30	6	13	20	27
Villages sprayed with emulsion						
Pashai	(a)	—	4.5	0.5	0	0
	(b)	—	0	0	0	0
	(c)	—	84.5	8.0	3.5	2.5
	(d)	—	2.0	0	0	0
Tigari	(a)	18.0	1.0	0	—	0
	(b)	0	0	0	—	0
	(c)	76.5	17.0	0.5	—	0
	(d)	—	2.0	0	—	0.5
Gumain	(a	—	6.0	0	0	0
	(b)	—	0	0	0	0
	(c)	—	58.5	4.5	1.0	0.5
	(d)	—	0	0	0	0
Tajkari	(a)	—	3.5	0.5	1.0	0
	(b)	—	0	0	0	0
	(c)	—	80.5	1.5	1.5	0
	(d)	—	3.5	0	2.0	0
Mariam	(a)	—	3.0	2.5	0	0
	(b)	—	0	0	0	0
	(c)	—	75.0	15.5	0	0
	(d)	—	2.0	0	0	0
Villages sprayed with wettable powder						
Chalmati	(a)	—	—	8.5	—	0
	(b)	—	—	0	—	0
	(c)	—	—	91.5	—	0
	(d)	—	—	4.0	0	—

The thick vertical line separates the collections made before and after spraying.

* (a) = *Anopheles culicifacies*
(b) = *Anopheles superpictus*
(c) = All anophelines
(d) = All culicines

Per-man-hour rate of collection during week ending								
September				October				
3	10	17	24	1	8	15	22	29
0.5	0	0	0	0.5	—	0	0	0
0	0	0	0	0	—	0	0	0
5.0	0	0.5	0	3.0	—	0	0	0
0	—	0.5	—	3.0	—	0	0	0
0	0.5	0	0	—	0	0.5	0	—
0	0	0	0	—	0	0	0	—
0.5	1.5	0	0.5	—	1.0	1.0	0	—
0	1.0	0	3.5	—	1.0	2.5	1.0	—
0	0	0	0	0	—	0	0	0.5
0	0	0	0	0	—	0	0	0
0	0	0	0	0	—	0	0	1.5
0.5	0	0	0	0	—	0	1.0	0.5
0	0	0	—	0	—	0	1.0	0
0	0	0	—	0	—	0	0	0
0	0	0	—	0	—	0	2.0	0
0	0	0	—	2.0	—	3.5	4.5	3.0
0	0	0	—	0	—	0	0	0
0	0	0	—	0	—	0	0	0
0	0	0	—	0	—	0.5	0	0
0	0	0	—	0	—	15.0	7.0	2.0
0	0	0	0	0	—	0	0	0
0	0	0	0	0	—	0	0	0
0	0	0	0	0	—	0	0	0
0	0.5	0	0.5	0.5	—	0	0	1.5

TABLE IX. ANOPHELINE AND CULICINE ADULTS COLLECTED IN ROUTINE CATCHING STATIONS, JULY-OCTOBER 1949 (continued) (EXPRESSED IN A PER-MAN-HOUR RATE)

Village	Mosquitos *	Per-man-hour rate of collection during week ending				
		July	August			
		30	6	13	20	27
Navalum	(a)	—	11.0	2.0	—	0
	(b)	—	0	0	—	0
	(c)	—	68.0	30.5	—	0
	(d)	—	1.0	3.5	—	0.5
Unsprayed villages						
Alishing	(a)	—	11.5	—	25.5	—
	(b)	—	1.0	—	0	—
	(c)	—	111.0	—	41.0	—
	(d)	—	—	—	3.0	—
Chardhi	(a)	—	—	26.0	14.8	25.5
	(b)	—	—	0	0	0
	(c)	—	—	60.0	22.5	39.0
	(d)	—	—	0.5	7.0	10.0
Haiderkhani	(a)	—	—	63.0	58.0	10.0
	(b)	—	—	0	0	1.0
	(c)	—	—	93.0	65.0	17.0
	(d)	—	—	1.0	4.5	3.0
Haramal	(a)	—	—	8.0	10.5	19.5
	(b)	—	—	0	0	0
	(c)	—	—	77.0	66.5	32.0
	(d)	—	—	—	9.0	1.0
Kalakot	(a)	—	—	—	78.0	49.5
	(b)	—	—	—	0.5	0
	(c)	—	—	—	89.5	65.0
	(d)	—	—	—	2.5	8.0

The thick vertical line separates the collections made before and after spraying.

*** (a) = *Anopheles culicifacies***
(b) = *Anopheles superpictus*
(c) = All anophelines
(d) = All culicines

Per-man-hour rate of collection during week ending								
September				October				
3	10	17	24	1	8	15	22	29
1.0	0	0	0	0	—	0	0	0
0	0	0	0	0	—	0	0	0
1.0	0	0	0	0	—	0	0	0
0	0.5	0	0	0	—	4.5	4.0	4.0
—	12.0	19.5	—	72.0	39.5	67.0	—	—
—	18.5	17.0	—	16.5	4.5	7.0	—	—
—	45.0	52.5	—	125.5	55.5	80.5	—	—
—	3.5	4.5	—	2.5	6.0	7.0	—	—
—	10.0	18.5	—	32.0	—	11.0	8.0	2.0
—	5.5	13.0	—	8.0	—	1.5	0.5	2.0
—	40.0	55.0	—	47.5	—	15.5	20.0	8.0
—	5.5	4.5	—	—	—	19.0	23.0	23.5
—	6.5	9.5	15.5	43.5	—	6.0	8.5	45.5
—	10.0	12.0	4.5	6.5	—	1.0	3.0	4.0
—	25.5	30.0	38.5	57.0	—	9.0	17.5	67.5
—	4.0	3.0	12.0	0.5	—	3.0	7.0	8.0
2.0	1.0	4.0	3.5	13.5	—	18.0	20.0	12.0
0	6.0	2.5	4.5	1.5	—	0.5	1.5	0
18.5	19.0	13.0	21.0	33.0	—	30.5	44.0	28.5
0	1.5	1.0	2.0	0	—	10.0	5.0	6.0
—	30.5	25.5	44.0	34.0	—	57.0	17.5	12.0
—	9.0	9.5	10.0	7.0	—	2.5	2.5	3.5
—	53.5	48.0	63.0	52.0	—	65.5	28.0	21.5
—	1.0	3.5	6.0	—	—	9.5	35.5	22.0

undoubtedly occurs in hyperendemic areas, and the disparity between infant and childhood parasite-rates are not altogether unknown. For instance in the hyperendemic Kanara District in India, Viswanathan & Parikh [3] found an infant parasite-rate of 33% in the unsprayed villages while the childhood parasite-rate in the same villages was only 23%.

3.6 *Infant parasite-rates*

Referring again to table IV it will be noted that of 72 infants examined in sprayed villages 6 showed parasites (infant parasite-rate 8.3%) as against 49 out of 70 (rate 70.0%) in unsprayed villages. This difference is certainly highly significant, but the fact that there were still over 8% infections calls for some comments and is discussed below.

3.7 *Morbidity statistics*

An effort was made to assess the degree of morbidity in selected villages, both sprayed and unsprayed, by an Afghan doctor but unfortunately was suspended because of his ill-health. Three sprayed villages were visited and an incidence of only 10-12 patients for the whole village was noticed. But in unsprayed villages the incidence as seen in the middle of October was very high and from general inquiries made it appeared that 2-3 patients were to be found in each house.

4. Discussion

The studies reported above have succeeded in showing that malaria is transmitted in the Eastern Province of Afghanistan by *A. culicifacies* and *superpictus* and that the transmission could be effectively checked by the use of DDT indoor residual sprays. The period of observation has been too short for revealing significant differences in spleen-rates and childhood parasite-rates, but a very clear reduction in the infant parasite rate has been noted. Yet the presence of an infant parasite-rate of over 8% in sprayed villages calls for some comment.

There are three possible explanations for the persistence of even this infant parasite-rate : (*a*) the season of transmission is much longer than generally assumed and therefore some transmission had taken place even before the dates of spraying; (*b*) some amount of outdoor resting of the vector anophelines takes place leading to incomplete cessation of transmission ; and (*c*) infected mosquitos infiltrate from adjoining unsprayed villages.

The rivers and streams in the area undoubtedly become suitable for breeding of *superpictus* in the middle of May, when climatic conditions are also quite favourable for effective malaria transmission. Fair numbers of *superpictus* adults have been collected in that month by the survey team. It is quite consistent with all known facts to presume that a low degree

[3] Viswanathan, D. K. & Parikh, R. O. (1946) *J. Malaria Inst. India*, **6**, 383

of transmission commences in May. In June, all the fields are flooded for rice cultivation and production of *culicifacies* begins on a gigantic scale. By the middle of July very high densities are already built up. Atmospheric conditions being very favourable, transmission by *culicifacies* can commence in a minimum of time. This " irrigation malaria " is of a much higher order than the low grade " *superpictus* malaria ". In the meantime the streams also become increasingly favourable for both *superpictus* and *culicifacies*, and towards the end of September the maximum rate of transmission with the combined efforts of the two species is established. The climatic conditions in October are still highly favourable for transmission, but with the beginning of the cold season in November transmission may be expected to become negligible. The season of transmission in Laghman may be schematically summarized as follows :

Month	*Species*	*Degree of transmission*	*Breeding-places*
May June	*A. superpictus*	low	rivers and streams
July August September October	*A. superpictus* and *culicifacies*	very high with the peak in September	rice-fields, channels, rivers, and streams
November to April	no transmission		

The first spraying was done in the first half of August at a time when even the high grade transmission had commenced. It is quite possible that all the 8% infants were infected before the spraying. It is highly desirable that the first spraying should be completed before the end of May and the second in the middle of August. The first would minimize the *superpictus* transmission of the earlier months and also effectively prevent the initiation of the *culicifacies* cum *superpictus* transmission of July. The second would completely check the vigorous transmission of August and September. An open mind is however kept regarding the utility of a single round of a large dosage (200 mg per square foot).

The degree of outdoor resting of the vector species during day-time requires careful study. As discussed above the indications are that it cannot be very high. But with a species like *culicifacies* occurring in such large numbers, it would not be unreasonable to expect some transmission even if a small proportion habitually rests outdoors and is prevented from contact with DDT film on the interior walls of the house. This theoretical possibility cannot be ignored and would be a tempting explanation for the 8% infant infections in sprayed villages.

The proximity of some unsprayed villages to the sprayed ones is the third plausible explanation. Laghman being a well-populated area, it was not possible to select all sprayed villages sufficiently removed from

unsprayed ones. In some cases the latter were within the effective flight-range of mosquitos. It is not an impossibility that some infiltration could have taken place. The only remedy for this is to include all the villages of the district, at least all villages in the same valley, in the spraying programme. It has been proposed that in 1950 the whole of Laghman district with a total population of about 70,000 and total area of 250 square miles (647 km²) should be taken up for spraying.

The present study has also answered, though partially, another debatable question : whether effective stoppage of transmission can take place when the entire human population habitually sleeps outdoors during the transmission season, while only the interior of the houses is sprayed. If the vector anophelines entirely avoided entering the dwellings for resting, the results could not be expected to be good. In the present case, transmission has been checked very well, which only goes to show that the place of biting is not material provided mosquitos do enter sprayed dwellings either for resting or for feeding.

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SUMMARY

A short malaria survey and a small-scale demonstration project for malaria control were carried out in Laghman district of the Eastern Province of Afghanistan from July to October 1949.

Malaria was found to be hyperendemic in all villages and *A. culicifacies* and *superpictus* were proved to be vectors. *Stephensi*, which also occurred in large numbers, was suspected of being a vector. The season of transmission is believed to extend from May to October, being of a very low grade in May and June and very intense from July to October. Malariogenic breeding-places are streams, rivers,

RÉSUMÉ

Une brève enquête sur le paludisme et une démonstration restreinte de lutte antipaludique ont été effectuées, de juillet à octobre 1949, dans le district de Laghman, situé dans la Province orientale de l'Afghanistan.

Il a été constaté que le paludisme sévissait à l'état hyperendémique dans tous les villages et que les vecteurs en étaient *Anopheles culicifacies* et *superpictus*, bien qu'on ait également soupçonné *stephensi*, présent en grand nombre. On pense que la transmission s'effectue entre mai et octobre : très faible en mai et juin, elle est extrêmement forte de juillet à octobre. Les gîtes larvaires favorables à la propa-

and swamps throughout the season and rice-fields and channels between July and October.

The very high degree of transmission noticed resulted in an infant parasite-rate of 70%.

DDT was sprayed as an indoor residual spray in August in 13 villages with a total population of 14,000. Formulations used were DDT-Aromex-soap emulsion and water wettable powders. Dosages were 200 mg per square foot (2.15 g per m^2) in some villages and 112 mg per square foot (1.21 g per m^2) in others. Anopheles densities in sprayed villages continued to be under effective control even at the end of 12 weeks after spraying. No difference was noted between the effects of various formulations and dosages. The average cumulative spleen-rate in sprayed villages at the end of the season was 62.0% and in unsprayed villages 89.1%. Infant parasite rates were 8.3% in sprayed villages as against 70.0% in unsprayed ones.

These results are discussed and it is suggested that for effective and complete control (1) the first round of spray should be in the middle of May and a second round in August and (2) the entire district should be treated to prevent infiltration of infected mosquitos from unsprayed to sprayed villages.

It has been shown that effective control can be established even if the entire human population sleeps outdoors at night, provided the bulk of the mosquitos seek shelter inside houses.

gation du paludisme sont constitués par les ruisseaux, les rivières et les marais, pendant toute la saison, et par les rizières et leurs canaux d'irrigation, de juillet à octobre.

Le haut degré de transmission s'est traduit par un indice parasitaire de 70% chez les nourrissons.

L'intérieur des habitations a été traité au moyen de DDT, au début d'août, dans 13 villages ayant ensemble une population de 14.000 habitants. Les préparations employées ont consisté en émulsion DDT-Aromex-Savon et en poudres mouillables à l'eau. On a employé des doses de 200 mg par pied carré (2,15 g par m^2) dans certains villages et de 112 mg par pied carré (1,21 g par m^2) dans d'autres. Les anophèles, dans les villages soumis aux pulvérisations, étaient encore tenus efficacement en échec 12 semaines après le traitement. On n'a constaté aucune différence dans les effets des préparations et dosages différents. L'indice splénique moyen d'ensemble était, à la fin de la saison, de 62,0% pour les villages ayant fait l'objet des pulvérisations et de 89,1% pour les villages non traités. L'indice parasitaire des nourrissons était de 8,3% dans les villages traités et de 70,0% dans les villages non traités.

Ces résultats font l'objet d'une discussion dont la conclusion est la suivante : pour que les mesures de lutte soient complètes et efficaces, il faudrait 1) procéder à une première série de pulvérisations au milieu du mois de mai et à une deuxième en août, et 2) traiter la totalité du district afin d'empêcher l'infiltration, dans les villages soumis aux pulvérisations, de moustiques infectés provenant de villages non traités.

Il a été démontré que l'on peut combattre efficacement le paludisme, même lorsque toute la population humaine dort en plein air la nuit, si la grande majorité des moustiques cherchent un abri à l'intérieur des habitations.