WORLD HEALTH ORGANIZATION

REGIONAL OFFICE FOR THE EASTERN MEDITERRANEAN

ORGANISATION MONDIALE DE LA SANTÉ

BUREAU RÉGIONAL DE LA MÉDITERRANÉE ORIENTALE

SECOND REGIONAL CONFERENCE ON MALARIA ERADICATION

ADDIS ABABA, 16 - 21 NOVEMBER 1959

EM/ME-Tech.2/11

19 October 1959
ENGLISH ONLY

MALARIA ERADICATION PILOT PROJECT WITH SPECIAL REFERENCE TO SAUDI ARABIA

by

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INTRODUCTION

The known history of malaria in Saudi Arabia is comparatively short. It hardly covers twenty years since malaria infections were distinctly observed amongst employees of the Arabian American Oil Company, in the Eastern Section of the country in the year 1941, as reported by Darby 1957. Prior to that date, Farid 1956, reported that malaria has been deeply rooted in Saudi Arabia since the pre-Islam era. Other fragmental records scattered in various literatures, provide limited information regarding the prevalence of the disease in some foci in the country. Towards the end of 1950 and the beginning of 1951 a severe local epidemic occurred in Jeddah-Mecca area, as well as the adjacent areas of Wadi Fatma. Hence, a lawfighting campaign was created by the Government to combat the epidemic in Jeddah town. Subsequently, the Government decided to take more serious steps in combating malaria, by requesting the assistance of WHO in the matter. On 19 March 1952, the WHO Malaria Control and Demonstration Team arrived at Jeddah and since then the project has continued with objectives which are listed hereunder:

1. Control of Anopheles culicifacies as well as other malaria vectors in Jeddah town and in villages of Wadi Fatma and villages situated along Jeddah-Mecca road, with about 100,000 inhabitants. This area will be referred to as "The Pilgrimage Area".

2. Demonstration of malaria control by DDT residual spraying of premises of Wadi Fatma and localities on Jeddah-Mecca road, to protect inhabitants not exceeding 4,000.

3. Training of a matching team in the modern scientific and most economical methods of combating malaria, in addition to training of a number of malaria inspectors and technicians.

4. Conducting malaria surveys in places to be agreed later on between the WHO Malaria Team Leader and the Ministry of Health. Since then, the duration of the project has been extended several times. It underwent different phases, until it was terminated on 30 June 1959.

The Government/WHO Project has demonstrably fulfilled its objectives. Modern methods of controlling malaria were demonstrated in other two areas, namely Southern Valleys and the Eastern Province since 1954 and 1956 respectively, in addition to the Pilgrimage Area which has been largely extended. Likewise, the total number of inhabitants directly protected has been significantly increased and reached 522,325 in the 1958-1959 season. Other parts of the country were covered by surveys. In 1954 the South Western Coastal Plain and in 1957 the North Western section of the country were surveyed. From the standpoint of training, the Government, with the help of WHO Team, established the Malaria Training Centre at Jeddah, which offers theoretical and practical training to different categories of national malaria workers. In the meantime, the National Malaria Service which did not exist before 1952 has occupied a recognized position in the Ministry of Health and its budget reached four million Saudi Rials during the last fiscal year.

RESULTS AND DISCUSSION:

Pilot Project Areas:

Pilgrimage Area: The sphere of activities of the WHO Team in the Pilgrimage Area spreads over an area of 30,000 square kilometers and includes the two largest cities in Saudi Arabia, i.e. Jeddah and the holy city Mecca. The western side of the area is the Red Sea coastal strip between Rabigh, 156 kilometers north of Jeddah, and Leith, 210 kilometers south of Jeddah. The eastern side is the road between Sale El Kebeer and Berkah, and the segment of Mahd El Dahab road from Berkah to El Mahd. The most northern valleys included are Wadi Hagor, 100 kilometers east of Rabigh and Wadi Mahani, 50 kilometers north of Berkah and 15 kilometers west of Mahd El Dahab road. The southern boundary of the area is Jeddah-Mecca road. Almost all localities and inhabited valleys penetrating the Hijaz escarpment within this area were covered by the Team's activities. (See map I).

The summer climate along the Red Sea coast is hot and damp. The temperatures are seldom above 100°F and the relative humidity is usually over 85 per cent. Humidity is generally less inside the line of foothills and on higher altitudes. The winter is warm and pleasant, with occasional showers. The average annual rainfall is 3.5 to 4.5 inches that flood the numerous valleys. At Jeddah, temperature seldom drops below 55°F with relative humidity of about 55 percent.

The southern section of this area, has been subject to control measures since 1942, i.e. Jeddah town, the Fatma and Jeddah-Mecca road. Later on, control measures were extended annually year by year, to cover an area of about 5,000 square kilometers during the 1958-1959 season affording protection to 356,000 inhabitants, and the rest of the area was left to serve as a control.

Before the commencement of the WHO pilot scheme no previous malariometric records concerning the project area existed that could be used as basis. The only records which partly gave an idea about the severe malaria endemic which occurred at Jeddah and the adjacent area in 1950-1951, are the clinical records of Jeddah Government Hospital. These indicate that 2,932 malaria cases were registered during the period from 3 to 30 December 1950, and 465 cases from 9 to 16 January 1951. No doubt, at least double the number of registered cases, or even more, did not report to the hospital.

1.1 The Urban Section of the Pilgrimage Area:

(a) Jeddah Town: At Jeddah town malaria transmission has been ended since 1955 when monthly regular larvicide cycles have been maintained, evidenced by the results of malariometric surveys among Jeddah school children carried out since March 1956. Only 8 positive cases could be detected during this period and were found to be imported cases. Also Jeddah town proper outskirts have been free from the vector A. gambiae, as indicated by the monthly entomological surveys throughout the 1958-1959 season.

(b) Mecca Town: Since February 1956 Mecca town and its outskirts have been included in the control operations. A routine monthly larviciding cycle preceded by monthly entomological survey has been performed. The first malariometric survey in the town was performed during February and March 1958. No single case of parasite positive could be detected among 1705 school children. Among out-patient attendance at Mecca Government Hospital, four infections which were proved to be imported from neighbouring countries, namely Yemen, were found. The crude spleen rate was as low as 0.17. Such results leave no doubt that Mecca has since become a malaria-free town, though A. gambiae used to be found in odd numbers in February and March 1958.

1.2 The Rural Section of the Pilgrimage Area:

The first reliable record is the annual malariometric pre-spray survey by the WHO Team in Wadi Fatma in December 1952. The spleen rate was 31.5% and the crude parasite rate was 6.7%. Since then, Wadi Fatma and localities of Jeddah-Mecca road have been annually surveyed, followed by DDT residual spraying. Accordingly, up to 1957, malaria endemicity was largely reduced and transmission interrupted. Spleen rate became as low as 7.9% and infant parasite rate 0% and crude parasite rate 0.4%. All of the few parasite positive cases were proved to be imported.

Early in 1958, the project area was subject to exceptional reported high floods and heavy rainfall which produced extensive swamps everywhere. This was coupled with favourable weather conditions for the principal vector A. gambiae which prolifically reproduced and recorded an outstanding index in the unsprayed part of the project area, where consequently a severe malaria epidemic occurred. In the unsprayed area the spleen rate was as high as 65.3% and infant parasite rate 35.3% and crude parasite rate was 45.5%. All age groups were affected in similar degree. 1.8% of the parasitic positives were double infection with both P. vivax and P. falciparum. 85.2% of malaria cases were P. falciparum and 16.9% P.vivax. The sprayed area was slightly affected due to the infiltration of vectors from the unsprayed area and caused resumption of focal transmission in the upper and middle stretches of Wadi Fatma as well as in a locality north of Wadi Fatma called Hada Sham where alteration of premises took place. The spleen rate was increased to 17% and infant parasite rate was 0.7% and the crude parasite rate was 2.5%, while Jeddah town was successfully protected.

During October and November 1958, the regular annual survey was carried out in both sprayed and unsprayed areas. In the former area, it served as a post-operational survey for January and February 1958 DDT application, as well as pre-operational for October and November 1958 spraying. In the unsprayed area, it provided information concerning the natural annual fluctuation of the prevalence of the disease as well as pre-operational survey for the first DDT spraying which would be applied during December 1958. Results of these surveys showed that the endemicity of the sprayed area was reduced to a level similar to that of January 1957, and epidemiological investigations done on positive cases proved that all were either imported or relapses from the previous year's epidemic, with the exception of two cases from Hada Sham north of Wadi Fatma that proved to be autochthonous. The endemicity of the unsprayed area has been relatively reduced and spleen rate became 22% and infant parasite rate 10.7%. It was also noted that P. malariae, which could seldom be found in previous annual surveys, was propagated and recorded a relatively pronounced rate of 4.6%, while 78.9% of the infections were P. falciparum and 16.5% P. vivax.

The last post-operational survey which was carried out during April and May 1959, provides the most recent information regarding the area which received several regular annual sprayings as well as the area sprayed for the first time. In the former area the endemicity was greatly reduced, as evidenced by a spleen rate as low as 2.9%, infant parasite rate 0% and crude parasite rate 0.5%. The few positive cases proved to be all imported cases. Neither adults nor larvae of A. gambiae and A. sergenti could be encountered. In the area which received only the last spraying, the reduction of the endemicity was more pronounced. The spleen rate became 14.8%, infant parasite rate 5.1% and the crude parasite rate 6.4%. Also investigation done on positive cases proved that all were either relapses or imported. No adult vector could be detected (for detailed malariometric data see Annex I).

During the 1958-1959 season, areas behind the Hijaz mountain wall were surveyed for the first time. Malaria endemicity was found relatively low in localities at an elevation of about 2,000 feet; such as Madrakah

and Rabat 150 kilometers northeast of Jeddah. This may be due to the absence of the principal vector A. gambiae. Areas 80 kilometers further inland, where elevation reaches 3800 feet, such as Wadi Mahani and Eshaira, were found malaria-free and none of the known vectors could be detected.

Regarding the food preference, A. gambiae is endophagous with very little exophilic tendency. Zahar (1958) found that out of 104 blood-fed females collected from a sitting room, 94 were engorged with human blood, giving an anthropophilic index of 90.4%. During the same season, he also found that among 141 specimens dissected from different localities within the Pilgrimage Area, 5 had their salivary glands infected with sporozoites, providing sporozoite rate of 3.55%.

The degree of malaria endemicity and epidemicity in the Pilgrimage Area may therefore be concluded to vary from year to year and is positively correlated with the amount and periodicity of rainfall. In seasons during which heavy rainfall and high floods occur, spacious swamps which are produced everywhere provide ideal breeding places to the principal vector A. gambiae. Such conditions increase tremendously the capacity of the environment in putting up the prolificity of the vector which may cause serious outbreaks. It was also observed that the density of A. gambiae reaches its peak during December and January. The secondary vector A. sergenti is usually found in small numbers everywhere and over a longer season. A. sergenti seems to maintain a low rate of transmission and endemicity of the disease, until the principal vector A. gambiae occurs in relatively high density and causes the spread of the disease and its exacerbation which may sometimes reach epidemic forms.

It is noteworthy that movement of popuation also influences the dispersion of the disease and importation of new infections in the Pilgrimage Area in particular. A considerable portion of the population live as semi-nomad and nomad bedouins. They move over a large area of the country, grazing their livestock during the pasture season, which coincides with the malaria transmission season. Secondly, a continuous introduction of source of infection occurs by labourers coming from Yemen, seeking opportunities in Jeddah-Mecca Area. The third category of source of malaria importation is the infection which comes with the mass agglomeration of pilgrims, as evidenced by the results of pilgrims' blood survey which will be presented in later section of this report. This subject has been extensively studied by Farid (1956) and Zahar (1957) and it is emphasized that the pilgrimage season is advancing to coincide with the malaria transmission season in the Pilgrimage Area in four years' time and will remain so for about twenty years.

In the light of the achieved results, the present status of malaria in the Pilgrimage Area can be recognized as a step toward eradication. The neighbouring areas north and south should receive intensive DDT spraying before the discontinuation of insecticide application in the Pilgrimage Area, otherwise, it will be threatened by the re-infiltration of the principal vector A. gambiae, while the area is flooded with

parasite carriers as earlier indicated. On the other hand, since the Pilgrimage Area lies on the outskirts of A. gambiae geographical distribution, this vector is considered here out of its home, and intensive use of residual insecticide on a local coverage basis might lead to eradication of the species from the area. It is recommended that active surveillance be immediately organized. The aim of this system is the elimination of the residual pockets of transmission maintained by the secondary vector A. sergenti, and where larviciding measures are ineffective.

2. The Southern Valleys:

This is the second area where the WHO Team demonstrated the effect of modern control methods. These valleys lie east of the Asir escarpment, extending from 400 kilometers south of Taif until the Yemen frontier. These valleys are Bisha 400 kilometers south of Taif, Tibala 20 kilometers west of Bisha, Tathleeth 120 kilometers south of Bisha, Hobuna 320 kilometers south of Tathleeth and Negran 30 kilometers south of Hobuna and close to Yemen. The inhabitants in these areas are estimated at 31,000.

The climate of this area is generally hot and dry in summer, very cold in winter. Rainfall usually starts in autumn. Floods are frequent and flow from the western and southern highlands i.e. Asir and Yemen.

Since the malaria outbreak which occurred in Negran Valley in October 1954, it has been annually surveyed prior to DDT residual application. The initial pre-operational infant parasite rate was considerably high (45%) accompanied by crude parasite rate of 23.9% and spleen rate of 37.2%. A year after the first DDT residual spraying which had been applied in November 1954, the infant parasite rate dropped down to 0% as well as the spleen rate to 4.4%. Prior to November 1956 DDT application, exceptional heavy rainfall and high floods occurred at an early date i.e. July 1956. This offered the principal vector A. gambiae favourable conditions to reproduce and maintain transmission in a limited area in the upper stretch of the valley, where alteration of premises took place and disturbed the protection offered by the previous residual spraying. Accordingly, in November 1956 infant parasite rate recorded 10.4% and spleen rate increased to 10.7%. The third DDT spraying of November 1956 was successful in bringing down the infant parasite rate to 0% and spleen rate to 6.9%.

In November 1956 and 1957 the annual Negran operation was extended north to include Wadi Hobuna, Wadi Tathleeth, Wadi Bisha and Wadi Tibala, where the vectors are also A. gambiae and A. sergenti with the exception of Tathleeth where only A. sergenti was found. The combined pre-spray spleen rate for all these localities was 27.9%, infant parasite rate 13.6% and the crude parasite rate 19.2%. 75.6% of the malaria cases were P. falciparum infections, 21.2% were P. vivax and 3.2% were P. malariae. Of course, the degree of malaria intensity varied from valley to valley and from village to village within one valley. Some villages, as in Bisha valley, were suffering badly from severe malaria outbreak.

In November 1957, [illegible] spraying [illegible] followed by [illegible] 1.[illegible] [illegible] crude [illegible] rate 3.7% ([illegible] see Annex I).

The 1958 operation could not be carried out due to shortage of DDT supply.

2. The Eastern Province is the part of the Kingdom located along the Persian Gulf between Kuwait and Oman excepting Qatar Peninsula. It is separated from Najd by a great belt of sand dunes known as Dahna. To the south of the Province lies the Empty Quarter. Within the Eastern Province lie the rich oil fields of Saudi Arabia. Very close to the coast of the Persian Gulf lie two oases, Qatif and El-Hassa, with their rich water springs and millions of palm trees.

The spring, summer and autumn climate in Qatif is hot and damp, while in El-Hassa the surrounding bodies of sand tend to reduce the degree of humidity. Winter is generally comfortable with few showers during the period from December to April. The average annual rainfall is about 3 inches.

Daggy (1959) published a comprehensive paper on "Malaria in Oases of Eastern Saudi Arabia", which indicates that pre-control morbidity rates among Saudi Arab employees of the Arabian American Oil Company, during the period from 1941 to 1947 and preceding control measures, varied from slightly over 1000/10,000 in less malarious years to 2,300/10,000 in more malarious years with mean annual morbidity rate of 1,631/10,000. He also added that malaria was responsible for 22 deaths per 100,000 annually among the company employees during the same period, and that P. falciparum infections, particularly cerebral malaria, were the most common infections causing fatalities. Although such data did not provide a complete idea about morbidity and mortality rates for the population of the area as a whole, they are indicative of the fact that malaria was causing a serious health problem in the Eastern Province.

Daggy gives the results of the first malariometric survey carried out in Qatif oasis in 1947 which indicates that infant parasite rate was 100% and crude parasite rate was 86%. Spleen rate in the 2-9 age group was 96% and crude spleen rate was 93%. Of course, the total number examined (4.5) was comparatively small to represent the population as a whole, in addition to the fact that the survey was carried out in some particular villages selected to represent typical oasis conditions from the standpoint of the investigator. It indicates, however, that a severe malaria epidemic was occurring at that time in these particular villages. Taking the results of this survey as representative of the whole area, may give an exaggerated picture of the intensity of malaria.

From 1948 to 1954 Qatif Sub-Province received annual DDT application, except for 1950, while El-Hassa Sub-Province received four biennial DDT applications from 1949 to 1955.

In April 1954 the spleen rate and the crude parasite rate were found by the WHO team to be 9.1% and 2.8% respectively, while the main vector A. stephensi was abundantly present in all localities and found heavily sprayed.

Since Davidson reported in April 1955 that A. stephensi showed resistance to DDT, dieldrin has been applied annually.

Up to 1957 satisfactory results had been achieved as evidenced by the post-spray survey which was carried out in March 1957 and which showed a zero (0%) infant parasite rate, and only one falciparum case, thus giving a crude parasite rate of 0.03%. In 1958, due to administrative difficulties, the annual spray operation was delayed and started in Quatif in mid-October. Consequently results of pre-spray survey showed that the spleen rate became 5.1%, infant parasite rate 1% and 62 P. falciparum infections were found in Quatif only. Investigation of 50 cases revealed that they were autochthonous. Another case proved to be imported from Iraq. Transmission would have been interrupted, if the last dieldrin spraying would have been applied before the onset of the transmission season, in the month of August.

The transmission season in this area starts as early as August and continues through spring. A. stephensi and A. sergenti are considered the principal malaria vectors in the Eastern Province. Prior to the first DDT application in 1948 and until dieldrin was used during 1954, A. stephensi used to be found in large numbers while A. sergenti was very scarce. At present the density of A. sergenti has become greater than A. stephensi, as evidenced by the results of the survey carried out in Quatif during November and December 1958. The indices were found to be 3.2 and 14.2 adult mosquitoes per 100 rooms for A. stephensi and A. sergenti respectively.

Current trials of measuring the susceptibility of A. sergenti to dieldrin were unsuccessful due to an high mortality on both the exposed and the control insects. Results of testing A. stephensi larvae from El-Hasa Sub-Province as well as adults from Quatif Sub-Province to dieldrin, indicated no signs of resistance. LC_{50} of larvae was a little below 0.0008 p.p.m. and none survived at concentration of 0.1 p.p.m. LC_{50} of adults was 0.05% and none survived at 0.4% concentration.

When the results of the DDT susceptibility tests done on adult A. stephensi from Quatif were statistically assessed, they indicated the presence of two populations in term of tolerance to DDT. One had LC_{50} about 0.5% and the other had LC_{50} 1.4%. Such results might suggest that a rapid reversion to DDT resistance by A. stephensi will occur once DDT will be used again.

Regarding the food preference of four Anopheles species, according to precipitin tests carried out by Dr. B. Waiz, Liverpool Institute, England, it was found that 296 A. stephensi were resting in animal rooms and donkey sheds and none was in sleeping rooms. More than 77.6% of the smears were found to be animal blood and none was human blood.

Also 160 A. sergenti were [illegible] animal rooms and only one was in sleeping room. 82.5% [illegible] were found [illegible] animal blood including this one [illegible] found in a sleeping room, no males were found engorged with human blood. Such findings showed a [illegible] endophily and zoophily. Thirty-two A. fluviatilis were found only in animal rooms and all on the smears [illegible] animal blood. 310 A. pulcherrimus were found in animal rooms, except three which were found resting in a sleeping room. One of these was found engorged with human blood, while the other two were found engorged with animal blood. 82.6% of the [illegible] from A. pulcherrimus were animal blood and 1.9% (6 adults) were found to [illegible] human blood.

Results	A. Stephensi No.	%	A. Sergenti No.	%	A. Fluviatilis No.	%	A. Pulcherrimus No.	%
Man	0	0	0	0	0	0	6	1.9
Horse.....	183	61.7	16	10.0	3	4.0	67	21.6
Ox	38	12.8	116	72.5	21	65.7	157	50.7
Ox/Horse	0	0	6	3.8	1	3.1	0	0
Und. Bovid	9	3.1	10	6.2	1	3.1	32	10.3
Negative or No. of smears	57	19.3	10	6.2	5	15.6	26	8.4
Total	296	100	160	100	32	100	310	100

Such findings bear witness to high zoophilic and endophagous and endophobous tendency, except A. pulcherrimus which is proved to be endophagous as well as exophagous.

It should be noted that this conclusion is only valid for the Anopheles population which rest indoors during day-time. This finding also provides a clue that the anthropophilic vector, either A. sergenti or A. stephensi, which is responsible for the authochthonous cases that were detected last season do not rest indoors. More investigations should be done in outside day-time resting places for collecting more representative samples of bloodmeals. At the same time dissection of salivary glands is also necessary for incriminating the vector.

In conclusion, the clear cut resistance of A. pulcherrimus, A. fluviatilis and A. coustani to dieldrin, in addition to the recent record of resistance in A. sergenti also to dieldrin, provide sufficient warning for the possibility of the principal vector A. stephensi following the same pattern and becoming resistant to dieldrin, especially after the switch-over from DDT to dieldrin in 1956, as A. stephensi had earlier shown resistance to DDT. The role of A. sergenti in propagating malaria from [illegible]/residual foci of transmission, has to be also reckoned with in this area, after the bulk of infection transmitted by A. stephensi has been eliminated. It should be emphasized that anti-malaria activities in the

Eastern Provinces bordering through which the pilgrims should receive considerable [illegible] recommended to be immediately [illegible] observer of malaria [illegible] will be [illegible]. The [illegible] susceptibility of A. sergenti and A. ser[illegible] to dieldrin or DDT [illegible] out [illegible] time.

SURVEYS:

1. The Northwestern Section of the Country:

The Government/WHO team carried out a quick survey during November 1957 in the section of the country bordered on the west by the Red Sea and on the east by longitude 42° and in the south by the northern side of the Pilgrimage Area. Along and section in each section, the team surveyed 59 villages distributed in each section namely, Yanbo, 340 kilometers north of Jeddah; villages on Medina road between K.M. 276 and 320; Medina, 425 kilometers north of Jeddah; Al-Ola, 340 kilometers north of Medina; 334 kilometers southeast of Al-Ola; Tayma, 276 kilometers north of Khaiber; Tabouk, 260 kilometers west of Tabouk and Goreyat, 475 kilometers north of Tabouk.

Two types of climate can be distinguished within this large section. South of Khaiber mild winter and hot summer prevail with a limited amount of rainfall, similar to that of Jeddah area. North of Khaiber, a cold winter and frost frequently occur and mild summer prevails. Rainfall seems to be more than 4 inches per annum.

From the combined data obtained, the spleen rate was 9.5% and the infant parasite rate 11.6% and the gametocyte rate 9%. Out of 297 that were found [illegible] positive, 85.9% were P. falciparum infections and 14.1% were P. vivax while P. malariae could not be detected.

In general, the endemicity does not seem very high; however, in Khaiber, where endemicity [illegible], the spleen rate was 42.9%, infant parasite rate 26.8%, and a heavier infection rate was observed in the younger age groups. These results [illegible] findings of Faria (1951).

At Al-Ola, Medina and Goreyat the spleen rates were 11.2%, 6.2% and 14.6%, and the infant parasite rates were 7.8%, 6% and 5.5% respectively.

Other areas such as Yanbo, Medina road from K.M. 276 to 320 north of Jeddah, and Tabouk were found to contain residual foci of transmission.

These surveys, however, should not be taken as basic data for assessment since it represents a single observation. Also in areas where low endemicity is accompanied with a prevailing drought, the source vector may flare up, causing severe malaria outbreaks when suitable meteorological conditions prevail.

Furthermore, in August 1958, a survey limited to one locality in Al Jouf area, about 200 kilometers southeast of Gorayat, showed a spleen rate of 16.4% and parasite rate in infants of 1 to 2 years age group 11.8%, in 2-9 11.6% and in adults above 10 years 7.3%.

The transmission season at Medina and Khaiber area seems to occur in the autumn, but in the northern localities such as Gorayat transmission takes place during autumn and winter, more in winter because of climatic conditions. (For detailed malaria meteorological see Annex I.)

Regarding known vectors encountered, A. gambiae could be detected but in small numbers as far as 380 kilometers north of Jeddah on the coastal plain and up to 120 kilometers north of Medinah on Medina road. Zahar in 1953 also found the same species at Mecca.

A. sergenti can be found in varying density everywhere up to Gorayat. It forms the principal malaria vector up to Tebouk, about 1,000 kilometers north of Jeddah, especially at Medina and Khaiber where its density was as high as 646 adults per 100 rooms.

Further north in Al Jouf and Gorayat, A. superpictus is the main vector. At Gorayat its density was 911 adults per 100 rooms while A. sergenti was 11 only. At Al Jouf, a density of 659 adults A. superpictus per 100 rooms was recorded.

Regarding food preference of A. superpictus, 32 blood meals were collected from Al Jouf and the results show the following:

Site of collection	Tested No.	R E A C T I O N						
		Man	Ox	Goat	Horse	Camel	Mammal	Negative
Animal room	19	5	11	0	2	0	0	1
% Positive		26.3	57.9	0	19.5	0	0	5.3
Sleeping room	13	3	0	6	0	2	1	1
% positive		23.1	0	46.2	0	15.3	7.7	7.7
Combined	32	8	11	6	2	2	1	2
% positive		25	34.4	18.6	6.3	6.3	3.1	6.3

It can be noted that the above data indicate that the anthropophilic index of A. superpictus is 25%. Such index coupled with a relatively high density, i.e. 646 and 911 mosquitoes per 100 rooms at Al-Jouf and Gorayat respectively, do maintain a high degree of malaria transmission.

Zahar in 1957 found 63 A. sergenti resting in caves away from the inhabited area of Khaiber. Such observation provides an evidence that some population of A. sergenti have a tendency for exophily.

Results of precipitin tests, tabulated hereunder, indicate that the anthropophilic index of A. sergenti was 48% at Medina and 18.4% at Khaibar. A. multicolor was found to have an anthropophilic index of 11.1%.

Source of Blood Meal	A. sergenti Medina		A. sergenti Khaibar		A. multicolor Khaibar	
	No. of Smears	%	No. of Smears	%	No. of Smears	%
Human	23	48.0	17	18.4	8	11.1
Ox	9	18.7	57	62.1	43	59.7
Sheep and Goat	2	4.1	0	0	0	0
Und. Bovid	6	12.5	1	1.1	1	1.4
Und. Mammal	1	2.0	5	5.4	5	7.0
Donkey	7	14.5	8	8.7	7	9.7
Ox/Donkey	0	0	3	3.3	0	0
Negative	0	0	1	1.1	1	1.4
Total	48	100	92	100	72	100

2. South Western Coastal Plain:

In March 1954 the WHO Team carried out a reconnaissance survey along the coastal plain which lies south of Jeddah and west of the Hijaz mountain range. It is about 800 kilometers long and its width varies, being generally about 50 kilometers at Jizan and shrinking gradually toward the north until it becomes about 20 kilometers near Jeddah. This plain can be distinguished in the most southern part as Tihama Jizan and the northern part as Tihama Asir.

The climate of this area is generally hot and damp in summer. Tihama Jizan receives the influence of the monsoon and annual rainfall is between 10 to 12 inches while in Tihama Asir it is about 6 inches.

In south Leith, 210 kilometers south of Jeddah, 12 localities were surveyed. Malariometric data indicate that malaria incidence varies from place to place. Spleen rate was 22% in Qunfunda, 41% in Birk, while in Tihama Jizan it was 100% in Wasli, 86.3% in Abu Arish and 100% in Sheqaim. Parasite rate in Tihama Asir and Tihama Jizan were in the same order and varied between 4% to 37%.

A. gambiae is forming the principal vector along this plain. In Tihama Asir, it is always maintained in mother foci such as shallow wells, amongst palm, but spread rapidly with rainfall, breeding prolifically in swamps formed in course of valleys. In Tihama Jizan A. gambiae seemed to have formed a a permanent foothold, on account of regular rainfall and high destructive floods. From such information, malaria seems to be more stable in Tihama Jizan than any other part of the country surveyed.

3. Pilgrims Blood Survey:

As explained in an early section of this report due to the role of pilgrims in importing infection to the country, a pilgrims blood survey was carried out in two successive seasons, i.e. July 1957 and June 1958. In the first survey, out of 13,818 blood samples from 12 countries examined, 0.25% were parasite positive. In the second survey, a total of 19,184 collected from 40 different countries were examined and 0.38% were found parasite positive. These surveys indicated that the main source of importation came from African countries as well as from the south-western part of the Arabian Peninsula. Such a condition will demand active consideration in the development of plan of malaria eradication to protect the pilgrims and prevent them from acting as a continuous source of malaria importation. (For detailed results see Annex II.)

NATIONAL MALARIA SERVICE

The National Malaria Service consists of the Main Training Centre with its attached stations, and other three stations at Dammam in the Eastern Province, Riadh and Medina. A total of 317 permanent posts from different categories are designated for malaria service. About 200 temporary personnel namely sprayers and spraying-aides used to be engaged for four months during the spraying season.

The Main Training Centre at Jeddah is considered as the technical headquarters of the National Malaria Service. Planning of programmes for the other three malaria stations, research on problems, as well as the choice of insecticides and equipments needed, are all referred to the technical staff of the Main Training Centre.

From the financial and administrative aspects, the Main Training Centre, as well as any malaria station, is directly attached to the office of the Director General of the Ministry of Health. The Senior Officer of each station or centre has an authority in dealing with personnel and in administering the budget allocated to him according to the Government's official procedures.

RECOMMENDATIONS:

The National Malaria Service should be strengthened by the creation of new malaria stations in Taif, Qunfunda, Bisha, Negran and Jizan. At Khaibar a sub-station affiliated to Medina Station is necessary. Also the two sub-stations at Hayel and Sikaka should be developed to become independent stations.

A malaria section should be established, that will be developed later on to the central malaria organization.

Legislation: The Government should take the necessary steps towards passing some legal enactments such as stating the right of entry into premises for surveying as well as spraying, and submission to examination. Also in areas such as in the Project Area and the Eastern Province where elimination of the disease has been achieved, a law for compulsory notification of cases, either through private clinics, hospitals etc., through malaria drugs dealers, is very essential.

Health Education: The Ministry of Health is recognizing the importance of health education as well as the need of professional public health works. The new Government/WHO Sanitarians Training Centre at Riadh will greatly help in the matter. Furthermore, sanitarians graduated from this Centre will form the backbone of the country-wide malaria eradication programme.

ACKNOWLEDGMENT

The writer fully acknowledges the efforts of all other WHO experts who participated in this project since 1952 and to whom this work is attributed. He also thanks His Excellency the Minister of Health. The cooperation of the national matching team is highly appreciated.

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ANNEX (I)

Data of Malariometric Surveys

Pilgrimage Area:

Urban Section: Surveys since March 1956.

Jeddah:

	SPLEEN				BLOOD				
Date	No.Ex.	Spl.	S.R.%	AES	No.Ex.	P.v.	P.m.	P.f.	P.R.%
Mar.56	1016	28	2.8	1.1	461	0	1	2	0.1
Oct.56	1250	48	3.7	1.2	1250	0	1	1	0.1
Mar.57	913	78	8.5	1.0	913	0	0	0	0
Oct.57	0	-	-	-	1249	0	0	0	0
Jan.58	525	28	5.3	1.1	525	0	0	1	0.1
Oct.58	0	-	-	-	1803	0	0	1	0.05
Jan.59	0	-	-	-	1831	0	0	1	0.05

Mecca: Surveys of February and March 1958.

	SPLEEN					BLOOD				
Age	No.Ex.	Spl.	S.R.%	AES	AS	No.Ex.	P.v.	P.m.	P.f.	P.R.%
0-1	0	-	-	-	-	108	0	0	0	0
1 +	0	-	-	-	-	89	0	0	1	1.1
2-9	1405	2	0.14	1	0.0001	1663	0	0	0	0
10+	300	1	0.3	1	0.003	319	1	1	1	0.94
Ttl.	1705	3	0.17	1	0.002	2179	1	1	2	0.02

Rural Section:

Wadi Fatma: December 1952;

	SPLEEN					BLOOD				
Age	No.Ex.	Spl.	S.R.%	AES	AS	No.Ex.	P.v.	P.m.	F.R.	P.R.%
2-9	229		31.5						2.6	8.8
10+	127		47.4						3.8	8.7
Ttl.	356		39.1						3.1	8.7

Wadi Fatma & Jeddah-Mecca Rd.: January 1957 (Pre-operational)

	SPLEEN					BLOOD				
Age	No.Ex.	Spl.	S.R.%	AES	AS	No.Ex.	P.v.	P.m.	P.f.	P.R.%
0-1	0	-	-	-	-	129	0	0	0	0
1 +	111	6	5.4	1.6	0.09	112	0	0	0	0
2-9	644	51	7.9	1.15	0.09	652	2	1	1	0.6
10+	238	27	11.3	1.4	0.16	268	0	0	1	0.4
Ttl.	993	84	8.5	1.2	0.1	1161	2	1	2	0.4

Data of Malariometric Surveys

Sprayed Area : January 1958 (Pre-operational)

	SPLEEN					BLOOD				
Age	No.Ex.	Spl.	S.R.%	AES	AS	No.Ex.	P.v.	P.m.	P.f.	P.R.%
0-1	0	-	-	-	-	145	0	0	1	0.7
1 +	82	6	7.3	1.5	0.1	82	1	0	0	1.2
2-9	673	99	14.7	1.29	0.19	673	4	0	10	2.0
10+	283	71	25	1.33	0.33	290	0	0	13	4.5
Ttl.	1038	176	17	1.32	0.22	1190	5	0	24	2.5

Unsprayed Area: February 1958.

	SPLEEN					BLOOD				
Age	No.Ex.	Spl.	S.R.%	AES	AS	No.Ex.	P.v.	P.m.	P.f.	P.R.%
0-1	0	-	-	-	-	68	7	0	18	35.3
1 +	39	20	50.1	1.8	0.92	80	10	0	25	40.0
2-9	444	290	65.3	1.99	1.3	509	38	0	225	51.0
10+	502	334	66.6	1.77	1.19	560	37	0	204	42.5
Ttl.	985	644	65.3	1.86	1.25	1217	92	0	472	45.5

Sprayed Area: October 1958 (Pre-operational).

	SPLEEN					BLOOD				
Age	No.Ex.	Spl.	S.R.%	AES	AS	No.Ex.	P.v.	P.m.	P.f.	P.R.%
0-1	0	-	-	-	-	104	0	0	1	1
1 +	9	-	-	-	-	54	0	0	4	7.4
2-9	553	21	3.8	1.85	0.07	740	4	0	11	2
10+	436	17	3.9	1.64	0.07	584	12	0	5	2.9
Ttl.	989	38	3.8	1.76	0.07	1482	16	0	21	2.5

Unsprayed Area: November 1958 (Pre-operational).

	SPLEEN					BLOOD				
Age	No.Ex.	Spl.	S.R.%	AES	AS	No.Ex.	P.v.	P.m.	P.f.	P.R.%
0-1	0	-	-	-	-	119	4	0	9	10.7
1 +	0	-	-	-	-	81	2	1	16	23.5
2-9	540	119	22	1.78	0.39	785	34	12	170	27.4
10+	782	125	16	2.07	0.33	1180	18	3	82	8.7
Ttl.	1322	244	18.4	1.94	0.36	2065	58	16	277	17.0

Sprayed Area: May 1959 (Post-operational) received several sprayings

	SPLEEN					BLOOD				
Age	No.Ex.	Spl.	S.R.%	AES	AS	No.Ex.	P.v.	P.m.	P.f.	P.R.%
0-1	0	-	-	-	-	101	0	0	0	0
1 +	0	-	-	-	-	73	0	0	0	0
2-9	306	9	2.9	1.7	0.05	728	2	0	3	0.7
10+	280	2	0.7	1.5	0.01	469	0	0	2	0.4
Ttl.	586	11	1.9	1.6	0.03	1371	2	0	5	0.5

Data of Malariometric Surveys

Sprayed Area: April 1958 (Post-operational) one spraying only.

	SPLEEN					BLOOD				
Age	No.Ex.	Spl.	S.R.%	AES	AS	No.Ex.	P.v.	P.m.	P.f.	P.R.%
0-1	0	-	-	-	-	39	0	0	2	5:1
1 +	0	-	-	-	-	21	0	1	0	4:8
2-9	204	28	13.4	2.0	0.28	364	1	1	30	8:8
10+	212	34	16:0	1:8	0.29	275	2	0	8	3:6
Ttl.	416	62	14.8	1.9	0.28	699	3	2	40	6.4

The Southern Valleys:

Ngran Valley: 1954-1957

Malariometric	Nov. 1954 Pre-Operation Exam.	%	Nov. 1955 Post spray 1954 Exam.	%	Nov. 1956 Post spray 1955 Exam.	%	Nov. 1957 Post spray 1956 Exam.	%
Infant P.R.	20	43.3	30		125		269	0
Parasite 2-9	222	26:1	400	1.25	883	4:8	1281	0:5
Parasite 10+	145	26.2	84	0	356	6.4	369	0.3
Falciparum	397	19:4	514	0.8	1364	4.9	1847	0:2
Spleen 2-9	196	37:2	408	4.4	896	10:7	1281	6:9
Spleen 10+	109	44.9	84	8.3	366	33.3	369	25.7

Hobuna, Tathlooth, Bisha and Tibala valleys: Nov. 1956 & Nov.57

		SPLEEN					BLOOD				
	Age	No.Ex.	Spl.	S.R.%	AES	AS	No.Ex.	P.v.	P.m.	P.f.	P.R.%
Nov. 56	0-1	0	-	-	-	-	249	13	0	20	13:6
	1 +	202	45	22.3	1.95	0.43	202	12	0	53	32.2
	2-9	1504	411	27.9	1.91	0.52	1492	62	4	223	19.4
	10+	641	287	44:8	1:95	0:87	694	20	2	96	17:0
	Ttl.	2347	743	31.7	1.94	0.61	2637	107	6	392	19.2

	SPLEEN					BLOOD				
Age	No.Ex.	Spl.	S.R.%	AES	AS	No.Ex.	P.v.	P.m.	P.f.	P.R.%
Nov. 57										
0-1	0	-	-	-	-	562	1	0	5	1
1 +	374	35	9:3	1:80	0:16	374	5	1	13	5
2-9	2184	336	15.4	1:48	0:22	2184	5	3	77	3:9
10+	709	257	36.3	1.54	0.55	758	3	2	27	4:2
Ttl.	3264	628	19.2	1.53	0.29	3878	14	6	122	3.7

Data of Malariometric surveys

The Eastern Province: Sept., Oct., and November 1958.

	SPLEEN					BLOOD				
Age	No.Ex.	Spl.	S.R.%	AES	AS	No.Ex.	P.v.	P.m	P.f	P.R.%
0-1	0	-	-	-	-	1163	0	0	12	1:0
1 +	626	7	2.7	1:3	0.035	670	0	0	8	1:2
2-9	2800	135	5.1	1.32	0.064	2800	0	0	32	1:2
10+	665	69	10.9	1.46	0.152	665	0	0	10	1.5
Ttl.	4081	221	5.4	1.36	0.073	5298	0	0	62	1.17

The North Western Section of the Country: November 1957.

	SPLEEN					BLOOD				
Age	No.Ex.	Spl.	S.R.%	AES	AS	No.Ex.	P.v.	P.m.	P.f.	P.R.%
0-1	0	-	-	-	-	439	8	0	43	11.6
1 +	0	-	-	-	-	313	6	0	40	14:7
2-9	1791	171	9:5	1:51	0.15	1797	17	0	109	7:0
10+	746	94	12.6	1:81	0.21	766	11	0	65	9.7
Ttl.	2537	265.	10.4	1.66	0.17	3315	42	0	255	9.0

ANNEX (II)

Results of Pilgrims Blood Surveys

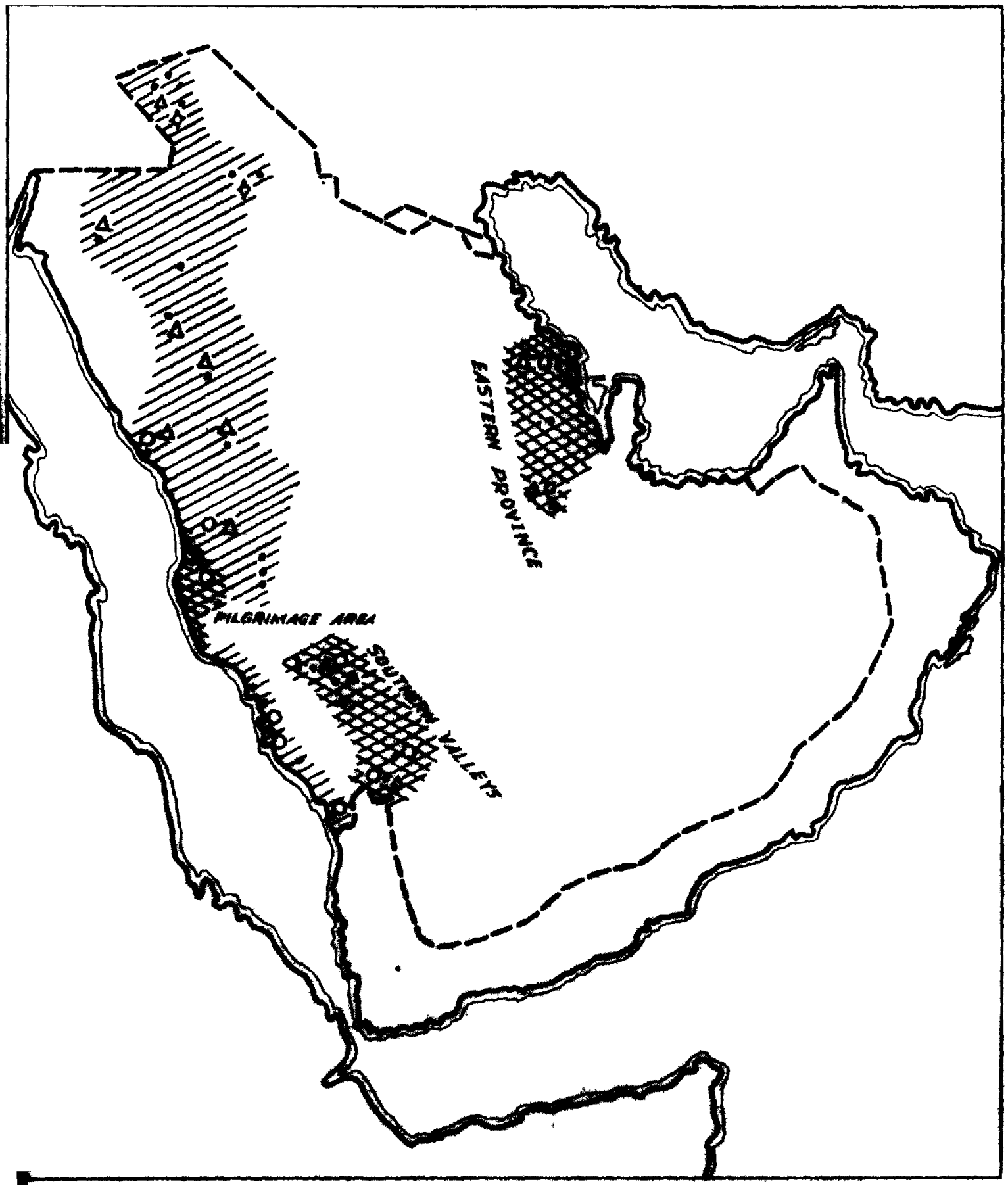
Country	No.Ex.	P.v.	P.m.	P.f.	Ttl.	P.R.%
July 1957						
Malaya	632	0	0	4	4	0.6
Sudan	993	0	0	6	6	0.6
T. Africa	1440	1	3	5	9	0.6
Afghanistan	196	1	0	0	1	0.5
Yemen	2330	1	3	3	7	0.3
India	910	0	0	4	4	0.1
Indonesia	757	0	1	0	1	0.1
Pakistan	742	0	0	1	1	0.1
Libya & N.Africa	814	0	0	1	1	0.1
Egypt	4586	0	0	0	0	0
Gaza	420	0	0	0	0	0
Total	13,820	3	7	24	34	0.25
June 1958						
Uganda	80	0	0	3	3	3.75
French Sudan	310	3	0	4	7	2.32
Nigeria	613	2	0	11	13	2.12
¤ Saudi Arabia (Jizan Area)	298	0	1	3	3	1.34
Tanganyika	84	0	0	1	1	1.19
Sudan	1351	2	1	11	14	1.04
Yemen	2742	2	5	14	21	0.77
Senegal	425	0	0	3	3	0.71
Aden	176	0	0	1	1	0.56
Afghanistan	512	1	0	1	2	0.39
India	998	0	0	1	1	0.1
Indonesia	1019	0	0	1	1	0.1
Iran	1113	0	0	1	1	0.09
U.A.R. (Egypt)	4054	1	0	0	1	0.02

The following twenty five countries showed no positive, the total samples of which is 5418 blood specimens.

Albania, Algeria, Burma, Cambodia, Eritrea, Ethiopia, Greece, Hadramout, Iraq, Jordan, Kenya, Qwait, Lebanon, Libya, Malaya, Morocco, Pakistan, Philippine, Qatar, Siam, Somalia, South Africa, Tunisia, Turkey and U.A.R. (Syria).

Total	19,184	11	7	55	72	0.38

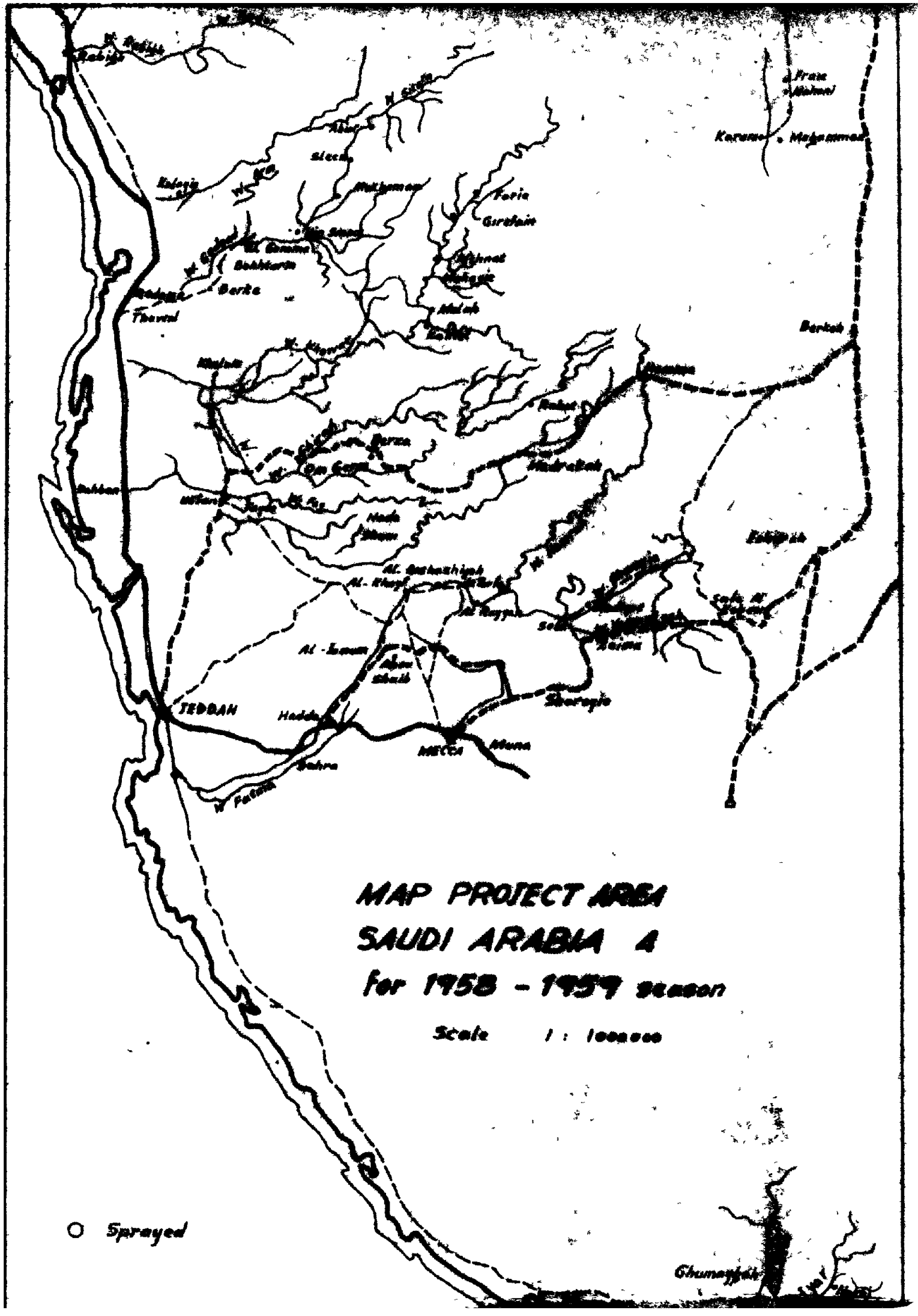
¤ One mixed infection P.f. & P.m.



SKETCH MAP OF SAUDI ARABIA SHOWING AREAS SURVEYED

Malarious Area Under Control

Area Surveyed And Found Malarious



MAP PROJECT ARBA
SAUDI ARABIA 4
for 1958 - 1959 season

Scale 1 : 1000000