MALARIA ERADICATION/CONTROL PROGRAMS

in

SUB-SAHARA AFRICA

By:
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National Institutes of Health

August, 1979

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Previous Programs and Factors which Influence Successful Programs

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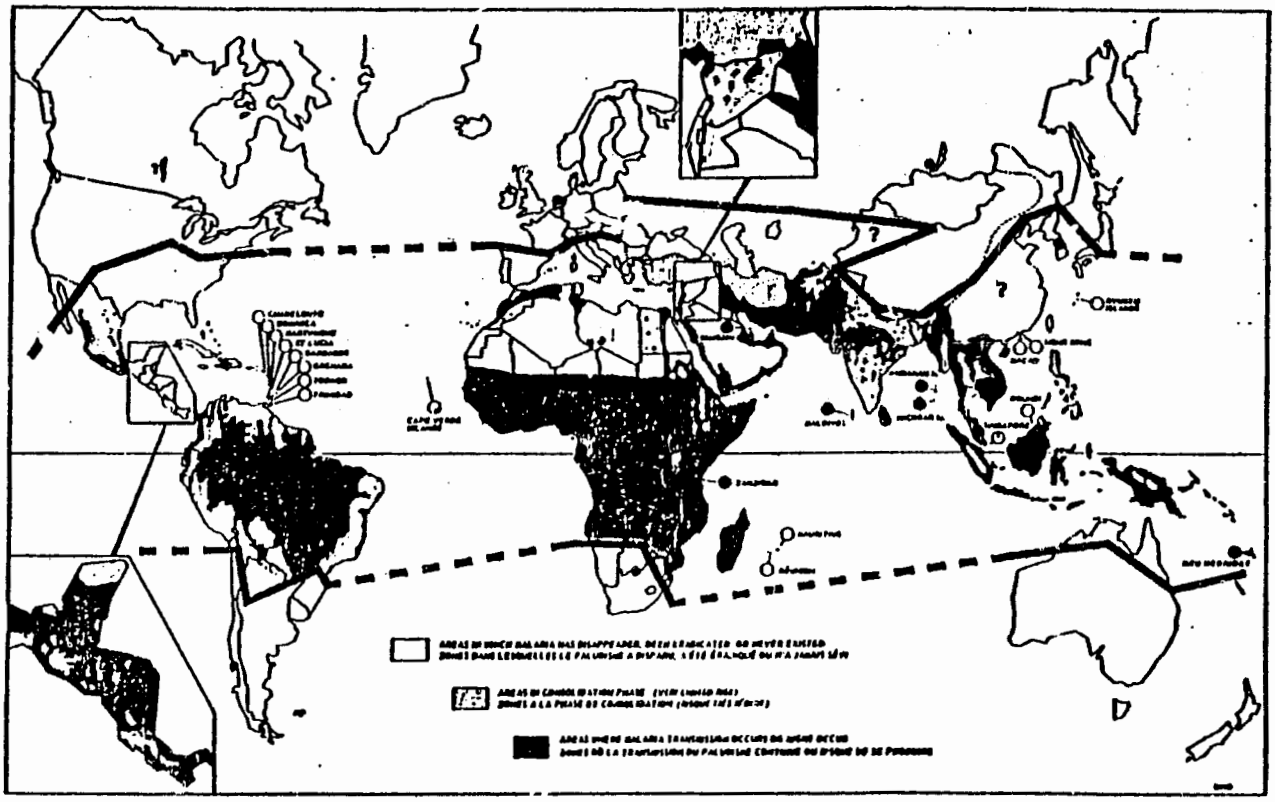
"THE MALARIA PROBLEM"



Geographical status of malaria at the end of 1973, as compared to its original boundaries (World Health Organization 1975b).

"There is no problem in tropical Africa that is not part of some other problem. All are intertwined; nothing can be treated in isolation."

(Huxley, E., African Dilemmas, Longmans Green, London. 1948)

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Summary

Seventy-five per cent of the 394 million people in sub-Sahara Africa, live in areas where the risk of malaria infection is moderate to high. The most aggressive attempts to eradicate malaria in Africa were initiated in the mid 1950s. The majority of the malaria eradication programs were deemed unsuccessful in that they failed to interrupt transmission; however, the rates of malaria transmission were reduced substantially. Among the reasons cited for failure to eradicate malaria were: financial, administrative, complex migratory patterns and local customs of recipients, apparent excitorepellant effect of DDT, resistance to pesticides, change in exophilic behavior of the vector, and lack of trained personnel and health services facilities.

The pressing need to expedite malaria control activities in Africa is accentuated by the rising cost of insecticides and antimalarial drugs, the potential for vector and parasite resistance to control measures, and lack of economical and/or alternative control measures.

INTRODUCTION

A. Purpose

The continuing interest of the Development Support Bureau/Agency for International Development (A.I.D.), the most recent Auditor Generals' report[1] and the renewed interest in malaria by the Africa Bureau/A.I.D. have all contributed to the need for assessing previous malaria eradication/control programs in Africa. A study of this magnitude is necessary before devising a strategy for malaria control in Africa.

B. Malaria in Africa

Malaria is a disease which has affected mankind from very early times. It has been claimed as one of the factors contributing to the fall of the Roman Empire.[2] Centuries later, malaria is still a problem in some parts of the world. Twenty-five percent of the 1,178 million people living in areas where malaria is a risk are in sub-Sahara Africa. In 1977, it was estimated that of the 342,000,000 people living in Africa, only ten percent lived in non-malarious zones and 291,000,000 lived in areas where malaria risk is moderate to high.[3] Table 1 shows those countries where malaria is no longer present or prevalent.

The severity of the malaria problems in sub-Sahara Africa is shown in Table 2. Of the nineteen countries reporting causes of diseases in their respective countries, malaria was unequivocally and by a large margin the number one cause of disease in those countries in which malaria had not been eradicated.[4] The problem is even more serious when one considers the facts that: 1) these are the reported cases and 2) only a small percent of the population has access to a hospital or a health center.

The effects of malaria can be measured in terms of morbidity, mortality and by its economic impact upon the community. In Nssuka, Nigeria, infants born to mothers infected with Plasmodium have a death rate of 6 percent compared to 3.4 percent for those infants born of mothers free of the parasite.[5] In Lagos, Nigeria, acute malaria was incriminated as the cause of death in 9-14 percent of children under eight years of age.[6] Similar statistics were quoted for children in Ituri, Zaire. Six years ago, it was estimated that there were a million deaths per year in infants and children below the age of 14; many of these deaths were attributed to malaria. This large number of deaths in the young population results in half of the population being 15 years or younger.

For those children and adults who survive the first five years, they can expect to miss approximately three days per year from school and work and additional days suffering from milder symptoms of malaria.[7] For a country of over 342 million population, this translates into significant loss of productivity in industry and school.

In countries or areas where malaria eradication or control has been practiced, the reversal of the morbidity and mortality due to malaria has been most dramatic. In Tanzania and Kenya, children in protected areas had less anemia, fewer clinical symptoms, appeared to be taller and less undernourished than children from unprotected areas.[8] In Malagasy Republic and Zanzibar, there was a tenfold and fourfold reduction, respectively in outpatient clinic attendance.

In Pare Taveta, Tanganyika (intervention between 1955-1959), the infant mortality rate was reduced from 165 per thousand to 78 per thousand.[8] Similar results were obtained in Kenya[9] and Senegal.[10] An increase in the number of

births was also observed in Kenya and Tanganyika. The number of hospital deaths due to malaria dropped to practically zero in Malagasy and Zanzibar as a result of malaria control/eradication programs.

C. History of WHO and US/AID Support for Malaria Eradication/Control Programs in Africa

The success of malaria eradication/control programs is due in part to the chemical DDT (dichloro-diphenyl-trichloroethane)[11] and to the success of operational research undertaken by the Rockefeller Foundation in Sardinia between 1946-1950.[12] In 1939, Mueller in Basel, Switzerland demonstrated that a chemical first synthesized by Feidler in Germany was a powerful contact insecticide. In addition, because of its chemical stability and low volatility, it remained lethal to insects months after having been sprayed on walls.

In Sardinia, 90 percent of the population was infected with malaria before eradication measures were undertaken. Initially the objective of the research was to eradicate the vector by larvicidal applications. When the method was changed to residual application of DDT to the interior walls, transmission of the malaria parasite was interrupted. As a result this method was successful on the mainland of Italy, Greece (1950) and Cyprus (1950).

As early as 1948, the malaria program was accepted as one of top priority for the World Health Organization (WHO).[9] Between 1949 and 1952, malaria control demonstration programs by joint WHO and national teams proved that the overall parasite rate as well as the infant parasite rate could be dramatically reduced[13] after one to two years of residual spraying with DDT.[14]

At the Eighth World Health Assembly held in May 1955, it was resolved and decided that since some Anopheles were showing resistance to insecticides,

that efforts to eradicate malaria world-wide should be expedited. (The differences between malaria control and eradication are presented in Table 3.) It was also decided that WHO would take the initiative to provide technical advice and that a special account would be established to allow countries to contribute money or commodities to this effort. As of September, 1959, the equivalent of 8.6 million U.S. dollars had been contributed by thirty-three countries; the United States contributed 8 million dollars.

As a result of this initiative, 13 countries (out of then 40 countries or political units living in malarious areas) in Africa undertook malaria eradication programs. Between 1962 and 1964, these programs were discontinued because the basic health services were unable to support the surveillance necessary for a successful consolidation phase.

In July, 1969, the Twenty-Second WHO assembly met and having considered the setbacks and slow progress in many malaria eradication programs "recognized malaria control as a valid and indispensable interim step where eradication is at present impractical."

Despite the lack of progress to eradicate malaria world wide, WHO persists in its struggle to eliminate malaria as a serious disease. At the Thirty-First World Health Assembly, the Committee drafted a resolution on malaria control strategy (Thirty-First World Health Assembly, Part II, Official Records of the World Health Organization, No. 248, Geneva, 8-24 May 1978). A year later at the Thirty-Second World Health Assembly it was noted that organized antimalaria activities had not yet been initiated in most African countries. The Committee took the following action: 1) urged member states to cooperate, collaborate and intensify their efforts

to implement malaria control activities and 2) requested the Director-General to strengthen WHO's functional structure so as to maximize its actions and to give even higher priority to the malaria control program in future Programme Budgets (Fourteenth Plenary Meeting, 25 May 1979, A 32/VR/14).

The support and interest in malaria eradication/control by U.S./A.I.D. dates back to the early 1950s.[15] The legislative support for eradication programs was established under the 1957 Mutual Security Act, Section 420. Support for these programs is provided for directly by A.I.D. or its predecessor agencies and indirectly through financial contributions to the Pan American Health Organization, the United Nations International Childrens' Educational Fund (UNICEF) and WHO.

The management of the malaria program has had some discontinuity within the Department of State.[15] The program was managed by A.I.D. and its predecessor agencies from 1950 to 1966. Between 1966 and 1973, the U.S. Public Health Service managed the program under a Participating Agency Service Agreement. Since 1973 the program has been managed by the Development Support Bureau/A.I.D.

In 1978, A.I.D. supported malaria control programs in Asia, the Americas and Africa. Six of the eight Asian countries with serious malaria problems are receiving assistance and assistance to the other two countries is being discussed. Assistance through grants and health sector loans is being provided to only one of the fifteen countries in the Americas where malaria is still a problem. In Africa, only two of the twenty-six countries with major malaria problems are receiving assistance; one program is being

phased out by 1980.

At its earliest inception, A.I.D. sponsored bilateral malaria control projects in Liberia and Ethiopia. Its most recent malaria control program is in Zaire. In 1963, the project in Liberia was discontinued for administrative reasons. At the time the program was discontinued, the United States had spent 0.51 million dollars on the project.

The Malaria Eradication Project in Ethiopia was begun in Fiscal Year 1958 after pilot malaria projects under USAID and World Health Organization/ United Nations Children's Fund (WHO/UNICEF) auspices indicated that malaria transmission could be drastically reduced by indoor residual insecticidal spraying. The basic objective of the project was to end the transmission of malaria by 1976.

Assistance to the Imperial Ethiopian Government (IEG) through Fiscal Year 1967 was provided by technical assistance grants for funding U.S. technicians, commodities, participant training and other costs. Technical assistance in the form of grants was continued until FY 1968. Subsequent assistance to the IEG in this program was to be provided mainly by a U.S. development loan signed on October 23, 1967. As of September 1976, the U.S. had contributed a total of 22.4 million dollars in grants and loans to the malaria eradication project in Ethiopia.

The malaria eradication program in Ethiopia was relatively successful.[1] In addition to reducing the morbidity and mortality due to malaria for 200,000 to 300,000 people, there has been a 10% increase in the amount of land under cultivation, and the establishment of two large sugar plantations, a cotton plantation, a paper mill and a meat processing plant in areas where malaria

is now controlled.

The malaria control project in Zaire was begun in fiscal year 1977. The objective of the project is to establish and successfully operate a pilot malaria control project in the Kinshasa Region and in one nearby rural area. A.I.D. will provide technical assistance for a period of five years. to date baseline surveys have been completed, residual spraying has begun and antimalarial drugs have been distributed to children under 15 years of age and to pregnant and lactating women.

D. Scope of Report

The materials for this report were gathered mainly from WHO publications, A.I.D. reports and evaluations, and published articles in medical journals. The inadequacies in the data may lie in not having access to unpublished information from countries that have locally funded malaria control/eradication projects. Chapter 11 includes geographic information and summaries of malaria control/eradication projects in A.I.D. assisted and in those countries south of the Sahara with malaria eradication/control programs. For those countries without identifiable malaria eradication programs, only the geographical and climate data are presented since this information is necessary for planning future malaria control programs. Chapter III explores some of the potential problems which may influence the effectiveness of malaria control programs.

Table 1

Areas in Sub-Sahara Africa with Malaria Eradication Programs as of 1976[1]

Malaria Measures Undertaken	Country or Political Unit
A. Never present or eliminated without specific eradication measures	Seychelles Spanish West Africa St. Helena
B. Malaria Eradication Programs	Cape Verde Islands Lesotho Madagascar (West Coast) Mauritius Natal Northern Transuaal Pemba Reunion Swaziland Union of South Africa Zanzibar

[1] References No. 10; 12; WHO Chronicle 31: 98-101. 1977

Table 2

The First and Second Highest Incidences of Disease Reported to Health Authorities in Sub-Sahara Africa[1]

Country (Reporting Year)	Number of Cases[2]	Estimated Populati (x 1,000)
Benin (1976)		3,100
Malaria	140,157	
Measles	9,514	
Central African Republic (1976)		1,200
Malaria	134,175	
Intestinal Parasites	111,328	
Chad (1976)[4]		4,000
Diarrhael diseases	114,225	
Congo (1976)		1,300
Malaria	169,153	
Influenza	29,872	
Equatorial Guineas (1975)		3.105
Malaria	1,149	
Bacillary Dysentery	305	
Ghana (1976)		9,900
Malaria	443,310	
Measles	129,861	
Lesotho (1976)[3]		1,000
Gonococcal Infections	13,292	
Enteritis	11,211	
Liberia (1975)[4]		1,700
Bacillary Dysentery	2,134	
Malaria	1,211	
Madagascar (1975)[3]		6,200
Influenza	601,749	
Measles	142,288	
Mali (1976)		5,700
Malaria	383,663	
Measles	39,673	

Table 2 (continued)

Country (Reporting Year)	Number of Cases[2]	Estimated Population (x 1,000)
Mauritania (1975)		1,300
Malaria	48,359	
Bacillary Dysentery	15,906	
Influenza	15,097	
Mauritius (1975)[3]		900
Gonococcal infections	241	
Tuberculosis, Respiratory system	217	
Nigeria (1975)		63,000
Malaria	1,083,263	
Measles	134,976	
Rwanda (1976)		4,200
Malaria	85,169	
Measles	77,707	
Senegal (1975)		4,100
Malaria	483,773	
Measles	26,567	
Sudan (1976)		18,000
Malaria	1,030,243	
Schistosomiasis	102,989	
Swaziland (1976)[3]		4,900
Measles	3,752	
Influenza	2,684	
Togo (1976)		2,200
Malaria	274,459	
Diarrhael diseases	137,130	
Uganda (1975)		11,500
Malaria	31,783	
Measles	29,592	
Upper Volta (1975)[4]		
Leprosy	92,278	
Amoebiosis	40,149	

Table 2 continued

[1] World Health Statistics. Volume II. Infectious Diseases: Cases and Deaths. WHO, 1978.

[2] The numbers indicate cases notified to the health authorities. The first and second highest disease incidences are reported.

[3] Countries where malaria has been eradicated or controlled.

[4] Did not report malaria as a disease.

TABLE 3

Differences between a Malaria Control Programme and a Malaria Eradication Programme

	CONTROL PROGRAMME	ERADICATION PROGRAMME
OBJECTIVE	The reduction of malaria to a prevalence where it is no longer a major public health problem	The ending of the transmission and the elimination of the reservoir of infective cases in a campaign limited in time
AREA OF OPERATIONS	Not necessarily covering all the area where malaria transmission takes place	Must cover all the area where malaria transmission takes place
MINIMUM STANDARDS	Good	Perfect
DURATION OF OPERATIONS	Without limits	Programme ends when certain requirements are met [see CHAPTER 9]
COST	Constantly recurring	Expenditure represents a capital investment and is not a permanently recurring cost
CASE-FINDING	Superfluous	Of paramount importance
EPIDEMIOLOGICAL INVESTIGATION OF POSITIVE CASES	Superfluous	Necessary in the late stages
EPIDEMIOLOGICAL EVALUATION OF RESULTS	By usual malariometric surveys	Proof of disappearance of indigenous new malaria cases
IMPORTED CASES	Do not deserve particular attention	Important and dangerous when spraying has been withheld
TOTAL COVERAGE	Unnecessary	Indispensable both for the spraying and the case-finding
ADMINISTRATION OF THE PROGRAMME	May not be the best and still be sufficient	Must be fully efficient and speedy; if not, danger of failure

The above table is a modification of that appearing in W.H.O., E.C.M. Sixth Report, p. 9 (1957).

Reference: Pampana, E., A Textbook of Malaria Eradication. Oxford University Press. 1963. London, England.

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1. Malaria Eradication Programs. Office of the Auditor General, Agency for International Development, Department of State. Audit Report Number 76-348, May 7, 1976.

2. Prothero, R.M., Migrants and Malaria in Africa. 1965. University of Pittsburg Press. Published in Great Britain by Longmans, Green and Co., Ltd.

3. Weekly Epidemiological Record. 54(14): 105-112. April 6, 1979.

4. World Health Statistics. Volume II. Infectious Diseases: Causes and Deaths. WHO. 1978.

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10. Afro Malaria Eradication Year Book No. 1. Who/AFRO.MAL/5. 1959.

11. Pampana, E., A Textbook of Malaria Eradication. Oxford University Press. London, England, 1963. p.4.

12. Brown, A.W.A., Haworth, J. and Zahar, A.R., Malaria eradication and control from a global standpoint. J. of Med Entomology 13: 1-25. 1976.

13. Countries included Afghanistan, Burma, Cambodia, Indonesia, Iraq, Lebanon, Bangladesh, Thailand, and Viet Nam.

14. Pampana, E.J. and Russell, P.F. 1955. Malaria, a world problem. WHO Chronicle 9: 31-100. 1955.

15. Report on Audit of the Malaria Eradication Program. Office of the Auditor General, Agency for International Development, Department of State. Audit Report No. 74-003. August 31, 1973.

II.

Malaria Control/Eradication Projects

A. West Africa[1]

Countries with MEP[2]

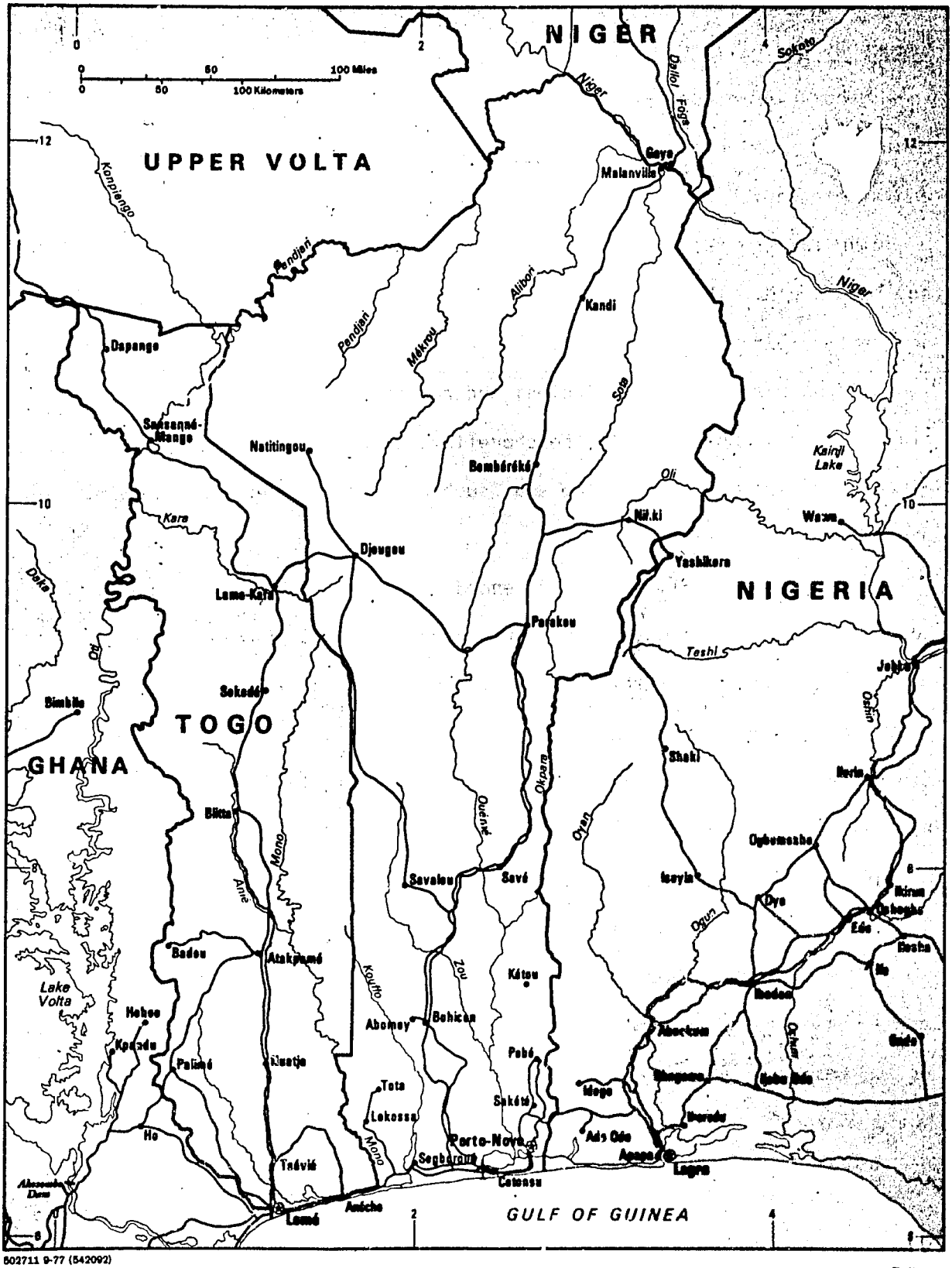
People's Republic of Benin
Republic of Ghana
Republic of Liberia
Federal Republic of Nigeria
Republic of Sierre Leone
Republic of Togo

Countries without MEP[2]

Republic of Guinea
Republic of Guinea-Bissau
Republic of Ivory Coast

[1]Stippled Area

[2]Malaria Eradication/Control Program



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Lambert Conformal Projection
Standard parallels 8° and 32°
Scale 1:3,500,000

DAHOMEY (NOW PEOPLE'S REPUBLIC OF BENIN)

Geography and Climate[1]

Dahomey is a coastal state of west Africa, located on the Bight of Benin between Nigeria and Togo. It has a total area of 43,483 square miles and stretches for some 435 miles, between 6° N and 12° N.

The land surface is generally of low relief and it rises gradually from south to north. The sedimentary coastal zone is part of the extensive sedimentary basin stretching from Nigeria to Togo. Along the coast itself lie sand bars and lagoons. Ancient and recently formed sand bars run in ridges roughly parallel with the shoreline, with occasional openings which give intermittent access to the sea, such as those of the Boca del Rio, and of Grand-Popo and Cotonou.

The Dahomeyan climate is influenced, as for most southerly coastal countries of west Africa, by the south monsoon winds, the northeast trade winds, the proximity of the sea, and the character of the relief. In southern Dahomey there is a temperate subequatorial climate, with temperatures that are high but not subject to great variations. The annual averages of minimum temperatures are around 72° F, those of maximum temperatures around 88° F. Annual rainfalls are moderate in amount in comparison with those of typical equatorial climates. Annual rainfalls are about 55 inches at Porto-Novo, 45 inches at Bohicon, and 35 inches at Grand-Popo. The main rainy season lasts from mid-March to mid-July, with a maximum in June. This is the season of heavy stormy rains and coincides with a period of warm humid weather.

From mid-November to mid-March there is the main dry season, during

Dahomey Climate continued

which rainfall is very low though it normally does not fail altogether. Between these two major seasons there are two minor seasons: the little rainy season lasts from mid-September to mid-November, with a maximum of rainfall usually in October, though always lower than the June maximum. This season is preceded by a dry season from mid-July to mid-September. Throughout the subequatorial zone, the relative humidity is high, ranging between 72 percent and 95 percent.

I. Country: Dahomey (Now Benin)

II. Project

Location: Porto Novo, Cotonou, Coastal belt.

Population: 714,000

Time: 1953-1957

Type: Pre-eradication

III. Endemicity: Highly endemic

IV. Parasite

m Primary: P. falciparum

Secondary: P. malariae

V. Insect Vector

Primary: A. gambiae

Secondary: A. funestus, A. pharoensis

VI. Type of Intervention

Insecticide: Dieldrin was used from 1953 to 1956; DDT (2 g/m^2) was used after 1956 twice annually.

Drug prophylaxis: In 1958 pyrimethamine (50 mg) and chloroquine (600 mg) were given once a month for eight months.

VII. Evaluation

After five years of spraying, the frequency of malaria had been reduced but not interrupted. Relatively good results were achieved with drug prophylaxis alone. After 19 months, the parasite rate in infants was reduced from 17 percent to 2 percent. However, the administration of the drug did coincide with the dry season, so the results may be equivocal.

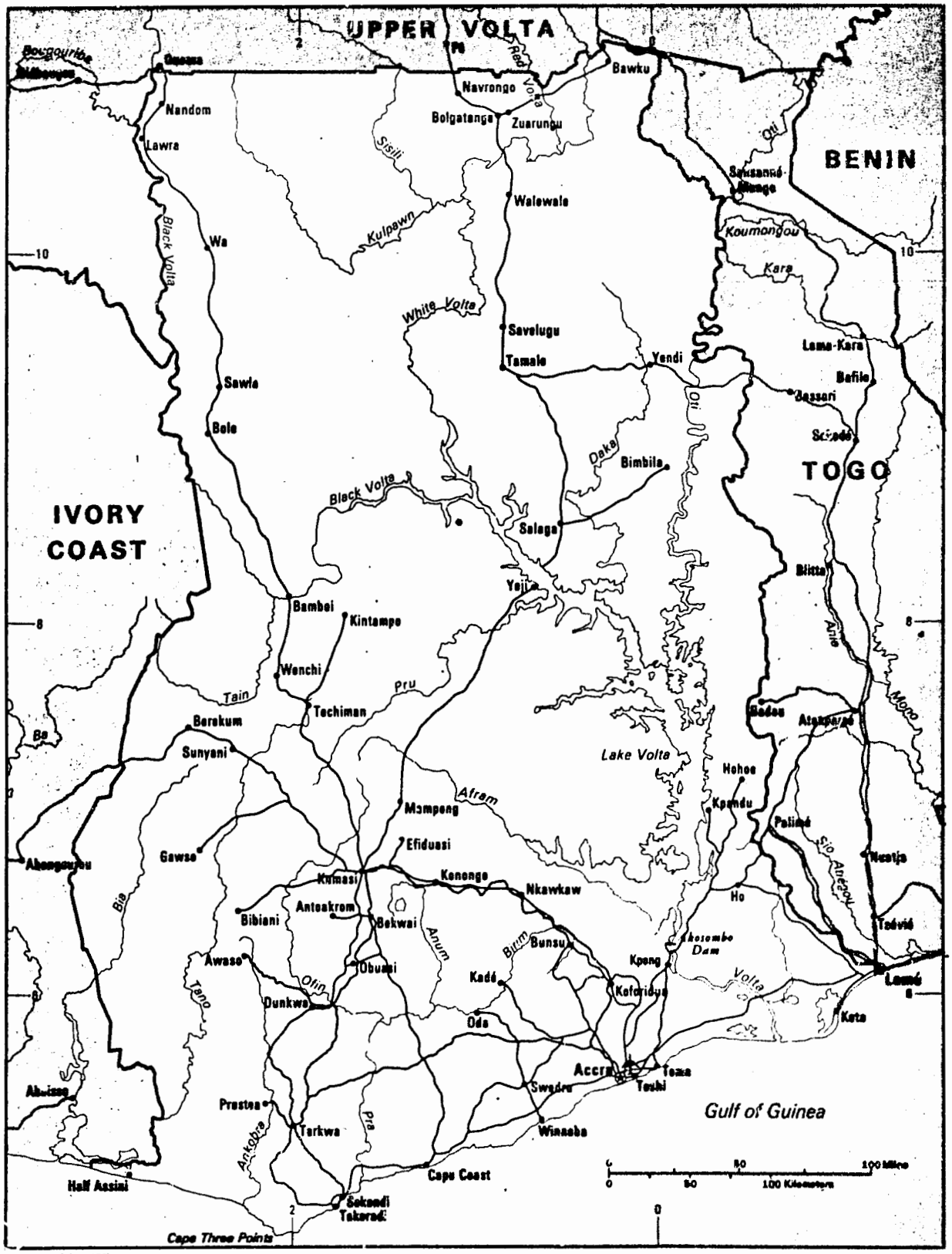
Dahomey Evaluation continued

In December 1959, the spraying and mass drug administration activities were discontinued. Some of the reasons given for failure to interrupt transmission were:

1. Insufficient supply of insecticide.
2. Large labor migrant population.
3. Houses are rethatched and replastered frequently.
4. Funerals and harvest feasts attract many people from unprotected areas.

Reference: Afro Malaria Yearbook No. 1, WHO Regional Office for Africa. AFRO/MAL/5, September 1959. Malaria Yearbook No. 2, WHO Regional Office for Africa. AFRO/MAL/7, December 1960.

Ghana



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Lambert Conformal Projection
Standard parallels 8° and 32°
Scale 1:3,450,000

Railroad
Road
Airport

REPUBLIC OF GHANA

Geography and Climate[2]

The Republic of Ghana lies on the southern side of the bulge of West Africa, just a few degrees north of the equator. It is bordered on the south by the Gulf of Guinea, on the east by Togo, on the north by Upper Volta, and on the west by the Ivory Coast. Ghana is roughly rectangular in shape with an area of 92,100 square miles, slightly smaller than the state of Oregon.

There are five geographic regions in the country. The low plains have a strip of coastal savanna with flat or slightly rolling land and include the delta of the Volta river. North of the lowlands lie the Ashanti uplands which receive considerable rainfall from moisture laden winds.

The Volta basin covers about one-half of Ghana's total area. Lake Volta, created by the damming of the Volta river, is one of the largest man-made reservoirs in the world, covering an area of about 3,275 square miles. In the far north and west are the high plains which have elevations between 500 and 1,000 feet and an annual rainfall of 40-50 inches. The Akwapim-Togo Range of low lying mountains lies in the extreme eastern part of the country. This range is mostly covered with deciduous forests.

The climate is tropical and is influenced by moisture laden trade winds blowing across the Atlantic and by hot, dry winds coming out of the north-east from the Sahara desert. The southern part of the country has high relative humidity during most of the year. Further inland the level of humidity is lower and varies depending upon the prevailing winds. The period from March to October is characterized by heavy rains, expecially in the regions influenced by the Atlantic trade winds, while during November to

February there is little rain. Mean maximum monthly temperatures range from 74-86 ^{o}F at Accra, to 64-95 ^{o}F at Tamale in the north.

Notes[2]

1. In 1967, a WHO Expert Committee on malaria reported 24 vector species of anopheles were resistant to DDT and/or Dieldrin.
2. In 1973-74, the country set aside $30,000 for antimalaria activities.
3. A project to develop the Volta river basin includes water impoundment which may impact upon future malaria control programs.
4. The Ghanian government has given top priority to developing rural areas and as a result several comprehensive rural health and family planning projects have been initiated.

I. Country: Ghana

II. Project

Location: Trans-Volta Territory

Population: 600,000

Time: March 1956 to June 1959

Type: Pilot (Proposed in 1959)

III. Endemicity: High, parasite rates, 65-84%

IV. Parasite

Primary: P. falciparum; responsible for 79% of infections (resistant to Daraprim and cross-resistant to Lapudrine)

Secondary: P. malariae; responsible for 19% of infections

Others: P. ovale; responsible for 2% of infections

V. Insect Vector

Primary: A. gambiae (resistant to Dieldrin) and A. funestus

Others: A. nili; A. hargreavesi

VI. Type of Intervention

Insecticide: Residual spraying with DDT

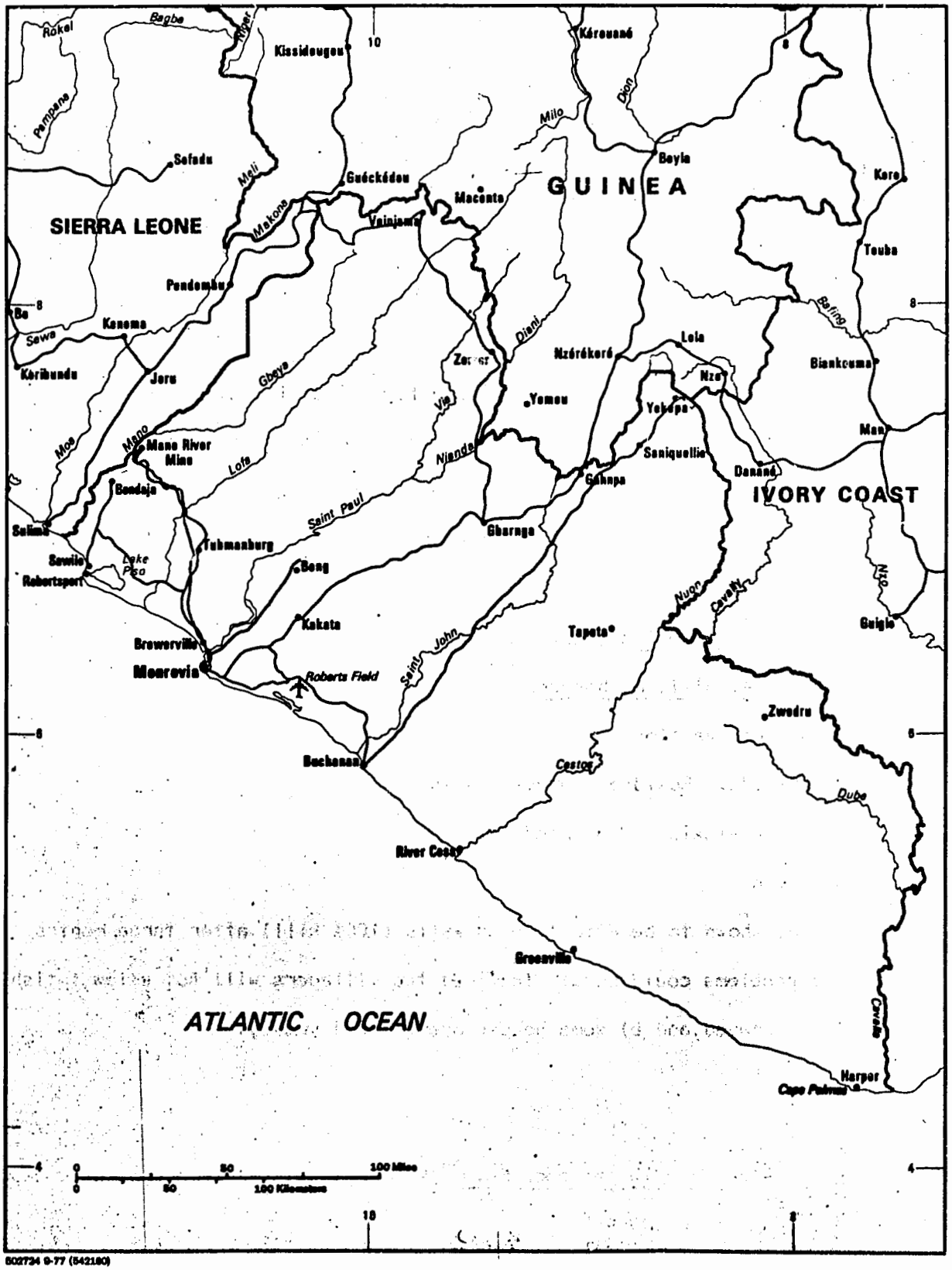
Drug prophylaxis: Medicated salt

VII. Evaluation

DDT was shown to be effective on walls (100% kill) after three months. Potential problems could result from: a) the villagers will not allow fetish huts to be sprayed and b) some houses are painted yearly.

Reference: Afro Malaria Yearbook No. 1, WHO Regional Office for Africa. AFRO/MAL/5, September 1959.

Liberia



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Lambert Conformal Projection
Standard parallels 6° and 32°
Scale 1:2,950,000

—— Railroad
—— Road
✈ Airport

REPUBLIC OF LIBERIA

Geography and Climate[2]

The Republic of Liberia is located on the west coast of Africa a few degrees off the equator, on the great bulge of the continent. It extends about 350 miles along the coast between Sierra Leone on the northwest and the Ivory Coast on the southeast. Guinea is to the north, and the Atlantic Ocean to the west and south. Liberia is about the size of Pennsylvania and covers an area of approximately 43,000 square miles.

There are three geographical zones. Topography ranges from the 30 to 50 mile wide low-lying coastal belt, characterized by mangrove marshes, lagoons, and tidal creeks; an interior tropical rain forest; a region of hills and plateaus extending to the country's inland border and rising to elevations of 600 to 1,000 feet; and the Guinea Highland in the far northern part of the country, where forest is sparse and mountains rise to 5,000 feet.

Although all main rivers carry a good volume of water the year round, there are great variations in flow because of the rainfall pattern and rapid run-off from the watersheds. Most streams overflow their banks after the heavy downpours that occur during the rainy season. The flooding of land creates stagnant pools of water which are breeding grounds for many vectors of such diseases as sleeping sickness, malaria, and schistosomiasis.

Liberia has the hot and humid climate usually associated with tropical countries. Humidity is seldom less than 80% except when the harmattan, a hot dust-laden wind that blows from the Sahara desert from December to February, sweeps the coast. At that time humidity may be as low as 50%.

There are two distinct seasons, dry and rainy. The latter lasts from

May to November and produces rains that account for approximately 85% of Liberia's coastal rainfall, averaging about 175 inches a year. The rainfall extremes vary from 70 inches inland to 250 inches along parts of the coast. Temperatures are warm and rather uniform throughout the country. During the entire year average temperatures are between 70 °F and 80 °F.

Notes[2]

1. Since 1971, larviciding and residual house spraying has been ongoing in all counties and territories of Liberia.
2. Malaria control programs since World War II have reduced malaria transmission in Monrovia but mosquito resistance to insecticides has resulted in malaria being a continuing cause of physical inefficiency, sickness and death.
3. WHO Expert Committee confirmed the resistance of anopheles to Dieldrin and cross-resistance to BHC in 1958 (WHO/MAL/198. Feb. 12, 1958).

I. Country: Liberia

II. Project

Location: Central Province of Liberia

Population: 54,000 in 1953; 142,000 in 1955; 200,000 in 1956.

Time: 1953-1957

Type: Pilot malaria eradication program

III. Endemicity: Holoendemic

IV. Parasite

Primary: P. falciparum; responsible for 82% of infections

Secondary: Mixed infection; responsible for 15% of infections

Others: P. ovale; responsible for 6% of infections, P. malariae; responsible for 12% of infections

V. Insect Vector

Primary: A. gambiae (resistant to Dieldrin and BHC), A. funestus

VI. Type of Intervention

Insecticides: DDT spraying; the first round of spraying was at 2.7 g/m^2 additional rounds were at 2 g/m^2.

Drug Prophylaxis: Pyrimethamine and/or chloroquine to approximately 80,000 people.

VII. Evaluation

A. funestus disappeared. A. gambiae was reduced but still is responsible for seasonal transmission of the disease. The mass drug administration project was abandoned.

Some of the problems associated with the failure of this project were:

1. Many of the villages were located in inaccessible forest areas.
2. Migration of laborers to Guinea and the Ivory Coast.

3. Agriculture people moved to their farm areas during the planting and harvest seasons and erected huts which were not sprayed.

Reference: Afro Malaria Yearbook No. 1, WHO Regional Office for Africa. AFRO/MAL/5; September 1959. Malaria Yearbook No. 2, WHO Regional Office for Africa. AFRO/MAL/7, December 1960.

I. Country: Liberia

II. Project

Location: Kpain

Population: 300,000

Time: 1953-1961

Type: Malaria eradication program

III. Endemicity: Holoendemic

IV. Parasite

Promary: P. falciparum

V. Insect Vector

Primary: A. gambiae, A. funestus

VI. Type of Intervention

Insecticide: Dieldrin in 1953; DDT (2.65 g/m^2) once per annum from 1957-1961.

VII. Evaluation

The parasite rate in infants was reduced from 67.5% to 0 and in children was reduced from 73.3% to 30%.

Reference: WHO/AFRO/MAL/9.43.

I. Country: Liberia

II. Project

Time: 1958-1959

Type: Pilot malaria eradication project

III. Endemicity: Holoendemic

IV. Parasite

V. Insect Vector

VI. Type of Intervention

Insecticide: DDT (2.65 g/m^2) once per annum.

VII. Evaluation

The parasite rate in infants was reduced from 72.5% to 0% after spraying. A 38% reduction in parasite rate was observed in older children.

Reference: WHO Expert Committee on Malaria. Fifteenth Report. WHO Tech. Rep. Series No. 467. 1971.

I. Country: Liberia

II. Project

Location: West of Bomi Hills to Kakata, Marshal on the east and inland to Bopulu.

Time: 3 years

Type: Demonstration project

III. Emdemicity: Hyperendemic

IV. Parasite

V. Insect Vector

Primary: A. gambiae melas; A. squamoses (found after spraying operations)

VI. Type of Intervention

Insecticide: Dieldrin - annual spraying; larviciding - main part of city only.

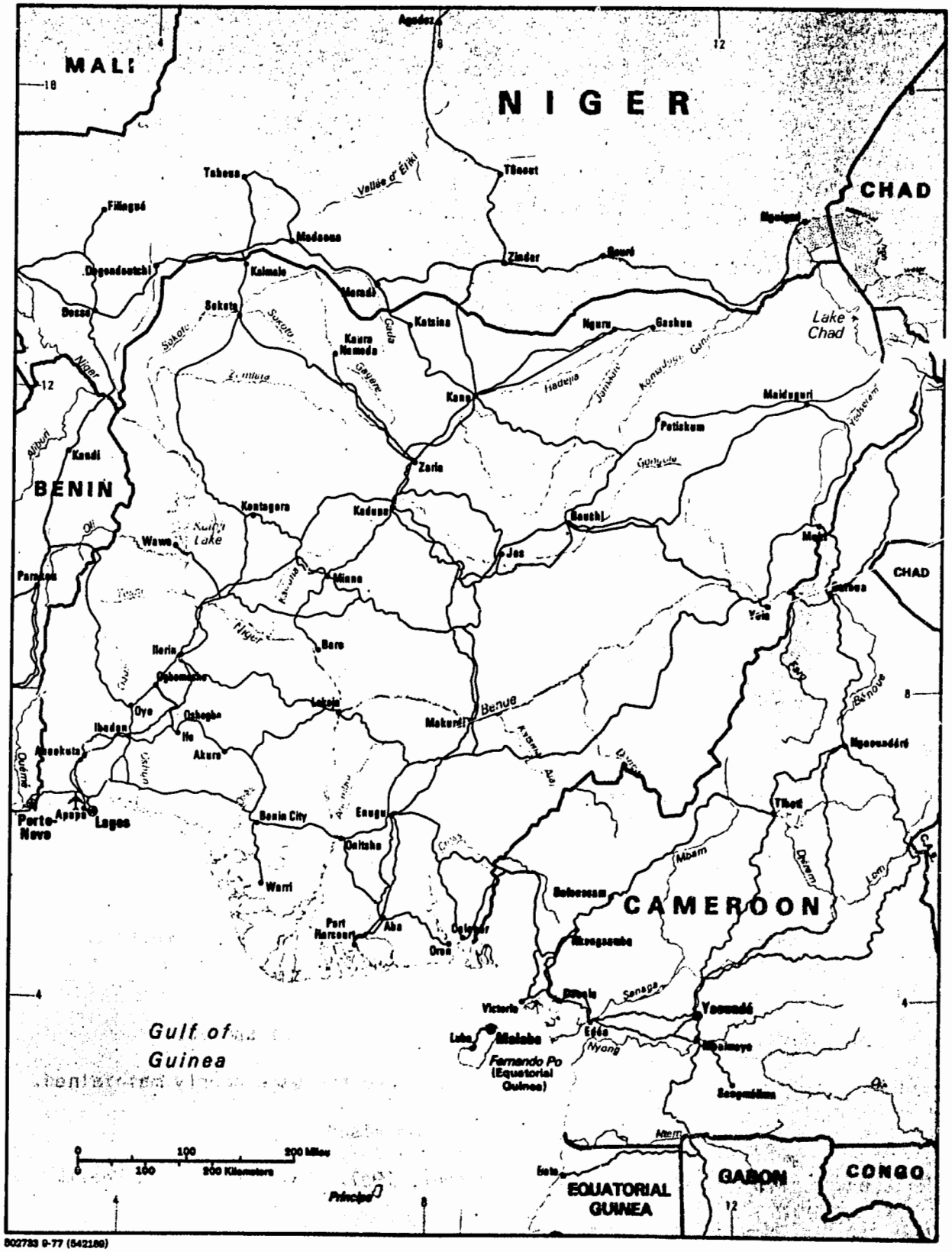
VII. Evaluation

After one year the parasite rate in infants was reduced from 75% to 43%. Significant reductions were not observed in successive years even though spraying was continued. Some of the reasons given for failure to interrupt transmission were:

1. Indifference on part of personnel.
2. Ineffectiveness of insecticide because of remudding of walls or soot.
3. Kitchen huts used in upland rice areas were not sprayed.
4. Vehicles deteriorated rapidly under use and were poorly maintained.
5. Spray teams were not adequately supervised.

Reference: Malaria Control Terminal Report, 1957. National Public Health Service, Monrovia, Liberia.

Nigeria



502733 9-77 (542189)
Lambert Conformal Projection
Standard parallels 8° and 32°
Scale 1:6,300,000

Railroad
Road
Airport

THE FEDERAL REPUBLIC OF NIGERIA

Geography and Climate[3]

Nigeria is the easternmost of the countries that face on the Gulf of Guinea in the West African bulge. It lies entirely in the tropics, its southern edge being only a few degrees above the equator and its northern border well below the Tropic of Cancer. It is bordered on the east by the Federal Republic of Cameroon and for a very short distance in the northeast by the Republic of Chad. The northern and northwestern borders are bounded by the Repbulic of Niger, and the western border is bounded by Benin, formally the Republic of Dahomey. The country has a total area of 356,669 square miles, and its boundries roughly form a square, excluding the great extension into the Gulf of Guinea of the Niger Delta. The greatest east-to-west distance is about 650 miles.

A number of major geographic divisions are readily distinguishable, stretching in generally east-west zones across the country. The Low Plains lie mainly in Western and Mid-Western States. They are bordered on the Gulf of Guinea by a coastal stretch of low-lying, often swampy land interspersed with lagoons and creeks and varying up to twenty miles or more in width. The Lower Niger Valley region lies roughly east of the Low Plains and consists of a comparatively narrow valley extending from the confluence of the Niger and Benue rivers at Lokoja southward for about 185 miles to the apex of the Niger Delta. In its upper section it comprises a number of quite narrow gorges between which lie somewhat broader stretches bordered by hills with elevations between 300 and 700 feet.

One of the major features of the West African coastline is the Niger

Federal Republic of Nigeria Climate continued

Delta, which projects into the Gulf of Guinea from the southern coast of Nigeria between the Bight of Benin and the Bight of Biafra. This great bulge of sedimentary material, deposited by the Niger River, stretches some 75 to 80 miles from its apex below the town of Aboh to the sea; it covers an area of about 10,000 square miles. Directly to the east of the Lower Niger Valley is a highly eroded plateau area characterized by prominent scarps, the Southeastern Scarplands. The region's chief geographic features are the Udi and Igala plateaus and the Akwa-Oriu Uplands. The Udi Plateau runs from north to south; it northern end merges with the Igala Plateau, which extends from east to west. The general elevation of these plateaus is about 1,000 feet above sea level, with escarpments rising considerably higher. The scarps on the northern and eastern edges drop abruptly at various points in their 500-foot descent in elevation.

The Southeastern Lowlands occupy the area between the Lower Niger Valley and the Niger Delta on the west, the Eastern Highlands on the east, and the Benue River valley on the north. The coastline of this region resembles that found in the Low Plains area; it is similiarly fringed with sandy spits and mangrove swamps.

The Western High Plains, of Plateau of Yorubaland, are part of the belt of high plains that extends through West Africa. They lie between the low western coastal plains and the Niger-Benue River Valley region and are broadest in the west near the border with Benin, where the land has a general elevation of more than 1,000 feet.

The combined valleys of the Niger and Benue rivers form a great east-west arc approximately across the middle of the country. The Niger River valley extends from the border with Benin on the west, and the Benue River

Federal Republic of Nigeria Climate continued

valley extends from the eastern border with Cameroon.

The Northern High Plains comprise a broad plateau area. The large central section of the plateau extends for about 300 miles from east to west. Sometimes designated the High Plains of Hausaland, the region consists of a series of stepped plains that range from about 600 feet above sea level at the outer edge to roughly 3,000 feet in the area surrounding the Jos Plateau. Some plains' levels are separated by prominent escarpments.

The Jos PLateau, surrounded by the south-central section of the Northern High Plains, includes distinctive features that set it aside as a separate geographic region. Covering an area of about 3,000 square miles, it is separated from the surrounding plains area by pronounced escarpments. The area's general elevation is over 4,000 feet above sea level, and hills in its eastern part attain heights of over 5,800 feet.

The Sokoto Plains occupy the extreme northwestern part of the country and are generally monotonous in appearance. In the western part erosion has left occasional tablelike hills that stand about 100 feet above the surrounding plain. Trenchlike stream and river valleys characterize this part. They have broad flat floors 2 or more miles in width and steep clifflike sides 100 to 200 feet high. Water in the rivers is largely seasonal and is limited chiefly to the short rainy season.

The Chad Basin consists of a broad plains area in the northeastern part of the country. In this area the land slopes gently eastward from the Northern High Plains to Lake Chad. The region has a general elevation of about 1,000 feet above sea level and is largely featureless except for fixed dune formations in the northern section, many of which are covered with trees and grass.

Federal Republic of Nigeria Climate continued

The eastern boundary with Cameroon is characterized for about 500 miles by mountainous country, the Eastern Highlands. The northern part of the highlands consists of several hill groups, with high points around 3,600 feet. To the south of these are the Mandara Mountains, which extend along the border to the Benue River valley. These mountains comprise a dissected plateau with a general elevation of about 4,000 feet . They encompass an area of some 300 miles in length with an average width of about 20 miles.

The climate is tropical throughout the country, but considerable variation exists between the south and north due to differences in the principal weather components: temperature, humidity, and the rainfall.

Above a line that runs east and west approximately north of the Niger and Benue river valleys, one rainy season and one dry season are relatively well defined. The rainy period in this area occurs between April and October, usually starting in late April or early May along the dividing line and continuing progressively northward; the rains in the far north usually begin in June. Peak rains are experienced throughout the area usually in August. About the middle of September harmattan winds begin moving southward, bringing dry, hot days and relatively cooler nights. By the middle of October the rains have generally ceased throughout the area north of the Niger-Benue River Valley region, and the harmattan continues to dominate the weather until the start of the next rainy season.

From the Niger-Benue River Valley southward, four seasons are usually distinguishable. These consist of a long rainy season, a short period in which the rains slacken, a short period of heavier rain, and a long dry season. The start of the rainy season in the south occurs in February along the coast and moves gradually northward, reaching the Niger-Benue

River Valley region in April. Heavier rains continue over the area through July. There is a decline in rainfall in August, and in some years it is particularly noticeable. Rains are again heavier from September to early November. By mid-November the harmattan usually covers the area to the coast, with the exception of the delta region and the southeast, where it becomes dominant usually in December. The dry period usually continues until February or March.

The amount of annual rainfall decreases northward from the coast. In parts of the Niger Delta and the southeast it totals over 140 inches a year. This area receives some rainfall during every month of the year, including the period of the harmattan. The southwest is drier, with Lagos averaging about 73 inches annually. A zone across the country from Lagos to the Eastern Highlands receives 80 or more inches annually. Farther inland total rainfall declines in the central part of the country to 40 or 60 inches. Within this area, the Jos Plateau, affected by its higher elevation, constitutes an island of greater precipitation registering an annual average of 60 to 80 inches. In the north rainfall declines to 20 or 30 inches annually and in parts of the extreme northeast falls below 20 inches.

The northern half of the country receives less than one inch of rainfall for periods of from five to seven months during the dry season. Water shortages are often acute; local streams and wells dry up in some areas, forcing villagers to travel considerable distances to obtain needed water. The lack of water also forces cattle raisers in the north to move their herds in the dry season to better watered areas, such as the valleys of the Niger or Benue rivers.

Temperatures throughout the country are comparatively high at all times

Federal Republic of Nigeria Climate continued

of the year, with mean maximums increasing northward from the coastal area. Mean annual minimum temperatures in the south are about 71° to 73° F. A variation of less than 2° F. occurs throughout the year. Mean annual minimum temperatures in the northern region range from about 66° to 71° F. During December and January in the dry season, mean monthly temperatures decline an average of about 10° F. from the annual minimum.

There is little daily variation between mean maximum and minimum temperatures in the coastal areas; the differences are usually less than 20° F. In the north, the range is between 30° to 40° F; actual readings on particular days during the harmattan season may vary as much as 70° F, with a low of less than 50° F.

The humidity varies considerably in different parts of the country and at varying times of the year. High nighttime humidities are registered regularly in the coastal regions and range between 95 and 99 percent throughout the year. During the rainy season midday humidities are above 70%; during the dry period they range from about 60 to 70%. In the north the humidity during the rainy period rises to above 90% at night and declines to 60 or 70% at midday. During the harmattan both daytime and nighttime humidities are quite low.

I. Country: Nigeria

II. Project

Location: Ilaro Town, Southwest Nigeria

Population: 12,500

Time: 1949-1953

Type: Malaria eradication program

III. Endimicity: Holoendemic

IV. Pasasite

Primary: P. falciparum

V. Insect Vector

Primary: A. gambiae; A. funestus

VI. Type of intervention

Insecticide: HCH (0.2 g/m^2), four cycles per annum.

VII. Evaluation

A. funestus was eliminated at the end of the first year but reappeared one year after cessation of spraying. A. gambiae was reduced by 90%. The parasite rate in infants decreased from 33.3% to 10.2% after spraying.

Reference: Info. Bull No. 3. Dept. Med. Services, Nigeria.

I. Country: Nigeria

II. Project

Location: Western Sokoto

Population: 500,000

Time: 1953-1959

Type: Malaria eradication program

III. Endemicity: Holoendemic

IV. Parasite:

Primary: P. falciparum

V. Insect Vector

Primary: A. gambiae; A. funestus

VI. Type of Intervention

Insecticide: Dieldrin (0.6 g/m^2) once per annum from 1953-1956;
DDT (2 g/m^2) twice per annum from 1956-1959.

VII. Evaluation

There was a decrease in the number of both species of insects in sprayed areas; both species were found in temporary shelters. The parasite rate in infants was reduced from 79.5% to 1.0%. Similar reductions in parasite rate were observed in children from 1-7 years old.

Reference: Mimeographed documents; Federal Malaria Service, Lagos, Nigeria. 1956-1957.

I. Country: Nigeria

II. Project

Location: Western Sokoto

Population: 500,000

Time: 1954-1957

Type: Pilot malaria eradication program

III. Endemicity: Holoendemic

IV. Parasite

Primary: P. falciparum

Secondary: P. malariae, found predominantly in children.

Others: P. ovale

V. Insect Vector

Primary: A. gambiae (resistant to Dieldrin), A. funestus

VI. Type of [illegible]

Insecticide: Dieldrin (0.25-0.54 g/m^2); BHC (0.4 g/m^2); DDT (2.2 g/m^2).

Eight to ten cycles every 6 months.

Drug Prophylaxis: Chloroquine (150 mg) or phrimethamine (25 mg) given monthly during the main transmission season.

VII. Evaluation

Insecticide spraying was effective in reducing the vectors which resulted in a reduction in the transmission rate of malaria during the dry season. Parasitemia was still present in children under 11 year of age.

In 1957, after the first round of mass drug administration, parasitemia in infants was eliminated and in older children was reduced considerably. In one village the trophozoite rate was 29% before drug distribution and was reduced to 3% after five months. With the onset of the rainy season, there

was an increase in the parasite rate which was not reversed by a second round of mass drug administration.

Reference: Afro Malaria Yearbook No. 1, WHO Regional Office for Africa. AFRO/MAL/5, September 1959. Malaria Yearbook No. 2. WHO Regional Office for Africa. AFRO/MAL/7, December 1960.

I. Country: Nigeria

II. Project

Location: 2 small villages located 20 miles from Lagos

Population: 421

Time: 14 months experimental period

III. Endemicity

IV. Parasite

V. Insect Vector

VI. Type of Intervention

Drug Prophylaxis: Chloroquine (100 mg) or pyrimethamine (25 mg) adjusted for body weight and given once monthly.

VII. Evaluation

After fourteen months, the parasite rates were reduced from 65% to 20% for those taking chloroquine and from 77% to 3% for those taking pyrimethamine. Some of the problems with mass drug administration were compliance and new arrivals to the village who did not participate in the program.

Reference: WHO/MAL/196; AFRO/MAL/1; Feb. 7, 1958.

I. Country: Nigeria

II. Project

Location: Garki District, Nothern Nigeria

Population: 50,000 (8 clusters with 2-4 villages each)

Time: 1969-1975

Type: Pilot malaria eradication project

III. Endemicity

IV. Pasasite

Primary: P. falciparum

Secondary: P. malariae

V. Insect Vector

Primary: A. gambiae (A and B); A. funestus

VI. Type of Intervention

a) Propoxur (2 g/m^2), 3 rounds at 2 monthly intervals.

b) Propoxur and [sulfalene (500 mg) - pyrimethamine (25 mg)] every 10 weeks.

c) Spraying and mass drug administration every two weeks in the wet season and every ten weeks in the dry season.

VII. Evaluation

The prevalence of P. falciparum varied according to the season, being most prevalent during the rainy season. The parasite rate varied between 30 to 55% in the untreated villages; between 27-37% in villages treated only with propoxur; between 2-28% in those villages treated with propoxur and drugs every ten weeks and between 1-5% in those treated with propoxur and drugs every two weeks.

During the time of intervention (1972-1973), the parasite rates dropped below baseline levels. In 1974, the parasite rates were up again due to the absence of control measures.

Reference: WHO Chronicle 30: 286-289, 1976; WHO/MAL/76,870; WHO/MAL/76.871; WHO/MAL/76.873; WHO/MAL/76.890; WHO/MAL/77.890.

I. Country: Nigeria

II. Project

Location: Kankiya, N. Nigeria

Population: 60,000 people (50,000 experimental, 10,000 control)

Time: November 1966 to August 1968

Type: Malaria eradication program

III. Endemicity

IV. Parasite

Primary: P. falciparum (responsible for 88-94% of infection)

Secopndary: P. malariae; P. ovale

V. Insect Vector

Primary: A. gambiae; A. funestus

VI. Type of Intervention

Insecticide: DDT spraying (2 g/m^2) every 4 months starting at end of dry season for 4 rounds.

Drug Prophylaxis: Chloroquine (150 mg) and pyrimethamine (15 mg) in a combined tablet once every sixty days.

VII. Evaluation

This method of spraying and mass drug administration was not effective in interrupting transmission of malaria. Before spraying the infant parasite rate was 5% (a non-transmission season), was reduced to zero at the beginning of intervention and increased to 13% during the transmission season. In the unprotected area, the infant parasite rate was 70% by the end of the transmission season.

Some of the reasons given for failure to interrupt transmission were:

1. Incorrect census.

2. Chloroquine is bitter tasting and induces vomiting, especially on an empty stomach.
3. Spraying may not have been thourough or effective (excito - repellent effect of DDT or short-lived effect on soot walls).
4. Mobility of mothers to deliver babies away from the village, especially in those villages that are unprotected by malaria control measures.
5. Many people sleep out of doors.
6. Labour immigration problems.

Reference: WHO/MAL/73.817.

I. Country: Nigeria

II. Project

Location: Klouta Area

Population: 86,000

Time: 1974

Type:

III. Endemicity: Mesoendemic to hyperendemic

IV. Parasite

Primary: P. falciparum

V. Insect Vector

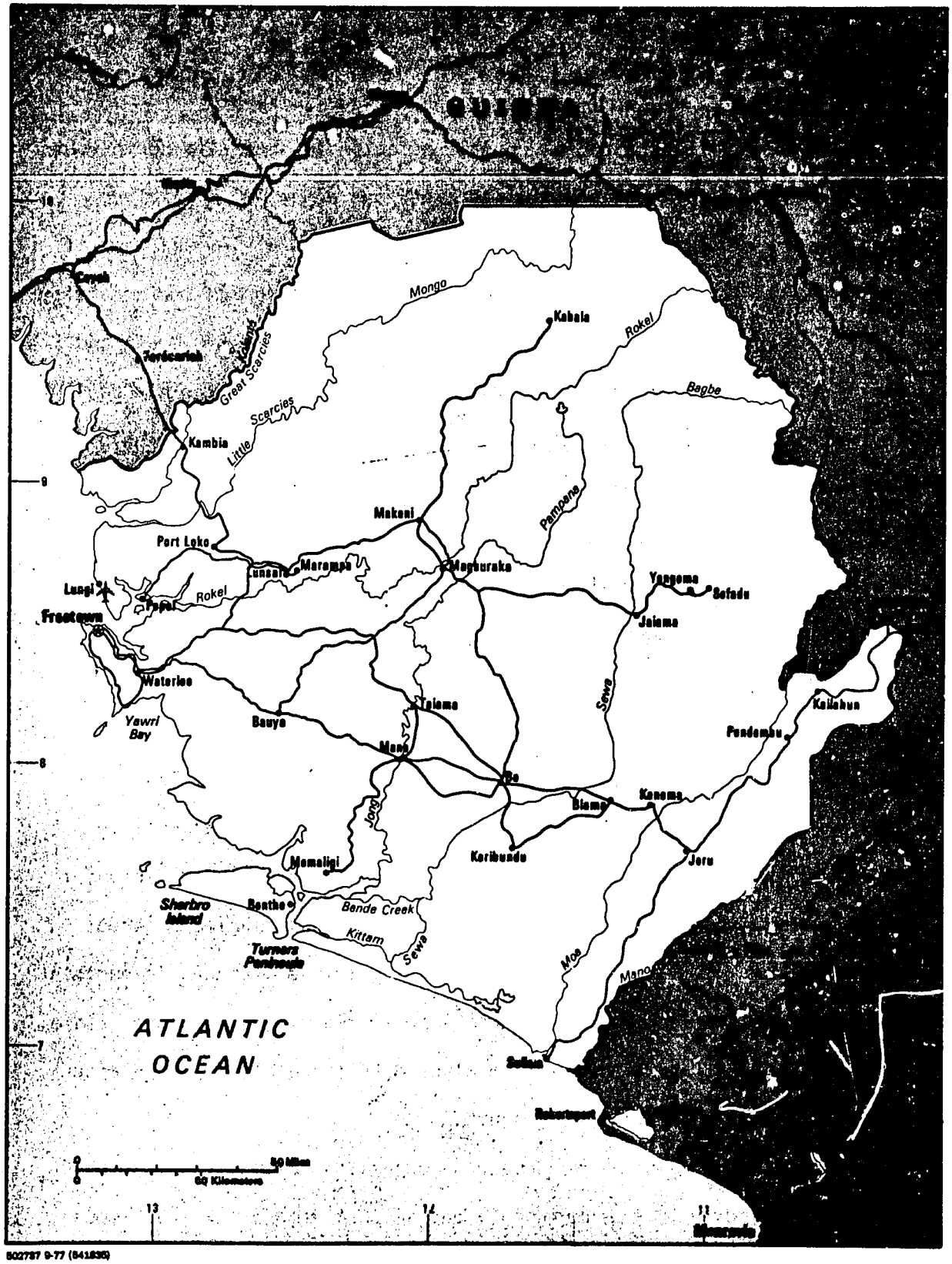
Primary: A. gambiae, A. funestus

VI. Type of Intervention

Insecticide: DDT spraying (2 g/m^2) one application

VII. The number of malaria cases was reduced from 10.3% to 6.9%. Parasite rates in infants were reduced from 32.8% to 15.5% after spraying and in adults the parasite rate was reduced by fifty percent.

Reference: WHO/MAL/IRC/72.28.



502787 9-77 (541835)
Lambert Conformal Projection
Standard parallels 8° and 32°
Scale 1:2,200,000

Railroad
Road
Airport

REPUBLIC OF SIERRA LEONE

Geography and Climate[3]

The Republic of Sierra Leone, roughly circular in shape-its north-south axis is about 215-miles long and the east-west one about 190 miles-is a compact country of 27,925 square miles located in the southwestern part of the great bulge of West Aftica. Lying between the seventh and tenth parallels north of the equator, it is bounded on the west by the Atlantic Ocean and inland by Guinea and Liberia. Its varied terrain includes the striking, mountainous Sierra Leone Peninsula; a zone of low-lying coastal marshland along the Atlantic Ocean; and a wide plains area extending inland to about the middle of the country. East of the plains the land rises to a broad, moderately elevated plateau from which emerge occasional hill masses and mountains that include West Africa's highest point.

The climate is marked by distinct annual wet and dry seasons. Rain in relatively appreciable quantity begins in eastern Sierra Leone in April, and by May the entire country has entered the wet season. From this time until the end of November more than 85 percent of the total rainfall is received everywhere except for a very small area in the interior lowland plains; twenty inches or more of rain fall in each month during a three- to four-month period. In the higher area rising to the plateaus in eastern and northeastern Sierra Leone only during one to two months is there rainfall above twenty inches; the plateaus themselves do not ordinarily experience rainfall over twenty inches in any month.

The mean annual rainfall for roughly four-fifths of the country is 100 inches or over. Only in the northern areas does it drop below that amount,

and only a small zone along the Guinea border receives less than eighty inches. Total precipitation increases from the interior to the coast, where a large zone receives from 120 to 200 inches; the Sierra Leone Peninsula's upper elevations have recorded close to 218 inches, and the average annual rainfall at Freetown is about 150 inches.

The December-April dry season is in sharp contrast to the wet period. During at least four months of this time the coastal and interior lowland zones have under 2.5 inches of rain, and for two to three of these months and average rainfall is under one inch. The eastern plateau area has a somewhat shorter extremely dry period, in part because of the greater amount of rainfall produced by convectional disturbances in this more elevated region. The mean amount of dry-season rainfall for most of the country actually does not exceed ten inches, and a considerable area receives five inches to less than one inch during this period. Although the growth of vegetation slows at this time, the rainfall received annually is adequate under normal conditions to support a profuse cover of moist vegetation types throughout the country.

Temperatures are consistently high throughout the country, ranging roughly between daytime readings of up to the middle 90 ^{o}F and readings in the middle 60 ^{o}F at night, depending on season and locality. Absolute minimums in the low 50 ^{o}F occurs at times in the savanna area of the eastern plateaus, and lower readings are presumably reached at upper elevations in the Loma and Tingi mountains. The coastal and interior lowland plains areas have mean annual temperatures of 79 ^{o}F or 80 ^{o}F and the eastern plateau region a mean of close to 77.5 ^{o}F.

Diurnal variations are most marked during the dry season, when there

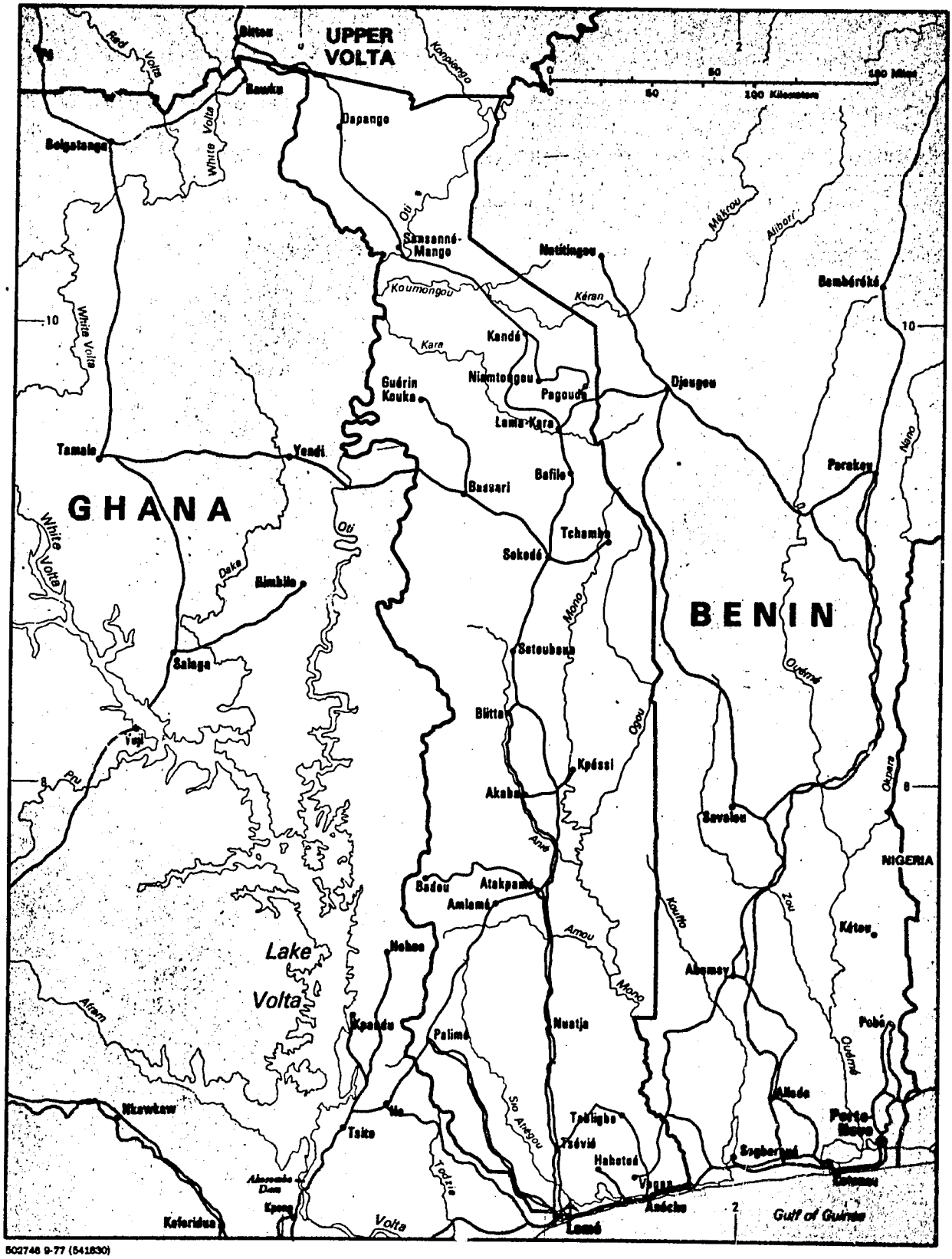
may be a difference of up to 30°F in the interior between monthly mean maximum and minimum temperatures. Absolute maximums may be above 95°F and minimums between about 50°F and the lower 60°sF at this time. The coolest temperatures usually prevail during the wet season in August except in the eastern plateaus, where they may occur at the onset of the dry period. In Freetown daytime temperatures during the rainy season are reported to run about 80°F and those at nighttime about 76°F. In the dry months corresponding temperatures average about 92°F and 74°F respectively.

The humidity, like the temperature, is usually high, although some amelioration is experienced during the harmattan period. In early morning during the rainy season the humidity is close to or above 90 percent throughout the country. By midafternoon it has decreased in the western half to 80 percent or slightly less and in the far northeast savanna to somewhat below 75 percent. In the dry period early morning humidity usually varies between 80 percent and almost 90 percent. A marked drop occurs as the day progresses, however, and at varying times during this season different localities reach lows of around 50 percent or under by midafternoon (in the area around Kabala in the northeast savanna country the humidity drops below 30 percent).

Malaria Control Activities (Freetown)

During World War II, A. gambiae and A. funestus were controlled by larviciding. Between 1946 and 1950, the Anopheles population remained stable but the parasite rate continued to increase. Larviciding was reinforced by residual spraying with BHC and a decrease in the Anopheles density and parasite rate was observed. Despite continued spraying, the anopheles density has continued to increase. (WHO/MAL/196. AFRO/MAL/Feb. 7, 1958).

Togo



502746 9-77 (541830)
Lambert Conformal Projection
Standard parallels 8° and 32°
Scale 1:2,750,000

Railroad
Road
Airport

REPUBLIC OF TOGO

Geography and Climate[1]

With a total area of 21,853 square miles, Togo stretches some 324 miles inland from a very narrow seafront on the Guinea coast of west Africa. It lies entirely within the tropics, between 6° N and 11° N, and roughly between 0° and 2° E. The coast on the Bight of Benin is only 31 miles long and the W-E width of the country ranges up to 87 miles.

Over half the country lies below 660 feet in altitude, and only a very small proportion is higher than 1650 feet. The ridges of the Togo mountains which cross the country diagonally from SSW to NNE are the southern part of the Atakora mountains that run from southeastern Ghana to the basin of the Niger river and which have been a historic barrier between islamic peoples to the north and most African peoples to the south. The mountains are much faulted and are divided by deep valleys into several plateaus with abrupt edges and rugged relief, such as the Kabre mountains in the northeast, the Fasaou massif of the centre and the Akposso plateau of the south. The highest point lies in the extreme south of the range, in Mount Agou at over 3,280 feet.

Togo's tropical climate comes under the seasonal influence of the high pressure areas respectively of the Sahara and the southern Atlantic. In the northern winter, with the Saharan anticyclone dominant, Togo experiences the dry, dusty harmattan wind from the northeast. In summer, the southwest monsoon, under the influence of the St. Helena anticyclone, brings rainfall with the humid winds off the ocean.

Rainfall conditions are different to north and south of latitude 8° N.

In the south the rainfall regime has two wet seasons, a maximum rainy period occurring between March and July, and a secondary season in September and October. North of this latitude, the climate is rather of Sudan type, with a single rainy season, from April to October. Highest annual rainfall amounts coincide with the highest, mountainous areas, totals reaching 60 inches or more. Equatorial conditions are experienced only in the central-west mountains.

An anomalous climatic condition of relative dryness (less than 15 inches of rain a year) affects the coastal zone of Togo, and of neighbouring parts of Ghana and Benin; there are rainfalls of over 4 inches in only 2-3 months of the year, and only a small number of days with rain.

Average maximum temperatures increase from south to north of the country (Lome, 86 °C; Nuatja, 91 °C; Mango, 93 °C) while average minima decrease (Lome, 73 °C; Nuatja, 70 °C; Mango, 66 °C). Highest temperatures are experienced at the end of the dry season, just before the first rains, but in the upland and mountainous areas the heat is felt less intensely. Relative humidity, highest in the south along the coast, ranges between 80 percent and 85 percent in the rainy season, but falls to as low as 20 percent in the north during the dry season, when the harmattan is blowing.

I. Country: Togo

II. Project

Location: Center of Coastal belt of Togo and extended areas

Population: 75,000 in 1953; 279,000 in 1957

Time: 1953-1957

Type: Pilot malaria eradication program

III. Endemicity: Holoendemic; transmission occurs throughout the year.

IV. Parasite

Primary: P. falciparum

Secondary: P. malariae

V. Insectd Vector

Primary: A. gambiae; A. funestus

VI. Type of Intervention

Insecticide: 1953-57 - DDT sprayed twice annually; 1957 Dieldrin used.

Drug Prophylaxis: Chloroquine (600 mg) and pyrimethamine (50 mg) given monthly.

VII. Evaluation

In zone 1 where residual spraying and mass drug administration were undertaken, the infant parasite rate was reduced from 33% to 8%. In zone 2 where the residents received only chemotherapy, there was no reduction in transmission. In areas where only residual spraying was used, transmission was not interrupted but the parasite rate in children 0-14 years old was reduced to 7%.

Some of the reasons given for failure to interrupt transmission were:

1. There is a seasonal migration of laborers from Ghana which accounts for one-third of Togo's population during the farming season.

2. Many huts were not sprayed because of tribal religions.
3. Soot covered walls reduced the efficacy of the spray.
4. Chemotherapy was given during the farming season when most people were away from their resident villages.
5. The drugs were administered as two separate tablets; compliance was also a problem.

Reference: Afro Malaria Yearbook No. 1, WHO Regional Office for Africa. AFRO/MAL/5, September 1959. Malaria Yearbook No. 2. WHO Regional Office for Africa. AFRO/MAL/7, December 1960.

I. Country: Togo

II. Project

Location: Rain forest zone - 58,000 people

Degraded forest zone - 29,000 people

Time: 1970-1973

Type: Pilot malaria eradication project

III. Endemicity

IV. Parasite

V. Insect Vector: A. gambiae; A. funestus

VI. Type of Intervention

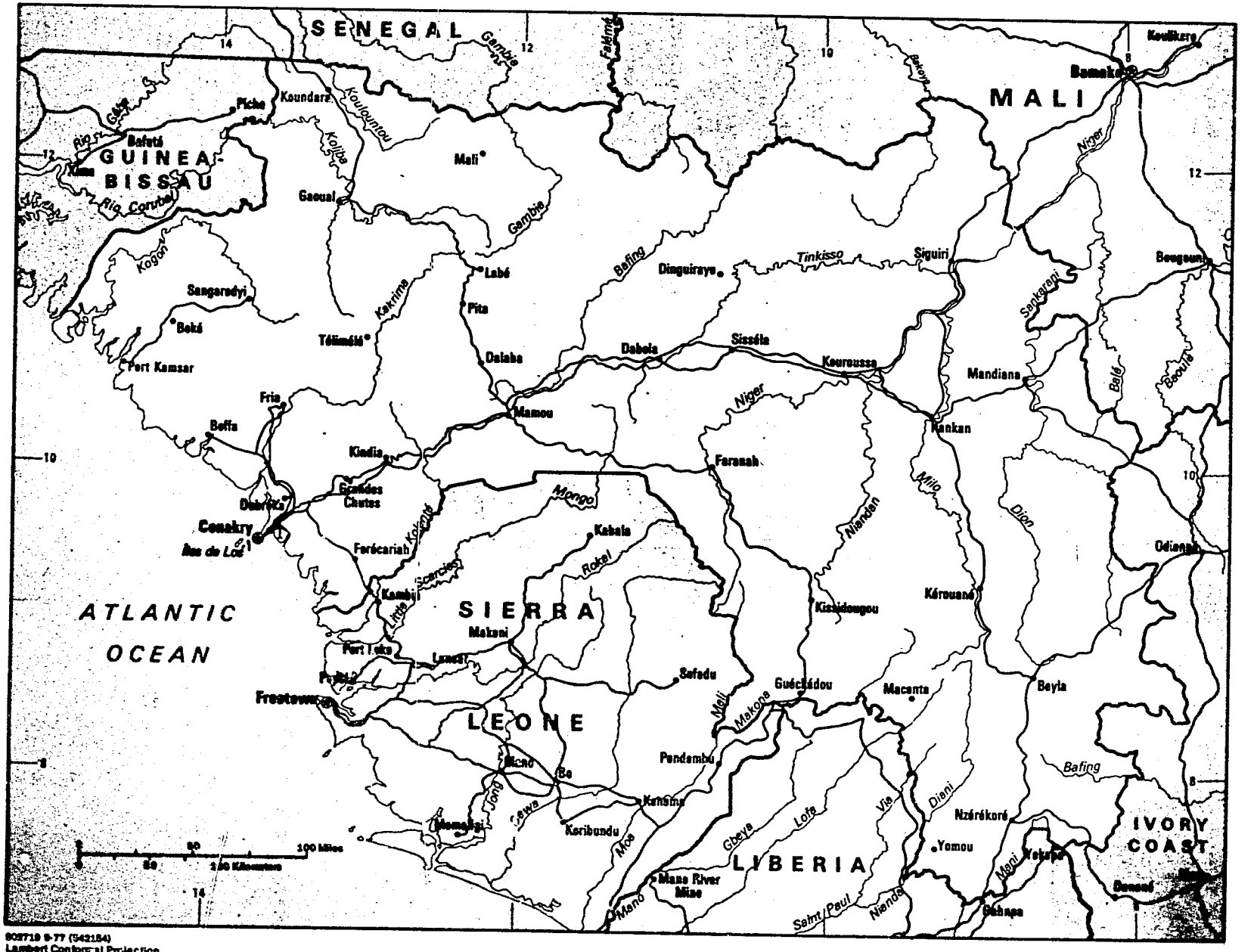
Insecticide: Single application of DDT (2 g/m^2)

VII. Evaluation

There was a marked reduction in the number of A. funestus in the degraded forest and rain forest for 2 years. There was a sharp decrease in the number of A. gambiae during the first two months only. In the degraded forest zone there was no change in the parasite rate of infants; children ages 1-14 years old showed a 25% to 50% reduction in parasite rate.

Reference: WHO/MAL/77.891; WHO/MAL/77.676.

Guinea


SENEGAL
MALI
GUINEA-BISSAU
SIERRA LEONE
LIBERIA
IVORY COAST
ATLANTIC OCEAN
Bamako
Koulikoro
Kayes
Bafatá
Gabú
Piche
Koundara
Koulountou
Kolda
Mali
Gaoual
Gambia
Fatimé
Bakoy
Niger
Rio Corubal
Kogon
Sangaredyi
Boké
Port Kamsar
Téliméli
Kakrima
Labé
Pita
Dalaba
Dinguiraye
Bafing
Tinkisso
Siguiri
Dabola
Sissèla
Koureussa
Mandiana
Sankarani
Bougouni
Balé
Baoulé
Fria
Beffa
Mamou
Kindia
Grandes Chutes
Dubréka
Conakry
Iles de Los
Forécariah
Kolenté
Mongo
Kabala
Rokel
Scarcies
Kambia
Little
Makeni
Port Loko
Lungi
Freetown
Safadu
Guéckédou
Macenta
Beyla
Faranah
Niandan
Milo
Dion
Kankan
Odienné
Kérouané
Kissidougou
Mali
Makona
Pendembu
Bo
Moyamba
Jong
Gawa
Kenema
Keribundu
Moa
Gbeya
Lofa
Via
Diani
Nzérékoré
Yomou
Bafing
Mano River Mine
Mano
Saint Paul
Nianda
Manni
Yekepa
Danané
Bohapa
Railroad
Road
Airport
Miles
Kilometers
602718 9-77 (542184)
Lambert Conformal Projection
Standard parallels 8° and 32°
Scale 1:4,000,000

REPUBLIC OF GUINEA

Geography and Climate[3]

Guinea is situated on the southwestern edge of the great bulge of West Africa, between roughly 7° and 12.5° north of the equator. From its westernmost limit bordering on the Atlantic Ocean, the country curves inland in a great southeasterly-bearing arc that averages some 150 to 200 miles in width. The maximum west-east distance is about 450 miles, that from north to south about 350 miles, and the country's total area is 94,925 square miles. On the arc's inner perimeter lie Sierra Leone and northern Liberia, and on its outer edge are the states of Guinea-Bissau, Senegal, Mali, and Ivory Coast.

The government distinguishes four geographic regions each of which is characterized by different morphological features and a somewhat different climate. Lower Guinea stretches inland from the Atlantic Ocean to the main mass of the Fouta Djallon. The coast is of the submerged kind lined by broad marshes through which drowned rivers (estuaries) open onto the sea. The Fouta Djallon highland mass constituting most of Middle Guinea consists of a complex of elevated, relatively level plateaus. About 5,000 square miles of this area are over 3,000 feet above sea level. The plateaus are deeply cut in many places by narrow valleys, many of which run at roughly right angles, giving the region a checkerboard appearance. The principal feature of Upper Guinea, which lies to the east of the Fouta Djallon, is the extensive lightly wooded, tall grass savannas. The Forest Region encompasses the southeastern corner of Guinea. Its major feature is the Guinea Highlands, which have general elevations ranging from about 1,500 feet above sea level in the west to over 3,000 feet in the east; peaks at several points attain

4,000 feet and above.

The climate is characterized by wet and dry seasons that vary in length in different parts of the country. In the far south the wet season begins in February or March but in the northeast may not begin until June. In general, however, the period of heaviest rains in most areas is from April or May to October or November. The dry season usually falls between November and April. The greatest rainfall is experienced everywhere during July and August. Lower Guinea has wet and dry seasons of roughly equal length. The region has a mean average rainfall of 110 inches or more annually, the highest anywhere in the Country. In some places the total rainfall may far exceed this average; for instance, at Conakry it is usually close to 170 inches and may in some years be over 200 inches.

The wet season in the Fouta Djallon rarely exceeds four months, but some rainfall occurs during most other months. A mean average of about 100 inches falls in areas close to Lower Guinea's coastal region, seventy or more inches in the more central part of the highland, and about sixty inches in the eastern part. East of the Fouta Djallon the savannas of Upper Guinea have a rainfall that rarely exceeds sixty inches. Rain falls there principally between June and September, but storms may occur during any month; less that one-half inch is usually registered monthly, however, between December and March.

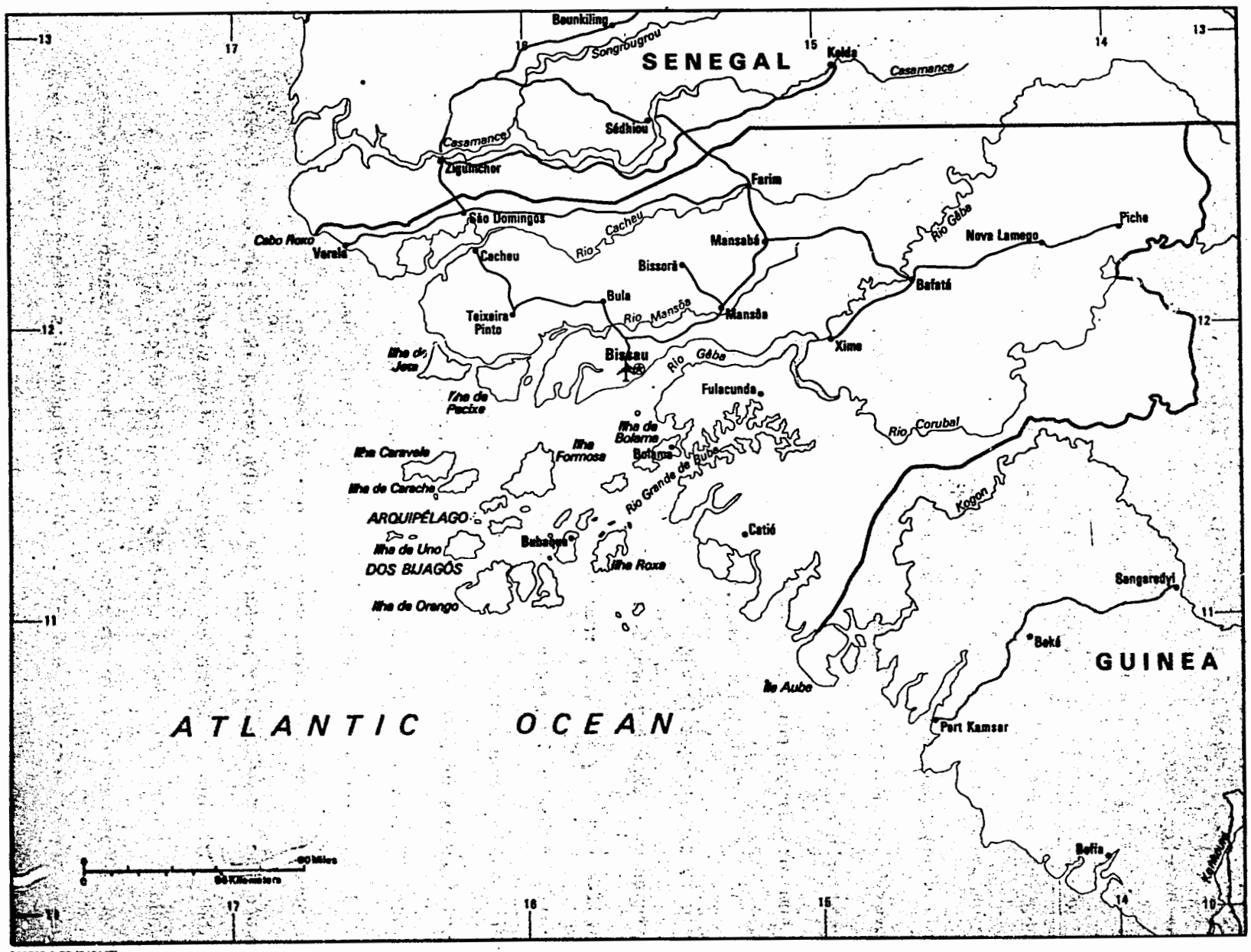
In much of the Forest Region precipitation occurs throughout most of the year; only in January is there usually less than one-half inch of rainfall. The average annual precipitation is somewhat less than in Lower Guinea, but the more extended period of rainfall permits growth of a rain forest vegetation in the region.

Temperatures and relative humidity are usually high in the coastal zone at all times. In Conakry, temperatures generally remain between 90°F and 75°F. The relative humidity ranges from about 70 to nearly 100 percent-the annual mean minimum is above 73 percent in the early afternoon and 89 percent in the early evening. In the Boke area away from the sea breeze, the annual mean maximum temperature is about 93°F, and during March and April daily mean maximums are 100°F or above. The humidity in Boke is usually above 90 percent by early evening throughout the year. The effects of the harmattan during the dry season, however, occasion a definite lowering of humidity in daytime to between 40 and 50 percent.

In the Fouta Djallon temperature readings are lower, and the range of humidity percentages is wider than in the coastal zone. Daily mean temperatures may range between 54°F and 94°F during the dry period, and the mean relative humidity may vary from 93 percent in early morning to, at some points, as low as 29 percent by late afternoon. In July and August daytime mean maximum temperatures, lowered by the rains, do not exceed 80°F, and at night they may drop to 65°F. The relative humidity during this time fluctuates between 95 percent in the morning and 84 percent in the early evening.

In Upper Guinea temperatures and especially the humidity are strongly influenced by the harmattan, when temperatures are over 90°F during the day-toward the end of the dry season they often exceed 100°F-and drop to 60°F or below at night. During the dry period relative humidities of 70 percent or above at night decline to under 40 percent at midday and may be between 20 and 30 percent by late afternoon. During the rainy season temperatures usually are between 70°F and 90°F. Relative humidities remain comparatively high during this time, generally between 70 and 90 percent or over.

Guinea-Bissau



602720 9-77 (542147)
Lambert Conformal Projection
Standard parallels 6° and 32°
Scale 1:2,100,000

Railroad
Road
Airport

REPUBLIC OF GUINEA-BISSAU

Geography and Climate[4]

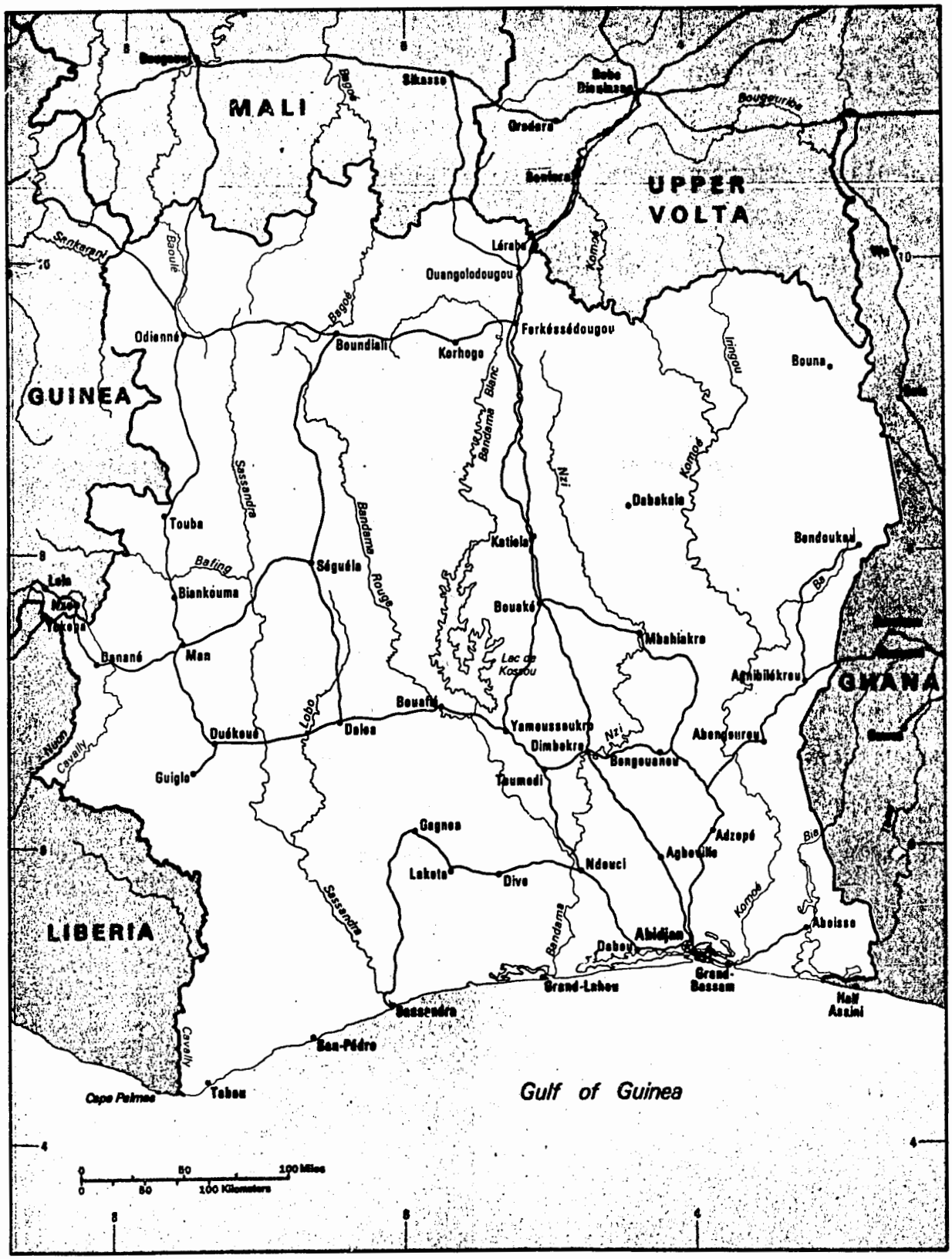
Guinea-Bissau is located on the West African coast between Senegal and Guinea. Its territory also includes the offshore Bijagos Archipelago.

A low coastal, swampy plain covers much of the country, especially in the southwest. The land rises gradually toward a savanna in the east; the highest elevation of 985 feet is in the southeast. Several rivers mark the coastline; the three most important-the Cacheu, the Geba, and the Corubal-are navigable for considerable distances.

The soil is largely alluvial and fertile. Palms and mangrove thickets cover most of the lowland along the coast and the rivers. Further inland is a transitional zone with hardwood forests, and in the interior are tree-dotted grasslands.

The climate is tropical with a mean average temperature of 77°F. The wet season lasts from June to November, followed by a dry season during which the northerly harmattan (dust-laden wind) blows from the Sahara Desert. April and May are the hottest months; December and January are the coolest. The city of Bissau annually receives about 70 inches of rain.

Ivory Coast



602721 9-77 (542156)
Lambert Conformal Projection
Standard parallels 6° and 32°
Scale 1:4,370,000

—— Railroad
—— Road
✈ Airport

REPUBLIC OF IVORY COAST

Geography and Climate[3]

The Republic of the Ivory Coast lies almost wholly between 5° and 10° north of the equator and is bisected by the fifth meridian west of Greenwich. Westernmost of the African countries that border the Gulf of Guinea, its outline is a rough square, oriented in the cardinal directions, with sides about 350 miles long and an area of approximately 124,000 square miles. The country is bounded for the entire length of its eastern border by Ghana. The northern boundary is shared for approximately equal distances by Upper Volta on the east and Mali on the west. Again for approximately equal distances, the western border, from north to south, abuts Guinea and Liberia. The shore of the Gulf of Guinea forms the southern boundary.

Geographically, most of the country is a wide plateau. The land is differentiated into three zones extending east to west across the entire country and running parallel to the coastline. The lagoon region (zone lagunaire) is a narrow coastal belt extending along the Gulf of Guinea from the Ghana border to the vicinity of Fresco, near the mouth of the Sassandra River. For its entire length, the coast of this region is fringed by a strip of low, sandy islands or sandbars, known as the cordon littoral.

Variously referred to in the Ivory Coast and by French writers as the zone de la foret or the foret dense, the dense forest region forms a broad belt that covers roughly a third of the country north of the lagoon region and extends from Ghana on the east to Liberia on the west. West of Fresco, it reaches all the way to the sea. Its northern boundary, although well-defined, is very irregular, descending in the form of a wide V from points on

the Ghana and Guinea borders some 200 airline miles inland, to within about 75 miles of the sea north of Grand-Lahou. The region gains its identity from the heavy tropical forest that flourishes throughout.

The savanna woodland region comprises all of the Ivory Coast lying north of the closed forest. It is characterized by a scattering of single trees or clumps of trees over continuous stretches of grass and low shrubbery and by narrow strips of heavier timber bordering the watercourses or lines of drainage. The size, types, and density of tree growth diminish progressively from south to north.

The dominant characteristics of the climate are sustained heat and seasonal rainfall. In the southern part of the country two distinct periods of maximum isolation occur annually following the equinoxes, causing two rainy and two dry seasons each. Farther north, the two rainy seasons merge into a single period of rain, alternating annually with a season of dry weather. The two resulting types of climate are classed as equatorial and tropical, respectively.

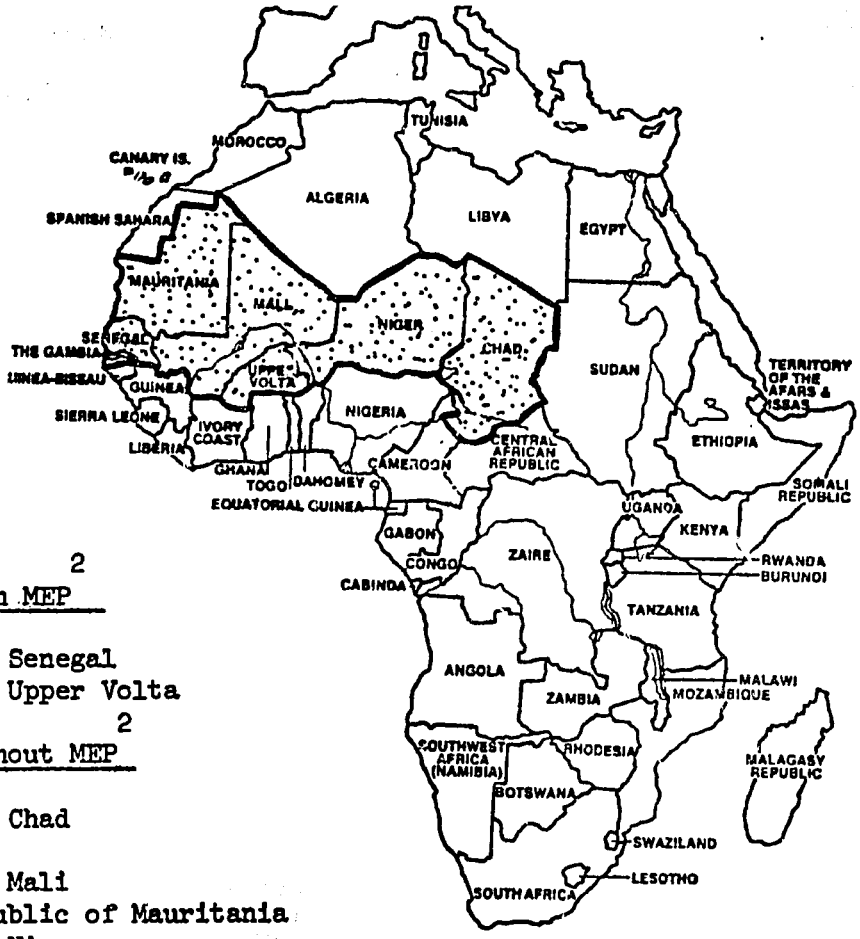
Along the coast, where the characteristics of the equatorial climate are most pronounced, there are wide variations in monthly rainfall, but no month is without significant precipitation. Four seasons are distinguished in this region. The major dry season occurs from December through April, followed by the major rainy season from May through July. The major seasons are followed by two minor seasons which repeat the cycle and form a minor dry season during August and September, and a minor rainy season during October and November. Although progressively modified inland by continental factors, this general pattern persists over the southern two-thirds of the country.

But farther north, the four seasons merge into only two; most of the rains fall between June and October; and the months from November to May are relatively dry. The contrast between rainy and dry seasons is more pronounced than in the south. At Firkessedougou, for example, average precipitation during the peak of the rains in August and September totals over 20 inches, whereas the total for December and January averages only about half an inch.

Relative humidity follows trends similar to the rainfall and is highest during rainy seasons. In the south the average is above 80 percent for the year, and both the annual and diurnal ranges are very small. Toward the north where the drying effect of the harmattan is stronger, yearly averages are 60 to 70 percent, and the ranges are much more pronounced. For example, the average relative humidity at Firkessedougou varies from 45% at the height of the dry season in January to 80% when the rains are heaviest in August.

Temperatures are warm throughout the year; in the southern third of the country average minimums during the coolest months do not fall below 70°F. On the other hand, average maximums during the warmest months may exceed 90°F, but only in the far north. Throughout the country, both the diurnal and annual ranges of temperature are small, but the ranges, although remaining moderate, increase progressively toward the interior.

B. Sahel[1]



Countries with MEP[2]

Republic of Senegal
Republic of Upper Volta

Countries without MEP[2]

Republic of Chad
The Gambia
Republic of Mali
Islamic Republic of Mauritania
Republic of Niger

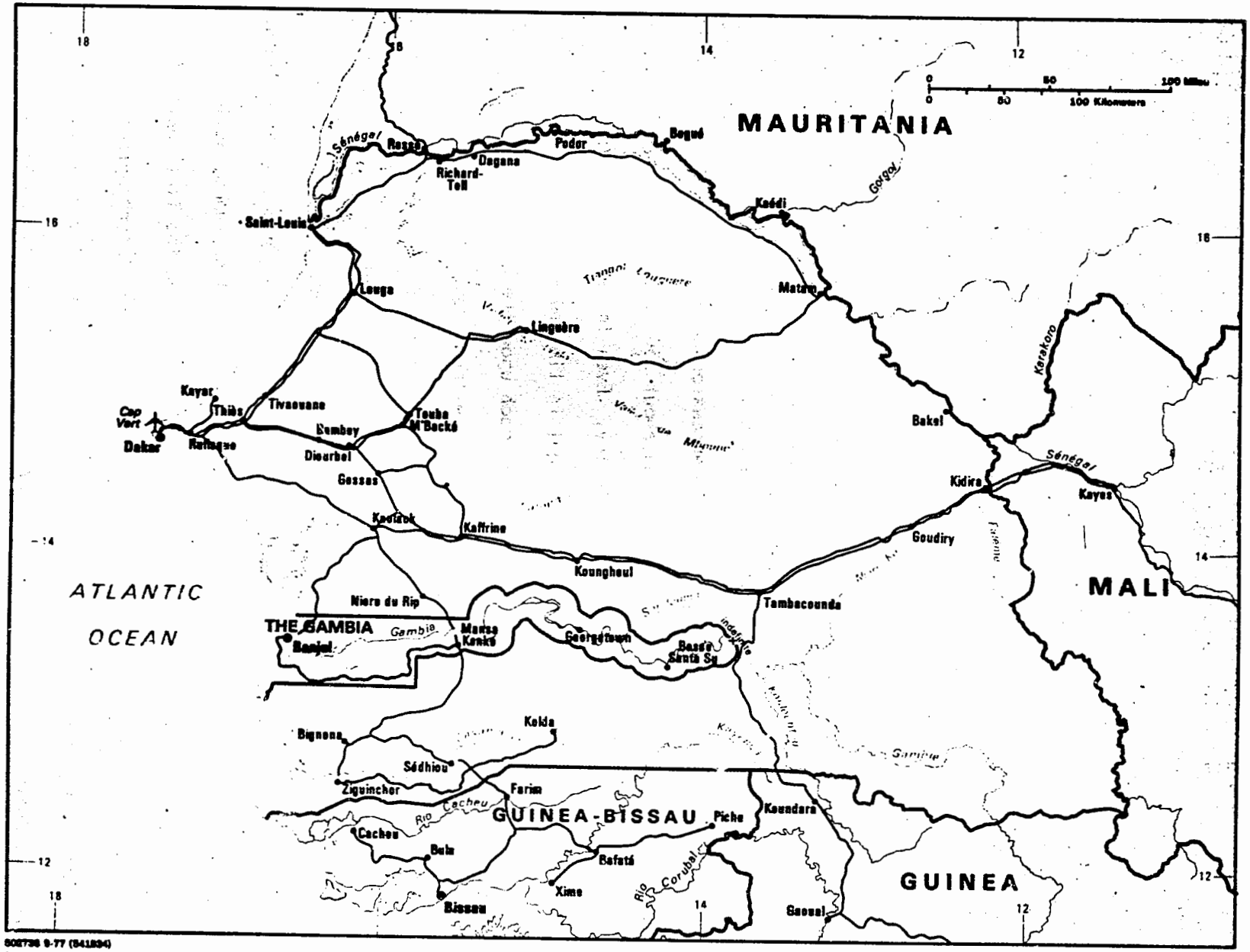
Successful MEP[2]

Cape Verde Islands

1 Stippled area on map

2 Malaria eradication/control programs

Senegal



508736 9-77 (541834)
Lambert Conformal Projection
Standard parallels 8° and 32°
Scale 1:3,000,000
Boundary representation is not necessarily authoritative

REPUBLIC OF SENEGAL

Geography and Climate[2]

Situated at the western extremity of Africa's tropical zone, the Republic of Senegal has an area of 78,684 square miles and a population of about four million people. It is bordered to the north and to the northeast by the Senegal River which separates it from Mauritania; to the east by the Faleme, a tributary of the Senegal River which separates it from Mali; to the south by Guinea and Guinea-Bissau; and, to the west by the Atlantic Ocean. The Gambia constitutes a finger of territory twenty miles wide and two hundred miles long that thrusts from the coast eastward deep into Senegal. Senegal is a flat country, lying in the depression known as the Senegal-Mauritanian Basin. Altitudes of more than about 330 feet are found only at Cap Vert and in the southeast of the country. Even in years of average rainfall, vegetation in most of northern Senegal is limited to fibrous grasses and thorn scrub. Southward more trees encroach upon the grassy, open areas and mixed subtropical forests prevail in the extreme south, particularly between the lower reaches of the Casamance River and the Border with Guinea-Bissau.

Senegal's climate is characterized by relatively high daytime temperatures throughout the year and a long annual dry season. Because the country lies well south of the Tropic of Cancer, days vary less in length and solar radiation is more intense and persistent than in temperate latitudes. Warm, humid equatorial and maritime air masses shift northward during the first half of the year, generating rainfall in a broad contact zone or intertropical front. The prevailing wind for the remainder of the year is from the northeast - the dry, dusty harmattan from the central Sahara. Interaction between these

two air masses produces a broad belt of instability and rain in late summer.

Average annual precipitation in southern Senegal is between fifty and sixty inches and is spread over a six-month period from May through October. In central Senegal precipitation measures twenty to thirty inches and falls during the four months from mid-June to mid-October. The north receives less than twenty inches, almost all of it limited to the three months of July, August, and September.

Temperatures in coastal areas rarely fall below 60 ^{o}F and daily, monthly and annual ranges are limited. Inland, away from the moderating influence of the ocean, seasonal daily temperatures reach as high as 100 ^{o}F. The difference between the mean monthly maxima and minima may be 35 ^{o}F and the daily range can be more than 40 ^{o}F. A narrow strip along the northwestern coast between Cap Vert and the border with Mauritania is an exception to the otherwise relative homogeneous climate. This area, influenced by the trade winds from the Atlantic Ocean and the cool water of the Canary current, has temperatures somewhat lower and more uniform than those of the interior and the rainy season is a few weeks shorter.

Notes[2]

1. Eighty-two percent of the population lives in malarious areas.
2. Senegal has a serious migrant labor problem. It has been estimated that 20% of the population is composed of migrant workers.
3. The government has several water developoment projects which may present serious problems for malaria control activity. These are to:
   a. Consolidate and hold as much water as possible by coordinating water development projects with neighboring countries

b. create a water supply network

c. develop the Senegal River Basin - two dams are to be constructed.

4. Drainage system in Dakar and Saint-Louis are inadequate during the yearly floods. As a result, large areas of the city are flooded with contaminated water which serves as an ideal breeding source for mosquitos.

5. The rural health services are decentralized so that local authorities determine what projects will be initiated.

I. Country: Senegal

II. Project

Location: Thies

Population: 494,000

Time: 1953-1957

Type: Pilot malaria eradication program

III. Endemicity: Highly endemic except in arid part of country.

IV. Parasite

Primary: P. falciparum (responsible for 99.5% of infections)

Secondary: P. malariae (responsible for 0.5% of infections)

V. Insect Vector

Primary: A. gambiae; A. funestus

VI. Type of Invervention

Insecticide: BHC used from 1953-1955; DDT (2 g/m^2) used from 1953 to 1957; houses sprayed annual

Chemotherapy: Pyrimethamine (25 mg) given weekly.

VII. Evaluation

In treated areas, some decrease in malaria indices were observed but interruption of transmission was not achieved. After six weeks of chemotherapy, the parasite rate dropped from 75% to 6% in children 0-14 years old. Between 1952 and 1955, the infant mortality rates fell from 177/1,000 to 50/1,000.

Some of the reasons given for failure to interrupt transmission were:

1. Inadequate planning,
2. Not all houses were sprayed,
3. Only 50% and 70% of the population received drugs at the appropriate

times.

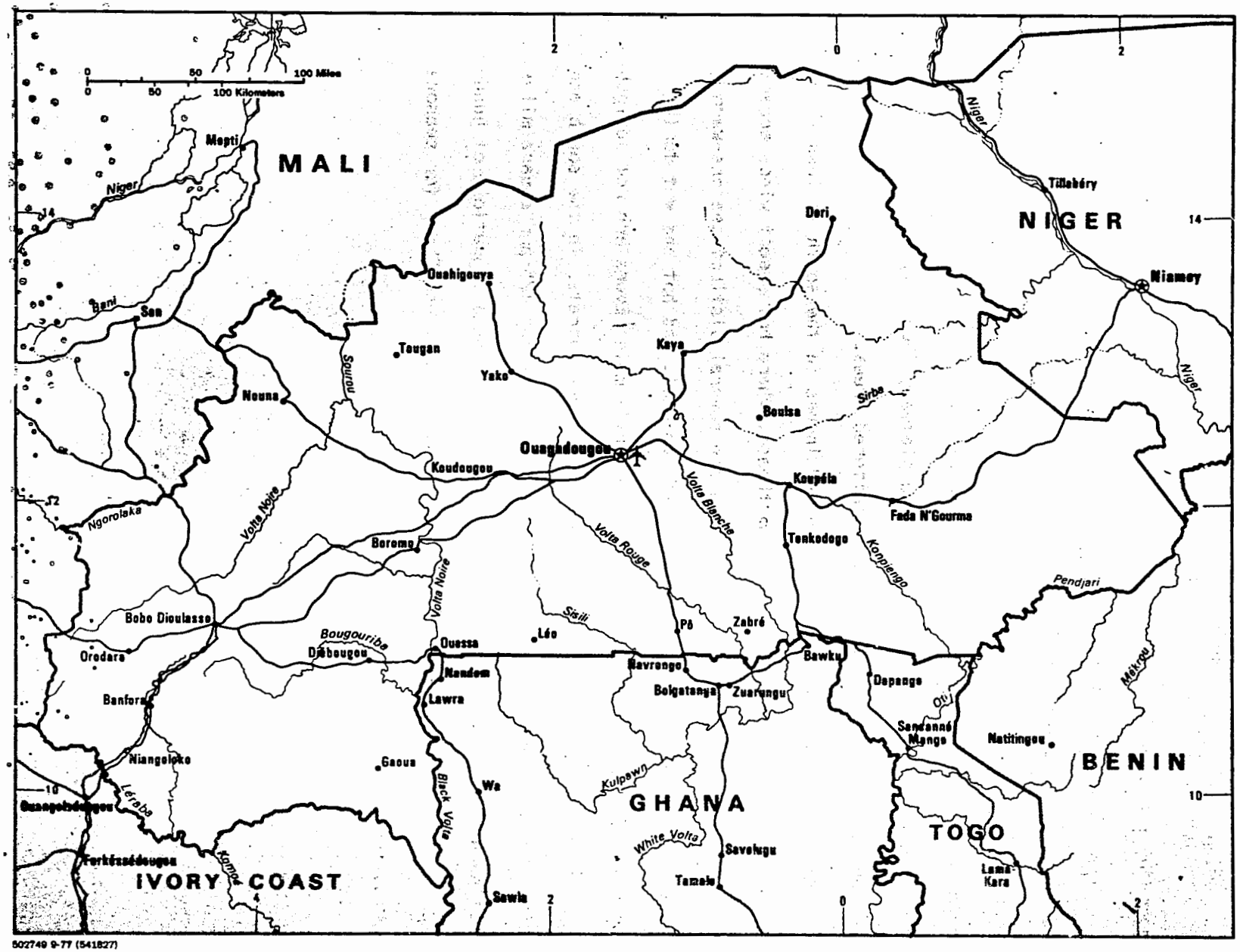
4. Soot covered walls reduced the efficiency of the spray.

5. Houses were rethatched or replastered periodically.

6. Nomadism.

Reference: Afro Malaria Yearbook No. 1, WHO Regional Office for Africa. AFRO/MAL/5, September 1959. Malaria Yearbook No. 2, WHO Regional Office for Africa. AFRO/MAL/7, December 1960.

Upper Volta



502749 9-77 (541827)
Lambert Conformal Projection
Standard parallels 8° and 32°
Scale 1:4,000,000
Boundary representation is not necessarily authoritative

REPUBLIC OF UPPER VOLTA

Geography and Climate[4]

Upper Volta is a landlocked country lying between the Sahara Desert and the Gulf of Guinea in the loop of the Niger River. It is bordered by Ivory Coast, Ghana, Togo, Benin, Niger, and Mali. The land is green to the south, with forests and fruit trees, and desert-like to the north. Most of central Upper Volta lies on a savanna plateau, 650 to 1,000 feet above sea level, with fields, bushes, and scattered trees.

Annual rainfall varies from about 40 inches in the south to less than 10 inches in the extreme north and northeast, where hot desert winds accentuate the aridity of the region. There are several distinct seasons-warm and dry (November-March), hot and dry (March-May), and hot and wet during the rainy season (June-October). The country's main rivers are not navigable.

The majority of Upper Volta's people are concentrated in the south and center of the country at densities sometimes exceeding 125 per square miles. This population pressure, rare in Africa, causes annual migrations of hundreds of thousands of Upper Voltans to the Ivory Coast and Ghana for seasonal agricultural work.

I. Country: Upper Volta

II. Project

Location: Bobo-Dioulasso

Population: 50,000

Time: March 1953 to June 1960

Type: Pilot malaria eradication program

III. Endemicity: Holoendemic

IV. Parasite

Primary: P. falciparum (resistant to pyrimethamine)

Secondary: P. malariae

V. Insect Vector

Primary: A. gambiae (resistant to Dieldrin); A. funestus (exhibits marked exophily)

VI. Type of Intervention

Insecticide: DDT (2.2 g/m^2) or BHC (0.11 g/m^2) annual or biannual

Chemotherapy: Chloroquine (600 mg) and pyrimethamine (50 mg)

VII. Evaluation

Three types of intervention were tried: 1) spraying, 2) spraying with drugs only at the beginning and peak of the transmission season or twice monthly for four months, 3) spraying plus drugs twice a month from June to September. Although transmission was not interrupted, the best results were obtained with method #3. Biannual spraying plus drug administration reduced the parasite rates to 6% in children 2-4 years old compared with 20% in areas where only spraying was used and 22% in areas where only drugs were used for intervention.

Some of the problems contributing to the failure to interrupt transmission were:

1. Seasonal migration of villagers during the harvest season
2. The reduced effectiveness of insecticides on soot covered walls
3. Local customs of sleeping out of doors and outside evening gatherings.

Reference: Afro Malaria Yearbook No. 1, WHO Regional Office for Africa. AFRO/MAL/5, September 1959. Malaria Yearbook no. 2, WHO Regional Office for Africa. AFRO/MAL/7, December 1960.

I. Country: Upper Volta

II. Project:

Location: Village of Koumbia

Population: 350 people of all ages

Time: one year

Type: Pilot malaria eradication program

III. Endemicity: Holoendemic

IV. Parasite

V. Insect Vector

VI. Type of Intervention

Chemotherapy: Chloroquine sulfate (5 mg/kg body weight)

VII. Evaluation

The spleen, parasite and gametocyte rates were reduced to one-fourth of pre-intervention rates. Whereas the antibody titer to the parasite was reduced markedly in children, no changes were observed in the adult antibody titers.

Reference: WHO/MAL/76.866.

I. Country: Upper Volta

II. Project

Location: Bobo-Dioulasso, Village of Wakara

Population: 1,100

Time: 1961 (June)

Type: Pilot malaria eradication program

III. Endemicity: Holoendemic

IV. Parasite:

Primary: P. falciparum

Secondary: P. malariae

V. Insect Vector:

Primary: A. gambiae, A. funestus

Secondary: A. nili

VI. Type of Intervention

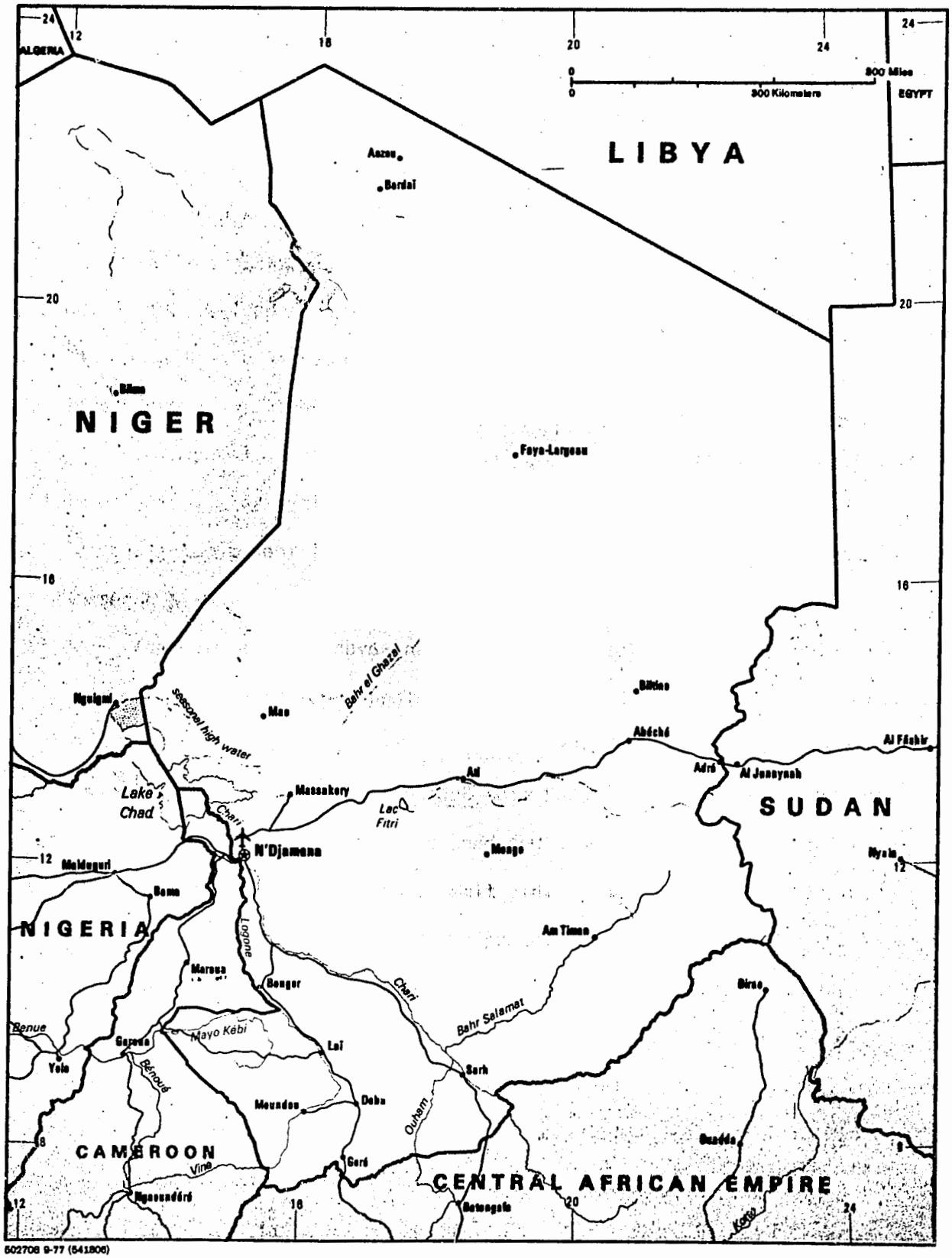
Insecticide: Dichlorvos (area sprayed with DDT prior to dichlorvos application); one dispenser per 500 ft^3.

VII. Evaluation

The insecticide was effective for three months during the wet season and five months during the dry season. The parasite rate in children (ages 1-9 years old) was reduced by 38%; parasite rates in infants were reduced by 55%. During the following transmission season (October 1961) the parasite rates began to rise in Wakara and remained high through March, 1962.

Reference: Bull. WHO 29:231-235. 1963; Bull. WHO 29:247-249. 1963.

Chad



502708 9-77 (541806)
Lambert Conformal Projection
Standard parallels 8° and 32°
Scale 1:8,900,000

Railroad
Road
Airport

REPUBLIC OF CHAD

Geography and Climate[3]

Chad extends north-south for more that 1,000 miles, from the Tropic of Cancer, which crosses the heart of the Sahara Desert at 23.5° N., through broad transitional zones of subarid and humid savanna to the edge of the tropical rain forest at about 7.5° N. The average distance across the country from east to west is 500 miles, and total land area is about 496,000 square miles. The nation is landlocked, having no easy or direct access to the sea. It shares frontiers with Libya, Sudan, the Central African Republic, Cameroon, Nigeria, and Niger.

The well-watered southern 10 percent of the country, which contains most of the productive arable land, consists of subtropical tree savanna and is inhabited by nearly half of the total population. Northward the land becomes a subarid transition zone (Sahel) of thornbush savanna and semidesert. The sparsely populated far north is a rocky wasteland consisting of southern extensions of the Sahara and Libyan deserts.

In the sourthern part of Chad (the Subtropical Southern Zone), the wet season extends from April through October, bringing from thirty-five to fifty inches of rain. Humidity during this time is often about 80 percent, and temperatures are relatively high throughout the year. Daytime maximum temperatures in Moundou are above 80° F even in January - the coolest month of the dry season - and in August, when the rains have some cooling effect. Temperature maximums during the hot months of March, April, and May are frequently above 100° F, and official temperatures above 113° F. have been recorded in the months of

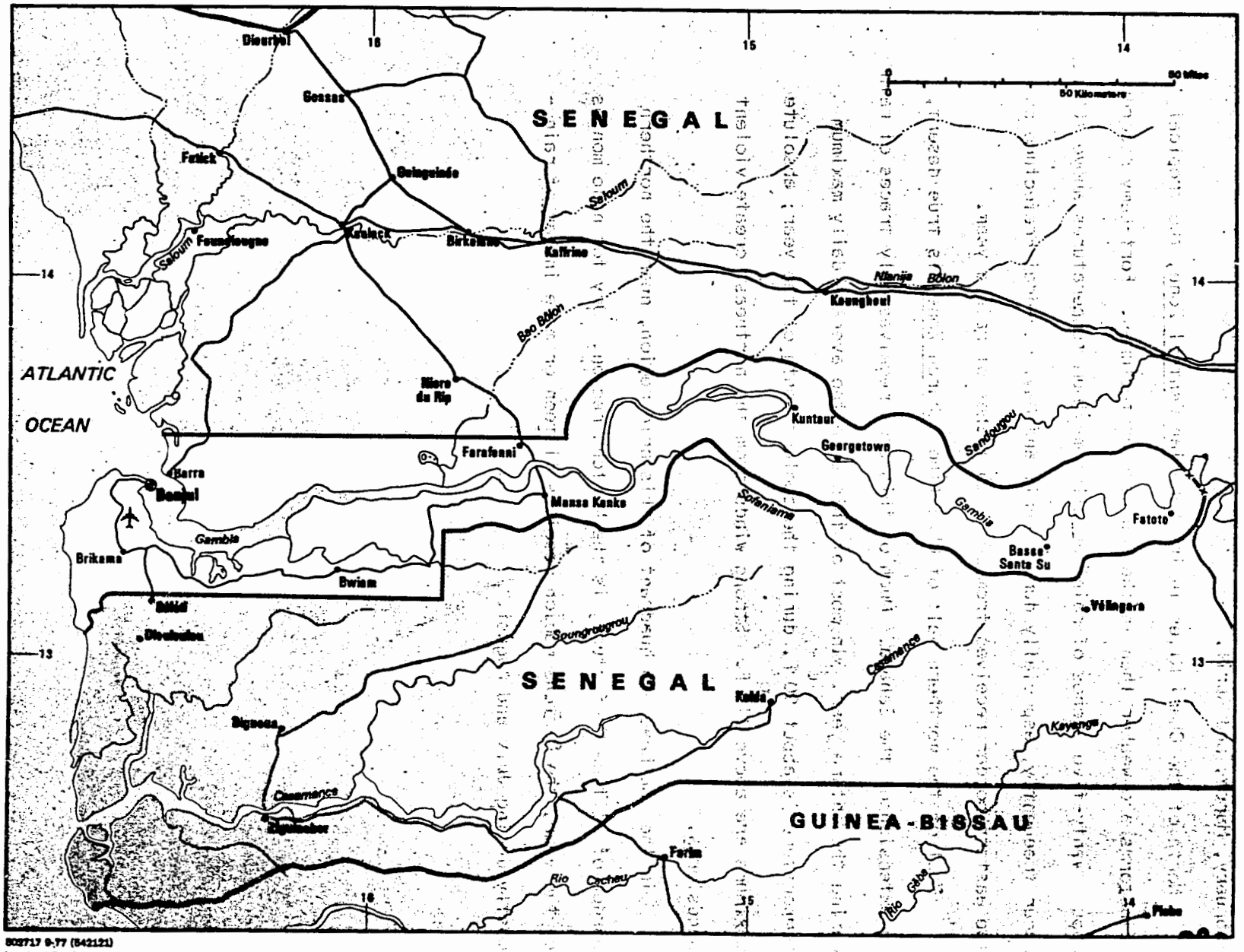
February, March, and April.

North of the Chari River in the Sahelian Central Zone, the tropical rainstorms are weaker than in the southern prefectures. Fort-Lamy records about twenty-five inches of rain annually; maximum temperatures above 100 °F. occur frequently, especially during April and May. Ouaddai Prefecture on the eastern border receives from 20 to 25 inches of rain a year.

Most of the northern half of Chad (the Saharan Zone) is true desert, an extension of the Sahara. Much of this area receives only traces of rain during the entire year. In most of this area the average daily maximum temperature is about 90 °F. during the coolest month of the year; absolute maximums are above 115 °F. Strong winds from the northeast create violent sandstorms.

In the southeastern quadrant of this arid region, near the northern border of Biltine Prefecture, is the Mortcha region. Dry for nine months of the year, the Mortcha region receives fifteen or more inches of rain - mostly during July and August.

The Gambia



802717 9-77 (542121)
Lambert Conformal Projection
Standard parallels 6° and 32°
Scale 1:1,800,000

Railroad
Road
Airport

THE GAMBIA

Geography and Climate[4]

The Gambia is located on the bulge of West Africa and comprises a narrow strip of land 7 to 20 miles wide along the lower reaches of the Gambia River. It extends inland 200 miles from the Atlantic Ocean and, except for the seacoast, is completely surrounded by the Republic of Senegal.

The Gambia is low-lying, with a maximum altitude of 120 feet above sea level. Thick mangrove swamps border the lower half of the Gambia River, where vegetation often rises 100 feet. Behind the mangroves are river "flats" which are submerged completely during the wet season, in some cases with salt water. Sand hills and rolling plateaus lie farther back from the river.

The climate is subtropical with a marked hot and wet season (June-October) and a cooler dry season (November-April). Annual rainfall varies from 30 to 55 inches and comes only in the summer. Temperatures range from 60 F to 110 F with daily temperatures exceeding 90 F from April to June.

Mali

502726 9-77 (542184)
Lambert Conformal Projection
Standard parallels 8° and 32°
Scale 1:11,000,000
Boundary representation is not necessarily authoritative

—— Railroad
—— Road
✈ Airport

REPUBLIC OF MALI

Geography and Climate[1,5]

The Republic of Mali is a landlocked country situated in the heart of West Africa. It covers an area of 92,700 square miles, sharing common borders with Mauritania and Senegal in the west, Algeria in the north, Guinea and Ivory Coast in the south, and Upper Volta and Niger in the east. Mali is a country of low relief, the highest point being Hombori at 3,770 feet, an isolated summit. Only some 13,500 square miles lie at altitudes above 1,650 feet, mostly around Adrar des Iforas. The greater part of the surface is about 1,000 feet above sea level and is generally very flat, except for the slopes around the edges of a number of plateaus and a few deep valleys cut into the less dissected parts of those plateaus.

Mali is divided into three climatic zones. The southern Sudanic climate zone extends up to 15° N. It receives from 20 to 60 inches of rainfall per year, the heavier falls being in the more southerly areas of the zone. In this zone average temperatures vary from 75° F to 95° F. Above the Sudanic climate zone is the Sahel whose southern portions receive about 20 inches of rain per year and whose northern areas receive about 7 inches. Temperatures vary from 80° F to 100° F. To the north of the Sahel is the Sahara climate zone where temperatures range from 120° F to 140° F. Rain in the Sahara is sporadic and scanty.

In all of these three zones, the climate is hot and dry. There are however two major seasons. The dry season, which extends from November to June, is characterized by progressively rising temperatures, especially from April through June. From November through January the aliza blows cool air

from the northeast causing a brief cool spell with temperatures falling to 70 °F. In February, the harmattan blows hot dry air out of the Sahara, continuing on into June. During this period, temperatures in the Sudanic zone and Sahel rise to a daily average of 105 °F.

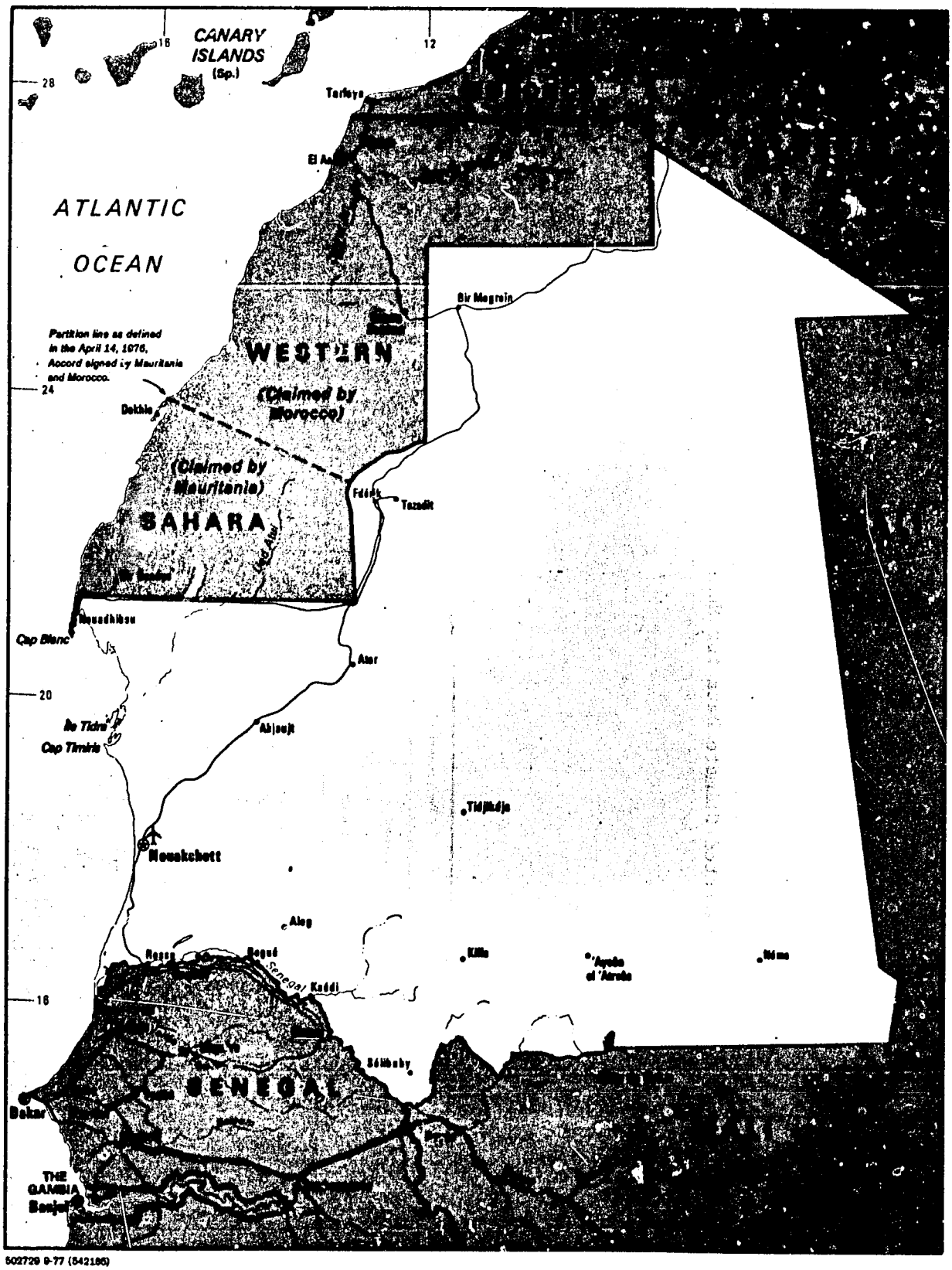
In mid-June the rainy season begins when a monsoon wind blows from the southwest bringing with it considerable moisture. The rainy season is characterized by a beginning and an end in which severe thunderstorms accompanied by much wind are common. Most of the rain falls during July and August, usually every few days. It is rare for a daily rain to last for more than a few hours. The rainy season is fairly cool but humid. Once the rains end in October, the climate becomes warm again and is uncomfortably humid until the cool alize winds begin to blow.

Selected Climate Data for Mali[1]

Station	Temperature °C				Rainfall			Relative humidity	
	Average maxima		Average minima		Average annual (mm)	Number of raindays	Months with over 100mm	Highest monthly %	Lowest monthly %
	Highest	Lowest	Highest	Lowest					
Sikasso	Mar. 37.7	Aug. 30.7	Apr. 24.2	Jan. 14.8	1,364	94	May-Oct.	Sept. 96	Feb. 30
Bamako	Apr. 39.5	Aug. 30.2	May 25.4	Dec. 17.3	1,100	81	Jun.-Sept.	Sept. 96	Mar. 34
Ségou	Apr. 39.9	Sept. 31.9	May 25.8	Jan. 15.4	720	70	Jul.-Sept.	Sept. 92	Mar. 30
Kayes	May 42.5	Jan. 33.8	May 28.4	Jan. 17.9	788	65	Jul.-Sept.	Sept. 93	Mar. 25
Mopti	May 40.5	Dec. 31.0	May 25.2	Jan. 13.8	465	64	Jul.-Sept.	Aug. 93	Mar. 29
Gao	May 42.5	Jan. 31.1	Jun. 27.5	Jan. 14.0	260	30	Aug.	Aug. 75	Mar. 20

Source: Service Météorologique du Mali.

Mauritania



502729 9-77 (542185)
Lambert Conformal Projection
Standard parallels 8° and 32°
Scale 1:8,200,000
Boundary representation is not necessarily authoritative

Railroad
Road
Airport

ISLAMIC REPUBLIC OF MAURITANIA

Geography and Climate[3]

Mauritania is located in northwestern Africa and is bordered on the north by Spanish Sahara and Algeria, on the east and south by Mali, on the south by the Senegal River and Senegal, and on the west by the North Atlantic Ocean. Of the total land area of 397,850 square miles, approximately two-thirds is part of the Sahara Desert, and the remaining third predominantly savanna grasslands. The virtually barren northern portions of the country are inhabited by nomads (75 percent of the total population), while the near-tropical Senegal River valley and certain savanna sections along the southern border with Mali are the site of sedentary agricultural populations.

It is common to distinguish Mauritania by the prevailing winds which results in four zones: the Saharan Zone, the Sahelian Zone, the Senegal River Valley Zone, and the Coastal Zone. The Saharan Zone comprises the northern two-thirds of the country and has an annual precipitation of 5.8 inches. Varying from 5.7 inches at Tidjikdja in the southern Saharan Zone to less than 1 inch in the far north, rain usually falls during the hivernage, or rainy season, lasting from July to September and is the result of fortuitous storms that dump large amounts of water in short periods of time.

Temperature in the Saharan Region has extreme diurnal variations but minimal annual variations. During the winter, variations may range from an early morning low of 32°F to a mid-afternoon high of 100°F. During the summer, temperatures range from 60°F in the mornings to more than 120°F by the afternoon. The mean yearly temperature at Atar is 99°F in the summer and 68°F in the winter. The coolest months are December and January; the warmest, May, June,

and July.

In the Sahelian Zone, the Mauritanian steppes and savanna grasslands consists of an east-west belt with its axis running through Boutilimit, Aleg, Kiffa, 'Ayoun-el'Atrous, and Nema. Great herds of cattle, sheep, and goats move across this zone from north to south following the season.

Precipitation varies from the minimum of 6 inches in the north to a maximum of 17.8 inches at Kankossa in the south. The hivernage begins earlier in the Sahel than in the Sahara, about June, and lasts until October. Again, annual variations are of significance: Kiffa had 7.2 inches in 1951, but 21.5 inches in 1936.

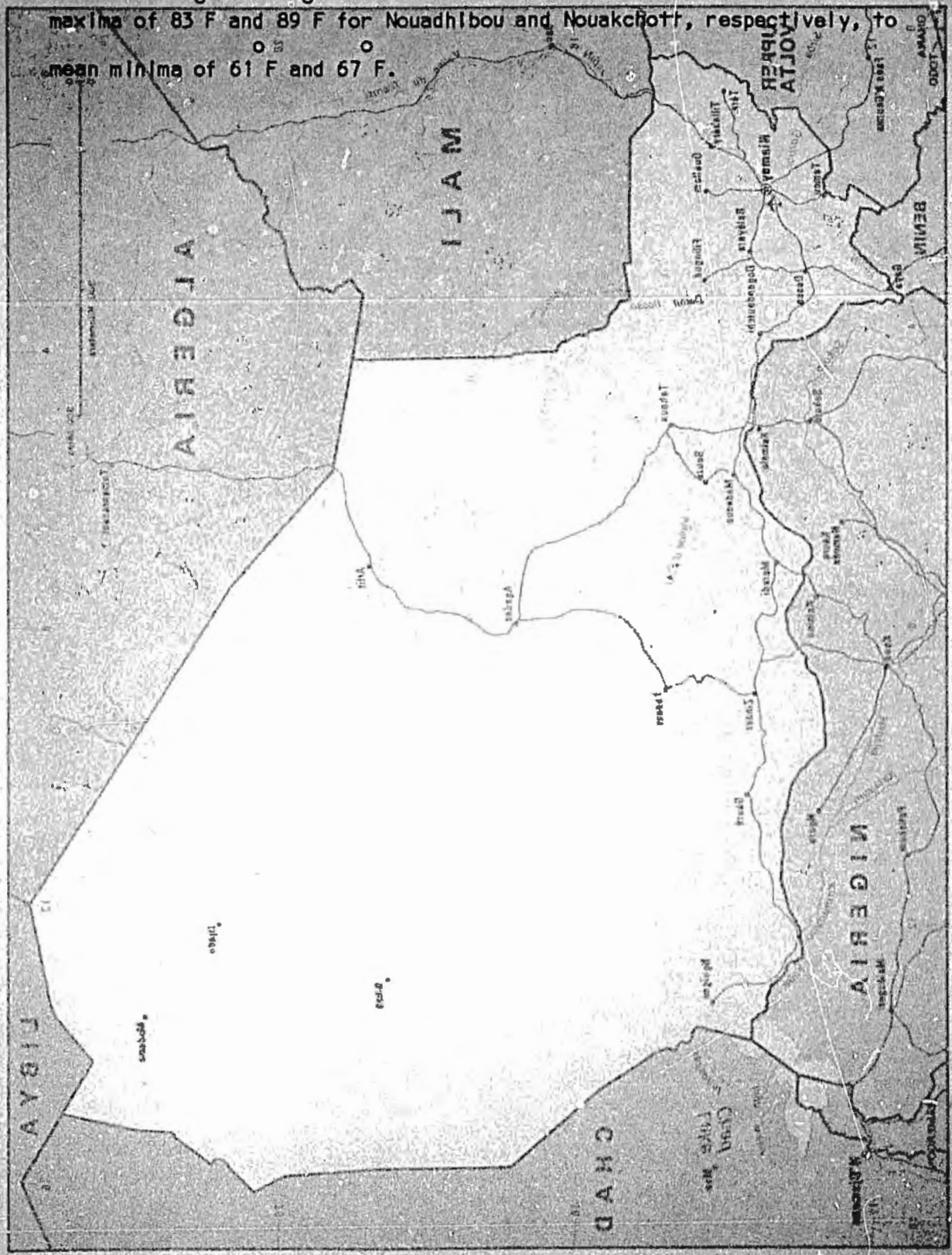
Although temperature extremes are somewhat less severe than in the Sahara, diurnal variations do range from 60 F to 70 F. The harmattan is the prevailing wind, but here it has a slightly higher moisture content than in the Sahara and thus slows rapid evaporation of surface water.

Rainfall in the Senegal River valley is generally the highest in the country. Ranging from 12 inches to 26 inches per year, precipitation begins in May and lasts until September.

Temperatures are cooler and are subject to less annual and diurnal variation. The mean yearly maximum and minimum temperatures for Kaedi are 94 F and 74 F, respectively. Humidity is much higher along the river and the air is often clouded by dense mists. During the rainy season tornadoes are a frequent occurrence. In this semi-tropical climate, unlike the rest of the country, malaria flourishes.

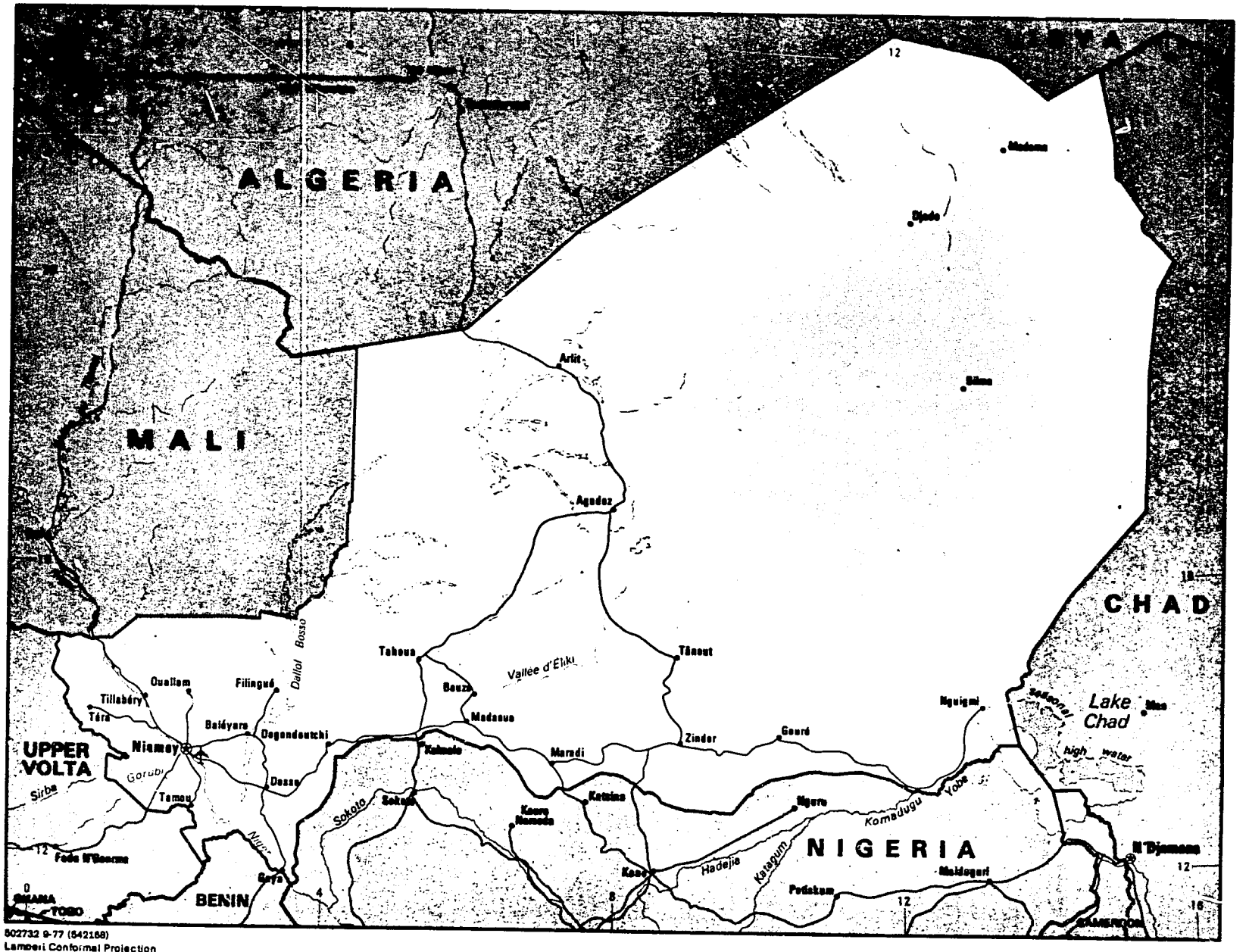
In the Coastal or Sub-Canarian Zone, rainfall is quite minimal. In Nouadhibou it averages less than 1 inch annually and occurs during the Saharan hivernage in July-September. Temperatures are moderate, varying from mean

maxima of 83 F and 89 F for Nouadhibou and Nouakchott, respectively, to mean minima of 61 F and 67 F.



Nigeria

Niger



502732 9-77 (542168)
Lambert Conformal Projection
Standard parallels 8° and 32°
Scale 1:8,300,000
Boundary representation is not necessarily authoritative

REPUBLIC OF NIGER

Geography and Climate[5]

The Republic of Niger lies within the northern tropics, between 11° 37' N and 23° 33' N. The greater area (over 386,000 square miles) stretches from the southern sahel northwards through a desert zone to the Tropic of Cancer, while a small projection to the southwest (some 46,332 square miles) stretches as far as the river Niger. This southwestern portion is surrounded by the Republics of Mali, Upper Volta, and Nigeria. The eastern and northern borders of the large land locked Republic of Niger are adjacent respectively to Chad Libya, and Algeria.

The largest part of the country lies in a desert region (1), receiving less than 12 inches of rain per year. In this saharan zone, which includes the vast districts of northern Tahoua, Agadez and Bilma, and most of Goure and N'Guigmi, cultivation is impracticable except around oases. South of this zone stretches a sahelian zone, running west to east, with rainfall over 15 inches, a savanna steppe with acacias, where most of Niger's cropland is located. Westwards and in the southwest, with increasing rainfall, trees become more abundant. Within the sahelian zone, several regions can be recognized.

In the west are the dissected plateaus (2), stretching east as far as the Ader-Doutchi, and the Niger valley (3) from Gaya north to Firkou. The Dallol Bosso and Dallol Maouri which in the north constitute the major livestock zone of Azaouak district. Eastwards lies a sequence of regions (5) which have strong links with northern Nigeria, namely Ader-Doutchi (Tahoua, Birni N'Konni and Madaoua), the Goulbis (Maradi, Tessaoua and southern Dakoro), and Zinder. The most easterly region is the Manga region (6) from the dugu

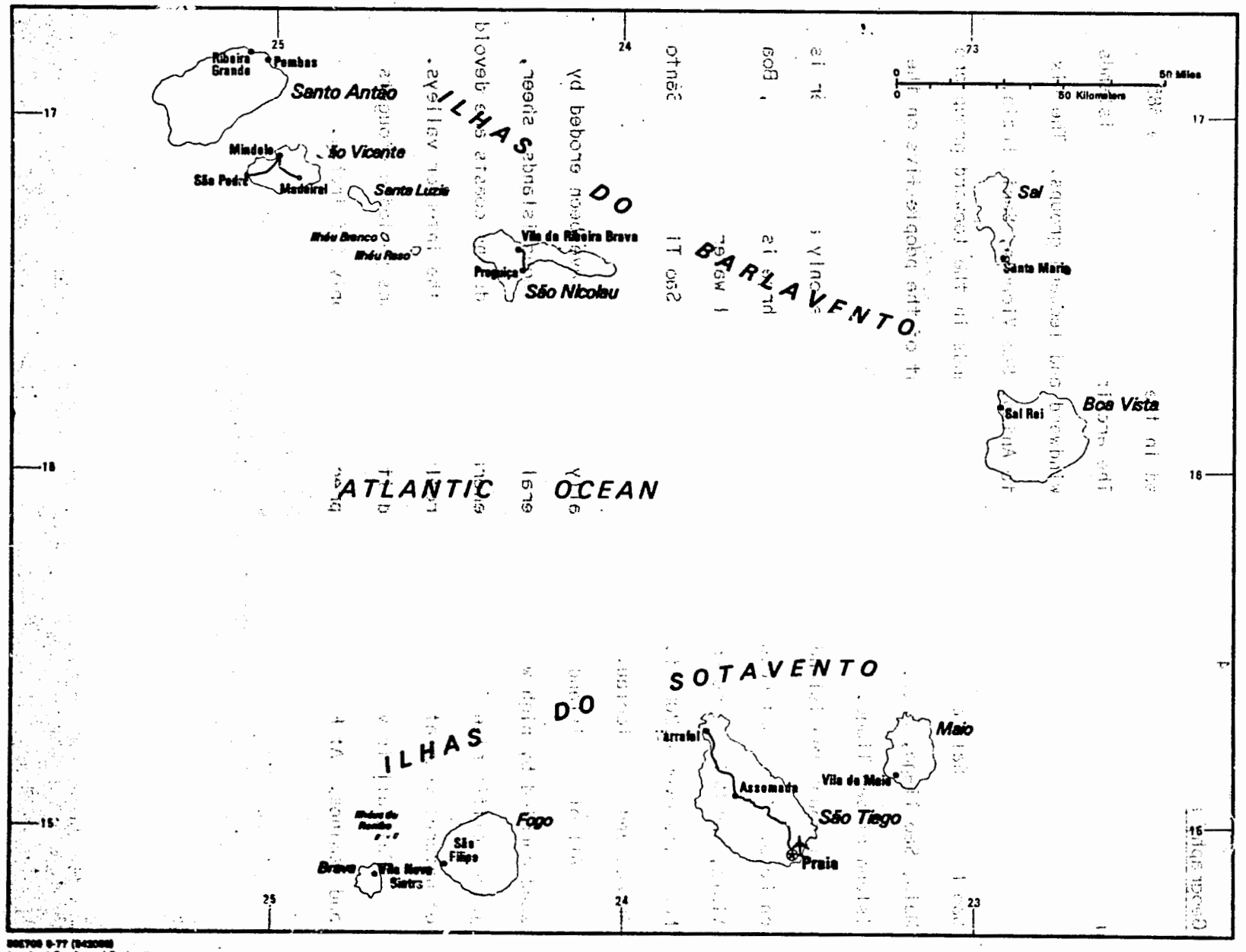
Yobe valley in the south to N'Guigmi on lake and westwards as far as Goure.

Rainfall is the most significant element in the climate of Niger. There are extreme variations both in amount and distribution of rain. The annual rainfall diminishes rapidly from south to north. At Gaya, in the extreme southwest at about 12° N, the annual rainfall is 33 inches and it decreases northwards to 14 inches at about 15° N (in the latitude of Tahoua and Goure) which is regarded as the northern limit for cultivation. Agades, in the south of the Air massif, receives 4 inches a year, while the higher land of the massif receives more rain than the surrounding deserts.

The rainfall is distributed very unevenly through the year. There is one rainy season, starting with storms in May in the south, July further north. August is the wettest month and then the rains recede between September and October, according to the latitude. The rainy season varies therefore from five months in the south to two months in the north.

Niger lies in one of the hottest zones of the world. Daily maximum temperatures of over 104° F occur in April-May, in advance of the first rains. During the rainy season they fall to 50° F, rise in October and fall again from December to February. Daily minimum temperatures fluctuate in a similar way but the daily temperature range is much greater during the dry season than in the rains, and is also much higher in the north than in the south. At Niamey in the southwest, absolute extreme daily temperatures are 43° F and 117° F; in the Air massif they can be 23° F and 122° F.

Cape Verde



Lambert Conformal Projection
Standard parallels 8° and 32°
Scale 1:1,700,000

CAPE VERDE ISLANDS

Geography and Climates[4]

The Cape Verde islands are located in the central Atlantic some 385 miles off the west coast of Africa. The archipelago consists of 10 islands and 5 islets, which are divided into windward and leeward groups. The six islands in the windward group are Santo Antao, Sao Vicente, Santa Luzia, Sao Nicolau, Sal, and Boa Vista. The four islands in the leeward group are Maio, Sao Tiago, Fogo, and Brava. Forty percent of the people live on the island of Sao Tiago.

Although the islands are volcanic in origin, the only active crater is on Fogo. (Its most recent eruption was in 1951.) Three islands - Sal, Boa Vista, and Maio - are somewhat level and lack natural water supplies. Mountains over 4,200 ft. are found on the islands of Sao Tiago, Fogo, Santo Antao, and Sao Nicolau.

All of the islands, but especially the windward, have been eroded by sand carried by high winds. On several of the mountainous islands, sheer, jagged cliffs rise from the sea. Generally the uplands and coasts are devoid of natural vegetation, which is largely confined to the interior valleys.

Rainfall is very irregular, and its failure causes periodic droughts and famines. At Praia the average precipitation is only 9.5 inches.

C. Equatorial Africa[1]

Countries with MEP[1]

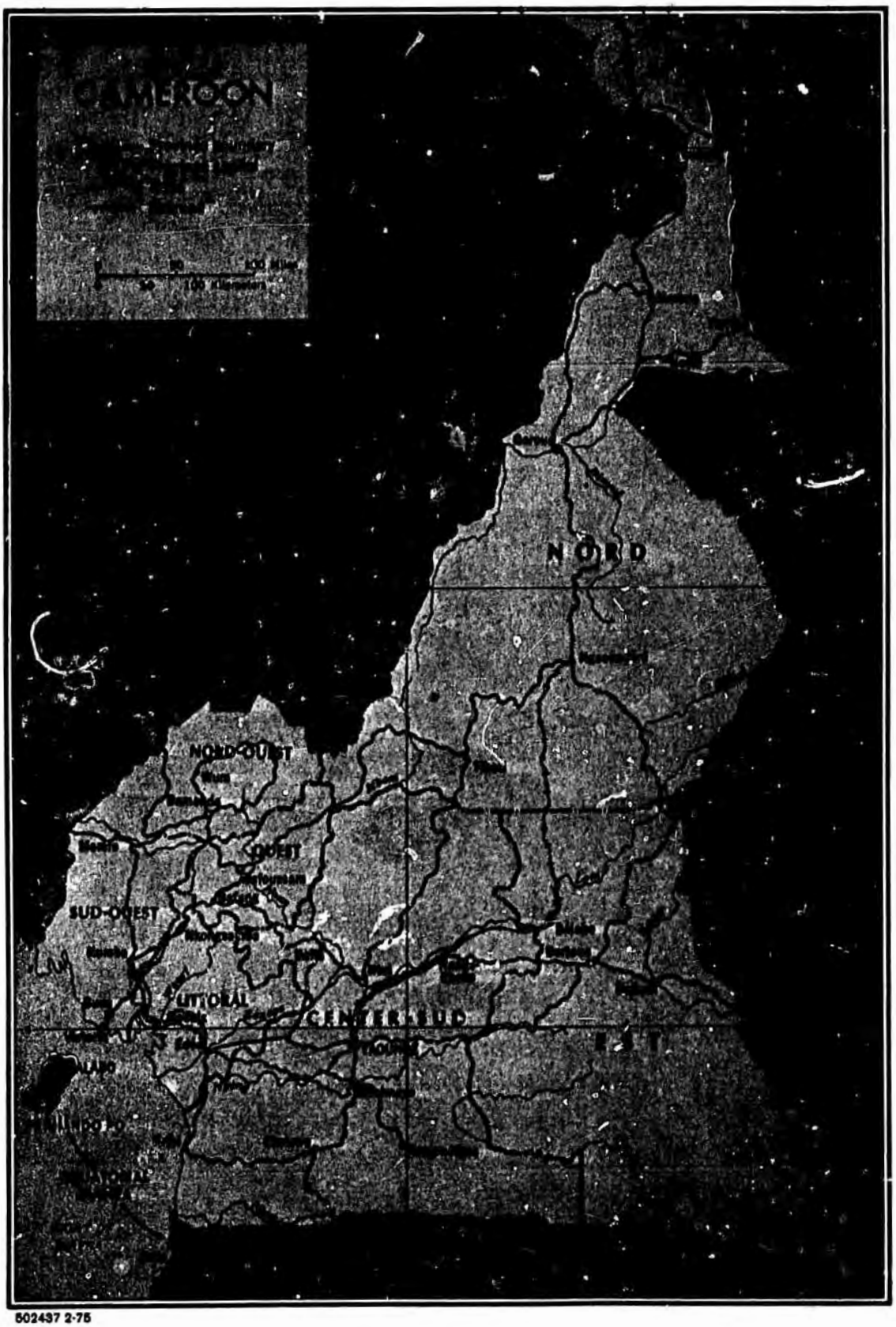
United Republic of Cameroon
Republic of Zaire

Country without MEP[2]

Central African Republic

[1]Stippled area on map.

[2]Malaria eradication/control programs.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UNITED REPUBLIC OF CAMEROON

Geography and Climate[3]

Cameroon covers about 183,500 square miles in west-central Africa, forming an irregular wedge extending northeastward from a coastline on the Gulf of Guinea, an arm of the Atlantic Ocean, to Lake Chad, 700 miles inland. The country has a 160-mile coastline on the Gulf of Guinea and approximately 2,765 miles of border with six countries: Nigeria to the west; Chad and the Central African Republic (CAR) to the northeast and the east; and the People's Republic of the Congo (Congo - formerly, Congo Brazzaville), Gabon, and Equatorial Guinea to the South.

The country can be divided geographically into four regions. The Northern Plains extends into Lake Chad, where the borders of Nigeria, Chad, and Cameroon intersect. The narrow neck of territory south of the lake is part of a shallow inland basin, several hundred miles wide, which extends in all directions from Lake Chad. In the Central and Southern Plateaus, the Adamaoua Plateau, lying between 7° N and 9° N latitude, extends from the eastern to the western border of Cameroon at elevations that are everywhere more than 3,000 feet above sea level and average about 4,500 feet. Surface features in the central parts of this high plateau include small hills or mounds capped by erosion-resistant granite or gneiss. South of the Adamaoua Plateau begins a series of lower plateaus that extend throughout most of South Central and Eastern provinces at elevations averaging about 3,000 feet but descending gradually southward to the border and westward toward a series of terraces leading downward to the coastal plain.

The Cameroon Mountains, the Western Highlands, is the highest range in the

country, extending southeastward from the Cameroon-Nigeria border area at about 160 miles. It is less than twenty miles wide in most of the area northwest of Mount Cameroon, which divides the northwestern coastal plain from the broader lowlands in the central coastal area.

The narrow neck of Northern Province is among the northernmost area reached by moisture-bearing winds from the equatorial rain belt (Subarid north). Southerly and southwesterly winds bring about forty inches of rain annually to the Garoua area and about thirty inches to much of the area farther north. Most of it is concentrated in a five-month season (May to September) in the Garoua region and in a shorter season near Lake Chad. Daytime temperatures are usually high except during and immediately after late summer rainstorms. Midday maximums are often above 90 ^{o}F, especially during February and March, but nights are usually much cooler, at least during the dry months when the diurnal range often covers thirty degrees and may be as much as fifty degrees.

Much of the Adamoua Plateau is an area of humid wooded savanna (central Savanna). At Ngaoundere, a town near the center of the Plateau and near the geometric center of Cameroon as well, annual rainfall is about 59 inches, twice as much as the average in the far north. The rainy season extends from April to October and is longer toward the south, where this region merges into the region of humid wooded savanna and forests.

Much of this subequatorial central area is from 3,000 to 5,000 feet above sea level, and elevation tends to moderate temperatures. Records taken at Ngaoundere (3,600-foot elevation) show average daily maximums ranging from about 82 ^{o}F in June during the rainy season to 95 ^{o}F in March at the end of the dry season. Daily minimums are about 60 ^{o}F or slightly higher

during several months of the summer rainy season.

Winter is a period of low humidity, which makes the area more comfortable for humans than the lower and wetter areas in the south and the southwest.

Southward the lower plateaus become progressively more rainy and humid. Rainfall ranges from 60 inches per year in areas near 5° N latitude to nearly 100 inches in the southern section of the coastal plains near the town of Campo. Diurnal and seasonal fluctuations in temperatures and humidity are within narrow ranges, especially at the lower elevations and along the coast. Yaounde's temperatures are typical, having an average daily maximum of 82° F and an average minimum of 72° F.

Relative humidity is not often below 50 percent, and it is frequently above 80 percent. Nevertheless, at 2,300-foot elevation, Yaounde and a large area to the north and east have a more comfortable climate than the southwestern coastal zone.

The southern area comes under the influence of equatorial airmasses from the south as well as Atlantic airmasses from the southwest. Among other complex climatic influences, one result is a pattern that includes two seasonal rainfall peaks annually and two seasons that are less rainy (somewhat inaccurately known as the dry season and the little dry season). The rains are moderately heavy in April and May, tapering off to the little dry season (four to six inches of rain per month) in June and July. Rainfall increases to more than thirteen inches per month in August and September and then recedes to as little as three to five inches per month in December and January.

In the Coastal and Montane Rain Forest, there is no dry season; temperature and humidity change very little from day to day or from month to month. The

western mountains are also a part of this rainy and humid zone, but altitude brings somewhat greater variations in the monotonous patterns of prolonged periods of cloud cover, heavy rain, and high humidity. Temperatures at the port of Douala, in the central coastal area, range from an average daily high of 84 ^{o}F to average lows of about 72 ^{o}F; record highs in this area are above 95 ^{o}F. The average relative humidity is between 85 and 90 percent throughout the year. Rainfall ranges from 100 inches per year south of the coastal town of Kribi to 158 inches at Douala.

Rainfall in the mountainous areas of Southwestern and Northwestern provinces varies greatly. Most areas, including those as far inland as the Bamenda Highlands, receive between 60 and 130 inches of rain per year. Some areas in the coastal plains and in the mountains near the sea receive twenty-five inches of rain per month in August and September, the wettest months.

Mount Cameroon stands near the coast and catches the full force of the wet winds from the Gulf of Guinea. Turbulence increases as the winds are pushed upward. Rainfall is heavy on the western slopes, sometimes continuing for days at a time. Stations on Mount Cameroon and on the nearby coastal plain are among the wettest in the world; a total of 250 inches per year has been recorded near the mouth of the Wouri River, and over 360 inches in a small area on the slopes of Mount Cameroon.

I. Country: Cameroon

II. Project

Location: Yaounde

Population: 130,000

Time: 1953-1957

Type: Pilot malaria eradication program

III. Endemicity: Hyperendemic

IV. Parasite: Primary: P. falciparum

Secondary: P. malariae

Other: P. ovale

V. Insaect Vector: Primary: A. gambiae, A. funestus, A. moucheti

Secondary: A. nili

VI. Type of Intervention

Insecticide: One-half of the area was sprayed with DDT (2 g/m^2) twice yearly and the other half sprayed with Dieldrin (0.6 g/m); cycle continued for two years.

VII. Evaluation

In treated areas, the parasite rate in infants dropped to 0% from an initial rate of 40% and in children 1-9 years to 1-2% from an initial rate of 60%. In 1959-1960, spraying of the total areas was discontinued and only the surrounding areas were sprayed (Surveillance Phase of malaria eradication scheme).

Reference: Afro Malaria Eradication Yearbook No. 1, 1959. WHO Regional Office for Africa, AFRO/MAL/5. Malaria Yearbook No. 2, 1960. WHO Regional Office for Africa. AFRO/MAL/7.

I. Country: Cameroon

II. Project

Location - Northern

Population: 400,000

Time: 1953-1957

Type: Pilot malaria eradication program

III. Endemicity: Hyperendemic

IV. Parasite: Primary: A. gambiae

Other: A. coustani; A. nili, A. pretoriensis; A. pharoensis; A. rufipes

V. Insect Vector: Primary: P. falciparum

Secondary: P. malariae

Other: P. ovale

VI. Type of Intervention

Insecticide: DDT was sprayed twice yearly. Smaller areas were sprayed either with BHC or DLD.

VII. Evaluation

Malaria indices remained high (82% initially and 12% after intervention).

Reasons given for failure to reduce transmission were:

1. Local custons such as sleeping out of doors and replastering and rethatching houses periodically reduced the effectiveness of intervention methods.

2. Nomadism.

3. The type of construction used in houses reduced the effectiveness of the insecticide to 6-8 weeks.

4. Rains rendered most roads impassable, therefore spraymen could not cover the entire area.

The project was discontinued in 1961.

Reference: Afro Malaria Yearbook No. 1, WHO Regional Office for Africa. AFRO/MAL/5, Sept. 1959. Malaria Yearbook No. 2, WHO Regional Office for Africa. AFRO/MAL/7, December 1960.

I. Country: Cameroon

II. Project

Location: Southern

Population: 800,000

Time: 1953-1957

Type: Pilot malaria eradication program

III. Endemicity: Hyperendemic

IV. Parasite, Primary: P. falciparum

Secondary: P. malariae

Other: P. ovale

V. Insect Vector, Primary: A. gambiae; A. funestus; A. moucneti

Secondary: A. nili

VI. Type of Intervention

Insecticide: Dieldrin sprayed yearly (0.6 g/m^2) for eight cycles.

VII. Evaluation

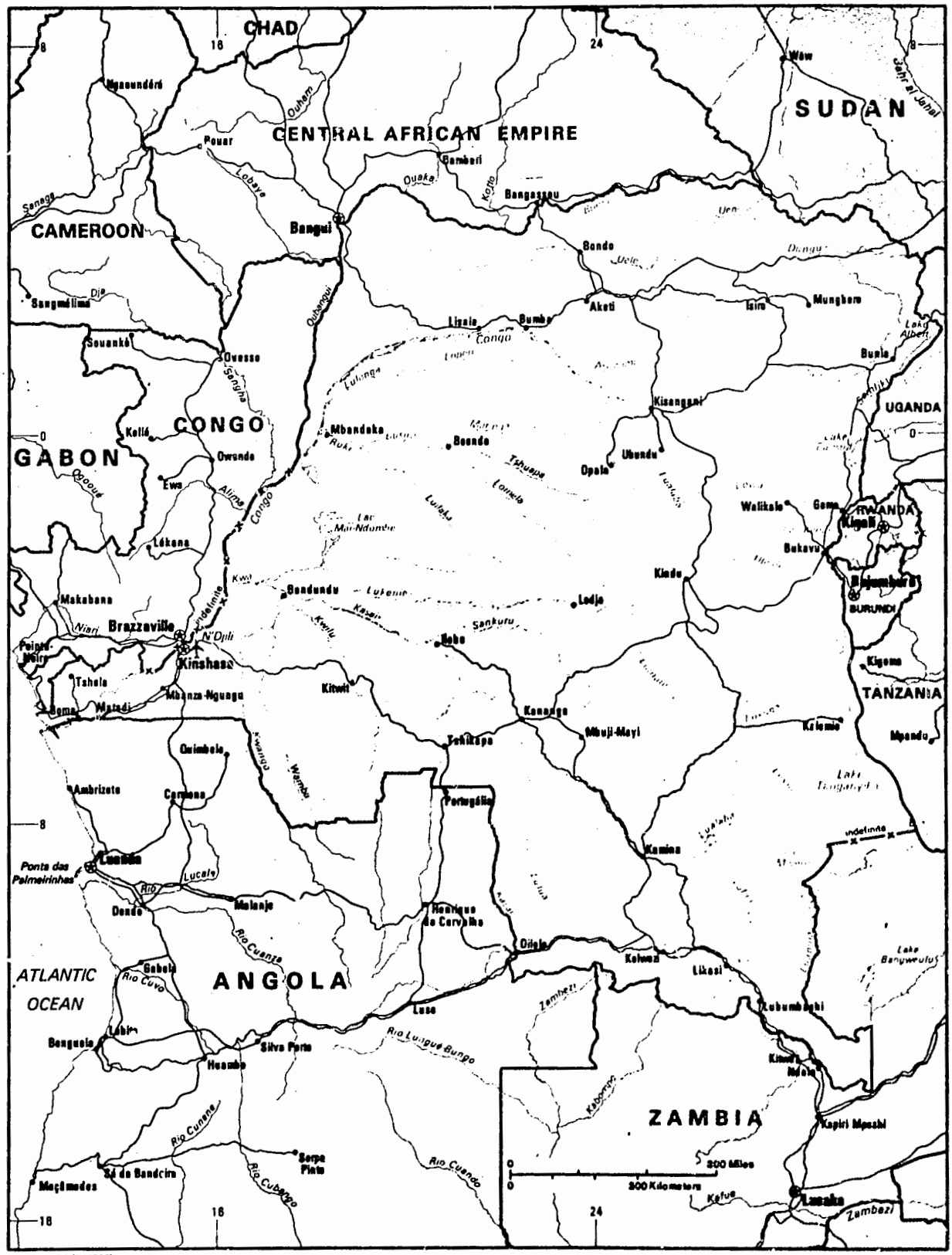
A. funestus disappeared. A. gambiae was reduced significantly. A. moucheti still persisted, probably due to its exophilic habits, but was susceptible to insecticides. The transmission of malaria was not interrupted and the spraying was discontinued in 1959-1960.

Some of the problems associated with the campaign were:

1. A large number of houses were not sprayed.
2. The planners assumed that no villages existed in the forest.
3. There were too few spraymen and their supervision was poor.

Reference: Atro Malaria Yearbook No. 1, WHO Regional Office for Africa. AFRO/MAL/5, Sept. 1959. Malaria Yearbook No. 2, WHO Regional Office for Africa. AFRO/MAL/7, Dec. 1960.

Zaire



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Mercator Projection
Scale 1:13,200,000
Boundary representation is not necessarily authoritative

Railroad
Road
Airport

REPUBLIC OF ZAIRE

Geography and Climate[2]

The Republic of Zaire is an almost totally landlocked country straddling the equator in the heart of Central Africa. Embracing a total area of 905,400 square miles, Zaire is the third largest country in Africa and is roughly equivalent to the size of the United States east of the Mississippi River. The country's sole outlet to the sea is a 20-mile strip of land leading to the Atlantic Ocean. Zaire is bounded on the west by the People's Republic of the Congo and the Cabinda enclave of Angola; on the southwest and south by Portuguese Angola and Zambia; on the east by Uganda, Rwanda, Burundi, and Tanzania's Lake Tanganyika; and, on the north by the Republic of Sudan and the Central African Republic. Its proximity to these nine African countries has facilitated large refugee movements in and out of Zaire over the course of its history. These continual migrations have also served as a vehicle for transmission of diseases from other countries to Zaire.

The topography is diverse, ranging from the large mountains of the Rift Valley in the east, among the highest mountains in Africa, marshes in the northwest, savannahs in the north and south highlands, and scattered woodlands in the southeast, to a dense equatorial rain forest in the central basin of the country, covering approximately 409,300 square miles.

The Zaire River, from which the country takes its name, is the principal body of water in the nation. By volume, it is among the largest rivers in the world, second only to the Amazon. Upstream, the Zaire River is navigable to Kisangani. Rocky channels and waterfalls along the

west and south of the river make these sections unnavigable as it flows toward the Atlantic. The Zaire River is navigable year-round, however, from Matadi, the nation's main port, to the point where it empties into the Atlantic Ocean.

Two principal climatic zones can be distinguished in Zaire: the equatorial and the tropical. Average rainfall in the area surrounding the equator is high, an average of 70 to 80 inches annually and the temperatures are generally equally warm year-round with a mean average temperature of 75 ^{o}F, varying up to 1 ^{o} annually. The tropical climate zone, which covers the major part of the Zaire River system basin, has two main seasons: rainy, with high temperatures and rainfall averaging 39 to 60 inches and dry with generally gray skies, no rain and mild temperatures. Although exceptions do occur, the seasons are generally reversed in the two hemispheres: the dry season usually extending from November 1 to March 30 north of the equator is concurrent with a rainy season south of the equator. This phenomenon plays an essential role in assuring regularity of flow of the Zaire River. Since the river covers an area both north and south of the equator, rain falls in its basin all year round. Line squalls, violent and potentially destructive winds are common throughout the Zaire River basin where they may occur up to 10 times per month during the rainy season.

Notes

A. Support by the Government of Zaire[2] of malaria control programs.

1. Zaire has legislative authority for its malaria control program through the National Commission for Malaria.

2. The National Malaria Service has conducted some spraying and larviciding operations. These operations have been inadequate due to lack of manpower, resources and professional expertise in entomology, parasitology and epidemiology.
3. Antimalarial drugs are available to the population, however, they do not take advantage of the service.
4. The country is making serious attempts to develop it's health services.

B. U.S./A.I.D. Support of malaria control programs

The agency completed an agreement with the government of Zaire in 1976 to establish an Endemic and Communicable Disease Control Program (Project No. 660-058-60031). One component of the project was a malaria control program. The objectives of the program are:

1. To establish the organizational capability and the trained manpower to plan, develop, and execute programs for the control of malaria and other vector-borne diseases in Zaire.
2. To establish and successfully operate a pilot project of malaria control in the Kinshasa Region and in one nearby rural area. The indicator of success would be a significant reduction in the number of deaths, particularly in younger children.
3. To extend and integrate the principles and practices of vector-borne disease control into the permanent health delivery system.

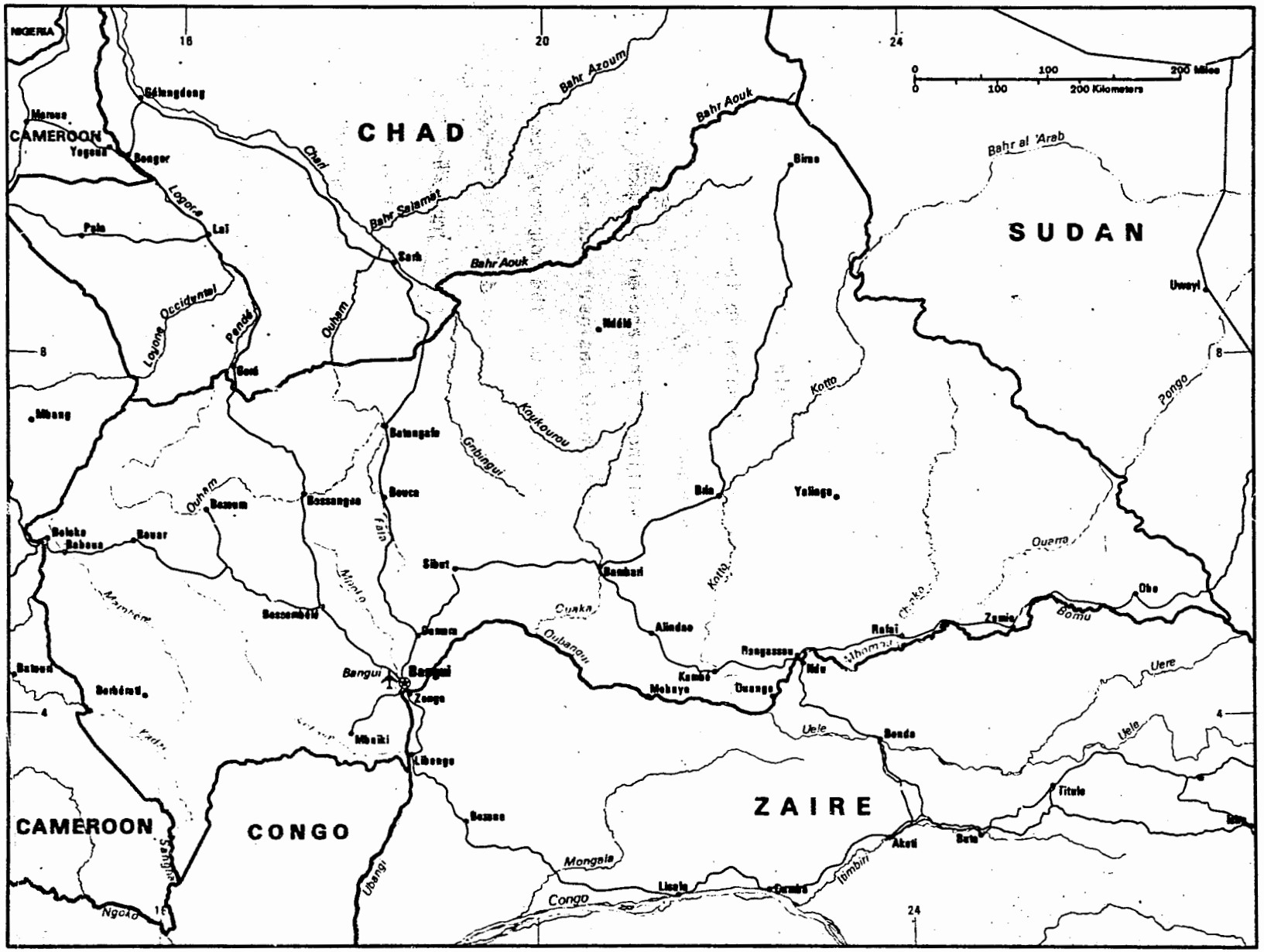
The technical assistance provided by the agency includes one full-time trained technician experienced in the techniques of malaria and vector-borne diseases for a period of five years and the necessary assistance from time

to time of malariologists, entomologists, epidemiologists, and environmental sanitation specialists. The estimated cost for the first two years is $134,500,000.

The project activities were described in the 1978 Annual Report of the Malaria Advisor and in the evaluation document (Development Support Bureau, Development Information and Utilization Office/AID). The principal activities were:

- Geographical reconnaissance
- Distributing chloroquine to persons under 15 years of age and pregnant/ lactating women complaining of fever.
- Gathering of epidemiology data
- Draining of ditches in four zones
- Spraying 8,000 houses with DDT
- Identification of A. gambiae
- Determining the sensitivity of A. gambiae to DDT.

Central African Empire


NIGERIA
CAMEROON
CHAD
SUDAN
ZAIRE
CONGO
Garoua
Maroua
Yagoua
Bongor
Pala
Lai
Sarh
Moundou
Bouar
Berberati
Bangui
Zongo
Mbaiki
Libenge
Bozoum
Bossangoa
Bouca
Batangafo
Sibut
Bambari
Kouango
Bria
Yalinga
Birao
Ndélé
Uweyi
Ouaka
Ouanda
Dim
Zemio
Obo
Rafai
Mobaye
Dungu
Bondo
Titule
Aketi
Bumba
Lisala
Dundu
Mongala
Congo
Ubangi
Uele
Ituri
Bomu
Kotto
Pongo
Bahr Azoum
Bahr Aouk
Bahr al 'Arab
Bahr Salamat
Chari
Logone
Logone Occidental
Pendé
Ouham
Koukourou
Gribingui
Lobaye
Mambéré
Sangha
Ngoko
Tomi
Ubangi
Ubangi
Ubang

CENTRAL AFRICAN REPUBLIC

Geography and Climate[5]

The Central African Republic is located at almost the precise center of Africa, about 400 miles from the nearest ocean. It covers 622,560 km^2 between the latitudes 3° N and 10° N and is surrounded by Chad on the north, Sudan on the east, Congo (Brazzaville) and Zaire on the south, and Cameroon on the West.

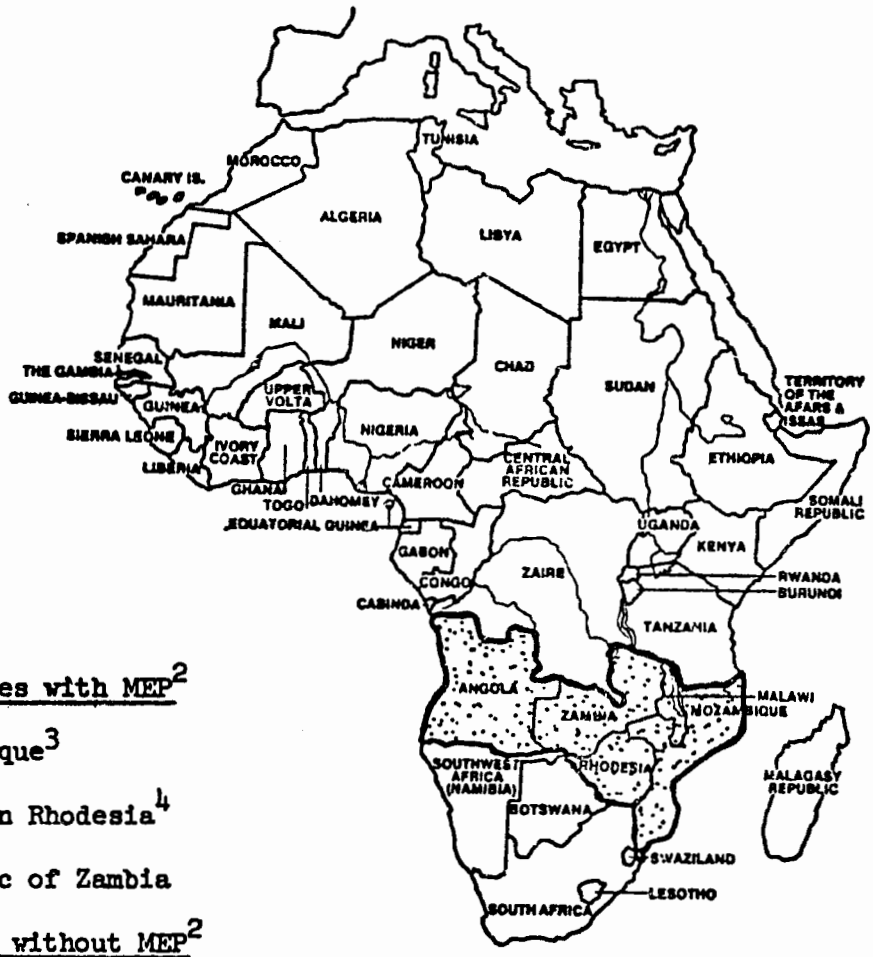
The country is a vast, well-watered plateau drained by two major river systems. The northerly system drains into the Chari Basin and eventually into Lake Chad. The southerly system drains into the Oubangui, a confluent of the Zaire River. Navigation is limited to the Oubangui and short sections of the Lobaye and the Sangha.

The republic lies athwart an upswelling of the ancient basement platform of Africa, which divides two major tectonic basins, those of Chad and of Congo. This dorsale, running west-east across the country, occupies more than half of the total area. Its plateaus, carved from the Pre-Cambrian crystalline basement rocks, average 1,800-2,000 feet in altitude, and its peneplain surface, the watershed between the Chad and Congo basins, is dominated by occasional inselbergs - kaga - which are usually composed of granite intrusions in the Pre-Cambrian basement.

In general, the climate is tropical continental in type, with a short dry season, though there is considerable variety of regional climates within the eight degrees of latitude across the country, with corresponding differences in vegetation. These bio-climatic zones range from the equatorial at Nola in the southwest to the sahelo-sudanese at Birao in the northeast.

The dry season starts in November and ends between March and June, depending on the locality and on variations in annual conditions. There is never total drought, and the seasonal rhythm of the climate is balanced by the high pressure areas over north Africa and the south Atlantic. Average annual temperatures are high, generally 77-79 ^{o}F, but 75 ^{o}F in the northeastern highlands. Annual rainfall amounts are moderate, ranging from 67 inches in the southern equatorial zones to 31 inches in the northeast. Because the rainfall is adequate and the dry season is short, climatic conditions favor a woodland-savanna vegetation and open forest over most of the country.

D. South Central Africa[1]



<u>Countries with MEP[2]</u>

Mozambique[3]

Southern Rhodesia[4]

Republic of Zambia

<u>Country without MEP[2]</u>

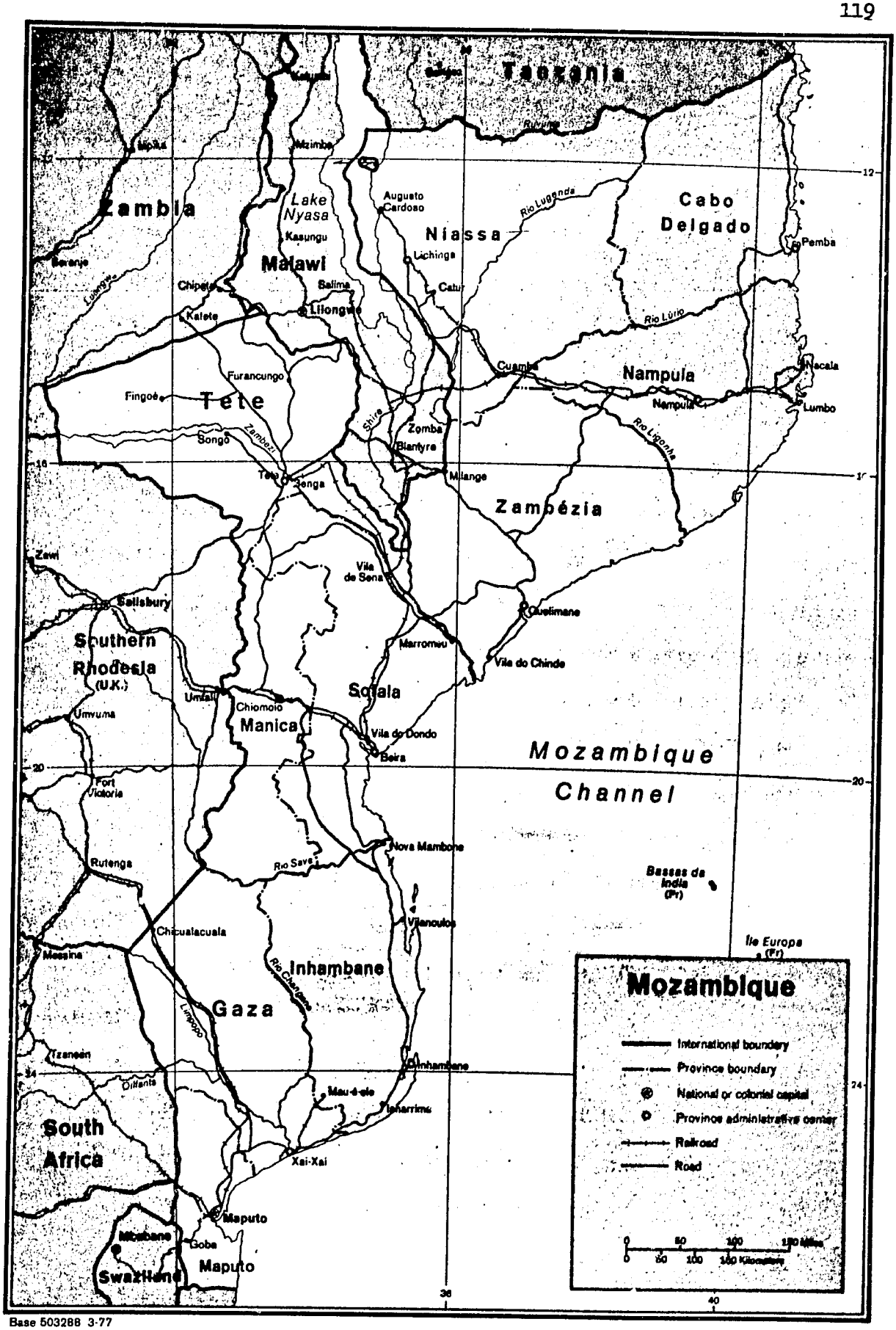
Republic of Malawi

[1]Stippled area on map.

[2]Malaria eradication/control program.

[3]MEP proposed but not initiated.

[4]Not an U.S./A.I.D. assisted country.



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MOZAMBIQUE

Geography and Climate[3]

Mozambique covers an area of 303,769 square miles, about twice that of California. Its 1,737 miles of coastline run from the northern extremity of the country, at the mouth of the Rovuma River, to the southern-most point at Ponta Ouro. It is bounded in the north by Tanzania for roughly 480 miles along the Rovuma River. Its most extensive border, 975 miles, is with Malawi, which penetrates the center of northern Mozambique: approximately 200 miles of that border run down the center of Lake Nyasa. There are 260 miles of frontier with Zambia in the northwest and 765 miles with Southern Rhodesia in the west, part of which is along the crest of the rugged Mashonaland Plateau. The southwestern and the short southern boundaries are with South Africa, about 305 miles long, not including the extreme southwestern border with Swaziland, which is 65 miles long.

The Zambezi Valley divides the country into northern and southern halves. 44 percent of Mozambique is littoral lowlands and marshes, mostly south of the Zambezi and especially south of the Save; 17 percent is low plateaus and hills roughly between 600 and 2,000 feet high; 26 percent is high plateaus and hills between 2,000 and 3,000 feet high; and 13 percent is mountains over 3,300 feet. The heaviest concentrations of population are along the littoral and its immediate hinterland, around the mouth of the Zambezi and near its confluence with the Shire, and in the Angonia Highlands.

Climate conditions are tropical. Characteristically each year has a wet and a dry season. About four-fifths or more of the total annual rainfall occurs during the wet season, lasting from October to April. Temperatures during this period are higher than average. The dry season, lasting from

April to September, is cooler than average, and little or no rain falls during this period. Fluctuations in rainall often result in droughts that bring about famines. There is no risk of frost, and lowland crops that need constant high temperatures and fairly abundant summer rainfall flourish.

The warm Mozambique current, flowing south from near the equator, raises temperatures and humidity along the coast. The temperature range at Pemba (formerly Porto Amelia) is 70.5 °F to 80 °F and at Beira, 70 °F to 82.5 °F. Rainfall is particularly heavy along the contral coast from Quelimane, which gets more than 48 inches annually, to Beira, which gets more than 56. North and south of this region the annual rainfall decreases. Along the southern coast it averages between 30 and 40 inches; the northern coast gets anywhere from 24 to 48 inches annually. Relative humidity follows the same pattern as rainfall along the coast, the highest year-round humidity being in the central coastal region. Beira has about 77 percent; Pemba has 81 percent. Humidity decreases to the north and south.

Inland there is considerable variation in the climate, largely because of differences in topography and the presence of such large natural features as Lake Nyasa. The northern region is within the zone of tropical monsoon climate. Temperatures are relatively high with little variation. The annual temperature range at Tete is from a mean maximum of 89 °F in the wet season to a mean maximum of 69 °F, which occurs in the dry season. Along the Southern Rhodesian frontier in northern Manica Province, rainfall in places exceeds 64 inches annually. A short distance to the north, in the Zambezi Valley of Tete Province, it drops to between 16 and 24 inches.

The southern region is in the subtropical anticyclonic zone. The annual temperature ranges from 80 °F to 65 °F at Maputo. It is on the whole

much drier, particularly in the Gaza region, which lies in the rain shadow of the Lebombo Mountains. Pafuri, on the western frontier of Gaza Province, has recorded a mean annual rainfall of about 12.8 inches. In some years no rain falls at all.

I. Country: Mozambique

II. Project

Population: 1,500,000

Type: Pilot malaria eradication program (proposed)

III. Endemicity: Hyperendemic (in 1956, 53% of deaths in Africans was due to malaria).

IV. Parasite

Primary: A. gambiae

Secondary: A. funestus

V. Insect Vector

Primary: P. falciparum (responsible for 90 percent of infections)

Others: P. vivax, P. malariae, P. ovale

VI Type of Intervention

Insecticide: DDT spraying

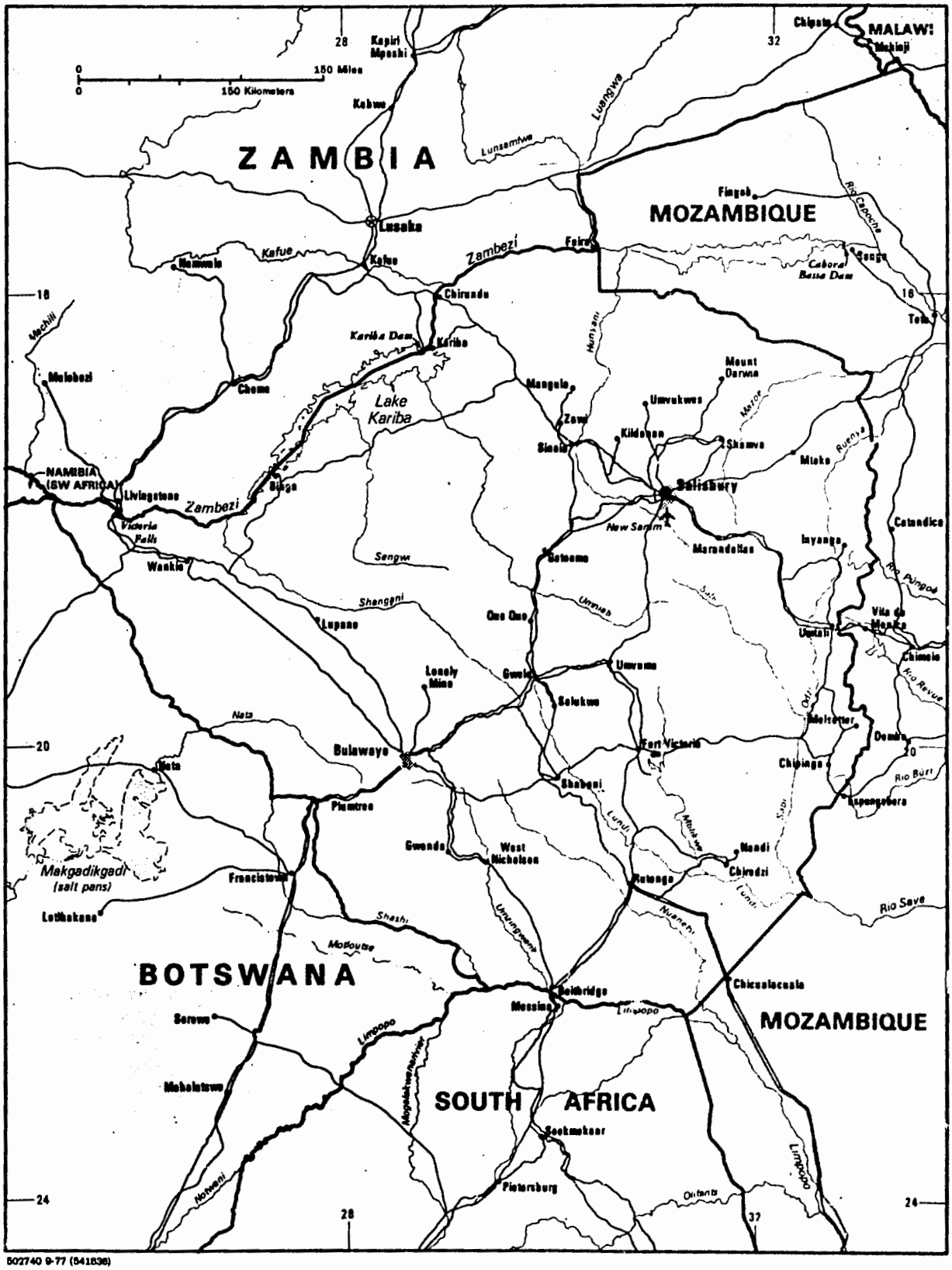
Chemotherapy: Anti-malarials to patients complaining of fever

VII. Evaluation

Potential problems for control measures were the movement of farming communities during the harvest season and the migration of laborers to Natal and Swaziland.

Source: Afro Malaria Year Book No. 1, WHO Regional Office for Africa. AFRO/MAL/5. September 1959.

Southern Rhodesia



502740 9-77 (541838)
Lambert Conformal Projection
Standard parallels 6° and 30°
Scale 1:5,550,000
Boundary representation is not necessarily authoritative

Railroad
Road
Airport

SOUTHERN RHODESIA

Geography and Climate[3]

Rhodesia, located within the tropics in southeastern Africa, has a land area of approximately 150,820 square miles. The geologic base is primarily a portion of the granite plateau that underlies most of the continent. The plateau rises in central Rhodesia to form an elevated savanna region, or highveld, from which the land slopes to three river basins: the Zambezi on the northern border, the Limpopo in the south, and the Sabi in the southeast.

Through most of its length the highveld is between 4,000 and 5,000 the territory's major river basins. On its northwestern and southeastern slopes, the highveld merges imperceptible into the medium altitude wooded grasslands (middleveld), generally defined as the area between 3,000 and 4,000 feet in elevation. In the southeast the lowveld, which is generally considered to include the land below 3,000 feet, extends from the nominal edge of the middleveld to the southery and southeastern borders, covering nearly one-fifth of the territory.

Throughout most of the highveld, daily maximum temperatures are between 80 °F and 90 °F for most of the year. Temperatures above 90 °F are recorded during September, October, and November (the early months of the warm season). By the end of November the earliest rains and associated partial cloud cover have a slight cooling effect. Temperatures are actually slightly lower during December, January, and February (the height of the southern summer) because these are also the wettest months of the rainy season. In the highveld accumulated daytime warmth dissipates quickly after sunset, and nights are cool. Nighttime frosts occur in July, which is the coolest month.

Annual rainfall in the upper levels of the veld ranges between 24 and 32 inches and may be higher in a small area near Salisbury. Although most rainstorms occur during a period of only three months, this is not a time of continuous cloud cover. Many of the rainstorms are brief, and rainy days are interspersed with periods of bright weather.

The eastern highlands have a cooler, wetter climate than that of the highveld. The area usually receives between 40 and 70 inches of rain per year.

The middle veld regions on both flanks of the central highveld are somewhat warmer and drier than the uplands. Annual rainfall averages 16 to 24 inches in the middle elevations on the southeastern side of the highveld and as much as 32 inches in the northwestern and northern sectors.

Rainfall declines to less than 16 inches per year in most lowveld areas. Beitbridge, on the southern border in the colony's most arid region, may in some years receive less than two inches of rain in January, its wettest month. Daytime temperatures in the lowveld in both the Limpopo and Zambezi river basins may exceed 100 ^{o}F. There is less nocturnal dissipation of surface warmth after nightfall than in upland regions and a somewhat higher average relative humidity, despite the scarcity of rainfall.

I. Country: Southern Rhodesia

II. Project

Location: 13 native reserves in 1951; 45 native reserves in 1956.

Population: 200,000 in 1951; 670,000 in 1956; 900,000 in 1959.

Time: 1949-1960.

Type: Malaria eradication program

III. Endemicity: Hyperendemic in Zambezi basin; seasonal on central plateau

IV. Parasite

Primary: P. falciparum (responsible for 95 percent of infections)

Secondary: P. vivax; P. malariae

V. Insect Vector

Primary: A. gambiae (exophilic and feeds on man and animals); A. funestus

Others: A. coustani; A. rufipes; A. pretoriensis; A. leesoni

VI. Type of Intervention

Insecticide: Annual spraying of BHC (40-80 mg/ft^2) or DLD (80.5 mg/ft^2)

Chemotherapy: Chloroquine and pyrimethamine given at the beginning and ending of the transmission season.

VII. Evaluation

The results varied as shown in the appended table. In July 1959 when spraying was resumed, malaria transmission was interrupted in the western section only (population 120,000). Some European farms and native reserves had an overall parasite rate of 13 percent. Although no more than 60 percent of the population received chemo-prophylatics, the parasite rate was reduced from 18 percent to 2 percent.

Reference: Afro Malaria Yearbook No. 1, WHO Regional Office for Africa. AFRO/MAL/5, Sept. 1959. Malaria Yearbook No. 2, WHO Regional Office for Africa. AFRO/MAL/7, Dec. 1960.

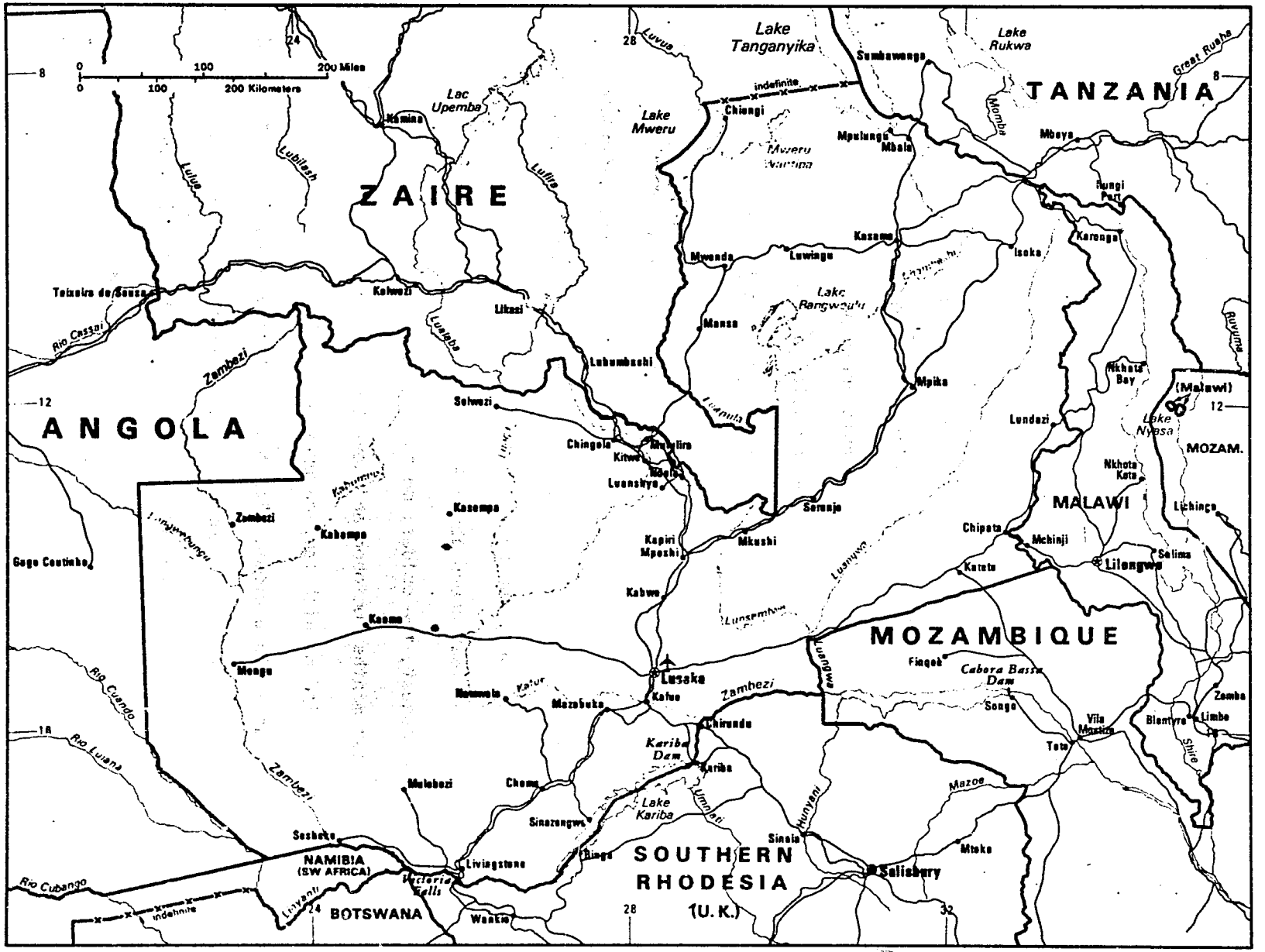
TABLE I

AREA	Population	0 - 12 mths			1 - 5 yrs			6 - 12 yrs		
		Nos. Ex.	Nos. Pos.	Par. Rate	Nos. Ex.	Nos. Pos.	Par. Rate	Nos. Ex.	Nos. Pos.	R
BUSHU Reserve (continuously sprayed since 1950)	4,000	121	12	9.9%	258	23	8.9%	136	23	(
MANGWENDI Reserve (No spraying since 1955)	45,000	87	1	1.1%	532	10	1.8%	-	-	
MADZIWA Reserve (continuously sprayed since 1950)	12,000	100	8	8 %	351	46	13.1%	60	7	11
UZUMBA Reserve Mazoe R. Section (two years spraying discontinued since 1955)	24,000	36	11	30.5%	134	71	53%	72	48	.6(
UZUMBA Reserve Central Section		79	6	7.6%	459	85	18.5%	156	33	21
SHAMVA Town Compounds & Vicinity (No spraying for several years)	1,000	33	3	10 %	100	21	21 %	17	3	17
SINOIA Location* (Sprayed for several years)		160	9	5.6%	190	5	2.6%	1	- 12 year	
SABIE Sprayed for 3 years	9,000	72	0	0 %	450	11	2.4%			
NDANGA ZAKA Res.** (Continuous spraying since 1954)	78,000	126	0	0 %	469	6	1,3%	110	0	

* This sample cannot be regarded as valid, in view of population fluctuations and lack of statistical experience of the Local Health Inspector
Survey not completed.

Ref: Afro Malaria Year Book No. 1. WHO Regional Office for Africa. AFRO/MAL/5, September 1959.

Zambia



502751 9-77 (541829)
Lambert Conformal Projection
Standard parallels 6° and 30°
Scale 1:7,500,000
Boundary representation is not necessarily authoritative

Railroad
Road
Airport

REPUBLIC OF ZAMBIA

Geography and Climate[3]

Zambia, formerly Northern Rhodesia, is in south-central Africa. It is bordered by Zaire (formerly Congo, Kinshasa), Tanzania, Malawi, Mozambique, Southern Rhodesia, Namibia (South West Africa), and Angola. The country measures over 800 miles in its longest east-west axis, and 700 miles north-south, covering approximately 290,000 square. miles. Most of it lies on a portion of high plateau extending from South Africa northeastward to the Red Sea. It consists of two major geographic areas partially separated by a salient called the Congo (Kinshasa) Pedicle, extending southeastward between the semiarid western region and the swampy Lake Bangweulu area located in the northeastern part of the country.

The sharply defined wet and dry seasons are salient features of a tropical savanna region tempered by altitude. There are three definable seasons: cool and dry, from May to August; hot and dry, from September to November; and warm and wet, during the rainy season from December to April.

In much of the plateau areas above 4,000-foot elevation, the mean temperatures for August, the coldest month, range between 26°F and 65°F; during the warmest months, October and November, they range between 85°F and 90°F. A second period of high temperatures occurs in April and May, when the rainy season draws to a close. For fully half the year, during the cool season from May to October or November, there is likely to be no rain anywhere in the country. During this season the weather is clear and the nights crisp. There are occasional frosts, and thin ice forms on quiet pools of the higher areas.

The southern areas are, in general, the areas of lower altitude, below 3,000 feet, and therefore have higher temperatures. Thus, areas in the Luangwa and Zambezi Valleys are warmer than the upland swamps and savannas between Lake Mweru and Lake Tanganyika, which are 9° nearer the Equator. Although the annual rainfall in these southern valleys is low, they are humid and disease ridden during the rainy months.

In the central highlands and in the Copperbelt rainfall ranges from approximately 25 inches on the plateau north of Livingstone to 50 inches or more near the Congo Pedicle. Westward from Livingstone into southern Barotse Province, rainfall shades downward from 25 inches annually and is less dependable. This is semidesert, sparsely populated and climatically related to the Kalahari Desert of Botswana and South-West Africa.

The northwest border area, from the Copperbelt westward to Angola, and most of northeastern Zambia, including Lake Bangweulu, receive about 50 inches of rain a year. Lusaka and the adjacent highlands occupy a transitional zone between the heat and drought of the south and the heavy rains of the north. Most of the central highlands and the Copperbelt area enjoy a fairly comfortable plateau climate.

I. Country: Zambia

II. Project

Location: Kabwe, Central Province

Type: Pilot malaria eradication program

III. Endemicity

IV. Parasite

Primary: P. falciparum (responsible for 90 percent of infection)

Secondary: P. ovale

V. Insect Vector

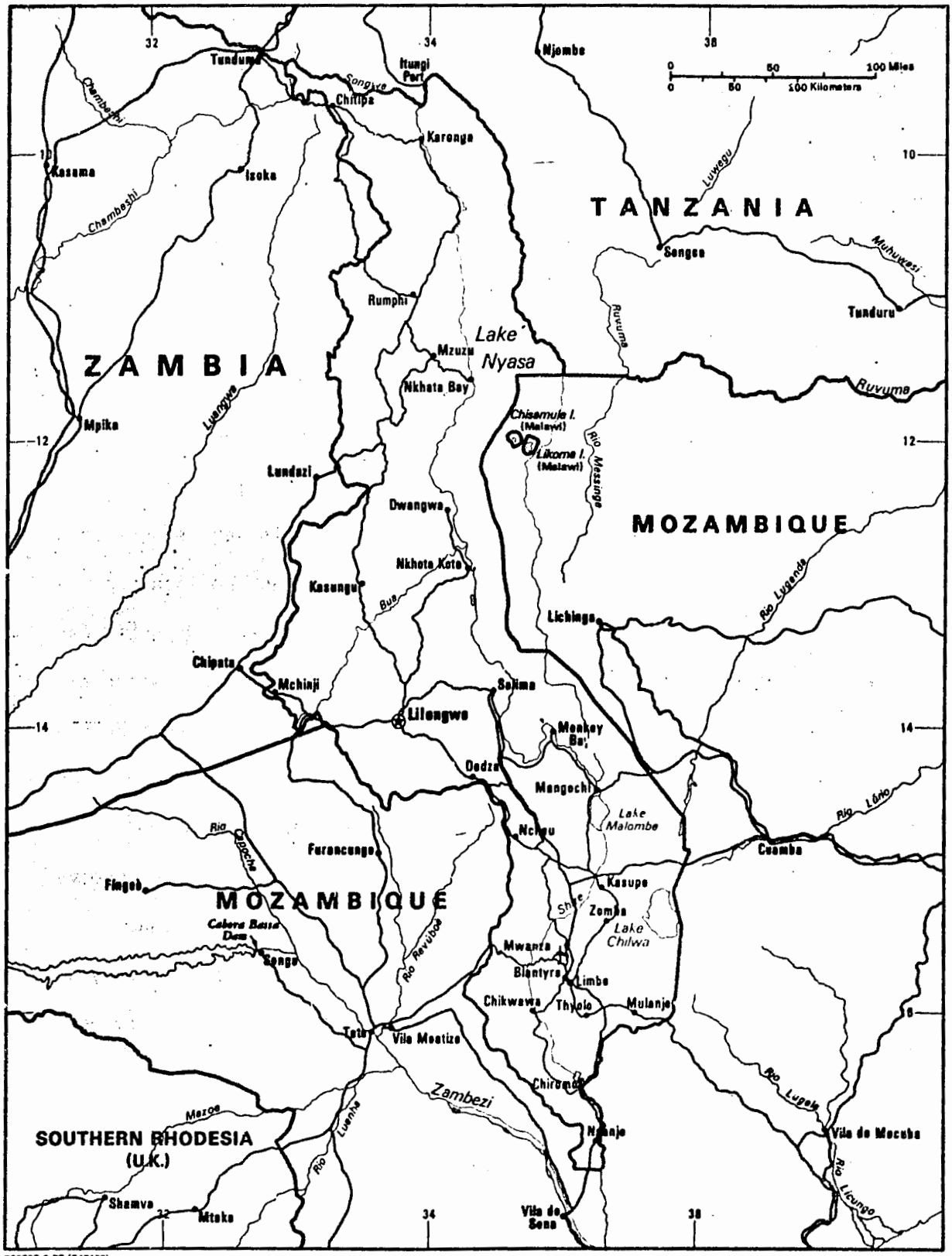
VI. Type of Intervention

Chemotherapy: Chloroquine was given biweekly between November and March and drug administration coincided with the malarial transmission season.

VII. Evaluation

Two groups with the appropriate controls were tested. In both experimental groups, the crude parasite rate was lowered by 40-50 percent compared with the controls. However, transmission was not interrupted.

Reference: WHO/MAL/75.845.



502727 9-77 (542163)
Lambert Conformal Projection
Standard parallels 6° and 30°
Scale 1:4,400,000

Railroad
Road
Airport

REPUBLIC OF MALAWI

Geography and Climate[3]

Malawi, an inland nation in southeastern Africa, is well within the southern tropics. Its territory extends north-south for 560 miles at an average width of less than 100 miles in a southern segment of the East African Rift Valley. Within its borders are about 36,325 sq. miles of land, plus 9,425 square miles of water area, mostly in Lake Malawi and two smaller lakes.

The prevailing climate ranges from warm to hot, and there are distinct annual wet and dry seasons. Malawi's warm season, which includes the wet season, extends from September or October to March or April. The rest of the year is slightly cooler and much drier. Rainfall is very sparse from May through September, when most areas receive less than one inch per month.

About 90 percent of the country receives between 30 and 60 inches of rainfall per year. Five percent of the country, mostly in the lower elevations of the Shire Valley and in the Rumphi area of the Northern Province, records 20 to 30 inches. The remaining 5% also includes two widely separated regions - the Mulanje and other highlands, in the southeast and long segments of the lake plains, in the Northern Region. These areas receive 60 to 100 inches of rain per year, well above the national average.

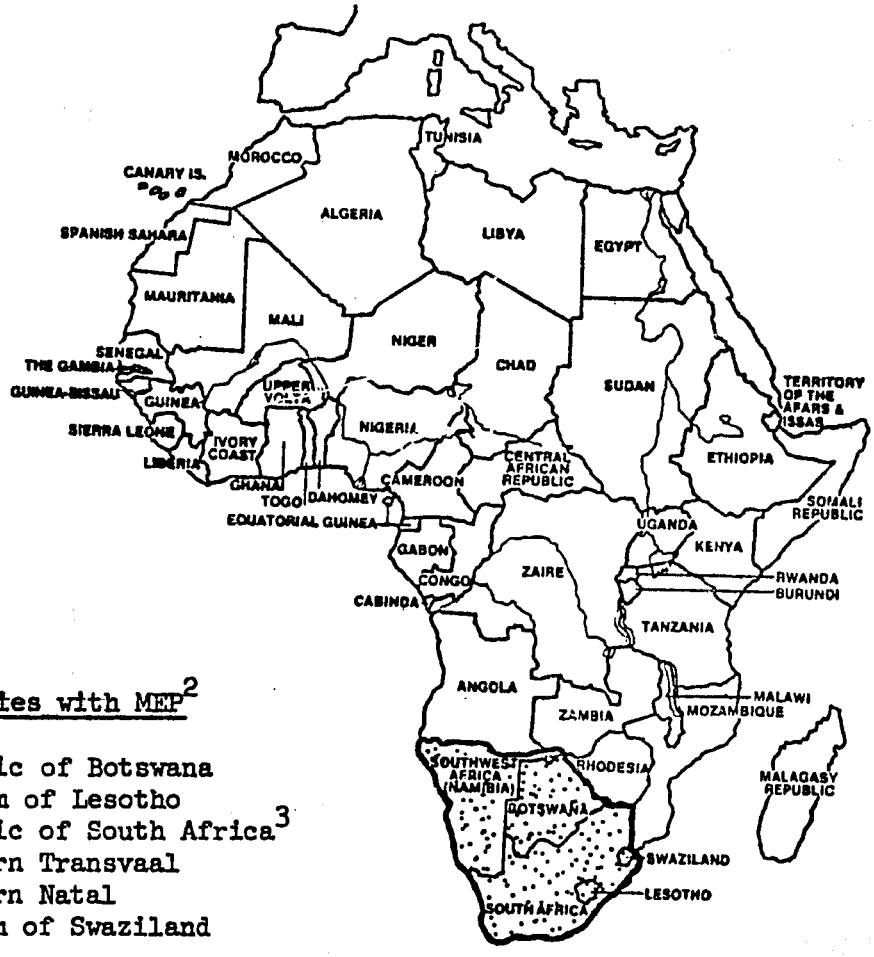
Low altitude areas such as the lower Shire Valley are usually very hot and humid during the rainy season. The relative humidity is usually between 50 and 80 percent in most of the country, even during the dry season. Temperature decreases as altitude increases and is usually bearable on the midlevel elevations, such as the plateaus and highlands around Lilongwe and Zomba, or at higher altitudes. The monthly average temperature at

Lilongwe, for example, is about 58°F in July, the coolest month, and about 74°F in November, the warmest month. Mean maximum temperatures at this altitude (approximately 3,400 feet) are from 80°F to 90°F, in November and 40°F to 50°F, in July.

Areas 4,000 to 4,500 feet above sea level usually have a relatively comfortable mean maximum of about 75°F and an absolute maximum of about 92°F. Night frosts occur during July in areas above the 8,000-foot level on the Nyika Plateau and the upper levels of the Mulanje Mountains.

The Mulanje Mountains' upper level is no more than 75 miles from the locale of Malawi's opposite extreme in temperature, the Nsanje area in the lower Shire Valley, only 200 feet above sea level. Nighttime temperatures remain uncomfortably high at this low altitude, and frosts are unknown. A high mean maximum, about 89°F, prevails in the riverine area, and an absolute maximum above 100°F is often recorded during October and November.

E. Southern Africa[1]



Countries with MEP[2]

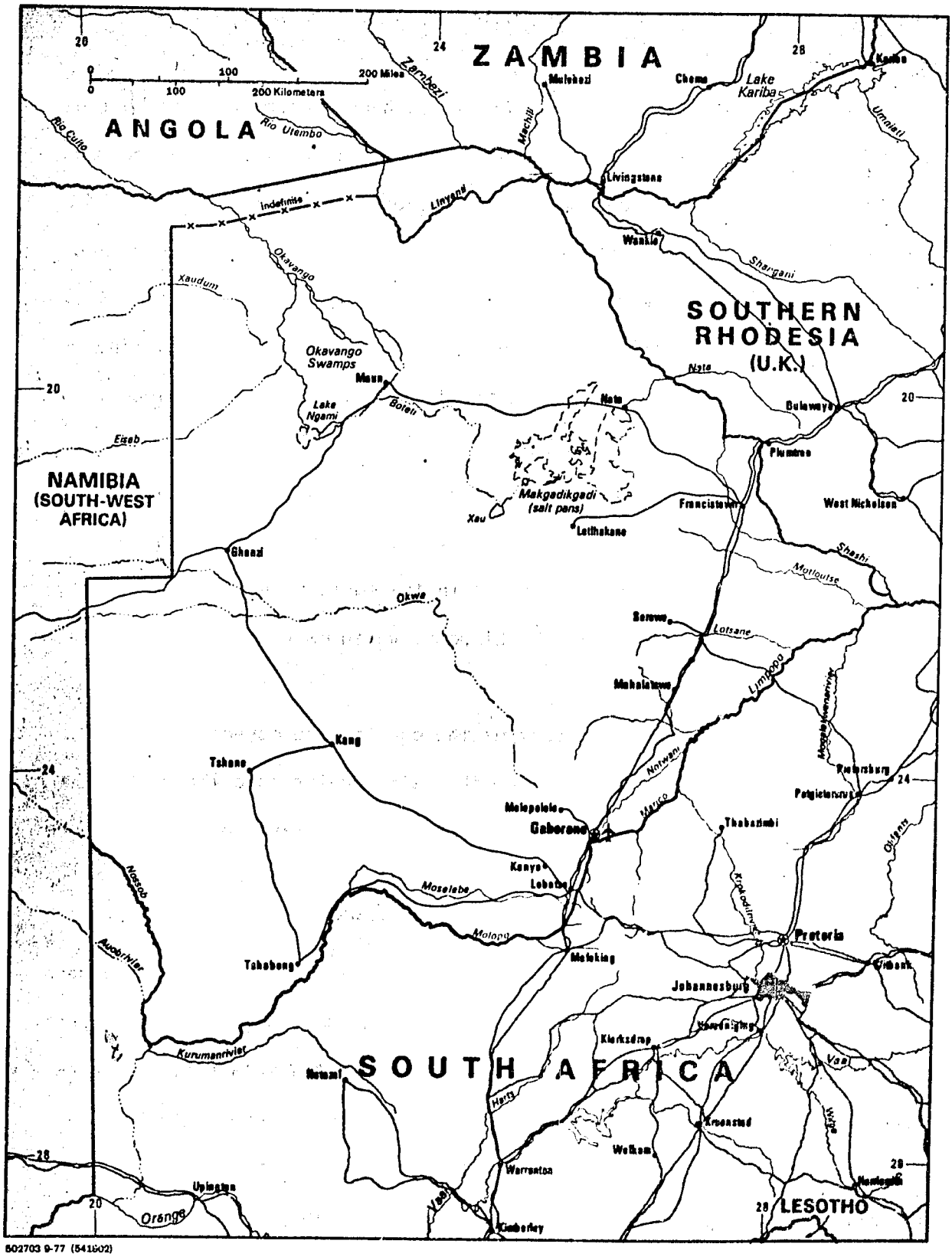
Republic of Botswana
Kingdom of Lesotho
Republic of South Africa[3]
Northern Transvaal
Northern Natal
Kingdom of Swaziland

[1]Stippled area on map.

[2]Malaria eradication/control program.

[3]Not an U.S./A.I.D. assisted country.

Botswana



502703 9-77 (541602)
Lambert Conformal Projection
Standard parallels 6° and 30°
Scale 1:6,500,000
Boundary representation is not necessarily authoritative

REPUBLIC OF BOTSWANA

Geography and Climate[2]

Botswana is situated in the center of southern Africa, bounded by the Republic of South Africa to the south, Southwest Africa (Namibia) and the Caprivi Strip to the west and north, and Rhodesia to the east. There is a direct link with Zambia at a point on the Zambezi River. The country has an area of 220,000 square miles, comparable in size to the State of Texas. Climatically and geographically Botswana is also similar to Texas. The area, a vast tableland with a mean altitude of 3,300 feet, is divided into three regions.

Eighty percent of the population lives in the east, where soil and rainfall are suitable for dryland farming. Here rainfall averages 19.7 inches in the southeast and 11.8 inches in the eastern central district. Rivers in this region flow into the Limpopo, which marks the border with South Africa.

The northwest and northern part of the country are covered by the Okavango River Delta. The water from the delta drains into the center of the country and the Makarikari Salt Pan, and into Lake Ngami. The Chobe River in the north marks the border between Botswana and Caprivi, and flows into the Zambezi above Victoria Falls.

The Kalahari (Kgalagadi) Desert covers much of the central and southern region of the country. This desert is a rolling sandy area covered in part with grass and bush. There is no surface water in the Kalahari, and rainfall averages less than 9 inches. Underground water is available from boreholes in the grazing areas on the edges of the desert.

The climate is tropical in the north and temperate in the rest of the

country. Temperatures vary from a mean of 56°F-87°F in January, the hottest month, to a mean of 41°F-74°F in July. Ground frosts occur during the winter months, but the days are warm. Temperatures reach 100°F in summer, but lack of humidity lessens the discomfort of the heat. Rains occur between October and April.

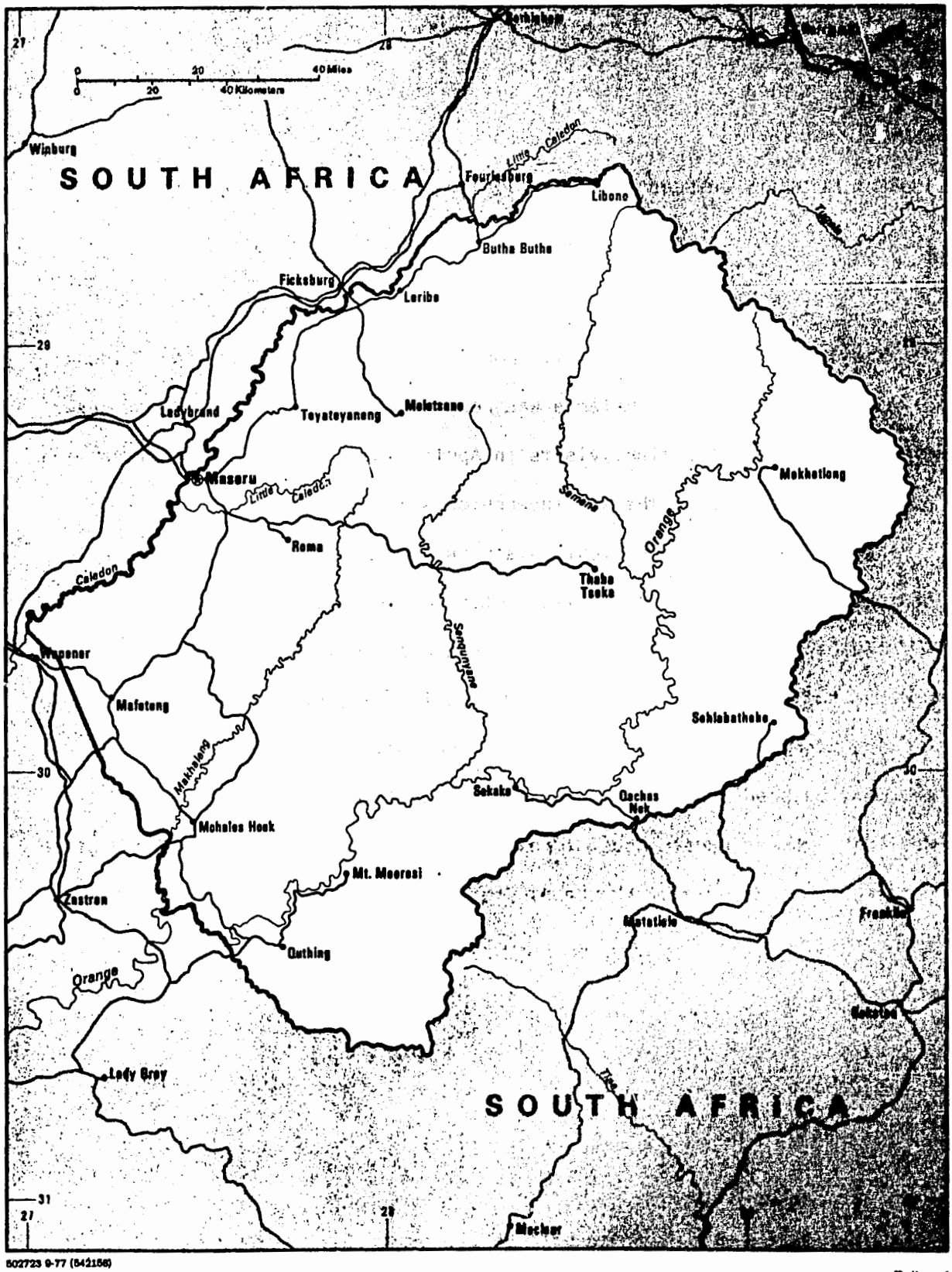
The Malaria Situation in Botswana[2]

The dry climate in the heavily populated areas restricts the incidence of malaria in Botswana. Malaria was responsible for 3.5 percent (52 cases) of the reported out-patient visits in April, 1979. (The leading cause of hospitalization and deaths was tuberculosis.)

Health services are unevenly distributed between the urban and rural communities. Existing facilities consist of 14 hospitals, 8 health centers, 37 clinics and 160 health posts. There are 52 medical doctors in Botswana and the ratio of physicians to population is 1/12,500.

The migration patterns in Botswana are varied. There is a seasonal movement between tribal villages, agricultural land and cattle posts as well as internal rural-urban migration. Laborors show a seasonal migration pattern to areas outside the country.

Lesotho



502723 9-77 (542156)
Lambert Conformal Projection
Standard parallels 6° and 30°
Scale 1:1,500,000

—— Railroad
—— Road

KINGDOM OF LESOTHO

Geography and Climate[2]

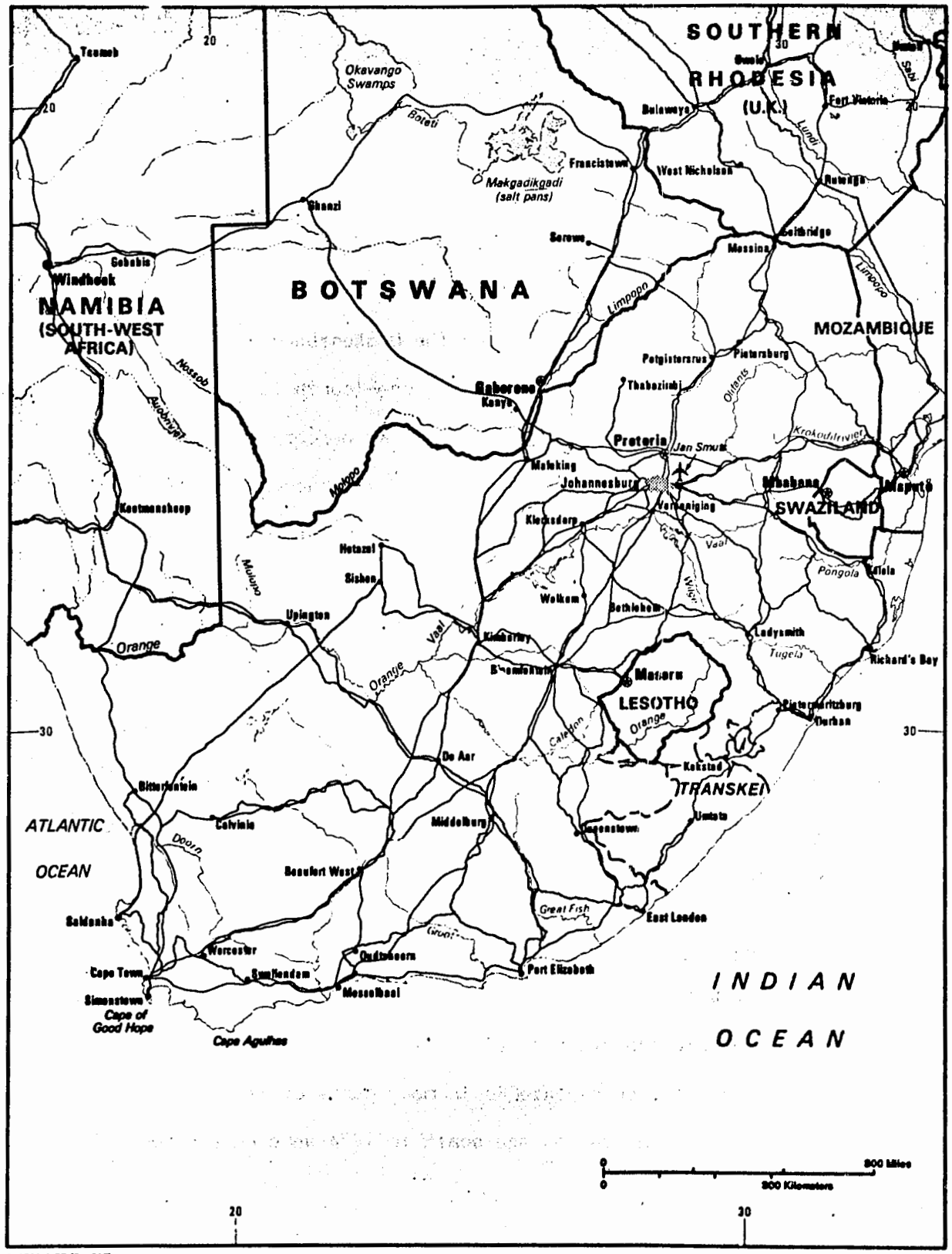
The country of Lesotho is roughly the size of the State of Maryland, covering 11,716 square miles. The country is largely mountainous and is completely surrounded by the Republic of South Africa. Its boundaries were determined politically and militarily without regard to its potential viability as an independent political entity. Three-fourths of the country is covered by foothills and mountains of the Drakensberg Range, rising to 11,000 feet above sea level. The remaining one-fourth is lowland, 5,000-6,000 feet in altitude. The lowlands support about 50 percent of the population and produce most of the agricultural crops. Mixed farming is practiced in the foothills, which cover 16 percent of the total land area and support some 30 percent of the population. The remaining 20 percent of the population is largely engaged in herding in the mountains, which extend over 57 percent of the nation's land.

The climate is temperate, varying from 20°F to 90°F in the lowlands. In the mountains, the winter temperature reaches below zero. Rainfall averages 28 inches per year in most of the country, and most of the rain falls between October and April.

The Malaria Situation in Lesotho[2]

The high altitude and a temperate climate are largely responsible for the absence of malaria and other tropical diseases (schistosomiasis, trypanosomiasis, and onchocerciasis) endemic in many parts of Africa. The most frequent cause of hospitalization and death in 1974 were respiratory diseases.

South Africa



502739 9-77 (541837)
Lambert Conformal Projection
Standard parallels 6° and 30°
Scale 1:10,100,000

Railroad
Road
Airport

REPUBLIC OF SOUTH AFRICA

Geography and Climate

The Republic of South Africa is the southernmost country of continental Africa. Its western limits are formed by the coastline of the Atlantic Ocean and its southern and eastern extremities by the Indian Ocean. It shares inland frontiers with South West Africa (Namibia) in the northwest, Botswana and Rhodesia in the north, and Mozambique and Swaziland in the northeast. South Africa's territorial landmass completely surrounds the small independent state of Lesotho. The country's four provinces are Transvaal, Cape Province, Natal, and the Orange Free State. Covering an area of 472,500 square miles, the country measures nearly 1,000 miles in its longest east-west axis and over 700 miles from north to south.

The major topographical features are a broad and lofty interior plateau, a steep semicircular escarpment that surrounds the plateau, and a narrow belt of coastal lowlands on the west, south, and east. The country ranges from temperate and subtropical farmland, grassland plains, and verdant valleys to craggy mountain peaks, semiarid scrubland, and sparsely inhabited desert. Approximately 70 percent of the land consists of mountains and semidesert, and no more than 15 percent of the country is cultivable.

The country has a variety of climatic conditions, largely because of topographical diversities and the effect of the ocean currents. The southwestern cape area enjoys a Mediterranean climate; the interior is semiarid; and subtropical conditions exist in northeastern Transvaal and eastern Natal. The annual average rainfall for the whole country is about 17.5 inches. It is unevenly distributed both seasonally and geographically, and about two-thirds of the country receives less than 15 inches a year. Drought conditions occur frequently in many regions.

I. Country: South Africa

II. Project

Location: Northern Transvaal

Type: Malaria eradication program

III. Endemicity

IV. Parasite

Primary: P. falciparum (greater than 95 percent of infections)

V. Insect Vector

Primary: A. funestus, A. gambiae

VI. Type of Intervention

Insecticide: DDT - residual spraying and larviciding.

Chemotherapy: Antimalarials used to combat epidemics

Engineering: Built dwellings away from breeding places; drainage.

Other - Inhabitants sleep indoors.

VII. Evaluation

The attack phase of the malaria eradication program started in 1940. The incidence of malaria is down to 0.5 percent. The behavior of A. gambiae has changed from anthrophilic to zoophilic and feeds outdoors as well as indoors.

The low rate of transmission may have been contributed to: 1) a small population of A. gambiae resistant to DDT or 2) a variant of A. funestus resembling A. aruni Sobti which is abundant in the area, is anthrophilic and is found mostly out of doors four hours following dusk.

Reference: South African Med. J. 48:1265-1269. 1974. Bull WHO 55:95-103. 1977.

I. Country: Union of South Africa

II. Project

Location: Northern Transvaal

Population: 500,000

Time: 1959

Type: WHO assessment of malaria eradication program

III. Endemicity: Low (small foci of endemicity)

IV. Parasite

Primary: P. falciparum

Other: P. malariae

V. Insect Vector

Primary: A. gambiae (zoophilic)

VI. Type of Intervention: Larviciding and residual spraying.

VII. Evaluation

The indigenous parasite rate in infants had been reduced to 0.9 percent. The WHO team suggested the use of DDT instead of BHC and to continue residual spraying in areas where the parasite rates were evident. The migrant laborers presented a small problem since they were carriers of the malaria parasite.

Reference: Malaria Year Book No. 2. WHO Regional Office for Africa. AFRO/MAL/7. December 1960.

I. Country: Union of South Africa

II. Project

Location: Northern Natal

Zone 1 - Transmission	- Population:	100,000
Zone 2 - Consolidation	- Population:	75,000
Zone 3 - Vigilance		

Time: 1959

Type: WHO assessment of malaria eradication program

III. Endemicity

IV. Parasite

V. Insect Vector

Primary: A. gambiae (exophilic behavior suspected); A. funestus

VI. Type of Intervention

Residual spraying with DDT; Zone 1 - sprayed twice yearly during transmission season; Zone 2 - sprayed once yearly; Zone 3 - spraying discontinued.

VII. Evaluation

WHO team proposed the following: Zone 1 - two sprayings annually for three cycles; Zone 2 - spraying only to prevent foci of transmission from developing; Zone 3 - free of malaria.

Source: Malaria Year Book No. 2. Who Regional Office for Africa. AFRO/MAL/7. December 1960.

I. Country: South Africa (Northern Transvaal

II. Project

Location: Makonde, Komatipoort, Tshimbupte Mhinga and Mutale areas

Time: April 1979

III. Endemicity

IV. Parasite

V. Insect Vectors: A. marshalli normal form, A. aruni, A. pretoriensis, A. marshalli pale form, A. funestus group, A. gambiae complex, A. rufipes

VI. Type of Intervention

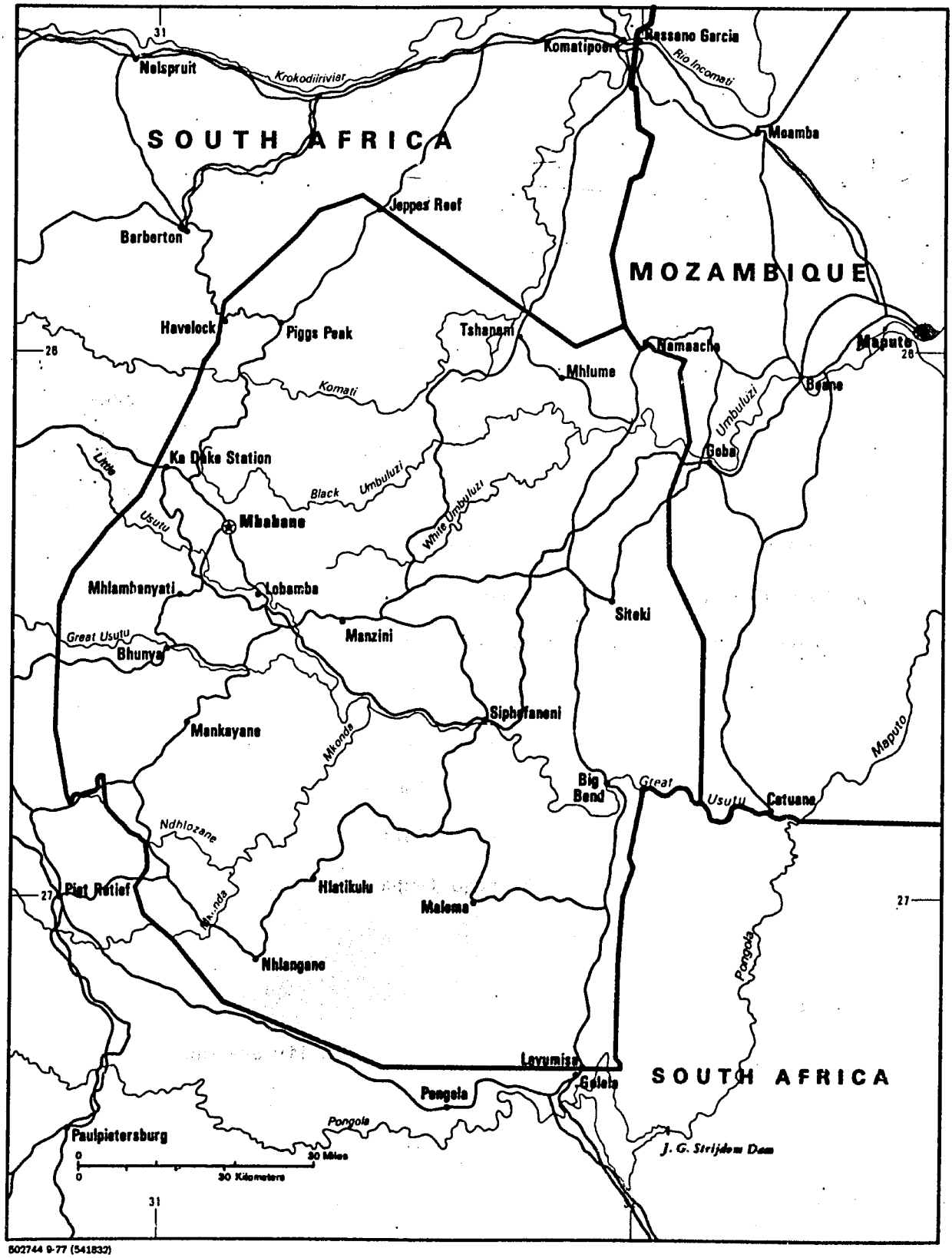
Insecticide: DDT

VII. This was a monthly report of an ongoing malaria project in the Northern Transvaal, South Africa, which summarized the entomology, serology and parasitology data collected in the four areas. In DDT treated houses, no anophelines were found in pyrethrum spray catches. Only in the Makonde and Komatipoort study areas were anophelines caught biting humans between 6:00 p.m. and 9:00 p.m.

During a four week period 151 cases of malaria were reported, of which 30 were active cases. Only four-tenths percent of the 33,839 blood smears examined were positive for Plasmodium.

Reference: Joint WHO/South African Operational Research Project on Malaria in South Africa. April 1979.

Swaziland



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Lambert Conformal Projection
Standard parallels 6° and 30°
Scale 1:1,150,000

—— Railroad
—— Road

KINGDOM OF SWAZILAND

Geography and Climate[2]

Swaziland is a small landlocked country surrounded on three sides by the Republic of South Africa and sharing a 70-mile border with Mozambique. The area of the country is 6,705 square miles. It is roughly the size of the State of New Jersey.

The land is divided geographically into four distinct parallel north/south regions. The westernmost region is mountainous highveld (900-1,800 meters above sea level). Here the climate is temperate and rainfall adequate to support pine forests, diversified agriculture, dairy farming, and sheep grazing (with 49.5 inches mean annual rainfall). The middleveld (300-1,000 meters) is subtropical and drier, with 36.7 inches of rainfall, and supports cattle grazing and irrigated farming of corn, cotton, citrus, pineapple, rice, and tobacco. The lowveld (60-700 meters) is a subtropical and semi-arid savanna with 25.7 inches of rainfall. Crops grown in this region include sugarcane, rice, citrus, and cotton, with irrigation. The eastern region, the Lubombo Plateau, is similar in altitude to the middle veld and averages 30.7 inches of rainfall. Cattle ranching and some mixed farming is practiced in this area. Average temperatures vary from 60°F in the highveld to 72°F in the lowveld.

The Malaria Situation in Swaziland[2]

Although the major causes of morbidity and mortality are gastroentestinal and respiratory track infection, malaria is potentially a problem. A malaria eradication program started in 1945 was successful in reducing the known cases from 6,850 to about 300 indigenous cases in 1971. Even with this

small percentage of cases (0.7 percent), the government considers malaria a major health problem. With an estimated 18 percent of the labor force being migratory and the annual rainy season, constant vigilance is necessary.

Health services are available in urban areas and almost nonexistent in rural areas. As of 1974, there were 53 doctors (overall physician to population ratio of 1/9,000). The country has 11 hospitals and 57 clinics.

I. Country: Swaziland

II. Project

Population: 237,041

Time: 1959-60

Type: WHO assessment of malaria eradication program

III. Endemicity: Overall parasite rate was 0.13 percent including imported cases.

IV. Parasite

V. Insect Vector

Primary: A. gambiae (exophilic, exophagic and zoophilic); A. coustani (anthropophilic and zoophilic)

VI. Type of Intervention

VII. Evaluation

Areas were sprayed from 1951 to 1956 and spraying was discontinued two years after no cases of malaria were found. People living near the irrigation schemes as well as migrant workers receive pyrimethamine every two weeks during the transmission season. The territory was under active surveillance as of 1959.

Source: Malaria Year Book No. 2. WHO Regional Office for Africa. AFRO/MAL/7, December 1960.

F. Eastern Africa[1]

Countries with MEP[2]

Empire of Ethiopia
Republic of Kenya
Somalia Democratic Republic
Republic of Tanzania
Uganda

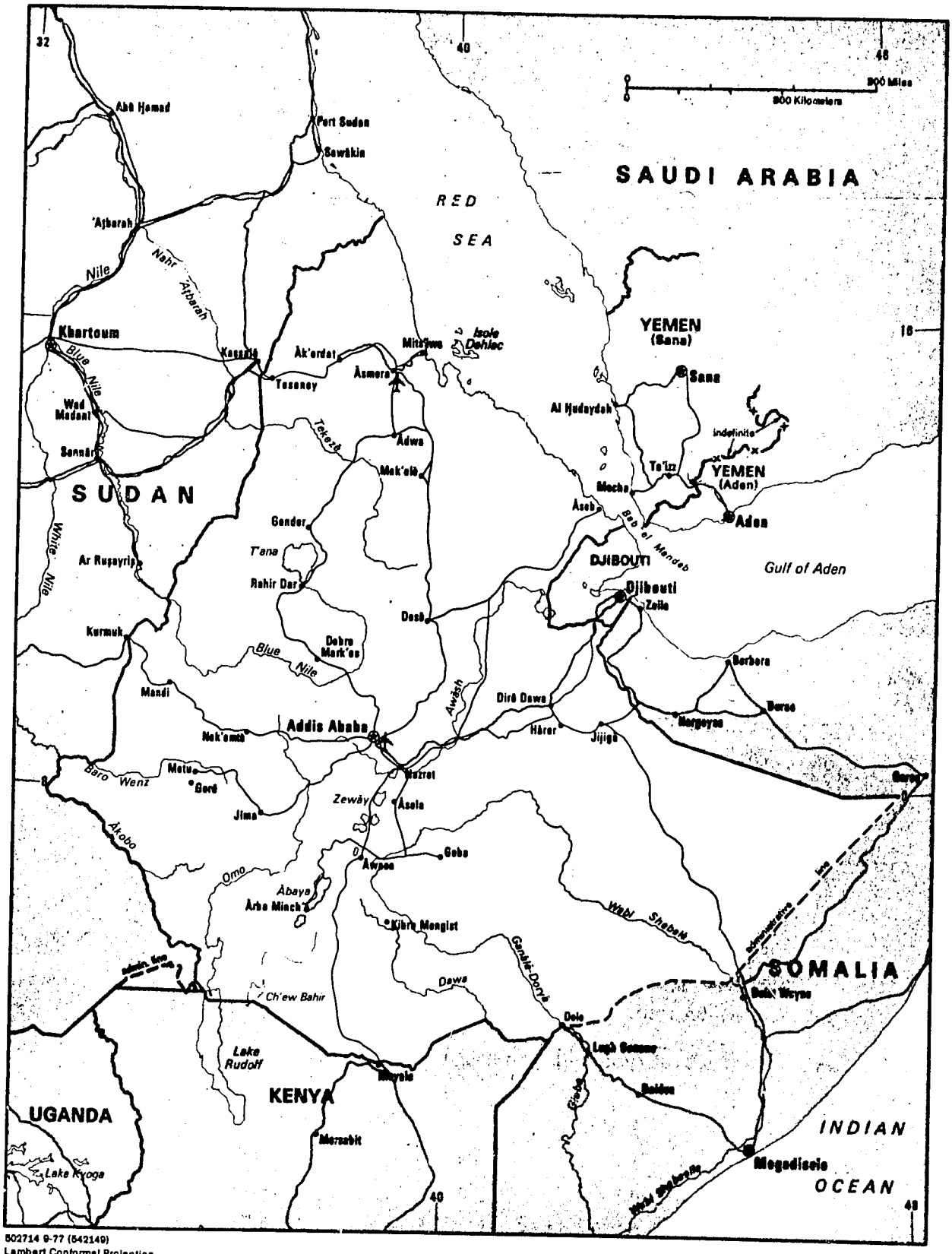
Countries without MEP[2]

Republic of Burundi
Republic of Djibouti
Republic of Rwanda

[1]Stippled area on map.

[2]Malaria eradication/control program.

Ethiopia



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Lambert Conformal Projection
Standard parallels 6° and 32°
Scale 1:10,700,000
Boundary representation is not necessarily authoritative

Railroad
Road
Airport

EMPIRE OF ETHIOPIA

Geography and Climate[2]

Ethiopia is located in the northeast part of Africa with the Sudan on the west and northwest, the Red Sea on the north, Somalia and the French Territory of Afars and Issas on the east and southeast, and Kenya on the south. Its size is approximately 472,000 square miles.

Topography is rugged. Two-thirds is mountainous plateau, with elevations of 5-10,000 feet above sea level, divided into two parts by a volcanic cleft called the Great Rift Valley. The terrain is not as rugged in the south and southeast, from the Somalian to the Kenyan borders, where the greatest portion of coffee is grown.

Rainfall and temperature patterns are diverse. There are three distinct temperature zones: (1) Hot zone (kolla): altitudes less than 6,000 feet, average annual temperature between 80°F-100°F, less than 20 inches of rain per year, located mainly in the Awash Valley and Somali Plateau; (2) Temperate zone (Woina Dega): elevations between 6-8,000 feet, average annual temperature about 72°F, annual rainfall varying from 20-60 inches, most densely populated and agriculturally productive, located in Central Highlands; (3) Cool zone (Dega): generally above 8,000 feet, annual average temperature about 61°F, with about 50-70 inches of rainfall. There are two seasons: wet (June to September) and predominantly dry the remainder of the year. Within the past two years, limited rainfall, especially in the northern provinces of Tigre and Wollo, has caused a drought of undetermined consequence.

I. Country: Ethiopia

II. Project Location: Ethiopia

Time: 1958 to present

Type: Malaria eradication program

III. Endemicity: Lowlands - hyperendemic; highlands - seasonal endemics. The parasite rate was found to be a function of elevation: under 5,000 feet - 8.8 percent; 1,600 - 1,799 meters, 4.4 percent; 1,800 - 1,999 meters, 2.6 percent; above 2,000 meters, 0.9 percent.

IV. Parasite

Primary: P. falciparum (responsible for 85 percent of infections)

Secondary: P. vivax

Others: P. malariae, mixed infections[2,3]

V. Insect Vector

Primary: A. gambiae

Secondary: A. funestus

Others: Possibly A. pharoensis; A. adenesis; A. coustani; A. nili

VI. Type of Intervention

Insecticide: DDT (2 g/m^2) twice annually.

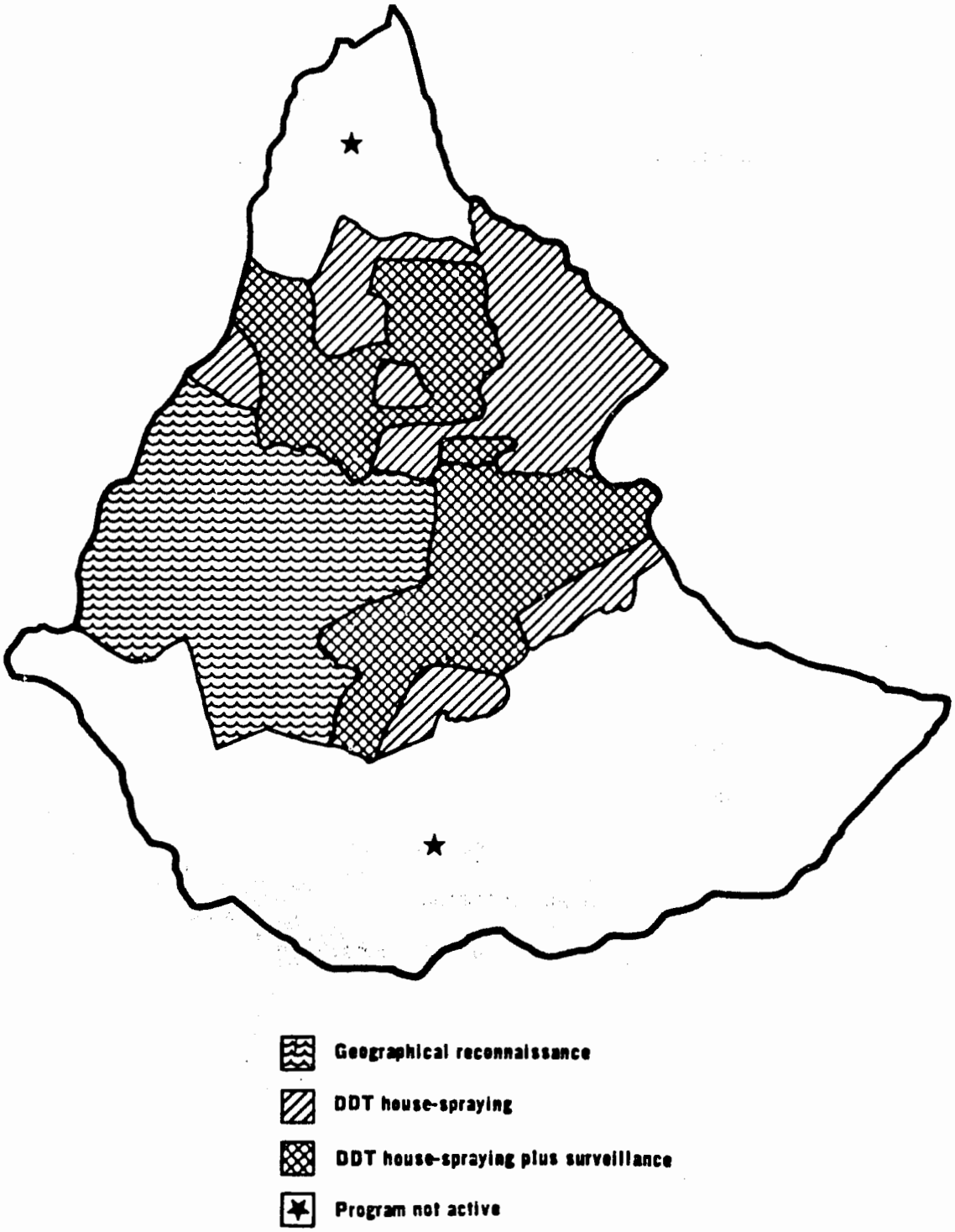
Drug prophylaxis: Chloroquine to suspected cases.

VII. Evaluation

For the purposes of malaria control, the country was divided into four areas (A, B, C, D), based on their ecologic similarities (Fig. 1). The initial spraying took place in area A which was subdivided into six zones and 36 sectors.

Approximately 575,000 in one zone was at risk before spraying began in 1957[4]. By 1964, three-fourths of the population in the area was protected

FIGURE 1
MAJOR MALARIA ERADICATION PROGRAM ACTIVITIES
ETHIOPIA, 1969



Reference: Malaria Program 1970 Annual Report. Center for Disease Control, Public Health Service, Atlanta, Geogria.

The pre-spraying overall parasite rate was 12.3 percent in October 1956 and after spraying was reduced to 0.44 percent by September 1959. Similar results were also observed in sprayed and unsprayed areas of other sectors (Table 1).

Despite effective control in some areas, the parasite rate in some sectors began to increase in the fall of 1965[5]. In one sector the parasite rate was 0.5 percent in April 1964 and had increased to 10-16% between September 1964 and March 1965. Similar increases were noted in three other sectors. In 1969, due to personnel, administrative and financial problems, surveillance activities were not possible and rephasing of the program was recommended.[6] It was suggested that: 1) the malaria eradication activities be changed to control activities, 2) spraying be continued in areas A and B and 3) activities in area C be postponed.[7]

Some of the reasons given for an unsuccessful malaria eradication program even though the government fully supported the project were:

1. Lack of adequate financial support.
2. Lack of co-ordination between technical advisors.
3. Insufficient number of trained personnel.
4. Unavailability of transportation.
5. Local customs of sleeping out of doors.

References:

1. Chen, S.F., O'connor, C.T., and Pletsch, D.J., Report of field visit to Adi Ugri Sector, Asmara Zone, April 6-9, 1965.

2. Jolivet, P.H.A., Observations on the Ethiopian Anopheles mosquito and their susceptibility to insecticides. (Report in AID files).

3. WHO/MAL/66.554.

4. Pletsch, D.J., Report on trip to Gonder, Azezo, Addis Zemen, Bakar Dar. December 27-31, 1964.

TABLE 1

PARASITOLOGICAL DATA

1963

Sector or Station	SPRAYED AREAS			UNSPRAYED AREAS		
	No. Smears	No. Positives	%	No. Smears	No. Positives	%
Addis Zemen	9,860	26	0.26	457	11	2.41
Alamata	7,131	82	1.15	140	2	1.43
Awash	944	74	7.84	130	11	7.91
Azezo	20.275	10	0.0.5	2,304	0	0
Bahar Dar	6,434	18	0.28	—	—	—
Combolcha	13,736	77	0.69	2,174	12	0.55
Debre Zeit	11,067	51	0.37	48	0	0
Delghi	8,001	12	0.15	216	3	1.39
Gambella	4,359	362	8.30	556	138	24.22
Jimma	818	6	0.73	592	1	0.17
Massawa	6,097	89	1.46	2,337	142	6.08
Nazareth	17,734	279	1.57	333	61	18.32
Robi	7,808	52	0.66	5,827	29	0.50
Woldia	—	—	—	—	—	—
Adamitulu	1,081	21	1.94	6,996	380	5.43
Adi-Ugri	—	—	—	22,247	1,227	5.51
Adua	—	—	—	8,302	380	4.58
Agordat	302	6	1.98	6,128	130	2.12
Arba Minch	—	—	—	—	—	—
Awassa	92	14	15.22	5,973	580	9.71
Barentu	—	—	—	6,372	412	6.46
Bedessa	—	—	—	3,940	212	5.38
Dangila	—	—	—	2,894	84	2.90
Dire Dawa	—	—	—	1,142	99	8.67
Deder	—	—	—	3,438	10	0.29
Endasetassie	—	—	—	4,866	218	4.48
Eritrea	—	—	—	334	3	0.90
Gojjam	—	—	—	2,205	9	0.41
Harar	—	—	—	6,603	1	0.02
Maji	—	—	—	—	—	—
Mekalle	—	—	—	6,961	230	3.30
Mieso	—	—	—	621	7	1.13
Muger (Mulo)	—	—	—	—	—	—
Nekemte (east)	—	—	—	1,337	17	1.27
Temben	—	—	—	4,534	425	9.37
Tesseney	—	—	—	6,614	209	3.16
Total	175,739	1,179	0.67	116,630	5,043	4.32

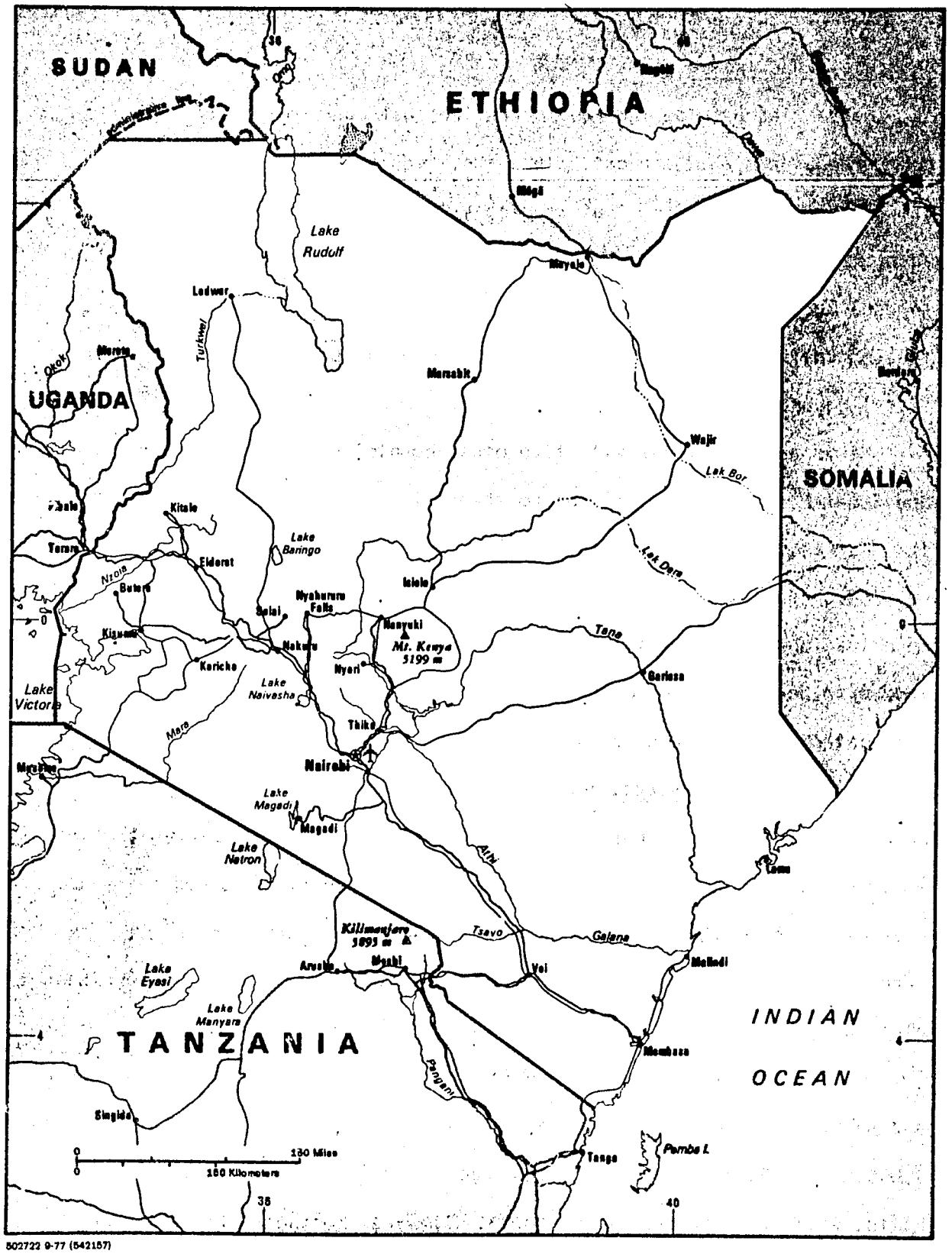
Total No. Smears — 231,477
Ttotal No. positives — 6,221

Ref: Malaria Eradication Service Bulletin 25 —
Vol. 3. Min. of Health, Ethiopia. April-June, 1964.

5. Pietsch, D.J., Summary Report - Trip to Dese Zone concerning reported malaria epidemic. October 18-22, 1965.

6. Report of an Indepentent Malaria Review Team in Ethiopia. May 24 - June 2, 1972.

7. Malaria Program. 1970 Annual Report. Center for Disease Control. U.S. Department of health, Education, and Welfare. Public Health Service, Health Services and Mental Health Administration, Atlanta, Georgia.



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Mercator Projection
Scale 1:6,030,000
Boundary representation is not necessarily authoritative

Railroad
Road
Airport

REPUBLIC OF KENYA

Geography and Climate[3]

Kenya lies astride the equator on the east coast of Africa with its northernmost and southernmost points about equidistant - somewhat over 4° north and south - from that imaginary line. The total area of 224,960 square miles includes almost 5,200 square miles of water, contained mainly in Lake Rudolf, known in Kenya as Lake Turkana (2,473 square miles), and the ocuntry's portion of Lake Victoria, known in Kenya as Victoria Nyanza (1,461 square miles).

Kenya has boundaries with five other countries: to the east and north are Somalia and Ethiopia; on the northwest lies Sudan; Uganda is directly to the west and Tanzania is to the south.

Geographically the country may be conveniently divided into seven major regions. The Coastal Region, extending some 250 miles from the Tanzanian border in the south to the Somalia border in the north, exhibits somewhat different features in its southern and northern parts.

The Coastal Hinterland, forming the southern part of this region, is a relatively featureless erosional plain broken only in a few places by small, somewhat higher hill groups. The Tana Plains section of the region is mainly a depositional plain - equally featureless and deficient in rainfall - extending northward from the upper part of the Coastal Region to the northern plainlands.

The Eastern Plateau Region consists of a belt of plains extending north and south to the east of the Kenya Highlands. Elevations run mainly between 1,000 and 3,000 feet (notable exceptions are the Chyulu Range and the Taita Hills, which rise to over 7,000 feet). The vast Northern Plainlands Region

stretches from the Uganda border on the west to Somalia in the east. It consists of a series of arid plains of differing origins--chiefly erosional or are formed by great outpourings of lava--and includes within its limits Lake Rudolf and the Chalbi Desert.

The Kenya Highlands Region, a large section of which was known as the White Highlands during the colonial period because of the concentration of the European population there, comprises the complex of high land found in the country's west-central part.

The great Rift Valley of eastern Africa, formed by a long series of faulting and differential rock movements, extends in Kenya from the Lake Rudolf area in the north generally southward through the Kenya Highlands and into Tanzania. In the vicinity of Lake Rudolf the valley floor is under 1,500 feet above sea level, but southward it rises steadily until in its central section in the area of Lake Naivasha the elevation is close to 6,200 feet. From that point southward it drops off to about 2,000 feet at the Kenya-Tanzania border.

The Western Plateaus Region forms part of the extensiva downwarped basin in which Lake Victoria lies. In Kenya the region consists mainly of faulted plateaus marked by escarpments that descend in a gentle slope from the Kenya Highlands Region to the shore of the lake.

Contrary to the expectation that Kenya's location on the equator and its adjacency to the Indian Ocean and Lake Victoria might result in a generally humid tropical climate, a large part of the country's experiences semiarid to arid weather conditions. Most of the country has two rainy and two dry seasons. Usually by late December the northeast trade winds flowing

from the Arabian Peninsula (and on the west from the Sahara) bring a dry season that lasts until about March. During March convergent southeast trade winds sweeping across a broad stretch of the Indian Ocean begin to deposit rain over Kenya, and in April rainfall encompasses all of the country to some degree. By July a second period of dry weather ensues - except in the western parts of the country. Dry conditions then prevail until September or October, when a reinstatement of the low-pressure belt over Africa and convergent trade winds bring what are known in Kenya as the small rains. These continue into December, when the seasonal cycle starts again.

Only about one-seventh of the total area receives with reasonable certainty an annual rainfall of thirty inches or more, and roughly another one-eighth can expect an average rainfall of between twenty and thirty inches per year. The remainder, over 70 percent of the country, usually records less than twenty inches of rain annually, and a considerable part of this area receives under ten inches.

Great variations in average temperatures exist between different parts of the country with altitude again a major factor. Outward from the highlands, as the elevation decreases, average temperatures increase. A zone immediately around the highlands has mean annual maximum temperatures between 79°F and 84°F and minima between 57°F and 64°F. Beyond this zone the low plateaus of eastern Kenya and the northern plains register mean annual maxima between 86°F and 93°F and minima from 64°F to over 72°F. One area to the west of Lake Rudolf and another along the Somalia border have mean maximum temperatures above 93°F; the latter area has recorded an absolute maximum of 115°F. The Rift Valley exper-

iences temperatures similar to those in eastern Kenya. The humidity in the semiarid to arid areas usually is between 60 and 70 percent in early morning. It decreases by midafternoon to roughly 40 to 45 percent and in some places to as low as 30 percent.

A zone along the coast experiences not only generally high temperatures but also high humidity. The hottest months are January through March; at Mombasa the mean monthly temperature is about 82°F during this time. Beginning in June and extending through August a cooler period sets in when afternoon temperatures may average about 82°F and night temperatures may drop to below 70°F. Little variation occurs, however, in the humidity, which throughout the year is above 90 percent early in the morning and usually between 60 and 70 percent in midafternoon.

I. Country: Kenya

II. Project

Location - Nyanza Province

Time - 3 1/2 year study

Type - Pilot malaria eradication program

III. Endemicity

IV. Parasite

Primary: P. falciparum

V. Insect Vector

Primary: A. gambiae (subspecies A and B), A. funestus

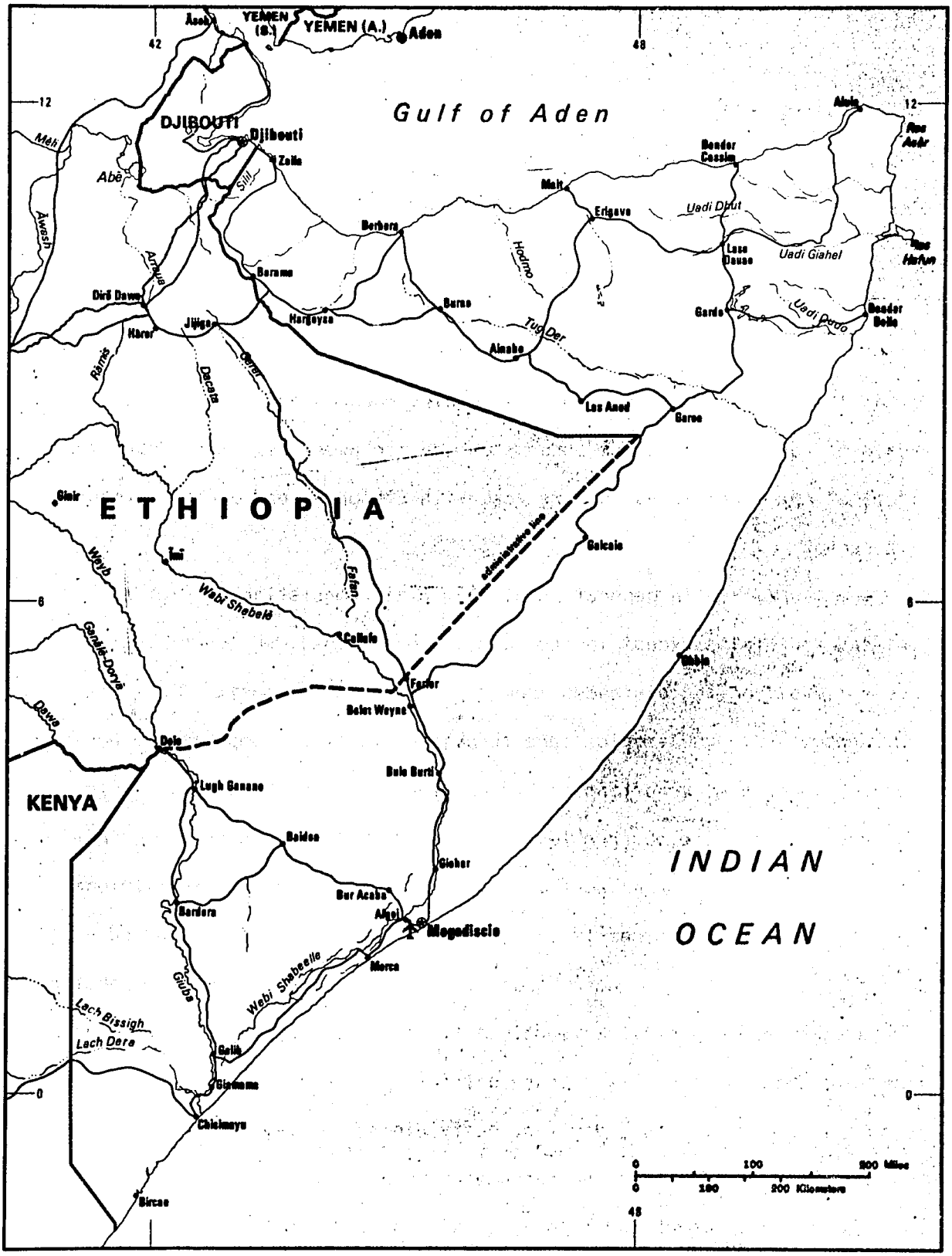
VI. Type of Interventi

Insecticide: Fenitrothion (40 percent formulation) - 8 rounds of spraying at 3 month intervals.

VII. Evaluation

The parasite rate decreased to 1.8% percent in the treated area compared to 35.6 percent in the untreated area. The general mortality rate was reduced from 23.9 to 13.5 deaths per 1,000 people; the crude infant mortality rate was reduced from 153 to 93 per 1,000 infants.

Reference: Bull. WHO 54: 369-376, 1976; WHO Cronicle 31: 102-105, 1977.



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Mercator Projection
Scale 1:7,750,000
Boundary representation is not necessarily authoritative

Railroad
Road
Airport

SOMALI DEMOCRATIC REPUBLIC

Geography and Climate[3]

Situated in northeast Africa and the easternmost country of that continent, the Somali Democratic Republic (Somalia) has a land area of 246,155 square miles, according to standard reference authorities, roughly comparable to that of the state of Texas.

Somalia's northern limits, which face the Gulf of Aden, lie about 12° north of the equator. Its eastern and southern bounds face the Indian Ocean; the southernmost point of the country reaches about 1.5° below the equator. Landward it shares borders on the northwest with the French Territory of Afars and Issas, on the west with Ethiopia, and on the southwest with Kenya.

The terrain is in general relatively flat, consisting of plateau surfaces and plains except in the north, where rugged, west-east mountain ranges lie at varying distances from the Gulf of Aden coast. Climatically the country is in the tropics, and throughout the year temparatures are hot, although there are exceptions at higher elevations in the north.

Four seasons are observable, two wet and two dry. These are determined by the northeast and southwest monsoonal winds and the transitional lulls between them that result in alternating periods of moisture and aridity. During the main periods of monsoonal airflow, winds blow parallel to the coast and deposit little rainfall. In the first of these periods - from late December or early January until about March, when the northeast monsoon is dominant - hot, dry, and dusty winds are prevalent. This season, known locally as jilal, is the harshest time of year for the nomadic groups.

Beginning in March and extending into May and sometimes June, a tran-

sitional period known as gu, during which the monsoonal winds change direction, brings the country's heaviest, though still comparatively meager, rains. The third and longest season, hagaa, begins in June as the southwest monsoon becomes ascendant. By July pastures and vegetation begin to dry up, and dust, blown by the strong winds, is everywhere. The hagaa season continues through August and is the hottest period of the year in the north; along the Gulf of Aden temperatures may soar to 120°F. Along the southwest coast, however, cooling sea breezes from the Indian Ocean make this period comparatively pleasant; showers also occur during this time in this coastal area. The second wet season, called dayr by the Somali, is the shorter of the two, but its intermittent rains during the lull between the southwest and northeast monsoons - mostly in October and November - account in some areas for about 30 percent of the annual rainfall.

Most of the country receives less than 20 inches annually; a large area, encompassing the northeastern and much of the northern pars, receives as little as two to six inches. Certain higher areas in the north, however, record over 20 inches annually. The southwest receives an average of 13 to 20 inches, and some coastal spots average more than 20 inches. Rainfall is largely in the form of showers or localized rains and is characterized by an extreme degree of variability.

Mean daily maximum temperatures range from 85°F to 105°F, although they are lower at the higher elevations and along the Indian Ocean coast. Mean daily minimum temperatures usually vary from the mid-60°s to the higher 80°s.

The northern part of the country has the greatest temperature extremes; readings range from below freezing in the highlands in December to more than 120°F in the coastal plain skirting the Gulf of Aden in July. The region's

relative humidity ranges from approximately 40 percent in midafternoon to 85 percent at night, varying somewhat with the season. During the colder months at the higher elevations, from December to February, visibility is often restricted by fog.

The southern part of the country exhibits less extreme temperatures, ranging from about 65 ^{o}F to 105 ^{o}F; the hottest season is from February through April. Coastal temperatures are usually from 10 ^{o}F to 15 ^{o}F degrees cooler than those inland. There is little variation in the coastal zone's relative humidity, which usually remains above 70 percent even during the dry seasons.

I. Country: Somali Democratic Republic

II. Project

Location: Somaliland Protectorate

Population: 650,000

Time: April 1958 - June 1959

Type: Malaria eradication Program (Pre-eradication operations)

III. Endemicity: Hyperendemic

IV. Parasite

Primary: P. falciparum (responsible for 95 percent of infections)

Others: P. malariae; P. vivax

V. Insect Vector:

Primary: A. gambiae

VI. Type of Intervention

Imagociding: DDT (2 g/m^2) or Dieldrin (0.3 g/m^2).

Larviciding: DDT spraying of man-made reservoirs.

Chemotherapy: Discretionary use - given to nomads to prevent reintroduction of parasite.

VII. Evaluation

Residual spraying reduced the incidence of malaria. Transmission still occuring due to the presense of man-made reservoirs and the nomadism of population in search of grazing areas and water for cattle. Therefore larviciding and administration of antimalarials to nomads were proposed in order to elimate these problems.

Reference: Afro Malaria Yearbook No. 1. WHO Office for Africa. AFRO/MAL/5, September, 1959.

I. Country: Somalia

II. Project

Location: 448 villages

Population: 139,859

Time: 1963-1967

Type: Malaria pre-eradication program

III. Endemicity

IV. Parasite

V. Insect Vector

VI. Type of Intervention: DDT (2 g/m^2) twice annually

VII. Evaluation

The operation was unsuccessful because:

1) many of the villagers refused to let their homes be sprayed because: a) an increase in the number of bed bugs and b) timing unsuitable,

2) walls replastered,

3) nomadism,

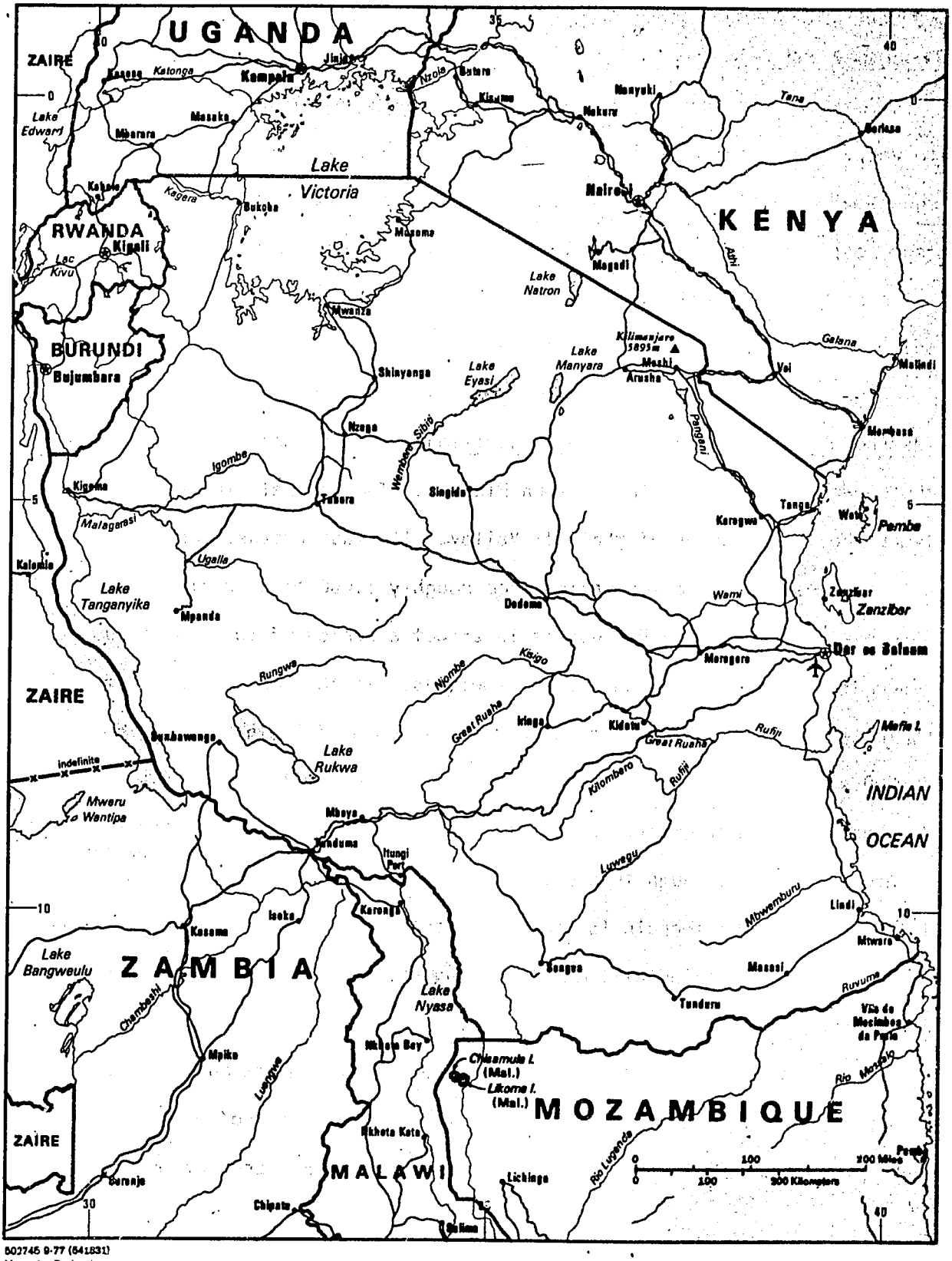
4) inadequate supervision and trained personnel,

5) public resistance and,

6) inadequate geographical reconnaissance.

Reference: Garofal, V. "Malaria Pre-Eradication Programme in the Republic of Somalia. Inter-Regional Malaria Conference. Beirut, 27 November - 3 December, 1968.

Tanzania



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Mercator Projection
Scale 1:7,800,000
Boundary representation is not necessarily authoritative

Railroad
Road
Airport

REPUBLIC OF TANZANIA

Geography and Climate[3]

Tanzania stretches 740 miles north to south and about 760 miles east to west. Its total area is 363,708 square miles, including nearly 8,000 square miles of inland water. The landscape is extremely varied, changing from rolling savannas and high arid plateaus to mountain ranges. It contains both the highest point in Africa, Mount Kilimanjaro, and the lowest, which is the floor of Lake Tanganyika.

There are four major ecological regions: high plateau, mountain lands, lakeshore region and coastal belt and islands. There are two major plateaus, the Central Plateau and the Eastern Plateau. The Central Plateau lies between the two branches of the Rift Valley. Its vast expanse forms a huge uplifted basin. Elevation varies from roughly 3,000 to 5,900 feet above sea level. The Eastern Plateau is in effect a series of lower plateaus descending gradually to the coastal lowlands. In the north it consists basically of the Masai Steppe, an extensive semiarid plain of more than 26,000 square miles. The steppe is almost a desert with vast areas of dry bush and scanty grass. South of the Uluguru Mountains the plateau broadens to form a rough triangle, the base stretching from Lake Nyasa to the coast. The terrain is broken and toward the coast is characterized by outcrops of isolated hill masses rising sharply from the surrounding land.

One of the major mountain zones includes the Usambara and Pare ranges, which together form a wedge-shaped mass reaching a height of almost 550 feet and the Northern Highlands, which contain Mount Kilimanjaro and Mount Meru.

Mount Kilimanjaro rises in two peaks united by a saddle. Both peaks receive considerable amounts of rain on the southern slopes, and tropical rain forest conditions prevail between the altitudes of about 5,600 and 9,500 feet above sea level on Mount Kilimanjaro and between 4,600 and 6,000 on Mount Meru.

The second zone stretches from the western shore of Lake Natron southward in a series of isolated mountains and mountain chains interspersed with lakes and craters and connected with the northern part of the eastern Rift.

The third major mountainous region includes the Southern Highlands. They stretch from the Nguru Mountains, about halfway between Dodoma and Dar es Salaam, and the Uluguru Mountains, farther south, to the Livingstone Mountains, which descend sharply toward the eastern shore of Lake Nyasa.

In the lakeshore region, the Northern portion of the Central Plateau slopes gently downward to form the large shallow depression containing Lake Victoria, which lies at an elevation of about 3,7000. West of the lake are long, narrow rocky hill ranges, which rise above flat lowlands. On the lakeshore are large flooded inlets.

The coastal belt is narrow in the north and south, averaging between ten and forty miles in breadth. It is broader in the center near the lowlands of the Rufiji River valley where it almost reaches the Uluguru mountain. The 500 mile coast is difficult to approach because of numerous coral reefs and shifting sandbars at the mouths of rivers. The inland slopes sufficiently toward the coast to cause most rivers to be unnavigable because of rapids.

The islands are basically coral. Zanzibar is separated from the mainland by a channel twenty-two miles wide at its narrowest point and is the largest coralline island on the African coast. It is about fifty miles long and twenty-five miles wide with a total area of 1,657 640 square miles. Zanzibar rises from a flat eastern plain to a more hilly western area.

Pemba is north of Zanzibar and is smaller. It is forty-two miles long and fourteen miles wide with a total area of 380 square miles. Its topography varies with small steep hills and valleys. Mafia is twenty-seven miles long and more than nine miles wide and is low island situated about halfway down the coast south of Tanzania.

The climate is basically determined by the country's position just south of the equator and by the airstreams coming from the Indian Ocean and southern Asia. Except for rainfall there is little seasonal variation. The rainy season varies. In general rains may begin as early as October or November in the southern part of the country and end in March. In the north, however, the heavy rains begin in March and end in May or June. There is also a good deal of local variation, and a few places, especially in the northern highlands, may sometimes benefit from a short rainy period in November or December.

Two major elements, rainfall and temperature, produce what is essentially a tropical equatorial climate. Temperatures are modified, however, by the altitude, resulting in a somewhat cooler climate in the higher regions, where mean daily maxima range between 72 ^{o}F and 90 ^{o}F. Altitude also plays a large role in determining rainfall patterns, with the higher elevations receiving more precipitation. Generally, the total

amount of rainfall is not very great. Only about half of the country receives more than thirty inches annually. There are, however, great variations, from more than 100 inches annually just northwest of Lake Nyasa to less than twenty inches in parts of the hot and dry Central Plateau and the Masai Steppe.

On the coast, including the area of the Rufiji Basin, which extends inland for more than sixty miles, a warm and humid climate prevails. The offshore islands have a more tropical climate, with higher average temperatures and more precipitation than the coast.

I. Country: Tanganyika and Kenya

II. Project

Location: Pare District of Tanganyika and Taveta - sub-district in Kenya (94,000 people); lowlands in Jushoto District

Population: 110,000

Time: September 1954 - December 1959

Type: Pilot malaria eradication project

III. Endemicity: Hyper- to holo- endemic

IV. Parasite

Primary: P. falciparum

Secondary: P. malariae (predominantly in children)

Others: P. vivax, P. ovale

V. Insect Vector

Primary: A. gambiae; A. funestus

VI. Type of Intervention

Insecticide: Dieldrin (1 g/m^2 initially and 0.4 g/m^2 afterwards).

VII. Evaluation

After spraying, A. funestus disappeared and A. gambiae was reduced by 90 percent. Adult spleen and parasite rates were reduced by 25 percent; more dramatic results were obtained in infants and young children. After three years of spraying, the crude death rate dropped from 23.5 percent in the first year to 14 percent in the third year.

Reference: Afro Malaria Yearbook No. 1. WHO Regional Office for Africa. AFRO/MAL/5, September 1959.
Malaria Yearbook No. 2. Who Regional Office for Africa. AFRO/MAL/7, Dec. 1960.
WHO/ECSS/WP/21, December 13, 1974.

I. Country: Tanganyika

II. Project Location: Morogoro

Population: 120 school children

Type: Therapeutic trial

III. Endemicity

IV. Parasite (all four species of *Plasmodium*)

V. Insect Vector

VI. Type of Intervention

Chemotherapy: Chloroquine silicate - single dose.

VII. Evaluation

The purpose of this trial was to evaluate the effectiveness of chloroquine silicate which unlike chloroquine diphosphate does not have a bitter taste and does not induce vomiting. This formulation was found to be as effective as chloroquine diphosphate in clearing the parasite infection.

Reference: *Bull. WHO.* 30: 135-136. 1964.

I. Country: Tanzania

II. Project

Location: Arusha region

Type: Pilot project

III. Endemicity

IV. Parasite

V. Insect Vector

VI. Type of Intervention: Medicated salt

VII. Evaluation

The parasite rate in infants was 23 percent before the introduction of the medicated salt and was 4 percent fifty-three months after its introduction into the community. Some of the problems associated with this method were: leaching of antimalarial compounds due to moisture and acceptance by the villages who were used to using course grain salt instead of fine grain salt.

Reference: Bull. WHO. 35: 962-968. 1966.

I. Country: Tanzania

II. Project

Location: Dar-Es-Salaam

Population: Entire population

Time: 1954 to 1971

Type: Malaria Control

III. Endemicity

IV. Parasite:

V. Insect Vector

VI. Type of Intervention

Insecticide: Dieldrin (50 mg/ft^2) once a year preceding the long rains.

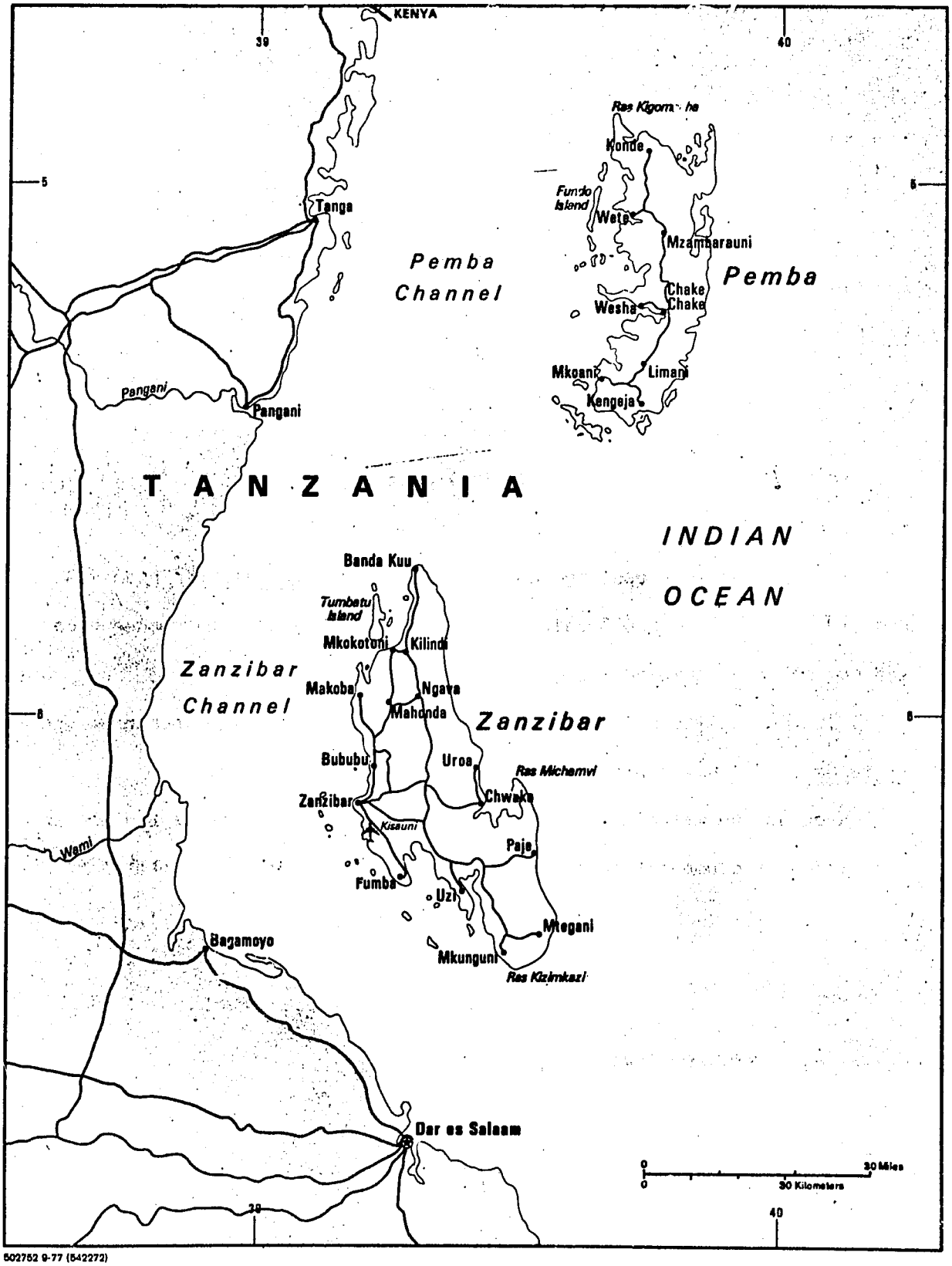
VII. Evaluati

In the treated areas, the number of female A. gambiae per room was reduced from 0.75 to 0.028 between 1954 and 1971. In the untreated area the number of A. gambiae was reduced from 22 per room in 1955 to 2 per room in 1971. During the rainy season, the number of A. gambiae increased whereas A. funestus did not exhibit a seasonal increase in numbers.

Whereas the malaria vectors declined in control townships and untreated vicinities, the population of Culex increased in coastal and lake shore areas.

Reference: WHO/VBC/73.440; WHO/VBC/73,439.

Zanzibar and Pemba



502752 9-77 (542272)
Mercator Projection
Scale 1:1,200,000

Railroad
Road
Airport

I. Country: Zanzibar Protectorate

II. Project

Location: Zanzibar and Pemba

Population: 299,100

Time: June 1957 to June 1960

Type: Pilot malaria eradication program

III. Endemicity: Hyperendemic

IV. Parasite

Primary: P. falciparum (responsible for 84 percent of infections)

Secondary: Mixed infections

Others: P. vivax, P. malariae

V, Insect Vector

Primary: A. gambiae (resistance to Dieldrin observed in later studies); A. funestus

Secondary: A. rivulorum, A. gambiae (salt water sub-species which is exophilic and zoophilic).

VI. Type of Intervention

Insecticide: Dieldrin (0.8 g/m^2) applied annually

Chemotherapy: Chloroquine (600 mg) and pyrimethamine (49.5 mg) issued monthly for six months.

VII. Evaluation

In Zanzibar, the houses were sprayed; in Pemba, residual spraying and mass drug administration were used as methods of intervention.

In Zanzibar, the infant parasite rates were reduced from 25 percent to 0 percent. After the second year, the parasite rate was 0.5 percent in those infants who had not left the island. In older children the parasite rates

were still high.

In Pemba, the parasite rate in infants was 65 percent before spraying and after two cycles of spraying was reduced to 0.8 percent. The uncontrolled distribution of the drugs was unsatisfactory and did not significantly reduce the rate of malaria transmission.

Some of the problems associated with the inability to interrupt transmission were:

1. Many migrant laborers who come from the mainland of East Africa to assist in clove harvesting are carriers of the parasite.
2. The height of some of the hut ceilings were 20 feet and were inaccessible for spraying.
3. Many of the villagers sleep out of doors.
4. Dieldrin resistance was observed during the course of the eradication program.

Reference: Afro Malaria Yearbook No. 1. WHO Regional Office for Africa. AFRO/MAL/5, Sept. 1959. Malaria Yearbook No. 2. Who Regional Office for Africa. AFRO/MAL/7, December 1960.

I. Country: Zanzibar

II. Project

Population: 124,065 (represented 83.5 percent of the total population)

Time: 1968

Type: Malaria eradication program

III. Endemicity

IV. Parasite

Primary: P. falciparum

V. Insect Vector

VI. Type of Intervention

Insecticide: DDT spraying once in February - March, 1968 (98 percent coverage) before mass drug administration.

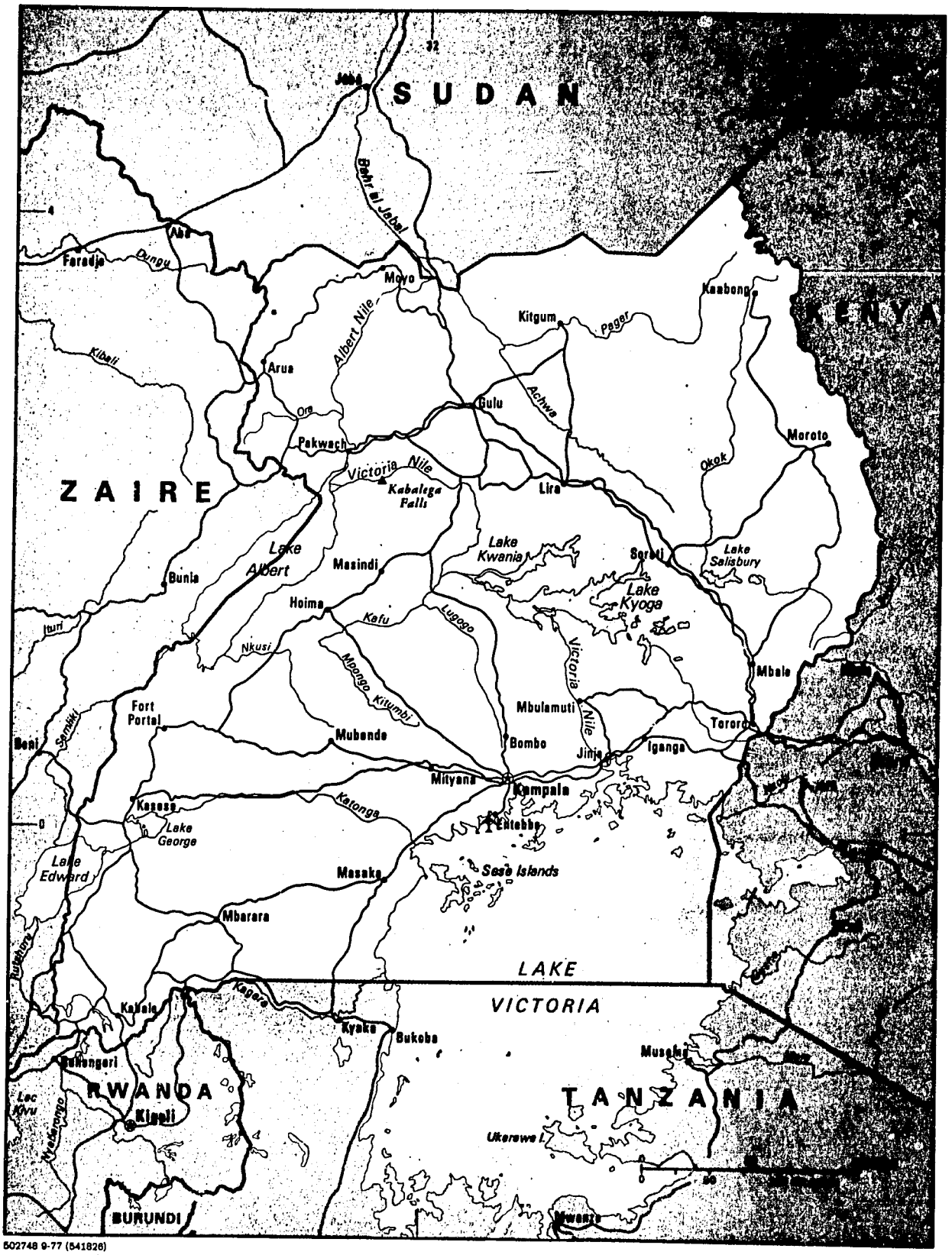
Chemotherapy: Chloroquine (150 mg) or camoprima (150 mg camoquin and 15 mg primaquine) at two monthly intervals.

VII. Evaluation

Mass drug administration was not effective in interrupting malaria transmission. Before mass drug administration, the crude parasite rate was 3.6 percent compared with 5.4 percent after mass drug administration.

Reference: East Afr. Med. J. 51(7): 529-531. 1974

Uganda



502748 9-77 (541826)
Mercator Projection
Scale 1:4,100,000
Boundary representation is not necessarily authoritative

Railroad
Road
Airport

UGANDA

Geography and Climate[3]

Situated astride the equator, Uganda is a landlocked country bordered by Sudan to the north, Kenya to the east, Tanzania and Rwanda to the south, and Congo (Kinshasa) to the west. The total area is 91,076 square miles, including 16,364 square miles of open water or swamp.

The country is predominantly a plateau 3,000 to 5,000 feet above sea level. The main mountain masses and other relief features are located on the borders. On the west are the western rift valley, the Ruwenzori Mountains, or Mountains of the Moon as they are often called, and the Mufumbiro volcanoes.

Lake Victoria includes much of the southern boundary, and the eastern boundary is mostly demarcated by highlands, which are dominated by volcanic Mount Elgon. The lowest altitude is 2,000 feet in the valley of the Albert Nile near Nimule on the Sudan border; the highest is the 16,763 feet of Margherita Peak, the summit of the Ruwenzori Range. Despite this large range of altitude, most of the country is a fairly regular plateau.

Twenty-two percent of the land gets less than 30 inches of rainfall a year. Seventy-two percent of the country obtains between 30-50 inches of rain per year and 6 percent over 50 inches. Thus, whereas rainfall ranges from an annual minimum of about 15 inches in the extreme northeast to over 80 inches on the Sese Islands, most of the country can rely on 30 inches or more in an average year.

Seasonal variations in climate allow the country to be divided roughly in half. The southern section has two rainy seasons with two clear peaks, one in April and May and the other in October and November; two dry spells

of comparatively short duration occur in June and July, and in December and January, though the dry periods are broken by occasional thunderstorms, especially near Lake Victoria. In the northern parts of the country, lying closer to the limits of the tropical wind zone, the two rainfall peaks merge into one long rainy season from April to October without a marked dry spell. The dry season from November to March is both more prolonged and severe than either of the two short dry seasons of the south.

I. Country: Uganda

II. Project

Location: Northern Kigezi

Population: 120,000

Time: 1959-1960

Type: Pilot malaria eradication program

III. Endemicity: Hyperendemic

IV. Parasite

Primary: P. falciparum (responsible for 80 percent of infections)

Secondary: P. malariae (responsible for 20 percent of infections)

Other: P. vivax

V. Insect Vector

Primary: A. gambiae (below 4,500 feet contour); A. funestus (above 5,000 feet contour)

VI. Type of Intervention

Insecticide: DDT (2 g/m^2); houses sprayed three times annually in hyperendemic areas and twice annually in mesoendemic areas.

Chemotherapy: Chloroquine (200 mg) and pyrimethamine (16.5 mg) administered in one tablet (about 80 percent coverage).

VII. Evaluation

After 12 months of intervention, the parasite rate was reduced from 23 percent to 0.5 percent in hyperendemic areas and from 12.5% to 0% in mesoendemic area.

Reference: Afro Malaria Yearbook No. 1, WHO Regional Office for Africa. AFRO/MAL/5, Sept. 1959. Malaria Yearbook No. 2, WHO Regional Office for Africa, AFRO/MAL/7, December 1960.

I. Country: Uganda

II. Project

Location: Northern Kigezi

Population: 40,562

Time: One year

Type: Pilot malaria eradication project

III. Endemicity: Hyperendemic and mesoendemic

IV. Parasite

V. Insect Vector

Primary: A. gambiae

VI. Type of intervention

Insecticide: DDT (2 g/m^2); mesoendemic areas sprayed twice a year; hyperendemic areas sprayed three times a year.

Chemotherapy: Mass drug administration at time of spraying; chloroquine (200 mg) and pyrimethamine (16.5 mg).

VII. Evaluation

The spleen rates were reduced from 39 percent to 10 percent and the parasite rates were reduced from 16 percent to 0.3 percent after 10-12 months of DDT protection.

Reference: East Afr. Med. J. 38(1) 1-26. 1961.

I. Country: Uganda

II. Project

Location: Namulonge

Population: 36 children during first 3 years of life

Type: Pilot malaria eradication program

III. Endemicity

IV. Parasite

V. Insect Vector

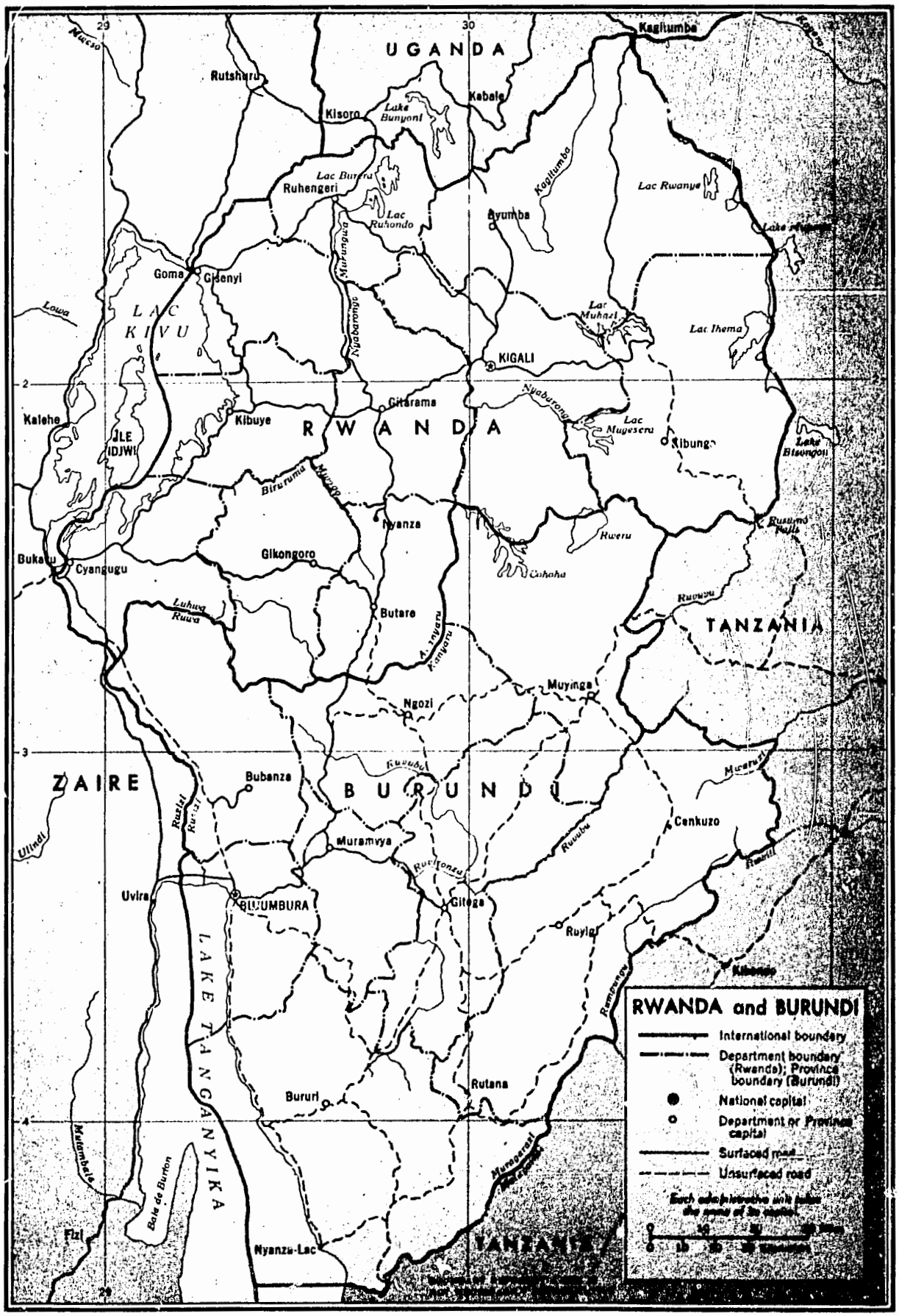
VI. Type of Intervention

Chloroquine (450 mg dose) and pyrimethamine (25 mg dose) adjusted for body weight and given once a month after first malaria attack for up to three years.

VII. Evaluation

Children were seen at the clinic once a month or whenever they were ill. All febrile cases were treated for malaria and were then given chemoprophylatic once a month thereafter. Thirty-six episodes of malaria occurred in 21 children; all but two occurred two weeks after chemotherapy. Monthly administration of drugs was not sufficient to prevent malaria.

Reference: Trans. R. Soc. Trop. Med. Hyg. 69(2): 261-262. 1975.



Base 502628 6-75

REPUBLIC OF BURUNDI

Geography and Climate[3]

Burundi is a landlocked nation covering 10,746 square miles, located between 2 1/4° and 4 1/2° south of the equator in east-central Africa, 700 miles from the Indian Ocean. It lies between 29° and 31° east, bordering Rwanda to the north, Tanzania to the east and south, and the Republic of the Congo (Kinshasa) to the west.

The geologic base of the country is an irregularly shaped area of the Great East African Plateau. Much of the countryside is covered by savanna grasslands and small farms extending over rolling hills, but there are also areas of both swamps and mountains. Most of the land is at least 3,000 feet above sea level; much of the central plateau has an average altitude of 5,000 to 6,500 feet, and the average for the entire country is about 5,300 feet. The heaviest concentrations of people are located in the central uplands, which are from 5,000 to 7,5000 feet in elevation.

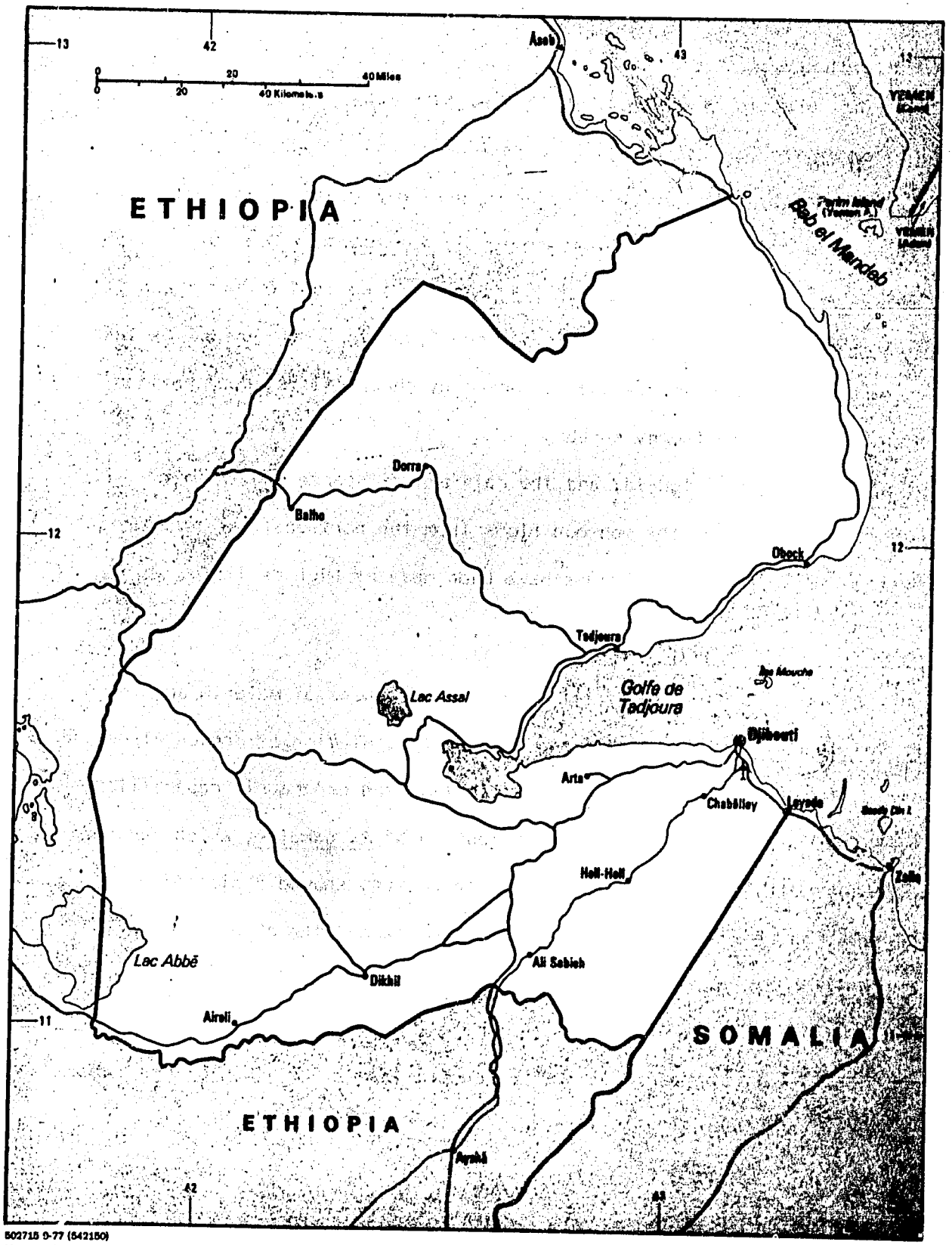
Daily temperatures in this tropical highland climate vary with elevation, which is the dominant temperature factor. The only land below 3,000 feet is a narrow plains area along the Rusizi River, which is at 2,600 feet above sea level and forms the western boundary north of Lake Tanganyika. The temperature in this region may reach a maximum of 93° F.; the average is about 73° F. The eastern border areas, generally below 5,000 feet, are also warmer than the heavily populated central plateaus, which averages 65° F to 67° F. In the mountainous areas, temperatures fluctuate between 57° F and 68° F during the day and may drop 20 degrees or more at night. Above 5,000-foot elevation in the central plateaus and

highlands, where most of the population is concentrated, the climate is rarely hot enough to be uncomfortable to humans, despite a location within 5° of the equator.

Total rainfall varies greatly between one locale and another and from year to year. The countrywide average is between 40 and 60 inches per year. Rainstorms at the higher elevations are usually longer but of lighter intensity than at the lower levels.

Although some rain falls during each month, June, July, and August are considered dry months, as the average during each of these months is less than one-half inch. From September until November or December, rainfall increases to about 6 inches per month then drops slightly during January and February. There is an increase to 7 or 8 inches per month during March and April, a sharp reduction to about 4 inches in May, followed by the three almost rainless months of June through August.

Djibouti



502715 9-77 (542150)
Mercator Projection
Scale 1:1,300,000

Railroad
Road
Airport

REPUBLIC OF DJIBOUTI

Geography and Climate[4]

The Republic of Djibouti is located in northeast Africa and is bounded by the Gulf of Aden, the Somali Democratic Republic, and Ethiopia.

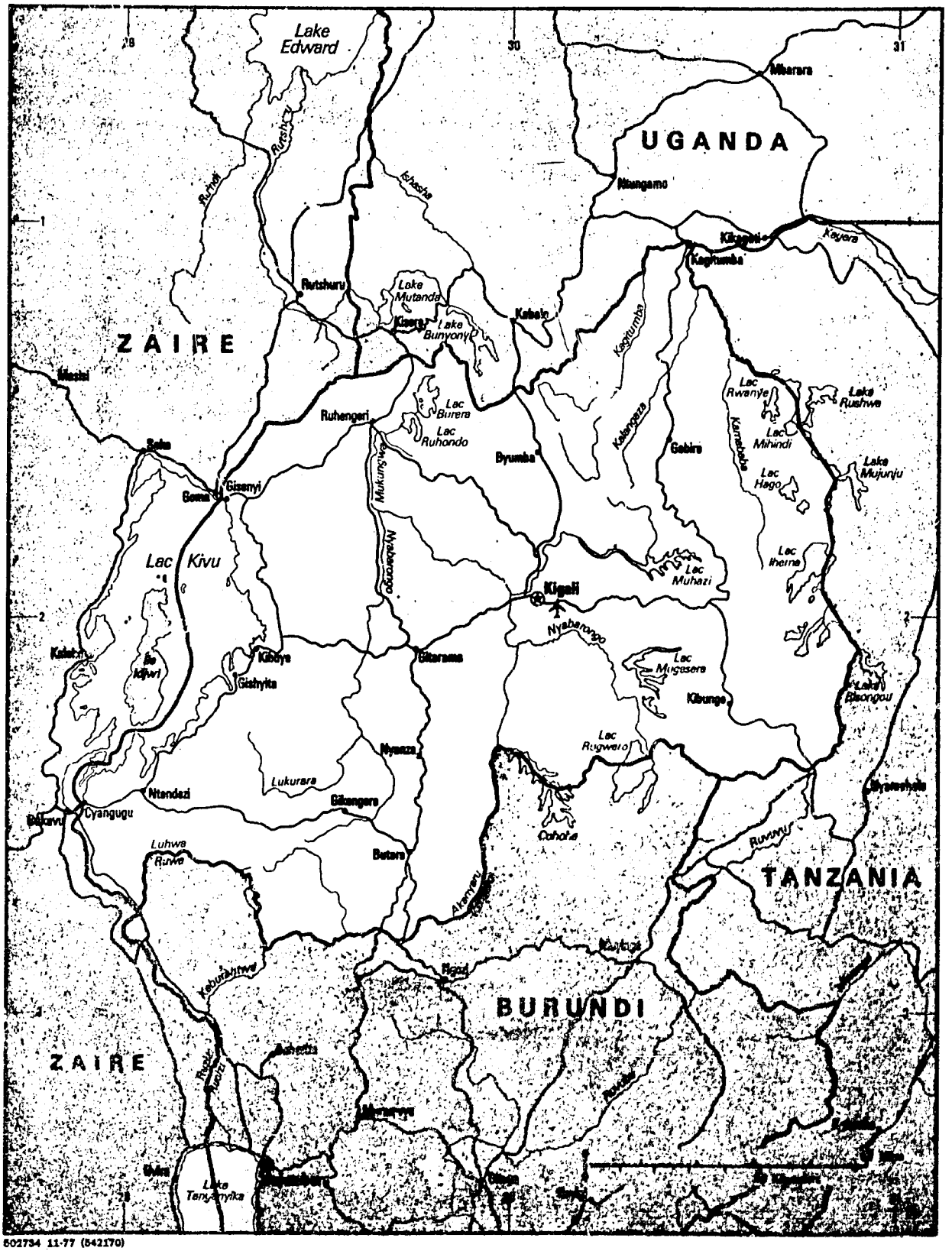
The Republic has three principal geographic regions: the coastal plain, less than 650 feet above sea level; the mountains, about 3,280 feet above sea level, with occasional peaks rising to 5,000 feet and the plateau behind the mountains, rising from 1,000 to 5,000 feet. The land is bare, dry, and desolate and is marked by sharp cliffs, deep ravines, burning sands, and thorny shrubs.

The climate is torrid, and the rainfall is sparse and erratic. From May to October, when the monsoon blows from the northeast, temperatures average 92 °F, although readings have been made as high as 113 °F.

Potential Malaria Situation in Djibouti

Between 1973 and 1976, 191 autochthonous cases of malaria due to *P. falciparum* were reported among the local population of French Afars and Issas Territory. Their monthly distribution and geographic repartition were studied, jointly with the distribution of *A. gambiae*, which had been recently collected in the Territory. This study showed a significant correlation between the presence of *A. gambiae* and the observed malaria cases which did not come from neighboring countries. The development of a small disseminated foci is expected, resulting from the simultaneous introduction of both the parasite and its anopheline vector. This brings about a new epidemiological situation for the Territory.

Reference: Carteron, B., Morvan, D. and Rodhain, L. Le probleme de l'endemie palustre dans la Republique de Djibouti: Med. Trop. 1978. vol 38, no. 3, 299-304.


Lake Edward
UGANDA
ZAIRE
TANZANIA
BURUNDI
Lac Kivu
Lake Mutanda
Lake Bunyonyi
Lac Burera
Lac Ruhondo
Lac Rwanye
Lac Mihindi
Lac Hago
Lac Ihema
Lac Muhazi
Lac Mugesera
Lac Rugwero
Lake Rushwe
Lake Mujunju
Lake Bisongou
Lake Tanganyika
Kigali
Gisenyi
Goma
Bukavu
Cyangugu
Kibuye
Gisenyi
Gitarama
Byumba
Gabiro
Kibungo
Ruhengeri
Rutshuru
Kabale
Kagitumba
Mbarara
Ntungamo
Kajara
Masisi
Butare
Gikongoro
Ntendazi
Lukurara
Nyanza
Kibungo
Ruhwa
Luhwa
Kabuhinwa
Ruzizi
Rusizi
Rusizi
Ruvuvu
Kagera
Nyabarongo
Mukungwa
Mwogo
Kalangala
Kagitumba
Kamabala
Ishasha
Ruchuru
Ruhindi
Bujumbura
Gitega
Ngozi
Muyinga
Ruyigi
Kayanza
Ruyigi
Bujumbura
Uvira
Kalemie
Kabalo
Kalemie
Kigoma
Mpulungu
Kasama
Mbala
Mbeya
Tabora
Mwanza
Musoma
Bukoba
Kisumu
Nairobi
Mombasa
Tanga
Dar es Salaam
Lindi
Mtwara
Mahenge
Iringa
Dodoma
Mpwapwa
Morogoro
Tanga
Mombasa
Kilimanjaro
Arusha
Mt. Kenya
Nairobi
Kisumu
Eldoret
Kitale
Lodwar
Gulu
Lira
Soroti
Tororo
Jinja
Kampala
Entebbe
Masaka
Mbarara
Kabale
Kigali
Gisenyi
Goma
Bukavu
Cyangugu
Kibuye
Gitarama
Byumba
Gabiro
Kibungo
Butare
Ruhengeri
Rutshuru
Kabale
Kagitumba
Mbarara
Ntungamo
Kajara
Masisi
Beni
Bunia
Kisangani
Bangassou
Bangui
Mongalla
Juba
Wau
Aba
Arua

REPUBLIC OF RWANDA

Geography and Climate[3]

The country is landlocked, covering 10,186 square miles, located south of the Equator in east-central Africa, 700 miles from the Indian Ocean. It borders Uganda to the north, Tanzania to the east, Burundi (previously called Urundi) to the south, and the Democratic Republic of the Congo and Lake Kivu to the west.

The geologic base is an irregularly shaped area of the Great East African Plateau. Much of the countryside is covered by grasslands and small farms extending over rolling hills, but there are also areas of swamps and rugged mountains, including volcanic peaks north of Lake Kivu, in the northwest border area. The divide between two of Africa's great watersheds, the Congo and Nile Basins, extends from north to south through western Rwanda at an average elevation of almost 9,000 feet. On the western slopes of this Congo-Nile ridgeline, the land slopes abruptly toward Lake Kivu in the Great Rift Valley on the western border of the country. The eastern slopes are more moderate, with rolling hills extending across the central uplands, at gradually reduced altitudes, to the plains, swamps, and lakes of the eastern border region.

Except for the eastern and western border areas, high altitudes are common. Most of the land is at least 3,000 feet above sea level; much of the central plateau has an average altitude of 4,700 feet, and the average for the entire country is about 5,200 feet. The heaviest concentrations of people are located in these central uplands, in the 5,000- to 7,500-foot-altitude levels.

Altitude, averaging 5,600 feet in the central plateau uplands, accounts for a relatively pleasant tropical highland climate, with daily temperature ranges of as much as 25 degrees, despite the nation's proximity to the Equator. Kigali, centrally located and at an average elevation, has an average temperature of approximately 66 °F from March through July and during November and December, with slightly higher averages at other times. Annual rainfall in this area is about 40 inches, slightly below that of the higher plateaus. Eastward, temperatures increase, and rainfall decreases, becoming sporadic and less dependable in the lower elevations. Daytime temperatures rise to 90 °F and slightly above. Westward and upward from the densely populated central pateau farmlands, the Congo-Nile Crest area is much cooler. Nighttime temperatures above the 9,000-foot level may drop below freezing, and annual rainfall may be as much as 70 inches.

Although normally no month of the year is completely dry, there are two wet and two relatively dry seasons annually. In terms of its importance to the subsistence farmer, the climatic year begins with a short dry season, lasting through January and February, followed by the long rainy season from March to May. June through September are relatively dry months, and rainfall increases again during the last quarter of the year. Heavy downpours are common during this wet season, interspersed with periods of bright sunshine.

G. Sudan and the Indian Ocean Islands[1]

Countries with MEP[2]

Republic of the Sudan
Malagasy Republic
Mauritius

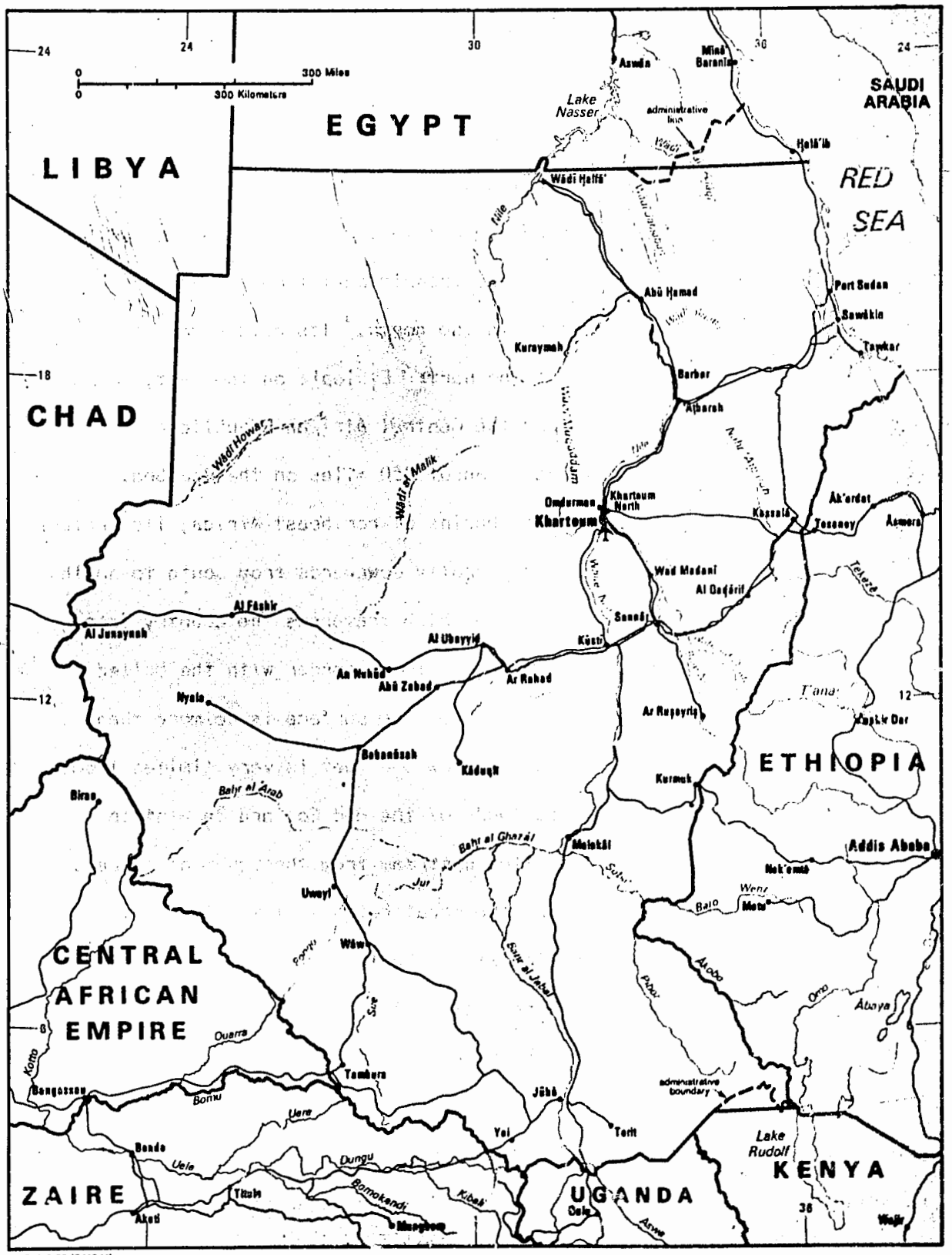
Country without MEP[2]

Comare Islands
Seychelles[3]

1 Stippled area on map

2 Malaria eradication/control program

3 Malaria not a problem



502743 9-77 (541841)
Lambert Conformal Projection
Standard parallels 8° and 32°
Scale 1:11,600,000
Boundary representation is not necessarily authoritative

Railroad
Road
Airport

REPUBLIC OF THE SUDAN

Geography and Climate[1]

With an area of 967,000 square miles the Republic of Sudan is the largest state in Africa. In longitude, it is located between 22° E and 39° E, and in latitude it stretches through about 18°, from 4° N, thus including within its territory a series of zones transitional from sub-equatorial forest in the south to arid desert in the north. Its neighbours are the United Arab Republic and Libya on the north, Ethiopia on the east, Kenya, Uganda and Zaire on the south, and the Central African Republic and Chad on the west. It has a coastline of about 450 miles on the Red Sea.

Sudan occupies one of the vast basins of northeast Africa, its surface being largely plains land, sloping gnerally downwards from south to north and towards the line of the river Nile which traverses the country from the southern border with Uganda to the northern border with the United Arab Republic. A very large proportion of the surface is no more than 1640 feet in height, though the area below 660 feet is very limited indeed, occurring only on the narrow coastlands of the Red Sea and in a strip bordering the Nile for some 155 miles upstream from the Egyptian border. While the plains are overlooked by the great heights of the Abyssinian plateau on the south, the mountains within Sudan are few and highly localized. They comprise the Jebel Marra, close to the western border in Darfur province, reaching 10,000 feet; the Nuba mountains in Kordofan province, reaching just over 5,000 feet; Jebel Imatong, on the edge of the Lake plateau of Uganda, generally over 8,000 feet and culminating in mount Kinyeti at 10,500 feet and the Red Sea hill ranges, which are discontinuous

but reach over 6,600 feet in isolated peaks.
Elsewhere smaller ranges of hills and inselbergs diversify the level or gently undulating surface.

The climate of the northern zone is characterized by the prevailing northerly winds and very low and unreliable rainfall. From Merowe northwards the average annual rainfall is less than one inch and is limited to August. Relative humidity is very low. From May to September day temperatures are very high. Winters are mild and dry though liable to have days with temperatures lower than average caused by cold air flooding south from winter depressions over eastern Europe. Both annual and diurnal temperature ranges are high. There is a rapid transition from the Saharan conditions of this zone to the Sudan type of climate in the central zone, though the changes are less noticeable within the Nile valley than on the surrounding plains.

The central zone has monsoonal conditions. The rainy season lasts from April to October in the south and becomes progressively shorter northwards, occurring only in July and August at Merowe. Annual rainfall amounts range from 31 inches in the south to one inch in the north, where they become rather unreliable from year to year. Areas of more prominent relief, such as Jebel Marra and the Nuba mountains, receive rather more rain than the surrounding plains. Highest temperatures occur in May and June and lowest temperatures in January; the annual temperature range is 49°F-57°F, lowest in the south.

The southern zone has a more equable equatorial type of climate, with an eight-month rainy period and annual rainfall amounts of 31-55 inches.

With the high August rainfalls, the summer temperatures are modified. The annual temperature range is only 5-7 ^{o}F, and maximum monthly mean temperatures occur in March or April. Relative humidity is high except from January to March.

The Red Sea Coast has different climatic conditions, influenced by the adjacent sea. Northerly winds are predominant. Rain is partly convectional, partly orographic is most likely to come in winter.

Additional Notes:

Plasmodium falciparum is the predominant causative species of malaria in the northern and southern parts of sudan. *P. ovale* was extremely rare in southern Sudan and absent in the north. During the transmission season 62 percent of the populace in one village was positive for malaria. A trial of mass chemotherapy resulted in a marked decline in prevalance after one year. (Am. J. Trop. Med. Hyg. 27(5): 858-863. 1978.)

Letter From Sudan

South Sudan Edges, Painfully, Into Modern World

JUBA

Every Tuesday and Friday at dusk the Dinka tribesmen gather to dance on the flat piece of ground near the airport and the sound of their singing and hand clapping floats over Juba. If Juba could count on the same regularity in any other aspect of life, especially its air service, the story of this inaccessible heart of Africa would be different.

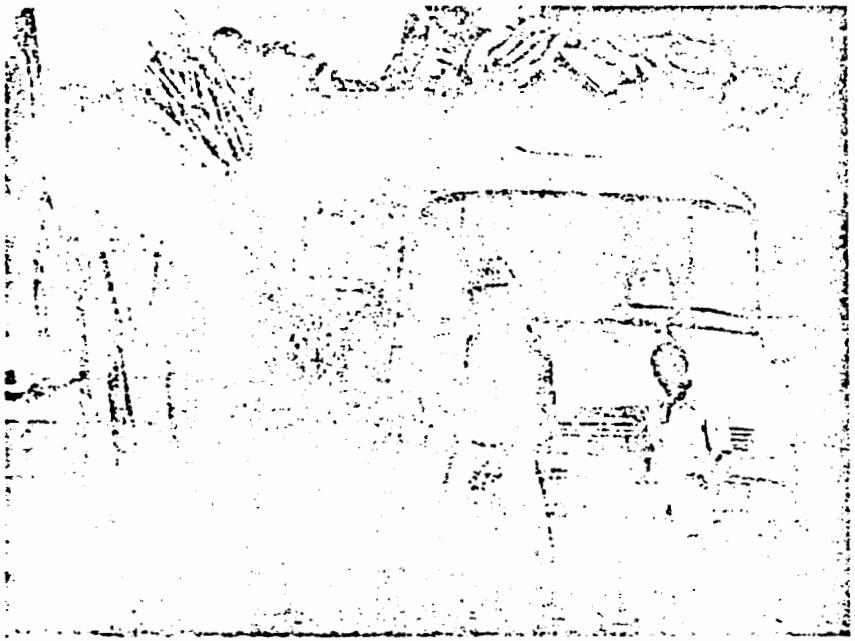
The daily flight from Khartoum no longer comes because of the shortage of fuel. The twice weekly flight from Nairobi, Kenya, can never be counted on. Even charter planes frequently cannot get out of Juba because they cannot refuel. Last weekend a World Health Organization helicopter that flew in from Zaire took off after six weeks on the tarmac.

Three West German hunters, playing cards under the trees in the Juba Hotel all day, sat silently drinking beer from Zaire, long ago having run out of conversation and no longer having the energy for the daily walk to the airport to see if there might be a plane going somewhere.

JUBA LIES 1,580 miles south of Khartoum, 1,270 miles southwest of Port Sudan and 1,125 miles northwest of Nairobi. It is self-sufficient in nothing and sheer distance makes its supply situation an administrator's nightmare.

Transport down the Nile takes about a month and much of the steamer equipment is broken. For the last two years almost all the area's fuel has been brought in through Uganda and Kenya, but no fuel has been delivered by road for more than two months because of the recent war to oust Uganda leader Idi Amin. An alternative $100 million road route from Kenya bypassing Uganda is still in the study stage, according to the vice president of the southern Sudan's autonomous government, Peter Gatkuoth.

Juba, the south's capital, is the center of a 239,000 million square miles of land where 3½ million people live, 80 percent of them in the rural areas where rain, floods and black cotton soil make it impossible for any vehicle to move for seven months of the year.



Reuter

The peril of this truck, pitched into the river from a ferry, shows transportation difficulties in southern Sudan, especially during the rainy season when the main roads are flooded and frequently made impassable.

A 17-year civil war with the north left the southern Sudan as untouched central African bush in 1972. When the government in Juba was set up by the Addis Ababa agreement seven years ago, it had only one Land Rover and a table that the ministers stood a round.

The rehabilitation of agriculture was, and remains, the first priority for the area. The first phase of a $12 million World Bank project to get returning refugees back into farming was completed in December. The project, on a 500-acre site at Yei southwest of Juba, last year produced 250 tons of high quality corn, ground nut and sorgum seeds, enough to plant 10,000 acres. It may be a humble begining, but the project has been successful enough for the World Bank to commit $50 million to start the second phase. Large planted acreages and improved seed may well have a multiplier effect throughout the region, but self-sufficiency for the south is still a long way off.

PERHAPS THE BIGGEST act of faith in the transformation of Juba was the creation of a university. Its 250 students are now in their second year and a small army of workers is building a permanent facility. The courses are practical—agriculture and adult education were two of the first and engineering and medicine are due to open next year. The southern balance in the university is maintained by admitting numerous "mature students" with two years experience in a ministry, since enough southern secondary school graduates simply are not available yet.

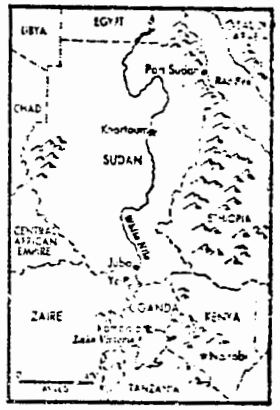
At the same time, an American aid program is trying to record some of the southern languages for the first time so that textbooks can be written, illustrating how basic many of the educational needs here are.

Aid to the southern Sudan comes from almost every conceivable source. The Yugoslavs built the $5 million government complex, and the Poles built the bridge over the Nile.

A cultural center worth $300,000, a gift from the Saudi millionaire Adnan Koshoggi, is nearing completion. West German aid was used to plant acres of teak forests and to supply six veterinarians to support the Ministry of Agriculture's vaccination program. It is now building dispensaries in rural areas.

The World Bank, the European Economic Community and the Norwegian government are among those committed to financing the town's lifeline south—the great road project from Juba to Kenya.

At the opposite end of the scale the small Geneva-based Lutheran World Service has breathed life into one part of the six-year development plan launched in 1976 by financing



By Richard Patno—The Washington Post

the first sorghum growing cooperative three years ago among the Shilluk people in Upper Nile province. It is now making money [illegible] members and will buy a tractor this year. Thirty more cooperatives are ready to begin operations, although they must wait for the Lutheran organization's tractors to plow their land.

Jonglei Canal, one of the greatest development projects in the Sudan, according to Gatkuoth, is at a standstill with bigger plans [illegible] to be redesigned on the [illegible] The canal is a joint Sudanese-Egyptian project to divert a quarter of the White Nile's flow away from the Sudd Swamp and harness it for vast agricultural irrigation projects. Gatkuoth said there had been no [illegible] for two months, but the Sudanese, in another of their leaps of imagination, still hope to have it finished in 1981.

—*Victoria Brittain*

I. Country: Sudan

II. Project

Location: Gezira

Population: 1,500,000 people in 2,200 locations

Time: January, 1975 to August, 1977

III. Endemicity

IV. Parasite

V. Insect Vector

Primary: A. gambiae (Resistant to DDT)

VI. Type of Intervention

Insecticide: Malathion (OMS 1) spraying ($2g/m^2$) once a year for 3 years; 80-90 percent coverage.

Chemotherapy: radical cure of microscopically diagnosed cases; all seasonal immigrants received chemotherapy.

Source reduction of breeding places

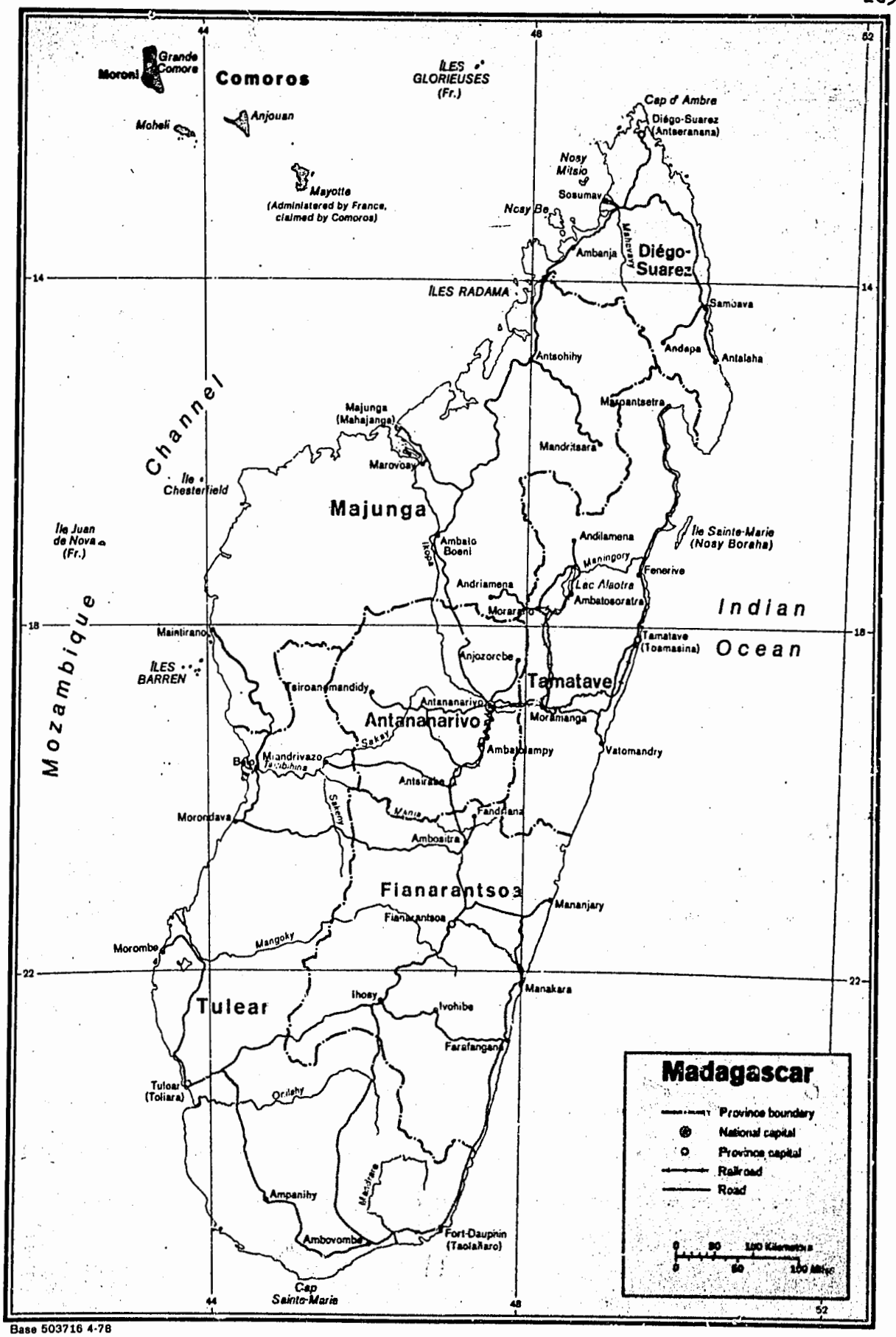
Use of gambusia fish

Larviciding with Abate during the dry season

VII. Evaluation:

The parasite rate was reduced significantly from 19.7 percent in January 1975 to 0.1 percent in August 1977.

Reference: El Gaddal, A.A. A Brief Review of Malaria Control in the Sudan (Unpublished results).


Madagascar
Province boundary
National capital
Province capital
Railroad
Road
Comoros
Grande Comore
Moroni
Moheli
Anjouan
Mayotte
(Administered by France, claimed by Comoros)
ÎLES GLORIEUSES (Fr.)
Cap d' Ambre
Diégo-Suarez (Antseranana)
Nosy Mitsio
Sosumav
Nosy Be
Ambanja
Diégo-Suarez
ÎLES RADAMA
Samoava
Antsohihy
Andapa
Antalaha
Mananpantsetra
Majunga (Mahajanga)
Mandritsara
Marovoay
Ile Chesterfield
Majunga
Ile Juan de Nova (Fr.)
Ambato Boeni
Andilamena
Ile Sainte-Marie (Nosy Boraha)
Fenerive
Lac Alaotra
Andriamena
Ambatosoratra
Indian Ocean
Mozambique Channel
Maintirano
Tamatave (Toamasina)
ÎLES BARREN
Anjozorobe
Tsiroanomandidy
Tamatave
Antananarivo
Moramanga
Miandrivazo
Ambatolampy
Vatomandry
Antsirabe
Morondava
Fandriana
Ambositra
Fianarantsoa
Mananjary
Morombe
Mangoky
Manakara
Tulear
Ihosy
Ivohibe
Farafangana
Tuleor (Toliara)
Ampanihy
Ambovombe
Fort-Dauphin (Taolanaro)
Cap Sainte-Marie
Base 503716 4-78

MALAGASY REPUBLIC

Geography and Climate[3]

The Malagasy Republic consists of all of Madagascar - the fourth largest island in the world - and a number of small coastal reefs and islands, or which only about five have more than a handful of inhabitants. Lying in the Indian Ocean astride the 47th meridian some 250 miles east of southern Africa, the main island is about 1,000 miles long and averages 350 miles in width.

All of the republic has a basically tropical marine climate, but the landmass of the island, particularly the eastern mountains, contributes to the creation of important regional differneces. A detailed analysis reflects five climatic regions. This breakdown includes the humid eastern belt; the wet extreme north, which is partially isolated from both east and west by mountains; the Central Highlands with a relatively pleasant tropical, high-altitude climate; the mid-level and lower western slopes shading into the broad west-coast plain, well-watered during the summer rainy season but dry for nearly half the year; and the south and southwest, a semidesert area.

The variations in temperature and rainfall are shown below for three cities. The mean temperatures in the city of Tananarive (altitude, 4,500 feet) are about 70 ^{o}F from December through March and about 60 ^{o}F from June through September (see table 1). This contrasts with Tamatave, the port city only 150 miles to the northeast, where humidity is high and mean temperatures are usually about 10 ^{o}F warmer (about 80 ^{o}F during the warmest months and 70 ^{o}F during the local winter). Majunga, a city on the northwest coast, has a quite different rainfall pattern but is nearly as warm and humid as Tamatave. Tulear, on the edge of the southern and southwestern semidesert region,

Table 1. Mean Temperature and Rainfall at Selected Stations, Malagasy Republic, 1967

	Tamatave		Tananarive		Tulear	
	Temperature (°F)	Rainfall (inches)	Temperature (°F)	Rainfall (inches)	Temperature (°F)	Rainfall (inches)
January	80	14.4	70	11.8	82	3.1
February	80	14.8	69	11.0	80	3.2
March	79	17.8	69	7.0	79	1.4
April	77	15.7	67	2.1	76	0.3
May	74	10.4	63	0.7	72	0.7
June	71	11.1	60	0.3	71	0.4
July	70	11.9	59	0.3	69	0.1
August	70	8.0	58	0.4	69	0.2
September	71	5.2	62	0.7	72	0.3
October	74	3.9	67	2.4	75	0.7
November	77	4.6	68	5.3	78	1.4
December	79	10.3	70	11.3	81	1.7
Annual	75	128.2	65	53.4	75	13.5
Altitude (in feet)		20		4,500		20

Source: Adapted from Alan B. Mountjoy and Clifford Embleton, *Africa: A New Geographical Survey*, New York, 1967.

records temperatures similar to those in other towns on both coasts but has, along with its lower annual rainfall, a lower average humidity.

I. Country: Malagasy Republic

II. Project Location: Coastal areas

Type: Planning of malaria eradication projects for coastal area.

III. Endemicity

IV. Parasite

Primary: P. falciparum (responsible for 99 percent of infections)

Others: P. vivax; P. malariae

V. Insect Vector

Primary: A. gambiae; A. funestus

Other: A. paulioni; A. mascarensis: A. coustani; A. marshalli

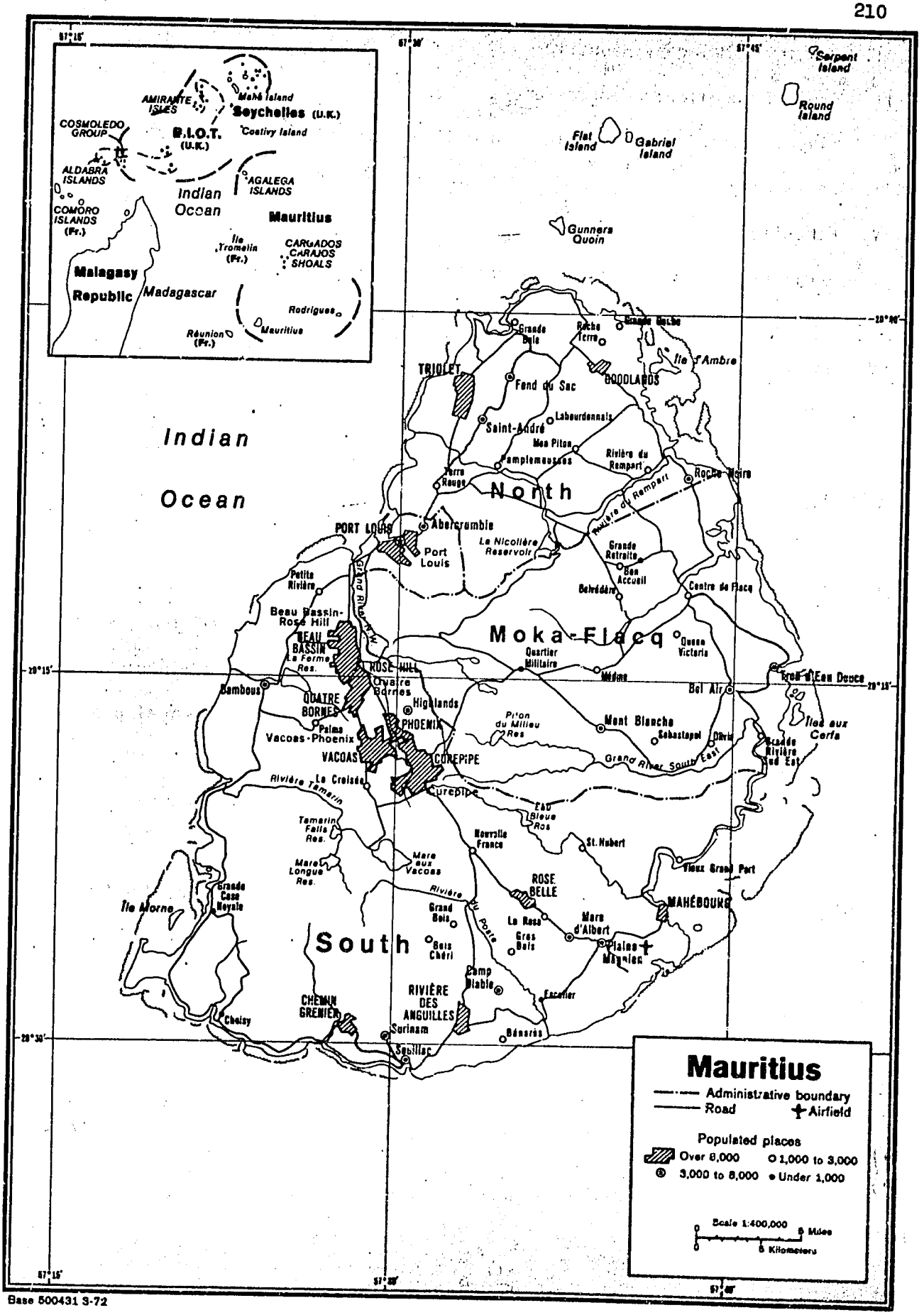
VI. Type of Intervention

Insecticide: DDT and Dieldrin

VII. Evaluation

A. gambiae and A. funestus were highly susceptible to DDT (LD_{50} was 0.4%) and Dieldrin (LD_{50} was 0.1%). Spraying and mass drug administration successfully interrupted the transmission of malaria in the central plateau.

Reference: Afro Malaria Yearbook No. 1, WHO Regional Office for Africa. AFRO/MAL/5, Sept. 1959. Malaria Yearbook No. 2, WHO Regional Office for Africa. AFRO/MAL/7, Dec. 1960.



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MAURITIUS

Geography and Climate

Mauritius is an island about 500 miles east of Madagascar in the Indian Ocean. Its dependencies are Rodrigues Island (40 square miles, 27,000 people, the Agalega Islands, and Cargados Carajos Shoals (27 square miles, 380 people).

Mauritius is volcanic in origin and almost entirely surrounded by coral reefs. The land rises from the coast to a central plateau which varies in altitude from 900 to 2,400 feet above sea level. The plateau is encircled by mountains which may have formed the rim of an ancient volcano.

The climate of Mauritius is conditioned by southeast trade winds. Tropical conditions prevail in the lowlands. The hot season is from December to April, the cool season from June to September. The island is humid throughout the year, with annual rainfall in some areas as high as 200 inches. Mean temperatures vary from 74 ^{o}F at sea level to 67 ^{o}F on the high plateau.

The eradication of malaria during World War II led to a population explosion on Mauritius, and population density is now among the highest in the world. Overpopulation and unemployment are the country's most important socioeconomic problems. Government efforts to curb population growth have been fairly successful, although the birth rate is still expected to increase slightly in the coming years as the percentage of people of child-bearing age increases.

I. Country: Mauritius

II. Project

Population: 400,000 is pop. of malarious areas

Time: 1949-1959

Type: Malaria eradication program

III. Endemicity: High in areas under 600 feet, low in other areas.

IV. Parasite

Primary: P. falciparum (west and northwest); P. vivax

Others: P. malarie, mixed (no sporozoites found in any of species)

V. Insect Vector

Primary: A. gambiae

Secopndary: A. maculipalpis; A. coustani (resistant to DDT)

VI. Type of Intervention

Insecticide: DDT spraying

VII. Evaluation

Country was in the surveillance phase of malaria eradication scheme. The residual transmission of malaria was due to population movements, local custom of washing and cleaning the walls immediately after spraying, and periodic replastering of walls.

Reference: Afro Malaria Yearbook No. 1, WHO Regional Office for Africa. AFRO/MAL/5, September 5, 1959. Malaria Yearbook No. 2, WHO Regional Office for Africa. AFRO/MAL/7, December 1960.

Country: Mauritius

Project: Malaria Eradication

Before 1866, malaria was unknown on the island. Immigrant labour and ships introduced malaria sometime between 1867 and 1868 when an epidemic caused 43,000 deaths. The history of the malaria eradication program on the island is:

1907 - Source reduction and larvicides to reduce the number of vectors.

1946 - The spleen rates were 50 percent-60 percent and the parasite rates were 36 percent; P. falciparum caused 44 percent of all infection and P. vivax caused 43 percent of all infections.

1949 - A. gambiae and A. funestus were reduced by residual spraying of DDT and HCH. As a result, the number of cases reported dropped from 46,000 in 1948 to 6,000 in 1950. The parasite rate was reduced from 9.5 percent to 0.1 percent during the same period.

1958 - Ceased spraying of all areas.

1966 - Only focal points for malaria were sprayed.

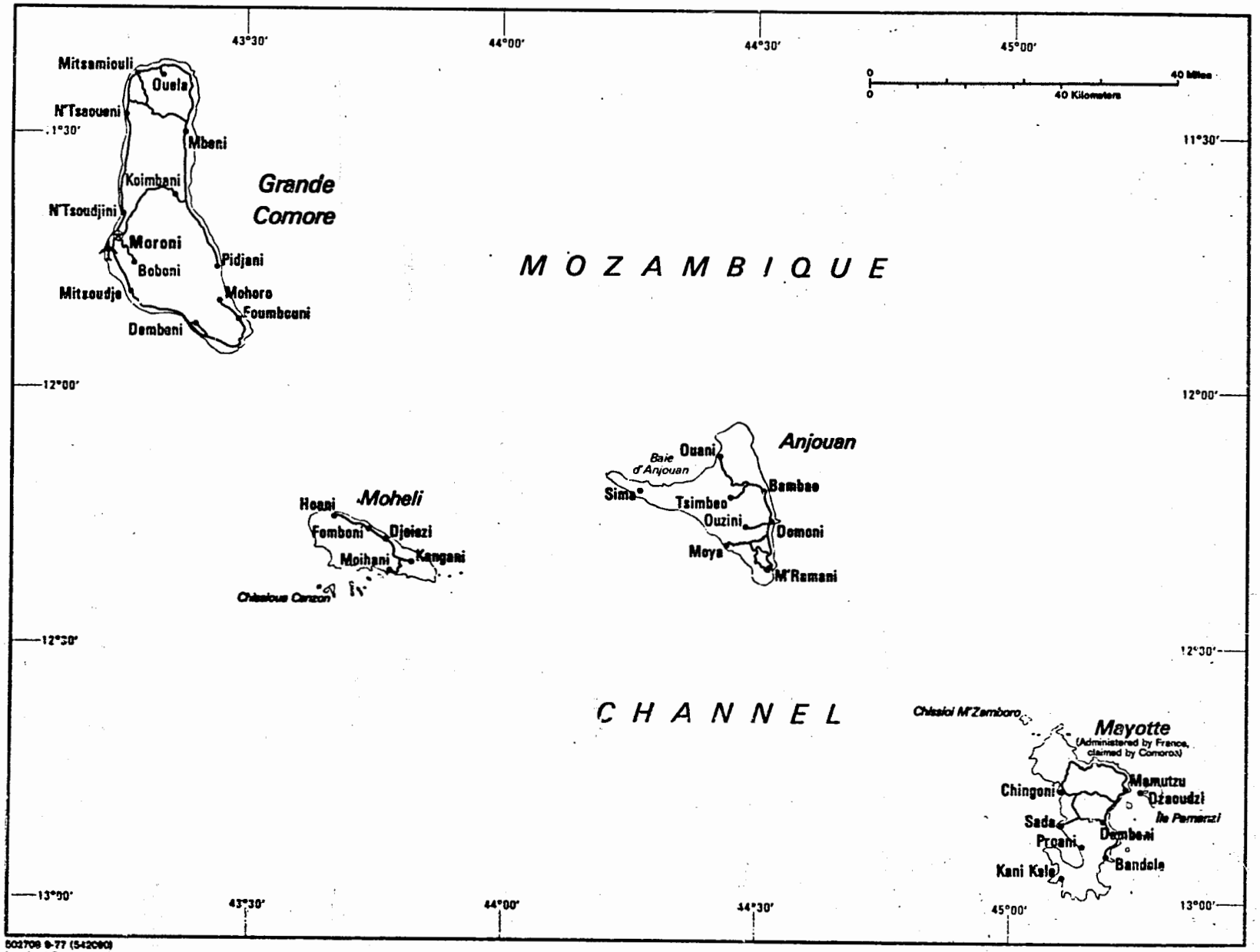
1968 - Last case of malaria occurred

1971 - Began surveillance phase of eradication program.

1974 - Malaria eradicated.

Reference: WHO/MAL/73.816.

Comoros



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Lambert Conformal Projection
Standard parallels 8° and 30°
Scale 1:1,200,000

COMORO ISLANDS

Geography and Climate[1]

The archipelago of the Comoro Islands lies between latitudes 11° S and 13° S and between longitudes 43° E and 55° E. It comprises four islands roughly aligned NW-SE with a total area of 822 square miles. The four islands, Grande Comore, Mohell, Anjouan and Mayotte, are of volcanic origin and all have marked relief.

There are two seasons in the tropical maritime climate of the Comoro Islands. A hot rainy season from November to May coincides with the cyclonic period, while a cool season, relatively dry and less humid, lasts through the southern winter, from June to October. The months May-June and October-November are transitional between the two seasons.

Rainfall comes chiefly in the form of showers, sometimes violent in intensity, giving 3 inches in an hour. The heaviest recorded daily rainfall has been registered at Moroni, on Grande Comore: 17 inches, on July 29, 1931. There are marked variations in amounts from one month to another and from one year to another.

Annual rainfall at sea level ranges from 40 inches to 100 inches, according to location. At higher altitudes amounts range from 100 inches to 240 inches or more. The southwesterly slopes of Karthala massif receive the highest rainfall though exact data are not available. Torrential rain in the south and southwest of the islands is liable to result from bursts of polar air from the south.

The annual range of temperature is small, generally around 4-5° F. Maximum daily temperatures occur between 1100 hours and 1400 hours, generally reaching 86° F in the hot season, sometimes reaching 93° F. In the cool

season, maximum daily temperatures are 80-82 °F. Minimum daily temperatures, occurring at dawn, are above 68 °F in the hot season, sometimes as high as 77 °F; in the cool season they are generally between 76 °F and 86 °F.

Minimum temperatures are influenced by the night breezes off the mountains, especially the Karthala massif. At Moroni, for example, minima of 57 °F may be experienced in July and August. At the summit of Karthala minimum temperatures can fall to below 32 °F.

Relative humidity is high, its annual variation following that of temperatures. Pamanzi records particularly high values. In the coastal regions, the annual average ranges between 75 per cent and 85 per cent, according to whether they are in windward or leeward locations.

Comoro Islands

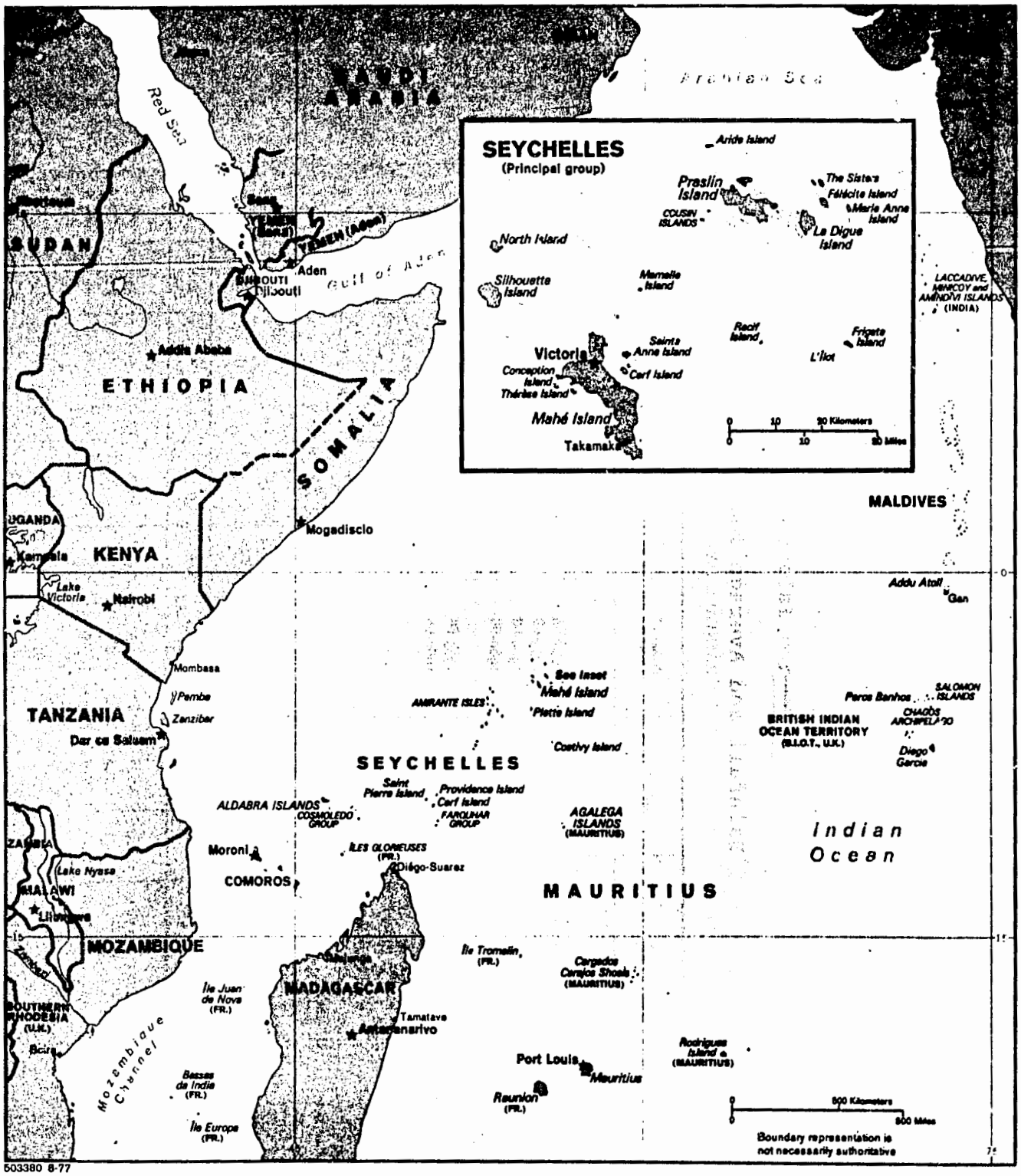
Rainfall and Average Temperatures[5]

RAINFALL DATA

	Altitude	Period of records	Average annual rainfall (mm)	Maximum	Minimum	Number of rain days
Grande Comore				January	October	100-150
Mitsamiouli	5m	1936-65	1,881			
Moroni	17m	1959-68	2,457			
Nioumbadjou	460m	1960-68	5,506			
Foumbouni	10m	1960-68	1,279			
Mohéli				January	August	100-150
Fomboni	5m	1959-68	1,272			
Miringoni	30m	1962-68	2,147			
Anjouan				January	July	70-150
Ouani	12m	1960-68	1,833			
M'Remani	720m	1960-68	2,443			
Mayotte				January	August	50-150
Pamanzi	6m	1959-68	1,219			
Coroni	126m	1959-68	1,525			

AVERAGE TEMPERATURES °C

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Moroni	27.0	26.9	26.8	26.4	25.3	24.0	23.2	23.0	24.4	24.5	25.8	26.6	25.2
Ouani	27.1	27.1	27.4	26.9	25.6	24.5	23.9	23.8	24.2	25.3	26.3	26.9	25.8
Pamanzi	27.2	27.2	27.4	27.2	26.4	25.2	24.2	23.7	24.4	25.4	26.4	27.0	26.0


SEYCHELLES
(Principal group)
Aride Island
Praslin Island
The Sisters
Félicite Island
Marie Anne Island
COUSIN ISLANDS
Le Digue Island
North Island
Silhouette Island
Mamelle Island
Reef Island
Frégate Island
L'Ilot
Saints Anne Island
Victoria
Conception Island
Thérèse Island
Cerf Island
Mahé Island
Takamaka
0 10 20 Kilometers
0 10 20 Miles
LACCADIVE, MINICOY and AMINDIVI ISLANDS (INDIA)
MALDIVES
Addu Atoll
Gan
SAUDI ARABIA
Red Sea
Arabian Sea
SUDAN
YEMEN (Aden)
Aden
Gulf of Aden
DJIBOUTI
Djibouti
Addis Ababa
ETHIOPIA
SOMALIA
Mogadiscio
UGANDA
Kampala
KENYA
Lake Victoria
Nairobi
Mombasa
Pemba
Zanzibar
TANZANIA
Dar es Salaam
See Inset
Mahé Island
Platte Island
AMIRANTE ISLES
Coetivy Island
SEYCHELLES
Saint Pierre Island
Providence Island
Cerf Island
FAROUHAR GROUP
ALDABRA ISLANDS
COSMOLEDO GROUP
AGALEGA ISLANDS (MAURITIUS)
Paros Banhos
SALOMON ISLANDS
CHAGOS ARCHIPELAGO
BRITISH INDIAN OCEAN TERRITORY (B.I.O.T., U.K.)
Diego Garcia
Indian Ocean
ZAMBIA
Lake Nyasa
MALAWI
Lilongwe
MOZAMBIQUE
Moroni
COMOROS
ÎLES GLORIEUSES (FR.)
Diégo-Suarez
MAURITIUS
Île Tromelin (FR.)
Cargados Carajos Shoals (MAURITIUS)
Rodrigues Island (MAURITIUS)
Port Louis
Mauritius
Reunion (FR.)
MADAGASCAR
Tamatave
Antananarivo
Île Juan de Nova (FR.)
Bassas da Indie (FR.)
Île Europe (FR.)
SOUTHERN RHODESIA (U.K.)
Beira
Mozambique Channel
0 500 Kilometers
0 500 Miles
Boundary representation is not necessarily authoritative
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SEYCHELLES

Geography and Climate

The British Crown Colony of the Seychelles is located in the Indian Ocean approximately 1,000 miles east of Kenya and consists of an archipelago of some 5 islands.

The islands in the Seychelles group are composed of either granite or coral. The 40 granite islands are predominantly mountainous, while the 45 coral islands are flat with elevated coral reefs at different stages of formation. There are, in addition, a number of tiny cays and rocks.

Mahe, the largest island, has an area of about 55 square miles and is encircled by a narrow coastal belt from which a mountainous mass rises abruptly to heights of almost 3,000 feet above sea level. The smaller islands, insignificant in size, are widely scattered.

The climate is equable and healthy, although quite humid, since the islands are small and subject to marine influences. Temperatures on Mahe vary from 75 ^{o}F to 85 ^{o}F, and rainfall ranges from 90 inches per year at Victoria to 140 inches per year on the mountain slopes. Precipitation is somewhat less on the other islands. The cooler season occurs during the southeasat monsoon period beginning about the end of May and continuing until September. The Colony lies outside the cyclone belt, so high winds are rarely encountered.

Seychelles is free of malaria and yellow fever. (Grove, A.T., Africa South of the Sahara. 2nd Edition. Oxford University Press. London. 1970.)

H. Conclusions

The interruption of malaria transmission has not been achieved in many areas of Africa where malaria is holo-, hyper- or mesoendemic. However, some methods of intervention have been effective in reducing morbidity and mortality.

Residual spraying combined with mass drug administration have proved most effective in reducing the incidence of malaria as determined by the parasite rates in infants and in the reduction or elimination of Anopheles. Significant reduction in transmission was also achieved with residual spraying. Mass drug administration alone, especially in areas of high endemicity was ineffective.

The success of the first two methods of intervention depended upon:

- Acceptance of program by the community
- Susceptibility of the vector to the insecticide of choice
- Spraying before the beginning of the malaria transmission season
- At least ninety per cent coverage of houses with insecticide spray
- Adequately trained personnel
- Sufficient numbers of staff and supervisory personnel
- Availability of insecticide and drugs
- Dependable transportation
- Drug administration to 90% of population
- Periodic drug administration

Until malaria is eradicated from the African Continent, the continued success of malaria control/eradication programs will depend upon constant

surveillance for increase in vector populations and/or parasite rates in infants[6].

The continuation of control measures in a community may result in decreased sensitivity of the vector to the insecticide, change in behavior (from endophily to exophily) or the adaptability of another species capable of transmitting the malaria parasite.[7] Therefore, control methods must be constantly evaluated for their effectiveness.

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III. Factors which Influence the Effectiveness of Malaria Control Programs

The complicated relationship which exists among the environment, host, vector, and parasite contributes to the persistence of malaria. Whereas, we must understand those conditions which perpetuate the disease (climate, geography, local customs and migratory patterns), effective control, for the present, depends upon our ability to eliminate the agents (vector and/or parasite) which are responsible for the cycle.

A. Climate

Africa is the ideal incubator for malaria. The three environmental factors (temperature, rainfall and humidity) which contribute to malaria transmission are present in heavily populated areas of Africa almost perennially. No species of Plasmodium can develop below temperatures of 59-61 ^{o}F within a mosquito. The relative humidity has an affect on the life of the mosquito; low relative humidity shortens the life span. Rainfall produces a breeding surface for mosquitos. Table 1 and the maps shown in Figure 1 emphasize the positive correlation between the malarious areas (heavy outline in Figure 1C) and the climate and rainfall in Figure 1A and 1B, respectively.

B. People

The host is an important agent in the spread of malaria. The asexual phase of plasmodium development takes place in the host and the host is also the natural reservoir for the parasite.

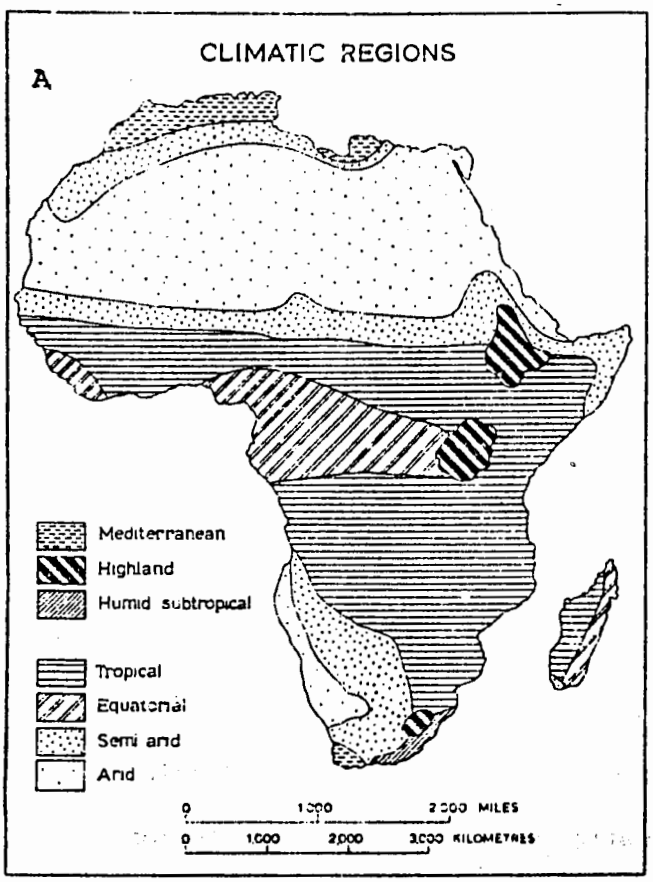
TABLE 1

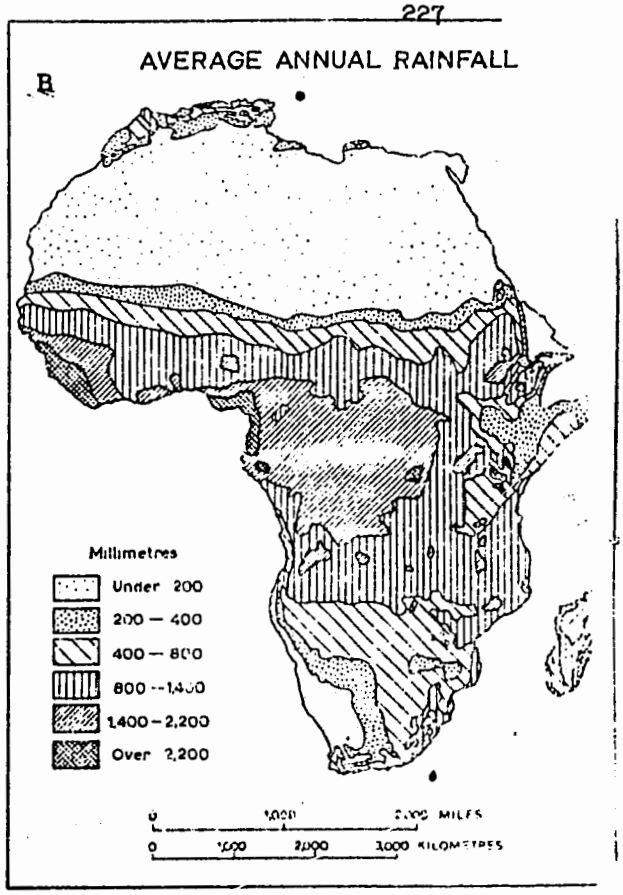
The Seasonal Periodicity of Malaria (Gill, 1938)

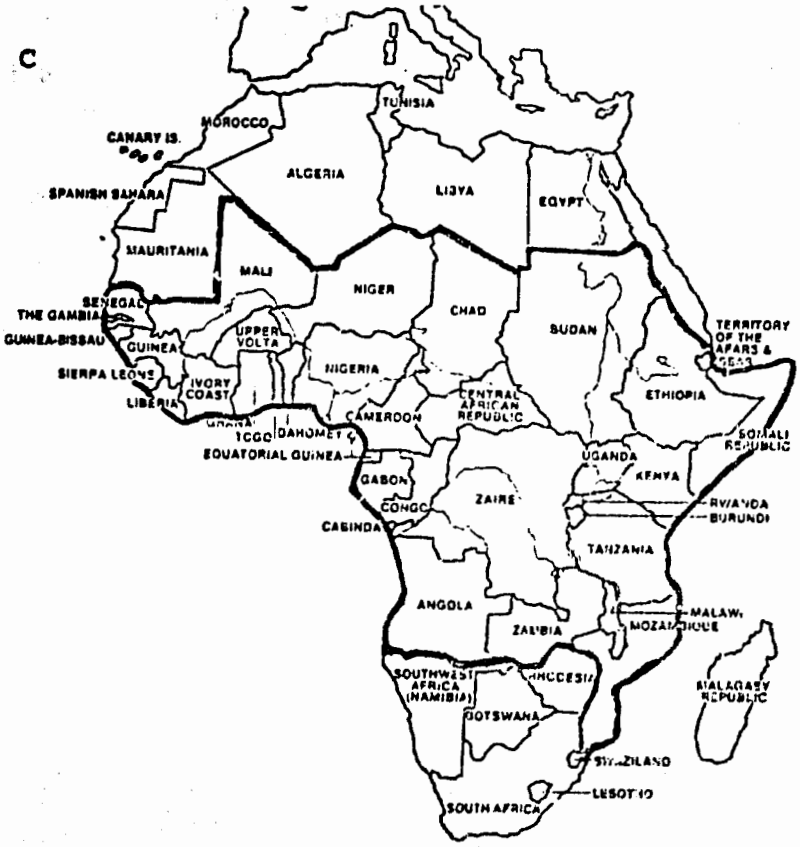
ZONE	AVERAGE MONTHLY TEMPERATURE OF HOTTEST MONTH	AVERAGE MONTHLY RELATIVE HUMIDITY (0800 HOURS READINGS)	ZONE LIMITED BY THE FOLLOWING ISOTHERMS OF THE HOTTEST MONTH
Temperate .	16–20° C.	Never lower than 70 per cent.	15·6° and 21·6° C. (60° and 70° F.)
Subtropical .	20–25° C.	Never lower than 50 per cent.	21·6° and 26·7° C. (70° and 80° F.)
Tropical .	25° C. or more	During some months lower than 50 per cent.	26·7° and 26·7° C. (80° and 80° F.)
Equatorial .	Never lower than 25° C.	Never lower than 70 per cent.	The equatorial forest areas included in the tropical Zone mentioned above

Reference: Pampana, E., A Textbook of Malaria Eradication. Oxford University Press. London. 1963.

Figure 1


A
CLIMATIC REGIONS
Mediterranean
Highland
Humid subtropical
Tropical
Equatorial
Semi arid
Arid
0 1,000 2,000 MILES
0 1,000 2,000 3,000 KILOMETRES


B
AVERAGE ANNUAL RAINFALL
Millimetres
Under 200
200 — 400
400 — 800
800 — 1,400
1,400 — 2,200
Over 2,200
0 1,000 2,000 MILES
0 1,000 2,000 3,000 KILOMETRES


C
CANARY IS.
MOROCCO
TUNISIA
ALGERIA
LIBYA
EGYPT
SPANISH SAHARA
MAURITANIA
MALI
NIGER
CHAD
SUDAN
SENEGAL
THE GAMBIA
GUINEA-BISSAU
GUINEA
UPPER VOLTA
NIGERIA
SIERRA LEONE
IVORY COAST
LIBERIA
GHANA
TOGO
DAHOMEY
EQUATORIAL GUINEA
CAMEROON
CENTRAL AFRICAN REPUBLIC
ETHIOPIA
TERRITORY OF THE AFARS & ISSAS
SOMALI REPUBLIC
UGANDA
KENYA
GABON
CONGO
ZAIRE
RWANDA
BURUNDI
CABINDA
TANZANIA
ANGOLA
ZAMBIA
MALAWI
MOZAMBIQUE
SOUTHWEST AFRICA (NAMIBIA)
RHODESIA
MALAGASY REPUBLIC
BOTSWANA
SWAZILAND
LESOTHO
SOUTH AFRICA

The spread of malaria is facilitated by high population densities, local customs and migratory patterns of people in malarious regions. The population density in Africa is highly variable and is due to the opportunities for employment and the availability of arable land. Table 2 shows the average population density for most countries south of the Sahara. Many of the West African countries, Bambia, Malawi, Burundi, Rwanda, Uganda, Cape Verde Islands, Comoro Islands, Mauritius and Seychelles have population densities greater than 40 people per square kilometer.

Recognition of the migratory patterns (Figure 2) in Africa is important for an effective malaria control program. The movements of people in Africa are complex and are done for many reasons[2]: trading, looking for arable land, visiting relatives, religious pilgramages, looking for employment and nomadic pastoralism. In West Africa, the movement is along the north-south axis and the reasons for migration are to harvest cash crops in Senegal, N. Niger, Ivory Coast and Ghana or to mine iron ore in Sierre Leone and Liberia. In Sudan and Somalia, pastoral nomads seek water and grazing areas for cattle during the dry season. Rhodesia and South Africa attract many laborers from Kenya, Swaziland, Tanzania, Lesotho, and Botswana to work in the mines.

Migrations build and maintain reservoirs of malaria transmission whether the migrant moves from an unprotected to a protected area or vice versa.

There are some factors which have a negative impact on effective malaria control and which cannot be changed or modified within a reason-

Figure 2

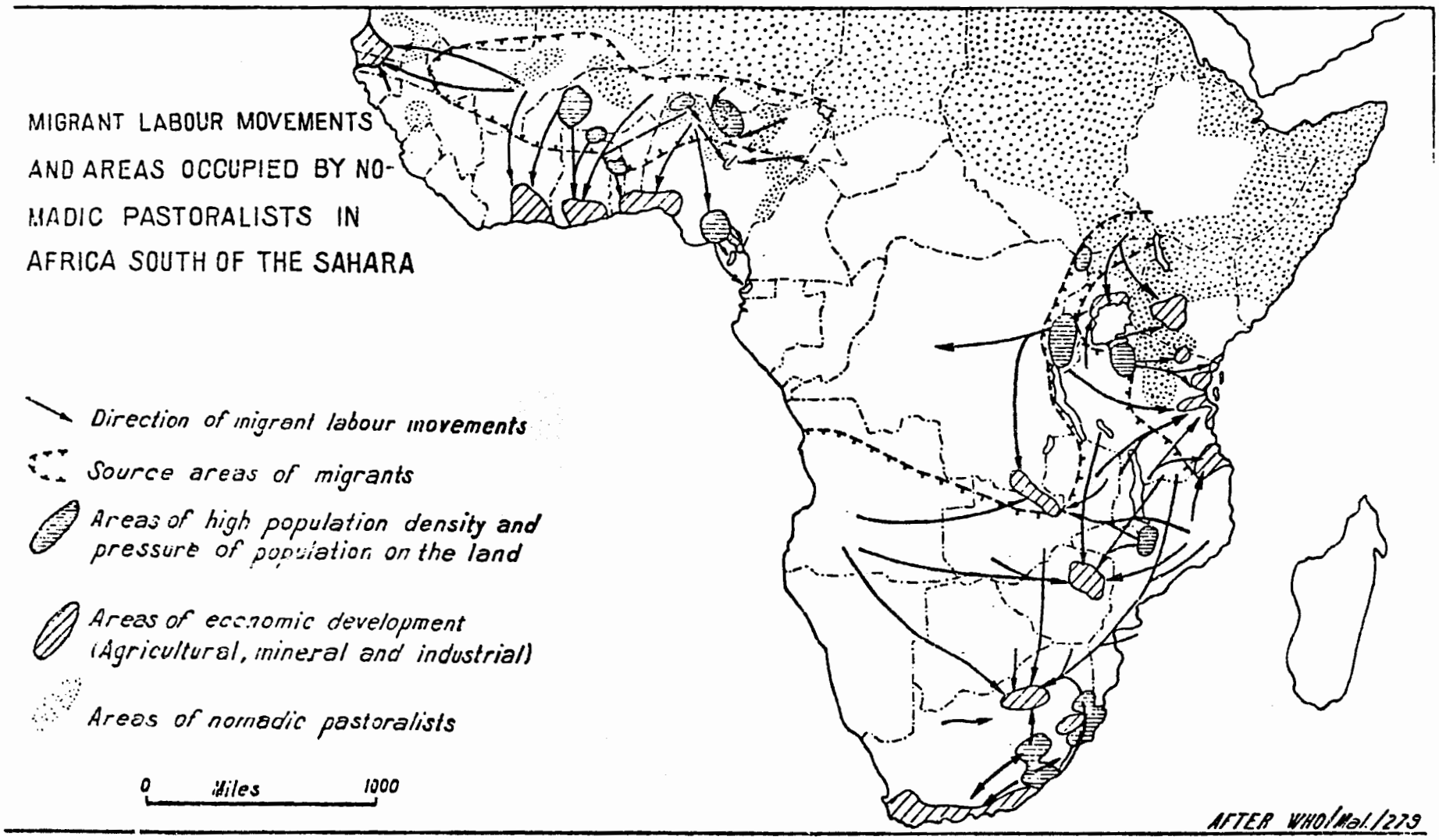

MIGRANT LABOUR MOVEMENTS
AND AREAS OCCUPIED BY NO-
MADIC PASTORALISTS IN
AFRICA SOUTH OF THE SAHARA
Direction of migrant labour movements
Source areas of migrants
Areas of high population density and pressure of population on the land
Areas of economic development (Agricultural, mineral and industrial)
Areas of nomadic pastoralists
0 Miles 1000
AFTER WHO/Mal./279

TABLE 2

Population Density in African Countries

South of the Sahara[1]

Country	Population x 10^3	Surface Area km^2	Population/ km^2
A. West Africa			
Benin	3,286	112,622	29[2]
Ghana	10,309	238,537	43
Guinea	4,529	245,857	18
Guinea-Bissau	534	36,125	15
Ivory Coast	5,017	322,462	16
Liberia	1,751	111,369	16
Nigeria	64,750	923,768	70
Sierre Leone	3,111	71,740	43
Togo	2,289	56,000	41
B. Sahel			
Cape Verde Islands	303	4,033	75
Chad	4,116	1,284,000	3
Gambia	538	11,295	48
Mali	5,844	1,240,000	5
Mauritania	-	-	-
Niger	4,727	1,267,000	4
Senegal	5,085	196,192	26
Upper Volta	6,174	274,200	23
C. Equatorial Africa			
Cameroon	6,531	475,442	14
Central African Rep.	-	-	-
Zaire	25,629	2,345,409	11
D. South Central Africa			
Malawi	5,175	118,484	44
Mozambique	9,444	783,000	12
Zambia	5,138	752,614	7
E. Southern Africa			
Botswana	693	600,371	1
Lesotho	-	-	-
South Africa	26,129	1,221,037	21
Swaziland	497	17,363	29
F. Eastern Africa			
Burundi	864	27,834	139
Djibouti	108	22,000	5
Ethiopia	28,191	1,221,900	23
Kenya	13,847	582,646	24
Rwanda	4,289	26,338	163
Somalia	3,261	637,657	5
Tanzania	15,607	945,087	17
Uganda	11,943	236,036	51

TABLE 2 continued

Country	Population x 10^3	Surface Area km^2	Population/ km^2
G. Sudan and Indian Ocean Islands			
Sudan	16,126	2,505,818	6
Comoro Islands	314	2,171	145
Malagasy Republic	8,266	587.041	14
Mauritius	895	2,045	438
Seychelles	59	280	212

[1] 1977 Statistical Yearbook. Department of International Economic and Social Affairs. United Nations. New York, 1978.

[2] To convert population per square kilometer to population per square mile, multiply population x 2.59.

able time period. These are local customs or ways of life of the villagers, some of which include:

- o Expectant mothers will return to their place of birth to deliver infants
- o Periodic repainting of walls and rethatching of roofs
- o Soot covered walls which reduce the effectiveness of residual spraying
- o Suspicions that operational crews are tax assessors
- o Sleeping out of doors
- o Evening gatherings which are held out of doors

C. Vector

Anopheles gambiae and A. funestus are the major transmitters of malaria in Africa. Whereas A. gambiae is widely distributed throughout Africa (Figure 3A), A. funestus is found predominantly in Ethiopia, Uganda and Madagascar. Six sub-species of A. gambiae have been identified in Africa[3]:

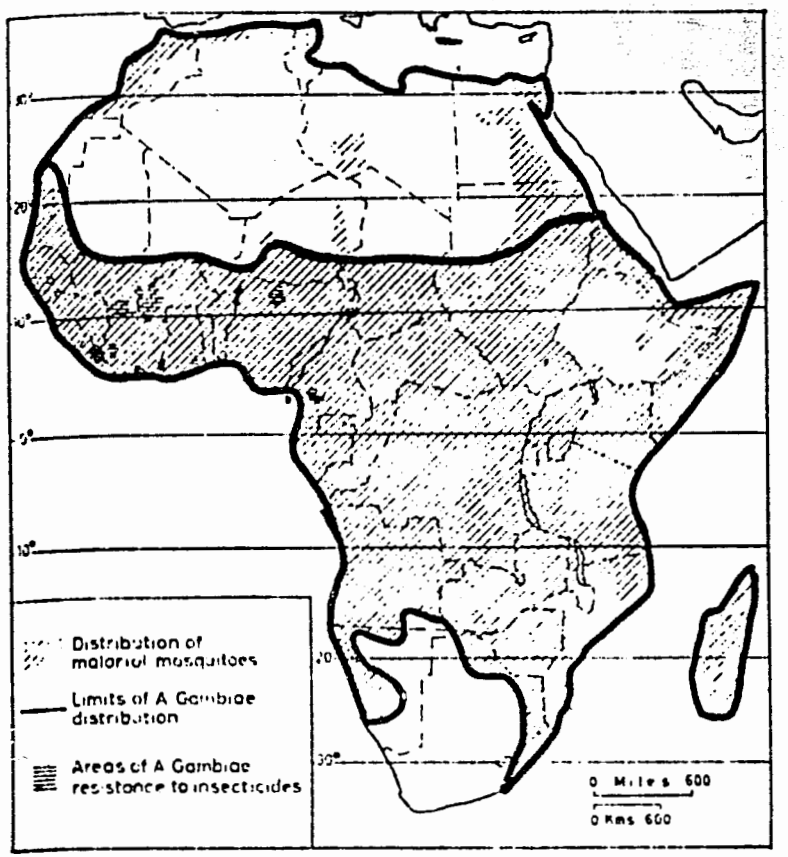
Fresh water sub-species

A
B - Widely distributed and the most important vectors

C - Discovered in South and East Africa

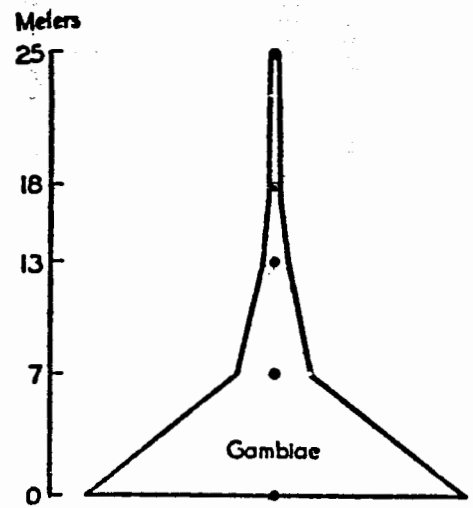
D - Discovered in Uganda

A



The distribution of malarial mosquitoes in Africa, the limits of *A. gambiae* and areas where vectors have shown resistance to residual insecticides. (Based on maps prepared by the Division of Malaria Eradication, World Health Organization.)

B



RELATIVE ABUNDANCE OF *Anopheles gambiae* AT DIFFERENT HEIGHTS IN THE MAMIRIMIRI FOREST, UGANDA, DURING THE WET SEASON. (REDRAWN FROM HADDOW, GILLETT, AND HIGHTON, 1947.)

Figure 3

Salt water sub-species

A. melas - Discovered in West Africa

A. merus - Discovered in East Africa

Anopheles is a highly adaptable species. Although A. gambiae prefers a more humid environment (Figure 3B), it can survive proicnged periods of drought.[4] As a result of residual spraying or lack of a preferential host the behavior of Anopheles can change from endophilic - anthropophilic to exophilic - zoophilic.[5]

Although mosquitos have a few natural predators[6], the control of mosquitos depends almost entirely on synthetic chemical pesticides. The pesticides DDT and Dieldrin have been used widely in malaria control programs. Both insecticides have been effective in controlling Anopheles in Africa, however, DDT has been reported to act as an excito-repellant in some areas in Sudan and East Africa.[7]

The continued use of insecticides for mosquto control has resulted in Anopheles showing reduced susceptibility to its effects.[8] The WHO Expert Committee on Insects noted that in 1976, 42 species of Anopheles were resistant to insecticide compared to 38 in 1968. Table 3 shows countries where resistance to insecticides has developed. It is important to note that resistance is found only in those regions with previous histories of malaria control programs.

With Anopheles showing increased resistance to DDT and Dieldrin, WHO initiated a Programme for Testing and Evaluating new insecticides for use in public health programs. The compounds listed in Table 4 were tested extensively and were found to be safe and effective for malaria control.

TABLE 3

Anopheles Resistance to Insecticides in Tropical Africa[1]

Anopheline Sub-Species	Resistance[2]	
	DDT and Dieldrin	Dieldrin
A. gambiae A	Benin, Cameroon, Empire Central Africa, Upper Volta, Nigeria	Congo, Ivory Coast, Gambia, Ghana, Guinea, Equatorial Guinea, Kenya, Liberia, Mali, Mauritania, Senegal, Sierre Leone
A. gambiae B	Senegal, Sudan, Swaziland	Ethiopia, Upper Volta, Kenya, Mauritania, Mozambique, Nigeria, Southern Rhodesia, Chad
A. funestus	-	Cameroon, Ghana, Upper Volta, Kenya, Nigeria
A. nili[3]	-	Ghana

1 Brengues, J. and Coosemans, M., Sensibilite et resistance des insectes aux insecticides en Afrique tropicale. WHO/VBC/77.680.

2 Resistance based on 15% survival at concentration of 4% DDT.

3 Susceptibility of anopheles to insecticides in "Notes and News", *WHO Chronicle* 29: 199-200. 1975.

TABLE 4

Insecticides[1] which are
Effective against Anophiline Mosquitos

Compound	Test Site	Results	References
OMS 1 (malathion)	S. Uganda	Spraying dose of 2 g/m^2 effective up to 4 months; more effective on thatch roof than corrugated iron roof.	Bull WHO 36: 913-935. 1967.
OMS 14 (dichlorvos)	Lagos, Nigeria	Liquid dispensers placed in huts; vapours were present after 3 months.	Bull WHO 29: 251-270. 1963.
OMS 33 (propoxur)	Kaduna, Nigeria	Spraying dose of 2 g/m^2 effective for 3-4 months.	WHO/VBC/68.108 WHO/VBC/69.113 WHO/VBC/69.128 WHO/VBC/69.135 Bull WHO 40: 67-90. 1969.
OMS 43 (fenitrothion)	Kano Plains, Nigeria	4 rounds every 3 months at a dose of 2 g/m^2 effective against *A. gambiae* and *A. funestus* .	WHO/VBC/72.391
OMS 43	Kisumu, Kenya	Effective for 6 months against *A. gambiae* and 10 months against *A. funestus*.	WHO/VBC/75.547 WHO/VBC/75.854
OMS 597 (Landrin)	Northern Nigeria	6 spraying rounds every 3 months (dose of 2 g/m^2) as effective as OMS 43.	WHO/VBC/68.104 WHO/VBC/69.113 WHO/VBC/75.597
OMS 33 (propoxur)	Garki District, Kano State, Northern Nigeria	3 spraying rounds at two monthly intervals proved effective.	WHO Chronicle 30: 286-289. 1976.

[1]The chemical composition of compounds can be found in WHO Techn. Rep. Ser. No. 356. 1967.

These compounds should receive initial consideration in areas where the vector population is resistant to DDT and/or Dieldrin.

The recent concern about insecticides and their effects upon the environment and increasing insecticide resistance suggest that biological control may be the only acceptable and reliable solution to vector control. In 1973, a National Academy of Science committee on technological innovation discussed the biological controls and advantages of their use in mosquito control. Their findings are summarized as follows:

1. Larvivorous fish - small size, diverse feeders, multiply rapidly, tolerate wide range use of temperature and salinity and moderate sewage pollution.
2. Invertebrate predators - mass reared and transported, cost competitive with chemicals, seek out small-container habitats.
3. Genetic Manipulation - specific for individual species; with continued use, the continued suppression using sterile or altered mosquitos may be more effective, economical and acceptable from an ecological standpoint.
4. Parasitic nematodes - *Reesimermis nielseni* can be easily cultured and maintained; are economical and have never been found to parasitize other organisms other than mosquitoes.
5. Parasitic protozoans - easily applied with equipment already in use in developing countries; can be stored for several months under moist, cool conditions; pathogens of mosquitoes appear to be host specific.

6. Parasitic fungi - most species of Coelomo-myces occur only in mosquitoes; can be used in combination with other mosquito control techniques.
7. Pathogenic bacteria - commercial production of Bacillus thuringiensis is available; can be used in combination with other control techniques; no indication that Bacillus is harmful to man or plants.
8. Juvenile hormone mimics - (insect growth regulators) - natural and synthetic chemicals which are biologically active at concentrations well below those of conventional insecticides; can be applied with standard equipment; compounds are biodegradable; can be used in conjunction with other control methods.

The application of these new biological control methods may require additional research in order to accommodate individual situations. For example, in Sudan, one species of Gambusia was very successful in reducing the number of mosquito larvae; a recent WHO communique sited that Gambusia affinis could not be established in Senegal. This merely points to the need to develop a more active species of Gambusia capable of surviving in Senegal.

Vector control is one of the most important ways of interrupting or reducing malaria transmission. Although biological control is possible and perhaps most desirable from an ecological standpoint, its effectiveness has not been tested. Efforts should be made to encourage research in biological controls so that control measures are practical and economical. For the present time, we must rely on those pesticides which

have proved effective against A. gambiae and A. funestus. The success of any chemical control method will depend upon:

- o Susceptibility of the species to the insecticide.
- o Measure of species resistance before, during and after control measures.
- o Continuous surveillance of vector for changes in behavior or host preference.

D. Parasite

The causal organism of malaria belongs to the genus Plasmodium. These are four species: falciparum, vivax, malariae and ovale. Plasmodium falciparum is the predominant parasite and is distributed throughout tropical Africa.[10] It also causes the most severe form of the disease. Plasmodium vivax is found most often in east Africa, Madagascar and Mauritius; P. ovale persists in east and west Africa and P. malariae is sporadically distributed throughout the continent.

Synthetic antimalarial drugs have been successfully used to prevent or to radically treat malaria. The most commonly used synthetic antimalarial drugs are listed in Table 5. Attempts to use anti-malaria drugs as the only method of intervention in malaria control/eradication programs, especially where the disease is endemic, have proved unsuccessful.

Different parasite species exhibit differences in virulence and response to drugs. P. falciparum requires higher doses for effective suppression than P. vivax. Treatment of acute attacks of P. falciparum also requires longer duration of drug therapy. Thus, the sensitivity of the parasite to the drug of choice and the duration of therapy should be

TABLE 5

COMMONLY USED SYNTHETIC ANTIMALARIAL DRUGS

Chemical group	*Name*	*Other names*
4 amino-quinolines	•Amodiaquine •Chloroquine	Camoquine Nivaquine, Aralen, Avloclor, Resochin
9 amino-acridines	Atebrin, Mepacrine, Quinacrine (no generally accepted name, all the same drug)	
8 amino-quinolines	•Pamaquine •Primaquine Quinocide	Plasmochin
Biguanides	•Proguanil •Chlorproguanil	Chlorproguanide, Paludrine, Lapudrine
Diaminopyrimidines	•Pyrimethamine	Daraprim, Malocide

SOME MIXTURES OF ANTIMALARIAL DRUGS

Name and approximate date of introduction	*Composition and dosage of combined tablets*	
'Chloroprim' (1958)	Pyrimethamine Chloroquine base	16·5 mg 200·0 mg
'Camoprim' (1957)	Primaquine base Amodiaquine base	15·0 mg 150·0 mg
'Daraclor' (1958)	Pyrimethamine Chloroquine base	15·0 mg 150·0 mg
'Lapaquine' (1957)	Chlorproguanil hydrochloride Chloroquine base	20·0 mg 150·0 mg

• Proposed International Non-proprietary Names.

Reference: Colbourne, M., Malaria in Africa. Oxford University Press, London, 1966.

determined for effective suppression of the infection.

Within the past five years, parasite resistance to antimalarials has developed in some areas in Burma, Vietnam, Brazil and possibly India.[12] The resistance is to 4-aminoquinolines and the dihydrofolate dehydrogenase inhibitors (DHFR).

Although earlier reports on the development of resistance to antimalarials in many parts of Africa[12] were not substantiated[13], there is current evidence that Plasmodium insensitivity to chemical prophylaxis is beginning to appear in East and West Africa. It was recently reported that two Americans who had traveled in North, Central, and East Africa suffered from malaria despite chemoprophylaxis with chloroquine phosphate (500 mg tablets) taken once a week before, during and after their visit.[14] Recovery was prompt with the administration of pyrimethamine or pyrimethamine plus sulfadiazine. Additional cases from Nigeria and East Africa have been reported in recent publications by the Center for Disease Control (CDC), Atlanta, Georgia, and the World Health Organization.

Confirmation of chloroquine resistant strains of P. falciparum has been accomplished by Dr. Chin of CDC (personal communication). The parasite was isolated from an American who had visited Tanzania. The resistant parasite was then used to infect primates and was grown in tissue culture; mild resistance to chloroquine was observed in primates and in culture.

The observed resistance to malaria has resulted in efforts to develop alternate methods of eliminating the infection. One method is

to use a combination of drugs,[15] i.e., sulfones or sulfonamides and DHFR inhibitors.

New antimalarials are presently being assessed.[16] Two of these include:

- Quinoline methanol - developed by the United States Malaria Research Program and released for limited use under the name of Mefloquine. Preliminary results look very promising.
- Co-trimoxazole - effective against bacterial infection but its efficacy in the treatment of malaria is equivocal.

The use of vaccines to eliminate smallpox and measles in endemic areas has been overwhelming successful in developing countries. Since 1966, A.I.D. has supported research for the development of a vaccine effective against malaria. Significant gains have been made in the areas of *in vitro* cultivation of the parasite and identification of the appropriate malaria immunogen. These research initiatives are necessary steps in the production of an efficacious vaccine.

E. Use of Pesticide for Agriculture and Water Development Projects

Many African countries depend heavily on agriculture for economic stability and for food production for the family. Africa possesses one third of the world's arid lands and approximated 60 percent of the continent is arid.[17] The drought in the Sahel during the early 1970's attest to the problems that exist in arid areas.

Modern technology has been instrumental in making the land more productive by using pesticide and implementing water development projects. In some areas, especially where cash crops are grown, pesticides are heavily used. Although export of pesticides by A.I.D. is meager, the U.S. government does export significant amounts of pesticides to African countries (Table 6). This may represent a minumum amount of pesticide usage since some African countries may purchase pesticides from other sources. To increase the productivity of arid lands, and to provide safe water to villagers, US.S/A.I.D. is also assisting many countries in water development schemes (Table 7).

The impact of previous pesticide use and existing and proposed water projects malaria control programs should be considered during the planning stages of all malaria control programs in Africa.

TABLE 6

U.S. Pesticide Exports by Destination and Value:
Total Exports in Calendar Years 1969-1974 Compared to AID-Financed Exports in Fiscal Years 1970-1975

Country	Total U.S. Exports ($000)							AID-Financed Exports ($000)							AID Share H/G
	CY 1969	CY 1970	CY 1971	CY 1972	CY 1973	CY 1974	Avg./ Year	FY 1970	FY 1971	FY 1972	FY 1973	FY 1974	FY 1975	Avg./ Year	
Column	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Africa															
Tunisia	NA	25	105	56	79	93	72	420	33	27	46	-	-	21	29.2%
Liberia	NA	129	139	82	77	89	103	1	-	-	-	-	-	Negl.	Negl.
Ghana	NA	55	29	13	158	150	81	7	-	-	24	4	-	6	7.4%
Nigeria	NA	NA	NA	19	81	642	247	2	-	-	-	-	-	Negl.	Negl.
Ethiopia	NA	56	673	199	656	623	441	1,175	756	552	470	1,397	871	809	100% +
Tanzania	NA	NA	NA	165	317	621	367	-	-	-	-	2	-	Negl.	Negl.
S. Africa	5,986	7,113	8,751	4,989	9,164	16,646	8,775	-	-	-	-	-	-	-	0%
All Others	balance	balance	balance	9,190	17,020	19,345	NA	-	-	-	-	-	5	1	NA
Total	14,237	17,573	19,952	14,713	27,552	38,209	22,039	1,605	789	579	540	1,403	876	965	4.4%

Reference: Environmental Impact Statement on the AID Pest Management Program. Volume 1 - Environmental Impact Statement May 13, 1977

TABLE 7

Water Development Projects[1]

Country	Number	Title	Purpose
A. West Africa			
Benin	680-0201	Rural Water Supply	To provide reliable and clean water to rural villages.
Togo	693-0214	Rural Water Resources Dev. and Management.	To increase the production of low-income farmers.
Togo	693-0210	Rural Water Supply and Sanitation	To provide safe and clean water for the rural populace.
B. Sahel			
Cameroon, Chad, Niger, Nigeria	625-0005	Lake Chad Basin Commission Institutional Development	To establish a planning unit for water resource utilization.
The Gambia, Senegal	625-0012	Gambia River Basin Dev.	Development program for the Gambia River Basin.
Senegal, Mali, Mauritania	625-0605	OMVS Agronomic Research II	Develop a capacity to carry out adaptive agricultural research.
Cape Verde, Chad, The Gambia, Mali, Mauritania, Niger, Senegal. Upper Volta	625-0932	Special Self Help Program	Village well-drilling, rice cooperatives.
Cape Verde	655-0003	Tarrafal Water Resources	Establish a regional irrigation program.
Cape Verde	655-0009	Watershed Management	A national watershed management plan.
Chad	677-0022	Rural Sanitary Water	Provide potable water to rural population by installing 500 small bore tube wells.

TABLE 7 cont. -2-

Country	Number	Title	Purpose
Mali	688-0202	Operation Mils	To increase agricultural productivity.
Mali	688-0204	Rural Works	Develop an effective community support system.
Mali	688-0206	Action Riz-Sorgho	To increase cereal production through improved technology.
Mali	688-0210	Operation Hauti Valee	Rural development program.
Mali	688-0213	Action Ble	To produce more cereals through co-operative irrigation systems.
Mauritania	682-0203	Rural Land Reclamation	Management and conservation of water resources.
Niger	683-0205	Niamey Department Rural Development	To increase food production.
Senegal	685-0208	Small Irrigated Perimeters	To introduce farmer managed irrigated crop production.
Upper Volta	686-0228	Rural Water Supply	To provide the rural poor with a water supply.
C. Equatorial Africa			
Cameroon	631-0012	Mandara Mountains Water Resources	To insure a year-round water supply.
Cameroon	631-0025	Mandara Area Wells	To provide safe year-round drinking water.
D. Southern Africa			
Lesotho	632-0088	Rural Water and Sani - tation	To install and maintain village water supply systems.

TABLE 7 cont. -3-

Country	Number	Title	Purpose
E. Eastern Africa			
Kenya	615-0172	Marginal Lands Development	To increase productivity and income of farmers in marginal areas through agricultural development plans.
Rwanda	696-0112	Fish Culture	To develop and maintain productive on-farm fish ponds.
Somalia	649-0104	Comprehensive Ground-water Development	To provide a safe source of water for Somalians and their livestock.
Tanzania	621-0143	Arusha Regional Planning and Village Development	Strengthen the villagers capabilities to implement development activities.

[1] Congressional Presentation, Fiscal Year 1980, Annex 1, Africa, Agency for International Development, Department of State.

F. Health Service Facilities

One of the major objectives of malaria control/eradication programs is to eventually integrate the principles and practices of vector-borne disease control into the permanent health delivery system. This proposal is based on the assumption that countries/regions have adequate health services: facilities, trained personnel, supplies, equipment and location of facilities so that they are accessible to the users. Table 8 gives the profile of expenditures for health and the number of hospitals and physicians for countries in Africa. Of the 27 countries reporting, eleven spent less than 5 percent, twelve spent between 5-8 percent and 4 spent between 8-11 percent of their total annual expenditures for health. The number of people per physician ranged from 2,000/1 in Djiboute and South Africa to 73,000/1 in Ethiopia*. Discrepancies in these figures would be due to inaccurate census information. For comparison, the population per physician in North American and European countries range from 363/1 in U.S.S.R. to 600-700/1 in the U.S.A., Sweden, England/Wales and Poland.

The number of health centers which include all health delivery facilities from hospitals to local dispensaries is insufficient to provide preventive care or proper malaria surveillance activities for the populace especially in rural areas. Moreover, numbers alone give no indication of the quality of service. Thus, the role and capabilities of health delivery systems in malaria control programs should be carefully assessed if they are to be included in the malaria control program.

(*Mali was exceptional in that it reported health expenditures of 10.9% of the budget, 3,623 health centers and 54 hospitals).

Table 8A

Health Expenditures, Personnel and Facilities
in
West Africa

		Health Expenditures				Facilities-Personnel			
Country	Reporting Year	Health Budget in U.S. $ (x10[6])	% of Total Expenditures	Expenditures per person	GNP per Capita[3]	No. Hospital	No. Health Center	No. Physicians	People per Physician
Benin	1974	6.3	10.5	$1.90	$130	54	312	95	36,000
Ghana	1973	29.1	5.7	2.83	580	243	48	981	11,000
Guinea	1967	.006	4.3	0.01	150	35	48	142	22,000
Guinea-Bissau	1969							30	18,000
Ivory-Coast	1970				610	56	204	252	21,000
Liberia	1970	4.0	4.8	2.22	450	32	300	132	13,000
Nigeria	1974	33.4	1.2	0.52	380			3,615	26,000
Sierre-Leone	1974	6.2	6.0	2.00	200	28		97	12,000
Togo					260	18	226	95	21,000

[1]African Statistical Yearbook. 1975 Part 2 (West Africa), Part 3 (East Africa). Economic Commission for Africa. United Nations. 1976.
African Statistical Yearbook 1976. Part 1 (North Africa) Part 4 (Central Africa). Economic Commission for Africa. United Nation. 1977.
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[2]1973 Constant dollar equivalents

[3]World Development Report, 1978. The World Bank, Washington D.C., August 1978.

[4]Comparable numbers for America and Europe are: United States- 622; Sweden-645; England/Wales-761; Poland-592; U.S.S.R-363.

Table 8B
Health Expenditures, Personnel and Facilities
in
Sahel

Country	Reporting Year in U.S. $ ($x10^6$)	Health Expenditures				Facilities-Personnel			
		Health Budget	%of Total Expenditures	Expenditures per person	GNP Per Capita	No. Hospital	No. Health Center	No. Physician	People per Physician
Cape Verde	1969							13	19,000
Chad	1971				120	5		63	44,000
Gambia	1974	1.2	6.7	2.20	175[1]	5		19	19,000
Mali	1970	4.4	10.9	0.77	100	54	3,623	121	39,000
Mauritania	1971				340	6		68	18,000
Niger	1973	4.6	6.5	0.97	160	57		97	41,000
Senegal	1973				390	93		287	14,000
Upper-Volta	1973	4.3	8.2	0.71	110			96	60,000

[1] Reporting year was 1974

Table 8C
Health Expenditures, Personnel and Facilities
in
Equatorial Africa

Country	Reporting Year	Health Expenditures: Health Budget in U.S. $ ($x10^6$)	Health Expenditures: % of Total Expenditures	Health Expenditures: Expenditures per person	Health Expenditures: GNP Per Capita	Facilities - Personnel: No. Hospitals	Facilities - Personnel: No. Health Center	Facilities - Personnel: No. Physicians	Facilities - Personnel: People per Physician
Cameroon	1972				290	88		279	26,000
Central Africa Republic	1971				230	48		49	27,000
Equatorial Guinea	1967							5	62,000
Gabon	1971				1,341	52		96	5,000
Zaire	1974	30.0	1.8	1.17	140			818	29,000

1 Reporting year was 1974

Table 8D
Health Expenditures, Personnel and Facilities
in
South Central Africa

Country	Reporting Year	Health Expenditures: Health Budget in U.S. $ ($x10^6$)	Health Expenditures: % of Total Expenditures	Health Expenditures: Expenditures per person	GNP per Capita	Facilities - Personnal: No. Hospital	Facilities - Personnal: No. Health Center	Facilities - Personnal: No. Physicians	Facilities - Personnal: People per Physician
Malawi	1974	3.7	3.3	0.72	140	93	370	104	38,000
Mozambique	1970	16.7	2.9	1.77	170	116	643	498	16,000
S. Rhodesia	1974	35.0	4.4		422[1]			860	6,000
Zambia	1974	44.4	0.5	8.69(?)	440	82	639	527	8,000

1 Reporting year was 1974

Table 8E
Health Expenditures, Personnel and Facilities
in
Southern Africa

Country	Reporting Year	Health Expenditures: Health Budget in U.S. $ ($x10^6$)	Health Expenditures: % of Total Expenditures	Health Expenditures: Expenditures per person	GNP per Capita	Facilities - Personnel: No. Hospital	Facilities - Personnel: No. Health Center	Facilities - Personnel: No. Physicians	Facilities - Personnel: People per physician
Botswana	1973	2.9	3.4	4.15	384	12		44	10,000
Lesotho	1974	1.4	4.5		170	19	83	50	20,000
South Africa	1973				1,340			12,060	2,000
Swaziland	1972				337	11	56	52	9,000

1 Reporting Year was 1974

Table 8F
Health Expenditures, Personnel and Facilities
in
Eastern Africa

Country	Reporting Year	Health Expenditures: Health Budget in U.S. ($x10^6$)	Health Expenditures: % of Total Expenditures	Health Expenditures: Expenditures per person	Health Expenditures: GNP per Capita	Facilities - Personnel: No. Hospital	Facilities - Personnel: No. Health Center	Facilities - Personnel: No. Physicians	Facilities - Personnel: People per Physician
Burundi	1975	2.3	5.6	2.65	120	18	126	91	49,000
Djibouti	1975					11		52	2,000
Ethiopia	1972	0.4	6.9	0.02	100	85	742	350	73,000
Kenya	1974	0.4	1.3	0.03	240			1,242	16,000
Rwanda	1975	3.6	7.7	0.83	110	26	167	112	54,000
Somalia	1973	4.6	7.3	1.40	110	24[1]	174	193	16,000
Tanzania	1973				180	236	1,555	726	28,000
Uganda	1971	14.5	1.0	1.22	240	23		1,117	21,000

2
Reporting year was 1966

Table 8G
Health Expenditures, Personnel and Facilities
in
Sudan and the Indian Ocean Islands

		Health Expenditures				Facilities - Personnel			
Country	Reporting year	Health Budget in U.S. $ ($x10^6$)	% of Total Expenditures	Expenditures per person	GNP per Capita	No. Hospital	No. Health Center	No. Physicians	People per Physician
Sudan	1975	11.5	1.8	0.71	290	122	138	1,349	12,000
Comoro Islands	1972							21	14,000
Madagascar	1973	11.5	4.9	1.39	200	186[2]	558[2]	687	11,000
Mauritius	1972	5.0	7.3	5.59	414	33	139	271	4,000
Seychelles	1969							21	3,000

[1] Reporting year was 1974
[2] Reporting year was 1966

Each countries economic situation should be considered before embarking upon a malaria control program. The per capita income of most African countries south of the Sahara is between $100 and $600 (Table 8). The figures on per capita income in most of the Middle Income Countries (per capita greater than $250) are deceptive, for with few exceptions these are actually poor countries with mineral enclaves employing only a small fraction of the work force (World Development Report, 1978, The World Bank, Washington, D.C., August 1978). Of the 37 countries reporting gross national product (GNP) per capita, one-third had GNP per capita of less than $200. The amount of expenditures for health per person varied from less than $0.02 to $5.59. The majority of the countries spent between $1-$2 on health care per person. It was estimated that in the Kisumu area of Kenya, the yearly cost for a malaria control program would be $3-$4 per capita (Report of Consultants - Africa Malaria, Office of Health, (TA/H), Agency for Internaitonal Development). Thus, most countries will have to increase their health expenditures tremendously to accommodate a comprehensive malaria control program.

G. Trained Personnel/Training Facilities

The need for trained personnel at all levels of malaria control programs cannot be over emphasized. One of the major reasons sited for the failure of previous eradication/control problems was lack of trained personnel. The human resources needed for control activities include:

1. Professionals

   Program Administrators/Advisors

   Malariologists

   Epidemiologists

   Medical Doctors

   Environmental Sanitation Engineers

   Sociologists

   Entomologists

   Ethnologists

2. Technical Personnel

   Business Manager

   Laboratory technician

   Clerks

   Spraymen

   Communication Specialists

   Public Relations/Education Specialists

   Health Education Advisor

3. Support Personnel

   Supply/Stock personnel

   Truck Drivers

   Mechanics

   Typists

Training for these professionals may require years or months depending on the level of competency. Periodic refresher courses are also necessary as new or improved equipment, techniques or chemicals are introduced.

Presently there are no comprehensive teaching facilities in Africa for training individuals in malaria control activities. In an attempt to increase the number of skilled personnel, WHO in September 1977 organized a francophone postgraduate Public Health Course with emphasis on malaria and parasitic diseases in Cotonou, Benin.

Training for junior and senior level personnel should be readily available on the continent and should be relevant to the malaria problems in Africa. Moreover, since about one-third of the U.S./A.I.D. assisted countries are French speaking, training courses should be taught in English and in French.

The World Health Organization keeps an updated inventory of African research institutions involved in research and training in tropical diseases. Since some of these institutes have malaria research programs, trained experts should be readily available. Table 9 lists five French and twelve English institutions with research and training capabilities in malaria. The use of these resources and facilities for training in malaria control should be explored and encouraged. Several of these institutions are geographically located so that consortium agreements are possible; this would undoubtedly provide an excellent environment for training.

Presently, there are several assistance programs within A.I.D. which may be utilized to train professionals and support personnel and to educate the general public about malaria control (Table 10). These programs could be expanded to contain education components specifically for malaria. It would also be economical in that these programs have

African Research Institues with Potential Capabilities for Malaria Training Programs[1]

French

1. Cameroon, Yaounde[1].
Institute de Rechercher Medicales et de plantes medicinales
(Scientific staff of 55)

2. Cameroon Yaounde[1].
Institute de Rechercher Scientique du Cameroun
(Scientific staff of 32)

3. Cameroon, Yaounde[1]
Organization de Coordination pour la Lutte Contre les Endemies en Afrique Centrale
(This institues has a one year training program for health workers in several areas)

4. Upper Volta, Bobo-Dioulasso
Centre Muraz
(Scientific staff of 18)

5. Upper Volta, Bobo-Dioulasse
Mission Entomologique aupres de l'OCCGE

English

1. Nigeria, Ibadan
Faculty of Medicine
University College Hospital

2. Nigeria, Lagos
Federal Malarial Service

3. Nigeria, Zaria
Ahmadu Bello University
Department of Medicine
(Scientific staff of 40)

4. Sudan, Khartoum
Institute of Research for Tropical Medicine (Scientific staff of 15)

5. Sudan, Kartoum
Malaria Control Service

6. Sudan, Khartoum
Medical Research Council

7. Sudan, Khartoum
National Council for Research

8. Sudan, Omdurman
Hospitan for Tropical Diseases (run jointly by the Ministry of Health and the National Council for Research)

9. Tanzania, Amani
East African Institute for Malaria and Vector-Borne Diseases
(Scientific staff of 9)

10. Tanzania, Arusha
East African Medical Research Council

11. Tanzania, Arusha
East African Tropical Pesticides Research Institute)Scientific staff of 12)

12. Tanzania, Dar-es-Salaam
Faculty of Medicine, Univ. of Dar-es-Salaam

[1] Special Programs for Research and Training in Tropical Diseases, WHO L/76.46.

Table 10
U.S./A.I.D. Education/Training Programs Which Could Be Expanded to Include Malaria Components

Project			
Country	Number	Title	Purpose
Cameroon	631-0009	Practical Training in Health Education	To establish a training system of health education which responds to the needs of the rural population
Cameroon	631-0016	Medical System for Cameroon	To develop and implement a nationally coordinated practical training system of health education activities responding to the needs of the rural population
Cameroon	631-0007	Social Science	(1) To develop a center for economic and social science research in Cameroon and (2) to carry out research and to collect and disseminate socioeconomic data for development programs in North Cameroon
Ethiopia	633-0188	Institute of Management and Training (IMT)	To improve the IMT's capability to analyze organizational reform and administrative training requirements, and to improve its capacity to conduct management training for more rapid expansion of government development programs
Ethiopia	633-0189	Non-Formal Education	To establish an adult education system enabling local communities to develop civic responsibility and to improve skills related to functional literacy, health and agriculture practices, cottage and small industry, and general community needs

Ethiopia	633-0213	Life Integrated Family Education II.	To assist urban and rural dwellers associations to deliver integrated nonformal education services to their members; train local leaders in providing nonformal education to adults.
Ghana	641-0088	Community Health Team Support	To establish a post-graduate level program in community health within the Ghana Medical School in order to provide the number of trained physicians necessary for an effective rural health delivery system
Guinea	657-0003	Primary Teacher Training	To support the government Guinea-Bissau to expand its capacity to train primary school teachers, and to improve the quality of instructions in primary teacher training schools
Liberia	669-0153	Rural Development Training	To train mid-level agricultural workers in agriculture management and rural development to effectively manage farm related projects and transfer agriculture technology, methods, knowledge to small farmers.
Liberia	669-0134	Rural Learning Delivery System	To develop a system of distance teaching which enhances the quality of life of rural populations not reached by the formal school system
Tanzania	621-0150	Tanzania School Health Program	To assist the Tanzania government achieve institutional capacity to provide comprehensive school health services to school-age children as an integrated part of the Rural Development Program.

Tanzania	621-0154	Continuing Education Center for Health Workers	To provide comprehensive continuing education to all health workers, including those paramedicals whose initial training has been in a narrow but highly technical specialty

already been implemented in seven countries where malaria is still considered a major health problem.

Efforts should also be made to increase the participation of Peace Corps volunteers and students (graduates and post-graduate) in medicine, public health, and tropical diseases in malaria control activities abroad. This kind of cooperation is of obvious mutual benefit.

There are several aspects of malaria control programs that have not been discussed in this report; these omissions in no way suggest their irrelevance in control programs. These areas are:

- Responsibility of the host government for legislative, financial and moral commitment to malaria control programs.
- Cost/benefit of using a particular method of malaria intervention.

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Epilogue

With few exceptions, the status of malaria control in Africa is not very different from what it was twenty-seven years ago when Balfour published what he thought was necessary in order to solve this problem in Africa.[1] His suggestion which are still valid today were:

- Objectives of the plan must be clear and definite, and they should have prospects of realization.
- The personnel needed for it must be competent, qualified, and, above all, available.
- The environment of the plan must be favourable for its realization. In other words, a need for the plan must be either felt by the population concerned or it must be created.
- Sufficient time must be realized for the job and there must not be too much pressure for immediate results.
- There must be adequate funds to carry out the plan, remembering that long term projects have considerable financial implication.

Some contemporary additions to these original ideas are:

- Correct identification of vector species
- Proved susceptibility of the vector and parasite to control measures
- Trained staff should include, preferably, host nationals at every position level
- Continued research in vector biology and behavior

1Balfour, M., "Administrative problems in connection with aid to Underdeveloped areas", Problems in High Fertility in Agrarian Societies. 1952 Milbank Memorial Foundation. New York, New York.

- Malaria control plans which are specific for each area based on climate, geography, local customs and migratory patterns of residents. It is also important to note that in the most recent report from Bendel State in Nigeria, an area which represents four ecological strata (rain forest, savanna, periurban and mangrove areas) there were entomological differences among the anopheline fauna in houses in the different ecological strata (WHO/Nigeria Malaria Field Research Project, (IRP/MDP/012) Technical Report, January - April, 1977). Thus, each ecological area represents a unique microenvironment.

The success of any country's malaria control program will depend upon how effective that country is in maintaining its malaria-free condition. Thus, the malaria situation in surrounding countries and surveillance of its borders are of primary importance. WHO, in realizing the problems involved with malaria control in Africa, has proposed an inter country control program to deal with potentially malarious situations in urban centers and economic development zones (AFR/MAL/154/1977). The proposal for a regional antimalarial program was set forth in which ecological, epidemiological and socioeconomic factors were considered. The program was constructed as a three-tiered system: (1) prevention of mortality and attenuation of suffering and incapacity, (2) reduction of incidence and prevalence and (3) eradication of malaria. The document presents a model plan for the first two levels only.

For the first level - "prevention of mortality and attenuation of

suffering and incapacity due to malaria" - the treatment would be immediate treatment of all febrile cases with a single dose of chloroquine of 10 mg per kg of body weight. The effectiveness of this action requires that someone locally be responsible for recognizing the symptoms and administering the proper dosage.

The second level - "reducing the morbidity rate in vulnerable groups and the prevelance in communities of economic importance" - requires commitment of funds at the national level to continue a long term program. Each government's plan would take into consideration its own priorities. The responsibility for common areas, such as ports, international airports, rural savanna or forest zones and development projects would be protected by those countries affected. Thus, countries sharing those areas would have similar epidemiological situations and would benefit greatly by cooperating in control programs. Appropriate measures are enumerated in this proposal for malaria control in the areas mentioned above. WHO would play a vital role by coordinating these efforts at the sub-regional level.

If malaria is to be controlled in Africa, it must be very soon. There are many factors which have a negative or potentially negative impact on malaria control. These are:

- o Increased resistance of vectors to insecticides in other areas of world; there is no reason to believe that Africa will be unique.
- o Increased use of insecticides for agriculture heightens the possibility of resistant vector strains

- Potential resistance of *Plasmodium falciparum* to antimalarials.
- Reluctance on the part of industry to develop new pesticides or antimalarials
- Reluctance to use pesticides for environmental/ecology reasons
- Increased cost of pesticide and antimalaria drugs because of inflation

A successful control program will mean an increase in the population because of the increased number of live births and a decrease in the overall death rate. In time more people will mean additional food, schools, jobs and housing. Therefore countries should implement positive measures to control population growth and anticipate providing the necessary amenities to its growing population.

V. Acknowledgements

I would like to thank Dr. Clifford Pease for affording me the opportunity to experience "life" in the Office of Health, Agency for International Development, Department of State. Mr. Edgar Smith's and Dr. James Erickson's enthusiasm for this project was the force which motivated me to accept this assignment. Ed and Jim were extremely helpful in providing resources, suggestions and discussions during all stages of this project. I, however, take full responsibility for for any deficiencies in this report.

A special thanks is due the A.I.D. librarians who were patient and helpful in responding to my many demands. Many thanks to Mr. David Scheid whose competence and care makes this document readable; may those same qualities continue to be an integral part of him when he attains his professional career objectives.

The offer to work on the malaria project was extremely compatible with the need to utilize my scientific background and familiarity with the health problems in Africa via my Peace Corps experiences. I have enjoyed this project and, in optimism, hope that it will be tremendously helpful to those for whom it is intended.