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MALARIA CONTROL IN ZANZIBAR: APPRAISAL OF PRESENT CONDITIONS DISCUSSION OF ALTERNATIVES

February 15 - April 15, 1989

by

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1. EXECUTIVE SUMMARY

The current USAID-sponsored Zanzibar Malaria Control Project (ZMCP) began in 1981, although actual operations did not start until 1984. Agency for International Development (A.I.D) support will end in September 1989. The goal of the program was to control malaria to a level where it no longer would be a major public health problem and the Government of Zanzibar (GOZ) would be able to maintain effective control using its own resources. Malaria has continued to be a leading cause of morbidity and mortality throughout the life of the project and that goal has not been achieved.

The pessimistic impression of the Project given by many has had a devastating effect on all aspects of the program. It is difficult to quantify the effect that the numerous restraints beyond the immediate control of the ZMCP have had on the Project's progress, but it certainly has had a negative influence on staff morale.

Besides numerous administrative problems, antimalarial drug and DDT resistance have contributed to the limited progress. It has been impossible to obtain two spray cycles a year with a high level of coverage because of shortages of insecticides and vehicles and poor scheduling of activities. In addition, an unknown number of houses were missed or left unsprayed due to refusals. The Project's inability to maintain a schedule has resulted in an extremely poor quality of vector control and continued malaria transmission. Given this history of spraying operations, it is doubtful that the ZMCP could be mobilized for effective use of alternative insecticides, which require much more precise planning and implementation than DDT.

DDT resistance is widespread on both islands and there is good evidence that it has been present throughout the life of the project. Further use of DDT is not recommended. If residual wall spraying is continued, malathion is the preferred alternative candidate because of overall efficacy, safety and cost. Insecticide susceptibility tests done with World Health Organization (WHO) test kits showed <u>Anopheles gambiae</u> to be susceptible to malathion in Unguja and Pemba. Past experience with people refusing to allow their houses to be sprayed with malathion due to its odor indicates that extensive health education will be needed. Fenitrothion would be the best second choice, but is more toxic to man and more expensive. Because of the potential for using synthetic pyrethroids to impregnate bed nets, these insecticides are not recommended at this time for residual spraying.

Besides the cost of the alternative insecticides, additional funds will be needed for storage and packaging of insecticides, protective clothing, training of all staff handling the insecticide and supervision. Before island-wide coverage can be recommended, field trials will be necessary to demonstrate the efficacy of the alternative insecticide under conditions found in Zanzibar and to develop the operational strategy required to guarantee that a spray cycle will be completed in two months.

The ZMCP has attempted to initiate many of the recommendations of consultants in the past, but has not followed through, as demonstrated by the numerous geographical reconnaissance (GR) starts. If the past is any indication, current attempts to complete a GR, improve entomological and epidemiological monitoring and establish an insectary will fail. The major reason for past failures has been the unavailability of necessary equipment and supplies and the inability to make long-term plans because of these shortages.

From a technical point of view, five years with an irregular flow of insecticides and commodities, including fuel for vehicles, is insufficient to achieve the goals stated in the Project Paper. It is doubtful that the GOZ has the money, particularly the foreign currency, to continue vector control after termination of A.I.D support. Consequently, the possibility of further donor assistance should be explored if the GOZ decides to continue vector control efforts.

Initial collection and analysis of geographical, climatological, socio-cultural-economic, housing, GR, entomological, epidemiological, antimalarial drug resistance and other data will be necessary before much more can be done with malaria stratification. Strategies of control already differ between urban and rural areas. The increase of irrigated rice will produce greater vector populations and if people migrate into these areas, additional malaria transmission is likely to occur. Vector control directed against this type of larval habitat will be difficult, and improved diagnosis and treatment may be the best approach. Bed nets impregnated with a synthetic pyrethroid may be an option in the future, but should not be considered until there is solid evidence that the nets lower malaria transmission. However, the use of these nets for field trials should be encouraged. There are fewer cases of malaria in the south of Unguja and many of these cases might not be malaria. If only a portion of Zanzibar is to be treated with insecticides, the south could be dropped from the program and handled through improved diagnosis and treatment of malaria.

All options available are related to the GOZ's budgetary restrictions. The most logical option would be to strengthen basic health services and concentrate on the improvement of rapid diagnosis and effective treatment of all cases of malaria,

with an emphasis on treating pregnant women, infants and small children, as outlined in WHO Tactical Variant No. 1 (See Annex G). This option will require additional parasitological laboratories and malaria agents at some health centers, quality control in reading blood films in all laboratories, better distribution of first- and second-line antimalarial drugs, improved standard treatment procedures and handling of severe clinical malaria, constant monitoring of antimalarial drug resistance and better epidemiological information. It is evident that this option will require money, time, additional staff and commodities before it becomes effective and efficient. Unfortunately, even this option may be impossible for the GOZ to implement without donor support.

The ZMCP has a core of highly trained people that should not be disbanded. Regardless of the option selected, the ZMCP is needed for expertise in parasitology, entomology, malaria epidemiology, monitoring, supervision and evaluation of the option.

2. INTRODUCTION AND BACKGROUND

2.1 General information

In response to a request from the Zanzibar Malaria Control Programme (ZMCP) and USAID/Tanzania, the Vector Biology and Control Project (VBC) provided technical assistance to the ZMCP from February 15 to April 15, 1989. The team consisted of two entomologists/vector control consultants from the United States and an entomologist from the Faculty of Medicine, University of Dar es Salaam, Tanzania.

The request for technical assistance was in response to recommendations made by an A.I.D. Internal Review Team to improve the activities of the ZMCP. The teams' terms of reference were jointly approved by the Government of Zanzibar (GOZ) and USAID/Tanzania. Certain changes were made as a result of further discussions with VBC, USAID/Tanzania and ZMCP staff members.

This report is based an observations made in Unguja and Pemba, review of current activities of the ZMCP, review of existing documents associated with the program and discussions with the staff of the ZMCP and other GOZ officials.

2.2 Objectives and Terms of Reference

The objectives outlined in the consultants' employment agreement are:

a) Assist in the establishment of a system to monitor insecticide resistance through insecticide susceptibility tests and bioassays using World Health Organization (WHO) test kits.

b) Evaluate existing insecticide resistance data and assist the GOZ/ZMCP and USAID/Tanzania in the selection of a new insecticide.

c) Evaluate appropriate chemical and non-chemical vector control measures in rural and urban areas of Zanzibar.

d) Assist in the development of a geographical reconnaissance and surveillance program for malaria control efforts.

e) Assist in the development of an insectary.

f) Assist in the organization and training of operational staff to conduct entomological surveys adapted to the current malaria control needs of Zanzibar.

The other activities assigned following discussions between USAID/Tanzania and the ZMCP held in Zanzibar on March 17-18, 1989 are:

a) Develop methods aimed toward beginning stratification of malaria control.

b) Evaluate the ZMCP Plan of Operation for 1989-1990 and develop guidelines for a contingency plan.

c) Assist in the identification and development of technical links with operational and research facilities in Tanzania.

d) Define the potential impact of agricultural development (irrigation and pesticide use) on future malaria control activities.

The short period of the assignment, lack of mosquitoes because of the dry season, deadlines for procurement of commodities and impending termination of donor support limited the effectiveness of the team's activities.

2.3 Background

2.3.1 Geographical

Zanzibar is composed of two large islands, Unguja and Pemba, and several smaller islands. Unguja has an area of about 1,658 square kilometers and Pemba an area of about 984 square kilometers. Both islands are located off the northeastern coast of the mainland. Pemba lies about 25 miles northeast of Unguja. Transportation between and within the islands is difficult.

Since the two islands have fairly fertile soil, agriculture is the principal industry. On relatively flat Unguja, the northern and central districts have more vegetation and are more suitable for agriculture and irrigation. The southern district is primarily coral, which may form rock holes for larval habitats. The southern part has fewer trees except along some of the coast. These geographical conditions might contribute to the lower number of malarial cases in the south.

Pemba has more pronounced hills and valleys. There are coastal plains, particularly in the north beyond Wete. Both islands have areas below sea level where drainage is difficult. Mangrove swamps occur on Pemba and Unguja, but An. merus appears to be confined only to Pemba.

2.3.2 Climate

Zanzibar has a hot, humid tropical climate, which is conducive to producing large populations of anophelines. A northeast monsoon brings hot, humid weather with rains beginning in October and generally ending in December. This year, however, the rains continued into the early part of February.

The hottest weather occurs from December to the latter part of March. There is little rainfall and many larval habitats become dry. The long, or Masika, rains begin in mid- to late March and end in mid-May to early June. Between June and August, it is fairly dry. In September, the winds increase and rain showers occur.

The amount of rainfall varies in areas of both islands. The average annual rainfall is 61.02 inches on Unguja and 75.9 inches on Pemba. In Zanzibar Town, it is 60.4 inches, with a range from 27.5 to 111.9 inches (see table 1, Annex A). The meteorological office at the Zanzibar Airport has climatological records from several weather stations on both islands.

Mosquito breeding increases shortly after the rains begin. The adult mosquito population peaks from two to four weeks before malaria cases peak.

2.3.3. Demography and Housing

The total population of Zanzibar is about 600,000. Most of the people live on Pemba and Unguja, but a number of smaller islands are also inhabited. Pemba has a population of about 250,000, with three fairly defined population centers, Chake Chake, Wete and Mkoani. The rural population is most dense along primary and secondary roads and there are some large villages, such as Micheweni, in the north. The ZMCP considers the entire island to be rural and designates all houses to be sprayed with residual insecticides.

The population of Unguja is over 325,000. Almost 50 percent of the people live in Zanzibar Town and its urban-rural fringe. The majority of the rural population is found close to primary and secondary roads, particularly in the north and central areas. Housing in the south also is clustered along the road, especially in coastal areas. The clustering of rural houses encourages

people to socialize out of doors for several hours during the evening and early night, exposing them to bites from exophagic mosquitoes.

About 77 percent of the population of Zanzibar is younger than 35, with children younger than four comprising almost 20 percent and dependents (15 years or younger) about 50 percent of the population. The extremely large proportion of young people contributes to the seriousness of malaria.

The majority of the houses in rural areas are made of mud walls with thatched roofs. However, some houses are made of cement walls and metal roofs and this type of construction is increasing. People continually replaster, repair mud walls and rethatch roofs, usually immediately before and during the early stages of the long rains. As a result, many sprayable surfaces may become ineffective during the period when insecticide action is most critical.

On the southern and eastern coast of Unguja, a large number of houses are constructed with pieces of coral joined together with either mud or cement. This type of construction is fairly common in other areas of Zanzibar.

Most houses do not have ceilings and many have high roofs, especially in Pemba. The texture and chemical composition of materials used to construct some walls may reduce the duration of effectiveness of insecticides and the height of the roofs makes complete coverage of all sprayable surfaces difficult.

2.3.4 Social and Economic Development

Zanzibar's economy is dependent on cloves, which account for 90 percent of its exports. About 70 percent of the total labor force is employed in agriculture. A UNDP-FAO project has about 500 hectares under irrigation for rice and could increase this to about 5,000 hectares. This may create malaria problems as larval habitats increase. As yet, few insecticides are used in the irrigated rice, but some malathion has been used in agriculture.

Over the past ten years, economic development has been stagnant and real growth of the economy negative. During the 1980s, the Gross Domestic Product fell from 979 million to 714 million shillings, using 1976 prices. As a result, government financing has not been expanding because of lack of funds. Food stuff accounts for more than 50 percent of total imports and Zanzibar has accumulated a large external debt. The inflation rate in 1987 was 39 percent, which also has a negative effect on the national debt.

The government is emphasizing the development of an economic infrastructure and has implemented an Economic Recovery Program to improve the financial situation. However, priorities including improvement of agriculture to a level of self sufficiency and improving roads, electricity, water supply, telecommunications and other essential public utilities, as well as other health services, will compete with the ZMCP for limited funds (57).

Even though the GOZ is optimistic about the future, socio-economic development will be slow and large expenditures of foreign currency for insecticides probably will not be given a high priority. (Some countries exchange products for insecticides. Since Zanzibar has a surplus of cloves, this possible means of obtaining insecticides could be explored.)

2.3.5 The Vectors

There are a number of anopheline species found on Pemba and Unguja. For malaria control, *An. gambiae* and *An. arabiensis* are considered the most important. These species are not separated by morphology. Consequently, separating them to determine exophilia, bloodmeal source, resting habits, sporozoite rates, insecticide resistance and other factors concerned with malaria transmission is difficult.

The final report of the WHO/UNICEF/GOZ Malaria Eradication Program (44) includes information about vector biology, ecology and distribution. The 1989/1990 ZMCP Plan of Operations updates the information (57). Dr. Lines of WHO and other investigators are collaborating with the ZMCP on special research on the species.

A summary of some observations on *An. gambiae* follows: *Anopheles gambiae* breed in standing water bodies that are exposed to sunlight. On Zanzibar, these include large open swamps, shallows and backwaters of rivers or any other collection of groundwater (15). Rice fields are now being established in low, flat areas and can be expected to increase. *An. gambiae* and *An. arabiensis* breed in rice fields until the plant cover is sufficient to shade out direct sunlight to the water surface.

Anopheles gambiae are strong fliers compared to many other species of the genus. When atmospheric conditions are favorable, flights of ca. 7 kg have been recorded within an angle of 80 degrees leeward (7 and 1) and flights of 2.4 km within an angle of 60 degrees into the wind have been observed (7). This high flight capacity and the relatively small sizes of Pemba (64 x 23 km) and Unguja (87 x 39 km) indicate that populations can intermix over a high percentage of the total area of either island.

Female An. gambiae show a constant mortality rate independent of their age, at least during the first few weeks of adult life (9 and 14). Thus, infected females do not die at a greater rate than nulliparous ones.

2.3.6 Health Services

The ZMCP is under the Director of Preventive Health Services, whose administrative jurisdiction also includes rural health services, health education, epidemiology and disease control, maternal and child health/Expanded Program of Immunization, family planning and the new AIDS program.

Currently there are 111 operating health centers and units, a number that increases yearly. These health facilities are classified as hospitals, rural-based cottage hospitals, maternal and child health clinics, and dispensaries or health centers run by the MOH. There are eight health units managed by the armed forces or by religious institutions. Provision for basic health services has been strengthened by primary health care workers and malaria agents. A summary of the health centers is provided in Annex A table 2.

All health facilities use medical strokeforms to collect epidemiological data, but many of the forms are not returned in time for statistical processing. Parasitological diagnosis of malaria is done at hospitals, cottage hospitals and the ZMCP headquarters at Unguja and Pemba. The last Health Information Bulletin (February 1989) showed malaria to be the most common diagnoses in Zanzibar during July-September 1988.

Age	Percent
0 - 4 years	41.1
5 -14 years	35.7
15 - years	33.5
Overall	36.5

2.3.7 History of Malaria Control

Technical assistance from WHO began in June 1957 with pre-operative malaria surveys. In 1958, WHO/UNICEF/GOZ signed a plan of operation agreement, and residual spraying with dieldrin at 0.8 g/m^2 began in April. Later dieldrin was replaced by DDT at 2 g/m^2 Baseline data showed the prevalence rate in two- to nine-year-old children to be 84.3 percent in Unguja and 68.4 percent in Pemba.

In addition to residual insecticides, the project used drug treatment, chemoprophylaxis and larviciding. In 1961, it was upgraded to a malaria eradication program. Because of

insecticide shortages and other factors, the spraying operations failed to interrupt malaria transmission and the program was reorganized again in 1967. The spraying operation was decentralized and the time needed to complete a spray cycle reduced to two months.

Among the shortcomings noted in the final report (44) of the program were:

a) Incomplete coverage of temporary shelters and new construction and replastering of sprayed surfaces.

b) An insufficient number of trained supervisors.

c) Lack of discipline among spraymen.

d) The absence of legislation to support house spraying.

e) Transportation problems.

f) Administrative problems, including financial ones.

g) Exophilic behavior of some mosquitoes.

h) Use of less than the recommended dosage of DDT per square meter of sprayable surface.

Although eradication failed, for a short time control was successful (prevalence rates of 7.8 in Unguja and 1.7 in Pemba). Malaria was only a minor health problem in June 1968, when the program ended after 10 years. Malaria began to increase almost immediately, and by 1973, the prevalence rate was 54.0 for Unguja and probably 9.9 for Pemba, illustrating the disastrous effects of halting malaria control activities. Some recommendations included in the WHO final report were:

a) Continuation of antimalarial activities.

b) Development of basic health services.

c) Health education directed toward awareness of the problem and available services.

d) Use of bed nets for personal protection.

Attempts to revitalize malaria control activities began in 1972. At first these attempts were unsuccessful, but eventually they led to a USAID/Tanzania loan and initiation of the current project in 1981. Assistance is scheduled to end in September 1989.

During the Project, a number of WHO and A.I.D. consultants/ advisors visited the ZMCP and wrote reports. Most of them came for specific assignments, including (a) geographical reconnaissance, (b) insecticide susceptibility assessment, (c) residual spraying operations, (d) space spraying and ULV activities, (e) larviciding, (f) training, (g) inventory management and procurement, (h) warehouse and garage construction, (i) program development, including strengthening the administrative infrastructure, (j) urban vector control and source reduction, including drainage and biological control, and (k) laboratory activities and entomology.

USAID/Tanzania staff (49 and 61) also wrote reports on visits to the ZMCP and there was an external (47) and an internal (41) review. These reports include some conflicting statements about ULV spraying, geographical reconnaissance, drainage and other issues. Many of the recommendations outlined in the reports were not implemented. The internal review final report addressed this problem and several others that interfered with the progress of the ZMCP.

Attempts to solve these problems should have begun when the long-term advisor was assigned to the project, but they seemed to have been ignored. A number of problems or underlying factors leading to the problems were and still are beyond the control of the ZMCP.

2.4. Comments on Vector Control

Gillett (8) wondered if Soper and his team, even with their quasi-military organization, motivation and energy at all levels of staff, would have been successful in fighting *An. gambiae* in its home environment. There is no one best method of malaria vector control. All strategies are lacking in part because of logistical and financial restraints. Vector control may produce excellent results in lowering mosquito densities without interrupting the transmission of malaria.

Although environmental management, source reduction, biological control, and larviciding are mentioned in the African context, only residual spraying has been evaluated more or less adequately. Throughout most of Africa, vector control has not had a good track record. Large populations of susceptible youngsters, the nature of the larval habitat of *An. gambiae*, drug and insecticide resistance, logistics, and the level of general education, training and supervision all work against it. Without improvements in economic conditions, governmental infrastructure, education and sanitation, vector control cannot be successful in most places.

Many associated with indirect management of vector control against malaria mosquitoes become too critical about the lack of progress instead of recognizing that progress, although slow, is being made. The mosquito has been around longer than man, and human behavior makes man more a friend than an enemy. Patience is necessary in vector control, and even the best projects are rarely successful in the short-term. In fact, success in controlling malaria vectors frequently has an adverse influence on the operation because it often leads to funding cuts, allowing the mosquito another victory.

3. GEOGRAPHICAL RECONNAISSANCE

3.1 Introduction

Geographical reconnaissance (GR) is an essential part of a successful malaria control program. The ZMCP has never successfully initiated and completed a GR. This void in the program has been responsible for many of its defects. The more comprehensive the GR, the easier it is to plan, implement and supervise spraying operations, conduct entomological and epidemiological surveys and evaluations, and manage and predict the program's future requirements.

The WHO Malaria Eradication Program began the first GR in Zanzibar in 1962-1963 by mapping only villages and blocks. In June-July 1965, the GR was repeated with sketch maps showing the number and location of every house. Road signs were erected to mark temporary houses and their locations were plotted on maps in 1966-1967. The program also began to use house cards to provide spraying and supervision history at the same time. Even with this high level of GR, the program never obtained total coverage (44).

In his 1983 consultant report, Turner (51), placed the highest priority on GR mapping. He ordered equipment and supplies to produce master maps. After being appointed long-term advisor, Turner recruited several consultants to assist in planning and training for GR. Wood (52) recommended a GR with operational maps to plan supervisory itineraries and epidemiological activities. A WHO team in 1984 (45) pointed out the need to do a GR and later Roche, one of the team, returned to start a GR (48). He recommended doing sketch maps to locate roads and villages, but did not do mapping or numbering of individual houses. A census was taken by visiting branch offices and collecting data on file. A detailed GR was not done because of the staff's inability to read maps, and the lack of planning and uniform distribution of staff. Roche left before the master maps were finished, but he did have 186 branch maps made. He trained 28 ZMCP staff to map to scale and do a GR, and suggested that urban areas be mapped to locate larval habitats.

Stokes (50) recommended a GR of Zanzibar Town to locate permanent and temporary larval habitats. He noted that maps already existed for Stone Town. The entire town had been divided into wards and the maps showed streets. He established urban zones that could be handled by existing control teams. Chinien (42) reviewed GR, which began anew in 1987. He noted that houses had not been numbered and there were discrepancies in the

way the number of houses and number of people per house had been recorded. He recommended using house cards, but not making maps because it was too difficult to read existing sketch maps.

Chinien (43) returned in 1988 to plan and implement GR activities. He found that houses still were not numbered for lack of paint and brushes. He concluded that local costs might have been an underlying factor and that there were several obstacles that training could not correct, including the lack of motivation, supervision and coordination, the workers' level of general education and their inability to understand maps. As a result, he repeated his suggestion that the Project use house cards but not maps for GR. The Internal Review Team (41) recommended conducting a comprehensive GR. This activity began in Unguja before the teams' arrival.

3.2 Objective of a GR

a) To make sketch maps and take a census of all houses in rural and urban-rural fringe areas using the branch as the basic map unit. Available urban maps with streets marked can be modified to locate larval habitats of *Culex* and *Anopheles* mosquitoes.

b) To develop accurate estimates of sprayable surface areas and the number of houses and other buildings to be sprayed and to assist in procurement, distribution and usage control of insecticides.

c) To improve the process of cost analysis of program activities and estimate human resources and commodity requirements.

d) To improve planning and supervision of house spraying and larviciding as well as the entomological, parasitological and epidemiological activities of the ZMCP.

e) To plan workloads and supervise malaria agents and to improve malaria surveillance at the peripheral level (i.e clustering of malaria cases and location of larval habitats in relation to the cases).

3.3. Procedure for doing a GR.

Malaria agents and their supervisors in all districts of Unguja were trained for GR in February-March 1989. The courses included two days of lectures and two or more days of practical mapping. Subject matter included drawing to scale, points of reference, map symbols, sequential numbering of houses and use of

forms. The chief of operations taught each course. In Pemba, the more simplified mapping method of Roche was followed. It was decided that the chief of operations would teach similar courses in Pemba so that agents on both islands would follow the same procedure. The procedure is described below.

a) Mapping teams consist of four malaria agents: one draftsman, one assistant, a census taker and a person to attach the house card. One map is drawn for each branch.

b) As each branch map is completed, it is checked by the field supervisor for errors and omissions and sent through channels to the chief of operations at the ZMCP office.

c) A trained draftsman redraws the sketch maps to produce masters. The original and copies are filed in the map room. Other copies are sent to district and regional health offices, rural and urban health centers, ZMCP field supervisors, and malaria agents for each the branch. (Note: maps must be redrawn soon or the entire exercise will end in failure.) Census forms should be copied, district-region-branch codes developed, and census data filed according to the code.

d) The malaria agents will revise each branch map and correct the census at least once a year. Corrections are to be forwarded to the ZMCP office to update the master maps and census.

3.4 Shortcomings of the GR

a) It is difficult to visualize the mapping area. Houses may be close together or widely scattered, paths wander and the teams are without compasses. Supervision is poor because of fuel shortages.

b) Houses are not numbered because paint and brushes are not available. (The director has ordered paint and brushes.)

c) House cards are used as a substitute for house numbering, but many of the cards are hung outside the house and will be lost.

e) Maps and forms have been done with hard lead pencils and cannot be read.

f) Sprayable surfaces of houses have not been measured.

g) A trained draftsman is not available and space has not been designated for a map room.

h) Supplies for making master copies are not in stock or have not been ordered.

i) The ZMCP does not have experience with GR and may not take full advantage of this tool.

3.5 Drafting Supplies Needed

a) Turner's report of January 3 to February 9, 1983, lists supplies on page 16a. This list should be compared with the inventory and replacements ordered.

b) Each team of malaria agents doing GR should have clipboards, tracing paper, masking tape, drawing boards, notebooks, house cards, census forms, ruler, pencils, pencil sharpener, tacks, white chalk, compass, paint and brush.

3.6 Uses of Maps

a) Sketch maps are used to: 1) determine staff requirements and itineraries; 2) plan the logistics of staff distribution and replenishment of supplies; 3) plan insecticide treatment cycles; 4) demonstrate the progress of coverage during a cycle; 5) locate larval habitats, particularly irrigated rice fields and large bodies of permanent or temporary water; 6) identify disease or vector risk areas; 7) plot location of malaria cases; 8) map drug and insecticide resistance; 9) pinpoint spraying and drug treatment defects; 10) develop as an aid to stratification; and 11) revise project activities and assist in costing of activities.

b) Special computer software is needed for graphics and mapping of data.

c) Scaled maps of streets and wards of Zanzibar Town can be sectioned according to the Stokes report and used to indicate health centers, case distribution by unit of time, malaria risk areas, mosquito (*Culex* and *Anopheles*) distribution, larval habitats, drainage systems, drainage problems and source reduction activities.

d) The government has large scale contour maps of Pemba and Unguja. There is at least one complete set at the ZMCP offices. The maps should be placed in a wall-

mounted map frame in the director's office for use during meetings and for general planning.

e) Monthly rainfall distribution maps of Tanzania are available and could be used in stratification planning.

3.7 Recommendations

a) An instructive manual should be prepared using available lecture notes from the GR courses on drawing to scale, determining and use of points of reference pace mapping, list of symbols, reading maps, sequence of house numbering, census taking, compass reading, design and use of forms, revision of GR and use of data at the peripheral levels. The manual should provide examples of maps and should be available to all malaria agents and their supervisors.

b) Malaria agents should continue to do the GR with numbers painted on houses and house cards placed inside of each house. They must revise work done before house numbering began.

c) Sketch maps and census data should be updated annually and sprayable surfaces measured and recorded during the next GR.

d) Establish a map office, equip it and train someone to make master maps. Census files and maps should be kept in the office.

e) Prepare a directional flow chart to follow the mapping process, a timetable for annual updating and a checklist for distribution of copies of the master maps.

4. INSECTICIDES

4.1 Overview of Past Insecticide Use for Residual Wall Spraying

From 1958 until 1968, the World Health Organization (WHO) and the United Nation International Children's Emergency Fund (UNICEF) sponsored and provided technical guidance for a malaria control program that reduced malaria transmission to a point where the disease was only a minor problem. This program had a highly organized schedule for spraying DDT on wall surfaces. The spray schedule was based on continued improvement of GR, the availability of sufficient equipment, insecticide and transportation, and the use of trained and well-supervised spray crews. By 1971, three years after the program ended in 1968, malaria was again a severe problem.

The current Zanzibar Malaria Control Project (ZMCP) was initiated in 1981 but did not begin operation until 1984. There is little evidence that the Project has reduced malaria transmission. It also used residual wall spraying of DDT, but lacked the organization of the WHO program. As a result, there were several long periods when no treatments were done and coverage was incomplete. DDT resistance was noted from the beginning. There is little evidence of strong leadership in the technical assistance provided by the sponsor. Malathion was used for residual wall spraying in Pemba in 1984 and 1985, but in 1986-1987, DDT was used again. In November 1987, the rest of the malathion supply was used in one district of Pemba until it had been exhausted. DDT was used in Pemba in 1988. No malathion has been used for residual wall spraying in Unguja.

4.2 Current Efficacy of DDT

At the present time, DDT lacks operational efficacy in Zanzibar. This situation has existed since at least 1984. Careful examination of the DDT susceptibility records is not easy, due to the frequent lack of control mortality data. When data were available, sometimes control mortalities were greater than 50 percent, indicating that the actual percent mortality for DDT was lower than the reported values. The frequent but spotty occurrence of tests showing 50 percent or less mortality for DDT susceptibility demonstrates the definite presence of DDT-resistant components. Even these values would no doubt be much lower if they had been corrected for control mortality.

This pattern of DDT susceptibility in the data occurs in the data from both Unguja and Pemba. One of the most incriminating documents to support the present conclusion is a 1984 map of

Unguja on which DDT susceptibility data, generated independently by the ZMCP and by WHO, are plotted. The pattern of DDT susceptibility data on this map is a clear indication of the lack of operational potential for that insecticide. The lack of effectiveness of DDT is frequently mentioned in the reports of consultants and reviews of ZMCP. It is difficult to understand why the long-term advisor and the external review team did not consider this issue important enough to suggest changes.

It should be noted that when insecticide resistance develops within field populations, mortality values do not suddenly shift from overall values that are very high to ones that are very low, but to an irregular or spotty pattern. Such is the case in Zanzibar. This pattern, plus the small size of the islands and the flight range of An. gambiae, means that DDT lacks operational efficacy in Zanzibar.

4.3 Conditions Necessary for Continuing Residual Wall Spraying

Given that the ZMCP has not been successful in reducing the severity of malaria and that a program can no longer be based on DDT, it is essential to consider what conditions are required for any alternate insecticide to provide efficacy in a residual wall spraying program.

First, we know that the 1958-1968 WHO-UNICEF program was successful, and therefore that it is possible to reduce malaria transmission through residual wall spraying. If this option is selected, however, it must also be realized that a program based on an insecticide with only 50 percent or less of the residual wall toxicity of DDT will require a much shorter spray cycle and therefore a higher degree of operational organization.

The shorter residual toxicity that can be expected with alternate insecticides (probably two to three month maximum for organophosphorus and carbamates) dictates that the spraying cycle be reduced to two months or less. In order to accomplish this objective, spray teams must make simultaneous treatments in the various districts. This can only be accomplished if sufficient equipment, insecticide, trained personnel and transportation are available during the two-month period before each of the two rainy seasons. Thus, for a residual wall spraying program to be effective, two spraying cycles would have to be used: a) one during August and September, immediately before the October-November rains and (b) one from January 15 through March 15, before the March-May rains. Since the latter period is longer, the timing of this spray cycle is very important. The most inaccessible areas might have to be treated first in case of earlier than expected rains. Also, as the existing epidemiological data are refined and carefully analyzed,

stratification should be used to ensure that the most critical areas are treated before the wet weather begins (see Annex A).

Simultaneous insecticide application in the various districts on each island cannot be accomplished without multiple teams. Currently, there are about 80 operating spray pumps at Unguja and about 60 at Pemba. These numbers would have to be substantially increased to provide for a two-month spray cycle on each island.

There are special problems on Pemba due to the higher roofs of some houses. In this case, about 20 percent of the spray cans would have to be fitted with booms of a much longer length in order to allow coverage of the exposed, inside roof areas. During the 1958-68 WHO-UNICEF-GOZ program, one sprayman in each team of five was provided with an extended boom to spray the high roof area.

Any alternate insecticide would have to be available and distributed to the various districts prior to the initiation of the spray cycle. The amount of insecticide required in each district can be accurately calculated once the GR (Section 3) has been completed. Thus, the importance of the GR for numerous purposes cannot be overstated. A record of insecticide spraying (spray date and number of charges used) for each numbered house (located on a card in each respective house) is essential in order to establish the efficiency of the spraymen in accomplishing the required spray cycle and monitor the residual effect of the insecticide. If insecticide is stored in the field, it must be kept away from food stuffs and in a locked building.

Supervisors of spray teams in each district would be required to recruit and train spraymen to handle the new insecticide safely and apply it accurately under local conditions. It is estimated that eight to 10 houses per day could be done by each sprayman. Thus, the number of houses in each district divided by the number of working days in the two-month spray cycle provides the number of houses to be treated each working day. The latter values divided by the number of houses treated per sprayman gives the required number of spraymen.

For example, there are an estimated 57,570 sprayable houses in Pemba. Assuming a 5.5 day work week (Friday afternoon and Sundays off) for the August and September spray cycle, there would be 48.5 work days (minus any holidays that occur during this period). This indicates that it would be necessary to treat an average of 1,187 houses per day. If the average sprayman treats nine houses per day, as described above, then 132 spraymen working each of the 48.5 work days are required for the cycle. This value probably would have to be increased by at least five

percent to allow for absences. Thus, 132 x 1.05 = 139 spraymen are required for the August/September spray cycle on Pemba. The number of spray pumps required would be 139 plus 20 percent, or a minimum of 167. Note that, as mentioned previously, there are only about 60 pumps currently available in Pemba. The actual distribution of men, equipment and insecticide can be calculated once the GR is complete.

The amount of insecticide required for each spray cycle can also be estimated. For example, in Pemba houses average 310 square meters in Kusini, 285 square meters in Wete and 200 square meters in Micheweni. If these values are representative of the island, then the average house is about 265 square meters. If the alternate insecticide dose is 2 gm (AI)/m^2, then 530 gm (AI) per house are required; this value times 57,570 houses on Pemba equals 30,512,100 gm, or 30,512 kg of active ingredient. This value plus a 10 percent contingency factor (to allow for waste, spills etc) brings the required amount to 33,563 kg (AI). If the insecticide selected is a 50% WDP, then 67,126 kg of the formulation are required for a single spray cycle on Pemba.

In Unguja, there are about 59,447 sprayable houses, each with an average of 181 square meters in surface area (42). Assuming the same work schedule described above for Pemba (48.5 working days), 1,226 houses would have to be treated each day during August and September. If these data are correct, the average house size (181 m^2/house) is smaller than that for Pemba (average 264 m^2/house). The same report indicates 22,161 other sprayable structures are located near houses in Unguja, but provides no estimate of their surface areas. As a rough estimate, if their surface area equals approximately 10 percent of the area of the houses, then the combined area increases to 200 square meters per house. This is still below the 264 m^2/house area for Pemba, so it may be possible for each sprayman to treat 10 units per day. Therefore, 1,226 houses divided by 10 houses per spraymen per day requires 123 spraymen each day.

Assuming a five percent increase to cover absences, the number of spraymen increases to 130. The number of spray pumps currently available (80) would have to be increased to 130 plus 20 percent, or 156 units. Assuming the same alternate insecticide dose (2 gm (AI)/m^2), each house requires 400 gm (AI). That value times 59,447 houses equal 23,778,800 gm or 23,779 kg. The same 10 percent contingency factor used for Pemba increases this to 26,157 kg AI. If the formulation is 50% AI, then 52,313 kg are required for each two-month spray cycle on Unguja.

Thus, a rough estimate for a single two-month spray cycle for Pemba and Unguja would be 59,720 kg (AI) or 119,440 kg of 50% WDP for an alternate insecticide requiring a dose of 2 gm/m^2 (AI). If two spraying cycles are done per year before each rainy period, then the values above must be doubled. Please note that

these simple calculations are based on the limited statistics currently available; as more refined data on house numbers and sizes are available from the GR, more accurate values can be obtained.

Supervisory personnel would have to recruit spraymen within each district in excess of the numbers needed and disqualify those who were unable to learn the proper technique for applying the correct dosage consistently. A training period of at least one week would be necessary before each spray cycle. Spraymen would have to be provided with protective clothing, and other safety devices (e.g filtered breathing units, soap, boots, helmets) depending on the insecticide selected for use. A minimum of two sets of protective clothing also would be necessary for malathion and four sets for fenitrothion, and arrangements would have to be made to ensure that contaminated clothing were washed after use.

Local hospitals and medical personnel would have to be informed about the hazards of the alternate insecticide being used and provided with information and necessary antidotes. Information on antidotes and symptoms of poisoning are provided in Annexes C & D.

All persons regularly exposed to organophosphorus and carbamate insecticides should be monitored for depressions in their normal levels of acetylcholinesterase. Field test kits are available from WHO and from commercial sources. It is imperative that pre-exposure (baseline) levels be determined for each person because there are significant differences between individuals. Any large depression in the pre-exposure level, (for example, 50 percent), indicates an urgent need to remove that person from further exposure until his cholinesterase level returns to normal.

Supervisors would also be responsible for ensuring that insecticide-contaminated materials were disposed of properly and for decontamination of spillage (special attention should be given to prevent contamination of food and the floor areas of houses).

The fuel shortage problem is a real constraint to operating a well-timed spray cycle. This problem is not unique to the ZMCP. Even the cottage hospital at Micheweni, Pemba, cannot get fuel regularly to operate its electrical generator for three hours per day. In order to enable spray teams to complete the critical two-month spray cycle, the GOZ will have to allocate sufficient fuel to allow regular transport of men, equipment and insecticide.

Finally, because of the complexity of converting from the current operational system to the type described in this report,

it will be necessary to complete a pilot project with any alternate insecticide on both Pemba and Unguja (Annex E). Until such pilot projects have been successfully accomplished, no attempt should be made to conduct a complete spray cycle on either island.

4.4 Alternative Insecticides

No alternative insecticides are available that have DDT's long persistence on wall surfaces or are as safe to man and animals as DDT. In addition, none are as inexpensive. The residual wall toxicity of various alternative insecticides will vary not only with their individual chemistry and formulations but also according to the type of surfaces to which they are being applied. Therefore, it is imperative that pilot field studies be conducted to determine the actual time of effectiveness for each alternative insecticide selected and for each type of wall surface that will be treated. (see Annex E).

For details on the chemistry, available formulations, physical characteristic and toxicology of the various alternative insecticides, see Annexes C & D. This section will discuss consideration of alternate insecticides based on past use, safety, cost and the potential for insecticide resistance.

4.4.1 Organophosphorus Insecticides

Organophosphorus insecticides act by inhibiting the important nerve enzyme acetylcholinesterase. This enzyme is involved in normal nerve function to break down the impulse-transmitter substance known as acetylcholine. It is the accumulation of acetylcholine that causes toxicity. Numerous organophosphorus insecticides have been commercially developed and about 12 of them have been used in mosquito control programs for larviciding or adulticiding in various parts of the world. The organophosphorus insecticides were first produced commercially in the early 1950s and many are still in common use.

4.4.1.1 Malathion

First introduced for commercial use in 1952, malathion has been used widely in mosquito control programs in many different countries. It is available in a number of different formulations, but the 50% (AI) water dispersible powder (WDP) was developed specifically for residual wall spraying against mosquitoes. This insecticide usually has been the first alternative following the loss of chlorinated hydrocarbons, such as BHC, dieldrin and DDT, as a result of insecticide resistance. Malathion has been chosen over other organophosphorus compounds

because of its greater safety, length of residual activity and lower cost.

Malathion 50% WDP is generally used at a dose of 4 gm/m^2 (2 gm AI/m^2) and has been applied to all interior, and some exterior, surfaces. The residual activity varies considerably with the type of surface; wood surfaces exhibit a much longer residual than thatch and thatch much longer than mud (21). The actual residual period must be measured on the various surfaces that require treatment, (eg. mud, cement, coral, stone, thatch or wood) in pilot evaluations (Annex E).

Like other organophosphorus compounds, malathion inhibits acetylcholinesterase and it cannot be applied with the sloppy techniques often used by spraymen applying DDT. This problem can be overcome through training, continued supervision of spray crews and health education. A trial program using 49.5 tons of malathion 50% WDP in Pemba during 1984-1985 and in a single district in 1987, did not result in any occurrence of poisoning to spraymen. Some inhabitants who re-entered their houses, prior to the two hour interval when they were told to remain outside reported incidence of headache and nausea. There were also complaints that nuisance insects became apparent, which was no doubt due to the insecticide's irritability to insects resting within the wall and roofs.

The ZMCP has monitored the insecticide susceptibility of An. gambiae in both Pemba and Unguja following the recommended WHO procedure for diagnostic testing (WHO/VBC/81.806) and using the one-hour tentative exposure to 5% malathion paper, but has not found any evidence of resistance. This is not surprising because malathion was used only for short periods in Pemba and was never used for mosquito control in Unguja.

In March 1989, we sought to obtain baseline data on malathion susceptibility using the WHO recommended procedure (WHO/VBC/81.805). Unfortunately, due to dry conditions, only limited numbers of An. gambiae larval could be collected for rearing to adults and adult biting collections provided few numbers. For unknown reasons, these adults frequently died after being transported back to the laboratory. Nevertheless, in the limited tests that were conducted, a consistent pattern of susceptibility was apparent. A summary of these insecticide susceptibility tests appears below.

Summary of insecticide susceptibility tests of Anopheles gambiae adult females to 5% malathion versus control paper (in % uncorrected mortality of individual tubes).

Island	Locality	Date	Exposure to Control paper 15 min	20 min	Exposure to Malathion paper 15 min	30 min
Unguja	Mwera	18/3/89		10 a	94 a	100 a
				8 a		100 a
						100 a
						100 a
						100 a
						100 a
Unguja	Mwera	24/3/89	10a		100 a	
Pemba	Wete north	21/3/89		6 b	100 b	100 b
Pemba	Wete north	22/3/89	20b		100 b	

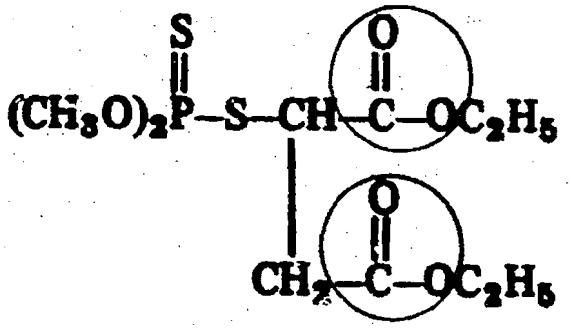
a Adults reared from larval collection in rice fields

b Adults caught in overnight biting collections

It is clear that An. gambiae are highly susceptible to malathion. In four tests (total) at the 15-minute exposure, only a single adult survived; there was no survival in eight tests with 30 minute exposures. All tests used controls. Obviously, additional baseline data are needed to further substantiate malathion susceptibility, should this compound be selected as an alternate insecticide. It appears that the tentative diagnostic exposure time of one hour to 5% malathion for Anopheles (WHO/VBC/81 806) is correct for Zanzibar because 30 minutes appears to be the minimum time required to achieve 100 percent mortality in An. gambiae and this value should be doubled (60 minutes) in order to select a time after which any survivors would cause real concern of insecticide resistance.

There is no question that if malathion were used extensively in Zanzibar over a long enough period of time, insecticide resistance would appear. The reason for the selection of malathion as the first of any organophosphorus compounds to replace DDT is that the type of biochemical mode of resistance that often develops to the compound may not affect

other commercially available OP insecticides. The structure of malathion is shown below:



The molecule contains two carboxyester groups (circled). Resistance to malathion often results from the selection of enzymes known as carboxyesterases, which attack the carboxyester linkage shown above. A very significant factor is that other commercially available alternative OP insecticides that could be used in Zanzibar do not have such carboxyester components and therefore could be used against malathion-resistant populations.

On the other hand, if other organophosphorus compounds were first used extensively for a long enough period of time, the type of resistance mechanism likely to be selected (mixed-function oxidases) would also be effective in detoxifying malathion. So it would also be advantageous to first select malathion rather than other organophosphorus materials because of the type of resistance mechanism that is likely to develop.

Proper storage conditions for malathion formulations is very important. Storage should not result in long-term exposure to elevated temperatures, e.g. in non-ventilated metal sheds exposed to direct sunlight. Such adverse storage conditions can result in the slow, cumulative formation of isomalathion, which is highly toxic. If the isomalathion contact becomes too great (greater than 1.8 percent), the exposed batch cannot be used and must be disposed properly.

The cost of malathion must also be considered. The estimated price of malathion 50% WDP recently obtained from Cyanamid International (March 1989) was $US 1.874 per kg for full container loads. If the shipping cost is assumed to be 15 percent, then the delivered price becomes $US 2.15/kg.

The examples of calculations to determine the amount of required insecticides per spray cycle in section 4.3 assumed 2.0 gm (AI)/m^2 and a 50% WDP formulation, as would be the case for malathion. According to these calculations, an estimated 119,440 kg would be necessary to treat both Pemba and Unguja in a

single spray cycle and the insecticide cost would be $US 256,796. The cost of two spray cycles (one before each rainy season) would be $US 513,592 per year.

4.4.1.2 Fenitrothion (Sumithion TM)

Fenitrothion, another organophosphorus insecticide that has been used effectively in residual wall spraying programs for many years, is being used for mosquito control in Dar es Salaam and Tanga. The 40% WDP formulation is applied as a 5% suspension in water. The required dose is the same as for malathion (2 g/m^2). Since the residual effectiveness can be expected to vary from one to three months depending on the wall surface characteristics, it must be established under local field conditions.

A major problem with fenitrothion is cost. An estimate obtained in March 1989 was $US 5.75 per kg of fenitrothion 40 WDP. When a 15 percent shipping cost is added, the delivered price becomes $US 6.61 per kg. Not only is this much more expensive than malathion 50 WDP, but the formulation is 10 percent less AI. The total cost for treating both Pemba and Unguja for one spray cycle would be equal to 149,300 kg of 40% WDP times the delivered price ($US 6.61/kg), or $US 986,873 per spray cycle. The cost for two spray cycles per year (one before each rainy season) would be $US 1,973,746. Thus, the cost is 3.8 times that of malathion for a two-cycle per year treatment for Zanzibar.

4.4.2 Carbamate Insecticides

These insecticides also inhibit acetylcholinesterase. All of the same safety problems described for the organophosphorus insecticides also apply to the carbamates.

4.4.2.1 Bendiocarb (Ficam TM).

This carbamate is a highly effective insecticide against a wide variety of insects. It is available for residual wall spraying as an 80% AI WDP and a dose of 0.4 gm/m^2 is recommended. The residual toxicity on walls varies from one to three months depending on the type of surface. Again, pilot studies (Annex E) would be essential in order to determine the residual toxicity on a given type of wall under local conditions. Since 0.4 gm/m^2 are required, only 20 percent of the amount of insecticide AI that has to be applied at 2.0 gm AI/m^2 is required. Thus, only 11,944 kg AI would be needed to treat both Pemba and Unguja for one spray cycle. Since the formulation is 80% AI, than 14,930 kg of 80 WDP would be required. In March 1989, an estimated price

for bendiocarb 80 WDP (including shipment) was $US 40/kg. Therefore, it would cost $US 597,200 to treat both Pemba and Unguja for one spray cycle, or $US 1,194,400 for two spray cycles. This is 2.3 times the cost of malathion.

4.4.3. Synthetic Pyrethroids

Synthetic pyrethroids are related in structure to the natural pyrethrums. They are very stable and several of them have been used as mosquito control agents. Their mode of action is apparently the same (or very similar) to that of DDT--interference with the sodium (voltage-gated) channels in nerves. This factor is now considered very significant since selection for insecticide resistance through long-term DDT exposure can result in cross-resistance to the synthetic pyrethroids. The first reports of DDT-resistant strains of mosquitoes with cross-resistance to pyrethroids began appearing in the literature in 1977 (3,17,18,19), and they have continued since. In areas where pyrethroids have been heavily used in agriculture, there are now numerous reports of lepidoptera showing resistance (1987 and 1989 reports in U.S.).

Several of the pyrethroids are currently effective for treating bed nets, curtains and clothing to repel and kill adult mosquitoes. This technique could be of special importance in the future if the GOZ decides not to continue residual wall spraying. Therefore, it seems questionable at the present time to use pyrethroids to pressure DDT-resistant populations of *An. gambiae* in a broad residual wall spraying program.

Further research on the relationship between DDT resistance and cross-resistance to pyrethroids is continuing. Until further clarifications are made, it would appear best not to pressure the existing DDT-resistant strains of *An. gambiae* on Zanzibar with pyrethroids. For additional information, see *Parasitology Today* 4 (No 7) 1988, pages S1-S20. Some of the additional alternative pyrethroids that might be considered in the future include deltamethion, lambda-cyhalothrin and permethrin.

4.4.4 Summary of Alternate Insecticides That Could be Selected For Continued Residual Wall Spraying

Based on the following information, which was provided locally and through the various available reports, the amounts and costs of three alternate insecticides were calculated for each spray cycle on both Pemba and Unguja. They are summarized below.

	No. Sprayable Houses	Average Size (m)	Total m to be sprayed per spray cycle
Pemba	57,570	264	15,198,480
Unguja	59,447	200 (a)	11,889,400
Total			27,087,880

Alternate Insecticide and Formulation		Estimated Cost (Delivered US$ (b)	Kg Formulation Per Spray Cycle	Cost (US$) per Spray Cycle
Malathion	50% WDP	$ 2.15	119,440	$256,796
Fentrothion	40% WDP	$ 6.61	149,300	$986,873
Bendiocarb	80% WDP	$40.00	14,930	$597,200

a Area of sprayable houses plus 10% allowance to spray small structures in close proximity to houses.

b Delivered price equals U.S. price + estimated 15% shipping charge.

Again, note that these values are based on the data currently available, which will no doubt be substantially improved when an accurate GR is completed.

5. ALTERNATIVE CONTROL

The application of residual insecticides on walls and other surface areas in houses and other buildings is still the method of choice for vector control in rural areas. Integrated vector control is encouraged, but as yet many techniques are more theoretical than practical. In Africa, few alternatives are even considered, and residual insecticide use has been questioned because of the costs and logistics involved in the spray campaign.

Before DDT, vector control against malaria was primary urban-oriented and a number of techniques were integrated into the system. With the increased cost involved in any type of vector control, especially those using chemicals, and the difficulties in managing a large campaign, new strategies are needed. In malaria control, the first responsibility is to reduce human mortality. Routine vector control should be implemented only if there is a clear indication of long-term financial support. However, in case of epidemics or other risk situations, emergency vector control is a realistic tactic. In Zanzibar, some vector control most likely will continue in Zanzibar Town and possibly other urban areas.

5.1. Urban Malaria Control

5.1.1 Rationale

The population of Zanzibar Town represent more than 40 percent of the island population, while the town area is less than two percent of the island's land area. Pemba has three townships: Mkoani, Chake Chake and Wete. It is estimated that the population of these townships may constitute more than 50 percent of the Pemba population. It is likely, therefore, that more than 60 percent of the population of Zanzibar is urban.

The malaria situation has not changed significantly in Zanzibar Town since 1983. Malaria blood smear figures have remained over 40 percent. It would appear that whatever control measures have been used in the town area have not been as effective as expected. There is an overdue need to reorient the control strategies, since effective malaria control in these relatively small areas might protect the majority of the population. It was reported that in 1984, positive malaria cases recorded at the Zanzibar Town (Lenin) hospital constituted 73 percent of all malaria cases on the island. Although records of origin of these cases are incomplete, it can be assumed that the majority came from Zanzibar Town or the urban-rural fringe.

Problems in urban vector control have been related to the fact that the ZMCP and GOZ function separately from the municipality. The town has a staff of about 125 to partially clean drainage ditches, but many drainage pumps do not function, vast areas are below sea level and more drainage ditches are necessary. The ZMCP does some experimental larviciding with dimilin, in addition to irregular use of oils and temephos. Space spraying has been done, but with very limited success. Most control has been directed against Culex, not Anopheles, mosquitoes. Both larviciding and space spraying will be of little use until scheduling, application and evaluation improve.

The urban-rural fringe is the gateway to the city and is changing continuously because of rapid growth. The ZMCP does vector control in the fringe, but more coordination is needed. As people migrate into urban areas, they bring their diseases with them. Since the fringe has permanent larval habitats, including rice paddies, transmission of malaria is year-round. The malaria problem is not only a vector control responsibility but could be solved in part by monitoring land use, long-term urban planning and engineering. A joint municipal/MOH-ZMCP committee should be formed to designate responsibility and funding.

5.1.2 Geographical Reconnaissance (GR)

See section 3 for details. A comprehensive GR is as important in urban areas as rural ones. Fortunately, street maps and ward or zone maps exist for Zanzibar Town. These maps do not show the locations of individual houses, but that information will not be needed unless house spraying with residual insecticides is continued. Permanent larval habitats, areas likely to be flooded during rainy seasons, drainage ditches and drainage construction, malaria risk areas and Culex breeding sites should be indicated on the maps. Maps showing mosquito breeding sites should be used to plan, schedule and supervise larval control.

Street maps can be used for space spraying operation. There is no excuse for not using maps for urban vector control.

5.1.3 Source Reduction

In urban areas, source reduction may be a cost effective alternative to chemical mosquito control, if the cost is spread over several years and there is proper maintenance. It also provides a long-term alternative to the costly recurrent larviciding operations. With a good GR and classification of larval habitats, it is possible to identify sites best suited for

management or manipulation, either by mechanization or labor-intensive methods. Using Stokes' report, the team examined mosquito breeding sites and found a number of sites that could be drained, filled in or modified to decrease breeding. Many of these sites could be modified with help from the community, if adequate health education were available. Other sites would require assistance from the municipality or the ZMCP. In some areas, such as the gravel pit, shoreline modification and the use of larvivorous fish might reduce mosquito breeding.

Other areas, such as the lagoon by the Bwawani Hotel, will require major engineering and are beyond the capacity of the city to correct without external assistance. The possible landfill from dredging of the harbour should be pursued.

Culex breeding in the Kilimani flat complex is not a control function of the ZMCP. If the Project inherits this task, special funding should be made available and engineering solutions should be sought.

Mosquito breeding occurs in a number of rice paddies within the city. These might be handled through legislation, but it must be understood that rice growing within Zanzibar reduces its need to import rice.

As far as it is practically possible, source reduction should be preferred over chemical larviciding. It must be stressed that engineers tend to look at the overall drainage problem and its expense, but fail to consider that source reduction can be done on a small scale over a period of time and still produce acceptable results. Stokes' report needs to be re-examined in this context.

5.1.4 Larviciding

Larviciding is often considered the method of choice for urban vector control because there are relatively fewer breeding sites in urban areas and the sites are accessible and easily mapped.

5.1.4.1 Choice of larvicides

The mixture of oil, diesel and Triton x 207 has been used in Zanzibar. Its efficacy has been difficult to measure because the proportions of the mixture often were not correct and applications were done infrequently. Since there was an absence of accurate records on areas treated and the amount of the oil mixture used, application rates were subject to error. It is hard to justify use of this method if no evaluation data are kept and there is no diesel for fuel.

Temephos granules and EC also have been used in Zanzibar. Insecticide susceptibility tests on Culex and Anopheles larvae showed no resistance to temephos, but the efficacy of temephos was not evaluated adequately. Whenever possible, a larvicide that is different from the adulticide should be used to delay development of insecticide resistance. A supply of temephos should be on hand to treat some permanent larval habitats.

5.1.4.2 Spraying operations

After the completion of the GR and the classification of breeding sites, the Town area should be divided into operationally manageable zones and specific teams assigned to each zone, as outlined in the Stokes report. There should be a plan of operation and a schedule for each zone, including adequate larvicide, transport and supervision. The forms illustrated by Stokes should be used.

Since many of these activities will undoubtedly be directed against Culex, the Town should provide financial support. Some of its staff members could be trained to do the work.

5.1.5 Biological Control

Most biological control methods are largely untested and beyond the capabilities of the ZMCP. More biological and ecological information (multiplication rates, growth rates survival rates, food preference, susceptibility to insecticides in use, etc.) is needed before biological control can be adopted as a control strategy.

Larvivorous fish are found in Zanzibar. The team demonstrated that a single fish can eat 100 or more mosquito larvae per day under laboratory conditions. However, these fish would not be effective in the small temporary breeding places of An. gambiae or in large flooded areas during rainy seasons. They might be considered along with shoreline management in some of the smaller permanent breeding sites and in ornamental pools, tanks and wells. There may be a greater possibility of using fish against Culex, particularly in the pools and slowly running water immediately outside of the basements of the Kilimani Flats. The role of fish should be evaluated by the ZMCP.

5.1.6. Residual House Spraying

Some areas of the urban-rural fringes may be treated with larvicides, but the majority of the fringe area should be treated according to rural strategies. The requirements and methods for

residual house spraying in the fringe are similar to those discussed in section 4 and below. If rural residual spraying were continued at the fringe, it might form a barrier for incoming mosquitoes. This approach has been used around Zanzibar Town and some experimental residual house spraying, primarily against Culex has been done in the Kilimani Flats.

5.1.7 Space Spraying (ULV and Thermal)

Space spraying has been used in Zanzibar Town, especially Stone Town, but its value has not been evaluated adequately. Preliminary evaluation using bioassay cages of adult mosquitoes showed poor control. Some areas of Stone Town are not suited for space spraying because of the height of the buildings and extreme narrowness of the streets. Wind velocities along the coast during certain times of the year blow the insecticide out of the target area. We noted that many buildings had their windows closed at all times. Health education would be needed to get people to open their windows during spraying. Space spraying equipment is on hand. Both vehicle-mounted ULV and hand-carried thermal foggers may be used. The ZMCP is inclined to use the foggers because people can see the spray. Unfortunately, the order for spare parts for the foggers has not been received.

Space spraying can complement urban larviciding and residual house spraying activities, but it must be evaluated before widespread use can be recommended. It is a costly operation and should only be used where the most benefits can be obtained. Space spraying could be used to knock down adult mosquitoes in risk areas when their densities are reaching their peak or if an increase in malaria cases is observed. Some thought should be given to directing space spray activities towards grass and resting places near larval habitats to control newly emerged adult or females returning to these habitats to oviposit.

Routine evaluation of flow rates, particle size, vehicle speed, insecticide use and effect on adult mosquito population is essential. Routes and spray schedules must be planned and activities supervised. Should ULV spraying be continued, a technical grade malathion should be considered instead of the insecticide currently in use.

5.2 Insecticide-Impregnated Bed Nets/Curtains

The use of insecticide-impregnated bed nets and curtains is a relatively new approach to vector control that may be applicable to both urban and rural situations. The method has been demonstrated to reduce man-mosquito contact and kill adult mosquitoes. Whether it significantly reduces malaria

transmission under African conditions is still an open question. The latter is being investigated in a number of pilot studies throughout Africa, including Tanzania. Impregnated mosquito bed nets and curtains have an advantage over ordinary bed nets because the insecticide repels or kills the mosquitoes and the mesh can be larger, allowing for more ventilation. Like residual house spraying, this intervention could be targeted to pregnant women and infants and other priority populations.

Many behavioral and socio-cultural issues need to be addressed before widespread use of bed nets can be recommended for Zanzibar. The Save the Children Fund pilot study has identified some of these issues, including continued use of bed nets when mosquito population are low, stolen or sold bed nets, frequent washing of bed nets, monitoring actual use, the role of exophilic mosquitoes and blood-feeds on people before they go to bed, and people's acceptance of the nets.

There are also questions about the cost of nets, the best fabric for nets, frequency of repair and retreatment, best synthetic pyrethroid and formulation, optimum dose, and conditions best suited for using nets, that should be answered before a large scale use in Zanzibar.

We suggest that the ZMCP encourage commercially and institutionally funded pilot studies on use of bed nets and curtains in Zanzibar. The ZMCP should have a role in coordination and evaluation of these pilot studies. However, the GOZ/ZMCP should not make a financial commitment to extensive use of bed nets until it has been demonstrated conclusively that this approach effectively lowers malaria transmission and maintains the reduction over a long period of time at a cost affordable to the government.

5.3 Rural Malaria Control

5.3.1 Agricultural Relationships

Zanzibar's future lies primarily in the development of a rural economy to achieve self-sufficiency in rice, sugar and other food stuffs and in increased exportation of cash crops. Rice, sugar cane and other products rely on water resource development, such as the FAO irrigation project, which is designed to irrigate a projected 5,000 hectares. It is not appropriate for the health sector to take a negative view of agricultural development, even when it lies within the rural-urban fringe or the city proper.

Irrigation will increase mosquitoes and may create enormous mosquito densities over a longer time period. As a result,

malaria transmission is likely to increase. The ZMCP should have close contact with the Ministry of Agriculture and FAO to discuss future plans and location of irrigation projects. If these projects can be improved structurally (e.g. delivery and drainage channels) at a reasonable cost, this should be encouraged. When such improvements are not possible and if there is an expected increase in permanent or temporary migration near the irrigation project, health education by the malaria agents should be strengthened and additional health centers considered.

There have been a number of proposals on water management in rice culture, use of fish and other methods to reduce larval mosquito populations. Some have been shown to be effective in temperate climates or in special topographical conditions. However, there is little evidence that they work in tropical climates with pronounced rainy seasons and irrigation systems similar to those of Zanzibar. In fact, there probably is no concrete evidence that any inexpensive strategy to alter water flow has had a positive effect on lowering mosquito larvae densities under conditions like those of Zanzibar.

In villages close to irrigated areas, the Ministry of Agriculture or FAO might be encouraged to subsidize screening houses, or use of insecticide-impregnated curtains or bed nets, since it will be the workforce involved with rice production or their families who will have malaria and since the increase in malaria will be due to agricultural practices.

5.3.2 Larviciding

Since *An. gambiae* breeds in a wide variety of standing water sources (swamps, ponds, pools, rice paddies and in most water collections that receive sunlight) throughout Pemba and Unguja and since these sources in rural areas are largely inaccessible during the rainy seasons, larviciding is not feasible. In order to have any degree of success in rural locations, it would be necessary to control large areas. Logistically and financially, this is not possible in Zanzibar. There might be exceptions in villages and in the urban-rural fringe if a few larval habitats were shown to produce the majority of the adults.

5.3.3 Other Options

a) Since *An. gambiae* generally do not breed in polluted water, some herbage pollution may be tried during the dry season unless known breeding sites are used for potable or household water (field trials will be necessary to determine the value of this method).

b) Different Eucalyptus trees may have a drying effect on water-logged land. Planting these trees apparently work in India and their use has been suggested for some coastal lowlands on the mainland.

c) Water management techniques, including stagnating, salinifying, compounding, intermittent drying, and fluctuating, may limit An. gambiae breeding in some of the larger water bodies, but they would be difficult to employ in Zanzibar.

d) Mosquito coils are sold in most rural village and many urban stores. The number of boxes in stock indicates that coils are a popular way to repel biting female mosquitoes. The ZMCP should evaluate the effectiveness of coils. If the coils prove effective, the ZMCP could promote their use before people retire at night.

5.4. Comments on Alternative Control Methods

Few new appropriate methods that can be easily employed under the conditions found in Zanzibar have been developed. Given the reality that the future will bring less money for malaria control, antimalarial drugs should be preferred over the more complicated and burdensome anti-vector measures. House-spraying is the only Anopheles control method that has been evaluated in Africa (22), and with the use of insecticides that are more toxic and expensive than DDT, its long-term use in Zanzibar is questionable.

Community involvement has yet to prove an inexpensive alternative to structured vector control without ample health education to motivate the workforce and tolerance of supervision. People in Zanzibar Town are taxed for public services and consider mosquito control to be such a service.

In our opinion, there is little hope in the near future for the emergence of an alternative vector control measure that is effective under the conditions found in Zanzibar. This is a pessimistic viewpoint, but the history of malaria vector control from 1968 until the present date gives us little reason for optimism on this point.

6. ENTOMOLOGICAL MONITORING

6.1 Introduction

A number of mosquito collection methods have been used during the project. The basic fault of these surveys has been the inability to do the work routinely because of either lack of transportation or petrol/diesel for the vehicles. As a result, it is extremely difficult to use the information for anything more than numbers in reports (see Annex A).

Other shortcomings in the information system are the under-utilization of the insects collected, incomplete insect identification (everything is called An. gambiae), confinement of collections largely to indicator sites, insufficient epidemiological data, absence of climatological data or insecticide treatment history, and lack of real analysis of information available. Since all information was piecemeal, it is doubtful that the ZMCP could have done much more. This was due in part to the ZMCP staff being trained to collect information but not on how to use it.

It is too late in the life of the Project but not in the ZMCP program to correct these shortcomings so information could be used to develop or redesign control strategies. Various techniques are outlined below that could lend themselves to decision making, if some type of vector control continues. It is not suggested that every collection method be used. The selection of methods and their scheduling will depend upon the future control strategies and available staff of the ZMCP. About 10 percent or more of all adult mosquitoes caught should be used for sporozoite rate determinations, age and parity studies, and blood source determinations.

6.2 Night Biting Collections

Night biting collections have been used as a standard method in both Unguja and Pemba. They have not been done every month, but collectively have provided some information (see Annex A). Four indicator sites were used in Unguja and four in Pemba. From time to time other indicator sites and spot checks were included. Data from these collections were never really compiled.

6.2.1 Objective of Night Collections

a) To determine and compare the number of mosquitoes by species collected from human bait indoors and outdoors.

b) To determine and compare the number of mosquitoes by species collected from human bait by hour from 1800 to 0600 hours.

c) To compare these collections by season and determine and measure the climatic, seasonal and environmental factors that might influence the number of mosquitoes collected.

d) To compare collections from one location with another by month and year.

e) To determine the sporozoite rates of the captured mosquitoes and relate them to objectives a - d.

f) To relate mosquito densities (bites per unit time) to malaria transmission rates near the indicator sites, and adjust control strategies accordingly.

g) To collect adult female mosquitoes for insecticide susceptibility tests.

6.2.2 Types of Night Biting Collections

a) Indicator sites that are shown to be comparable with other areas of a district or are situated in a known or potential risk area, such as an irrigation project.

b) Random or selective designation of sites to check a new site with indicator sites, collect mosquitoes for special studies, or study special situations, including areas with a sudden increase or decrease in malaria transmission.

6.2.3 Collection Strategies

a) Follow the present time frame and methodology but reduce the number of collections to correspond with past information on population peaks in the indicator sites (between four to six collections per year with collections made during the same months each year).

b) Additional all-night collections may be made near health centers showing high rates of malaria transmission (if residual application of insecticide is being done).

c) Stop all night biting collections if insecticide treatments at indicator sites are discontinued. Do

collections only if insecticide field trials or other research is contemplated.

6.2.4 Essentials of Studies

a) Follow through to get optimum information, including sporozoite rates and parous rates and relationships to climatic, environmental, epidemiological and insecticide treatment information.

b) Run current comparisons with information from the previous month and the same month in previous years on all collections.

c) Discuss information with chief of operations and the director to develop or change strategy.

d) Compare night biting collections with other entomological findings in the same general area and with climatological information (e.g. rainfall, wind, condition of moon) at the time of collection (day, month, season). Standard procedures and scheduling are extremely important.

6.3. Window Exit Trap, Spread Sheet and Resting Collections

These methods are grouped together because they all produce similar information and have been used irregularly by ZMCP because of the lack of fuel, vehicles and pyrethrum, in addition to problems with logistics, collection time schedules and weather. Data collected during the GOZ/UNICEF/WHO Malaria Eradication Program and recent collections indicate that the window exit trap and resting catches have not yielded many mosquitoes.

6.3.1 Objectives

a) Determine the endophilic nature of the mosquito. (Does it rest indoors after a bloodmeal or exit following a bloodmeal?)

b) Determine the efficacy of insecticide over a period of time after application (number collected and level of mortality afterwards).

c) Determine resting habits (location within house or outdoors), density, resting surface preference and distribution by season and location.

d) Special research on insect behavior, host preference, movement.

6.3.2 Methods of Collections

Collection methods are understood and are being followed, but information is not being analyzed to meet the objectives and collections are not sufficient to form impressions. Of these three methods, the one most applicable to ZMCP conditions is the resting collections, but unfortunately, collections have not been standardized to time. These collections yield better information if they are done early in the morning and should be done at about the same time (0600-0700 hours) for the same time interval (e.g. 15 minutes per house per collector). This will ensure that information is comparable (number of female mosquitoes by species per room or house per 15 minute search). At least 10 collections should be done per spot check or indicator site area.

If adequate pre-insecticide catches have been made, insecticide efficacy and treatment defects can be monitored through routine resting collections following insecticide application. They might also show changes in behavior resulting from the use of insecticide. Consequently, results of resting and other mosquito collections must be made available to the chief of operations.

For blood source determinations, resting collections may be made in outbuildings near houses or in vegetation near houses and breeding sites. Such collections may yield different species than those found indoors and may be done if behavior information is under question. Sweep net collections can be used on vegetation near houses, animal shelters or breeding sites to obtain similar collections.

6.4 Light Trap Collections

Light traps were ordered by the ZMCP but the wrong type arrived. Consequently, they never were used fully as an evaluation tool. Recently Dr. Lines and Ms. Maxwell began to use CDC-type battery-driven light traps for their special activities with good results. ZMCP is requesting several additional traps because *An. gambiae* and *An. arabiensis* are attracted to the traps.

6.4.1 General Objectives

a) To monitor and compare mosquito densities or species by month and by location in indicator sites and in spot surveys.

b) To measure the effects of control measure(s) on a mosquito population and monitor changes in the population over time after the measure has been used.

c) To obtain mosquitoes for taxonomy, sporozoite rates, parous rates and other uses to define entomological-epidemiological variables in an area.

6.4.2 Methods of Operation

a) Select one or more locations depending on the number of light traps available and run them on a standard schedule (number of nights per month; exact site of trap, i.e inside-outside house, proximity to bed net, time of beginning and ending of collection and method transporting of mosquitoes).

b) Redesign forms to include climatological data and note the following information: cloud cover, rainfall, wind, and stage of the moon.

c) Record any changes, including human population, insecticide application, season and malaria cases on the forms.

d) While transporting captured mosquitoes to the laboratory, keep them out of sunlight and maintain a high humidity by placing a damp towel over the pan holding the mosquito bags. Avoid insecticide contamination.

e) Separate Culex from Anopheles species from each trap, count and record the number of each. Use captured mosquitoes for different tests.

f) Express collections as the average number of each species per trap per night per month. This allows comparisons of one month and the preceding ones or of a month from one year and the same month from past years. Trap sites can be compared to detect differences in the consistency of control measures in areas.

g) Collected female mosquitoes can be dissected for gonotrophic cycle or parous rates or used for special tests to determine sporozoite rates.

h) If an evaluation of insecticide treated areas shows increases in population density or sporozoite rates, this may indicate a treatment defect. Confirm by

checking malaria cases reported at the nearest health center and/or intensify control measures.

6.4.3 Special Activities

a) For evaluation of insecticide field trials.

b) Rapid taxonomic and distribution studies.

c) As sentinels in epidemiological surveillance, i.e sporozoite rates.

6.5. Larval Collections

The ZMCP does larval collections in Zanzibar Town to classify habitats producing only *Culex*, only *Anopheles*, or both genera. It quantifies the collections by number of dips but uses dippers of various sizes. Some attempt has been made to evaluate larvicides, but without improved methods little will be accomplished. In rural areas, irrigated rice paddies and other areas with more or less permanent breeding are sampled. The collections have been used for larvae or adults for insecticide susceptibility tests.

6.5.1 Objectives

a) To locate larval habitats and monitor them by season to determine changes in species, population densities or breeding habits.

b) To assist in determining the distribution of adult mosquitoes and evaluate potential for rapid increases in adult populations.

c) To evaluate impact of larviciding, biological control or other antilarval measures on larval density. (Sometimes also used to monitor effects of adulticides).

d) To collect samples of larvae for larval and adult susceptibility tests and bioassay tests or to establish colonies.

6.5.2 Methods and Assessment

a) *Culex* larvae are found in more polluted habitats than *An. gambiae*. *An. merus* is found in more saline water.

Experience and multiple sampling are needed to find larval habitats.

b) Dipping is the best method to use under local ZMCP conditions. Although any type of dipper can be used if only scattered collections are made, some degree of standardization is needed. All dippers should be of the same size. They should be measured and their capacity determined.

c) The most common method of recording larvae density is taking a standard number of dips and expressing the collection as the mean number of larvae per dip.

d) In order to collect large numbers of larvae rapidly, water taken from the habitats can be poured through a small mesh sieve to concentrate them.

e) If ZMCP decides to conduct routine larval surveys, a sketch map should be made indicating the sites, as well as houses, animals and shelters, that might influence the adult mosquito distribution.

f) Studies to determine changes in density and the effects of larviciding or other control measures must be done on a set schedule over a long time period.

g) When larval control measures are evaluated, the habitat receiving the control measure should be compared with a similar habitat not receiving the measure both before and after the measure is begun.

6.6. Bioassays

The Pemba and Unguja offices of the ZMCP have WHO Bioassays kits and instructions on their use. Ideally, adult mosquitoes from colonies with a known history of insecticide exposure that are susceptible to the test insecticide (100 percent mortality at the diagnostic dose) should be used. If field-collected larvae are reared through to adults, WHO susceptibility tests could be done on a representative sample of the reared adults. Field-collected adult mosquitoes should only be used if there is 100 percent mortality at the diagnostic dose or if the degree of mortality is constant and high, but only if no other alternative is available or if the local mosquito population is being followed.

The objective of the adult bioassay tests is to evaluate the duration of the residual effect of an insecticide applied to different surfaces over a period of time, either in the laboratory or under field conditions. In addition to evaluating

the insecticide, it is also possible to evaluate the quality of the spraying operation.

The types of surfaces tested will depend on the types of construction material used in walls in Zanzibar. At a minimum, they should include mud, cement, plastered, coral, stone and wood surfaces. Unsprayed check material should be used as a control. It is particularly important to do bioassays as part of any pilot field studies to select alternative insecticides. Bioassays can be done on impregnated bed nets to evaluate the duration of the insecticide action. Tests should be done in replicate at a minimum of once every two weeks. Changes in the number of live mosquitoes after exposure and holding for 24 hours is a measurement of duration of the insecticide action.

In general it is doubtful that the entomological section (PARENTO) can do more than resting and light trap collections and bioassays for routine insecticide evaluations. These activities can be done with one man and a motorcycle. Larval collections should continue to supply adult mosquitoes for bioassays and insecticide susceptibility tests.

Since the exposure time for malathion is known and the diagnostic dose-exposure time is the same as that recommended by WHO, deviations of mortality (less than 100 percent) in future tests should be studied and confirmed.

Recommendation

If insecticide use is to be continued, the ZMCP will have to improve the quality of entomological monitoring. A minimum of wall bioassays, resting collections, light trap collections and sporozoite determination is needed. Data should be summarized weekly and submitted to an external evaluator each month for comment.

7. ZMCP INSECTARY MANAGEMENT

7.1 Introduction

The insectary has functioned primarily as a holding place for field-caught mosquitoes and as a room where insecticide susceptibility tests are performed. The room is small and poorly well ventilated. Daily maximum temperatures of 38 degrees centigrade or even higher have been recorded. For the time being, insectary activities have been transferred to the health education room, but this is not a permanent solution.

Perhaps the main reason for the present interest in the insectary was a recommendation for the establishment of a DDT-susceptible colony of An. gambiae. Since DDT resistance is extremely high and widespread in both Unguja and Pemba and further use of DDT is unlikely, this recommendation cannot be satisfied without importing the mosquito and is probably unnecessary.

Few colonies of An. gambiae are started from the wild. The collections currently being made in Unguja are from rice fields and are thought to contain An. arabienses as well as An. gambiae. If a colony is deemed necessary, it is suggested that a staff member go to either Amani (NIMR), Arusha (TPRI), or the Dar es Salaam Faculty of Medicine, all of which have old, established colonies, to learn the techniques of maintaining the colony. When the training is finished, he could bring back material to start a colony.

However, given the physical condition of the present insectary and the limited use of insectary-reared insects (an insectary has never been considered a priority during the USAID/Tanzania involvement), we suggest that field-caught mosquitoes will suffice for the ZMCP's needs in the immediate future, unless an alternative insecticide is used. In that case, a colony susceptible to that insecticide should be established.

7.2. Insectary Management

The following outline is suggested for rearing colonies of Culex quinquefasciatus and Aedes aegypti. It will also serve for rearing field-collected anopheline larvae to adults and to hold field collected adults and larvae for laboratory activities.

7.2.1 Uses of Mosquito Colonies

a) Insecticide susceptibility tests: colonies known to be susceptible to an insecticide can be used for comparisons with field-collected insects against a specific or range of insecticides.

b) Bioassay tests in the field with insects known to be susceptible to a specific insecticide.

c) Research.

7.2.2. Physical Conditions Required for an Insectary

a) A source of water for washing glassware and rearing immature stages.

b) Electric lights and outlet plugs.

c) Cages for adult mosquitoes.

d) Pans for immature mosquitoes.

e) Assorted glassware.

f) An air conditioner or fan to help control temperatures and a thermometer.

g) Some type of humidity control for adult mosquitoes.

h) Screened windows and doors to protect against contamination.

i) Shelves or tables with legs protected by ant traps to hold cages.

j) A timer to regulate light and dark periods.

k) One or more dissection microscopes.

7.2.3 Starting a Colony of Mosquitoes

a) Mosquito colonies are usually started with either larvae or adults collected from a single location.

b) Colonies are also begun from eggs, larvae or adults received from an established colony.

c) Care must be taken that all individuals placed in a colony are of the same species.

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b) Colonies are also begun from eggs, larvae or adults received from an established colony.

c) Care must be taken that all individuals placed in a colony are of the same species.

d) All pans and cages should be labeled with the name of the species, habitat, site of original collection, and date collected.

7.2.4 Larval Management

a) Tap water at ZMCP may be used for most activities. If water is cold, let it stand until it is room temperature before putting larvae into the pan.

b) Sometimes it may be necessary to use water from the natural habitat of the larvae. Field-collected water should be filtered before using to remove any natural enemies of the larvae.

c) Distilled water may be used for special insecticide tests or if tap water kills the larvae.

d) The ZMCP larvae pans can hold 200 to 250 third and fourth instar larvae and slightly more first and second instars.

e) Dry yeast, dog biscuits, liver extract and powdered milk are used for larval food. All food should be finely ground. When held for several days and mixed with boiled cracked grain (rice), boiled hay-grass infusion is a source of larval food. Even ground bread crumbs can be used for *Culex*.

f) Some grasses have been found to be useful in *Anopheles* larvae rearing, but care must be taken that the grass is not contaminated with agricultural pesticides. A few stems with roots and leafs are washed out and added to the pans.

g) Larvae should be fed first thing every morning. Only a small amount of food is required.

h) The water level in the pan should be maintained at about a half inch from the top.

i) Clean the water surface of exuviae (cast skins) and bacterial scum daily.

j) Cover pans holding larvae with mosquito netting at night to decrease contamination.

k) All pans and small containers holding larvae should be labeled by species, location of collection and date collected.

7.2.5 Larvae Uses at ZMCP

a) To start a colony for susceptibility tests of adults.

b) To do larval insecticide tests (i.e. temephos).

c) Bioassay for larvicide field testing.

7.2.6 Pupae

a) Each day collect all pupae from the larvae pan and put them into small glasses or petri dishes that are placed into the adult cage.

b) Either do not blood-feed colonies with pupal emergence containers in them or fit a paper cone over the glass or dish to allow emerging adults to escape but limit gravid females entering and ovipositing.

c) Be sure the pupae are placed in the correct adult cage.

d) Remove and clean glasses and dishes from the cages every two days.

7.2.7 Adult Management

a) Use only engorged and gravid females when selecting field-caught adults to start a colony. Do not feed field-caught females on humans.

b) Five to ten percent sugar water or fruit should be available in the adult cage. This food should be changed twice a week (Monday and Thursday). If sugar water is used, more water may have to be added to dampen the cotton.

c) Female mosquitoes should be given bloodmeals twice a week (Monday and Thursday mornings). If females initially refuse to take blood, remove the sugar water or fruit for 24 hours and offer them blood again. Remember that newly emerged females do not feed on blood immediately.

d) Once a colony is established, the females may feed at any time. At first, offer a blood source early in the morning or put the cage under a cloth cover or in a dark room to induce feeding. Initially, blood-feeds may have to be done at night.

e) Chickens (Culex) and small laboratory-reared mice or rats eventually may be used for a blood source. At ZMCP, a specific staff member should be used as a blood source for a specific cage of Anopheles to avoid disease transmission. He should insert his forearm into the cage and hold it motionless for 20 to 30 minutes, or until the females stop feeding. The staff member's name should be placed on the label to identify him as the blood source.

f) Record daily maximum and minimum temperatures and relative humidity.

g) Remove dead mosquitoes from the cage every day. This helps detect abnormal mortality.

h) Culex and Aedes aegypti mosquitoes usually mate readily in the cage, but many anophelines require artificial mating. Pages 175 - 178 of the Manual on Practical Entomology in Malaria - Part II should be consulted.

i) If the insectary is air-conditioned, it may be necessary to raise the humidity. Even without air conditioning, this may be necessary during the hot dry season. A wet cloth towel placed over the cages should be sufficient, but it may be necessary to dampen the towel two or more times a day.

j) Cages should have labels and be dated.

k) Maintain a history of each colony in a notebook.

7.2.8 Collection and Handling of Eggs

a) Mosquitoes oviposit on or at the edge of water in the oviposition glasses in the cage. No special care is needed for Culex because they oviposit the egg rafts directly on the water surface.

b) Anophelines may oviposit eggs singly or in groups on the water surface or on a moist substrata. A petri dish half-filled with water or with a damp layer of cotton wool covered by a single sheet of filter paper that is firmly in contact with the cotton wool to keep it damp, can be used to collect eggs.

c) Eggs from a colony should be collected daily. Culex and Anopheles eggs may be placed in larvae pans immediately. Eggs, if kept moist, can be transported to start colonies. (Aedes aegypti: eggs are deposited in the damp area immediately above the water line.

This area may be lined with filter paper, paper towels, cloth or other material that remains moist. The eggs are kept damp for about three days, then the substrata is allowed to slowly dry. Once dried, the eggs may be held for months. To hatch, the substrata is placed into water.)

7.2.9 Problems/Solutions

a) Ants can rapidly destroy an adult mosquito colony. Ant traps filled with water, water with salt, oil or other barriers should be placed under the legs of tables and shelves holding mosquito cages.

b) Doors and windows should be screened and doors should be kept closed to limit flying insects from entering or exiting the insectary.

c) Except for insecticides used for susceptibility tests, no insecticides should ever be brought into the insectary. Insecticides or insecticide application equipment should not be stored near the insectary.

d) All glassware should be washed and dried after use. Glassware for the insectary should not be used for other activities.

e) Escaped adult mosquitoes should be captured and destroyed every day.

f) Only those authorized to be in the insectary should be allowed in it. One person should be responsible for activities, but more than one person should be trained for insectary management and to do special tasks. However, only one person should do a specific activity at any one time.

g) Some cage types are harder to clean than others. If any amount of insectary work is contemplated, other cages could be made. Cage size may influence mating and feeding. The present cages might be too small.

h) Sometimes when an enormous numbers of mosquitoes (larvae or adults) are collected and the adults are crowded into a cage, some individuals will mate and a colony can be started.

i) Initially, blood-feeding should be done at night for *An. gambiae*.

7.3 Recommendations

a) If an insectary is to be established, a new room is needed in Unguja. The air-conditioned health education room is not being used currently and could be made into an insectary. The room in Pemba is acceptable, but it needs air conditioning and water.

b) An *An. gambiae* colony is required only if the option to use alternative insecticides for vector control is selected. However, insectary facilities will still be needed.

8. PARASITOLOGICAL MONITORING

8.1 Need for Increased Laboratory Facilities

The malaria diagnostic laboratories at the hospitals, cottage hospitals and the ZMCP are inadequate to provide rapid diagnostic services throughout the islands. If malaria control becomes treatment-oriented, some of the health centers will have to be equipped with microscopes and facilities to enable them to provide rapid diagnostic services. Additional staff will have to be trained and a system devised to ensure that the facilities have the supplies needed to function efficiently.

The creation of these new laboratories will not only reduce the time between the blood smear and accurate treatment but will increase coverage and provide more meaningful data than are now available. It should be possible to maintain and review appropriate records locally and to improve the present mechanism for data flow. These improvements call for training for additional microscopists and refresher courses in malaria diagnosis. All outpatient departments of hospitals should also be strengthened to increase diagnostic capabilities. This will in turn reduce the number of malaria cases only clinically diagnosed, which may be wasting antimalarial drugs.

8.2 Need for Improved Malaria Diagnosis

Currently the majority of laboratories only do thick films. These are good for the diagnosis of infection, but species diagnosis is best done on thin films. With very little additional training, quantification (i.e. parasites per field or parasites per white blood cells or parasites per volume) could be introduced, if more exacting studies were believed necessary. These are more meaningful in areas of chloroquine resistance than the subjective ++ notation. It is also apparent that few attempts are being made outside of the ZMCP to identify mixed infections. Once a parasite is detected, the blood smear is scored positive and examination stops. Therefore, the proportion of mixed infections is not being determined accurately. The opportunity to obtain some indication of gametocyte rates in the population is also being missed at hospitals and cottage hospitals.

8.3 Need for Quality Control.

In many laboratories the number of clinically diagnosed malaria cases is much greater than the parasitologically confirmed ones, but it is not possible to determine the accuracy

of the parasitological examination. Currently, the proportion of slides being re-examined is very low and consequently slackness in diagnosis cannot be detected. The proportion should be increased to more than 20 percent of negatives and positives and there should be a regular exchange between laboratories and between technicians within the same laboratory. The chief of PARENTO should coordinate this activity and recommend refresher training when necessary.

8.4 Need for Standardized Malaria Treatment.

Chloroquine at 25 mg per kg should still remain the first-line drug for treatment in every health facility. Efforts should be made to ensure that the alternative drugs are used only when specifically indicated for treatment. It is important, therefore, that chloroquine should be available at all times in the health units. Only then can the ACD and the blood smear exercises be meaningful and appreciated. Consideration could be given to distributing treatment regimens to all health units and offering special courses on management of severe malaria cases to physicians and nurses.

8.5 Need for Monitoring Chloroquine Resistance

Determination and continuous monitoring of the extent and degree of resistance is essential throughout the islands. *In vivo* chloroquine sensitivity tests should be done regularly, preferably annually and at the some localities. There is also a need for periodically assessing the susceptibility of the parasite to the alternative antimalaria drugs. The expertise to do these tests exists in Zanzibar.

Recommendations

- Each month, a sample of blood smears from the ZMCP, the hospitals and the cottage hospitals should be sent to Amani or the Faculty of Medicine to confirm diagnosis.

- The drug distribution system of antimalarials for hospitals should be evaluated and the inventory and system adjusted accordingly. The evaluation could be done by a staff member of the Faculty of Medicine, University of Dar es Salaam.

9. CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

a) There has been minimal dialogue between USAID/Tanzania and the ZMCP about consultants' technical reports and other Project documentation .

b) Objectives, targets and goals were not adequately evaluated or adjusted during the Project. Technical input to alter procedures is difficult now because of the short time remaining until the Project ends.

c) New strategies and adjustment of old ones cannot be implemented or evaluated during the remaining life of the Project because most will require in-depth protocols and pilot studies to evaluate any changes.

d) Lack of fuel and local currency, poor communication within the infrastructure of government, logistics and other factors beyond the control of the ZMCP have seriously reduced progress in malaria control.

e) The GOZ cannot support malaria control beyond the minimum outlined in Tactical Variant No. 1 of the WHO (see Annex G) without some donor assistance.

f) The GOZ should study possible options besides vector control and develop a plan of operation and a contingency plan designed to function within the budgetary limitations. Any plan must define the objectives, targets and goals and provide a means of evaluation.

g) The continued use of DDT as a residual insecticide negatively influenced the ability of the Project to meet the primary objective. It should no longer be used.

h) Selection and procurement of alternative insecticides cannot be justified for island-wide use without adequate pilot studies that demonstrate the effectiveness of the insecticide and the ZMCP's ability to provide near total coverage in a two-month cycle.

i) The latest geographical reconnaissance has many of the same defects seen in past attempts and must be upgraded and improved annually. Requirements include a map room, a draftsman, a protocol of use and more in-service training.

j) Supervision of field activities is extremely weak. No one seems to understand the meaning and importance of such supervision. Data processing will continue to be slow and feed-back to the field of little value unless the system is made more efficient.

k) Entomological studies were conducted at irregular intervals and the information collected could not be analyzed fully. The Project Paper and the many reports on the project do not appear to have explained the need for such studies or how the resulting information should be used.

l) Present insectary conditions do not warrant the establishment of an An. gambiae colony, which will be needed only if vector control continues to be a major function of ZMCP. However, provisions for handling field-caught mosquitoes should be maintained.

m) Although all of the senior ZMCP staff members have excellent technical training, they have little understanding of the management of vector control operations and the planning process of using technical information for decision making and program adjustment. This reflects more on the training process than on the staffs' ability.

n) Any research conducted by the ZMCP must have a peer-reviewed protocol. The peer review group should also be involved in periodic on-site inspections and evaluation.

o) A number of factors known to the ZMCP and USAID/Tanzania make procurement difficult. The problem is complicated at this time because the last procurement order should reflect the GOZ's decision about future malaria control strategies and should be made only after a plan of operation has been completed. Procurement should be directed toward increasing and improving malaria diagnosis at the peripheral level.

p) Basic health services are improving, but they have not reached a level that will ensure reduced morbidity and mortality from malaria. It would not be difficult to strengthen these services.

q) Insecticide-impregnated bed nets and curtains reduce man-mosquito contact, but a significant reduction in malaria transmission has not been demonstrated. Should financial and technical donor support be available, the MOH-ZMCP should consider becoming involved with

projects that could evaluate the role of bed nets and curtains in reducing malaria transmission.

r) Alternative insecticides would require about 139 spraymen on each of the two main islands, 167 spray pumps in Pemba and 156 in Unguja, and considerably more funds than formerly used for DDT to ensure enough insecticide for near total house coverage.

9.2 Recommendations

Any recommendations will have to be adjusted to the future policy of the GOZ towards malaria control.

a) The use of DDT for residual wall spraying should be discontinued.

b) If residual wall spraying is continued, malathion should be considered the best choice of the available alternative insecticides and should be field tested. Synthetic pyrethroids should be reserved for bed net studies.

c) Pilot studies in both Pemba and Unguja are necessary to demonstrate the effectiveness of any insecticide and the ZMCP organizational design to function effectively before an island-wide campaign is considered.

d) No alternative insecticide should be ordered until there are sufficient funds available to ensure long-term success. Projected funding should be for at least five years. Less time would not be cost effective.

e) The GOZ must seriously consider options to malaria control that are less expensive than insecticides, including rapid diagnosis and treatment of cases. The possibility of improving malaria control through other donor-supported health activities should be explored.

f) The committees outlined in the 1989/1990 ZMCP Plan of Operations should be established only after precise terms of reference and an agenda are provided. Membership in the committees needs review.

g) USAID/Tanzania should assist in creating a peer group of national and international scientists working in Tanzania to review, evaluate and advise on technical changes in future ZMCP activities.

h) The ZMCP should ask WHO to support a course on management of clinically severe malaria in Zanzibar.

i) Studies to determine and map antimalarial drug resistance should continue.

j) Establish a database of possible variables for stratification. If computer hardware and software are improved, the Vector Biology and Control Project could be asked to provide programs.

k) Improve planning of operations and protocol development within the ZMCP regardless of the control option selected. Perhaps a WHO/MAP/AFRO team similar to the one that visited Tanzania in 1984 could be requested.

l) Reactivate and intensify health education in the ZMCP and retrain malaria agents and other peripheral health staff in malaria awareness and roles of community.

m) Begin sporozoite rate determinations and other entomological studies that would be useful in current bed net and epidemiological evaluations. These studies would continue to improve the information needed for stratification in addition to maintaining a baseline should vector control be selected as the future strategy.

n) The ZMCP should encourage bed net studies and participate in their evaluation, but financial and technical assistance would be required throughout the study from sources outside the ZMCP.

o) Variations of WHO Tactical Variants No. 1 and No. 2 should be considered as affordable options. Microscopes and blood slide supplies could be ordered at any time to strengthen peripheral laboratory diagnosis. Malaria agents and other peripheral health workers could be given additional responsibilities in malaria control (e.g. treating malaria patients with first-line drugs and taking blood smears at homes of patients). Before introduction of any option, the ZMCP should do a resource study of the health units to determine malaria caseloads per individual unit and staff and commodity requirements in order to upgrade units in risk areas.

p) A certain level of larviciding should continue in Zanzibar Town. Space spraying equipment and insecticides should be used for emergencies and the municipality should be encouraged to increase drainage work.

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ANNEX A

STRATIFICATION AND ANALYSIS OF EXISTING DATA

1. Introduction

Malaria control is measured through changes in indicators. The ZMCP has used entomology, parasitology and epidemiology to monitor progress. Many of these evaluation indicators are of little value because the information is incomplete and defies analysis. Soon the current financial support will stop and the GOZ will be faced with selecting a new strategy that fits its ability to finance or to seek and find monies elsewhere. Improved data would be beneficial in the selection of a new strategy and might influence donors to assist the program.

Although stratification of malaria has been considered the introduction to scientific malaria control, the ZMCP's progress in this area has done little to create a foundation for selection of appropriate control measures. The objective of stratification is to identify relevant variables and relate them to malaria epidemiology and control in different areas in order to develop more effective control strategies for these areas. The ZMCP has a computer for analysis and can create a database on malaria transmission and control. Various other governmental agencies (Agriculture, Finance, Meteorology) have specific information that could be used. It is understood that the database will not be perfect, but if the time is taken to study the database, the information that should be added, deleted or strengthened to make it more sensitive will soon be evident. Some data that might help are provided at the end of this Annex.

Common sense should be used in stratification in order to avoid the tendency to study more and more variables. Specific variables will differ and those given below are for guidance only. The variables should be sensitive to changes in number and severity of malaria cases and to changes in the relevant predictive factors of malaria.

2. Stratification factors

2.1 Climatology

a) Rainfall: monthly accumulation by area as it affects mosquito population and malaria and as it relates to present and past conditions.

b) Temperature: daily means over time.

- o probably has less influence on malaria than rainfall
- o it is possible to compare two week averages with the number of malaria cases using graphs

c) Humidity: average relative humidity.

- o Known to influence longevity of adult mosquitoes: a high relative humidity may increase the number of infected females.
- o Compare relative humidity with mosquito population, aging and sporozoite rates. However, as with temperature, it will be difficult to demonstrate any influence on islands of this size.

2.2 Geographical

a) Flat vs. hilly regions.

- o Compare larval habitats, drainage, number of malaria cases in both Zanzibar and Pemba. Influence may be greater during the dry seasons than during the rainy ones.

b) Drainage: bodies of water below sea level in urban areas, number, size and feasibility for draining.

c) Vegetation - soil type

- o North A, North B, Central Districts compared with South (coral and non coral) in Unguja as related to malaria.

d) Climate - Geographical

- o logistical problems by control strategy, e.g. vector control/treatment of human cases.
- o season and logistics

2.3 Demographic

a) percent urban-rural population

b) age distribution: urban - rural population

c) population movement - migration to city or irrigation area

d) number and type of construction of houses per political unit (Branch)

e) number of inhabitants per house per political unit

f) level of education - knowledge and response to health education

2.4 Socio-economic

a) land use, especially in agricultural areas and the urban-rural fringe

b) projected and real irrigation areas and their locations

c) size and type of housing (amount of sprayable surface-type of surface, if insecticide is used)

d) effect of irrigation on income and living conditions

e) cost of different control strategies (ability to finance)

f) agricultural pesticide use as it relates to the vector

g) economic consequence of malaria by categories of people

h) human behavior as it relates to seeking treatment, influencing vector habitats and community participation

i) level of education

j) personal protection measures in use or available

2.5 Epidemiology

a) morbidity and mortality by age group by area and by time

b) number of clinically vs parasitologically confirmed cases - quality of case detection

c) disease load and distribution

d) malariometric surveys
e) migration into and from risk areas

f) habits and special activities (type of work) to increase exposure

g) infant and pregnant mothers - What indicators are available?

h) variation in control strategy and coverage by specified areas

i) response to case treatment and quality of treatment by type of health unit

j) distribution of health units, type of staff and laboratory facilities

2.6 Parasite

a) species involved by rank and distribution - percentage of mixed infections - amount of misdiagnosis by area

b) type, amount and distribution of antimalarial drug resistance and changes in progress

c) effectiveness of different drugs and regimens

2.7 Entomological

a) species involved and their distribution

b) vector population densities by season, area etc.

c) sporozoite rates by species, area, rate of transmission, age, etc.

d) exophilic- exophagic or endophilic-endophagic nature of vector (feeding and resting habits)

e) blood source: human or non-human and potential changes

f) age of biting females by season

g) type and effectiveness of monitoring surveillance

h) type of vector control measures used by specific area

i) amount of agriculture chemicals used and their distribution

j) vector resistance to insecticides:
   - o used for malaria control
   - o used in agriculture

k) distribution and degree of insecticide resistance by vector species

l) attitude of public towards insecticide use

2.8 Health Infrastructure

a) number, distribution and quality of parasitology laboratories and personnel

b) number, type, and distribution of health units

c) quality of clinical diagnosis and treatment

d) number and location of referral facilities and level of use

e) number of malaria agents and distribution

f) quality of health education

g) channels of communication

h) quality of statistics-database

3. Stratification: Observations And Questions

a) The following are areas of interest of the ZMCP:

   - o urban: especially Zanzibar Town and the urban-rural fringe for vector control
   - o rural: irrigated - non-irrigated land and its future importance in malaria transmission
   - o rural: North-South of Unguja (mosquito populations and the distribution of human cases)

b) There are observable differences in vector population/malaria cases by rainy season/dry season. Rainfall distribution differs among areas of Zanzibar. Can vector control be improved by altering application cycles?

c) The South of Unguja has fewer malaria cases and fewer anopheline mosquitoes. Topography, housing type and distribution may be factors, but which are really the most important?

d) A large proportion of mosquitoes bite outside and before 2200 hours. How will this influence bed net studies and future use of residual spraying of houses?

e) Any attempt at stratification will be linked to economics. (Study budget and risk areas.)

f) There is interest in carrying stratification beyond a simple rural-urban strategy, but the tools are still lacking. What research is necessary?

g) Past data collecting and analysis have provided little worthwhile information, but they should be studied. How can the process be improved?

h) Local funding is too limited and irregular to make nationwide vector control practical. Can or will communities respond to relieve some of the financial burden the GOZ will soon face?

i) The islands are small and the potential flight range of the vector may influence the interpretation of the data needed for stratification.

j) Political-people pressure may force the use of a single island-wide strategy unless extensive health education is done.

h) Integration of stratification methodology may be beyond the managerial and technical capability of the ZMCP. Who can help?

4. Stratification Capabilities

Regardless of the control strategy, GR and analysis of data are essential. If data are to be collected, the possibility of variables influencing malaria epidemiology and control should be studied. Information is available for most of the variables listed above with which to begin a database. Many of the variables may prove worthless, but the process of studying them will be worthwhile. The Vector Biology and Control Project has expertise in this field and might be able to help develop programs. The ZMCP has two small computers but lacks hardware capacity and software for database development and graphics.

Distribution of insecticide resistance, antimalarial drug resistance, seasonal distribution of rainfall, health centers, malaria risk areas and other available information should be mapped and graphs made on which the effects of one or more variables can be plotted.

5. Existing Data and Potential Value

The following tables provide some of the information available at the ZMCP.

Table 1: Rainfall Data from 1985-1988 for Unguja and Pemba
(in mm)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Unguja												
1984	32.9	TR	135.5	628.9	213.2	156.4	100.3	18.4	57.8	121.9	364.2	88.9
1985	102.1	117.5	228.2	405.6	222.9	9.3	60.4	27.4	7.1	59.8	339.2	316.5
1986	30.6	1.4	317.2	713.0	345.5	30.3	TR	13.9	44.1	147.0	368.7	321.4
1987	54.7	3.3	33.2	204.2	524.2	0.4	36.5	74.2	14.0	47.4	53.6	184.3
1988	99.2	4.0	63.5	327.5	129.4	192.6	199.6	25.9	106.8	41.4	124.4	278.8
Pemba (reported as mm but obviously not)												
Micheweni												
1985	0.3	0.7	0.7	0.6	1.0	0.3	0.4	0.2	0.2	0.2	0.7	0.6
1986	16.9	NIL	39.5	28.0	33.8	21.7	37.0	39.3	NIL	4.3	15.1	27.6
1987	NIL	25.0	20.8	26.2	27.7	7.3	14.5	18.2	NIL	17.3	14.7	8.5

Table 1: Rainfall Data from 1985 - 1988 for Unguja and Pemba (Continued)
(in mm)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Wete												
1985	0.3	1.5	0.9	1.0	2.4	0.48	0.4	NIL	NIL	NIL	NIL	NIL
1986	NIL	NIL	38.9	18.2	30.9	6.5	13.5	3.0	2.7	4.7	14.0	7.4
1987	NIL	7.5	59.0	22.4	31.9	6.6	11.6	27.3	NIL	14.1	13.6	15.8
Chake Chake												
1985	1.2	1.3	0.9	1.6	1.9	0.3	0.9	0.4	0.2	0.1	0.4	0.8
1986	10.7	NIL	11.0	35.7	75.9	28.3	2.7	14.0	1.0	7.4	30.3	45.1
1987	43.0	8.0	49.0	38.8	11.0	8.1	21.9	42.7	11.0	3.3	NIL	NIL
Mkoani												
1986	44.2	NIL	12.4	30.9	62.2	32.7	3.7	22.2	9.0	5.9	17.0	12.4
1987	6.8	NIL	50.0	20.2	40.0	6.8	30.8	18.7	NIL	5.0	28.0	23.1
1988	15.8	14.3	16.6	39.6	35.3	14.5	5.1	9.7	9.4	16.8	17.0	23.0

Table 2a: Health Facilities in Unguja and Pemba

	General Hospitals	Special Hospitals	Maternity Homes	Cottage Hospitals	Dispen-saries PHC	Total
Unguja 1985	1	2	2		42	47
Pemba 1985	3	0	0		31	34
Total	4	2	2		73	81
Unguja 1988	1	3		2	67	
Pemba 1988	3	1		2	49	
Total*	4	4		4	116**	116

* In early 1989, 107 health units (including those in army camps and prisons) and 4 health centres were in operation. With the opening of 4 new units in the near future, all of Zanzibar's population will live within 5 km distance from a PHC-facility (Health Information Bulletin) No. 47, Statistical Unit, MOH, Zanzibar. (Note: 12 hospitals also included as PHC.)

** There are 118 malaria surveillance agents in Zanzibar (84 in Unguja and 34 in Pemba).

Table 2b: Percent of Patients Admitted for Malaria* and Subsequently Dying, by Major Age Group - 1986

Cause of Death	0-4 years	5-14 Years	15 years and Over	All Ages
Malaria	12.5	4.7	3.4	6.8

* For all ages the fatality rate was about 7%.

Table 2c: Health Statistics for the Life of the Project

	1984	1985	1986	1987	1988
Percent of all diagnoses for malaria in Zanzibar Hospitals	35.1	32.7	32.2	34.8	NA
Percent of all deaths in Zanzibar hospitals due to malaria	27.8	27.8	27.8	31.5	NA
Percent of all new diagnoses that were malaria in Zanzibar PHC-units and centers	29.1	28.1	30.1	30.7	34.7*

* 9 Months only

Table 3a: Malaria by Clinical Diagnosis in Health Clinics, 1987

Health Unit	Malaria Cases	All Diagnosis	% Malaria
North A, January 1987			
Nungwi	141	731	19.3
T/Gomani	144	499	22.9
PW/Mchangani	245	908	26.9
Matemwe	371	1313	28.3
Kidoti	499	1341	37.2
T/Jongowe	61	162	37.7
Chaani	705	1711	41.2
Mkokotoni	631	1401	45.0
North A, March 1987			
Nungwi	83	523	15.9
Matemwe	179	290	20.1
T/Jongowe	40	137	20.2
T/Gomani	112	525	21.3
PW/Mchangani	100	447	22.4
Kidoti	247	1001	24.7
Chaani	331	1098	30.1
Mkokotoni	404	1087	37.2
North A, June 1987			
T/Gomani	194	600	32.3
Matemwe	455	1047	35.5
Nungwi	295	825	35.8
PW/Mchangani	319	836	38.2
J/Jongowe	130	331	39.3
Chaani	501	1237	40.5
Kidoti	657	1505	43.7
Mkokotoni	584	1220	47.9
North A, September 1987			
PW/Mchangani	95	533	17.8
T/Gomani	110	392	22.1
Matemwe	269	1042	25.3
Nungwi	172	678	25.4
Kidoti	308	988	31.2
T/Jongowe	77	244	31.6
Mkokotoni	280	834	33.6
Chaani	346	960	36.0

Table 3a: Malaria by Clinical Diagnosis in Health Clinics, 1987 (Continued)

Health Unit	Malaria Cases	All Diagnosis	% Malaria
North A, November 1987			
P/W/Mchangani	200	940	21.3
Nungwi	213	780	27.3
T/Jongowe	110	350	31.4
Matemwe	323	941	34.3
Kidoti	416	1188	35.0
T/Gomani	297	812	36.2
Mkokotoni	335	882	37.9
Chaani	532	1337	39.2

Table 3b: Malaria by Clinical Diagnosis in Health Clinics, 1987

Health Unit	Malaria Cases	All Diagnosis	% Malaria
Mkokotoni Health Centre, 1987 (North A)			
January	631	1401	45.0
February	400	1328	30.1
March	404	1087	37.2
April	249	1085	22.9
May	217	700	31.0
June	584	1220	47.9
July	450	1095	41.1
August	324	826	39.2
September	280	834	33.6
October	312	850	36.7
November	335	882	37.9
December	397	867	45.2

Table 4a: Summary of Results of Insecticide Susceptibility Tests with 4% DDT on Adult Female *Anopheles gambiae* sl.

Year	No. of Tests Conducted	Percent Mortality		
		Minimum	Maximum	Mean
1981	12	16.4	58.5	31.2
1982	--	--	--	--
1983	17	20.0	90.0	60.8
1984	68	14.0	95.0	58.0
1985	6	39.9	100.0	42.6
1986	18	8.0	97.5	50.0
1987	9	15.0	96.7	45.1

Table 4b: Spraying Operations in Unguja and Pemba

Cycles Round/District	1984 1st	1984 2nd	1985 1st	1985 2nd	1986 1st	1986 2nd	1987 1st	1987 2nd	1988 1st	1988 2nd
UNGUJA										
North A	-	+	+	+	-	+	+	+	-	+
North B	-	+	+	+	-	+	+	+	-	+
Central	-	+	+	+	-	+	+	+	-	+
South	+	+	+	+	-	+	+	+	-	+
West	-	+	+	+	-	+	+	+	-	+
Peri-urban	-	-	-	-	-	-	-	+	-	+
PEMBA										
Wete	-	+*	-	-	-	+	-	+	-	+
Micheweni	-	+*	-	-	-	+	-	+	-	+
Chake Chake	-	-	+*	-	-	+	+	-	-	+
Mkoani	-	-	+*	-	-	+	+	-	-	+

\+ Spraying carried out.
\- Spraying not done.
* Malathion was used, otherwise DDT.

Table 5: Average number of mosquitoes per trap night per year and percent of total mosquitoes captured per year for each indicator site*

Indicator Site	YEAR					
	1984	1985	1986	1987	1988	1989
Indoors						
North A						
No.	189.17	50.56	235.11	94.57	51.56	164.00
Percent	24.10	6.44	29.95	12.05	6.57	20.89
North B						
No.	70.16	5.14	1.00	0.00	1.33	1.00
Percent	89.25	6.53	1.27	0.00	1.68	1.27
Central						
No.	84.60	28.01	16.60	12.20	36.38	30.50
Percent	40.62	13.45	7.97	5.86	17.46	14.64
Outdoors						
North A						
No.	280.33	59.67	233.78	81.86	77.11	51.00
Percent	35.77	7.61	29.83	10.44	9.84	6.51
North B						
No.	79.50	6.57	3.60	1.44	2.11	2.00
Percent	83.49	6.90	3.78	1.51	2.22	2.10
Central						
No.	101.20	66.64	41.40	39.20	45.50	29.50
Percent	31.29	20.60	12.80	12.12	14.07	9.12

* Indicator site south not included as only three mosquitoes were collected.

Table 6: Average number of Anopheles[1] collected per night and per hour from night collections made at four indicator sites from May 1984 through February 1989*

Month	Average Per Night **		Average Per Hour	
	Indoors	Outdoors	Indoors	Outdoors
January	50.18	31.73	4.18	2.64
February	10.33	16.76	0.86	1.40
March	4.62	9.77	0.39	0.81
April	74.00	99.50	6.17	8.29
May	169.60	160.60	14.13	13.38
June	68.40	92.40	5.70	7.70
July	27.71	38.57	2.06	3.21
August	26.31	44.44	2.19	3.70
September	24.75	18.75	2.06	1.56
October	26.86	41.57	2.24	3.46
November	26.00	52.35	2.17	4.36
December	103.18	112.70	8.60	9.39
Average	44.55	55.10	3.71	4.59

1 No attempt was made to identify species of Anopheles

* Based on a total of 154 all night biting collections

** Rains begin in late March and reach a peak in April but continue into June (early July in 1988). The other rainy season is November-December. The biting catch begins to move upward in April, peaks in June and decreases in July. It peaks in December but remains high in January in relation to the short rain.

Table 7: Number and percent of mosquitoes collected during all night biting catches by four hour time period at three indicator sites from May 1984 through February 1989*

Indicator Site	Total	1800 - 2200**		2200 - 0200**		0200 - 0600**	
		No.	Percent	No.	Percent	No.	Percent
Inside							
Central	1392	392	28.16	585	40.03	415	29.81
North A	5160	1331	25.79	2517	48.78	1312	25.53
North B	476	34	7.14	251	45.17	227	47.69
Total	7028	1757	25.02	3317	47.18	1954	27.80
Outside							
Central	2153	1013	47.05	868	40.32	272	12.63
North A	5692	1640	28.81	2765	48.58	1287	22.61
North B	577	81	14.04	274	47.49	222	38.47
Total	8422	2734	32.46	3907	46.38	1781	21.16

* The south district is not included as only 2 mosquitoes were collected indoors and 1 outdoors during the study.

** During the WHO Malaria Eradication Program, it was found that *An gambiae* was active throughout the night, but activity from 1800-2200 hours was the highest (42% of the catch) in Zanzibar and in Pemba only 20%. In the ZMCP study, the greatest activity was from 2200-0200 hours (about 47% of catch). More mosquitoes were caught Outdoors than indoors. No determination of species was made.

Table 8: Total numbers of Anopheles collected per hour from 1800 to 0600 hours at each indicator site and average number of bites per each hour from all sites.

Indicator Site	Time of Collections											
	6-7	7-8	8-0	9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5	5-6
A. INDOORS												
Central	57	106	104	93	154	139	135	157	112	143	73	85
North A	147	294	322	578	633	840	502	539	593	300	235	184
North B	3	6	13	12	38	57	46	74	85	80	40	22
South	0	0	1	1	0	0	0	0	0	0	0	0
Total	209	406	440	683	825	1036	561	770	790	523	343	291
Average	1.3	2.64	2.86	4.44	5.36	6.73	3.64	5.00	5.13	3.40	2.26	1.89
B. OUTDOORS												
Central	199	319	209	291	229	250	208	180	194	145	153	91
North A	193	356	395	513	798	815	637	520	404	297	274	260
North B	3	25	21	32	41	70	75	88	86	55	50	30
South	0	0	0	0	0	0	0	0	0	0	0	0
Total	395	700	625	836	1069	1135	920	783	684	497	477	381
Average	2.56	4.55	4.06	5.43	6.94	7.37	5.97	5.12	4.44	3.23	3.10	2.47

Table 9: Summary of Night Biting collections*

Data on night biting catches from 154 collections

		Indoors	Outdoors
Number of negative collections			
	Anopheles	61	52
	Culex	91	101
Number of mosquitoes collected			
	Anopheles	7030	8658
	Culex	769	659
Percent of mosquitoes collected			
	Anopheles	44.8	55.2
	Culex	53.9	46.1
Rank of indicator site for mosquito production by percent			
		Anopheles	Culex
	North A	70.2	4.9
	Central	22.9	15.8
	North B	6.8	17.3
	South	> 0.1	62.0

* Note: These data can be compared with human cases from health unit nearest indicator site and with rainfall for stratification.

Table 10: Average number of *Culex* captured during night biting collections by indicator site for years 1984 to 1988

	YEAR					
	1984	1985	1986	1987	1988	Average*
Inside						
Central	14.40	0.60	4.80	0.50	0.38	3.05
North A	5.00	0.00	3.00	0.14	0.33	1.53
North B	3.00	1.00	0.80	0.00	0.22	0.86
South	60.60	25.00	5.00	12.63	2.00	19.39
Outside						
Central	17.40	0.50	1.50	0.20	0.50	2.63
North A	0.50	0.22	0.22	0.28	0.00	0.23
North B	24.67	3.86	1.60	0.11	0.00	5.11
South	41.00	17.33	10.60	2.30	3.43	12.60

* Unlike *Anopheles*, the south reported the larger *Culex* catches. It is also an endemic area for filariasis. In 1987 a project to put plastic balls in pit latrines began and the project is ongoing. This control tactic may account for some of the reduction in *Culex* catches in the south.

Table 11: Resting collections of Anopheles and Culex mosquitoes by year (May 1984 - February 1989)*

Indicator Site	Anopheles						Culex					
	1984	1985	1986	1987	1988	1989	1984	1985	1988	1987	1988	198
North A	11	91	41	79	106	33	0	0	0	0	0	0
North B	2	0	0	0	5	0	1	0	0	2	0	0
Central	136	10	4	3	31	1	35	0	0	1	3	0
South	0	0	0	0	0	0	42	1	37	168	0	0
Total	149	101	45	82	142	34	78	1	37	171	3	0

* Absolute numbers and number of collections and collection times varied. However, standardized valuable information should be available on insecticide treatment efficacy over time and to highlight any treatment defects. More frequent collections might help in study mosquito-malaria case changes if insecticide had been more effective.

Table 12: Average number of mosquitoes per light trap night from Miwani and Bumbwisudi*

	MIWANI			BUMBWISUDI		
	Trap Nights	Anopheles	Culex	Trap Nites	Anopheles	Culex
1988						
May	8	29.63	22.75	11	103.18	15.64
June	14	40.21	45.43	14	64.50	10.79
July	14	6.50	81.57	14	15.50	18.57
August	16	0.19	3.19	18	1.56	2.89
September	16	0.06	0.00	12	0.42	4.08
October	8	0.00	0.00	8	0.50	0.50
November	8	14.50	1.13	11	25.36	6.64
December	6	15.67	6.67	9	44.89	4.11
1989						
January	8	247.38	85.00	12	274.83	34.33
February	4	3.00	62.50	11	1.27	14.36
March						

* Two traps were run at Miwani and either two or three traps were run at Bumbwisudi each collection period. The ZMCP are using unadjusted monthly collection numbers which mean little if not adjusted to average light trap use. Could compare with night biting collections by month and with climatological data.

ANNEX B

CONTINGENCY PLAN

1. Introduction

The ZMCP was established through a loan from A.I.D. and followed the approach outlined as WHO Tactical Variant No. 3 (see Annex G) including a specialized vector control operation and an entomological-parasitological monitoring system. Funding will end before the objectives of the Project Paper have been met.

The GOZ probably does not have sufficient economic development to continue malaria vector control throughout the country. Even with donor support, the strategy of widespread long-term residual application of insecticides cannot be considered seriously because until now it has not been a technical success. Insecticide coverage requires a level of perfection that will be difficult to achieve given the technical and administrative constraints found in Zanzibar, including vector and people resistance to DDT and people resistance to malathion when it was used in Pemba, as well as lack of fuel and field supervision, which has resulted in incomplete coverage and long treatment cycles.

There are a number of options to be considered but each has its own defects and would not offer the level of malaria control possible under an effective vector control program. Options such as insecticide-impregnated bed nets and curtains have not been sufficiently evaluated. Bed nets, extensive source reduction and other methods directed towards the mosquito are expensive. Therefore, the best approach for the available money is to direct it toward man, not the mosquito, and to upgrade the case treatment activities as funds become available and general health services improve.

One of the first steps will be to determine how much malaria the government and people are willing to tolerate and what resources are needed to reach and maintain this level. When this has been decided, options can be investigated, selected and implemented. The ZMCP should immediately set in motion the mechanisms for developing a contingency plan and outlining its role in such a plan. In reality, final procurement of commodities through A.I.D. should not be done until the available options have been evaluated and a contingency plan written.

The plan most likely to be manageable would be a flexible combination of the WHO Tactical Variants No. 1 and 2. Vector control equipment and insecticides might be considered for urban areas and for emergencies. The plan is based upon a gradual improvement of general health care, particularly maternal and child health and nutrition. The plan would require additional staff and improved in-service training, as well as laboratory equipment and supplies.

The problem with options is time because A.I.D. has placed a deadline on procurement. Even if residual spraying were possible, it would be almost a year before insecticide would arrive and the next cycle would be completed. The obvious conclusion is that in all probability, cases of malaria will increase. This conclusion supports the use of the existing basic health infrastructure to provide improved rapid diagnosis and treatment of cases.

2. Objectives

a) To reduce malaria mortality to the maximum extent through prompt diagnosis and adequate treatment of malaria cases.

b) To identify risk areas and populations and reduce malaria prevalence to as low a level as possible.

c) To encourage additional efforts to protect pregnant women and infants from the disease.

d) To strengthen the role of the malaria agents, rural health centers and other health units in prevention, diagnosis and treatment of malaria.

e) To improve the epidemiological reporting system and establish effective linkage between the health services and the ZMCP.

f) To continue to monitor resistance to antimalarial drugs and improve the clinical management of severe cases of malaria.

g) To develop and stimulate malaria research through collaboration with international and national research institutions and industry.

3. Targets

a) In 1989, survey existing malaria statistics, identify risk areas, determine future rural and urban health

center and staff requirements related to malaria epidemiology, prepare a list of equipment and supplies and work out the logistics of maintaining an adequate supply of drugs at all health units.

b) In 1989, prepare a flow chart of levels of responsibility and decision making. Begin meetings at branch, region, district and other government-political levels to inform those at every level of changes in strategy and their obligations to make the changes efficient and effective.

c) Before the end of 1989, develop and begin workshops, seminars and meetings at the MOH and the ZMCP to train general health services staff and other primary health care workers on changes in routine duties and responsibilities for malaria diagnosis-treatment.

d) At the same time, provide written guidelines and training for the treatment regimen of first and second line anti-malarial drugs.

e) Immediately request that WHO give a course on the clinical management of severe malaria to physicians, nurses and possibly paramedical personnel.

f) Procure microscopes, chemicals and supplies for additional parasitological laboratories by early 1990.

g) After medical and paramedical personnel complete the WHO course, begin an assessment of patients' response to the different aspects of treatment and case management.

h) In 1990, reactivate the malaria health education unit with emphasis on community and individual awareness and response to the changes in malaria control, and on future involvement, including financial and labor support.

i) As soon as adequate computer hardware and software are available, improve the use of information for project evaluation and development of a stratification strategy.

j) By the end of 1990, increase morbidity monitoring by blood smear examination of suspected malaria cases by 50 percent.

k) By the end of 1990, increase available field incubators, basic field kits and trained staff for

monitoring of P. falciparum sensitivity to anti-malaria drugs and map the geographical distribution and severity of chloroquine resistant strains.

4. Malaria Strategies and Activities

4.1 Malaria Diagnosis

Several problems now exist in malaria diagnosis. Only a few cases are confirmed parasitologically because health centers do not have the facilities or staff for blood smear identification. Even where facilities and staff are available, blood smears might not be taken or examined because of lack of electricity and water, patient overload, or the indifference of some of the medical profession towards the need for case confirmation. Microscopic examination is essential for correct diagnosis, accurate detection of antimalarial drug resistance without specialized tests, and modification of treatment for clinical cases not responding to therapy.

Many of the health units could be upgraded easily to provide parasitological confirmation of malaria for the unit and for smaller ones nearby. Selection would depend upon the unit's caseload and staff and the population served. The ZMCP, as well as several laboratories on the mainland, can provide training. Because of shortages of electricity, microscopes should have mirrors for field illumination. A quality control check (section B) will be needed. The ZMCP should become a core group for training, laboratory inspection, and quality control. It should also be responsible for helping the statistical unit compile and analyze malaria statistics. The WHO-APO should be encouraged to take an active part in planning strategies.

The ZMCP should have at least one motorcycle or small four-wheel drive vehicle and one driver per island to pick up slides from health units without laboratories, delivery results and handle the logistics for quality control of diagnosis.

4.2 Malaria Treatment

Shortages of chloroquine phosphate syrup and injections have been reported from 25 to 50 percent of the health units. Other first-line antimalaria drugs are only occasionally in short supply. Confusion still exists about proper treatment despite the provision of courses and the availability of drug literature. The ZMCP reports wide variations on prescriptions received from various health units. Refresher training and a directive issued by the proper authority within the MOH might correct some of these errors.

Chloroquine still must be considered the first choice antimalarial drug in Zanzibar. As more is learned about the level and pattern of resistance, this may change. Until, then all health units should maintain a supply of chloroquine tablets, syrup and injections. In high risk areas and during transmission peaks, supplying malaria agents with tablets and syrup might be considered. This might expedite early treatment of small children.

All patients referred to major health centers, cottage hospitals, hospitals and ZMCP should have blood smears made for diagnosis. Sufficient information should be obtained at all health units so that malaria agents can follow up on cases. If patients do not respond to the first standard course of treatment and are not critically ill, they should receive a second standard course of treatment and a daily blood smear examination should be made. If the patient still does not respond to chloroquine or if the patient is critically ill, a second-line antimalarial drug should be given (46).

Monthly records of the amount of each type of malaria drug used be used to improve the drug delivery system. One motorcycle or small vehicle and one driver in Pemba and two in Unguja could supply rural health units with antimalarial drugs and collect epidemiological information. The EDP is responsible for the rural health units. The ZMCP would have to develop a support system for urban health units. The two programs involved in the distribution of malaria drugs should coordinate their activities.

4.3 Malaria Education

The front-line contact with the public is the malaria agents and dispensary/health center staff. Many staff members have received primary health care training with an emphasis on malaria. However, there remains considerable confusion among the malaria agents and their immediate field supervisors about their duties. Considerably more training in communication skills and malaria will be needed before their role in motivating the public through malaria education will be effective.

Some health education professionals will be needed at the ZMCP. Their function should be more than poster design because dialogue at the community level is the first step toward decisions and commitment. Radio, television, party offices and schools are points where communication can begin. Health education efforts will require extensive follow-up at the peripheral level.

4.4 Epidemiological Information

Evaluation and program design require accurate, current statistics. The ZMCP has begun to look at the malaria information available from strokeforms at the peripheral health centers. This is the same information used by the statistical unit for its administrative and political division summaries. It is subject to the same error and criticism often aimed at health statistics, but represents a beginning at the peripheral level to understand the dynamics of malaria and attempt to develop concepts of variables useful in stratification. The chief of PARENTO should be encouraged to continue and expand this work, particularly if better computer facilities become available.

4.5 Vector Control

More urban vector control is possible in Zanzibar Town and elsewhere (section 5). The ZMCP can locate and map larval habitats, do chemical and non-chemical treatment evaluations, and advise on or actually do larviciding. Activities against *An. gambiae* should be given priority over those involving *Culex quinquefasciatus* control, but public pressure will undoubtedly make it necessary to control both species.

Temephos should be considered the larvicide of choice, but it will have limited success when applied during heavy rains or where there is a rapid flow of water. Strategies for space spraying to kill adult mosquitoes have not been fully developed, but the ZMCP has the equipment and expertise to do so.

Most mosquito problems in urban areas are engineering, rather than vector control-oriented. Consequently, town governments should attempt to eliminate breeding site instead of taking on the long-term expense of larviciding. The ZMCP should help municipal governments seek funds to improve drainage.

4.6 Evaluation

The level of supervision and evaluation of the vector control program has been poor. These deficiencies result in expensive mistakes and should not be tolerated when funds are limited. It is of little value to select and implement any option without having a reliable supervision/evaluation system. Decision makers and those allocating funds should demand the level of commitment, the targets and goals, and other checks and balances needed in a plan of operation to ensure progress. Adequate funding for evaluation must also be available.

The report of Ivarro Cano (46) should be studied for parameters and indicators for evaluation that are applicable to

the WHO Tactical Variants No. 1 and No. 2 in Tanzania. The NIMR could advise on evaluation methods that have worked on the mainland.

5. Present Plan of Operation 1989/1990

As a management tool to increase work efficiency and effectiveness, the plan is failure. Clear-cut priorities, targets and goals, and program strategy are missing. Since the objective of the original Project Paper is still proposed and it is obvious that it has not been met, a more flexible approach is needed. The plan should openly discuss reasons for failures in all administrative, budgetary and technical categories. It should provide remedies to be implemented during the life of the plan.

A new plan of operation including a contingency plan recognizing the end of A.I.D involvement should be prepared. Committees proposed in the present 1989-1990 plan should be formed and assigned tasks related to their technical or administrative capacity. The committees should be actively involved in drafting certain sections of the plan according to outlines and agenda prepared by the ZMCP.

The ZMCP should continue to seek donor support and technical assistance. A stronger case could be developed if activities were costed and implementation and evaluation procedures designed to achieve the objectives and targets outlined.

The UNICEF/WHO/GOZ Malaria Eradication Program final report and subsequent consultant/advisor reports should be studied by a MOH committee and staff members from the NIMR and the Faculty of Medicine for background information on changes required to make the ZMCP more effective. Their findings should be incorporated into the plan of operation/contingency plan. There is a wealth of information in these documents that would be of value to Zanzibar and the mainland.

ANNEX C

GENERAL INFORMATION ON INSECTICIDES

The following is a list of documents given to the Zanzibar Malaria Control Program for reference.

a) National Agricultural Chemicals Association. Disposing of Pesticide Containers.

b) GIFAP. Guidelines for Emergency Measures in cases of Pesticide Poisoning.

c) EPA. Suspended, Cancelled and Restricted Pesticides.

d) EPA. Recognition and Management of Pesticide Poisoning, Third Edition.

e) Gerberg, E.C. and R.F. Fontaine. Sumithion, Safe Handling and Use in Malaria Control.

f) WHO. The WHO Recommended Classification of Pesticides and Guidelines to Classification 1988-1989

g) Parasitology Today, Vol. 4, No.7. Pyrethroid Insecticides in Public Health, 1988.

h) Zerba, E. 1988. Insecticidal Activity of Pyrethroids on Insecticides of Medical Importance. Parasitology Today Vol. 4, No. 7.

i) Miller, T.A. 1988. Mechanisms of Resistance to Pyrethroid Insecticides. Parasitology Today Vol. 4, No. 7.

j) Malcolm, C.A. 1988. Current Status of Pyrethroid Resistance in Anophelines. Parasitology Today Vol. 4 No. 7.

k) Quelennac, G. 1988. Pyrethroids in the WHO Pesticide Evaluation Scheme (WHOPES). Parasitology Today Vol. 4 No. 7.

l) Lines, J.D. 1988. Do Agricultural Insecticides Select for Insecticide Resistance in Mosquitoes? A look at the Evidence. Parasitology Today Vol. 4, No 7.

m) XU Jinjlang, et al. Evaluation of Permethrin-Impregnated Mosquito Nets against Mosquitos in China. WHO/VBC/88.922.

n) Lines, J.D. et al. Tests of Repellent or Insecticide-Impregnated Curtains, Bed Nets and Anklets against Malaria Vectors in Tanzania. WHO/VBC/85.920.

o) Company Literature

- Cyanamid, Malathion Insecticide for adult mosquito control.
- ICI, ICON. The new broad spectrum public health insecticide.
- ICI, lambda-Cyhalothrin in Public Health.
- Marman, Fentrothion 40% VP.
- Marman, Propoxur 50% - Label.
- Marman, Malathion ULV.
- Nov-AM, Ficam VC-Label.
- Nov-AM, Ficam D, 1% Dust insecticide - Label.
- Nov-AM, Ficam ULV - Label.
- Nov-AM, Ficam W, Residual mosquito adulticide.
- Nov-AM, Ficam ULV, for adult mosquito control.
- Cyanamid, Malathion 50 WP, Material Safety Data Sheet.
- Cyanamid, Technical Information, Cythion. The Premium Grade Malathion.
- Cyanamid, Cythion - Malathion ULV Concentrate.

ANNEX D

INSECTICIDE DATE SHEETS

These documents are available at the ZMCP.

1. VBC/DS/77. 29 Malathion.
2. Sheet No. 0086-01 Cythion - Premium Grade Malathion.
3. Sheet No. 0087-01 Malathion ULV.
4. VBC/DS/77.30 Fenitrothion.
5. VBC/DS/82.52 Rev. 1. Bendiocarb.
6. VBC/DS/84.50 Deltamethrin.
7. VBC/DS/84.51 Permethrin.
8. Specifications for Pesticides Used in Public Health.
   a) WHO/SIT/10.R5 Malathion.
   b) WHO/SIT/17.R2 Fenitrothion.
   c) WHO/SIT/23 Bendiocarb.
   d) WHO/SIT/24 Deltamethrin.

ANNEX E

PROTOCOL FOR FIELD TESTING OF INSECTICIDES

1. Objectives

   a) Determine the effectiveness over a period of time of one or more insecticides.

   b) Develop and improve application management strategies.

   c) Determine environmental factors that might adversely influence the efficacy of the test insecticides.

   d) Determine the acceptance of the insecticides by the people.

   e) Determine the safety of the insecticides used under existing field conditions.

   f) Determine the effect of the insecticide application on malaria transmission (if the pilot project is of sufficient size).

2. Criteria for Selection of Villages

   a) The number and type of construction of houses in all villages should be similar.

   b) Similar geographical and climatological conditions.

   c) Similar human population and age distribution.

   d) Similar socio-economic and human behavioral patterns of the human population.

   e) Similar *Anopheles* species, population densities and sporozoite rates.

   f) Similar level of malaria transmission in the human population.

   g) Similar insecticide resistance history.

At least 100 houses per village in Unguja and Pemba are required for the village trial using malathion 50% WDP. If possible, the villages should be fairly isolated. The larger

trial of 10 percent of Unguja and 12.5 percent of Pemba should be located where malaria transmission is high.

3. Pre-Treatment Preparation

a) Select potential villages and begin communications to inform authorities and residents of activities.

b) Begin health education to inform, motivate and obtain cooperation of the people.

c) Do a comprehensive geographical reconnaissance (section 3).

d) Begin entomological surveys.

1) At least two indoor and two outdoor sites in each village should be used for weekly light trap collection.

2) Morning resting catches from 0600-0700 for 15 minutes per room should be made in at least 10 houses per village.

3) One window exit trap per village should be run each night for five days before treatment and weekly thereafter.

4) Indoor-outdoor night biting collections from 1800-0600 hours should be done at least twice at each village and every two weeks after treatment.

5) Do insecticide susceptibility tests on mosquitoes collected in the villages using test insecticides and WHO test kits and instructions .

6) Using mosquitos known to be susceptible to the test insecticides, do bioassays of the various types of sprayable surfaces in the villages.

e) Do parasitological surveys (if doing a large scale trial) of children 0-9 years of age. Either record and identify negatives and positives and compare at end the of trial or treat all positives until parasitological examinations shows them to be negative and determine conversions at the end of trial.

f) Train all spraymen and supervisors in the safe handling of the insecticides and on changes in application procedures (see 5 below).

g) Inform supervisors of symptoms of overexposure to the insecticide and procedures for treating an emergency. Do cholinesterase levels on all staff handling the insecticides and repeat at two week intervals during insecticide application.

h) Issue protective clothing, including two changes for malathion and four if fenitrothion is used. Impermeable shoes, rubber gloves, helmet and face masks should also be used, and soap and paper towels should be available in the field.

i) Prepare cost estimates for all activities:

- o labor, salary and per diem
- o transportation, fuel and maintenance
- o insecticide and equipment
- o packaging and distribution of insecticide
- o protective clothing
- o monitoring and evaluation
- o administration

4. <u>Application of Insecticides</u>

a) Test all equipment (spray pumps) for pressure leaks, nozzles, hoses and general operation. Issue a numbered pump to each sprayman. Record history of pump during trial.

b) Inspect and calibrate equipment. Inspect spraymen for protective clothing and field materials.

c) Give a final briefing on safety procedures and symptoms of overexposure to insecticides being tested.

d) Using GR mapping material, assign each sprayman the houses he will treat for that day.

e) Spraymen should inform house occupants on safety procedures and inspect houses for removal of food, water, clothing, etc. Do not spray food or floor. All animals and people should be out of the house.

f) Spray houses with the recommended dose, record the insecticide used and sign the house card.

g) Inspect houses for insecticide spills on floor and clean up.

h) The supervisor should rotate among spraymen for inspection.

i) At the end of the day, record the amount of insecticide used and the number of houses and surface area sprayed and determine the dosage. All used and unused containers are to be returned each day to the supervisor.

j) Follow-up monitoring of overexposure symptoms of occupants and death of domestic animals is necessary.

5. Safety Considerations

a) Do not store insecticide near food or water or in living quarters. Lock storeroom.

b) If possible, purchase insecticide prepackaged or repackage it under strict safety conditions at a central store (available water and passive ventilation).

c) Worn-out protective clothing should be replaced immediately and no one should be allowed to work without protective clothing.

d) Have cholinesterase monitoring kits and atropine sulfate kits available.

e) Read insecticide label and other information on safety procedures.

f) Sweep and bury insects killed by insecticide during house spraying.

g) Do not wash out spray pumps or mixing buckets near water or dump the remaining insecticide from spray pumps in water. If disposal is necessary, dig a hole and bury the insecticide container.

h) Consult literature on proper disposal of different types of insecticide containers.

i) Provide refresher training.

6. Post-Treatment Evaluation

a) Begin entomological monitoring to determine differences between pre- and post-treatment vector population and between treated and non-treated villages (see 3d):

- by weekly light trap collections

- by resting collections
- by window exit traps
- by night biting catches every two weeks
- by weekly bioassays of surfaces

b) Retreat houses using the same procedure and insecticide every three months or when the wall bioassays show residual toxicity is gone. The trial should run for one year. The time interval can be adjusted if entomological information so indicates.

c) During the field trial, malaria agents should actively search for suspected malaria cases and take blood smears. Nearby health centers should do the same.

d) At the end of the field trail, a parasitological survey of the children originally sampled should be made.

e) At the completion of the trial, WHO susceptibility tests should be done on field-caught mosquitoes from all villages using the test insecticides.

f) During and at the end of the trial, occupants should be interviewed to determine acceptance of the insecticide, disadvantages/advantages of the treatment, and for other observations that might influence future use of the insecticide.

7. <u>Preparation of Insecticide Evaluation Report</u>

a) List objectives, villages selected, location and other information, date of trials, insecticide used and general observations, i.e. rainfall.

b) Describe methods used throughout the trial.

c) Tabulate the results of the trial:

- housing: number, type, sprayable surface, dates and frequency of individual applications, type of nozzle used
- total insecticide used per cycle, amount of insecticide (active ingredient) per square meter of sprayed surface, and cost

- compare pre- and post-entomological findings
- compare pre- and post-malaria parasite surveys (if applicable)
- compare cholinesterase levels before and after each spray cycle
- list adverse toxicological observations, if important
- include results of public acceptance surveys

d) Discuss operation; conclusions on effectiveness, affordability and public acceptance etc; make recommendation for or against future use.

e) Circulate the report to those assigned the task of deciding on options for control and preparation of budget requests for financing future activities.

8. <u>Large-Scale Pilot Spray Program</u>

After the first trial of a village of 100 or more houses has successfully been completed (if the first trial is not successful, it should be repeated at another location before attempting the larger pilot spray program), a larger scale project should be undertaken. This will require additional coordination of activities by the supervisors to keep progress moving. It will be a test of managerial skill to ensure the presence of enough men, equipment and insecticide at the correct time and place. A comprehensive GR will be of great value in allowing this to occur.

This program should include large areas, e.g. one-eighth of Pemba and one-tenth of Unguja. One objective of this trial is to work out any problems before attempting the first complete treatment of each island within the two-month spray cycle period. Success will depend upon the active involvement of all supervisory staff of the ZMCP.

Wall bioassays will have a special evaluation function to demonstrate the length of the residual toxicity on different surfaces and at several locations. The bioassays should be done every two weeks until a lack of effectiveness is clearly apparent. Control bioassays on untreated surfaces be done at the same time.

Any type of failure experienced during the pilot study will have to be corrected before a complete spray cycle is attempted.

If major difficulties that will influence the outcome of the study occur during the pilot spray program or if major changes in procedure occur, the entire pilot study should be repeated at another location. If a second trial is necessary, the spraymen should be recruited from the new area (not moved from the previous one). This will give the supervisors additional experience in training local people.

ANNEX F

TECHNICAL LINKAGES

1. International

a) **The World Health Organization (WHO).**

WHO has offices in both Zanzibar and Dar es Salaam. AFRO has experts in malariology and medical entomology. The Malaria Action Programme and the Division of Vector Biology and Control at the headquarters has staff to handle most technical problems. The WHO has an interest in malaria in Zanzibar and has provided a number of advisors in the past. The ZMCP staff maintains contact with a number of sections in WHO/AFRO and WHO/HQ. WHO has specifications on insecticide and insecticide application equipment, and any orders of these items should request that these specifications be met.

b) **London School of Hygiene and Tropical Medicine.**

Several investigators from the school are doing research on various aspects of malaria in Zanzibar and on the mainland. ZMCP personal, however, do not seem to take full advantage of the opportunity to improve their entomological capabilities. Some of the research findings should be used in decision making and reorientation of control strategy and activities.

c) **Others**

International and bilateral donor organizations, including UNICEF, UNDP and FAO, frequently have projects that are related to malaria or influence disease transmission. Insecticide companies often sponsor applied research to evaluate their products. Some private foundations have an interest in specific facets of malaria control.

2. Regional

The following institutions on the mainland do research or could furnish technical assistance on various aspects of malaria and malaria vectors:

a) National Institute for Medical Research (NIMR)

The Amani/Muheza Centre in Tanga does research in malaria chemotherapy, drug sensitivity, mosquito taxonomy, mosquito age grading, sporozoite rates and insecticides, all of which are relevant to the ZMCP. It maintains a colony of An. gambiae, which was started by Dr. Curtis, that does not readily transmit parasites. If appropriate, ZMCP staff members could be trained at the center in the rearing of An. gambiae. There also is an insecticide-impregnated bed net project based at Muheza. The progress made in this study should be followed.

b) Swiss Tropical Institute Field Laboratory (STIFI)

The STIFI is located at Ifakara and does research on malaria chemotherapy, immunology and epidemiology in rural areas. Entomologists with experience in malaria vectors are based there.

c) Muhimbili Medical Centre (MMC)

The Department of Parasitology-Medical Entomology does research on malaria chemotherapy, drug sensitivity and mosquito control techniques. The Department also trains medical laboratory technicians in medical parasitology. It maintains a colony of An. gambiae.

d. Tropical Pesticides Research Institute (TPRI)

The TPRI is located in Arusha and does research on pesticides and application methods. It maintains a laboratory colony of An. gambiae and may soon begin collaborating with WHO on a large trial against malaria vectors using residual synthetic pyrethroids.

e) The MOE National Malaria Control/Vector Control Section

This section is cooperating with the Dar es Salaam Vector Control Project (a joint JICA-City Council undertaking). Fenitrothion is used for mosquito control. Since it has urban mosquito problems similar to those of Zanzibar Town, exchange of information is important.

Over the years, the ZMCP has made contacts with some workers in the above institutes and staff members have attended meetings

on malaria on the mainland. Part of the problem of maintaining linkages is the expense and difficulty of travel. A combination of some of these institutes could provide specialized training on some specific techniques relevant to the ZMCP. Workers from the mainland could be invited tc actively participate in research activities within the ZMCP. Scientists of the institutes could serve on review and planning committees of the ZMCP. The cooperation of a national on this consultation is seen as a positive step forward.

ANNEX G
THE TACTICAL VARIANTS

AID MALARIA STRATEGY MEETING
Columbia, Maryland 7-10 June 1983

Annex 5

ANTI-MALARIA METHODOLOGIES: THE TACTICAL VARIANTS

The Seventeenth Report of the WHO Expert Committee on Malaria (WHO, Geneva, 1979: Technical Report Series 540) defines a malaria control program as an organized effort to institute, carry out and evaluate such anti-malaria measures as are appropriate to the prevailing epidemiological and socio-economic conditions, in order to achieve the greatest possible improvement in the health situation of a population subjected to the burden of this disease or exposed to the risk of its resurgence.

The purpose of such a program is to reduce the impact of malaria on the population to the lowest possible level. The control measures selected should be economical and the methods of operation and evaluation must be chosen in relation to the set objectives.

The following sequence of goals and associated anti-malaria methodologies, referred to in the Expert Committee Report as tactical variants, encompasses the major posssibilities of malaria control.

1. Tactical Variant No. 1

Goal: Reduction and prevention of mortality due to malaria.

This represents the most elementary form of a malaria control program. For such a program, the only practical measure is the administration of curative doses of an effective schizonticidal drug. For the patient, it will shorten the duration of each episode of malaria fever, reduce absenteeism from school and work, and, in areas where *Plasmodium falciparum* is prevalent, contribute to an improvement in general health.

2. Tactical Variant No. 2

Goal: Reduction and prevention of mortality and morbidity.

In this variant, it is necessary not only to provide effective anti-malarial drugs in sufficient quantities for the early treatment of acute malaria cases, but also to pay special attention to certain selected groups (e.g., infants and young children, nursing and expectant mothers, high-priority members of the labor force, etc.). This special attention takes the form of chemoprophylaxis to prevent malaria.

3. Tactical Variant No. 3

Goal: Reduction of prevalence and endemicity of malaria.

Tactical Varients Nos. 1 and 2 are limited "holding operations" which can reduce malaria-related mortality and morbidity but which have relatively little impact on malaria prevalence and endemicity. Tactical Variant No. 3 requires additional measures designed to reduce malaria prevalence. Measures to be taken will be selected on the basis of the epidemiological and environmental situation, fund availability and administrative capacity. They include (in addition to chemotherapy and chemoprophylaxis) such vector control measures as the reduction of mosquito breeding habitats, careful selection of building sites, destruction of adult mosquitoes by residual spraying or space spraying of insecticides, and destruction of mosquito larvae through the use of chemical or biological larvicides. These measures may and usually will vary, not only from country to county, but also among ecological and epidemiological settings within a country. Such a program need not be nation-wide in its application; it may be carried out in areas where technical feasibility exists, while Tactical Variant Nos. 1 and 2 are being conducted elsewhere in the country.

4. Tactical Variant No. 4

Goal: Countrywide malaria control, aiming at the ultimate objective of eradication.

This variant requires a long-term malaria control program with specific time targets for attaining the interim objectives described under Variants 1,2 and 3, and leading ultimately to eradication.

ANNEX H

ITINERARY

February	10	Arrive Arlington, Va. Briefing at VBC.
	13	Arrive Geneva. Briefing at WHO/VBC and WHO/MAP.
	14	Discussions with Drs. Curtis and Lines on Bed Nets
	15	Arrive Dar es Salaam. Briefing Ms. Tavrow USAID/Tanzania.
	16	Arrive Zanzibar. Briefing Mr. Haji ZMCP.
	17	Terms of Reference and duties at ZMCP.
	18	Review ZMCP Plans of Operation and Field Data Forms.
	20	Colonization of Culex and review information system.
	21	Insectary: Anopheles larvae, Larvivorous fish experiment, analysis of night biting studies.
	22	GR supervision: Mtoni and Kama.
	23	GR course at Mohanda.
	24	Practical Field work of GR course, Night Biting Catch Miwani.
	25	Continuation of night biting catch, Miwani Insectary Management.
	27	Meeting with Dr. Muchi. Visit Mapping Section of GOZ. Analysis of night biting collections.
	28	Visit Larval Habitats in Zanzibar Town.
March	1	Visit Larval Habitats in Zanzibar Town.
	2	GR Course at Mkokotoni.
	3	Insectary Management.
	4	Meetings at Mayors Office and FAO.

March	6	Adult resting collection at Fuoni. Larval dip collections at Mwere. Temephos test on Culex and Anopheles larvae.
	7	Meeting on PHC and EDP at MOH.
	8	Visit health centers at Muyuni and Jambiani. Visit cottage hospital at Makunduchi.
	9	Discussion with Dr. White and Mr. Haji on research. Visit Zanzibat Town drainage program. Adult and larval insecticide susceptibility tests.
	10	Discussions with Mr. Mohamed of Pemba on pending visit. Move insectary to Health Education Office. Read susceptibility tests.
	11	Staff training on susceptibility tests. Briefing on Dar es Salaam vector control project.
	13	Visit to Save the Children Fund Bed Net Study, Miwani. Rice field larval collections.
	14	Rice field larval collections, Central District Dr. Schaefer arrived.
	15	Discussions with ZMCI staff on insecticide work. Visit administrative sections of ZMCP.
	16	GR field evaluations in Central District. Visit storehouse facilities and garage. Dr. Minjas arrived.
	17	Larval collections at Mwera. Meetings USAID and ZMCP staff. Night biting catches at Mwera.
	18	Meeting with USAID, MOH and ZMCP staff. Adult Anopheles susceptibility testing.
	19	Rear larvae for adult susceptibility tests.
	20	Trip to Pemba, briefing at ZMCP office Chake Chake. Malathion test with Anopheles adults.
	21	Visit GR activities at Mkoani. Visit rural health center and District Hospital, Mkoani. Read malathion test and set up another test.

March	22	Visit Micheweni cottage hospital and village. Visit District Hospital and Medical Stores at Wete. Read malathion test and set up another test.
	23	Meeting with Senior Medical officer of Pemba, Wete. Return to Zanzibar.
	24	Malathion test with Anopheles from larvae from Mwera. Begin drafting report.
	25	Adult susceptibility test, malathion. Continue drafting report.
	26	Continue drafting report. Dr. Minjas departs for Dar es Salaam.
	27	Continue drafting report.
	28	Briefing at Office of Director Prev. Hlth. Services. Continue drafting report.
	29	Dr. Schaefer departs for Dar es Salaam. Continue drafting report.
	30	Word processing of report. Discussions of report with Dr. Muchi and Mr. Haji.
	31	Report writing and editing.
April	1	Report writing and editing.
	3	Report writing and editing.
	4	Adult resting catches at Mwera.
	5	Culex bendiocarb testing.
	6	Continue susceptibility testing.
	7	Bed net bioassay test at Miwani. Anopheles bendiocarb test.
	8	Results of bed net bioassays and bendiocarb tests. Prepare protocol for future bioassay bed net studies.
	9	Proofread and edit draft of report.

April	10	Bioassay of bed nets at Miwani, 30 minute exposure *Culex* bendiocarb testing.
	11	Meeting at Principal Secretary's office on report Read *Culex* test.
	12	*Anopheles*/Malathion test. To Dar es Salaam.
	13	Meetings Sumitomo, SIDA, NIMR, and USAID. Proofread report.
	14	Debriefing at USAID. Proofread report.
	15	Depart Dar es Salaam.
	16	Arrive in USA.

ANNEX I

PERSONS CONTACTED

Government of Zanzibar

Mr. Muhammed Salim Sulaiman
Principal Secretary

Dr. Omar M. Shauri
Deputy Principal Secretary

Dr. Vledi M. Kisumku
Director of Preventive Services

Dr. Maua A. Daftari
Director of Hospital Services

Mr. Joop Garesen
Health Statistics Unit

Mr. Silima Khamis
Senior Medical Assistant, EDP

Dr. Mohamed Salim
Senior Medical Officer-Pemba

Zanzibar Malaria Control Program

Dr. Juma Muchi
Director

Mr. Hamad Haji
Chief Parasitology-Entomology Section

Mr. Juma Rajab
Chief Operation Section

Mr. Sultan Issa
Assist. Chief Parasitology-Entomology, Unguja

Mr. Khalfan Mohamed
Assist. Chief Parasitology-Entomology, Pemba

Mr. John Herman Kihongwe
Assist. Chief Operations, Pemba

Mr. Abdulla S. Ali
Island Officer, Pemba

Mr. Abu Makame
Island Officer-Chief Administration, Unguja

Mr. Abd. Muhammed
Regional Malaria Officer-South District, Unguja

Mr. Nassor S. Nassor
Field Entomologist, Unguja

International Organizations

Mr. A. I. Khatibu
FAO, National Project Coordinator, Irrigation

Dr. Boris Tolstopiatov
UNICEF, Project Officer

Dr. Alberto Matteelli
WHO Associate Professional Officer, ZMCP

Dr. F. A. Duale
WHO Representative-Tanzania

Ms. Caroline Maxwell
Save the Children Fund

USAID/Tanzania

Mr. Joseph F. Stepanek
Representative, USAID

Ms. P. Tavrow
Program Officer

Mr. Z. Hahn
Program Officer

Mr. John Starnes
Engineer

Zanzibar Municipal Council

Mr. M. H. Mjaka
Mayor

Mr. Mzee K. Juma
Public Health Engineer

World Health Organization, Geneva

Dr. J. A. Najera Director, MAP
Dr. V. Ivarro Cano, MAP
Dr. N. Gratz, MAP
Mr. R. Bos, PEEM
Mr. G. Shidrawi, VBC
Dr. B. Knudsen, VBC
Dr. A. Ismail, VBC
Dr. Guelennet, VBC
Dr. J. Lines, VBC Bed Net Study Group
Dr. C. Curtis, VBC Bed Net Study Group

Vector Biology & Control Project

Dr. Robert Lennox, Director
Dr. Andy Arata
Dr. Lerry Lacey
Dr. Barry Silverman
Ms. E. Nayeri
Mr. Ralph Schmidt
Mr. W. W. Lylerly, Jr., AID Bureau of Africa

Others

Dr. G. White
ICI Vector Control Specialist

Dr. W. Kilama
Director, NIMR

Mr. A. R. Majali
Tanzania MOH Vector Control Section

Mr. Hasnein Gulamhussein
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Mr. Kazuo Kawakami
Sumitomo Corporation