Central America Malaria Research Station in San Salvador

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Malaria, one of the earliest recognized and most devastating plagues of mankind, has been the target, for the last decade, of what may be the largest health program ever undertaken. In some instances, malaria eradication has been dramatically successful. Through a combination of DDT spraying, improvements in living conditions, and water control measures, about 710 million people (including some in the southeastern United States) who were once at risk from the disease are now virtually free of the danger of exposure.

An additional 800 million people live in areas where malaria eradication or control is being attempted. The remaining malarious areas, including most of the continent of Africa, have no control measures.

Status of malaria	*Population*
World	[1] 2,828,521,000
Nonmalarious areas	1,026,890,000
Malarious areas	1,801,631,000
Malaria eradication claimed	709,632,000
Under malaria eradication programs	630,272,000
Some malaria protection	175,120,000
No malaria protection	286,607,000

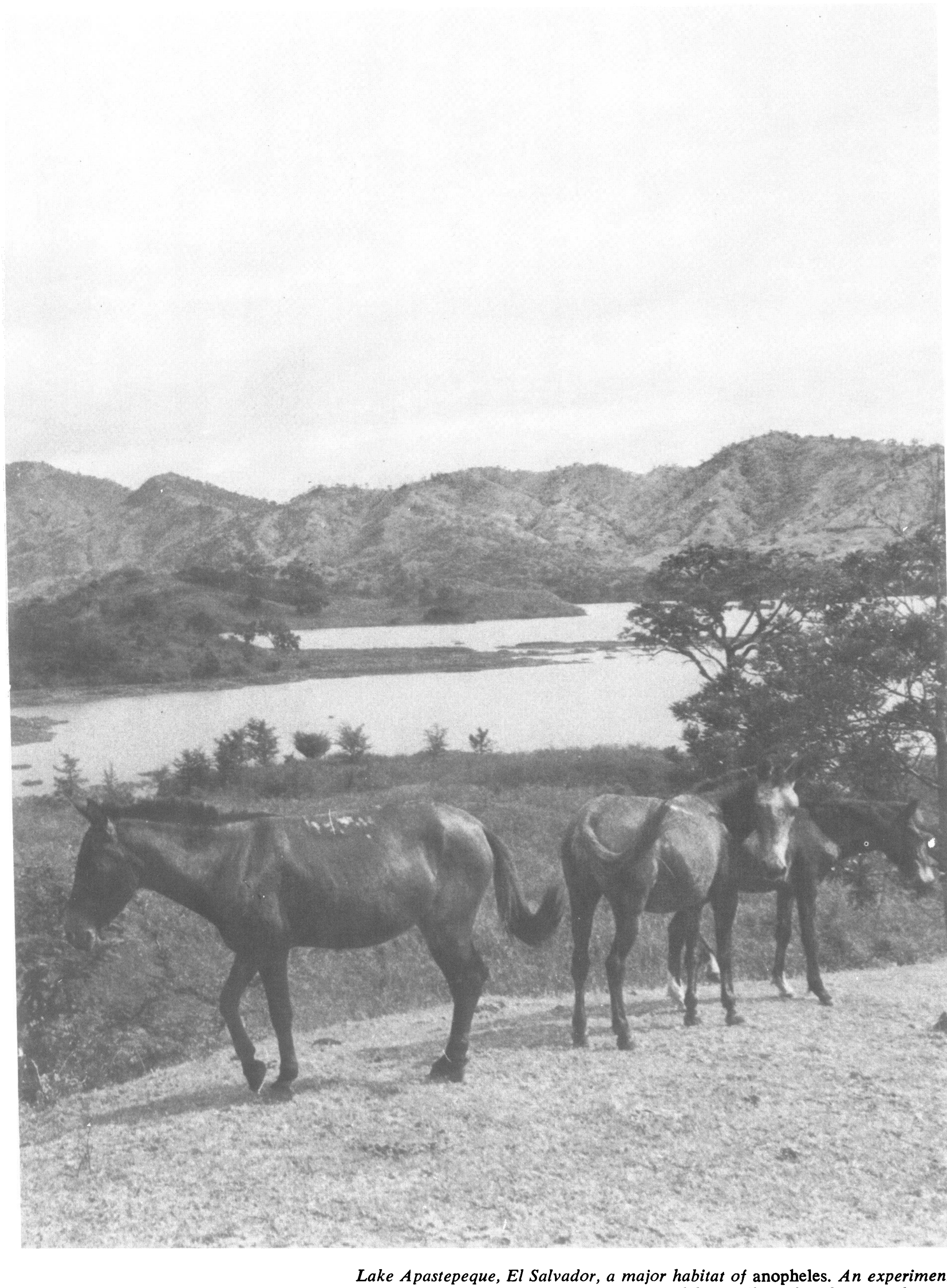
[1] Does not include China, North Korea, and Vietnam.
SOURCE: World Health Organization, Malaria Eradication, Geneva.

Early successes led many people to believe that malaria would soon join smallpox and poliomyelitis on the list of eradicable diseases, but the countries where malaria has been conquered are the exception. In many of the countries with active malaria eradication programs (including much of Central and South America), the disease is no longer declining.

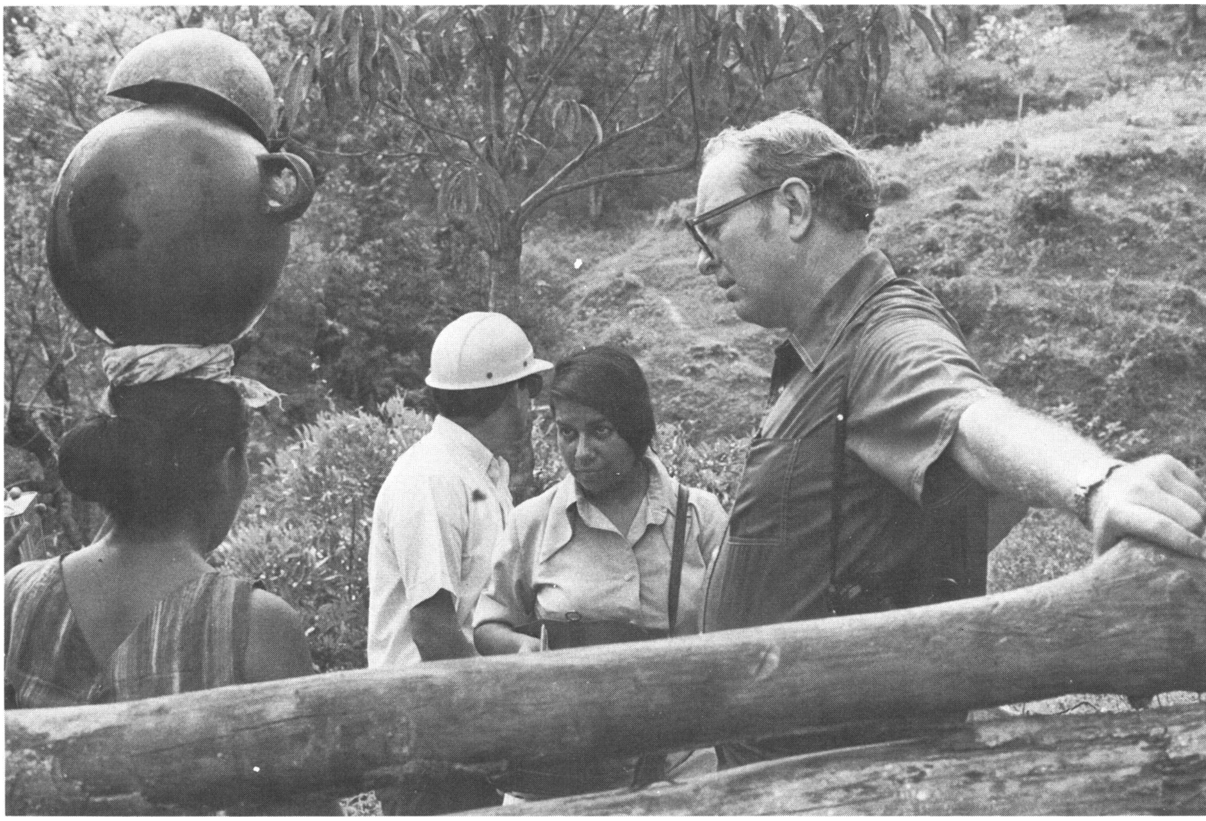
Control in Central America

Attempts to control malaria in Central America began in 1900 in El Salvador with water management and larviciding. When DDT became available in the 1940's, the World Health Organization adopted malaria eradication as a goal. By 1958, all six countries on the Central American isthmus had malaria eradication programs underway. The basic plan called for a series of intradomiciliary sprayings of insecticides with residual properties. The entire program was to be carried to a successful conclusion before mosquitoes could develop resistance to the insecticides.

Difficulties arose very soon. First, the mosquitoes became resistant to dieldrin, then to DDT. Also, ecological studies indicated that the vectors were biting and resting outdoors rather than in-



Lake Apastepeque, El Salvador, a major habitat of anopheles. *An experiment on mosquito control by sterile-male release is planned*



Station medical technologists, Ana Julia Larín and McWilliam Warren, conduct surveys to determine the history of malaria among the people of an area

doors. And, finally, since the control programs tended to continue much longer than the 3 years originally planned, people became bored with the spraying, drug prophylaxis, and health education efforts.

Thus, in 1965, the Center for Disease Control, Health Services and Mental Health Administration, Atlanta, Ga., which has been actively associated with 18 national malaria programs since 1966, proposed to the Agency for International Development that field research on malaria be undertaken in a tropical area of Central America. The Central America Malaria Research Station (CAMRS) in San Salvador, El Salvador, was the result.

This station was established in 1967 in response to the growing realization that the existing methodology and knowledge of malaria were inadequate to deal with the multiple serious problems facing malaria programs in the area. CAMRS includes laboratories, an extensive malaria library, insectaries, and offices. CAMRS has an epidemiologist, two parasitologists, a biologist-chemist, two entomologists, and a health education specialist among its U.S. technical personnel and also 35 Salvadoran employees. From the beginning, the research of CAMRS was intended to cover a wide range and to be flexible and creative in its approach to the problems posed by malaria.

Strategy for Eradication

The strategy of malaria eradication has been based on the interruption of transmission of the disease at a specific phase in the life cycle of *Plasmodium*—between the time a mosquito ingests parasites from the blood of an infected person and the time it introduces them, as it feeds, into the blood of a previously uninfected person. Interruption of transmission is accomplished when the mosquito rests on a surface sprayed with insecticide and dies, as a result, before the malaria parasite can reach the proper stage of development to be infective to a human host.

The recalcitrance of malaria in some areas does not invalidate this basic concept. When conditions are right, malaria can be eradicated by using indoor residual insecticides. But when people do not live in houses with solid walls, when houses in malarious areas are inaccessible, when the foci of malaria go undetected, or when mosquitoes bite in the daytime while people are out of doors, indoor insecticide spraying cannot effectively interfere with the transmission of malaria.

Theoretically there are many other stages of the plasmodial cycle during which malaria is vulnerable to attack, and CAMRS covers a variety of research topics. The resistance of *Plasmodium* to various drugs is being studied. Entomological studies include vector ecology, insecticides, water management, and biological control methods.

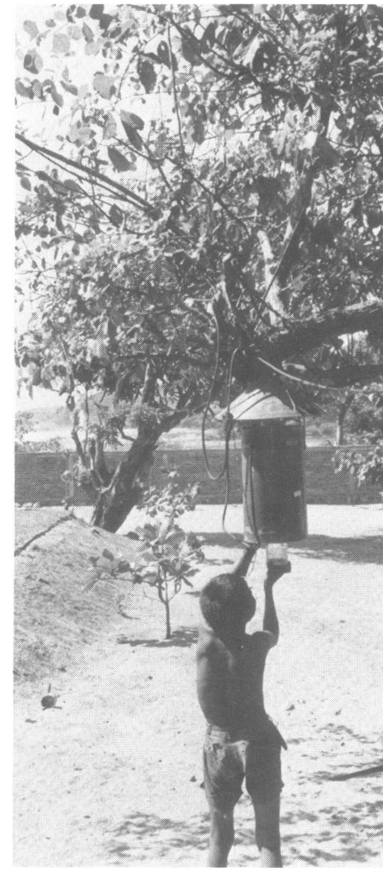
Breeding Habits of Vector

To learn where mosquitoes are found and at what time of year they are prevalent, the breeding habits and seasonal distribution of these malaria vectors must be determined. It has been shown that in Central America there is an interaction between location of breeding sites and season of the year; mosquitoes use certain sites in the dry season and other sites in the rainy season. Rivers and estuaries, for example, are major depositories of mosquito larvae during the dry season, but the larvae are flushed out to sea during the rainy season. While no single habitat supports the breeding of *Anopheles* mosquitoes throughout the year, permanent bodies of water, such as lakes in the craters of volcanoes, contain varying amounts of larvae year round. Information about anopheline breeding is needed for selection of appropriate vector control measures, such as larviciding.

Mosquitoes require more than a simple body of water for breeding. In one project at CAMRS, water samples were dipped from various sites. These sites were paired to be similar in every way except that, at one, plants intersected the surface of the water and, at the other, the surface appeared clean. This study showed that mosquitoes require an environment with a plant-air-water interface for breeding. The type of plant does not seem to matter —floating detached mangrove leaves supported breeding as well as surface-breaking aquatic plants.

The study of aquatic habitats relates primarily to the larvae of mosquitoes. Several methods are used at the research station to determine where adult mosquitoes are most likely to be found at various times of the day, including capture by three different kinds of light traps and by biting human beings. Information on anopheline densities aids in evaluating control measures and planning new attack measures.

Studies of feeding references have revealed that *Anopheles albimanus*, the principal vector of malaria in Central America, actually feeds on cattle more than twice as frequently as on human beings. Since the human malaria parasite cannot live in cattle, this observation, along with others, has caused CAMRS researchers to wonder how the species continues to survive in Central America. A recent CAMRS report suggested that the species *A. albimanus* may actually include a series of physiological variants, each having a different ecology and different habits and, therefore, a different vectorial capacity. While no such variants have yet been identified, the techniques necessary to identify them have been proposed.) Any such identification of specific vectors contributes to the economy and efficiency of attack measures.



Light traps are used to check mosquito density

Control Methods

Since malaria control and eradication rely heavily on insecticides, widespread resistance to them makes the development and testing of alternative insecticides urgent. Improved methods of applying insecticides are also being developed.

In collaboration with the Tennessee Valley Authority and the Department of Agriculture, researchers at CAMRS are also studying biological control methods. In El Salvador, some mosquito pathogens have been investigated; anophelines have been infected with nematodes in the laboratory. The staff at the CDC Technical Development Laboratory has been studying synthetic juvenile hormones as larvicides. These compounds affect the development of mosquito larvae, producing 95 percent mortality at levels of 0.1 ppm.

Finally, the CAMRS staff, in collaboration with a Department of Agriculture group in Gainesville, Fla., is testing a technique in which sterile male mosquitoes are released. Release began in April 1972. Baseline anopheline densities have been determined, and male pupae are being bred at the station.

Some new data on the relapsing pattern of *Plasmodium vivax* may answer one of the most puzzling questions about malaria in Central America, that is, why case rates continue to be high during January and February, a time when mosquito populations are low. Investigators from the National Institutes of Health have inoculated human volunteers with Salvadoran strains of *P. vivax* under controlled conditions. The results show that these strains have a latent period of about 200 days between the primary attack and the first relapse, so that the parasite can survive a prolonged period of low anophelism.

Acceptance of Control Methods

Antimalarial drugs have been used for a long time for cure, suppressive treatment, and prophylaxis. If drugs interrupt the transmission of malaria by killing the parasite or arresting its development, they can be thought of as eradication or control measures. Mass distribution of drugs, however, has not been notably successful in the past, largely because of lack of acceptance by the people.

The CAMRS staff has therefore tried to determine the pattern of people's acceptance and refusal of drugs, identify the specific complaints of drug recipients, and find the measures which might increase the population's acceptance. In addition, different drug combinations have been tested. Drug acceptance averaged about 60 percent in the study area, and the drugs did seem to reduce transmisson of the disease.

In every CAMRS program, an effort is also made to evaluate the people's responses to antimalarial measures other than drugs and to test various educational methods that are designed to combat adverse attitudes and behavior. Person-to-person communication, as opposed to a mass media approach, is strongly recommended for bringing about changes in attitude and producing a clearer understanding of health activities. Before insecticide spraying is done, for example, it should be adequately explained to the occupants of a house.

Now that antimalarial activities in many areas will probably be changing from a strategy of eradication and full coverage to one of control and focal coverage, rapid and accurate surveillance becomes even more important. The CAMRS staff is evaluating several surveillance methods, including voluntary collaborator posts and the newer serologic tests. (Voluntary collaborators are native residents of the villages who receive training from the malaria program personnel in taking blood samples and dispensing antimalarial drugs. Thus, they are a kind of malaria "first aid" system and function as passive case detectors.)

In cooperation with the Laboratory of Parasitic Diseases, National Institutes of Health, Chamblee, Ga., the CAMRS staff is evaluating the indirect fluorescent antibody test (IFA) through field seroepidemiology. Serologic tests reveal a person's history of malaria; the traditional parasitological methods—direct microscopic examination of blood slide—reveal the current presence of parasites in the blood. The endemicity of malaria in an area can be defined by comparing the level of positive serologic tests in human beings with the level of parasitic positives.

Communication

Clearly, there are many pressing questions in malaria research, some of which were taken up at the Inter-American Malaria Research Symposium held in El Salvador in November 1971. Its purpose was to encourage mutual understanding and interdisciplinary communication between researchers, fieldworkers, and program management officials. Jointly sponsored by the Government of El Salvador, the Pan American Health Organization, and the Center for Disease Control, the symposium was attended by more than 150 persons representing 20 nations. Papers were read on every phase of malaria research — epidemiology, sociology and economics, serologic tests, immunologic response, antimalarial drugs, vector ecology, and biological and chemical control.

Now that the emphasis in malaria programs is shifting to multiple control methods suited to local conditions, deficiencies in basic information about the vector, the parasite, and the human host at risk from malaria are more significant. With the information generated by CAMRS, it is hoped that malaria programs will be able to avoid past errors by providing basic information on the vector-parasite-man relationship in Central America as well as in other malarious areas of the world.